Revealing of the plant diversity in China's biodiversity hotspots

Edited by
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EDITORIAL

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China's biodiversity hotspots revisited: A treasure chest for plants

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China has been recognised as having exceptionally high plant biodiversity since the mid-19th century, when western plant explorers brought their discoveries to the attention of modern botany (Bretschneider 1898). The "Flora of China" recorded 31,362 vascular plant species, half of which could not be found anywhere else on earth (Raven and Hong 2013), making China one of the planet's biologically wealthiest countries.

Biodiversity hotspots, by definition, are areas with exceptional concentrations of endemic species (containing at least 0.5% of the Earth's plant species as endemics) and are experiencing increasing, large-scale habitat loss, at least 70% of which is caused by human disturbance (Myers et al. 2000). China hosts, mostly or partially, four of the world's 36 biodiversity hotspots (Myers et al. 2000, CEPF 2019). The hotspots in China range from the arid northwest of the country, across Qinghai-Tibet Plateau, the highest and largest plateau of the world, to the tropical and subtropical southern China. The "Mountains of Central Asia" biodiversity hotspot reaches its eastern limit in China, including the eastern Tien Shan Mountains in central Xinjiang and the

mountain ranges along China-Kyrgyzstan and China-Tajikistan borders. The mountains that surround the southern part of the Qinghai-Tibet Plateau, which extend from the western barrens to the humid southeast in Tibet (Xizang), form a significant portion of the "Himalaya" biodiversity hotspot. The "Mountains of Southwest China" biodiversity hotspot is found almost entirely within China, stretching from southeast Tibet, through western Sichuan and extending into northwest Yunnan, with only a narrow range along the western slope of the Gaoligong Mountains, located in northern Myanmar. The northeast part of the "Indo-Burma" biodiversity hotspot begins in the west of Yunnan, crosses over southern Yunnan to central Guangxi and then runs along the coast of southern China from the Guangxi-Vietnam border to eastern Guangdong, including the entire Hainan Island.

Biodiversity hotspots play a substantial role in understanding China's unique flora. Currently, the native vascular flora from China's biodiversity hotspots has yet to be investigated in its entirety and the estimated number of species could be more than 25,000 based on the "Flora of China" and recent surveys (The Biodiversity Committee of Chinese Academy of Sciences 2019). This accounts for approximately three quarters of China's flora. China's biodiversity hotspots are mainly located in remote mountain areas, where access is difficult and there are diverse microclimates. These isolated habitats are often associated with high levels of endemism and there is great potential for the discovery of new plant species in these regions (Joppa et al. 2011). Although rapid economic growth and urbanisation in China is driving landscape modification and environmental deterioration, the flourishing development of infrastructure, such as expansion of road networks, has improved accessibility to remote areas, thereby fostering the discovery of additional undescribed diversity in the country. For example, according to records in the International Plant Names Index (IPNI), 1038 new vascular plant species were described or reported for China from 2013 (the year when the "Flora of China" was completed) to the end of 2018, with some 73% of the species deriving from China's biodiversity hotspots (Figure 1, Appendix 1). The future discovery of additional new plant species in these regions is likely.

The "Flora of China" represents the most comprehensive catalogue, description and illustration of known vascular plant species of China. However, a few of the early treatments published were essentially updated translations of the "Flora Reipublicae Popularis Sinicae" and for a number of other groups, no specialists were available at the time when the treatments were completed, so that they are in essence preliminary. A great deal of further taxonomic work, often simulated by the "Flora", has improved our understanding of many groups, very often adding to the number of recognised species. For example, recent taxonomic revisions of Chinese *Aristolochia*, which included only 45 species in the "Flora of China", split the genus into two genera with 78 species in total, of which 19 were newly described (Zhu et al. 2019b, Zhu X.-X. personal communication), two of them in this special issue (Zhu et al. 2019a). It is quite clear than many more species are present in China than are now recognized, and likely that most of these will come from the hotspots.

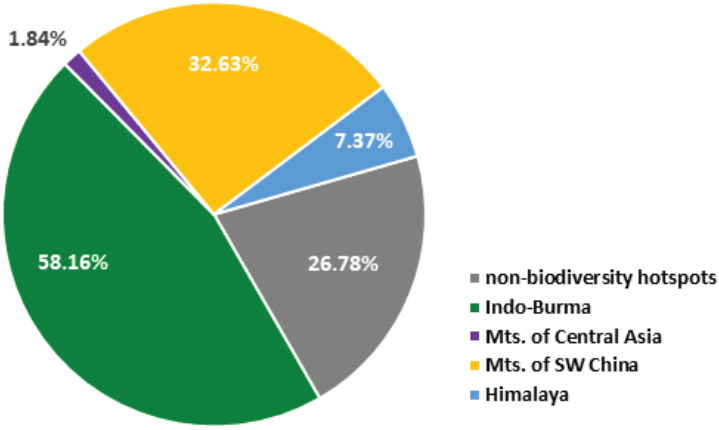

Figure 1. Chart of new species reported to occur in China's biodiversity hotspots, based on data from IPNI, 1 Jan. 2013- 31 Dec. 2018

The application of DNA barcodes and other sequence data in the past decade has helped to improve our understanding of the species and relationships in many groups of plants (Kress et al. 2005, CBOL Plant Working Group 2009, China Plant BOL Group 2011, Hollingsworth et al. 2016). To fully understand the diverse flora of China, these tools must be applied widely (e.g. Liu et al. 2011, Yan et al. 2015, Yu et al. 2015).

To better document, understand and conserve China's biological heritage, Chinese scientists have conducted a series of initiatives to facilitate the understanding and conservation of plant diversity, particularly over the past twenty years. These range from baseline, floristic surveys to long-term monitoring studies that document dynamic patterns of biodiversity with a specific focus on Southwest China and the Qinghai-Tibet Plateau, where many ecosystems are being degraded as a result of human activities and global warming (Liu et al. 2018). Indeed, much action is urgently needed to mitigate the effect of human disturbance and climate change in these hotspots and elsewhere in China.

With extended collaboration amongst Chinese scientists and coordination of networks on plant conservation and taxonomy across China, we have synthesised a special issue entitled "Revealing the plant diversity in China's biodiversity hotspots", to present the latest findings by Chinese botanists and to update knowledge of the flora for China and adjacent countries. This issue, comprising 18 articles, includes descriptions of 23 species new to science and new insights into the diversity of *Scleroglossum* (Polypodiaceae) based on DNA barcodes. The new species originate from the following hotspots: Indo-Burma (13), Mountains of Southwest China (2), Himalaya (4), Mountains of Central Asia (1) and 3 from areas with conservation interest outside the hotspots.

The new species published in this special issue reflect ongoing taxonomic and floristic research across China. It is hoped that these new discoveries will contribute to the

objectives of the updated Global Strategy for Plant Conservation (GSPC) 2011–2020 and China's Plant Conservation Strategy, in general. In particular, we also strive to facilitate national and local policy-makers to develop more effective conservation guidelines. The naming and describing of new species are fundamental steps for understanding China's natural history and assessing its plant diversity is the first "stepping-stone" to securing the success of our biodiversity initiative. In short, the value of botanical inventories and taxonomic work should be recognised through prioritised funding opportunities, inspired taxonomy training schemes, wider public involvement and an integrated GSPC post-2020 framework.

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Appendix 1

List of new vascular plant species occured or described from China between 2013–2018 (data from IPNI).

Family	Scientific name	Publication year	Discovered from Biodiversity hotspots*	IPNI Plant Name Id
Acanthaceae	*Justicia weihongjinii* Y.F.Deng, Y.Tong & Y.S.Huang	2016	IB	77153239-1
	Rungia flaviflora Z.L.Lin & Y.F.Deng	2018	IB	77185931-1
	Rungia sinothailandica Z.L.Lin & Y.F.Deng	2017	IB	77174700-1
Adiantaceae	*Adiantum* × *ailaoshanense* Y.H.Yan & Ying Wang	2015	IB	77151658-1
	Adiantum dentatum A.H.Wang, F.G.Wang & F.W.Xing	2017	IB	77160197-1
	Adiantum longzhouensis A.H.Wang, F.G.Wang & F.W.Xing	2017	IB	77160199-1
	Adiantum obovatum A.H.Wang, F.G.Wang & F.W.Xing	2017	IB	77160198-1
	Coniogramme bashanensis X.S.Guo & Bin Li	2013		77129783-1
Alangiaceae	*Alangium indochinense* W.J.de Wilde & Duyfjes	2016	IB	77160208-1
Alliaceae	*Allium kirilovii* N.Friesen & Seregin	2015	CA	77147239-1
	Allium montanostepposum N.Friesen & Seregin	2015		77147238-1
Amaryllidaceae	*Lycoris* × *hubeiensis* Kun Liu	2018		77188002-1
	Lycoris hunanensis M.H.Quan, L.J.Ou & C.W.She	2013		77132590-1
Annonaceae	*Alphonsea glandulosa* Y.H.Tan & B.Xue	2017	IB	77159533-1
	Polyalthia yingjiangensis Y.H.Tan & B.Xue	2017	IB	77174697-1
Apiaceae	*Acronema crassifolium* Huan C.Wang, X.M.Zhou & Y.H.Wang	2013	SW	77127272-1
	Angelica muliensis C.Y.Liao & X.G.Ma	2017	SW	77179082-1
	Bupleurum baimaense X.G.Ma & X.J.He	2013	SW	77135889-1
	Bupleurum dracaenoides Huan C.Wang, Z.R.He & H.Sun	2014	SW	77136465-1
	Bupleurum shanianum X.G.Ma & X.J.He	2014	SW	77146546-1
	Chamaesium jiulongense X.L.Guo & X.J.He	2017	SW	77174717-1
	Hydrocotyle peltiformis R.Li & H.Li	2013	SW	77144604-1
	Libanotis laoshanensis W.Zhou & Q.X.Liu	2015		77154495-1
	Ostericum atropurpureum G.Y.Li, G.H.Xia & W.Y.Xie	2013		77131197-1
	Pternopetalum monophyllum J.B.Tan & X.J.He	2014	SW	77145115-1
	Pternopetalum porphyronotum J.B.Tan	2018	SW	77179091-1
	Semenovia gyirongensis Q.Y.Xiao & X.J.He	2017	H	77163815-1
Aquifoliaceae	*Ilex calcicola* W.B.Liao & K.W.Xu	2017	IB	77177671-1
	Ilex chuguangii M.M.Lin	2013	IB	77129105-1
	Ilex gansuensis D.Y.Hong	2015		77150544-1
	Ilex jingxiensis Y.F.Huang & M.X.Lai	2014	IB	77144567-1
	Ilex sanqingshanensis W.B.Liao, Q.Fan & S.Shi	2015		77154790-1
	Ilex shukunii Y.Yang & H.Peng	2018	SW	77192550-1
	Ilex venusta H.Peng & W.B.Liao	2017		77161288-1
Araceae	*Amorphophallus bubenensis* J.T.Yin & Hett.	2016	IB	77157352-1
	Arisaema chenii Z.X.Ma & Yi Jun Huang	2018	IB	77195372-1
	Arisaema longitubum Z.X.Ma	2018	SW	77186325-1
	Pinellia hunanensis C.L.Long & X.J.Wu	2013		77133084-1
Arecaceae	*Guihaia lancifolia* K.W.Luo & F.W.Xing	2017	IB	77161298-1
Aristolochiaceae	*Aristolochia compressicaulis* Z.L.Yang	2015	SW	60469243-2
	Aristolochia gongchengensis Y.S.Huang, Y.D.Peng & C.R.Lin	2015	IB	77174904-1
	Aristolochia huanjiangensis Yan Liu & L.Wu	2013	IB	77135912-1
	Aristolochia hyperxantha X.X.Zhu & J.S.Ma	2017		77176269-1
	Aristolochia involuta X.X.Zhu, Z.X.Ma & J.S.Ma	2017	IB	77174882-1
	Aristolochia longlinensis Yan Liu & L.Wu	2015	IB	77148099-1
	Aristolochia melanocephala X.X.Zhu & J.S.Ma	2018	IB	77192596-1
	Aristolochia mulunensis Y.S.Huang & Yan Liu	2013	IB	77130236-1
	Aristolochia pilosistyla X.X.Zhu & J.S.Ma	2018	IB	77192597-1
	Aristolochia pseudocaulialata X.X.Zhu, J.N.Liu & J.S.Ma	2018	IB	77187811-1

Family	Scientific name	Publication year	Discovered from Biodiversity hotspots*	IPNI Plant Name Id
Aristolochiaceae	*Aristolochia sinoburmanica* Y.H.Tan & B.Yang	2018	IB	60475913-2
	Aristolochia tongbiguanensis J.Y.Shen, Q.B.Gong & Landrein	2018	IB	77190831-1
	Aristolochia weixiensis X.X.Zhu & J.S.Ma	2015	SW	77150406-1
Asclepiadaceae	*Hoya mcclurei* Kloppenb.	2018	IB	60476784-2
	Hoya yingjiangensis J.Feng Zhang, L.Bai, N.H.Xia & Z.Q.Peng	2015	IB	77148268-1
	Vincetoxicum xinpingense H.Peng & Y.H.Wang	2018	IB	77187228-1
Aspleniaceae	*Asplenium* × *huawuense* Z.R.Wang ex Viane & Y.X.Lin	2013		77133567-1
	Asplenium × *kidoi* Sleep ex Viane, Y.X.Lin & Reichst.	2013		77133568-1
	Asplenium × *mickelii* Viane & Reichst.	2013		77133561-1
	Asplenium × *mitsutae* Viane & Reichst.	2013	SW	77133563-1
	Asplenium × *wudangshanense* Viane, Reichst., Rasbach & Y.X.Lin	2013		77133564-1
	Asplenium cyrtosorum K.W.Xu, Li Bing Zhang & W.B.Liao	2018	IB	77179208-1
	Asplenium guangdongense Y.Fen Chang & H.Schneid.	2018	IB	77190779-1
	Asplenium mae Viane & Reichst.	2013		77133482-1
	Asplenium normaloides Y.Fen Chang & H.Schneid.	2018	IB	77190778-1
	Hymenasplenium chingii K.W.Xu, Li Bing Zhang & W.B.Liao	2018	IB	77186055-1
	Hymenasplenium denticulatum K.W.Xu, Li Bing Zhang & W.B.Liao	2018		77186056-1
	Hymenasplenium hastifolium K.W.Xu, Li Bing Zhang & W.B.Liao	2018	IB	77176507-1
	Hymenasplenium laterepens N.Murak. & X.Cheng ex Y.Fen Chang & K.Hori	2018	IB	77191769-1
	Hymenasplenium pseudobscurum Viane	2013	IB	77133491-1
	Hymenasplenium sinense K.W.Xu, Li Bing Zhang & W.B.Liao	2018		77186062-1
	Hymenasplenium speluncicola Li Bing Zhang, K.W.Xu & H.He	2018	IB	77186063-1
	Hymenasplenium wangpeishanii Li Bing Zhang & K.W.Xu	2018		77186064-1
Asteraceae	*Anaphalis hymenolepis* Y.Ling	2013	SW	77133458-1
	Aster oliganthus W.P.Li & Zhi Li	2017	SW	77177658-1
	Aster tianmenshanensis G.J.Zhang & T.G.Gao	2015		77148277-1
	Aster veitchianus Hutch. & J.R.Drumm. ex G.J.Zhang & T.G.Gao	2013	SW	77136165-1
	Chrysanthemum yantaiense M.Sun & J.T.Chen	2018		77191578-1
	Chrysanthemum zhuozishanense L.Q.Zhao & Jie Yang	2014		77147571-1
	Cremanthodium bomiense L.Wang, C.Ren & Q.E.Yang	2016	H	77159886-1
	Cremanthodium hongshanense L.Wang, C.Ren & Q.E.Yang	2018	SW	77187042-1
	Cremanthodium liangshanicum L.Wang, C.Ren & Q.E.Yang	2016	SW	77159851-1
	Cremanthodium maoxianense L.Wang, C.Ren & Q.E.Yang	2018	SW	77187043-1
	Cremanthodium wumengshanicum L.Wang, C.Ren & Q.E.Yang	2015		77151705-1
	Faberia pinnatifida Ying Liu, Y.S.Chen & Boufford	2018	SW	77185933-1
	Hieracium sinoaestivum Sennikov	2014		77140258-1
	Ligularia jiajinshanensis Y.S.Chen	2016	SW	77159887-1
	Ligularia lhunzensis Y.S.Chen	2016	H	77159888-1
	Ligularia secunda Y.S.Chen	2016	H	77159889-1
	Ligularia zhengyiana Xin W.Li, Q.Luo & Q.L.Gan	2014		77144564-1
	Melanoseris jilongensis Ze H.Wang & H.Peng	2018	H	77185970-1
	Parasenecio anhuiensis Y.S.Chen & Lian S.Xu	2016		77159301-1
	Pertya markamensis Cai F.Zhang & T.G.Gao	2017	SW	77165473-1
	Pertya multiflora Cai F.Zhang & T.G.Gao	2013		77133645-1
	Saussurea austrotibetica Y.S.Chen	2014	H	77143044-1
	Saussurea bhutanensis Y.S.Chen	2014	H	77143048-1
	Saussurea bijiangensis Y.L.Chen ex B.Q.Xu, N.H.Xia & G.Hao	2013	SW	77131020-1
	Saussurea chinduensis Y.S.Chen	2015		77147918-1
	Saussurea dulongjiangensis Y.S.Chen	2015	SW	77147919-1
	Saussurea fuscipappa Y.S.Chen	2014	H	77140926-1
	Saussurea glandulosissima Raab-Straube	2017	H	77161042-1
	Saussurea gongriensis Y.S.Chen	2015	H	77147909-1
	Saussurea habashanensis Y.S.Chen	2015	SW	77147906-1
	Saussurea haizishanensis B.Q.Xu, G.Hao & N.H.Xia	2013	SW	77138680-1
	Saussurea hengduanshanensis Raab-Straube	2017	H	77161044-1

Family	Scientific name	Publication year	Discovered from Biodiversity hotspots*	IPNI Plant Name Id
Asteraceae	*Saussurea jindongensis* Y.S.Chen	2015	H	77147905-1
	Saussurea jiulongensis Y.S.Chen	2015	SW	77147925-1
	Saussurea kawakarpo Raab-Straube	2017	SW	77161043-1
	Saussurea langpoensis Y.S.Chen	2014	H	77143045-1
	Saussurea lhozhagensis Y.S.Chen	2014	H	77143049-1
	Saussurea lhunzensis Y.S.Chen	2014	H	77143046-1
	Saussurea liangshanensis Y.S.Chen	2014	SW	77140928-1
	Saussurea minutiloba Y.S.Chen	2015	SW	77147910-1
	Saussurea multiloba Y.S.Chen	2015	SW	77147911-1
	Saussurea nyingchiensis Y.S.Chen	2015	H	77147915-1
	Saussurea pagriensis Y.S.Chen	2014	H	77143047-1
	Saussurea pseudoeriostemon Y.S.Chen	2015	H	77147912-1
	Saussurea pseudograminea Y.F.Wang, G.Z.Du & Y.S.Lian	2014	SW	77138689-1
	Saussurea pseudojiulongensis Y.S.Chen	2015	SW	77147928-1
	Saussurea pseudoleucoma Y.S.Chen	2015	H	77147902-1
	Saussurea pseudolingulata Y.S.Chen	2015	SW	77147913-1
	Saussurea pseudoplatyphyllaria Y.S.Chen	2015	SW	77147907-1
	Saussurea pseudorockii Y.S.Chen	2014	SW	77140929-1
	Saussurea pseudosimpsoniana Y.S.Chen	2015	H	77147903-1
	Saussurea pseudotridactyla Y.S.Chen	2015	H	77147901-1
	Saussurea pseudoyunnanensis Y.S.Chen	2015	SW	77147920-1
	Saussurea qamdoensis Y.S.Chen	2014	H	77140930-1
	Saussurea septentrionalis Raab-Straube	2017	SW	77161045-1
	Saussurea shangrilaensis Y.S.Chen	2014	SW	77141455-1
	Saussurea shuiluoensis Y.S.Chen	2015	SW	77147924-1
	Saussurea sichuanica Raab-Straube	2017	SW	77161046-1
	Saussurea sikkimensis Raab-Straube	2017		77161041-1
	Saussurea sobarocephaloides Y.S.Chen	2015	SW	77147923-1
	Saussurea sunhangii Raab-Straube	2017	SW	77161049-1
	Saussurea tsoongii Y.S.Chen	2015		77147900-1
	Saussurea wenchengiae B.Q.Xu, G.Hao & N.H.Xia	2013		77130903-1
	Saussurea xianrendongensis Y.S.Chen	2015	SW	77147914-1
	Saussurea xiaojinensis Y.S.Chen	2014	SW	77140931-1
	Saussurea yangii Y.S.Chen	2015	SW	77147929-1
	Saussurea yanyuanensis Y.S.Chen	2015	SW	77147921-1
	Saussurea yui Y.S.Chen	2015	SW	77147908-1
	Saussurea zayuensis Y.S.Chen	2015	H	77147916-1
	Saussurea zogangensis Y.S.Chen	2015		77147904-1
	Senecio changii C.Ren & Q.E.Yang	2016	SW	77153507-1
	Senecio pseudodensiserratus T.J.Tong, M.Tang, C.Ren & Q.E.Yang	2018	SW	77178965-1
	Sphagneticola × *guangdongensis* Q.Yuan	2015	IB	60469219-2
	Youngia baoxingensis Y.S.Chen	2018	SW	77192561-1
	Youngia gongshanensis Y.S.Chen & R.Ke	2016	SW	77157759-1
	Youngia jiulongensis Y.L.Peng, X.F.Gao & Li Bing Zhang	2017	SW	77167357-1
	Youngia purpimea Y.L.Peng, W.B.Ju, X.F.Gao & Y.D.Gao	2015	SW	77151636-1
	Youngia zhengyiana T.Deng, D.G.Zhang, J.W.Zhang & H.Sun	2014		77141045-1
Balsaminaceae	*Impatiens baokangensis* Q.L.Gan & X.W.Li	2016		77157482-1
	Impatiens guiqingensis S.X.Yu	2016	SW	77158514-1
	Impatiens liboensis K.M.Liu & R.P.Kuang	2013		77141790-1
	Impatiens lixianensis S.X.Yu	2013	SW	77130092-1
	Impatiens lizipingensis Q.Luo	2015	SW	77150282-1
	Impatiens menghuochengensis Q.Luo	2014	SW	77144565-1
	Impatiens pandurata Y.H.Tan & S.X.Yu	2015	IB	77156517-1
	Impatiens pterocaulis S.X.Yu & L.R.Zhang	2013	IB	77137129-1
	Impatiens shennongensis Qiang Wang & H.P.Deng	2016		77152020-1
	Impatiens tianlinensis S.X.Yu & L.J.Zhang	2015	IB	77150201-1

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Balsaminaceae	*Impatiens unguiculata* K.M.Liu & Y.Y.Cong	2013	H	77130230-1
	Impatiens wawuensis Bo Ding & S.X.Yu	2016	SW	77157741-1
	Impatiens xanthinoides G.W.Hu	2015	IB	77150202-1
Begoniaceae	*Begonia bambusetorum* H.Q.Nguyen, Y.M.Shui & W.H.Chen	2018	IB	77175485-1
	Begonia ehuangzhangensis Q.L.Ding, W.Y.Zhao & W.B.Liao	2018	IB	77192653-1
	Begonia ferox C.I Peng & Yan Liu	2013	IB	77138236-1
	Begonia gulongshanensis Y.M.Shui & W.H.Chen	2018	IB	77175487-1
	Begonia jinyunensis C.I Peng, Bo Ding & Qian Wang	2014	SW	77142829-1
	Begonia leipingensis D.K.Tian, Li H.Yang & Chun Li	2016	IB	77152009-1
	Begonia longgangensis C.I Peng & Yan Liu	2013	IB	77138235-1
	Begonia medogensis Jian W.Li, Y.H.Tan & X.H.Jin	2018	H	77186060-1
	Begonia pellionioides Y.M.Shui & W.H.Chen	2015	IB	77151735-1
	Begonia pulchrifolia D.K.Tian & Ce H.Li	2015	SW	77147124-1
	Begonia qingchengshanensis H.Z.Li, C.I Peng & C.W.Lin	2018	SW	77178758-1
	Begonia rhytidophylla Y.M.Shui & W.H.Chen	2018	IB	77175490-1
	Begonia ufoides C.I Peng, Y.H.Qin & C.W.Lin	2017	IB	77176458-1
	Begonia wuzhishanensis C.I Peng, X.H.Jin & S.M.Ku	2014	IB	77142841-1
Berberidaceae	*Berberis* × *baoxingensis* X.H.Li	2015	SW	77150118-1
	Berberis bowashanensis Harber	2017	SW	77165384-1
	Berberis brevipedicellata Harber	2016	SW	77154636-1
	Berberis dokerlaica Harber	2016	SW	77154634-1
	Berberis viridiflora X.H.Li	2017	SW	77165327-1
	Berberis yiliangensis Harber	2016		77154635-1
	Berberis zhaotongensis Harber	2017		77165383-1
	Epimedium jinchengshanense Yan J.Zhang & J.Q.Li	2014	SW	77141433-1
	Epimedium muhuangense S.Z.He & Y.Y.Wang	2017		77176610-1
	Epimedium tianmenshanense T.Deng, D.G.Zhang & H.Sun	2015		77149069-1
	Epimedium xichangense Yan J.Zhang	2016	SW	77155713-1
	Epimedium zhaotongense G.W.Hu	2017		77160545-1
Betulaceae	*Betula hainanensis* J.Zeng, B.Q.Ren, J.Y.Zhu & Z.D.Chen	2014	IB	77145107-1
	Betula skvortsovii McAll. & Ashburner	2013	SW	77128710-1
Boraginaceae	*Bothriospermum longistylum* Q.W.Lin & Bing Liu	2017		77179093-1
	Microula roseiflora W.T.Yu	2016	SW	77153856-1
	Myosotis wumengensis L.Wei	2017		77174642-1
	Onosma lhokaensis Y.He & Q.R.Liu	2018	H	77188007-1
	Sinojohnstonia ruhuaii W.B.Liao & Lei Wang	2014		77147570-1
	Trigonotis jiaochengensis Q.R.Liu & R.Y.Yan	2016		77174587-1
Brassicaceae	*Aphragmus pygmaeus* Al-Shehbaz	2015	SW	77153427-1
	Braya sichuanica Al-Shehbaz	2014	SW	60468196-2
	Cardamine hongdeyuana Al-Shehbaz	2015	H	77144177-1
	Cardamine kokaiensis Yahara, Soejima, Kudoh, Šlenker & Marhold	2018		77187973-1
	Cardamine kuankuoshuiense M.T.An, Yun Lin & Y.B.Yang	2016		77155969-1
	Cardamine pseudotrifoliolata Al-Shehbaz	2015		77153429-1
	Cardamine xinfenii Al-Shehbaz	2015	SW	60470438-2
	Draba dongchuanensis Al-Shehbaz, J.P.Yue, T.Deng & H.L.Chen	2014		77142950-1
	Eutrema bulbiferum Y.Xiao & D.K.Tian	2015		77148264-1
	Eutrema giganteum G.Q.Hao, Al-Shehbaz & J.Quan Liu	2017	SW	77163811-1
	Eutrema nanum G.Q.Hao, J.Quan Liu & Al-Shehbaz	2018	SW	60477015-2
	Eutrema racemosum Al-Shehbaz, G.Q.Hao & J.Quan Liu	2015	SW	77149658-1
	Eutrema tianshanense G.Q.Hao, J.Quan Liu & Al-Shehbaz	2016	CA	77159339-1
	Eutrema zhuxiense Q.L.Gan & Xin W.Li	2014		77147526-1
	Hilliella rhombea D.D.Ma & W.Y.Xie	2018		77185950-1
	Orychophragmus longisiliquus Huan Hu, J.Quan Liu & Al-Shehbaz	2018		77193103-1
	Orychophragmus zhongtiaoshanus Huan Hu, J.Quan Liu & Al-Shehbaz	2018		77193104-1
	Solms-laubachia tianbaoshanensis H.L.Chen, Al-Shehbaz, J.P.Yue & H.Sun	2018	SW	77192259-1
Buddlejaceae	*Buddleja jinsixiaensis* R.B.Zhu	2014		77138131-1

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Burmanniaceae	*Thismia gongshanensis* Hong Qing Li & Y.K.Bi	2013	SW	77129874-1
	Thismia hongkongensis Mar & R.M.K.Saunders	2015	IB	77145069-1
Buxaceae	*Sarcococca longipetiolata* M.Cheng	2014	IB	77142444-1
Campanulaceae	*Adenophora dawuensis* D.Y.Hong	2015	SW	77153678-1
	Adenophora linearifolia D.Y.Hong	2015	SW	77153682-1
	Campanula microphylloidea D.Y.Hong	2015		77150199-1
	Campanula rotata D.Y.Hong	2015		77150198-1
	Codonopsis bomiensis D.Y.Hong	2014	SW	77141201-1
	Codonopsis elliptica D.Y.Hong	2014	SW	77141206-1
	Codonopsis gongshanica Qiang Wang & D.Y.Hong	2014	SW	77144108-1
	Codonopsis hemisphaerica P.C.Tsoong ex D.Y.Hong	2014	SW	77141202-1
	Codonopsis lixianica D.Y.Hong	2014	SW	77141205-1
	Cyananthus ligulosus D.Y.Hong	2015	H	77153669-1
	Lobelia drungjiangensis D.Y.Hong	2015	SW	77153691-1
	Lobelia gaoligongshanica D.Y.Hong	2015	SW	77153690-1
	Lobelia hongiana Q.F.Wang & G.W.Hu	2018	IB	60475915-2
	Pseudocodon petiolatus D.Y.Hong & Q.Wang	2015	SW	77145980-1
Capparaceae	*Capparis longgangensis* S.L.Mo & X.S.Lee ex Y.S.Huang	2013	IB	77135584-1
Caryophyllaceae	*Silene langshanensis* L.Q.Zhao, Y.Z.Zhao & Z.M.Xin	2016		77155102-1
	Stellaria abaensis H.F.Xu & Z.H.Ma	2018	SW	60477672-2
	Stellaria zhuxiensis Q.L.Gan & Xin W.Li	2014		77139160-1
Celastraceae	*Glyptopetalum verticillatum* Q.R.Liu & S.Y.Meng	2015	IB	77151396-1
	Salacia menglaensis J.Y.Shen, L.C.Yan & Landrein	2018	IB	77193158-1
Chenopodiaceae	*Chenopodium perttii* Sukhor.	2014	H	77144443-1
	Corispermum iljinii Sukhor. & M.Zhang	2014		77141446-1
	Corispermum nanum Sukhor. & M.Zhang	2014		77141852-1
	Dysphania geoffreyi Sukhor.	2015	H	77145964-1
	Dysphania himalaica Uotila	2013	H	77131040-1
	Dysphania kitiae Uotila	2013	SW	77131041-1
	Grubovia brevidentata G.L.Chu	2017	CA	77174792-1
	Grubovia mucronata G.L.Chu	2017		77174815-1
	Micropeplis densiflora Z.B.Wen & G.L.Chu	2017	CA	77174817-1
	Neobotrydium corniculatum G.L.Chu	2017	SW	77165145-1
	Neobotrydium corniculatum G.L.Chu & M.L.Zhang	2016	SW	77174837-1
	Neobotrydium longii G.L.Chu	2017	H	77165158-1
	Neobotrydium ornithopodum G.L.Chu	2017	SW	77165155-1
	Neobotrydium ornithopodum G.L.Chu & M.L.Zhang	2016	SW	77174838-1
	Salicornia crassispica G.L.Chu	2017	CA	77174816-1
	Salicornia erectispica G.L.Chu	2017	CA	77174804-1
	Suaeda turgida G.L.Chu	2017	CA	77165188-1
	Sympegma elegans G.L.Chu	2017	SW	77174808-1
Convallariaceae	*Aspidistra australis* S.Z.He & W.F.Xu	2013		77134253-1
	Aspidistra austroyunnanensis G.W.Hu, Lei Cai & Q.F.Wang	2018	IB	77185868-1
	Aspidistra chongzuoensis C.R.Lin & Y.S.Huang	2015	IB	77147323-1
	Aspidistra chunxiuensis C.R.Lin & Yan Liu	2015	IB	77147208-1
	Aspidistra cleistantha D.X.Nong & H.Z.Lü	2018	IB	77191654-1
	Aspidistra crassifila Yan Liu & C.I Peng	2013	IB	77142915-1
	Aspidistra erythrocephala C.R.Lin & Y.Y.Liang	2016	IB	77158522-1
	Aspidistra extrorsa C.R.Lin & D.X.Nong	2018	IB	77178757-1
	Aspidistra guizhouensis S.Z.He & W.F.Xu	2015		77145935-1
	Aspidistra leucographa C.R.Lin & C.Y.Zou	2017		77162984-1
	Aspidistra lingchuanensis C.R.Lin & L.F.Guo	2015	IB	77144888-1
	Aspidistra lingyunensis C.R.Lin & L.F.Guo	2013	IB	77137128-1
	Aspidistra longgangensis C.R.Lin, Y.S.Huang & Yan Liu	2015	IB	77148872-1
	Aspidistra longshengensis C.R.Lin & W.B.Xu	2015	IB	77147209-1

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Convallariaceae	*Aspidistra maguanensis* S.Z.He & D.H.Lv	2017	IB	77174286-1
	Aspidistra nankunshanensis Yan Liu & C.R.Lin	2013	IB	77131012-1
	Aspidistra ovatifolia Yan Liu & C.R.Lin	2014	IB	77147618-1
	Aspidistra pingfaensis S.Z.He & Q.W.Sun	2014		77143073-1
	Aspidistra qijiangensis S.Z.He & X.Y.Luo	2018	SW	77186348-1
	Aspidistra radiata G.W.Hu & Q.F.Wang	2016	IB	77161470-1
	Aspidistra revoluta Hao Zhou, S.R.Yi & Q.Gao	2016	SW	77154724-1
	Aspidistra ronganensis C.R.Lin, Jing Liu & W.B.Xu	2016	IB	77157342-1
	Aspidistra sessiliflora Aver. & Tillich	2018	SW	77192625-1
	Aspidistra sinensis Aver. & Tillich	2016	IB	77155594-1
	Aspidistra stenophylla C.R.Lin & R.C.Hu	2014	IB	77140919-1
	Aspidistra tenuifolia C.R.Lin & J.C.Yang	2014	IB	77138489-1
	Aspidistra wujiangensis W.F.Xu & S.Z.He	2015		77150616-1
	Aspidistra yizhouensis B.Pan & C.R.Lin	2016	IB	77152931-1
	Aspidistra yunwuensis S.Z.He & W.F.Xu	2015		77146882-1
	Aspidistra zhenganensis S.Z.He & Y.Wang	2017		77160874-1
	Disporopsis bakerorum Floden	2015	SW	60475820-2
	Disporopsis yui Floden	2015	IB	60475821-2
	Disporum sinovietnamicum R.C.Hu & Y.Feng Huang	2016	IB	77155596-1
	Disporum xilingense X.X.Zhu & Lin Zhang	2016	SW	77153735-1
	Heteropolygonatum hainanense Floden	2018	IB	77190162-1
	Heteropolygonatum wugongshanense G.X.Chen, Ying Meng & J.W.Xiao	2017		77177721-1
	Ophiopogon yangshuoensis R.H.Jiang & W.B.Xu	2013	IB	77134259-1
	Peliosanthes minutiflora N.Tanaka, J.Murata & S.K.Wu	2013	IB	77131481-1
	Polygonatum campanulatum G.W.Hu	2015	IB	77151629-1
	Polygonatum dolichocarpum M.N.Tamura, Fuse & Y.P.Yang	2014	SW	77144425-1
	Polygonatum gongshanense L.H.Zhao & X.J.He	2014	SW	77143846-1
	Polygonatum luteoverrucosum Floden	2015	H	77151663-1
	Polygonatum sinopubescens M.T.An, Yun Lin & Jia G.Wang	2016		77178692-1
	Polygonatum undulatifolium Floden	2018	H	77191727-1
	Tricyrtis xianjuensis G.Y.Li, Z.H.Chen & D.D.Ma	2014		77142359-1
	Tupistra hongheensis G.W.Hu & H.Li	2013	IB	77144640-1
Convolvulaceae	*Convolvulus xanthopotamicus* J.R.I.Wood & Scotland	2015		77147662-1
Corylaceae	*Carpinus insularis* N.H.Xia, K.S.Pang & Y.H.Tong	2014	IB	77140462-1
	Carpinus langaoensis Z.Qiang Lu & J.Quan Liu	2017		77160329-1
	Carpinus tibetana Z.Qiang Lu & J.Quan Liu	2018	SW	60476297-2
Crassulaceae	*Rhodiola daochengensis* J.Q.Zhang & G.Y.Rao	2015	SW	77149647-1
	Rhodiola tricarpa S.Y.Meng & G.Y.Rao	2015		77149655-1
	Sedum kuntsunianum X.F.Jin, S.H.Jin & B.Y.Ding	2013		77129875-1
	Sedum spiralifolium D.Q.Wang, D.M.Xie & Lu Q.Huang	2014		77143615-1
Cucurbitaceae	*Gomphogyne hainanensis* X.L.Zheng	2017	IB	77163861-1
	Herpetospermum operculatum K.Pradheep, A.Pandey, K.C.Bhatt & E.R.Nayar	2014	IB	77142405-1
	Trichosanthes napoensis D.X.Nong & Lu Q.Huang	2015	IB	77147130-1
Cycadaceae	*Cycas chenii* X.Gong & Wei Zhou	2015		77166521-1
Cyperaceae	*Carex bamaensis* X.F.Jin & W.Jie Chen	2015	IB	77150597-1
	Carex concava H.B.Yang, Xiao X.Li & G.D.Liu	2016	IB	77159299-1
	Carex daxinensis Y.Y.Zhou & X.F.Jin	2014	IB	77140321-1
	Carex diaoluoshanica H.B.Yang, G.D.Liu & Qing L.Wang	2014	IB	77137990-1
	Carex fangiana X.F.Jin & Y.Y.Zhou	2014	SW	77140322-1
	Carex helingeeriensis L.Q.Zhao & Jie Yang	2013		77130892-1
	Carex honglinii Y.F.Lu & X.F.Jin	2018		77191014-1
	Carex huangshanica X.F.Jin & W.J.Chen	2015		77150848-1
	Carex jianfengensis H.B.Yang, Xiao X.Li & G.D.Liu	2015	IB	77148926-1
	Carex longicolla Tang & F.T.Wang ex Y.F.Deng	2014	IB	77143317-1
	Carex nodosa S.R.Zhang, J.Zhang, Z.Y.Liu, S.Qu & R.G.Han	2018	SW	77192871-1

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Cyperaceae	*Carex pararadicalis* X.F.Jin & J.M.Cen	2015	SW	77150598-1
	Carex pengii X.F.Jin & C.Z.Zheng	2013	IB	77132652-1
	Carex procumbens H.B.Yang, Xiao X.Li & G.D.Liu	2015	IB	77145896-1
	Carex pseudomitrata X.F.Jin & J.M.Cen	2015		77148010-1
	Carex remotistachya Y.Y.Zhou & X.F.Jin	2014		77140320-1
	Carex scopulus X.F.Jin & W.Jie Chen	2015		77150596-1
	Carex sinosupina Y.F.Lu & X.F.Jin	2017	SW	77174714-1
	Carex tingnungii X.F.Jin	2015		77150599-1
	Carex xueyingiana H.J.Yang & Han Xu	2017	IB	77163575-1
	Fimbristylis longquanensis X.F.Jin, Y.F.Lu & C.Z.Zheng	2017		77174068-1
	Fimbristylis minuticulmis X.F.Jin & C.Z.Zheng	2017		77174069-1
	Sumatroscirpus rupestris Lév.-Bourret & J.R.Starr	2018	IB	77194736-1
Dryopteridaceae	*Ctenitis jinfoshanensis* Ching & Z.Y.Liu	2015	SW	77146883-1
	Dryopteris damingshanensis Li Bing Zhang & Hong M.Liu	2014	IB	77141619-1
	Dryopteris erythrovaria K.Hori & N.Murak.	2018		77190681-1
	Dryopteris shiakeana H.Shang & Y.H.Yan	2015	IB	77148225-1
	Dryopteris subtsushimensis K.Hori & N.Murak.	2018		77194708-1
	Polystichum alluvium Li Bing Zhang, N.T.Lu & Yi F.Duan	2017		77177419-1
	Polystichum deltatum Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188039-1
	Polystichum duyunense Li Bing Zhang, X.Y.Miao & Chun X.Li	2017		77160176-1
	Polystichum gejiuense Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188040-1
	Polystichum hainanicola Li Bing Zhang, Liang Zhang & X.F.Gao	2013	IB	77125862-1
	Polystichum hanmengqii Li Bing Zhang & Yan Liu	2018	IB	77188041-1
	Polystichum hastipinnum G.D.Tang & Li Bing Zhang	2017	IB	77174044-1
	Polystichum hubeiense Liang Zhang & Li Bing Zhang	2013		77131021-1
	Polystichum luteoviride Li Bing Zhang, Yi F.Duan, N.T.Lu & Liang Zhang	2017		77176293-1
	Polystichum malipoense Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188042-1
	Polystichum mulunense X.L.Shen & R.H.Jiang	2015	IB	77153712-1
	Polystichum muscicola Ching ex W.M.Chu & Z.R.He	2013	SW	77133798-1
	Polystichum oblongipinnarum Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188043-1
	Polystichum pingbianense Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188044-1
	Polystichum recavum H.J.Wei & Li Bing Zhang	2018	IB	77191641-1
	Polystichum rectum Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188045-1
	Polystichum superum Li Bing Zhang, M.Q.Han & Yan Liu	2018	IB	77188046-1
	Polystichum tiandengense H.He & Li Bing Zhang	2017	IB	77175793-1
	Polystichum zhijinense Li Bing Zhang, Yi F.Duan & Kropf	2017		77174931-1
	Tectaria × *hongkongensis* S.Y.Dong	2016	IB	77155799-1
Ebenaceae	*Diospyros leei* Yan Liu, Song Shi & Y.S.Huang	2015	IB	77174862-1
	Diospyros minutisepala Kottaim.	2018	IB	77195755-1
Elaeocarpaceae	*Sloanea longiaculeatae* Y.F.Xie & Z.X.Zhang	2018	IB	77177789-1
Ericaceae	*Agapetes xiana* Y.H.Tong	2016	H	77153889-1
	Cheilotheca crocea L.Wu & Yan Liu	2016	IB	77155124-1
	Gaultheria ciliisepala Airy Shaw ex P.W.Fritsch & Lu Lu	2015	SW	77145871-1
	Gaultheria gonggashanensis P.W.Fritsch & Lu Lu	2015	SW	77154770-1
	Gaultheria marronina P.W.Fritsch & Lu Lu	2016	SW	77158467-1
	Gaultheria stenophylla P.W.Fritsch & Lu Lu	2015	SW	77145878-1
	Rhododendron baihuaense Y.P.Ma	2013	SW	77130537-1
	Rhododendron bailiense Y.P.Ma, C.Q.Zhang & D.F.Chamb.	2015		77144884-1
	Rhododendron leigongshanense C.H.Yang, Z.G.Xie, Y.F.Yu & Z.R.Yang	2015		77178680-1
	Rhododendron longipedicellatum Lei Cai & Y.P.Ma	2016	IB	77159155-1
	Rhododendron microcarpum R.L.Liu & L.M.Gao	2018		77185869-1
	Rhododendron xiaoxueshanense R.L.Liao & Y.P.Ma	2015	SW	77151708-1
	Vaccinium damingshanense Y.H.Tong & N.H.Xia	2014	IB	77146547-1
Euphorbiaceae	*Bischofia racemosa* W.C.Cheng & C.D.Chu ex Yi F.Duan & X.R.Wang	2016		77158535-1
	Euphorbia maoershanensis F.N.Wei & J.S.Ma	2013	IB	77127273-1

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Euphorbiaceae	*Tsaiodendron dioicum* Y.H.Tan, Z.Zhou & B.J.Gu	2017	IB	77164524-1
Fagaceae	*Quercus pseudosetulosa* Q.S.Li & T.Y.Tu	2018	IB	77191553-1
Flacourtiaceae	*Flacourtia turbinata* H.J.Dong & H.Peng	2013	IB	77128867-1
Gentianaceae	*Swertia subuniflora* B.Hua Chen & Shi L.Chen	2016	IB	77159053-1
	Tripterospermum maculatum Adr.Favre, Matuszak & Muellner	2013	SW	77130745-1
Gesneriaceae	*Anna rubidiflora* S.Z.He, F.Wen & Y.G.Wei	2013		77130241-1
	Briggsia leiophylla F.Wen & Y.G.Wei	2015		77145932-1
	Didissandra chishuiense R.B.Zhang	2015		77153579-1
	Didymocarpus anningensis Y.M.Shui, Lei Cai & J.Cai	2015		77154513-1
	Didymocarpus dissectus F.Wen, Y.L.Qiu, Jie Huang & Y.G.Wei	2013	IB	77130005-1
	Didymocarpus tonghaiensis J.M.Li & F.S.Wang	2014		77146545-1
	Hemiboea crystallina Y.M.Shui & W.H.Chen	2018	IB	77176620-1
	Hemiboea lutea F.Wen, G.Y.Liang & Y.G.Wei	2013	IB	77135583-1
	Hemiboea malipoensis Y.H.Tan	2014	IB	77142385-1
	Hemiboea roseoalba S.B.Zhou, Xin Hong & F.Wen	2013	IB	77178534-1
	Hemiboea suiyangensis Z.Y.Li, S.W.Li & X.G.Xiang	2018		60476482-2
	Loxostigma hekouense Lei Cai, Gui L.Zhang & Z.L.Dao	2017	IB	77175302-1
	Oreocharis brachypodus J.M.Li & Zhi M.Li	2015		77146847-1
	Oreocharis crispata W.H.Chen & Y.M.Shui	2017	IB	77164334-1
	Oreocharis curvituba J.J.Wei & W.B.Xu	2016	IB	77159066-1
	Oreocharis duyunensis Z.Y.Li, X.G.Xiang & Z.Y.Guo	2018		77192883-1
	Oreocharis jinpingensis W.H.Chen & Y.M.Shui	2013	IB	77134255-1
	Oreocharis ninglangensis W.H.Chen & Y.M.Shui	2016	SW	77155208-1
	Oreocharis ovata L.H.Yang, L.X.Zhou & M.Kang	2018	IB	77193002-1
	Oreocharis parviflora Lei Cai & Z.K.Wu	2017	SW	77177745-1
	Oreocharis purpurata B.Pan, M.Q.Han & Yan Liu	2017		77177720-1
	Oreocharis striata F.Wen & C.Z.Yang	2015	IB	77174895-1
	Oreocharis synergia W.H.Chen, Y.M.Shui & Mich.Möller	2015	SW	77150839-1
	Oreocharis tsaii Y.H.Tan & Jian W.Li	2015	IB	77144882-1
	Oreocharis uniflora Li H.Yang & M.Kang	2017	IB	77160516-1
	Oreocharis yunnanensis Rossini & J.Freitas	2014	IB	77140287-1
	Oreocharis zhenpingensis J.M.Li, Ting Wang & Y.G.Zhang	2017		77163084-1
	Paraboea crassifila W.B.Xu & J.Guo	2016	IB	77154217-1
	Paraboea dushanensis W.B.Xu & M.Q.Han	2017		77174037-1
	Paraboea sinovietnamica W.B.Xu & J.Guo	2017	IB	77174038-1
	Paraboea tetrabracteata F.Wen, Xin Hong & Y.G.Wei	2013	IB	77133174-1
	Paraboea wenshanensis Xin Hong & F.Wen	2018	IB	60476045-2
	Paraboea xiangguiensis W.B.Xu & B.Pan	2017	IB	77174039-1
	Paraboea yunfuensis F.Wen & Y.G.Wei	2016	IB	77157473-1
	Petrocodon ainsliifolius W.H.Chen & Y.M.Shui	2014	IB	77142559-1
	Petrocodon asterocalyx F.Wen, Y.G.Wei & R.L.Zhang	2018	IB	77177603-1
	Petrocodon confertiflorus Hui Qin Li & Y.Q.Wang	2015	IB	77147097-1
	Petrocodon hunanensis X.L.Yu & Ming Li	2015		77144886-1
	Petrocodon laxicymosus W.B.Xu & Yan Liu	2014	IB	77141625-1
	Petrocodon lithophilus Y.M.Shui, W.H.Chen & Mich.Möller	2014		77142561-1
	Petrocodon longgangensis W.H.Wu & W.B.Xu	2014	IB	77141626-1
	Petrocodon pseudocoriaceifolius Yan Liu & W.B.Xu	2014	IB	77141627-1
	Petrocodon pulchriflorus Y.B.Lu & Q.Zhang	2017	IB	77160033-1
	Petrocodon retroflexus Qiang Zhang & J.Guo	2016		77155598-1
	Petrocodon urceolatus F.Wen, H.F.Cen & L.F.Fu	2017		77174676-1
	Petrocodon villosus Xin Hong, F.Wen & S.B.Zhou	2014	IB	77142626-1
	Petrocodon viridescens W.H.Chen, Mich.Möller & Y.M.Shui	2014	IB	77142562-1
	Petrocosmea chrysotricha M.Q.Han, H.Jiang & Yan Liu	2018	IB	77179090-1
	Petrocosmea funingensis Qiang Zhang & B.Pan	2013	IB	77125525-1
	Petrocosmea glabristoma Z.J.Qiu & Yin Z.Wang	2015	IB	77151734-1
	Petrocosmea magnifica M.Q.Han & Yan Liu	2017		77176611-1

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Gesneriaceae	*Petrocosmea melanophthalma* Huan C.Wang, Z.R.He & Li Bing Zhang	2013	IB	77137989-1
	Petrocosmea viridis M.Q.Han & Yan Liu	2017		77179033-1
	Primulina albicalyx B.Pan & Li H.Yang	2017	IB	77175151-1
	Primulina alutacea F.Wen, B.Pan & B.M.Wang	2016	IB	77153658-1
	Primulina argentea Xin Hong, F.Wen & S.B.Zhou	2014	IB	77144595-1
	Primulina beiliuensis B.Pan & S.X.Huang	2013	IB	77135659-1
	Primulina bullata S.N.Lu & F.Wen	2013	IB	77128701-1
	Primulina cangwuensis Xin Hong & F.Wen	2018	IB	77186304-1
	Primulina carinata Y.G.Wei, F.Wen & H.Z.Lü	2014	IB	77147651-1
	Primulina cordistigma F.Wen, B.D.Lai & B.M.Wang	2016	IB	77152079-1
	Primulina crassirhizoma F.Wen, Bo Zhao & Xin Hong	2013	IB	77178533-1
	Primulina curvituba B.Pan, L.H.Yang & M.Kang	2017	IB	77174715-1
	Primulina davidioides F.Wen & Xin Hong	2018	IB	77179004-1
	Primulina debaoensis N.Jiang & Hong Li	2013	IB	77133646-1
	Primulina dichroantha F.Wen, Y.G.Wei & S.B.Zhou	2017	IB	77163880-1
	Primulina diffusa Xin Hong, F.Wen & S.B.Zhou	2014	IB	77142358-1
	Primulina dongguanica F.Wen, Y.G.Wei & R.Q.Luo	2014	IB	77141126-1
	Primulina duanensis F.Wen & S.L.Huang	2014	IB	77148862-1
	Primulina effusa F.Wen & B.Pan	2017	IB	77175213-1
	Primulina fengkaiensis Z.L.Ning & M.Kang	2015	IB	77146194-1
	Primulina gigantea F.Wen, B.Pan & W.H.Luo	2016	IB	77159842-1
	Primulina glandaceistriata X.X.Zhu, F.Wen & H.Sun	2014	IB	77143943-1
	Primulina guizhongensis Bo Zhao, B.Pan & F.Wen	2013	IB	60461605-2
	Primulina hengshanensis L.H.Liu & K.M.Liu	2018		77176509-1
	Primulina heterochroa F.Wen & B.D.Lai	2015	IB	77147015-1
	Primulina hiemalis Xin Hong & F.Wen	2018	IB	77179005-1
	Primulina huaijiensis Z.L.Ning & Jing Wang	2013	IB	77131011-1
	Primulina huangii F.Wen & Z.B.Xin	2018	IB	77178940-1
	Primulina hunanensis K.M.Liu & X.Z.Cai	2015		77154763-1
	Primulina jianghuaensis K.M.Liu & X.Z.Cai	2013		77137130-1
	Primulina jiangyongensis X.L.Yu & Ming Li	2014		77143055-1
	Primulina lechangensis Xin Hong, F.Wen & S.B.Zhou	2014	IB	77178668-1
	Primulina lepingensis Z.L.Ning & Ming Kang	2014		77143841-1
	Primulina linearicalyx F.Wen, B.D.Lai & Y.G.Wei	2016	IB	77156700-1
	Primulina lutescens B.Pan & H.S.Ma	2017	IB	77174730-1
	Primulina lutvittata F.Wen & Y.G.Wei	2013	IB	77130904-1
	Primulina mabaensis K.F.Chung & W.B.Xu	2013	IB	77127679-1
	Primulina maciejewskii F.Wen, R.L.Zhang & A.Q.Dong	2016	IB	77161526-1
	Primulina maculata W.B.Xu & J.Guo	2015	IB	77156518-1
	Primulina malipoensis Li H.Yang & M.Kang	2018	IB	77175494-1
	Primulina melanofilamenta Y.Liu & F.Wen	2016	IB	77154836-1
	Primulina minor F.Wen & Y.G.Wei	2013		77143404-1
	Primulina moi F.Wen & Y.G.Wei	2015	IB	77150285-1
	Primulina pengii W.B.Xu & K.F.Chung	2015	IB	77156519-1
	Primulina petrocosmeoides B.Pan & F.Wen	2014	IB	77144566-1
	Primulina porphyrea X.L.Yu & Ming Li	2015		77147207-1
	Primulina pseudoroseoalba Jian Li, F.Wen & L.J.Yan	2014	IB	77139170-1
	Primulina qingyuanensis Z.L.Ning & Ming Kang	2013	IB	77133454-1
	Primulina rubella L.H.Yang & M.Kang	2017	IB	77174703-1
	Primulina rubribracteata Z.L.Ning & M.Kang	2015		77151713-1
	Primulina suichuanensis X.L.Yu & J.J.Zhou	2016		77155595-1
	Primulina tsoongii H.L.Liang, Bo Zhao & F.Wen	2013	IB	77137131-1
	Primulina versicolor F.Wen, B.Pan & B.M.Wang	2016	IB	77153657-1
	Primulina wenii Jian Li & L.J.Yan	2017	IB	77178746-1
	Primulina wuae F.Wen & L.F.Fu	2017	IB	77175898-1
	Primulina yandongensis Ying Qin & Yan Liu	2018	IB	77193180-1

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Gesneriaceae	*Primulina yangchunensis* Y.L.Zheng & Y.F.Deng	2014	IB	77140273-1
	Primulina yangshanensis W.B.Xu & B.Pan	2015	IB	77156520-1
	Primulina yingdeensis Z.L.Ning, M.Kang & X.Y.Zhuang	2016	IB	77159797-1
	Primulina zhoui F.Wen & Z.B.Xin	2018	IB	77178939-1
	Raphiocarpus jinpingensis W.H.Chen & Y.M.Shui	2015	IB	77153711-1
	Tremacron hongheense W.H.Chen & Y.M.Shui	2015	IB	77151819-1
Grammitidaceae	*Oreogrammitis hainanensis* Parris	2013	IB	77133850-1
	Oreogrammitis orientalis T.C.Hsu	2017	IB	77162889-1
	Oreogrammitis sinohirtella Parris	2013	IB	77133851-1
Hydrocharitaceae	*Ottelia guanyangensis* Z.Z.Li, Q.F.Wang & S.Wu	2018	IB	77187252-1
Lamiaceae	*Isodon aurantiacus* Y.P.Chen & C.L.Xiang	2017	H	77175276-1
	Isodon delavayi C.L.Xiang & Y.P.Chen	2014	SW	77137826-1
	Isodon villosus Y.P.Chen & H.Peng	2016	IB	77156696-1
	Meehania hongliniana B.Y.Ding & X.F.Jin	2018		77193006-1
	Nepeta wuana H.J.Dong, C.L.Xiang & Jamzad	2015		77150066-1
	Pogostemon henanensis Gang Yao	2015		77145867-1
	Salvia lagochila T.Wang & L.Wang	2016	SW	77154837-1
	Salvia luteistriata G.X.Hu, E.D.Liu & C.L.Xiang	2017	SW	77176301-1
	Salvia petrophila G.X.Hu, E.D.Liu & Yan Liu	2013	IB	77138690-1
	Scutellaria wuana C.L.Xiang & F.Zhao	2017	SW	77164113-1
Lauraceae	*Alseodaphnopsis ximengensis* H.W.Li & J.Li	2017	IB	77165686-1
	Beilschmiedia turbinata Bing Liu & Y.Yang	2013	IB	77128395-1
	Caryodaphnopsis malipoensis Bing Liu & Y.Yang	2013	IB	77130681-1
	Litsea dorsalicana M.Q.Han & Y.S.Huang	2013	IB	77130684-1
Leguminosae	*Astragalus animaqingshanicus* Y.H.Wu	2015		77157961-1
	Astragalus gandeensis Y.H.Wu	2015		77157958-1
	Astragalus jigenensis Y.H.Wu	2015	CA	77157967-1
	Astragalus magnibracteus Y.H.Wu	2015	CA	77157955-1
	Astragalus majixueshanicus Y.H.Wu	2015		77157959-1
	Astragalus maquensis Y.H.Wu	2015	SW	77157963-1
	Astragalus nuoergongensis L.Q.Zhao & Xu Ri	2018		77193175-1
	Astragalus wulingensis Jia X.Li & X.L.Yu	2014		77138130-1
	Astragalus xijiangensis L.R.Xu & Y.H.Wu	2015	CA	77157965-1
	Bauhinia hekouensis T.Y.Tu & D.X.Zhang	2013	IB	77132598-1
	Dalbergia changhuagensis G.A.Fu, Y.K.Yang & Wen Q.Wang	2015	IB	77165106-1
	Hedysarum cuonanum P.L.Liu, J.Wen & Zhao Y.Chang	2017	H	77160511-1
	Hedysarum xichuanicum Y.H.Wu	2015	SW	77157997-1
	Hedysarum yushuensis Y.H.Wu	2015		77157996-1
	Indigofera pseudonigrescens X.F.Gao & X.L.Zhao	2015	SW	77149467-1
	Lespedeza jiangxiensis Bo Xu, X.F.Gao & Li Bing Zhang	2013		77130627-1
	Lespedeza pseudomaximowiczii D.P.Jin, Bo Xu & B.H.Choi	2018		77193152-1
	Oxytropis anyemaqensis Y.H.Wu	2015		77157976-1
	Oxytropis barunensis Y.H.Wu	2015		77157980-1
	Oxytropis burhanbudaica Y.H.Wu	2015		77157974-1
	Oxytropis datongensis Y.H.Wu	2015		77157995-1
	Oxytropis gandeensis Y.H.Wu	2015		77157975-1
	Oxytropis huashixiaensis Y.H.Wu	2015		77157978-1
	Oxytropis qaidamensis Y.H.Wu	2015		77157970-1
	Oxytropis xidatanensis Y.H.Wu	2015		77157977-1
	Oxytropis xinghaiensis Y.H.Wu	2015		77157972-1
	Oxytropis zadoiensis Y.H.Wu	2015		77157979-1
	Oxytropis zaquensis Y.H.Wu	2015		77157993-1
	Pseudarthria panii R.Zhang, T.S.Yi & B.Pan bis	2018	IB	77190130-1
	Pueraria grandiflora B.Pan bis & Bing Liu	2015	SW	77145972-1
	Vicia aktoensis Y.H.Wu	2015	CA	77157999-1
Liliaceae	*Amana wanzhensis* Lu Q.Huang, B.X.Han & K.Zhang	2014		77143001-1

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Liliaceae	*Lilium yapingense* Y.D.Gao & X.J.He	2013	SW	77130239-1
	Saussurea bogedaensis Yu J.Wang & J.Chen	2018	CA	77180814-1
Lowiaceae	*Orchidantha yunnanensis* P.Zou, C.F.Xiao & Škorničk.	2017	IB	77162277-1
Lycopodiaceae	*Huperzia nanlingensis* Y.H.Yan & N.Shrestha	2014	IB	77141799-1
	Huperzia shresthae Fraser-Jenk.	2018	IB	77191157-1
	Lycopodium verticale Li Bing Zhang	2013	SW	77133467-1
	Spinulum lioui Li Bing Zhang & H.He	2017		77163016-1
Lythraceae	*Lagerstroemia densa* C.H.Gu & D.D.Ma	2015	IB	77146188-1
Magnoliaceae	*Magnolia kwangnanensis* S.G.Chen & Q.W.Zeng	2013	IB	77131015-1
	Magnolia tiepii V.T.Tran & Duy	2015	IB	77150281-1
	Manglietia admirabilis Y.W.Law & R.Z.Zhou ex L.Fu, Q.W.Zeng & X.M.Hu	2014	IB	77141391-1
	Manglietia guangnanica D.X.Li & R.Z.Zhou ex X.M.Hu, Q.W.Zeng & L.Fu	2014	IB	77147528-1
Malpighiaceae	*Hiptage ferruginea* Y.H.Tan & Bin Yang	2018	IB	77191588-1
	Hiptage pauciflora Y.H.Tan & Bin Yang	2018	IB	77191587-1
Malvaceae	*Malva xizangensis* Y.S.Ye, L.Fu & D.X.Duan	2015	SW	77147329-1
Marantaceae	*Phrynium yunnanense* Y.S.Ye & L.Fu	2017	IB	77163010-1
Melanthiaceae	*Chamaelirium viridiflorum* Lei Wang, Z.C.Liu & W.B.Liao	2018		77185949-1
	Chionographis nanlingensis L.Wu, Y.Tong & Q.R.Liu	2016	IB	77155663-1
Melastomataceae	*Bredia changii* W.Y.Zhao, X.H.Zhan & W.B.Liao	2017		77163004-1
	Bredia repens R.Zhou, Q.J.Zhou & Ying Liu	2018		77194739-1
	Fordiophyton chenii S.Jin Zeng & X.Y.Zhuang	2016	IB	77153256-1
	Fordiophyton huizhouense S.Jin Zeng & X.Y.Zhuang	2016	IB	77153257-1
	Fordiophyton zhuangiae S.Jin Zeng & G.D.Tang	2016	IB	77159141-1
	Phyllagathis guidongensis K.M.Liu & J.Tian	2016		77161451-1
	Sonerila trinervis Q.W.Lin	2015	IB	77151737-1
Menispermaceae	*Stephania novenanthera* Heng C.Wang	2013	IB	77132616-1
Moraceae	*Ficus cornelisiana* Chantaras. & Y.Q.Peng	2014	IB	77142617-1
Musaceae	*Musa ruiliensis* W.N.Chen, Häkkinen & X.J.Ge	2014	IB	77141452-1
Myrsinaceae	*Ardisia bullata* G.H.Huang & G.Hao	2018	IB	77193172-1
	Ardisia medogensis C.M.Hu & G.Hao	2018	H	77191512-1
	Ardisia nutantiflora S.Z.Mao & C.M.Hu	2018	IB	77193157-1
	Ardisia rubricaulis S.Z.Mao & C.M.Hu	2013	IB	77133457-1
	Sadiria longistyla Ze H.Wang & H.Peng	2018	IB	77177770-1
Orchidaceae	*Anoectochilus dulongensis* Ormerod	2013	SW	77137327-1
	Anoectochilus longilobus H.Jiang & H.Z.Tian	2014	IB	77140335-1
	Anoectochilus nandanensis Y.Feng Huang & X.C.Qu	2015	IB	77154757-1
	Apostasia fogangica Y.Y.Yin, P.S.Zhong & Z.J.Liu	2016	IB	77158583-1
	Arachnis bouffordii Ormerod	2014	IB	77136159-1
	Bulbophyllum chrysolabium L.Li & D.P.Ye	2018	IB	77191936-1
	Bulbophyllum huangshanense Y.M.Hu & X.H.Jin	2015		77150284-1
	Bulbophyllum jingdongense A.Q.Hu, D.P.Ye & Jian W.Li	2017	IB	77163074-1
	Bulbophyllum lipingtaoi Jiu X.Huang, J.Y.Wang & Z.J.Liu	2017	IB	77160509-1
	Bulbophyllum menglaense Jian W.Li & X.H.Jin	2017	IB	77164286-1
	Bulbophyllum mengyuanense Q.Liu, Jian W.Li & X.H.Jin	2015	IB	77151668-1
	Bulbophyllum nujiangense X.H.Jin & W.T.Jin	2014	SW	77141124-1
	Bulbophyllum pingnanense J.F.Liu, S.R.Lan & Y.C.Liang	2016	IB	77155742-1
	Bulbophyllum salweenensis X.H.Jin	2015	SW	77150855-1
	Bulbophyllum yingjiangense B.M.Wang & J.W.Zhai	2017	IB	77161275-1
	Bulbophyllum yongtaiense J.F.Liu, S.R.Lan & Y.C.Liang	2018	IB	77178918-1
	Bulbophyllum yunxiaoense M.H.Li, J.F.Liu & S.P.Chen	2017	IB	77174896-1
	Calanthe bingtaoi J.W.Zhai, L.J.Chen & Z.J.Liu	2013	SW	77132014-1
	Calanthe longgangensis Y.S.Huang & Yan Liu	2015	IB	77149688-1
	Calanthe taibaishanensis M.Guo, J.W.Zhai & L.J.Chen	2017		77177695-1
	Calanthe wenshanensis J.W.Zhai, L.J.Chen & Z.J.Liu	2013	IB	77132013-1

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Orchidaceae	*Calanthe wuxiensis* H.P.Deng & F.Q.Yu	2017	SW	77176471-1
	Cestichis pingtaoi G.D.Tang, X.Y.Zhuang & Z.J.Liu	2015	IB	77151433-1
	Changnienia malipoensis D.H.Peng, Z.J.Liu & J.W.Zhai	2013	IB	77130095-1
	Cheirostylis acuminata Zhi L.Liu & Q.Liu	2016	IB	77158509-1
	Coelogyne pianmaensis R.Li & Z.L.Dao	2014	SW	77138678-1
	Collabium yunnanense Ormerod	2013	SW	77137331-1
	Cremastra malipoensis G.W.Hu	2013	IB	77130401-1
	Cymbidium daweishanense G.Q.Zhang & Z.J.Liu	2018	IB	77191723-1
	Cymbidium lii M.Z.Huang, J.M.Yin & G.S.Yang	2017	IB	77176352-1
	Cymbidium puerense Z.J.Liu & S.R.Lan	2018	IB	77185942-1
	Danxiaorchis singchiana J.W.Zhai, F.W.Xing & Z.J.Liu	2013	IB	77124909-1
	Danxiaorchis yangii Bo Y.Yang & Bo Li	2017		77162990-1
	Dendrobium bannaense Y.Q.Tian & Y.B.Huang	2017	IB	77177715-1
	Dendrobium libingtaoi Q.Xu & Z.J.Liu	2018	IB	77176514-1
	Dendrobium longlingense Q.Xu, Y.B.Luo & Z.J.Liu	2014	IB	77142382-1
	Dendrobium luoi L.J.Chen & W.H.Rao	2016		77155442-1
	Dendrobium maguanense Q.Xu & Z.J.Liu	2016	IB	77159344-1
	Dendrobium wenshanense Q.Xu, Y.B.Luo & Z.J.Liu	2014	IB	77142381-1
	Dendrobium zhenghuoense S.P.Chen, Liang Ma & Ming H.Li	2016	IB	77158455-1
	Dendrobium zhenyuanense D.P.Ye ex Jian W.Li, D.P.Ye & X.H.Jin	2014	IB	77143319-1
	Gastrochilus dulongjiangensis Q.Liu & J.Y.Gao	2018	SW	77177530-1
	Gastrochilus jietouensis Ormerod	2013	SW	77137333-1
	Gastrochilus kadooriei Kumar, S.W.Gale, Kocyan, G.A.Fisch. & Aver.	2014	IB	77140315-1
	Gastrochilus tianbaoensis Q.Liu & Y.H.Tan	2016	IB	77159092-1
	Gastrodia damingshanensis A.Q.Hu & T.C.Hsu	2014	IB	77142938-1
	Gastrodia huapingensis X.Y.Huang, A.Q.Hu & Yan Liu	2015	IB	77149471-1
	Goodyera makuensis Ormerod	2013	SW	77137395-1
	Goodyera malipoensis Q.X.Guan & S.P.Chen	2014	IB	77143809-1
	Habenaria fimbriatiloba Kolan.	2015		77145880-1
	Habenaria luquanensis G.W.Hu	2015		77151687-1
	Habenaria malipoensis Q.Liu & W.L.Zhang	2017	IB	77174902-1
	Habenaria pseudorostellifera Kolan., Szlach. & Kras	2015		77174894-1
	Habenaria yachangensis Z.B.Zhang & W.Guo	2015	IB	77144532-1
	Hemipilia galeata Ying Tang, X.X.Zhu & H.Peng	2016	IB	77158484-1
	Herminium gongganum Ormerod	2013	SW	77137396-1
	Herminium motuoense X.H.Jin	2017	H	77177751-1
	Herminium tibeticum X.H.Jin, Schuit. & Raskoti	2017	H	77161963-1
	Holcoglossum singchianum G.Q.Zhang, L.J.Chen & Z.J.Liu	2013	IB	77125663-1
	Holopogon pekinensis X.Y.Mu & Bing Liu	2017		77177662-1
	Hygrochilus tsii M.H.Li, Z.J.Liu & S.R.Lan	2014		77138128-1
	Liparis funingensis Yong Y.Su, Yuan Meng & Z.J.Liu	2014	IB	77141198-1
	Liparis meihuashanensis S.M.Fan	2017	IB	77177439-1
	Liparis pingxiangensis L.Li & H.F.Yan	2013	IB	77131431-1
	Liparis tsii H.Z.Tian & A.Q.Hu	2015	IB	77159236-1
	Liparis vivipara H.X.Huang, Z.J.Liu & M.H.Li	2018	IB	77180815-1
	Liparis wenshanensis Yong Y.Su, Yi L.Huang & G.Q.Zhang	2015	IB	77146844-1
	Malaxis malipoensis Y.F.Meng, A.Q.Hu & F.W.Xing	2014	IB	77140780-1
	Malleola tibetica W.C.Huang & X.H.Jin	2013	H	77135582-1
	Neottia bicallosa X.H.Jin	2014	SW	77143043-1
	Neottia nujiangensis X.H.Jin	2016	SW	77159994-1
	Nervilia brevilobata C.S.Leou, C.L.Yeh & S.W.Gale	2013		77131195-1
	Odontochilus napoensis H.Tang & Y.F.Huang	2016	IB	77157455-1
	Oreorchis yachangensis Z.B.Zhang & B.G.Huang	2016	IB	77155582-1
	Paphiopedilum notatisepalum Z.J.Liu, Meina Wang & S.R.Lan	2017	IB	77162273-1
	Pendulorchis gaoligongense G.Q.Zhang, K.Wei Liu & Z.J.Liu	2013	SW	77125661-1
	Phalaenopsis pingxiangensis Hua Deng, Z.J.Liu & Yan Wang	2015	IB	77151701-1

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Orchidaceae	*Platanthera anatina* Ormerod	2013	SW	77137397-1
	Platanthera australis L.Wu, X.L.Yu, H.Z.Tian & J.L.Luo	2017		77163273-1
	Platanthera danghatuensis Ormerod	2013	SW	77137401-1
	Platanthera fugongensis Ormerod	2013	SW	77137412-1
	Platanthera fujianensis B.H.Chen & X.H.Jin	2016	IB	77159362-1
	Platanthera guangdongensis Y.F.Li, L.F.Wu & L.J.Chen	2018	IB	77177592-1
	Platanthera nanlingensis X.H.Jin & W.T.Jin	2015	IB	77174831-1
	Platanthera yadongensis X.H.Jin & W.T.Jin	2014	H	77136231-1
	Platanthera zijinensis Q.L.Ye, Z.M.Zhong & Ming H.Li	2018	IB	77177593-1
	Platystyliparis malipoensis G.D.Tang, X.Y.Zhuang & Z.J.Liu	2015	IB	77151432-1
	Pleione × *baoshanensis* W.Zhang & S.B.Zhang	2018	SW	77179038-1
	Pleione × *maoershanensis* W.Zhang & S.B.Zhang	2018	IB	77179039-1
	Pleione jinhuana Z.J.Liu, M.T.Jiang & S.R.Lan	2018		77177709-1
	Spiranthes himalayensis Survesw., Kumar & Mei Sun	2017	IB	77167300-1
	Thuniopsis cleistogama L.Li, D.P.Ye & Shi J.Li	2015	IB	77147753-1
	Vanda funingensis L.H.Zou & Z.J.Liu	2016	IB	77154813-1
	Vanda malipoensis L.H.Zou, Jiu X.Huang & Z.J.Liu	2014	IB	77143831-1
	Yunorchis pingbianensis Z.J.Liu, G.Q.Zhang & Ming H.Li	2015	IB	77145332-1
	Zeuxine ovalifolia L.Li & S.J.Li	2013	IB	77132060-1
Oxalidaceae	*Oxalis wulingensis* T.Deng, D.G.Zhang & Z.L.Nie	2013		77130727-1
Papaveraceae	*Corydalis hegangensis* W.T.Wang	2017		77175066-1
	Corydalis hualongshanensis D.Wang	2017		77163013-1
	Corydalis huangshanensis L.Q.Huang & H.S.Peng	2018		77192894-1
	Corydalis latilepidota W.T.Wang	2017	SW	77175065-1
	Corydalis pseudoamplisepala D.Wang	2017		77175263-1
	Corydalis pseudohemsleyana D.Wang	2017		77174716-1
	Meconopsis × *kongboensis* Grey-Wilson	2014		77143504-1
	Meconopsis lhasaensis Grey-Wilson	2014		77143508-1
	Meconopsis zhongdianensis Grey-Wilson	2014	SW	77143509-1
Phytolaccaceae	*Phytolacca exiensis* D.G.Zhang, L.Q.Huang & D.Xie	2017		77174910-1
Pinaceae	*Picea neohirtella* Silba	2015	SW	77150057-1
Piperaceae	*Piper jianfenglingense* C.Y.Hao & Y.H.Tan	2017	IB	77174928-1
	Piper magen B.Q.Cheng ex C.L.Long & Jun Yang bis	2017	IB	77176453-1
	Piper peltatifolium C.Y.Hao, H.S.Wu & Y.H.Tan	2015	IB	77151669-1
Poaceae	*Achnatherum pilosum* Z.S.Zhang & W.L.Chen	2018	SW	77178922-1
	Capillipedium alpinum H.Sun & Boufford	2016	SW	60477087-2
	Dendrocalamus atroviridis D.Z.Li & H.Q.Yang	2016	IB	77151941-1
	Dendrocalamus jinghongensis P.Y.Wang, Y.X.Zhang & D.Z.Li	2016	IB	77157469-1
	Dendrocalamus longiauritus S.H.Chen, K.F.Huang & R.S.Chen	2013	IB	77138281-1
	Dendrocalamus yingjiangensis D.Z.Li & H.Q.Yang	2015	IB	77174758-1
	Deyeuxia gaoligongensis Paszko	2013	SW	77127682-1
	Deyeuxia sorengii Paszko & W.L.Chen	2013		77133459-1
	Elymus dolichorhachis S.L.Lu & Y.H.Wu	2013		77135533-1
	Elymus qingnanensis S.L.Lu & Y.H.Wu	2013		77135534-1
	Elymus zadoiensis S.L.Lu & Y.H.Wu	2013		77135532-1
	Fargesia microauriculata M.S.Sun, D.Z.Li & H.Q.Yang	2016	SW	77159818-1
	Fargesia weiningensis T.P.Yi & Lin Yang	2013		77132561-1
	Gelidocalamus xunwuensis W.G.Zhang & G.Y.Yang	2017		77165358-1
	Gigantochloa callosa N.H.Xia, Y.Zeng & R.S.Lin	2014	IB	77144152-1
	Holttumochloa hainanensis M.Y.Zhou & D.Z.Li	2017	IB	77174625-1
	Leymus golmudensis Y.H.Wu	2013		77135531-1
	Oligostachyum heterophyllum M.M.Lin	2017	IB	77176053-1
	Orinus intermedius X.Su & J.Quan Liu	2017	SW	77175809-1
	Phyllostachys acutiligula G.H.Lai	2013		77131122-1
	Phyllostachys corrugata G.H.Lai	2013		77131124-1
	Phyllostachys hirtivagina G.H.Lai	2013		77131123-1

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Poaceae	*Phyllostachys purpureociliata* G.H.Lai	2013		77131125-1
	Pseudosasa xishuangbannaensis D.Z.Li, Y.X.Zhang & Triplett	2013	IB	77134702-1
	Ptilagrostis arcuata Z.S.Zhang & W.L.Chen	2016	SW	77157281-1
	Ptilagrostis contracta Z.S.Zhang & W.L.Chen	2017	SW	77158315-1
	Schizostachyum longinternodium N.H.Xia, R.S.Lin & C.H.Zheng	2014	IB	77143644-1
	Stipa dickorei M.Nobis	2016		77155874-1
	Stipa zhadaensis L.Q.Zhao & K.Guo	2017		77163865-1
	Yushania gigantea T.P.Yi & L.Yang	2014	SW	77135675-1
	Yushania pianmaensis T.P.Yi & L.Yang	2014	SW	77135676-1
Podocarpaceae	*Podocarpus hookeri* de Laub.	2015	IB	77153935-1
	Cladopus yinggelingensis Q.W.Lin, Gang Lu & Z.Y.Li	2016	IB	77157336-1
	Terniopsis daoyinensis Q.W.Lin, Gang Lu & Z.Y.Li	2016	IB	77157337-1
Polygonaceae	*Fagopyrum hailuogouense* J.R.Shao, M.L.Zhou & Qian Zhang	2015	SW	60471656-2
	Fagopyrum longzhoushanense J.R.Shao	2017	SW	77160031-1
	Fagopyrum luojishanense J.R.Shao	2015	SW	77153445-1
	Koenigia chuanzangensis Z.Z.Zhou & Y.J.Min	2015	SW	77155422-1
	Koenigia hedbergii Bo Li & W.Du	2016		77157437-1
	Persicaria changhuaensis H.W.Zhang & X.F.Jin	2017		77174677-1
	Persicaria lankeshanensis T.J.Liang & Bo Li	2014	IB	77178666-1
	Persicaria wugongshanensis Bo Li	2014		77136296-1
Polypodiaceae	*Lepisorus simulans* Ching & Z.Y.Liu	2015	SW	77146884-1
	Leptochilus mengsongensis M.X.Zhao	2017	IB	77176470-1
Potamogetonaceae	*Ruppia brevipedunculata* Shuo Yu & Hartog	2014		77142902-1
	Ruppia sinensis Shuo Yu & Hartog	2014		77142903-1
Primulaceae	*Lysimachia dabieshanensis* Kun Liu & S.B.Zhou	2014		77142378-1
	Lysimachia huangsangensis J.J.Zhou, X.L.Yu & Y.F.Deng	2015		77147698-1
	Lysimachia jinzhaiensis S.B.Zhou & Kun Liu	2014		77141573-1
	Lysimachia septemfida Ze H.Wang & E.D.Liu	2016	IB	77165309-1
	Lysimachia sinopilosa C.M.Hu & G.Hao	2017	IB	77163864-1
	Lysimachia tianmaensis Kun Liu, S.B.Zhou & Ying Wang	2018		77178766-1
	Primula anthemifolia G.Hao, C.M.Hu & Yuan Xu	2015	SW	77174897-1
	Primula centellifolia G.Hao, C.M.Hu & Y.Xu	2017	SW	77177673-1
	Primula chimingiana G.Hao, S.Yuan & D.X.Zhang	2017	SW	77179003-1
	Primula dejuniana G.Hao, C.M.Hu & Yuan Xu	2014	SW	77145096-1
	Primula hubeiensis Xin W.Li	2017		77175796-1
	Primula hunanensis G.Hao, C.M.Hu & X.L.Yu	2014		77148873-1
	Primula hydrocotylifolia G.Hao, C.M.Hu & Yuan Xu	2015	SW	77148008-1
	Primula jiugongshanensis J.W.Shao	2017		77174675-1
	Primula luteoflora X.F.Gao & W.B.Ju	2018	SW	77190134-1
	Primula mianyangensis G.Hao & C.M.Hu	2013	SW	77133180-1
	Primula pelargoniifolia G.Hao, C.M.Hu & Z.Y.Liu	2014	SW	77139176-1
	Primula pengzhouensis C.M.Hu, G.Hao & Y.Xu	2017	SW	77174626-1
	Primula persimilis G.Hao, C.M.Hu & Y.Xu	2016	SW	77157456-1
	Primula scopulicola G.Hao, C.M.Hu & Y.Xu	2016	SW	77159817-1
	Primula undulifolia G.Hao, C.M.Hu & Y.Xu	2016		60472693-2
	Primula wawushanica G.Hao, C.M.Hu & Yuan Xu	2016	SW	77155597-1
	Primula zhui Y.H.Tan & B.Yang	2017	IB	77174729-1
	Stimpsonia nanlingensis G.H.Huang & G.Hao	2017	IB	77174635-1
Proteaceae	*Helicia yangchunensis* H.S.Kiu	2013	IB	77132615-1
Pteridaceae	*Pteris dixitii* Fraser-Jenk. & Pariyar	2015		77161778-1
Ranunculaceae	*Aconitum basitruncatum* W.T.Wang	2014	SW	77141210-1
	Aconitum hezuoense W.T.Wang	2015	SW	77149689-1
	Aconitum lianhuashanicum W.T.Wang	2015	SW	77149690-1
	Aconitum luanchuanense W.T.Wang	2015		77149687-1
	Aconitum novoaxillare W.T.Wang	2014	SW	77141209-1
	Aconitum qianxiense W.T.Wang	2013		77134723-1

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Ranunculaceae	*Aconitum rotundocassideum* W.T.Wang	2013		77138280-1
	Aconitum tuoliense W.T.Wang	2016	CA	77160240-1
	Aconitum wumengense J.He & E.D.Liu	2018		77177553-1
	Actaea muliensis J.P.Luo, Q.E.Yang & Q.Yuan	2016	SW	77161534-1
	Anemone brachystema W.T.Wang	2014	H	77142643-1
	Anemone jiachaensis W.T.Wang	2014		77142644-1
	Anemone milinensis W.T.Wang	2013		77135654-1
	Anemone motuoensis W.T.Wang	2014	H	77142642-1
	Aquilegia hebeica Erst	2017		77176452-1
	Aquilegia xinjiangensis Erst	2017	CA	77176451-1
	Aquilegia yangii Y.Luo & Lu Li	2018	SW	77178664-1
	Caltha dysosmoides Tao Zhang, Bing Liu, Y.Q.Hao, Y.Yang & Y.J.Lai	2016	SW	77159219-1
	Clematis chaohuensis W.T.Wang & L.Q.Huang	2014		77140156-1
	Clematis diebuensis W.T.Wang	2015	SW	77145271-1
	Clematis dongchuanensis W.T.Wang	2014		77142362-1
	Clematis jingxiensis W.T.Wang	2016	IB	77160245-1
	Clematis maguanensis W.T.Wang	2015	IB	77147798-1
	Clematis melanonema W.T.Wang	2016		77160243-1
	Clematis wuxiensis Q.Q.Jiang & H.P.Deng	2017	SW	77160575-1
	Clematis yuntaishanica W.T.Wang	2016		77160242-1
	Delphinium brachyurum W.T.Wang	2014	SW	77145301-1
	Delphinium breviscaposum W.T.Wang	2018	SW	77194230-1
	Delphinium callichromum Q.L.Gan & Xin W.Li	2017		77175709-1
	Delphinium dicentrum W.T.Wang	2018	H	77193142-1
	Delphinium filibracteolum W.T.Wang	2018	SW	77194231-1
	Delphinium furcatocornutum W.T.Wang	2014	SW	77137692-1
	Delphinium lagarocentrum W.T.Wang	2014		77142465-1
	Delphinium lagarolobum W.T.Wang	2018	H	77193145-1
	Delphinium langxianense W.T.Wang	2014		77142462-1
	Delphinium latilimbum W.T.Wang	2018	H	77193144-1
	Delphinium longibracteolatum W.T.Wang	2013	SW	77135649-1
	Delphinium longziense W.T.Wang	2018	H	77193139-1
	Delphinium menyuyanense W.T.Wang	2016		77160241-1
	Delphinium pingwuense W.T.Wang	2015	SW	77147315-1
	Delphinium quinqueflorum W.T.Wang	2014	SW	77142464-1
	Delphinium tephranthum W.T.Wang	2014	SW	77142463-1
	Delphinium trichophoroides W.T.Wang	2014	SW	77142461-1
	Delphinium viridiovarium W.T.Wang	2018		77193141-1
	Delphinium xanthanthum W.T.Wang	2018	H	77193140-1
	Delphinium yongdengense W.T.Wang	2016	SW	77154492-1
	Delphinium zhanangense W.T.Wang	2018		77193143-1
	Delphinium zuogongense W.T.Wang	2013	SW	77135650-1
	Dichocarpum wuchuanense S.Z.He	2015		77150121-1
	Ranunculus chongzhouensis W.T.Wang	2015	SW	77150244-1
	Ranunculus dayiensis W.T.Wang	2015	SW	77150241-1
	Ranunculus decandrus W.T.Wang	2013	SW	77135658-1
	Ranunculus duoxionglashanicus W.T.Wang	2013		77135657-1
	Ranunculus gongheensis W.T.Wang	2015		77150245-1
	Ranunculus laohegouensis W.T.Wang & S.R.Chen	2015	SW	77151736-1
	Ranunculus lujiangensis W.T.Wang	2018		77193105-1
	Ranunculus shanyangensis M.R.Luo & L.Zhao	2013		77178536-1
	Ranunculus tongrenensis W.T.Wang	2015		77150242-1
	Ranunculus wutaishanicus W.T.Wang	2016		77160244-1
	Ranunculus zhouquensis W.T.Wang	2015	SW	77150243-1
	Semiaquilegia guangxiensis Yan Liu & Y.S.Huang	2017	IB	77160163-1
	Thalictrum austrotibeticum Jin Y.Li, L.Xie & L.Q.Li	2015		77147128-1

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Ranunculaceae	*Thalictrum brachyandrum* W.T.Wang	2017		77163361-1
	Thalictrum callianthum W.T.Wang	2013		77135652-1
	Thalictrum cuonaense W.T.Wang	2014	H	77145302-1
	Thalictrum daguanense W.T.Wang	2017		77165388-1
	Thalictrum dingjieense W.T.Wang	2018	H	77194208-1
	Thalictrum jilongense W.T.Wang	2017	H	77165391-1
	Thalictrum lasiogynum W.T.Wang	2017	SW	77163362-1
	Thalictrum latistylum W.T.Wang	2017	SW	77165389-1
	Thalictrum minutiflorum W.T.Wang	2017		77163359-1
	Thalictrum panzhihuaense W.T.Wang	2016	SW	77154493-1
	Thalictrum sexnervisepalum W.T.Wang	2017	SW	77165390-1
	Thalictrum spiristylum W.T.Wang	2017	SW	77165392-1
	Thalictrum tsaii W.T.Wang	2018		77194199-1
	Thalictrum xiaojinense W.T.Wang	2017	SW	77163363-1
	Thalictrum xinningense W.T.Wang	2017		77163360-1
	Thalictrum yadongense W.T.Wang	2018	H	77194204-1
	Thalictrum yuoxiense W.T.Wang	2014		77146200-1
	Thalictrum zhadaense W.T.Wang	2017		77165393-1
Rhamnaceae	*Sageretia liuzhouensis* Yi Yang & H.Sun	2017	IB	77174078-1
Rosaceae	*Argentina songzhuensis* T.Feng & Heng C.Wang	2014	SW	77146009-1
	Cerasus laoshanensis D.K.Zang	2017		77163885-1
	Cerasus xueluoensis C.H.Nan & X.R.Wang	2013		77130902-1
	Eriobotrya × *daduheensis* H.Z.Zhang ex W.B.Liao, Q.Fan & M.Y.Ding	2015	SW	77147555-1
	Potentilla jiaozishanensis Huan C.Wang & Z.R.He	2013		77131196-1
	Potentilla tuberculifera J.Z.Dong	2017		77175794-1
	Prunus nutantiflora D.G.Zhang & Z.H.Xiang	2018		77193174-1
	Prunus pananensis Z.L.Chen, W.J.Chen & X.F.Jin	2013		77124052-1
	Rosa longshoushanica L.Q.Zhao & Y.Z.Zhao	2016	SW	77155109-1
	Rubus pseudoswinhoei Huan C.Wang & Z.R.He	2016		77155201-1
	Rubus yingjiangensis Huan C.Wang	2017	IB	77163881-1
	Sorbus calcicola W.B.Liao & W.Guo	2016	IB	77155205-1
	Sorbus cibagouensis H.Peng & Z.J.Yin	2017	SW	77174586-1
	Sorbus dolichofoliolatus X.F.Gao & Meng Li	2015	SW	77150196-1
	Sorbus prunifolia W.B.Liao & H.J.Jing	2016	SW	77154795-1
	Spiraea × *transhimalaica* Businský	2015		77149889-1
	Spiraea fangii H.Y.Hu & X.J.He	2016	SW	77156678-1
	Spiraea lanatissima Businský	2015	SW	77149886-1
Rubiaceae	*Gardenia reflexisepala* N.H.Xia & X.E.Ye	2016	IB	77154583-1
	Hedyotis austrosinica L.Wu & L.H.Yang	2018	IB	77179092-1
	Hedyotis nanlingensis R.J.Wang	2015	IB	77146981-1
	Hedyotis taishanensis G.T.Wang & R.J.Wang	2018	IB	77190121-1
	Leptodermis hechiensis R.J.Wang	2018	IB	77178711-1
	Mussaenda campanulata T.T.Duan & D.X.Zhang	2016	IB	77155581-1
	Mycetia fangii K.J.Yan & Z.Q.Song	2016	IB	77155089-1
	Ophiorrhiza gaoligongensis L.Wu, Hareesh & R.H.Tu	2018	SW	77194408-1
	Ophiorrhiza guizhouensis C.D.Yang & G.Q.Gou	2018		60476091-2
	Ophiorrhiza macrocarpa L.Wu, Q.R.Liu, Y.H.Tan & Hareesh	2018	IB	77179095-1
	Rubia austrozhejiangensis Z.P.Lei, Y.Y.Zhou & R.W.Wang	2013		77130002-1
	Rubia hangii L.E Yang & Z.L.Nie	2017	IB	77160030-1
	Rubia pianmaensis R.Li & H.Li	2013	SW	77133583-1
	Rubia urceolata X.F.Wang & C.H.Wang	2018		77190161-1
	Spiradiclis coriaceifolia R.J.Wang	2014	IB	77143408-1
	Spiradiclis danxiashanensis R.J.Wang	2015	IB	77146980-1
	Spiradiclis glabra L.Wu & Q.R.Liu	2016	IB	77161525-1
	Spiradiclis glandulosa L.Wu & Q.R.Liu	2014	IB	77146551-1
	Spiradiclis jingxiensis R.J.Wang	2016	IB	77158468-1

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Rubiaceae	*Spiradiclis longanensis* R.J.Wang	2015	IB	77148932-1
	Spiradiclis lui Yan Liu & L.Wu	2018	IB	77188006-1
	Spiradiclis pauciflora L.Wu & Q.R.Liu	2015	IB	77174763-1
	Spiradiclis pengshuiensis B.Pan & R.J.Wang	2016	SW	77154905-1
	Spiradiclis quanzhouensis J.Liu & W.B.Xu	2017	IB	77179034-1
	Spiradiclis tonglingensis R.J.Wang	2014	IB	77143409-1
	Spiradiclis yangchunensis R.J.Wang	2016	IB	77155443-1
Salicaceae	*Salix alexeii* Kottaim.	2017	SW	77174640-1
Saxifragaceae	*Chrysosplenium zhangjiajieense* X.L.Yu, Hui Zhou & D.S.Zhou	2016		77158754-1
	Saxifraga kegangii D.G.Zhang, Ying Meng & M.H.Zhang	2017		77174074-1
	Saxifraga luoxiaoensis W.B.Liao, L.Wang & X.J.Zhang	2018		77179043-1
	Saxifraga viridipetala Z.X.Zhang & Gornall	2018	SW	77176502-1
Scrophulariaceae	*Bonnaya sanpabloensis* Y.S.Liang & J.C.Wang	2014	IB	77144208-1
	Mazus sunhangii D.G.Zhang & T.Deng	2016		77157495-1
	Pedicularis milliana W.B.Yu, D.Z.Li & H.Wang	2018	SW	77185944-1
	Pedicularis wanghongiae M.L.Liu & W.B.Yu	2015	SW	77147975-1
	Pterygiella luzhijiangensis Huan C.Wang	2017		77179094-1
	Rehmannia chrysantha M.H.Li & C.H.Zhang	2016		77155584-1
	Scrophularia jinii P.Li	2018		77178920-1
Selaginellaceae	*Selaginella chuweimingii* X.M.Zhou, Z.R.He, Liang Zhang & Li Bing Zhang	2015		77150615-1
	Selaginella daozhenensis Li Bing Zhang, Q.W.Sun & Jun H.Zhao	2015		77147115-1
	Selaginella guihaia X.C.Zhang	2017	IB	60474541-2
	Selaginella wangpeishanii Li Bing Zhang, H.He & Q.W.Sun	2014		77140329-1
Smilacaceae	*Smilax hirtellicaulis* C.Y.Wu & C.Chen ex P.Li	2016	IB	77157761-1
	Smilax microdontus Z.S.Sun & C.X.Fu	2015		77147575-1
Solanaceae	*Lycium amarum* Lu Q.Huang	2016		77158466-1
Styracaceae	*Styrax rhytidocarpus* W.Yang & X.L.Yu	2015		77150409-1
Taxaceae	*Taxus calcicola* L.M.Gao & Mich.Möller	2013	IB	77136027-1
Theaceae	*Camellia concinna* Orel & Curry	2015	IB	77151428-1
	Camellia psilocarpa X.G.Shi & C.X.Ye	2018	IB	77176063-1
	Camellia tomentosa Orel & Curry	2015	IB	77151406-1
	Eurya makuanica C.X.Ye & X.G.Shi	2015	IB	77154773-1
	Eurya pilosa C.X.Ye & X.G.Shi	2015	IB	77174759-1
Thelypteridaceae	*Cyclogramma costularisora* Ching ex K.H.Shing	2014	IB	77145114-1
Thymelaeaceae	*Daphne ogisui* C.D.Brickell, B.Mathew & Yin Z.Wang	2014	SW	77141997-1
Trilliaceae	*Paris caojianensis* B.Z.Duan & Yu Yu Liu	2017	SW	77177679-1
	Paris nitida G.W.Hu, Zhi Wang & Q.F.Wang	2017		77176304-1
	Paris qiliangiana H.Li, Jun Yang bis & Y.H.Wang	2017		77177750-1
	Paris tengchongensis Y.H.Ji, C.J.Yang & Yu L.Huang	2017	SW	77162987-1
Ulmaceae	*Celtis neglecta* Zi L.Chen & X.F.Jin	2017		77161265-1
	Ulmus erythrocarpa W.C.Cheng ex Yi F.Duan & X.R.Wang	2016		77158537-1
	Ulmus kunmingensis W.C.Cheng	2013		77137832-1
	Ulmus multinervis W.C.Cheng ex Yi F.Duan & X.R.Wang	2016		77158536-1
Urticaceae	*Debregeasia hekouensis* W.T.Wang	2016	IB	77156529-1
	Elatostema androstachyum W.T.Wang, A.K.Monro & Y.G.Wei	2013	IB	77134637-1
	Elatostema anlongense W.T.Wang	2016		77158908-1
	Elatostema arcuatipes W.T.Wang & Y.G.Wei	2014		77141252-1
	Elatostema atrostriatum W.T.Wang & Y.G.Wei	2013	IB	77178529-1
	Elatostema austroyunnanense W.T.Wang	2014	IB	77141437-1
	Elatostema baoshanense W.T.Wang & Z.Y.Wu	2016	SW	77165300-1
	Elatostema biformibracteolatum W.T.Wang	2014	IB	77141253-1
	Elatostema bioppositum L.D.Duan & Yun Lin	2013	IB	77178535-1
	Elatostema bomiense W.T.Wang & Z.Y.Wu	2013	SW	77130899-1
	Elatostema brunneobracteolatum W.T.Wang	2014	IB	77141264-1
	Elatostema brunneostriolatum W.T.Wang	2014	IB	77141413-1

Family	Scientific name	Publication year	Discovered from Biodiversity hotspots*	IPNI Plant Name Id
Urticaceae	*Elatostema caudatoacuminatum* W.T.Wang	2013	IB	77144616-1
	Elatostema chiwuanum W.T.Wang	2013	SW	77144627-1
	Elatostema costatoalatum W.T.Wang & Z.Y.Wu	2014	IB	77141444-1
	Elatostema crassicostatum W.T.Wang	2014	IB	77141441-1
	Elatostema crassimucronatum W.T.Wang	2014		77141242-1
	Elatostema cuipingfengense W.T.Wang & Z.Y.Wu	2016	IB	77165302-1
	Elatostema cyrtandrifolioides W.T.Wang	2014	IB	77141269-1
	Elatostema daxinense W.T.Wang & Z.Y.Wu	2013	IB	77130900-1
	Elatostema dentatocaudatum W.T.Wang & Z.Y.Wu	2016	SW	77165298-1
	Elatostema femineocymosum W.T.Wang	2018	SW	77193107-1
	Elatostema flexuosicaule W.T.Wang & Z.Y.Wu	2016	SW	77165307-1
	Elatostema fulvobracteolatum W.T.Wang	2013	IB	77144630-1
	Elatostema furcatibracteum W.T.Wang	2014	H	77141240-1
	Elatostema furcatiramosum W.T.Wang	2014	IB	77141412-1
	Elatostema globosostigmatum W.T.Wang & Z.Y.Wu	2016	SW	77165334-1
	Elatostema gyronanophyllum W.T.Wang	2018	SW	77193109-1
	Elatostema heterocladum W.T.Wang, A.K.Monro & Y.G.Wei	2013	IB	77134638-1
	Elatostema hygrophilifolium W.T.Wang	2013	IB	77144609-1
	Elatostema jingxiense W.T.Wang & Y.G.Wei	2013	IB	77178530-1
	Elatostema laevicaule W.T.Wang, A.K.Monro & Y.G.Wei	2013	IB	77134636-1
	Elatostema linearicorniculatum W.T.Wang	2014	IB	77141447-1
	Elatostema longiciliatum W.T.Wang	2014	IB	77141426-1
	Elatostema longicuspe W.T.Wang & Y.G.Wei	2013		77130004-1
	Elatostema magni-auriculatum L.D.Duan & Yun Lin	2015	IB	77178674-1
	Elatostema melanocarpum W.T.Wang	2013	IB	77144614-1
	Elatostema melanocephalum W.T.Wang	2014		77141442-1
	Elatostema melanoceras W.T.Wang	2014	IB	77141427-1
	Elatostema menghaiense W.T.Wang	2013	IB	77144626-1
	Elatostema odontopterum W.T.Wang	2013	IB	77144607-1
	Elatostema oligotrichum W.T.Wang	2017	SW	77174976-1
	Elatostema ornithorrhynchum W.T.Wang	2014	IB	77141246-1
	Elatostema pachycephalum W.T.Wang	2016	IB	77158909-1
	Elatostema pallidinerve W.T.Wang	2014	IB	77141254-1
	Elatostema pellionioides W.T.Wang	2014	IB	77141241-1
	Elatostema petiolare W.T.Wang	2014	IB	77141425-1
	Elatostema pinghianense W.T.Wang	2014	IB	77141257-1
	Elatostema planinerve W.T.Wang & Y.G.Wei	2013		77130003-1
	Elatostema pseudolongipes W.T.Wang & Y.G.Wei	2014	IB	77141420-1
	Elatostema pseudonanchuanense W.T.Wang	2014	IB	77141243-1
	Elatostema purpureolineolatum W.T.Wang	2013	IB	77144631-1
	Elatostema quadribracteatum W.T.Wang	2014	IB	77141255-1
	Elatostema quinquetepalum W.T.Wang	2013	IB	77144611-1
	Elatostema retrostrigulosoides W.T.Wang	2014	IB	77141272-1
	Elatostema ronganense W.T.Wang & Y.G.Wei	2014	IB	77141458-1
	Elatostema schizodiscum W.T.Wang & Y.G.Wei	2013		77178531-1
	Elatostema septemcostatum W.T.Wang & Z.Y.Wu	2014	IB	77141263-1
	Elatostema simaoense W.T.Wang	2013	IB	77144628-1
	Elatostema simianshanicum W.T.Wang	2017	SW	77174977-1
	Elatostema tiechangense L.F.Fu, Y.G.Wei & A.K.Monro	2017	IB	77160160-1
	Elatostema tritepalum W.T.Wang	2014	IB	77141268-1
	Elatostema viridibracteolatum W.T.Wang	2014	IB	77141262-1
	Elatostema viridicarinatum W.T.Wang	2017	IB	77162747-1
	Elatostema viridicostatum W.T.Wang & Z.Y.Wu	2016	SW	77165304-1
	Elatostema viridinerve W.T.Wang	2014	IB	77141271-1
	Elatostema weii W.T.Wang	2014	IB	77141430-1
	Elatostema wenshanense W.T.Wang	2017	IB	77162745-1

Family	Scientific name	Publication year	Discovered from Biodiversity hotspots*	IPNI Plant Name Id
Urticaceae	*Elatostema yongtianianum* W.T.Wang	2013		77144619-1
	Elatostema zhengyuanum W.T.Wang	2018	SW	77193110-1
	Elatostema zhenyuanense W.T.Wang & Z.Y.Wu	2014	IB	77141445-1
	Laportea jinganensis W.T.Wang	2016		77156528-1
	Laportea lageensis W.T.Wang	2014	H	77138094-1
	Metapilea jingxiensis W.T.Wang	2016	IB	77155150-1
	Pellionia calcifera W.T.Wang	2016	IB	77154996-1
	Pellionia laibinensis W.T.Wang	2017	IB	77164278-1
	Pellionia mollissima W.T.Wang	2014	IB	77139051-1
	Pellionia simianschanica W.T.Wang	2017	SW	77174975-1
	Pellionia tritepala W.T.Wang	2016		77154995-1
	Pilea gongjueensis W.T.Wang	2016		77156533-1
	Pilea lageensis W.T.Wang	2014	H	77138095-1
	Pilea longruiensis W.T.Wang	2017	IB	77174980-1
	Pilea longzhouensis W.T.Wang	2017	IB	77174978-1
	Pilea luochengensis W.T.Wang	2016	IB	77156532-1
	Pilea lushuiensis W.T.Wang	2017	SW	77174979-1
	Pilea minima W.T.Wang	2017	SW	77174981-1
	Pilea nonggangensis Y.G.Wei, L.F.Fu & A.K.Monro	2017	IB	77176278-1
	Pilea weimingii Huan C.Wang	2018		77186306-1
	Pilea yuanbaoshanica W.T.Wang	2017	IB	77174983-1
	Urtica chengkouensis W.T.Wang	2017	SW	77164277-1
	Urtica malipoensis W.T.Wang	2014	IB	77140819-1
	Zhengyia shennongensis T.Deng, D.G.Zhang & H.Sun	2013		77125828-1
Violaceae	*Viola hybanthoides* W.B.Liao & Q.Fan	2015	IB	77145097-1
	Viola nujiangensis Y.S.Chen & X.H.Jin	2015	SW	77150548-1
Vitaceae	*Cyphostemma dehongense* L.M.Lu & V.C.Dang	2017	IB	77167306-1
	Pseudocayratia speciosa J.Wen & L.M.Lu	2018	IB	77193893-1
Woodsiaceae	*Athyrium sessilipinnum* X.C.Zhang & R.Wei	2016	IB	77160655-1
	Diplazium yinchanianum Zi Yue Liu, H.J.Wei & Y.H.Yan	2018	IB	77177560-1
	Hypodematium confertivillosum J.X.Li, F.Q.Zhou & X.J.Li	2018		77174973-1
Zingiberaceae	*Amomum hainanense* Y.S.Ye, J.P.Liao & P.Zou	2018	IB	77193005-1
	Amomum velutinum X.E.Ye, Škorničk. & N.H.Xia	2017	IB	77187998-1
	Boesenbergia kingii Mood & L.M.Prince	2013	IB	77130879-1
	Curcuma gulinqingensis N.H.Xia & Juan Chen	2013	IB	77135581-1
	Hedychium dichotomatum Picheans. & Wongsuwan	2013	IB	77127653-1
	Hedychium viridibracteatum X.Hu	2018	IB	77191580-1
	Roscoea glaucifolia F.J.Mou	2015	SW	77149685-1
	Zingiber hainanense Y.S.Ye, L.Bai & N.H.Xia	2015	IB	77147977-1
	Zingiber leucochilum L.Bai, Škorničk. & N.H.Xia	2018	SW	77192884-1
	Zingiber pauciflorum L.Bai, Škorničk., D.Z.Li & N.H.Xia	2017	IB	77179030-1
	Zingiber tenuifolium L.Bai, Škorničk. & N.H.Xia	2015	IB	77150125-1
	Zingiber ventricosum L.Bai, Škorničk., N.H.Xia & Y.S.Ye	2016	IB	77155186-1
	Zingiber zhuxiense G.X.Hu & S.Huang	2015		77174765-1

*Biodiversity hotspots abbreviation. CA: Mountains of Central Asia, H: Himalaya, IB: Indo-Burma, SW: Mountains of Southwest China, Blank: non-biodiversity hotspots area. Species which recognized as nomen illegitimum were excluded.

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A new species of *Amentotaxus* (Taxaceae) from China, Vietnam, and Laos

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Abstract

A new species *Amentotaxus hekouensis* L.M. Gao is described as new to science from Hekou, Yunnan of China, Lao Cai of Vietnam and Xiang Khouang of Laos. The new species is similar to *A. argotaenia* (Hance) Pilg. in linear or linear-lanceolate leaves, stomatal bands white and microsporophylls 6–8, each with 4–6 pollen sacs, but differs from the latter by its larger leaf size with 8–12.5 cm × 0.9–1.4 cm (vs. 2–11 cm × 0.5–1.1 cm in *A. argotaenia*), long acuminate leaf apex (vs. rounded to sharply triangular in *A. argotaenia*), stomatal bands with 25–30 rows (vs. 15–25 rows in *A. argotaenia*), stomatal bands equal to or slightly narrower than marginal bands (vs. narrower than marginal bands in *A. argotaenia*); pollen-cone racemes borne 1–2 (vs. 2–4 (10) in *A. argotaenia*), cones in 12–16 pairs (vs. ca. 12 pairs in *A. argotaenia*). Its distinctive nature has also been confirmed through DNA barcoding analysis of this genus. The new species is provisionally assessed as endangered (EN) due to its restricted distribution, small population size and the prevalence of habitat destruction within its range.

Keywords

Amentotaxus hekouensis, New species, Endangered species, DNA barcoding, China

Introduction

Amentotaxus Pilg. (Taxaceae), comprising of five or six species, is confined to southern China (including Taiwan), small areas of the eastern Himalayas and parts of Indo-China (Farjon 2010). All species of *Amentotaxus* are currently assessed as threatened at either national or global level (Wang and Xie 2004; IUCN 2016a). They usually occur in the understorey of moist submontane and montane semi-deciduous or evergreen forests (Gao et al. 2017). *Amentotaxus argotaenia* Pilg. is the most widespread species in this genus, recorded from most provinces of southern China as well as several areas of Vietnam and Laos (Fu et al. 1999; Farjon 2010; Nguyen et al. 2004; Averyanov et al. 2014). *Amentotaxus yunnanensis* H.L. Li is generally confined to the evergreen forests in the karst formation of southeast Yunnan, southwest Guizhou and adjacent areas of Vietnam and Laos (Fu et al. 1999; Farjon 2010; Averyanov et al. 2014). In 1996, *A. hatuyenensis* T.H. Nguyen was described from a single locality in Hagiang Province, northern Vietnam (Nguyen and Vidal 1996), but it is now regarded as a synonym of *A. yunnanensis,* based on morphological and molecular data (Phan et al. 2014; Gao et al. 2017). The remaining accepted species are restricted to Taiwan of China, eastern Himalayas and central Vietnam.

In September, 2006, specimens of an *Amentotaxus* tree were collected from limestone montane forest near Longyinchong village, Nanxi town, Hekou county, Yunnan province, China. Its morphology differed markedly from *A. yunnanensis* which commonly occurs in this region. In 2012, a second collection with the same morphology was found in the same region. In our DNA barcoding study (Gao et al. 2017), specimens from Hekou formed a distinct clade with specimens with similar morphology from Lao Cai in Vietnam and Xiang Khoang in Laos. The putative new species differs from all other recognised species in the length and width of the leaves, the shape of the leaf apex, curvature of the leaf margin, stomatal band width and its ratio to the leaf marginal bands. In 2016, several further surveys collected specimens with male cones that showed differences in the number of pollen sacs and the length of the racemes. Data analysis of *trnL-F* and ITS sequences for the newly collected specimen GLM-164271 had an identical sequence with the specimen GLM-06209 (Am 20) and CKF250 (Am 24), used in our DNA barcoding study (Gao et al. 2017), lending further support to the recognition of a new species (Figure 1). Although female cones have not yet been collected, other species in the genus do not show significant differences in the female cones (Fu et al. 1999; Farjon 2010).

Materials and methods

All measurements of the new *Amentotaxus* species were taken from dried herbarium specimens and field notes. In the description, length and width are represented as length × width. In total, eleven dried specimens of the new species were examined. All measurements of *A. argotaenia* (Hance) Pilg. and *A. yunnanensis* H.L. Li were based on literature (Fu et al. 1999; Farjon 2010) and our observations.

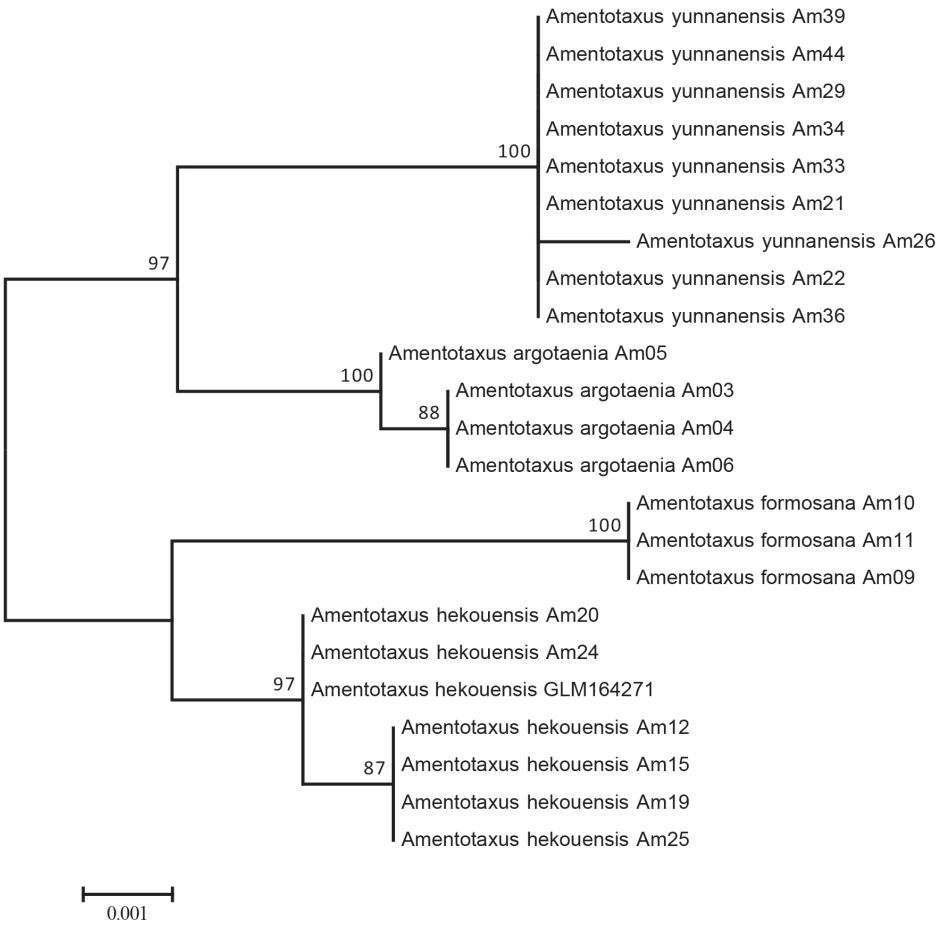

Figure 1. Neighbour-joining (NJ) tree of ITS and *trnL-F* sequences of *Amentotaxus* based on P-distance with bootstrap values above 50%.

Taxonomic treatment

Amentotaxus hekouensis **L.M. Gao, sp. nov.**
urn:lsid:ipni.org:names:60479341-2
Figs 2, 3, Table 1

Diagnosis. *Amentotaxus hekouensis* L.M. Gao resembles *A. argotaenia* (Hance) Pilg., but differs in its larger leaf size (8–12.5 cm × 0.9–1.4 cm), long acuminate leaf apex, leaf margin flat with slightly wavy, stomatal bands white or greenish-white with 25–30 rows, stomatal bands equal or slight narrower than marginal bands; pollen-cone racemes borne 1–2, cones in 12–16 pairs, microsporophylls 6–8, each with 4–6 pollen sacs.

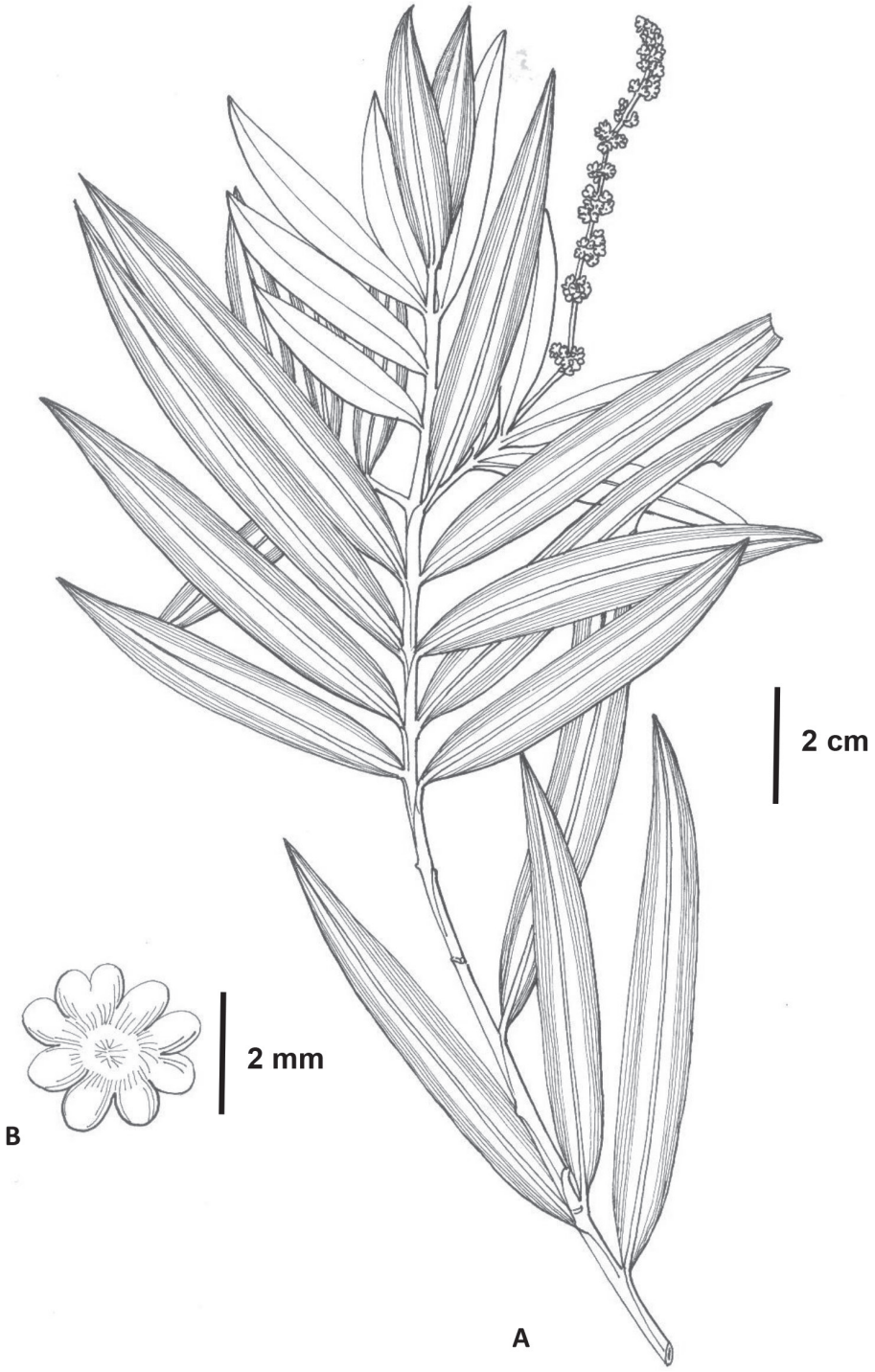

Figure 2. *Amentotaxus hekouensis* L.M. Gao (from the holotype, drawn by Ling Wang). **A** Branchlets with male cone **B** pollen sacs.

Table 1. Morphological character comparison amongst the three regional *Amentotaxus* species.

Characters	*A. hekouensis*	*A. argotaenia*	*A. yunnanensis*
Length of leaf	8–12.5 cm	2–11 cm	3.5–10 cm
Width of leaf	9–14 mm	5–11 mm	8–12 mm
Texture of leaves	thin, leathery	thick, leathery	thick, leathery
Apex of the leaves	long acuminate	rounded to sharply triangular	obtuse or tapered
Width of stomatal bands	2.1–3.0 mm	1–2 mm	3–4 mm
No. rows of each stomatal band	25–30	15–25	ca. 40
Ratio of stomatal band/marginal band	0.75–1	< 1	> 2
Colour of marginal band	bright green in fresh	Yellowish-green	Yellowish-green in fresh
No. raceme per male cone	1–2	2–4 (10)	4–6

Type. CHINA. Yunnan: Honghe, Hekou County, Nanxi Town, Longyinchong village, 22°41'8.9"N, 104°01'11.5"E, 926 m alt., 16 April 2016 (with male cone), *G. L. Zhang, GLM-164271* (holotype: KUN!; isotypes: KUN!)

Morphological description. Small tree to 4–5 m tall; branch cylindric or subtetragonal, grey; leafy branchlets ascending or sub-erect, broadly rectangular to oblong-elliptic in outline, 6–12 × 11–20 cm, axis green in 1st year, greenish-yellow in 2nd and 3rd years, quadrangular or subterete in cross section. Leaves borne at 50–80° to branchlet axis, distichous, twisted at the short petiolate or nearly sessile base, petiole 2–4 mm long, almost opposite, 4–6 leaf pairs on each branchlet; leaves leathery, thin, linear or linear-lanceolate, 8–12.5 × 0.9–1.4 cm, straight, slightly falcate at the apex, cuneate at base, asymmetric, apex long acuminate, leaf margin flat or slightly down-curved, usually slightly wavy; leaf marginal band dark green in fresh, yellowish-green in dry, 2.5–3.2 mm wide; stomatal bands white or greenish-white, 2.1–3.0 mm wide, equal or slight narrower (> 3/4) to marginal bands, 25–30 rows, densely arranged; midvein slight sunken or flat adaxially, raised abaxially, 1.2–2.0 mm wide, narrower than the stomatal bands and marginal bands, green, same colour as the branchlet. Male-cone racemes borne 1–2, ca. 8.0 cm long; cones in 12–16 pairs, ovoid, cones at base maturing earlier than those at apex; microsporophylls 6–8, peltate, each with 4–8 pollen sacs. Ovulate cone and mature seed unknown. Male cones maturing March to April.

Additional specimens examined. CHINA. Yunnan: Hekou County, Nanxi Town, 20 Sept 2006, *L. M. Gao et al. GLM-06209* (KUN!); ibid., 20 Oct 2012, *L.M. Gao GLM-123943* (KUN!), ibid., 31 Jan 2016, *L. M. Gao et al. GLM-164258, GLM-164259* (KUN!), ibid., 21 Oct. 2001, *Y. M. Shui et al. 15078* (KUN); Funing County, Long-may, 24 April 1940, *C.W. Wang 88812* (KUN); Malipo County, 4 Jan. 1940, *C.W. Wang 86175* (KUN). Vietnam. Lao Cai: Muong Khuong, Nam Chay commune, Moi village, 21 Nov. 2009, *CKF team CKF250* (KUN, CPC, CMBG); Hoa Binh: Mai Chau, Pa Co commune, 3 Dec. 2003, *S.G. Wu et al. WP413* (KUN). Laos. Xiang Khouang: Phak Leung Mt., Tanh village, Dec. 2008, *X. Gong GX-5* (KUN).

Distribution and ecology. *Amentotaxus hekouensis* L.M. Gao has only been found in small disjunct areas in China (Funing, Malipo and Hekou County, Yunnan Province), Vietnam (Muong Khuong, Lao Cai Province; Mai Chau, Hoa Binh Province) and Laos (Xiang Khouang) (Figure 4). It is confined to the montane evergreen forest on lime-

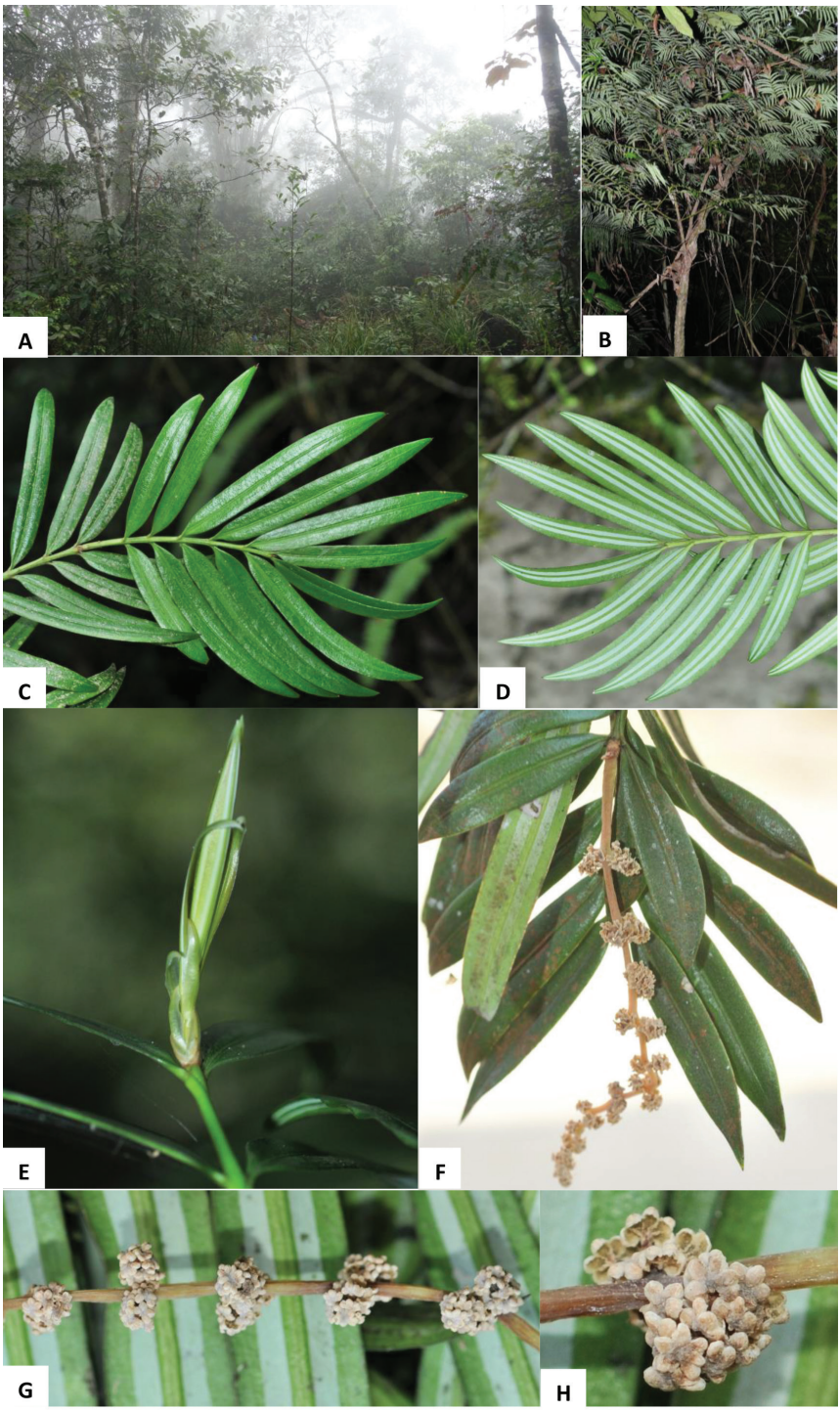

Figure 3. *Amentotaxus hekouensis* L.M. Gao. **A** Habitat **B** habit **C** branchlet with adaxial leaves **D** branchlet with abaxial leaves **E** young shoot **F** branchlet and male cone racemes with microsporophylls **G** male cone racemes **H** microsporophylls and pollen sacs.

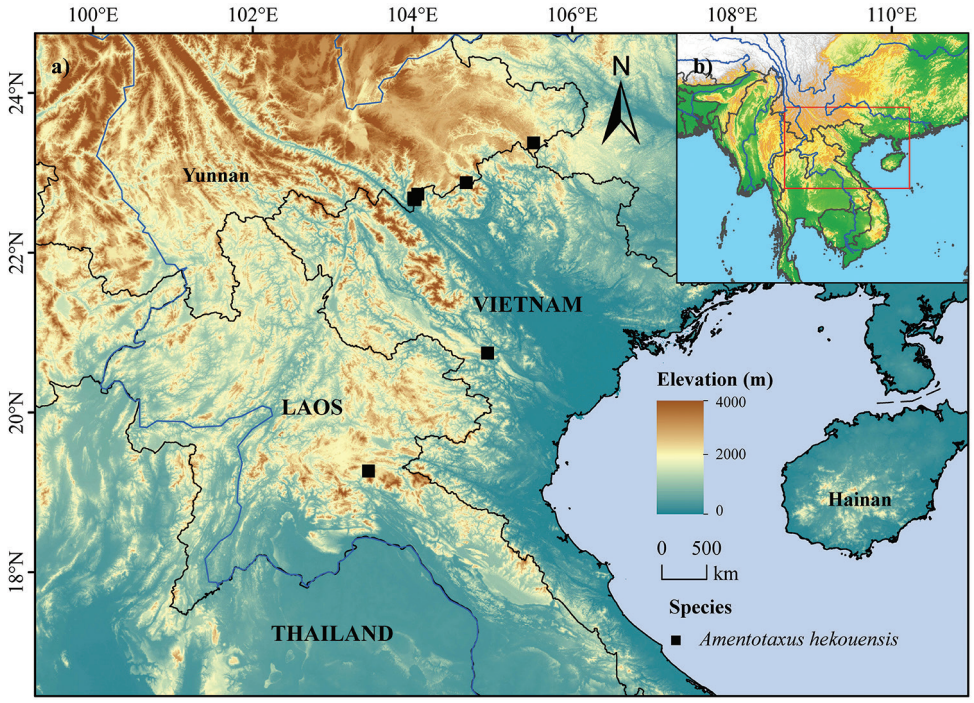

Figure 4. Geographical distribution of *Amentotaxus hekouensis* L. M. Gao.

stone mountains at elevations between 850 and 1200 (-1750) m. In part of its distribution along the border between China and Vietnam, it is sympatric with *A. yunnanensis*.

Phenology. Male cones of *Amentotaxus hekouensis* mature in March to April; seeds have not been seen so far.

Etymology. The specific epithet refers to the type location in Hekou County.

Conservation status. Several surveys have been carried out in this region since 2006 and only a few small trees of the new species are known. *Amentotaxus hekouensis* occurs in small and isolated patches of forests at very low densities. All the known localities are subject to degradation from surrounding agriculture and forest clearance. Given its montane habitat, the new species may also be susceptible to the impacts of climate change. The combination of a restricted, fragmented distribution with very limited Area of Occupancy, small population size and habitat conversion and destruction throughout its range indicate that its IUCN status should be Endangered under Criterion B2ab(ii,iii) (IUCN 2016b).

Discussion

Amentotaxus hekouensis has distinct morphological features compared to the closely related *A. argotaenia* and the sympatric *A. yunnanensis* (Table 1). Its distinctive nature has also been supported by DNA barcoding analysis of this genus (Figure 1). Therefore,

the description of a new species is supported by both morphological and molecular evidence. Due to its restricted distribution, small population size and the prevalence of habitat destruction within its range, *A. hekouensis* is assessed as endangered (EN).

Acknowledgements

We are grateful to Ms. Ling Wang from KUN for drawing the illustration of the holotype. We also thank Profs. Xun Gong, Yumin Shui from Kunming Institute of Botany, Chinese Academy of Sciences for providing the specimens from Laos and Vietnam of the new species. This work was supported by the Large-scale Scientific Facilities of the Chinese Academy of Sciences (Grant No: 2017-LSFGBOWS-02), the Strategic Priority Research Program of the Chinese Academy of Sciences (XDB31010000), and the Program of Science and Technology Talents Training of Yunnan Province, China (Grant No: 2017HA014). The Royal Botanic Garden Edinburgh is funded by the Rural and Environment Science and Analytical Services division of the Scottish Government.

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RESEARCH ARTICLE

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Bulbophyllum reflexipetalum (Orchidaceae, Epidendroideae, Malaxideae), a new species from Xizang, China

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Abstract

Bulbophyllum reflexipetalum, a new species from Motuo County, Southeast Xizang, China, is described and illustrated here. This new species belongs to *Bulbophyllum* sect. *Umbellata* Bentham & J. D. Hooker, and it is morphologically similar to *B. umbellatum* Lindley, *B. guttulatum* (J. D. Hooker) N. P. Balakrishnan and *B. salweenensis* X.H. Jin, but is distinguished from them by having reflexed petals, base of dorsal sepal with 1 dentate on each side, lip with significantly revolute margin, adaxially with dark brown spots or patches and one longitudinal groove.

Keywords

Taxonomy, *Bulbophyllum*, Section *Umbellata*, Xizang Province, China

Introduction

Bulbophyllum Thouarm (Orchidaceae) is one of the three largest genera in the orchid family, comprising about 2200 species widely distributed in tropical Africa, Asia and America (Lang and Tsi 1987, Pridgeon et al. 2014). There are about 105 species in China (Chen and Vermeulen 2009), with several new species described in recent years (Zhou and Jin 2015, Liu et al. 2016, Zhai et al. 2017). Motuo is an important area in the eastern Himalaya biodiversity hotspot, but the species diversity in this region is poorly known, and some new taxa are discovered and described in recent years (Lai and Jin 2012, Huang et al. 2013, Raskoti et al. 2017). More conservation efforts are needed in this region to counteract the increasing anthropogenic disturbance and destruction. During our field survey in Motuo County, Xizang Autonomous Region, a new *Bulbophyllum* species of sect. *Umbellata* Bentham & J. D. Hooker was found in the subtropical broad-leaved forest and described below.

Materials and methods

Type specimens were collected in Motuo County, Xizang Autonomous Region, China, during a field expedition in 2016. Photographs were taken in field. Shapes, colors and other details given in the description were based on living materials (five individuals). The column and pollinia morphological photographs were taken using an Olympus SZX16. Voucher specimens were deposited at the herbarium of Kunming Institute of Botany, Chinese Academy of Sciences (**KUN**). The conservation status of the new species was evaluated based on the guidelines of the International Union for Conservation of Nature (IUCN 2012).

Taxonomy

Bulbophyllum reflexipetalum **J.D.Ya, Y.J.Guo & C.Liu, sp. nov.**
urn:lsid:ipni.org:names:77201398-1
Figure 1, 2

Diagnosis. *Bulbophyllum reflexipetalum* is similar to *B. salweenensis* X.H. Jin, *B. umbellatum* Lindley and *B. guttulatum* (J. D. Hooker) N. P. Balakrishnan in terms of morphological structure and shape of the flowers. The new species can be distinguished from *B. salweenensis* by the absence of sheaths on the pseudobulbs and rhizome, scape longer than leaf and petals apex mucronate. It can be distinguished from *B. umbellatum* with smaller and flattened void or ovoid-conic pseudobulbs, shorter leaf blade, petals apex caudate. In addition, the new species can be distinguished from *B. guttulatum* with leaf blade oblong and apex emarginated, shorter pedicel and ovary, lip papillae with a single longitudinal ridge.

Type. CHINA. Xizang Autonomous Region: Motuo, subtropical, evergreen broad-leaved forest, 1378 m, 17 Mar 2016, *J.-D. Ya, Y.-J. Guo, Q.-R. Zhang 18HT1419* (holotype: KUN!).

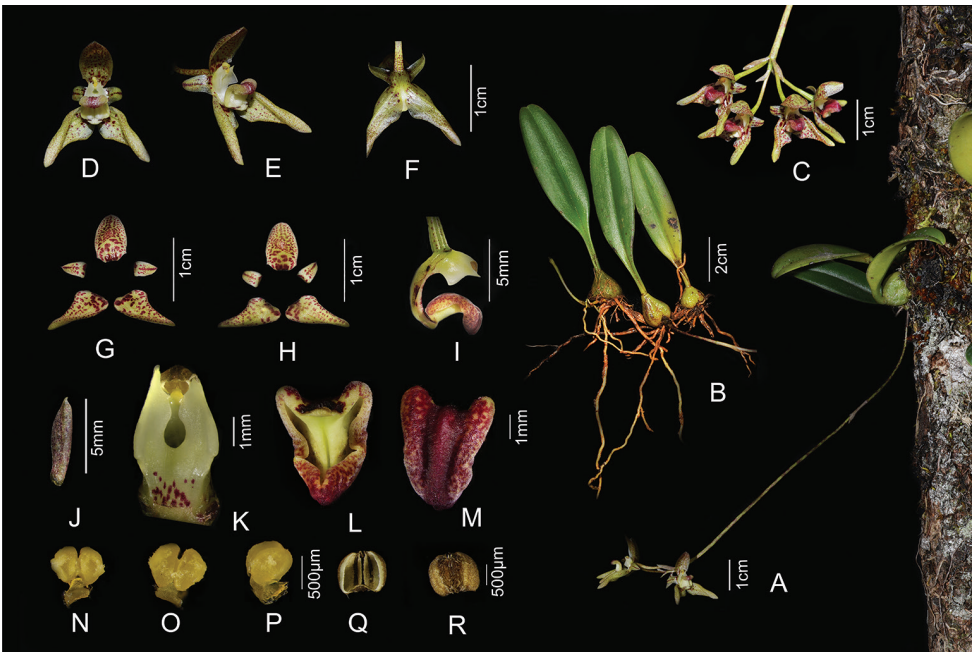

Figure 1. *Bulbophyllum reflexipetalum* sp. nov. **A** habitat **B** plant **C** inflorescence **D** front view of flower **E** lateral view of flower **F** dorsal view of flower **G** adaxial sepals and petals **H** abaxial sepals and petals **I** lateral view of column and lip **J** bract **K** front view of column **L** dorsal view of labellum **M** front view of labellum **N** dorsal view of pollinarium **O** front view of pollinarium **P** lateral view of pollinarium **Q** abaxial anther cap **R** adaxial anther cap (Photographed by J.-D. Ya).

Description. Epiphytic herbs. Rhizome creeping and rooting, 3–4 mm in diam. Roots arising from the nodes, 0.5–1.5 mm in diam. Pseudobulbs often 1–2 cm apart on rhizome, flattened ovoid or ovoid-conic, ca. 10–16 × 8–15 mm, with a terminal leaf. Leaf blade oblong, 50–65 × 15–20 mm, leathery, apex obtuse and emarginate, base narrowing into a petiole; petiole 10–20 mm. Scape arising from the base of pseudobulb, 13–20 cm long, longer than leaf; umbellate, often 3–4-flowered; peduncle ca. 1.5 mm in diam, with 3 tubular sheaths; floral bract lanceolate, acuminate, concave, ca. 6.3 × 2.0 mm; peduncle and ovary ca. 10–15 mm long. Flowers greenish yellow, sepals and petals with dark brown spots; lip greenish yellow, adaxially with dark brown spots or patches. Dorsal sepal ovate, concave, apex obtuse, base with 1 dentate on each side, ca. 8.10 × 4.95 mm, 5-veined; lateral sepals falcate-lanceolate, base adnate to column foot, twisted inward near base, ca. 10.30 × 5.26 mm, 5-veined; Petals reflexed, broadly ovate-triangular, ca. 3.23 × 2.52 mm, 1-veined, margin entire, apex mucronate; lip deflexed, triangular-lingulate, ca. 4.02 × 2.94 mm, base subcordate with papillae on the edge, margin revolute, apex obtuse, adaxially with a longitudinal ridge from base to apex, abaxially with a longitudinal groove; column ca. 3.25 mm, with deltoid, rounded wings along lower margins, stelidia deltoid, ca. 1 mm, foot ca. 6.86 mm, apex attached to lip; anther cap subglobose with many longitudinal lamellae when dry. pollinia 4, in 2 pairs, 0.72–0.93 mm, yellow, ovate, waxy, attached to sticky substance. Fl. February–March.

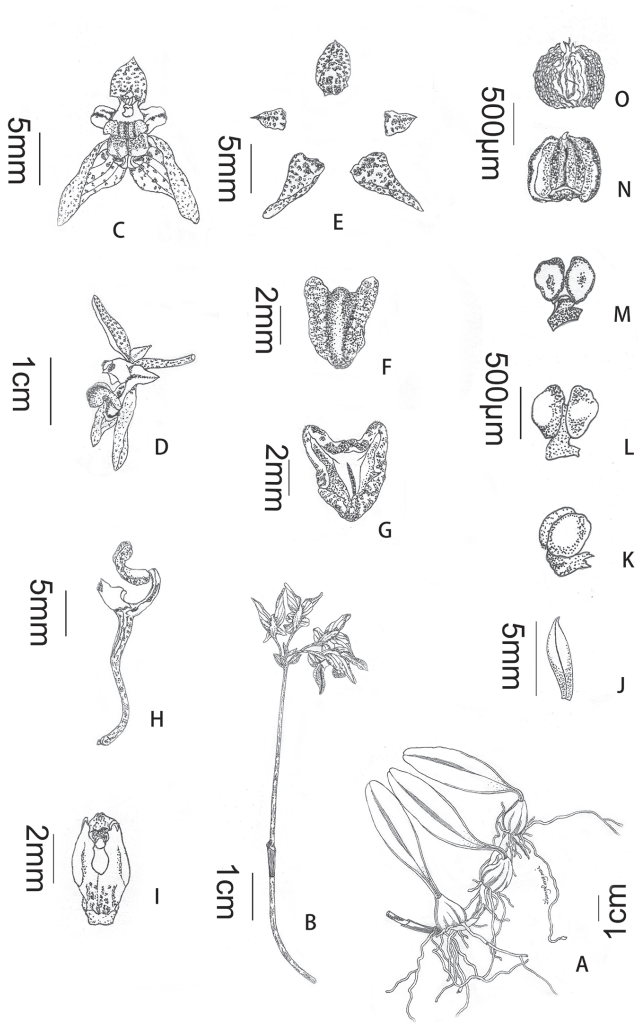

Figure 2. *Bulbophyllum reflexipetalum* sp. nov. **A** plant **B** inflorescence **C** front view of flower **D** lateral view of flower **E** adaxial sepals and petals **F** front view of labellum **G** dorsal view of labellum **H** lateral view of column and lip **I** front view of column **J** bract **K** lateral view of pollinarium **L** front view of pollinarium **M** dorsal view of pollinarium **N** abaxial anther cap **O** adaxial anther cap (Drawn by Rong-Mei Zhang).

Etymology. The specific epithet "*reflexipetalum*" refers to reflexed petals of this new species.

Vernacular name. Fan Ban Juan Ban Lan (Chinese pronunciation); 反瓣卷瓣兰 (Chinese name).

Distribution and habitat. *Bulbophyllum reflexipetalum* is currently known only from the type locality of Motuo, Southeast Xizang, China. It is a predominantly epiphytic species that grows on tree trunks, under broadleaf evergreen forest at the elevation between 1300 m and 1400 m.

Conservation status. During our 2-weeks field survey, only 2 populations were found. As this new species may also grow in the broadleaf evergreen forest of vicinity region, we regard its status as Data Deficient (IUCN 2012).

Discussion

Bulbophyllum reflexipetalum belongs to sect. *Umbellata* based on the umbellate inflorescence (Chen and Vermeulen 2009). Morphologically, this new species is similar to *B. salweenensis*, *B. umbellatum* and *B. guttulatum* in terms of vegetative morphology and shape of the flowers (Figure 3), but is easily recognized by its reflexed petals, the dentate of dorsal sepal and the revolute margin of lip (Table 1). Beyond that, *B. reflexipetalum* can be distinguished from *B. salweenensis* by the absence of sheaths on the pseudobulbs and rhizome (vs. pseudobulbs and rhizome with sheaths), scape longer than leaf and petals apex mucronate (vs. the scape shorter than leaf); it differs from *B. umbellatum* with smaller and flattened void or ovoid-conic pseudobulbs, shorter leaf blade, petals apex caudate (vs. obtuse-rounded petals)

Table 1. Morphological comparison of *Bulbophyllum reflexipetalum* and its closely related species.

Characters	*Bulbophyllum reflexipetalum*	*B. salweenensis*	*B. umbellatum*	*B. guttulatum*
Pseudobulbs	flattened ovoid or ovoid-conic, without sheaths	ovoid-conic, with sheaths	ovoid-conic or narrowly ovoid, without sheaths	ovoid or ovoid-conic, without sheaths
	10–16 × 8–15 mm	10–40 × 4–6 mm	20–25 × 7–10 mm	13–35 × 10–20 mm
Leaf blade	oblong, apex emarginate, 5–6.5 × 1.5–2 cm	narrowly oblong, apex emarginate, 4–16 × 0.5–2.5 cm	oblong, apex emarginate, 8–19× 1.3–2.8 cm	elliptic-oblong, apex rounded, 7–14 × ca. 3 cm.
Scape	13–20 cm, longer than leaf	4–9 cm, shorter than leaf	10–15 cm	8–12 cm
Pedicel and ovary	10–15 mm	ca. 10 mm	ca. 20 mm	ca. 25 mm
Flowers	greenish yellow with dark brown spots	greenish yellow with purplish red spots	dark greenish yellow or brown with purplish apex	yellow with red spots
Dorsal sepal	Ovate, apex obtuse, base with 1 dentate	ovate, acuminate, entire.	ovate, concave, apex acute	broadly ovate, apex mucronulate
Petals	Reflexed, broadly ovate-triangular, ca.3.23 × 2.52 mm, apex mucronate	lanceolate, denticulate, ca. 5 × 2 mm, apex caudate	ovate, ca. 7 × 5 mm, obtuse-rounded	broadly ovate-triangular, ca. 4.5 × 4 mm, apex mucronate
	greenish yellow, adaxially with dark brown spots or patches	whitish purple at base, pink at apex, keel pink.	white	white with purple spots
Lip	triangular-lingulate, apex obtuse, ca. 4.02×2.94 mm	lingulate, apex obtuse, ca. 8×3 mm;	lingulate, apex obtuse, ca. 8×3 mm;	subovate, apex emarginated, 5 × 3.4 mm
	adaxially papillae with a longitudinal ridge, margin revolute, abaxial with a longitudinal groove;	adaxially papillae with a longitudinal ridge	adaxially papillae with a longitudinal ridge	adaxially with 3 longitudinal ridges

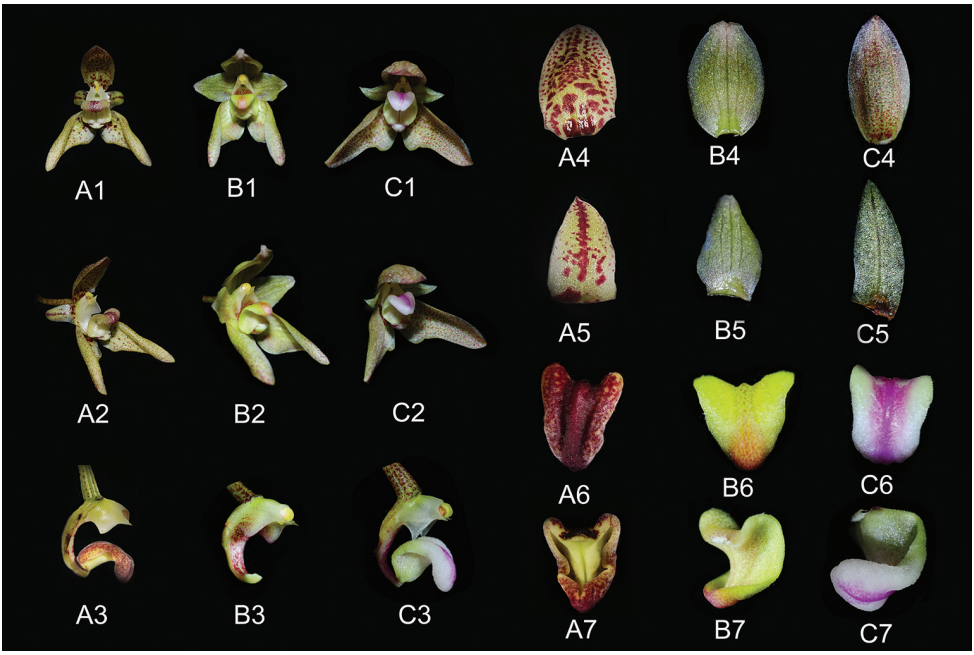

Figure 3.A *Bulbophyllum reflexipetalum* **B** *B.umbellatum* **C** *B.salweenensis* **1** front view of flower **2** lateral view of flower **3** lateral view of column and lip **4** dorsal sepal **5** petal **6** front view of column **7** dorsal or lateral view of labellum (Photographed by J.-D. Ya & H. Jiang).

; and it differs from *B. guttulatum* with leaf blade oblong and apex emarginated (vs. leaf blade elliptic-oblong and apex rounded), shorter pedicel and ovary, lip papillae with a single longitudinal ridge (lip with three ridges in *B. guttulatum*) (Chen and Vermeulen 2009, Zhou and Jin 2015).

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We are grateful to Xiaohua Jin, Chao Hu for their valuable discussion and suggestions. We convey our special thanks to Qiaorong Zhang, Huajie He, Shaofa Qin, Fengqiong Zhang and Changhong Li for their kind assistance in the field. This study was financially supported by National Science & Technology Infrastructure and the Large-scale Scientific Facilities of the Chinese Academy of Sciences (2017-LSFGBOWS-02).

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RESEARCH ARTICLE

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Ceropegia jinshaensis (Apocynaceae), a new species from northwestern Yunnan, China

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Abstract

Ceropegia jinshaensis D.T.Liu & Z.K.Wu (Asclepiadoideae, Apocynaceae), a new species from northwestern Yunnan along the upper Yangtze river of China, is described and illustrated. This species is similar to *C. meleagris* H. Huber, *C. dorjei* C. E. C. Fischer and *C. aridicola* W. W. Smith, but can be distinguished easily by its leaf shape and floral features, especially the corolla shape and size, the interior of corolla tube and coronal characters.

Keywords

Apocynaceae, *Ceropegia*, new species, Yunnan, Yangtze River

Introduction

Traditionally, the genus *Ceropegia* Linn. (Apocynaceae, Asclepiadoideae) comprises more than 220 species which mainly occur in seasonally dry places in and around the semi-arid regions of the Old World, from China to the northern tip of Australia, India, Arabian Peninsula and southern Africa (Albers and Meve 2002, Surveswaran et al. 2009, Kambale et al. 2012, Bruyns et al. 2017). A recent phylogenetic study of *Ceropegia* with

a far wider selection of species and more gene regions than before showed that the highly succulent stapeliads and *Brachystelma* R.Br. ex Sims are nested within *Ceropegia*. A revised and expanded classification of *Ceropegia* that included *Brachystelma* and all genera of the stapeliads was proposed with more than 700 species in 63 sections, making it by far the largest genus in the Apocynaceae (Bruyns et al. 2017).

According to the Flora of China, a total of 17 species of *Ceropegia* and 2 species of *Brachystelma* occur in China (Li et al. 1995), mainly distributed at low elevations in southwestern China and southern China.

During botanical exploration in northwestern Yunnan in 2015 and in 2018, an unknown species of Apocynaceae was collected on an open stony slope of the valley of the Jinsha River (upper part of Yangtze River). Its clear sap, tubular flower with a basal inflation, erect lobes coherent at their apices and forming a canopy and corona in two series, fit the main characters of *Ceropegia* in the narrow sense. After investigation of the specimens of *Ceropegia* from the main herbaria (PE, KUN and IBSC) in China, and careful consultation of the literature, especially newly published species from Asia (Swarupanandan and Mangaly 1992, Li et al. 1995, Albers and Meve 2002, Bhaskar 2006, Meve 2009, Kullayiswamy et al. 2013, Kidyoo 2014, 2015, 2018a, 2018b, Kidyoo and Paliyavuth 2016, 2017, Rodda and Meve 2017, Kumar et al. 2018), we concluded that this plant represents a species new to science and we describe it here.

Materials and methods

Morphological observations and measurements of the new species were carried out based on living plants and dry specimens with Vernier calipers. Literature studies included relevant monographs and recently published papers of *Ceropegia* (see introduction). Specimens at PE, KUN and IBSC were checked via Chinese Virtual Herbarium (CVH, http://www.cvh.ac.cn) and KUN (http://kun.kingdonia.org), the images of type specimens of *C. meleagris* H. Huber and *C. dorjei* C. E. C. Fischer were obtained from JSTOR Global Plants (http://plants.jstor.org/).

Results

Taxonomic treatment

Ceropegia jinshaensis **D.T.Liu & Z.K.Wu, sp. nov.**
urn:lsid:ipni.org:names:77201383-1
Figs 1, 2A–F

Diagnosis. This species differs from the Nepalese *C. meleagris* by having heart-shaped leaves, a small and narrowed upper part of corolla tube, corolla lobes coherent at the top to form a pentagonal canopy and glabrous internal surface of corolla. It also differs from *C. dorjei* by having smaller corolla and differs from *C. aridicola* W. W.

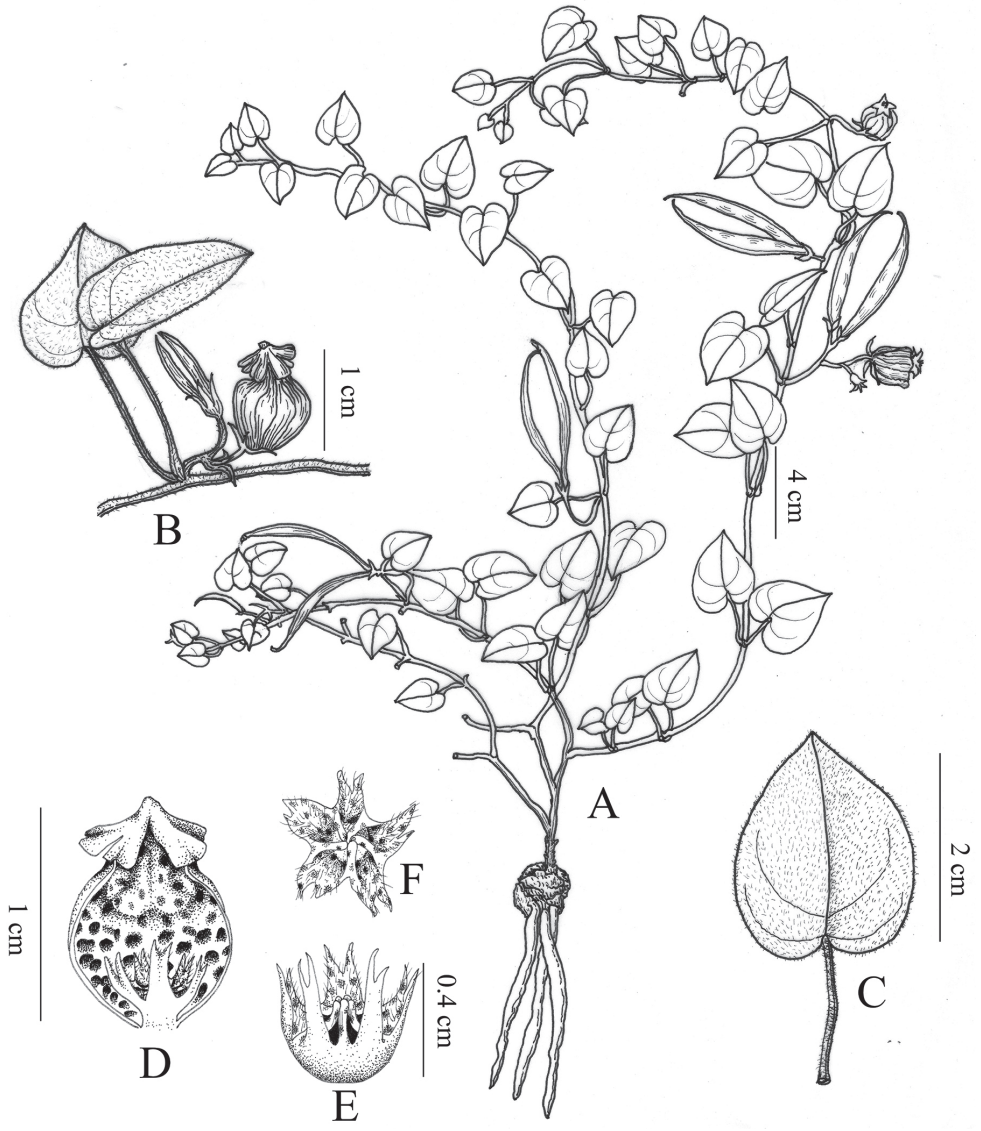

Figure 1. *Ceropegia jinshaensis* sp. nov. **A** plant **B** flower with young follicles **C** leaf **D** corolla tube dissected showing corolla interior and corona position **E** side view of corona **F** front view of corona. Drawn by Rongmei Zhang from holotype.

Smith by having a different shape of leaf apex, smaller flower, different corolla color and canopy structure.

Type. CHINA. Yunnan: Ninglang county, in the vicinity of Ahai Dam, 27°19'56.80"N, 100°30'29.39"E, 1500 m a.s.l., on stony slope of dry and hot valley, 28 Aug 2015, *Z.K. Wu et al. LJBG2015130* (holotype KUN!, isotype KUN!).

Description. Perennial herbs 25–35 cm tall; *Rootstock* consisting of many fusiform roots, 3–7 cm long, 0.2–0.4 cm diameter. *Stems* creeping or decumbent, not twining,

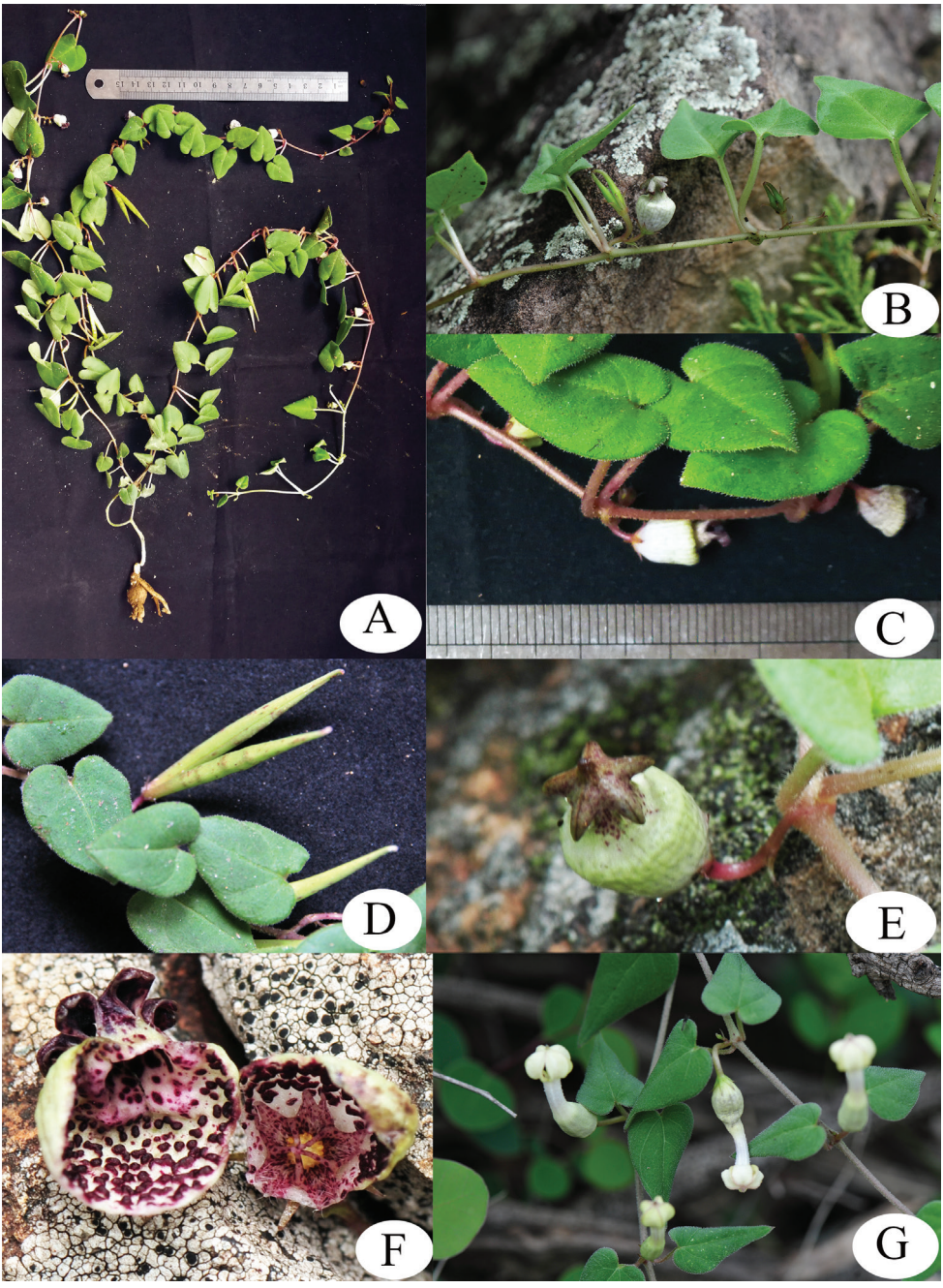

Figure 2. Morphological comparisons of *C. jinshaensis* and closely related species: **A–F** *C. jinshaensis* **A** plant **B, C** leaves and flowers **D** immature follicles **E** front view of flower showing pentagonal canopy **F** dissected corolla tube showing interior of basal corolla tube and corona **G** leaves and flower of *C. aridicola*. Photographed by Z.K. Wu.

up to 95 cm long, solitary or branched from base, pubescent. *Leaves* opposite, blade heart-shaped, 1.6–2.3 × 1.3–1.8 cm, both surfaces pubescent, somewhat fleshy, base cordate, apex acute to subacute, margin entire, petioles 1.4–2.3 cm, pubescent. *Inflorescences*, 1 to 3-flowered, on short peduncle, 4 mm long, pedicel 3–5 mm long, green or pinkish white, pubescent. *Sepals* deeply 5-parted, lobes ovate-lanceolate, greenish or reddish at tip, 3 × 1 mm, outside sparsely pubescent. *Corolla* tubular with lobes facing upwards and fused at tips, 8–12 mm long, outside pale-green towards mouth of tube with dark purple speckles at the top part, sparsely pubescent, inside white to pale green with dark maroon irregular swellings in basal inflation of tube towards mouth; *tube* 10–11 mm long, with basal inflation 6–8 mm long, 5.0–6.5 mm diameter, then abruptly narrowing to 2 mm diameter and remaining the same width at mouth; *lobes* 2–3 mm long, 1–2 mm broad at base, brown or purple both sides, joined at tips to form flat pentagonal canopy, apex emarginate or 2-cleft. *Corona* 4.0–4.5 × 4–5 mm, sessile; *outer lobes* 3–4 mm, notched in middle to ca. 1/3, pinkish with purple verrucae and many white hairs; *inner lobes* 2.5–3.0 mm, purple or pink, glabrous. *Follicles*, 3.8–5.5 cm long, 3.5–4.5 mm diameter in the middle, glabrous.

Etymology. *Ceropegia jinshaensis* is named after its type locality, which lies along the Jinsha River.

Vernacular name. Chinese mandarin: jin sha jiang diao deng hua (金沙江吊灯花).

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

Distribution and habitat. *Ceropegia jinshaensis* is currently known from two localities in NW Yunnan and grows on the open stony slope of dry-hot valley along the Jinsha River dominant by *Opuntia monacantha* (Willd.) Haw., *Vitex negundo* L. thicket and with *Hibiscus aridicola* J. Anthony, *Hemerocallis fulva* (L.) L. and *Munronia pinnata* (Wall.) W. Theob.

Conservation status. Only known from two gatherings. The population of type locality is ca. 0.5 km downstream from the crest of Ahai dam; the original habitat could be disturbed or changed by human activities such as road expansion and other building construction. Based on the IUCN criteria 3.1 (IUCN 2012), the conservation status is categorized as Critically Endangered (CR A3c+B2b (iii)).

Additional specimens examined (paratypes). CHINA: Yunnan, Yulong County, Fengke, 27°35'35.06"N, 100°26'22.11"E, 1619 m a.s.l., 22 Sep 2015, *J.D. Ya and C. Liu 15CS11213* (paratype KUN!).

Discussion

The general corolla shape of *C. jinshaensis* is very similar to *C. meleagris* which is restricted to Nepal both in respect of the inflated urceolate corolla tube at the base and the very short lobes. It differs from *C. meleagris* by having shorter leaf blade with cor-

date base, corolla lobes fused at the top into a pentagonal canopy, glabrous internal surface of entire corolla tube and shorter inner coronal lobes than outer ones. The corolla of *C. jinshaensis* is similar to the Bhutanese species *C. dorjei*. Both of them have the inflated corolla tube at the base and shorter inner lobes than outer lobes of the corona, while the present new species has heart-shaped leaves and much shorter corolla lobes than corolla tube, unlike the corolla lobes in *C. dorjei* which is mostly as long as the corolla tube. The dry-hot valley habitat, non-twining stem and heart-shaped leaves of *C. jinshaensis* remind one of the Chinese endemic *C. aridicola*, which occurs ca. 100 km from the type locality of this new species. However, in *C. aridicola* the apex of the leaf blade is acuminate, the flower is up to 1.5 cm long, the corolla tube is more than twice as long as broad and the flower color is pale green to light pink. A detailed morphological comparison is given in Table 1.

Although the last taxonomic treatment of *Ceropegia* in China recorded 17 species, it is essential to revise the provisional treatment provided in the Flora of China (Li et al. 1995). *C. jinshaensis* is the only new species of *Ceropegia* reported from China since the family was revised two decades ago. This new species presents a corolla with well-inflated corolla tube at base and shorter lobes and this shape is unique among all the known *Ceropegia* species recorded from China. It is crucial to conduct further taxonomic study on this kind of neglected group equipped with up-to-date methods and insight in order to better understand China's plant diversity before it is too late.

Table 1. Comparison of morphological features between *C. jinshaensis*, *C. meleagris*, *C. dorjei* and *C. aridicola*.

Characters	*C. jinshaensis*	*C. meleagris*	*C. dorjei*	*C. aridicola*
Petiole length (cm)	1.4–2.3	1–2	0.4–1.0	0.4–0.6
Leaf shape and size (cm)	heart-shaped, 1.6–2.3 × 1.3–1.8	2–5 × 1.5–4.0	elliptic-ovate to broad-ovate, 1.2–2.8 × 2–4	ovate-triangular, 0.5–1.5 × 0.3–1.0
Leaf base	Cordate	Rounded	rounded	Cordate
Leaf apex	acute to subacute	Acute	acute	Acuminate
Inflorescences	1–3-flowered	2–4 (6)-flowered	1-flowered	1–3-flowered
Pedicel (cm)	0.3–0.5	0.3–0.6	1.2	0.3–1.0
Flower size and color	shorter than petiole, 0.8–1.2 cm long; pale green with the lobes purple or brown	slightly longer than petiole, 1.1–1.6 cm long; pale green	longer than petiole, 2.6–3.8 cm long; pale yellow with the mouth and lobes dark	longer than petiole, 1.0–1.5 cm long; pale green to white tinged with pink
Inflated basal tube size (mm)	6–8 × 5.0–6.5	6–10 × 7–10	20–22 × 12–15	3–5 × 2–3
Elongated upper tube length (mm)	2–3	almost absent	2–3	3–5
Corolla lobes	adherent at the tip to form pentagonal canopy	fuse to form cone	adhering by their apices	joined to form canopy with short central mucro
Internal corolla surface	with swellings, glabrous	with swellings and long hairs	smooth with long hairs	glabrous
Outer corona lobes	bifid to 1/3 of lobe	slightly bifid	shallowly bifid	triangular, not bifid
Distribution	China	Nepal	Bhutan	China

Acknowledgements

We would like to thank Xinxin Zhu and Ulrich Meve for their suggestion in manuscript preparation, Dr. Peter Bruyns for his critical comments and revision to improve the manuscript, Mrs. Rongmei Zhang for her illustration, the Chinese Virtual Herbarium and JSTOR Global Plants for allowing access to huge numbers of specimen resources. This study was supported by the key project of new product development from Yunnan Provincial Department of Science and Technology: Investigation and development of aromatic plants in Yunnan province (grant no. 2016BC013).

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RESEARCH ARTICLE

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Disporum nanchuanense (Colchicaceae), a new species from Chongqing, China

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Abstract

Disporum nanchuanense (Colchicaceae), a new species from Jinfo Mountain National Nature Reserve, Nanchuan District, Chongqing, China, is described and illustrated. It is similar to *D. longistylum* and *D. megalanthum*, but differs from the former in its stem branched type, tepals colour and size, stamens and pistil size; and it differs from the latter in inflorescence position, tepals shape, stamens position, pistil position and size. Meanwhile, the new taxon is assessed as Vulnerable (VU D2), according to the IUCN Red List criteria. Furthermore, an identification key to all Chinese species of *Disporum* is provided.

Keywords

Jinfo Mountain, Liliaceae, morphology, taxonomy

Introduction

Disporum Salisbury (1812) includes about 24 species distributed in Bhutan, China, India, Japan, Korea, Laos, Malaysia, Myanmar, Nepal, Russia, Sikkim, Thailand and Vietnam (Liang and Tamura 2000; Li et al. 2007; Hu et al. 2016; Zhu et al. 2016; Hareesh et al. 2018; WCSPF 2018). According to Liang and Tamura (2000), there

are 14 species in China, including 8 endemic species. Recently, three new species were described by Li et al. (2007), Hu et al. (2016), and Zhu et al. (2016) from China.

During three field expeditions in Jinfo Mountain of Nanchuan District, Chongqing, an unknown species of *Disporum* was collected. After careful studies of the genus, particularly the flower characteristics of those species in the adjacent regions, as well as comparison amongst the unknown species and their related species, we conclude that it is a new species of *Disporum*, which has usually a simple stem, terminal inflorescence, large flower, white tepals with purple, apex obtuse and distinctly exserted stamens and style. A detailed description, along with line drawings, photographs, habitat, distribution and conservation status, as well as morphological comparison to similar species are also provided. Furthermore, a key to Chinese species of *Disporum* is provided.

Taxonomy

***Disporum nanchuanense* X.X.Zhu & S.R.Yi, sp. nov.**
urn:lsid:ipni.org:names:60479342-2
Figures 1, 2, 3 and 4A-C

Type. CHINA. Chongqing: Nanchuan District, Jinfo Mountain National Nature Reserve, 29°02.67'N, 107°11.32'E, 1386 m a.s.l., 30 March 2018, *X.X.Zhu ZXX18025* (holotype: CSH [CSH 0151769!]; isotypes CSH!, KUN!).

Diagnosis. *Disporum nanchuanense* X.X.Zhu & S.R.Yi is similar to *D. longistylum* (Léveillé & Vaniot) Hara and *D. megalanthum* Wang & Tang, but it differs from *D. longistylum* in its stem which is usually simple, rarely branched, tepals white with purple, apex obtuse, 22–25 × 2.8–4 mm, filaments 20–24 mm long, anthers 5.2–5.6 mm long and ovary ca. 4.6 mm long, style 27–29 mm long; and it differs from *D. megalanthum* in its inflorescences terminal, petiole 3–13 mm long, tepals white with

Table 1. Morphological comparisons amongst *Disporum nanchuanense*, *D. longistylum* and *D. megalanthum*.

Characters	*D. nanchuanense*	*D. longistylum*	*D. megalanthum*
Stem	usually simple, rarely branched, 20–45 cm	usually branched distally, 30–100 cm	usually slightly branched distally, 30–60 cm
Inflorescence	terminal	terminal	opposite to a leaf or terminal on a short lateral branchlet
Petiole	3–13 mm long	3–10 mm long	2–4 mm long
Tepals	white with purple, oblanceolate, apex obtuse, 22–25 × 2.8–4 mm	green or greenish-yellow, spatulate-oblanceolate to obovate, apex subacute, 10–17 × 2–4(–8) mm	white, obovate-oblanceolate, apex acute, rarely obtuse, 20–38 × 5–8 mm
Stamens	distinctly exserted	distinctly exserted	included
Filaments	20–24 mm long	10–16 mm long	14–22 mm long
Anthers	5.2–5.6 mm long	2.5–4.5 mm long	4–6 mm long
Ovary	ca. 4.6 mm long	2–4 mm long	2–3 mm long
Style	27–29 mm long, distinctly exserted	8–17 mm long, exserted	12–18 mm long, included

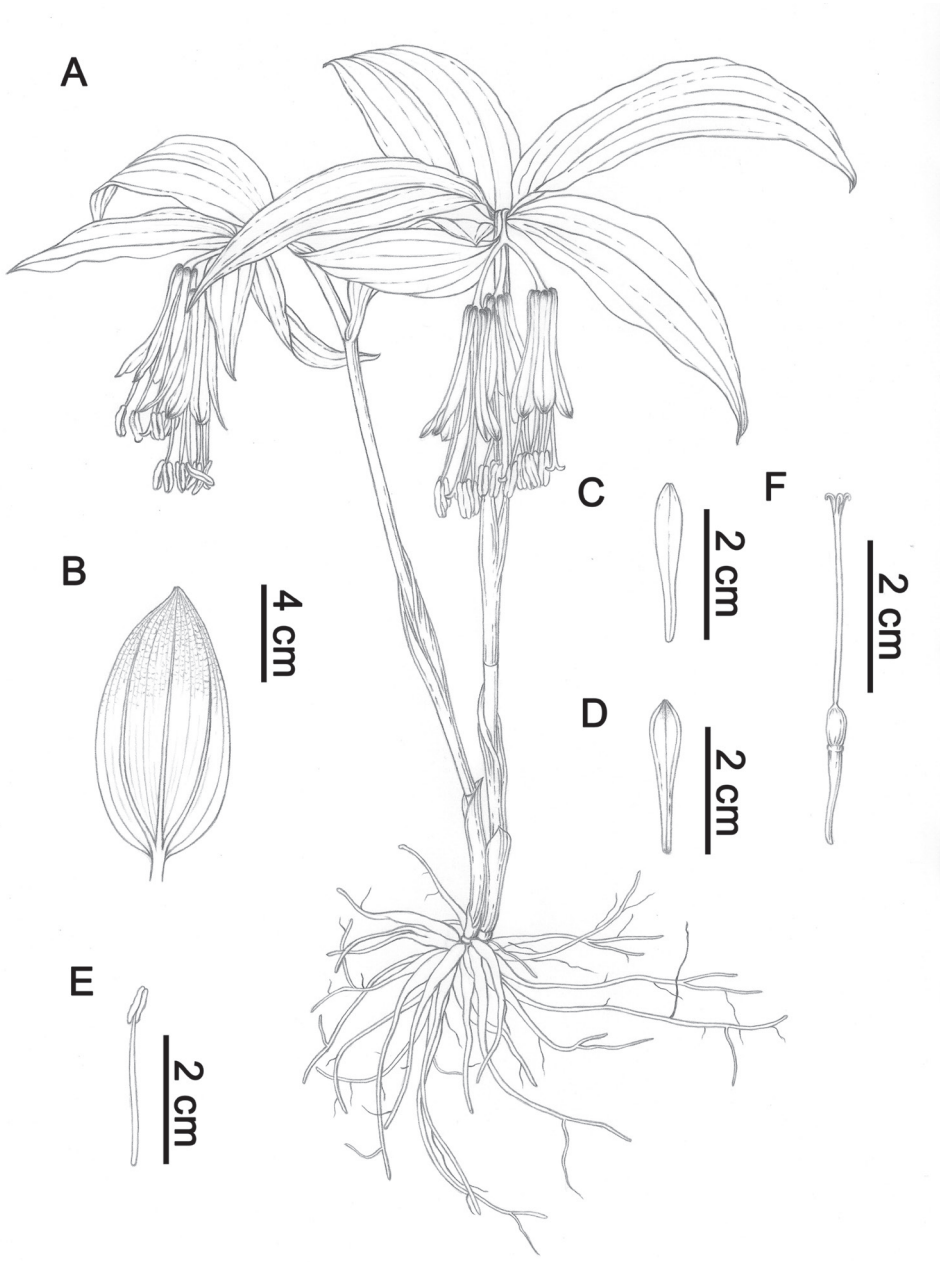

Figure 1. *Disporum nanchuanense* X.X.Zhu & S.R.Yi. **A** Plant **B** Leaf **C** Tepal in frontal view **D** Tepal in back view **E** Stamen **F** Pistil. Illustration by Huixia Dong.

purple, oblanceolate, apex obtuse, stamens distinctly exserted and ovary ca. 4.6 mm long, style 27–29 mm long, distinctly exserted. Detailed morphological comparison is shown in Table 1 and Figure 4.

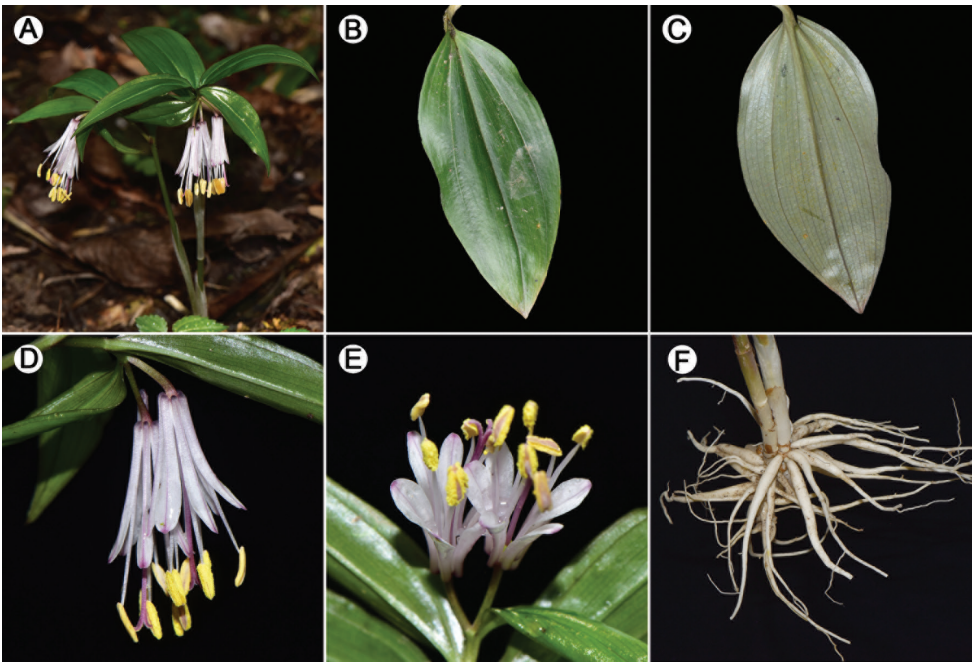

Figure 2. *Disporum nanchuanense* X.X.Zhu & S.R.Yi. **A** Plant **B–C** Leaves **D–E** Inflorescences **F** Roots. Photographed by Xinxin Zhu

Description. Perennial herb with short rhizomes; occasionally with stolons. Roots densely tufted, fleshy. Stem usually simple, rarely branched, 20–45 cm high, proximally with several sheaths. Leaves alternate, concentrated in distal part of stem; petiole 3–13 mm long; blade ovate-lanceolate to oblong, papery to thinly leathery, 6.5–12.5 × 1.1–6 cm, apex shortly acuminate to acute, base broadly cuneate or roundish, glabrous, 3–5-nerved. Inflorescence terminal, 2–7-flowered, non-pedunculate. Pedicels 10–13 mm long. Flowers narrowly campanulate, nodding; tepals 6, oblanceolate, white with purple, glabrous on both surfaces, minutely papillose on the lower margin, 22–25 × 2.8–4 mm, apex obtuse, base gibbous-spurred; spurs ca. 1.5 mm long. Stamens inserted at the base of tepals, distinctly exserted; filaments glabrous, 20–24 mm long, anthers 5.2–5.6 mm long. Ovary oblong, green, glabrous, ca. 4.6 mm long; style glabrous, 27–29 mm long, distinctly exserted, trifid at the apex, branches 3, densely papillose inside.

Phenology. Flowering from March to April. No fruiting specimens have been seen.

Etymology. The specific epithet refers to the type locality, Nanchuan District, Chongqing, China. The Chinese name is given as "南川万寿竹".

Distribution and habitat. *Disporum nanchuanense* is presently known only from the type locality in Jinfo Mountain National Nature Reserve, Nanchuan District, Chongqing. It grows under conifer-broadleaved forest at 1386–1411 m, together with *Arisaema bockii* Engl. (Araceae), *Cardamine hygrophila* T.Y.Cheo & R.C.Fang

Figure 3. Holotype of *Disporum nanchuanense* X.X.Zhu & S.R.Yi (CSH-0151769!).

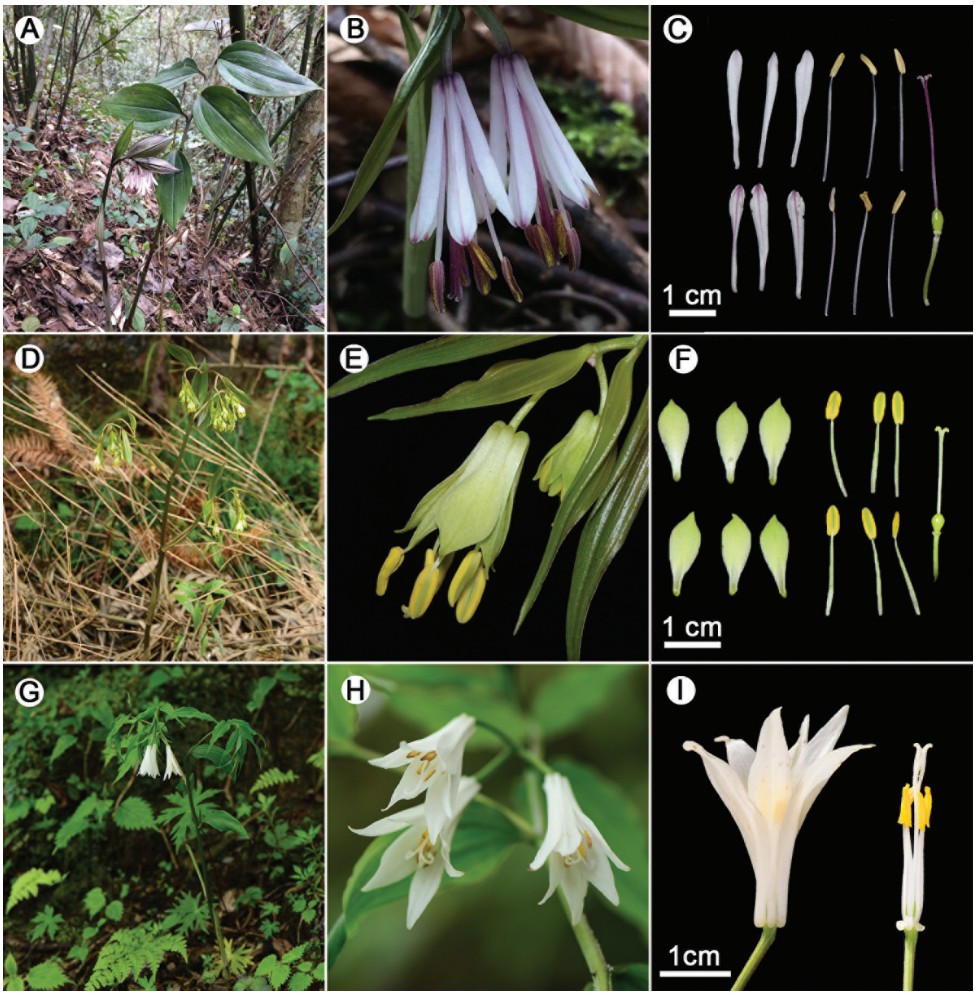

Figure 4. A-C: *Disporum nanchuanense* X.X.Zhu & S.R.Yi. **A** Plant **B** Inflorescence **C** Flower dissection **D-F:** *D. longistylum* (Lévl. & Vant.) Hara **D** Plant **E** Inflorescence **F** Flower dissection **G-I:** *D. megalanthum* Wang & Tang **G** Plant **H** Inflorescence **I** Flower dissection. **A-H:** Photographed by Xinxin Zhu; I: Photographed by Renbin Zhu.

(Brassicaceae), *Cephalotaxus fortunei* Hook. (Cephalotaxaceae), *Liriodendron chinense* (Hemsl.) Sargent. (Magnoliaceae), *Pinus massoniana* Lamb. (Pinaceae), *Rhododendron coeloneurum* Diels (Ericaceae), *Sanicula orthacantha* S.Moore (Apiaceae) etc.

IUCN Red List category. *Disporum nanchuanense* is known from only one population, with fewer than fifty individuals seen at this site. Therefore, the new species is assigned a preliminary status of Vulnerable (VU D2), according to IUCN Red List criteria, indicating a population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer).

Specimens Examined (Paratypes). CHINA. Chongqing: Nanchuan District, Jinfo Mountain National Nature Reserve, 28 March 2017, *S.R.Yi ZXX17109* (CSH!, KUN!).

Key to the 18 species of *Disporum* in China

1 Tepals dark purple to purplish or yellow **2**
2 Tepals dark purple to purplish..... **3**
3 Tepals long spurred, spurs cylindric, 4–5(–8) mm..... ***D. calcaratum***
3' Tepals shortly spurred, spurs gibbous, 1–3 mm..... ***D. cantoniense***
2' Tepals yellow..... **4**
4 Leaf blade broadly elliptic to oblong-ovate; filaments minutely papillose proximally; Anhui, Chongqing, Hebei, Hubei, Jiangsu, Jiangxi, Liaoning, Shaanxi, Shandong, Sichuan, Zhejiang ..... ***D. uniflorum***
4' Leaf blade linear-lanceolate to oblong-lanceolate; filaments glabrous; Taiwan.... ..... ***D. shimadae***
1' Tepals white to cream, sometimes purple red distally **5**
5 Tepals minutely puberulent on both surfaces, apex long acuminate..... ..... ***D. acuminatissimum***
5' Tepals glabrous on both surfaces, apex obtuse to acuminate **6**
6 Flowers tubular-campanulate, not widely opening; tepals broadest in the upper part 7
7 Tepals smaller, 5–10 mm long..... ***D. hainanense***
7' Tepals larger, 10–38 mm long..... **8**
8 Leaves rather thick, subleathery, with distinct cross veins ..... ***D. trabeculatum***
8' Leaves thinner, herbaceous to thinly leathery, without distinct cross veins..... **9**
9 Stamens and pistil distinct exserted; tepals larger, 10–25 mm long..... **10**
10 Tepals white with purple, oblanceolate, apex obtuse, 22–25 mm long; filaments 20–24 mm long; style 27–29 mm long..... ***D. nanchuanense***
10' Tepals green or greenish-yellow, spatulate-oblanceolate to obovate, apex subacute, 10–17 mm long; filaments 10–16 mm long; style 8–17 mm long .... ***D. longistylum***
9' Stamens and pistil shorter than tepals **11**
11. Tepals larger, 20–38 mm long, white, apex acute, rarely obtuse; Chongqin, Guizhou, Hubei, Shaanxi, Sichuan ..... ***D. megalanthum***
11. Tepals smaller, 15–22 mm long, white with green tips and violet spots or cream with red spot at tips, apex blunt tip; Taiwan..... **12**
12 Plant deciduous, with stolon; inflorescences all truly terminal; tepals white with green tips and violet spots ..... ***D. nantouense***
12' Plant evergreen, without stolon; inflorescence pseudoterminal; tepals cream with red spot at tips ..... ***D. kawakamii***

6' Flowers obconic to turbinate, widely opening; tepals broadest in the lower or middle part **13**
13 Roots densely puberulent; tepals larger, 23–31 mm long..... **14**
14 Leaf blade narrowly lanceolate, thinly leathery; tepals white, oblong, broadest in the middle part, lower part not navicular-scaphoid ..... ***D. sinovietnamicum***
14' Leaf blade ovate to elliptic, papery or herbaceous; tepals greenish-yellow or white, lanceolate, broadest in the lower middle, lower part navicular-scaphoid . ..... ***D. xilingense***
13' Roots glabrous; tepals smaller, 10–18 mm long..... **15**
15 Stem often branched distally, 30–80 cm high, with 3–7 leaves below branching; tepals are 2–3 times as long as stamens; filaments as long as anthers..... ..... ***D. viridescens***
15' Stem simple or few-branched, 15–35 cm high, with 0–2 normal leaves below branching; tepals are 1.5–2 times as long as stamens; filaments are 2 times as long as anthers **16**
16 Leaves 4–9 all on the upper 2/3 to whole part of the stems; petioles less than 2 mm long; Shandong, Korean Peninsula, Japan ..... ***D. smilacinum***
16' Leaves 3–4 all on the upper 1/3 part of the stems; petioles 2–4 mm long; Chongqing, Guizhou, Hunan, Sichuan, Yunnan **17**
17 Tepals greenish-yellow, (6)8–12 mm long; stamens (5)6–8 mm long; filaments 3–4.5 mm long ..... ***D. bodinieri***
17' Tepals white, 13–17 mm long; stamens 8–11 mm long; filaments 5–7 mm long ..... ***D. jinfoshanense***

Discussion

Disporum nanchuanense is morphologically similar to *A. longistylum* and *A. megalanthum*. However, the new species differs from the two species in vegetative and reproductive characters, which have been summarised in Table 1, as well as those shown in Figure 4.

Though *Disporum* comprises only 24 species, the genus is still taxonomically problematic and many species are difficult to identify, with either diagnostic characters too variable and/or obscure or having been provided with incomplete descriptions due to a lack of sufficient field investigations (Hara 1984; Hara 1988; Hareesh et al. 2018). In an effort to achieve a better understanding of the taxonomy of *Disporum*, we have been working on the genus since 2016. Plants from 16 *Disporum* species from ca. 100 populations have been well observed and collected in the field during the past two years, especially for species from China. About 3800 specimens from 35 herbaria (AU, BM, BNU, CDBI, CIB, CSH, E, HENU, HHBG, HITBC, HTC, HX, IBK, IBSC, IFP, K, KUN, KYO, LBG, MO, NAS, NEFI, NKU, NWAFU, NY, P, PE, PEM, QTPMB, SCUM, SZ, TAI, TI, US and WUK; abbreviations follow Thiers in Index Herbariorum available at http://sweetgum.nybg.org/science/ih/) have been carefully checked. Here, a new identification key to 18 species of *Disporum* in China is provided based on our study and previous publications (Léveillé 1905; Hara 1988; Liang and Tamura

2000; Li et al. 2007; Hu et al. 2016; Zhu et al. 2016), in order to better evaluate of the position of the new species in *Disporum*.

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RESEARCH ARTICLE

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Gentianella macrosperma, a new species of *Gentianella* (Gentianaceae) from Xinjiang, China

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Abstract

Gentianella macrosperma Ma ex H.F. Cao, J.D. Ya & Q.R. Zhang, a new species of Gentianaceae from Xinjiang, Northwest China is described and illustrated. This new species is unique in having equal length of corolla lobe and corolla tube, nectaries located at the throat of the corolla tube and large seeds up to 1.6 mm in diameter. In addition, an updated identification key to the Chinese species of *Gentianella* is provided.

Keywords

Gentianella, ITS, matK, Morphology, Swertiinae, Taxonomy, Xinjiang

Introduction

Gentianella Moench (Gentianaceae) consists of approximately 300 species distributed from the temperate, arctic and alpine regions of the Northern Hemisphere, to South America, Australia and New Zealand (Pringle 2017). About 70% of species (ca. 200 spe-

cies) occur in South America, where new species continue to be discovered (Pfanzelt et al. 2015; Pringle 2015, 2017; Pringle and Grant 2017). Molecular phylogenetic studies indicated that *Gentianella* was polyphyletic, and the new circumscription of *Gentianella* s. str. contains species with one nectary per petal lobe (von Hagen and Kadereit 2001, 2002). However, the taxonomic placement of the Asiatic species with two nectaries per corolla lobe has yet to be determined. Before the phylogenetically-based concept of Asiatic gentianellas proposed, the description of this genus published in Flora of China (Ho and Pringle 1995) remains applicable in the present context. There are 10 species of *Gentianella* reported from China and mainly distributed in northern China and alpine areas of southwest China mountains (Ho and Pringle 1995, Chen et al. 2011).

During the field expedition to west of Xinjiang, China, an unusual species of Gentianaceae was collected. Its corolla campanulate without plicae and fringed scale, lobed to middle of corolla, two nectaries per corolla lobe located at the corolla tube fit the main characters of *Gentianella*. Subsequent morphological investigation and molecular study supported this species as new to science and described here.

Materials and methods

Specimen collections of *Gentianella* were carefully examined, especially the relevant species, including *G. holosteoides* Schott & Kotschy ex N.M. Pritch., *G. longicarpa* (Gilli) Holub, *G. sibirica* (Kusn.) Holub, *G. stoliczkae* (Kurz ex C.B. Clarke) Holub and *G. umbellata* (M. Bieb.) Holub. Collections at the following herbaria (BM, FR, GH, GLM, HIMC, HNWP, JE, K, E, KFTA, KUN, MA, MPU, MW, P, PE, PEY, W, WAG) were checked on-site and via Chinese Virtual Herbarium (CVH, http://www.cvh.ac.cn/), Global Biodiversity Information Facility (GBIF, https://www.gbif.org/) and Global Plants on JSTOR (https://plants.jstor.org/). The high-resolution images of type specimen of *G. sibirica* (LE01043410, LE01043411, LE00050650) were obtained from curators of LE. Relevant literatures were investigated (Gillett 1957; Shishkin and Bobrov 1967; Omer et al. 1988; Ho and Pringle 1995; Omer 1995; Struwe et al. 2002; Aitken 2007; Chen et al. 2011; Mohd et al. 2018). Line drawings, description and most of photographs were based on the latest collections (J.D. Ya et al. *17CS16327*), except that the images of seeds were from the type specimen (Shun-Li Chen *Tianyi281*, PE00029466). The conservation status of the new species was evaluated according to the guidelines of the IUCN Red List Categories and Criteria (IUCN 2017)

Fresh leaves of this new species were dried immediately by using silica gel for DNA extraction. Genomic DNA extraction, amplification and DNA sequencing of ITS and the plastid *matK* followed the protocol described by Xi et al. (2014) and sequences of relevant species were downloaded from GenBank (Appendix 1).

The molecular phylogenetic tree of 88 species representing 13 genera of Gentianaceae was reconstructed using Bayesian Inference (BI) and Maximum Likelihood (ML). *Chelonanthus alatus* (Aubl.) Pulle (Gentianaceae: Helieae) was chosen as outgroup (Figure 1). ITS and *matK* datasets were combined for analysis. BI analysis was

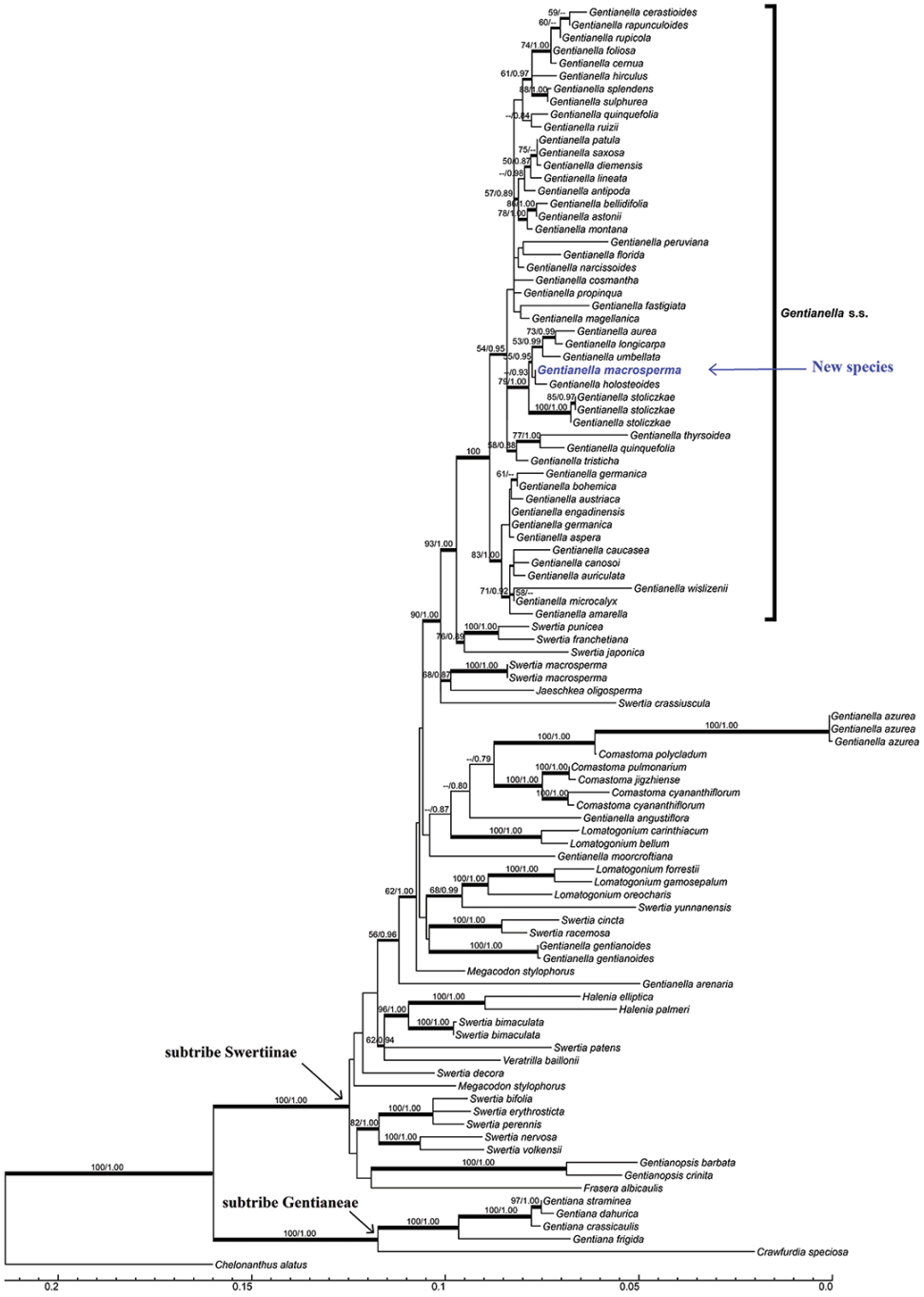

Figure 1. The major-rule consensus tree of ML analysis based on the total dataset, including ITS and *matK*. ML bootstrap values and BI posterior probabilities are shown on branches.

performed using MrBayes 3.26 (Ronquist and Huelsenbeck 2003). Markov Chain Monte Carlo (MCMC) analysis was performed using MrBayes for 10,000,000 generations for the combined dataset, with two simultaneous runs, with each run comprising four incrementally heated chains. BI analysis was started with a random tree and sampled every 1000 generations. The combined dataset was partitioned and the best-fit DNA substitution model for two DNA regions using Bayesian Information Criterion (BIC) was estimated using jModeltest 2 (Darriba et al. 2012). ML analysis was conducted with RAxML 8.2.10 (Stamatakis et al. 2008) using the GTR substitution model with gamma-distributed rate heterogeneity amongst sites and the proportion of invariable sites estimated from the data. Support values for nodes/clades were estimated from 1000 bootstrap replicates.

Results

The ITS matrix was 689 bp in length including 376 variable sites and 266 parsimony-informative sites and the *matK* matrix was 821 bp in length including 286 variable sites and 198 parsimony-informative sites. The best-fit BIC model of ITS and *matK* datasets was SYM+G and TVM+G, respectively. The major-rule consensus tree of both BI and ML analyses with support values is shown in Figure 1.

Phylogenetic analyses using ML and BI methods identified that *Gentianella*, *Swertia* L. and other genera in subtribe Swertiinae are not monophyletic, which shows a similar conclusion as previous studies (von Hagen and Kadereit 2001, 2002; Xi et al. 2014). Current new species and 44 other *Gentianella* species were strongly supported as monophyletic (BI PP = 1.00, ML BS = 93; Figure 1). *G. arenaria* (Maxim.) T.N. Ho, *G. angustiflora* H. Smith, *G. azurea* (Bunge) Holub, *G. gentianoides* (Franch.) H. Smith and *G. moorcroftiana* (Wall. ex G. Don) A. Shaw formed different clades with *Comastoma* Toyok., *Lomatogonium* A. Braun, *Swertia* and other genera in Swertiinae.

Phylogenetic analyses showed that this new species and *G. holosteoides* formed a clade (BI PP = 0.93), then sister to the clade including *G. aurea* (L.) H. Smith, *G. umbellata* and *G. longicarpa* (Figure 1). Three samples of *G. stoliczkae* were located at most basal of the new species clade (BI PP = 1.00, ML BS = 79).

Taxonomic treatment

Gentianella macrosperma **Ma ex H.F. Cao, J.D. Ya & Q.R. Zhang, sp. nov.**
urn:lsid:ipni.org:names:60479356-2
Figures 2, 3

Diagnosis. Resembles *G. holosteoides*, *G. longicarpa*, *G. sibirica*, *G. stoliczkae* and *G. umbellata*, but differs from them by having even flower size, corolla white, corolla lobe as long as corolla tube, nectaries located close to the throat of the corolla tube and larger seeds.

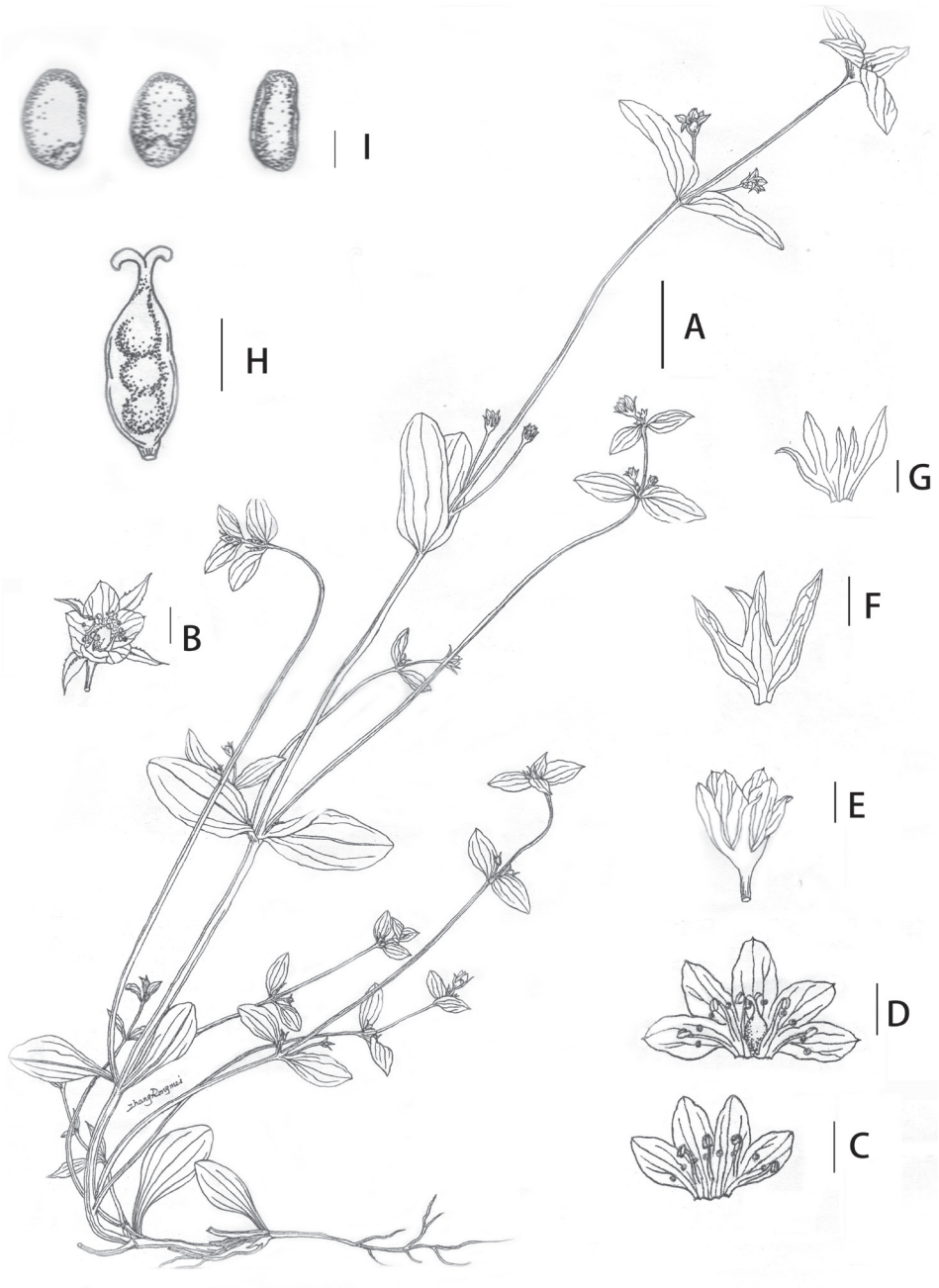

Figure 2. *Gentianella macrosperma*, sp. nov. **A** plant **B** flower, top views **C–D** show opened corollas, 4- and 5-merous, respectively **E** flower, showing the length of calyx and corolla subequal **F** calyx. showing 4-merous **G** calyx, showing 5-merous **H** capsule **I** seeds. Drawn by R.M. Zhang. **H** and **I** from the isotype *S.L. Chen Tianyi281* (PE00029471), others from the paratype *J.D. Ya, Q.R. Zhang & X.J. Hu 17CS16327* (KUN1443565). Scale bars: 2 cm (**A**); 5 mm (**B**); 2 mm (**C–H**); 0.5 mm (**I**).

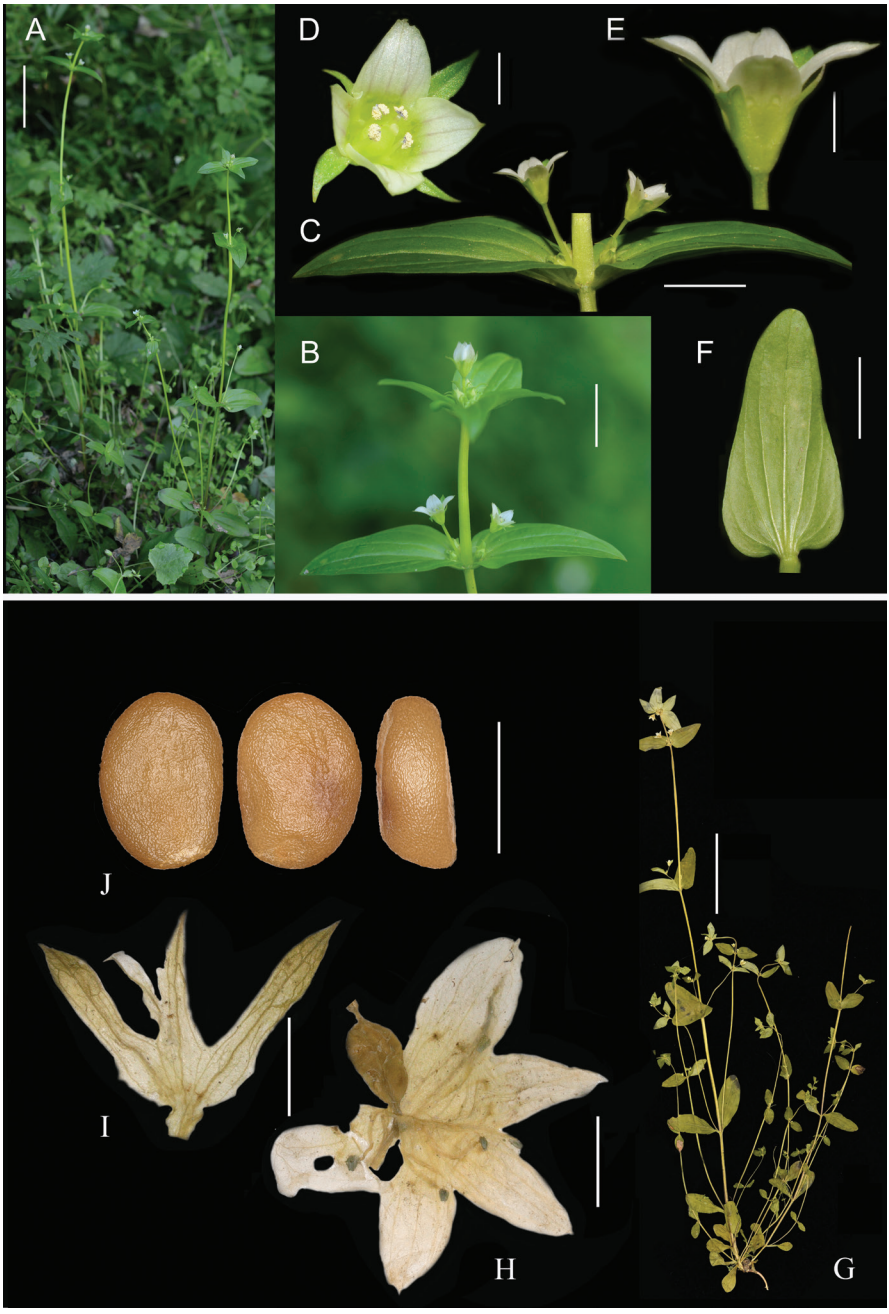

Figure 3. *Gentianella macrosperma*, sp. nov. **A** plant in nature habitat **B** flowers and inflorescence **C** flowers, showing pedicels and upper leaves **D–E** front view and side view of corolla, showing nectaries located close to the throat of the corolla tube **F** middle cauline leaf, abaxial view, showing veins **G** plants specimen (from KUN1443554) **H** opened corolla (5-merous) showing ovary **I** calyx **J** seed, front view (left and middle) and side view (right) (from *S.L. Chen Tianyi281* (PE00029471)). **I**, **H** from the paratype *J.D. Ya, Q.R. Zhang & X.J. Hu 17CS16327* (KUN1443565). Scale bars: 5 cm (**A, G**); 2 cm (**B**); 2 mm (**C–E, I, H**); 1 mm (**J**).

Type. CHINA. Xinjiang: Ili Kazak Autonomous Prefecture, Gongliu County, Ji'ergelang Township, Qiaxi Village, on the mountain ridge in the forest, 1780 m elev., 6 September 1956, *Shun-Li Chen Tianyi281* (holotype: PE00029466!; isotype: PE00029453!, PE00029471!).

Description. Herbs, annual. Roots slender, yellow. Stems 30–40 cm, erect, subquadrangular, glabrous, yellowish-green, 2.0–2.5 mm in diameter; branched from the base in axils of each node, more slender, suberect or slightly ascending. Leaves opposite, basal leaves not rosette and withered at anthesis, petiole conspicuous, 7–10 mm long, leaves oblong-spatulate, 14–17 × 2–6 mm, base tapering into petiole, margin entire, apex rounded, veins 3–5, raised abaxially and slightly sunken adaxially; lower cauline leaves obovate-spatulate or rounded-spatulate, petiole 10–18 mm long, leaf blades with petiole 18–31 × 10–11 mm, both surfaces glabrous, base tapering into conspicuous petiole, margin entire, apex rounded, veins 5–7 raised abaxially and slightly sunken adaxially; middle leaves on primary stem elliptic, ovate-elliptic, 25–38 × 10–15 mm, base rounded or truncate, inconspicuously short or subsessile, both surfaces glabrous, margin entire, apex rounded, veins 5–9, raised abaxially and slightly sunken adaxially; upper stem leaves ovate-elliptic to ovate, 15–25 × 7–12 mm, with terminal two pairs of leaves nearly in whorls, both surfaces glabrous, base rounded, sessile, margin entire, apex acute, veins 3–5, raised abaxially and sunken adaxially; lateral branches leaves smaller, 10–15 × 4–7 mm. Cymes terminal and axillary, 3–4 flowers per leaf axil, terminal inflorescence 8–10 flowers, dense, inflorescence flowering at different times, pedicel variable in length and up to 36 mm. Flowers 4-merous (rarely 5-merous), all flowers almost the same size (terminal corolla as long as or slightly longer than others), rotating arrangement. Calyx 3.5–4.5 mm long, slightly shorter than corolla or as long as corolla, divided almost to the base, calyx tube 0.7–0.8 mm long, membranous, lobes green, distinctly unequal, 2 slightly larger, oblanceolate to linear-oblanceolate, 3.0–3.5 × 0.7–1.0 mm, 2 (–3) slightly smaller, linear, 2.3–3.0 × 0.4–0.5 mm, apex acute or acuminate, margin scabrous, midvein raised abaxially, sinus obtuse. Corolla white, campanulate, 4.0–4.5(5.0) mm long; corolla tube 2.1–2.4 mm long; lobes ovate, with light brown fine longitudinal veins, 2.2–2.5 × 1.5–1.8 mm, apex obtuse and mucronate, margin entire. Nectaries 8(–10), green, oblong, naked and indistinct, two nectaries per corolla lobe located very close to the throat of the corolla tube, ca. 0.2 mm from the top of corolla tube. Stamens inserted at middle of corolla tube, filaments white, linear, 1.1–1.4 mm long, anthers blue, rectangular, 0.2–0.3 mm long; ovary elliptic, ca. 2.0 mm long. Style short, linear, 0.4–0.5 mm long, stigma small, 2-lobed. Gynophore short, 0.2–0.3 mm long. Capsule elliptic, a concavity sometimes present in the centre, 2.5–4.0 mm long, usually with 2–8 seeds each capsule. Seeds brown, glossy, flat-ellipsoid, 1.2–1.6 × 0.5–0.9 mm, seed coat wrinkled-reticulate (smooth when immature).

Phenology. Flowering and fruiting from June to September.

Distribution and habitat. *G. macrosperma* is distributed in Gongliu county and Xinyuan county, west of Xinjiang, China. It grows in thickets on the slope or on the mountain ridge in the forest of *Picea schrenkiana* Fisch. & Mey. at an elevation of 1729–1780 m.

Etymology. The specific epithet "macrosperma" refers to the larger seeds of this new species.

Vernacular name. Chinese mandarin: da zi jia long dan (大籽假龙胆)

Conservation status. Currently only known from three localities in west of Xinjiang, therefore considered to be Vulnerable (VU D2) (IUCN 2017).

Additional specimens examined (paratypes). CHINA. Xinjiang: Ili Kazak Autonomous Prefecture, Xinyuan County, on the road from Xinyuan County to the gold mine, 43°16'06.45"N, 83°17'42.90"E, 1729 m elev., 1 July 2017, *J.D. Ya, Q.R. Zhang & X.J. Hu 17CS16327* (KUN1443565!, KUN1443566!, KUN1443554!); Ili Kazak Autonomous Prefecture, Gongliu County, Mohuer Township, Damohe Village, 8 August 1976, *Shu-Run Liu s.n.* (HIMC0026063!, HIMC0026064!. the sheet 0026064 presents a mixture of *Swertia dichotoma* Linn. which was labelled as "A" and *G. macrosperma* labelled as "B")

Discussion

It was Prof. Yu-Quan Ma (also as Yu Chuan Ma), a specialist of Gentianaceae, who first recognised this plant as a distinct new species and inscribed the name "*Gentianella macrosperma* Ma" on the specimen kept at PE. Later the same year, he proposed another name "*Gentianella procumbens* Ma" to the same collections, corresponding to its procumbent stems. However, both names were never published. Based on field observation and specimen examination, procumbent stems occurred occasionally in some individuals, the character of larger seeds being easily distinguished from other *Gentianella* species.

In all the known Chinese species of *Gentianella*, the length of corolla lobes is shorter than that of the corolla tube and nectaries which are located at the base or middle of the corolla tube. The same length of corolla lobes and corolla tube and nectaries positioned at the throat of the corolla tube make *G. macrosperma* a distinctive species amongst them. Its large seeds up to 1.6 mm in diameter are perhaps unique amongst the Asiatic species of *Gentianella*.

G. macrosperma is similar in size and shape of the corolla lobe to *G. sibirica* and *G. longicarpa*, but further differs from them both in the lack of rosette basal leaves, predominant 4-merous flowers and smaller corolla, no more than 5 mm long, except the corolla lobed to the middle, nectaries position and seeds size. *Gentianella longicarpa*, which is endemic to Afghanistan, is also distinct from *G. macrosperma* in its light-pink, pale blue or lilac-violet flower and larger corolla up to 8 mm long and all calyx lobes are shorter than the corolla tube. *G. macrosperma* is similar in habit and inflorescences to *G. umbellata* and *G. stoliczkae*. The flower of *G. umbellate* is larger than those of *G. macrosperma* and, although the size of the corolla lobe in the two species overlaps, the corolla lobe is much shorter than the corolla tube in *G. umbellate*. In *G. stoliczkae*, flowers are in densely clustered cymes, the corolla are generally much larger up to 20 mm long with various colours from purple, pink, pale blue to yellow and the capsule has a short gynophore ca. 1–2 mm long.

The molecular evidence shows that *G. macrosperma* has the closest relationship with *G. holosteoides* which is native to Turkey and Pakistan and they also share similar floral whorls and basal leaves shape, but plants of *G. holosteoides* are smaller in stature, no more than 5 (7) cm height; it further differs from *G. macrosperma* in its smaller basal leaves, larger flowers with corolla lobes shorter than corolla tube, nectaries position at corolla base and smaller, numerous seeds. A detailed morphological comparison is given in Table 1.

Von Hagen and Kadereit (2001) proposed *Gentianella* s. str. to only include species with one nectary per petal lobe, however, *G. umbellata* and *G. stoliczkae* represented in their study are both binectariate species. Current molecular analyses also shows the binectariate *G. macrosperma* clustered into von Hagen and Kadereit's *Gentianella* s. str. A careful selection of species across wider geographic regions of this genus and data from more nuclear and chloroplast sequences may clarify the generic circumscription in *Gentianella*.

Key to species of *Gentianella* in China

The following key is based on Flora of China (Ho and Pringle 1995), Flora of the U.S.S.R. (Shishkin and Bobrov 1967) and other literature (Omer et al. 1988; Aitken 2007; Chen et al. 2011). It includes 11 species of *Gentianella* in China.

1 Corolla lobes fimbriate at base ..... ***G. acuta***
– Corolla lobes glabrous at base..... **2**
2 Nectaries above the middle of corolla tube **3**
– Nectaries at the base of corolla tube **4**
3 Plant 12–40 cm tall, nectaries close to the throat of corolla tube, seeds 1.2–1.6 mm in diameter ..... ***G. macrosperma***
– Plant 1–4 cm tall, nectaries just above the middle of corolla tube, seeds 0.7–0.8 mm in diameter ..... ***G. pygmaea***
4 Margin and midvein of calyx lobe blackish..... ***G. azurea***
– Calyx not as above **5**
5 Stem densely purple pilose ..... ***G. gentianoides***
– Stem glabrous (sometimes sparsely pilose in *G. moorcroftiana*) **6**
6 Flowers often angled, corolla tube 3–4 times longer than lobe ... ***G. angustiflora***
– Flowers not angled, corolla tube 1–3 time(s) longer than lobe..... **7**
7 Corolla lobes apically obtuse or round **8**
– Corolla lobes apically mucronate..... **9**
8 Flowers 5-merous, stem leaf blades linear ..... ***G. moorcroftiana***
– Flowers 4-merous, stem leaf blades spatulate to oblong-spatulate ..... ***G. arenaria***
9 Corolla lobes densely papillate outside ..... ***G. anomala***
– Corolla lobes glabrous outside..... **10**
10 Corolla 7–20 mm long, terminal ones ca. 20 mm, lobes 3–7 mm .... ***G. stoliczkae***
– Corolla 4–10 mm long, terminal ones up to 10 mm, lobes ca. 2 mm .... ***G. sibirica***

Table 1. Morphological comparison between *Gentianella macrosperma* and related species.

	G. macrosperma	*G. holosteoides*	*G. longicarpa*	*G. sibirica*	*G. stoliczkae*	*G. umbellata*
Plant height (cm)	12–40	up to 5	9–22	(1–)10–20(–30)	10–45(–60)	(4–)10–35
Basal leaves (mm)	not rosulate, obovate-spathulate 14–17 × 2–6	rosulate, spathulate-ovate or lanceolate, 3–5 × 1–3	rosulate, spathulate, oblong-obovate, 7–16 × 3–8	rosulate, oblong-obovate, 6–20 × 2–6	rosulate, ovate-lanceolate to ovate, 10–35 × 6–20	rosulate, spathulate, obovate-lanceolate, 8–25 × 5–12
Cauline leaves (mm)	ovate to ovaloid, apex rounded, the uppermost sometimes acute, 15–38 × (7–)10–15	lanceolate-oblanceolate or elliptic, apex acute, 5–15 × 2–6	ovate-oblong, ovate or ovate-lanceolate, apex obtuse, the uppermost acute, 8–26 × 4–9	ovate-oblong, ovate-lanceolate, apex acute, 6–20(–35) × 3–9	oblong-lanceolate, lanceolate to ovate-lanceolate, apex acute, (20–)25–40(–50) × (2–)10–15	oblong-ovate, oblong-lanceolate, apex acute, 8–25 × 4–18
Calyx length (mm)	3.5–4.5	4–8	4–5	3–6	8–11	4–10
Floral whorls	4(5)–merous	4(5)–merous	5-merous	5(4)-merous	5-merous	5-merous
Flower size	almost all of the same size	variable in size, terminal ones 1–2 × larger than others	variable in size, terminal ones 1–1.5 × larger than others	variable in size, terminal ones 1–2 × larger than others	variable in size, terminal ones 2–3 × larger than others	variable in size, terminal ones 2–3 × larger than others
Corolla colour	white	pale blue to blue	pale blue, light-pink, or lilac-violet	predominantly pink, yellowish or whitish, rarely pale blue.	purple, pink, pale blue or yellowish	pale azure, purple, pink, yellowish or mixture of these, rarely white
Corolla shape	campanulate	tubular to campanulate-tubular	tubular to campanulate-tubular	tubular or tubular-infundibular	tubular to campanulate-tubular	tubular to campanulate-tubular
Corolla length (mm)	4.0–4.5(–5.0)	6–12	(5–) 6–8	(5–) 6–7 (–10)	7–20	(5–) 8–11 (–15)
Corolla lobes	2.0 mm long, the same length as corolla tube	1.5–3.0 mm long, much shorter than corolla tube	2–3 mm long, shorter than corolla tube	ca. 2 mm long, much shorter than corolla tube	3–7 mm long, much shorter than corolla tube	2–3(4) mm long, much shorter than corolla tube
Nectaries	8(10), at top of corolla tube	8(10), at basal part of corolla tube	10, at basal part of corolla tube	8-10, at basal part of corolla tube	10, at basal part of corolla tube	10, at basal part of corolla tube
Stamens	1.1–1.4 mm	–	–	2–4 mm	ca. 7 mm	1–5 mm
Anthers	blue, 0.2–0.3 mm	–	–	blue, 0.5–0.7 mm	yellow, 1.0–1.2 mm	–
Gynophore	0.2–0.3 mm	subsessile	sessile	subsessile	1.5–2.2 mm	sessile
Seeds	2–8 per capsule, 1.2–1.6 mm in diameter	numerous per capsule, ca. 0.8–1.0 mm in diameter	numerous per capsule, 0.2–0.3 mm in diameter	numerous per capsule, 0.1–0.2 mm in diameter	numerous per capsule, ca. 0.8 mm in diameter	numerous per capsule, 0.2–0.3 mm in diameter

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Appendix

Appendix 1. Samples for phylogenetic analysis using matK and ITS sequences with voucher information, GenBank accession number.

Species	Voucher specimen (Herbarium/No.)	Locality	matK	ITS
OUTGROUP				
Chelonanthus alatus (Aubl.) Pulle	Maas 9316 (U)	French Guiana	KX904551	KX904610
GENTIANEAE GROUP				
Crawfurdia speciosa Wall.	KEKE 1244 (K)	N/A	AJ010512/ AJ011441	AJ294586/ AJ294646
Gentiana crassicaulis Duthie ex Burkill	xuechy090107 (KUN)	China	KC861277	KC861348
Gentiana dahurica Fisch.	xuechy0076 (KUN)	China	KC861279	KC861350
Gentiana frigida Haenke	N/A	Germany (Schachen Bot. Garden), cultivated	AJ388166/ AJ388236	AJ294588/ AJ294648

Species	Voucher specimen (Herbarium/No.)	Locality	matK	ITS
Gentiana straminea Maxim.	xuechy0065 (KUN)	China	KC861282	KC861353
SWERTIINAE GROUP				
Comastoma cyananthiflorum (Franch.) Holub	XHC120021 (KUN)	China	KC861250	KC861320
Comastoma cyananthiflorum (Franch.) Holub	CEE-88 (E 00025334)	China	AJ406324/ AJ406353	AJ294585/ AJ294645
Comastoma jigzhiense T.N. Ho & J.Q. Liu	Chensl0423 (KUN)	China	KC861231	KC861300
Comastoma polycladum (Diels & Gilg) T.N. Ho	xuechy090036 (KUN)	China	KC861275	KC861346
Comastoma pulmonarium (Turcz.) Toyok.	GLM-081307 (KUN)	China	KC861238	KC861306
Frasera albicaulis Griseb.	K. Gutsche 20 (MJG)	N/A	AJ406325/ AJ406354	AJ294587/ AJ294647
Gentianella amarella (L.) Börner	W.J. Schrenk (FR)	N/A	AJ406326/ AJ406355	AJ294591/ AJ294651
Gentianella angustiflora H. Smith	Edinburgh Makalu Expedition 430 (E 00025322)	Nepal	AJ406327/ AJ406356	AJ294592/ AJ294652
Gentianella antipoda (Kirk) T.N. Ho & S.W. Liu	CHR 510015	New Zealand	–	AY136500
Gentianella arenaria (Maxim.) T.N. Ho	T.N. Ho et al. 435 (E 00025341)	N/A	AJ406328	AJ294593/ AJ294653
Gentianella aspera (Hegetschw.) Dostál ex Skalický, Chrtek & Gill	K. Gutsche 45 (MJG)	N/A	AJ010517/ AJ011446	AJ294594/ AJ294654
Gentianella astonii (Petrie) T.N. Ho & S.W. Liu	CHR 509942	New Zealand	–	AY136494
Gentianella aurea (L.) H. Smith	H. Smith 4131 (E 00025348)	N/A	AJ406329/ AJ406357	AJ294595/ AJ294655
Gentianella auriculata (Pall.) J.M. Gillett	C. Tpyrgeba (K)	N/A	AJ406330/ AJ406358	AJ294596/ AJ294656
Gentianella austriaca (A. Kern. & Jos.Kern.) Holub	N/A (MJG)	Germany (Schachen Bot. Garden), cultivated	–	AJ294597/ AJ294657
Gentianella azurea (Bunge) Holub	xuechy090033 (KUN)	China	KC861284	KC861355
Gentianella azurea (Bunge) Holub	T.N. Ho, B. Bartholomew, M. Gilbert 1312 (E 00025339)	China	AJ406331/ AJ406359	AJ294598/ AJ294658
Gentianella azurea (Bunge) Holub	Yangyp-Q-0255 (KUN)	China	MN067526*	MK416127*
Gentianella bellidifolia (Hook.f.) Holub	19932974	Scotland (Edinburgh Bot. Garden), cultivated	AJ388162/ AJ388232	AJ294599/ AJ294659
Gentianella bohemica Skalický	015	Czech Republic	–	AJ580570
Gentianella canosoi G.L. Nesom & B.L. Turner	S. Gonzales, S. Acevedo 2033 (TEX)	N/A	AJ406332/ AJ406360	AJ294600/ AJ294660
Gentianella caucasea (Lodd. ex Sims) Holub	J. C. Archibald 8208 (E 00025347)	N/A	–	AJ294601/ AJ294661
Gentianella cerastioides (Kunth) Fabris	R. Greissl (MJG)	N/A	AJ010518/ AJ011447	AJ294602/ AJ294662
Gentianella cernua (Kunth) Fabris	C.Viteri 4410 (MO)	N/A	–	AJ294603/ AJ294663
Gentianella cosmantha (Griseb.) J.S. Pringle	J.G. Haukes, J.P.Hjirting, K. Rahn 3569 (L 424359)	N/A	AJ406333/ AJ406361	AJ294604/ AJ294664
Gentianella diemensis (Griseb.) J.H. Willis	H. Hurka (MJG)	N/A	AJ295332/ AJ295333	AJ294605/ AJ294665
Gentianella engadinensis (Wettst.) Holub	Ge002	Switzerland	–	AJ580559
Gentianella fastigiata (Benth.) Fabris	K. Gutsche (MJG)	N/A	–	AJ294606/ AJ294666
Gentianella florida (Griseb.) Holub	R. Ehrich 444 (MJG)	N/A	AJ406334/ AJ406362	AJ294607/ AJ294667
Gentianella foliosa (Kunth) Fabris	1994-508	England (Kew Bot. Garden), cultivated	–	AJ294608/ AJ294668
Gentianella gentianoides (Franch.) H. Smith	xuechy090065 (KUN)	China	KC861285	KC861356
Gentianella gentianoides (Franch.) H. Smith	xuechy090094 (KUN)	China	KC861286	KC861357
Gentianella germanica (Willd.) E.F. Warburg	20	Germany	–	AJ580562

Species	Voucher specimen (Herbarium/No.)	Locality	matK	ITS
Gentianella germanica (Willd.) E.F. Warburg	J.W. Kadereit (MJG)	N/A	AJ406335/ AJ406363	AJ294609/ AJ294669
Gentianella hirculus (Griseb.) Fabris	J.L. Clarke 1787 (QCNE)	N/A	–	AJ294610/ AJ294670
Gentianella holosteoides Schott & Kotschy ex N.M. Pritch.	Southhampton University 179 (K)	N/A	–	AJ294611/ AJ294671
Gentianella macrosperma Ma ex H.F. Cao, J.D. Ya & Q.R. Zhang	17CS16327 (KUN)	China	MN067523*	MK416132*
Gentianella lineata (Kirk) T.N. Ho & S.W. Liu	CHR 509866	New Zealand	–	AY136503
Gentianella longicarpa (Gilli) Holub	D. Podlech 12436 (M)	N/A	–	AJ294612/ AJ294672
Gentianella magellanica (Gaudich.) Fabris	K. Kubitzki, T. Feuerer 99-10 (MJG)	N/A	AJ406336/ AJ406364	AJ294613/ AJ294673
Gentianella microcalyx (Lemmon) J. M. Gillett	E. Joyal, J. Enrique 1853 (TEX)	N/A	AJ406337/ AJ406365	AJ294614/ AJ294674
Gentianella montana (G. Forst.) Holub	CHR 509944	New Zealand	–	AY136491
Gentianella moorcroftiana (Wall. ex G. Don) A. Shaw	R. McBeath 2093 (E 00025318)	N/A	AJ406338/ AJ406366	AJ294615/ AJ294675
Gentianella narcissoides (Gilg) T.N. Ho & S.W. Liu	L. Naessany 14 (MJG)	N/A	–	AJ294616/ AJ294676
Gentianella patula (Kirk) Holub	19932978	Scotland (Edinburgh Bot. Garden), cultivated	AJ406339/ AJ406367	AJ294617/ AJ294677
Gentianella peruviana (Griseb.) Fabris	19950534	Scotland (Edinburgh Bot. Garden), cultivated	AJ388163/ AJ388233	AJ294618/ AJ294678
Gentianella propinqua (Richardson) J.M. Gillett	G. Halliday A 333/75 (E 00025300)	North America	AJ406340/ AJ406368	AJ294619/ AJ294679
Gentianella quinquefolia (L.) Small	Bozeman, Ramseur, Radford 45200 (E 00025241)	North America	AJ406341/ AJ406369	AJ294620/ AJ294680
Gentianella quinquefolia (L.) Small	D. Pittillo 12106 (WCUH)	America	–	EU812469
Gentianella rapunculoides (Willd. ex Schult.) J.S. Pringle	R. Greissl 616 (MJG)	N/A	–	AJ294621/ AJ294681
Gentianella ruizii (Griseb.) Holub	Weigend, Weigend 2000/386 (NY)	N/A	AJ406342/ AJ406370	AJ294622/ AJ294682
Gentianella rupicola (Kunth) Holub	199930516	Scotland (Edinburgh Bot. Garden), cultivated	–	AJ294623/ AJ294683
Gentianella saxosa (G. Forst.) Holub	Gutsche (MJG)	N/A	–	AJ406343/ AJ406371
Gentianella splendens (Gilg) Fabris	J.L. Clarke 1855 (QCNE)	N/A	AJ295336/ AJ295337	AJ294624/ AJ294684
Gentianella stoliczkae (Kurz ex C.B. Clarke) Holub	LiuJQ0028 (KUN)	China	MN067524*	MK416130*
Gentianella stoliczkae (Kurz ex C.B. Clarke) Holub	LiuJQ0071 (KUN)	China	MN067525*	MK416131*
Gentianella stoliczkae (Kurz ex C.B. Clarke) Holub	O. Anders 8178 (M 50043)	N/A	AJ406344/ AJ406372	AJ294625/ AJ294685
Gentianella sulphurea (Gilg) Fabris	J.L. Clarke 1833 (QCNE)	N/A	–	AJ294626/ AJ294686
Gentianella thyrsoidea (Hook. f.) Fabris	D.N. Smith, F. Escalona 10134 (MO)	N/A	–	AJ294627/ AJ294687
Gentianella tristicha (Gilg) Fabris ex T.N. Ho & S.W. Liu	D.N. Smith, F. Escalona 10125 (MO)	N/A	–	AJ294628/ AJ294688
Gentianella umbellata (M. Bieb.) Holub	K91-G3	Georgia	–	Z48102/Z48132
Gentianella wislizenii (Engelm.) J.M. Gillett	M. Lavin 4947 (TEX)	N/A	–	AJ294630/ AJ294690
Gentianopsis barbata (Froel.) Ma	xuechy090085 (KUN)	China	KC861287	KC861358

Species	Voucher specimen (Herbarium/No.)	Locality	matK	ITS
Gentianopsis crinita (Froel.) Ma	N/A (MJG)	Germany (Mainz Bot. Garden), cultivated	AJ406345/ AJ406373	AJ294631/ AJ294691
Halenia elliptica D. Don	GLM-081543 (KUN)	China	KC861242	KC861310
Halenia palmeri A. Gray	K.B.v. Hagen 98/41 (MJG)	N/A	-	AJ294632/ AJ294692
Jaeschkea oligosperma (Griseb.) Knobl.	R. McBeath 2300 (E 00025275)	N/A	AJ388171/ AJ388241	AJ294633/ AJ294693
Lomatogonium bellum (Hemsl.) H. Smith	GLM-06075 (KUN)	China	KC861237	KC861305
Lomatogonium carinthiacum (Wulfen) Rchb.	V. Zuev 6649 (BR)	N/A	AJ406346/ AJ406374	AJ294634/ AJ294694
Lomatogonium forrestii (I.B. Balfour) Fernald	XHC120061 (KUN)	China	KC861261	KC861332
Lomatogonium gamosepalum (Burkill) H. Smith	GLM-081372 (KUN 1272996)	China	KC861241	KC861309
Lomatogonium oreocharis (Diels) C. Marquand	CLD-90 1106 (K)	N/A	AJ388174/ AJ388244	AJ294635/ AJ294695
Megacodon stylophorus (C.B. Clarke) H. Smith	GLM-081957 (KUN)	China	KC861245	KC861313
Megacodon stylophorus (C.B. Clarke) H. Smith	Kuming, Edinburgh, Gothenburgh Exp. 1378 (E 00025279)	China	AJ388177/ AJ388247	AJ294636/ AJ294696
Swertia bifolia Batalin	Chensl0388 (KUN)	China	KC861229	KC861298
Swertia bimaculata (Sieb. & Zucc.) Hook. f. & Thomson ex C.B. Clarke	XHC120026 (KUN)	China	KC861264	KC861335
Swertia bimaculata (Sieb. & Zucc.) Hook. f. & Thomson ex C.B. Clarke	XCY090050 (KUN)	China	JF956557	JF978820
Swertia cincta Burkill	XCY090098 (KUN)	China	JF956561	JF978823
Swertia crassiuscula Gilg	U. Hecker 1094 (MJG)	N/A	AJ406347/ AJ406375	AJ294637/ AJ294697
Swertia decora Franch.	XCY090077 (KUN)	China	JF956567	JF978825
Swertia erythrosticta Maxim.	xuechy090044 (KUN)	China	KC861267	KC861338
Swertia franchetiana H. Smith	XHC120048 (KUN)	China	KC861256	KC861326
Swertia japonica (Schult.) Makino	N/A (KYO)	Japan (Kyoto Bot. Garden), cultivated	AJ406348/ AJ406376	AJ294638/ AJ294698
Swertia macrosperma (C.B. Clarke) C.B. Clarke	XHC120060 (KUN)	China	KC861260	KC861331
Swertia macrosperma (C.B. Clarke) C.B. Clarke	J.H. de Haas 2765 (U 500099)	N/A	AJ406349/ AJ406377	AJ294639/ AJ294699
Swertia nervosa (G. Don) Wall. ex C.B. Clarke	XHC120053 (KUN)	China	KC861258	KC861328
Swertia patens Burkill	09CS1123 (KIB)	China	KC861233	KC861302
Swertia perennis L.	K.B. Hungerer (MJG)	N/A	–	AJ294640/ AJ294700
Swertia punicea Hemsl.	19943574	Scotland (Edinburgh Bot. Garden), cultivated	AJ406350/ AJ406378	AJ294641/ AJ294701
Swertia racemosa (Wall. ex Griseb.) C.B. Clarke	J.H. de Haas 2725 (U 500131)	N/A	AJ406351/ AJ406379	AJ294642/ AJ294702
Swertia volkensii Gilg	U. Hecker 1093 (MJG)	N/A	AJ406352/ AJ406380	AJ294643/ AJ294703
Swertia yunnanensis Burkill	XCY090089 (KUN)	China	JF956585	JF978836
Veratrilla baillonii Franch.	Kuming, Edinburgh, Gothenburgh Exp. 1326 (E 00025273)	China	AJ388196/ AJ388266	AJ294644/ AJ294704

* indicates the taxon was newly sequenced in the present study.

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Lysimachia fanii, a new species of Primulaceae from limestone area of Guangxi, China

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Abstract

Lysimachia fanii, a new species of *Lysimachia* (Subgen. *Idiophyton*, Primulaceae), is described and illustrated from Guangxi, China based on morphological and molecular data. *Lysimachia fanii* differs from *L. verbascifolia*, *L. rupestris* and *L. alpestris* mainly by the habit being nearly rosulate, leaves congested at the apex of the rhizome, leaf blades spatulate to narrowly oblanceolate and flowers solitary. Phylogenetic analyses supported *L. verbascifolia* as sister to *L. fanii*. This new species is endemic to limestone areas in Liucheng county of Guangxi, China.

Keywords

Lysimachia, subgen. *Idiophyton*, Primulaceae, taxonomy, limestone flora

Introduction

The genus *Lysimachia* L. (1753: 146) includes about 190 species and was originally placed in Primulaceae (Cronquist 1981, Takhtajan 1997), but later transferred into Myrsinaceae, based on morphological and molecular evidence (Anderberg and Ståhl 1995, Anderberg et al. 1998, 2002, Källersjö et al. 2000, Hao et al. 2004). Mysinaceae was later merged into Primulaceae s.l., hence *Lysimachia* was replaced into

Primulaceae (China Phylogeny Consortium 2016). The majority of species within the genus are distributed in temperate and subtropical regions of the Northern Hemisphere, with some species in Africa, Australia and South America. In China, the genus has 138 species (Hu and Kelso 1996) and is highly diversified in south-western China, especially in limestone areas. According to the flower and gland morphology, the genus is separated into five subgenera, viz. subgen. *Idiophyton* Hand.-Mazz., subgen. *Lysimachia*, subgen. *Palladia* (Moench) Hand.-Mazz., subgen. *Heterostylandra* (Hand.-Mazz.) F.H.Chen & C.M.Hu and subgen. *Naumburgia* (Moench) Klatt. (Chen and Hu 1979, Chen et al. 1989).

The south-western limestone karst area is one of China's biodiversity hotspots. These areas are fragile and sensitive to environmental change and, in the wake of the rapid economic development of China, they are facing serious threat. Documentation of the plant diversity in these regions is urgently needed. Thus, we are surveying traditional medicinal plants in the limestone areas of Guangxi and trying to increase our knowledge of these poorly studied areas. During fieldwork in May 2018, we discovered an unknown species in *Lysimachia*. This species is allied to subgen. *Heterostylandra* by having rosette leaves, but it differs in having heteromorphic flowers. It shows alliance to subgen. *Idiophyton*, subgen. *Lysimachia* and subgen. *Palladia* by having 5-merous flowers, but has unique filaments, anthers and glands. After morphological observation and consulting relevant literature (Chen and Hu 1979, Chen et al. 1989, Hu and Kelso 1996, Tong et al. 2017), we confirm that the rare plant is a new species and has been placed into subgen. *Idiophyton*, based on morphology and molecular analyses.

Material and methods

Taxon sampling

We followed the classification of *Lysimachia* of Chen et al. (1989) and Hu and Kelso (1996). Leaves were collected from the holotype (L.Y. Fan et al., FLY2018001 in GXMI) and paratypes (L.Y. Fan et al., FLY2018002 in IBK & GXMI) to represent the new species. Twenty related taxa within subgen. *Idiophyton*, one taxon within subgen. *Heterostylandra* and four taxa within subgen. *Lysimachia* were selected to ascertain the phylogenetic relationships within *Lysimachia* (Anderberg et al. 2002). Based on Yan et al. (2018), *Pelletiera verna* A. St.-Hil. and *Anagallis monelli* L. were selected as outgroups.

DNA sequencing

Total genomic DNA was extracted from silica-dried plant leaves by a modified CTAB protocol (Doyle and Doyle 1987). Four chloroplast DNA regions (*atp*F-*atp*H, *rpl*32-*trn*L, *trn*L-F and *trn*S-*trn*G) and one nuclear loci (ITS) were selected and amplified following Yan et al. (2018). Genebank Accession Numbers are listed in Table 1.

Table 1. Species of *Lysimachia* and related taxa sampled and GenBank accession numbers of sequences used in this study.

Taxa	*atp*F-*atp*H	*rpl*32-*trn*L	*trn*L-F	*trn*S-*trn*G	ITS
Anagallis monelli	MG950735	MG950945	MG951268	MG951373	MG877752
L. alpestris	MG950743	MG950953	MG951276	MG951381	MG877760
L. baviensis	MG950773	MG950983	MG951306	MG951410	MG877790
L. capillipes	MG950748	MG950958	MG951281	MG951386	MG877765
L. chapaensis	MG950749	MG950959	MG951282	MG951387	MG877766
L. confertifolia	MG950757	MG950967	MG951290	–	MG877774
L. crispidens	MG950759	MG950969	MG951292	MG951396	MG877776
L. engleri	MG950765	MG950975	MG951298	MG951402	MG877782
L. foenum-graecum	MG950770	MG950980	MG951303	MG951407	MG877787
L. heterobotrys	MG950779	MG950989	MG951311	MG951415	MG877796
L. insignis	MG950784	MG950994	MG951316	MG951420	MG877801
L. lancifolia	MG950788	MG960998	MG951320	MG951424	MG877805
L. laxa	MG950789	MG950999	MG951321	MG951425	MG877806
L. longipes	MG950792	MG951002	MG951324	MG951428	MG877809
L. microcarpa	MG950796	MG951006	MG951328	MG951432	MG877813
L. millietii	MG950797	MG951007	MG951329	MG951433	MG877814
L. nemorum	MG950799	MG951009	MG951331	MG951435	MG877816
L. nutantiflora	MG950801	MG951011	MG951333	MG951437	MG877818
L. peduncularis	MG950805	MG951015	MG951337	–	MG877822
L. petelotii	MG950808	MG951018	MG951340	–	MG877825
L. pittosporoides	MG950810	MG951020	MG951342	MG951445	MG877827
L. punctata	MG950813	MG951023	MG951345	MG951448	MG877830
L. trichopoda	MG950826	MG951038	MG951359	MG951461	MG877845
L. verbascifolia	MG950827	MG951039	MG951360	MG951462	MG877846
L. vittiformis	MG950828	MG951040	MG951361	MG951463	MG877847
L. vulgaris	MG950829	MG951041	MG951362	MG951464	MG877848
Pelletiera verna	MG950832	MG951044	MG951365	MG951467	MG877851
L. fanii 01	MK516268	MK516270	MK516272	–	MK516275
L. fanii 02	MK516269	MK516271	MK516273	MK516274	MK516276

Phylogenetic analysis

Sequences of each DNA region were aligned using MUSCLE 3.8.31 (Edgar 2004a, 2004b) and adjusted manually where necessary. Indels were treated as gaps and all regions were combined as a single region for further study.

Maximum Parsimony (MP) analyses were conducted using PAUP v.4.0b10 (Swofford 2002). Heuristic searches were carried out with 1000 replicates and tree-bisection-reconnection (TBR) branch swapping. A strict consensus tree was summarised from all the most parsimonious trees. Node support was assessed by 500 bootstrap replicates using TBR branch swapping.

Bayesian Inference (BI) analyses were conducted using MrBayes version 3.1.2 (Ronquist and Huelsenbeck 2003). The Markov chain Monte Carlo (MCMC) chains were run for 100 000 generations while trees were sampled every 100 generations. The MCMC chains were stopped when the average standard deviation of the split frequencies was 0.008 after 100 000 generations, which meant that the chains were converged to a stationary distribution. A majority-rule consensus tree was constructed after removing a burn-in of 25% of the trees. Posterior Probability (PP) values were used to estimate branch support.

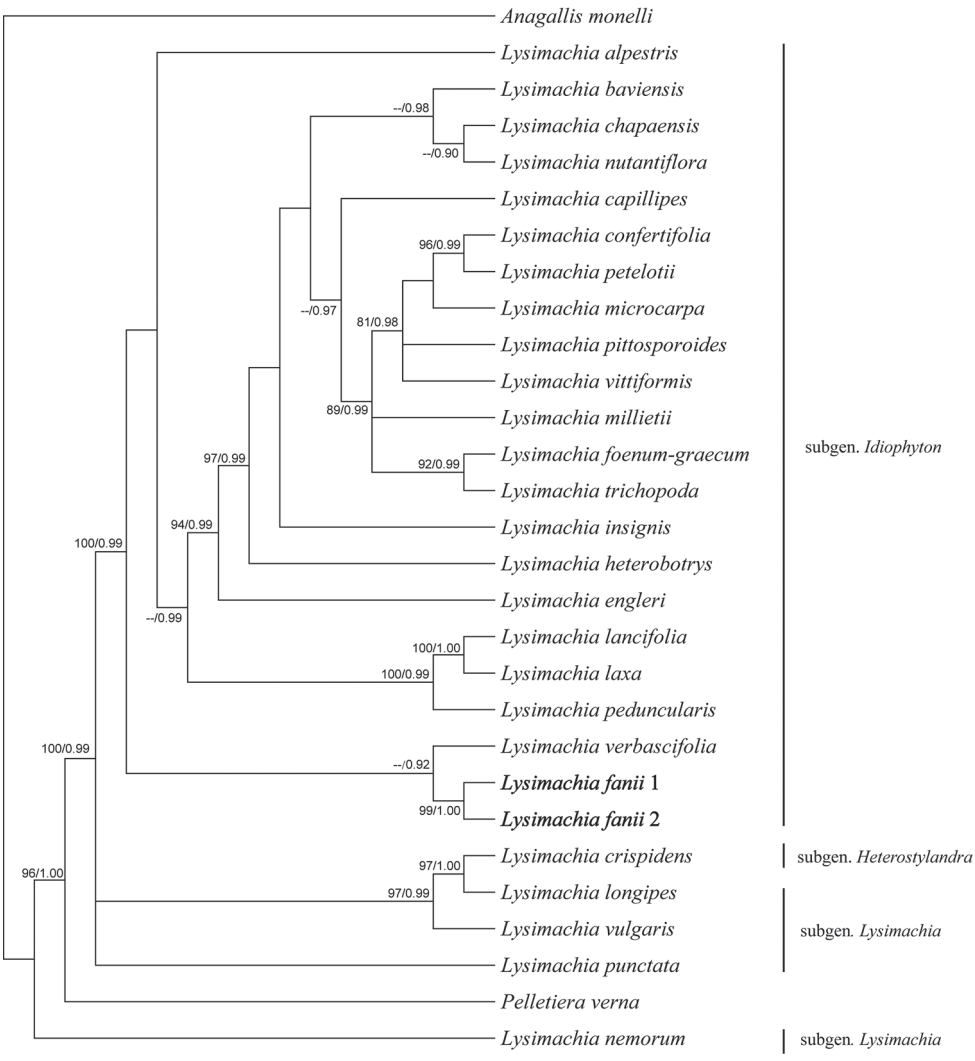

Figure 1. Phylogenetic tree inferred by MP and BI analyses based on the combined dataset of four plastid loci (*atp*F-*atp*H, *rpl*32-*trn*L, *trn*L-F and *trn*S-*trn*G) and nuclear ITS. Numbers above branches indicate maximum parsimony bootstrap/Bayesian inference posterior probability.

Results

Molecular systematic relationship

In total, 29 *atp*F-*atp*H, *rpl*32-*trn*L, *trn*L-*trn*F and ITS sequences and 25 *trn*S-G sequences were included. The combined matrix has a length of 3649 aligned characters (ITS: 653bp, *atp*F-*atp*H: 512bp, *rpl*32-*trn*L: 728bp, *trn*L-*trn*F: 946bp, *trn*S-G: 810bp), of which 363 are parsimony informative. The inferred phylogenies using MP and BI analyses are congruent (Fig. 1). The two samples of the new species (*L. fanii*)

are clustered into subgenus *Idiophyton* with strong support values in both MP and BI analyses (BS= 100%, PP = 0.99). *L. verbascifolia* is placed as the sister group to *L. fanii* with high support in the BI analysis (PP = 0.92).

Taxonomic treatment

***Lysimachia fanii* Y.Feng Huang, W.B.Xu & L.N.Dong, sp. nov.**
urn:lsid:ipni.org:names:60479343-2
Figs 2, 3

Type. CHINA. Guangxi Zhuangzu Autonomous Region: Liucheng County, Taiping Town, 23°42'50"N, 109°29'20"E, 320 m a.s.l., 21 May 2018, flowering, *L.Y. Fan et al. FLY2018001* (holotype, GXMI!; isotypes, IBK!, GXMI!).

Diagnosis. *Lysimachia fanii* differs from congeneric species in subgen. *Idiophyton* mainly by the habit being nearly rosulate, leaves congested at the apex of the rhizome, leaf blades spatulate to narrowly oblanceolate and flowers being solitary.

Description. Herbaceous perennial, glabrous. Rhizome subterete, 6–8 cm long, 4–6 mm in diameter, branched at the apex of the rhizome. Leaves papery, thickly papery to thinly leathery when dry, spirally arranged, congested at the apex of the rhizome, ± forming a rosette, subsessile, spatulate to narrowly oblanceolate, 6–21 × 0.6–2.0 cm, tapering towards the base, apex acute to obtuse, glabrous adaxially, glandular abaxially, veins invisible on both sides. Flowers solitary, axillary. Pedicel 3.0–6.0 cm long, ca. 1 mm in diameter, densely glandular. Calyx lobes lanceolate, 5–6 × ca. 3 mm, 5 (rarely 6), separate to near the base, apex acuminate, glabrous inside, glandular outside. Corolla yellow, deeply parted, tube 0.5–1.0 mm; lobes broadly ovate, 7.0 × 6.0 mm, apex obtuse, glabrous on both sides. Filaments ca. 1.5 mm long, lower 0.5 mm connate into a tube; anthers 3–3.5 mm long, ca. 1 mm in diameter, basifixed, opening by apical pores. Ovary globose, ca. 1 mm in diameter; style 2.8 mm long, slightly shorter than stamens. Capsule globose, 3.5–4 mm in diameter.

Phenology. Flowering from May to June.

Etymology. The new species is named after Mr. Li-Yong Fan, who first discovered and collected this rare species.

Distribution and habitat. *Lysimachia fanii* is known only from the type locality in Taiping Town, Liucheng County, Guangxi Zhuangzu Autonomous Region, China (Fig. 4). It grows on moist limestone rock surfaces at the entrance to caves.

Additional specimens examined. CHINA. **Guangxi:** Liucheng County, Taiping Town. 320 m a.s.l., 21 May 2018, *L.Y. Fan et al. FLY2018002* (IBK, GXMI).

Taxonomic notes. Based on the molecular phylogeny, *L. fanii* belongs to subgenus *Idiophyton*, that is also supported by the morphological characters of basifixed anthers, short filaments and anthers open by apical pores. *L. fanii* is morphologically similar to *L. verbascifolia* C.M.Hu & L.K.Phan that is endemic to limestone areas in Vietnam (Phan and Hu 2011), but can be easily distinguished by its spatulate to nar-

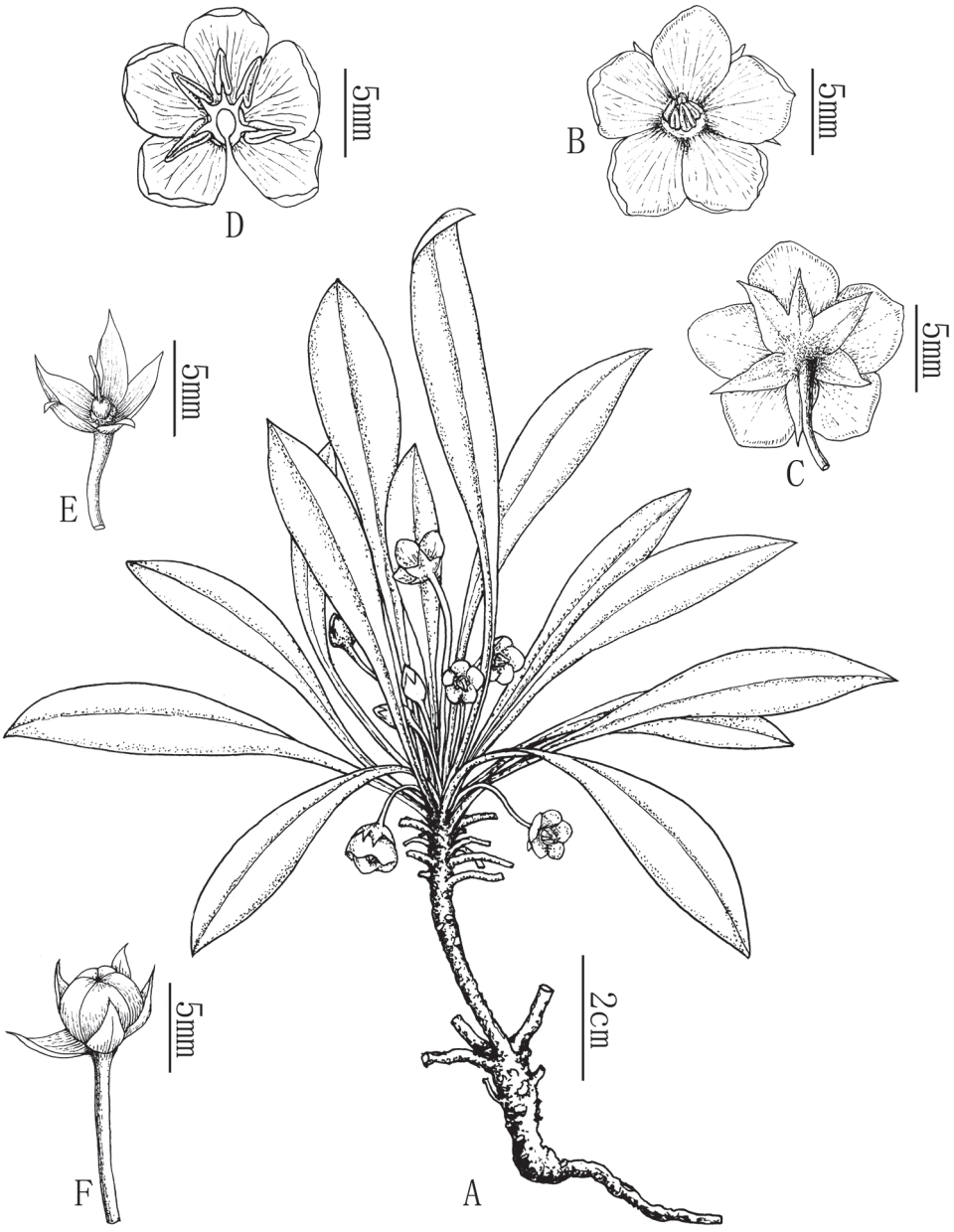

Figure 2. *Lysimachia fanii*. **A** Habit **B** flower, frontal view **C** flower, back view (showing six calyx lobes) **D** corolla opened showing stamens **E** calyx and pistil **F** capsule. (Drawn by X.C. Qu from the holotype).

rowly oblanceolate leaf blade and glabrous adaxially and glandular abaxially. *L. fanii* and *L. alpestris* Champ. ex Benth. resemble each other in having congested leaves and spatulate to narrowly oblanceolate leaf blades and invisible veins and solitary inflorescences but *L. fanii* differs from *L. alpestris* by its rhizome which is branched at the

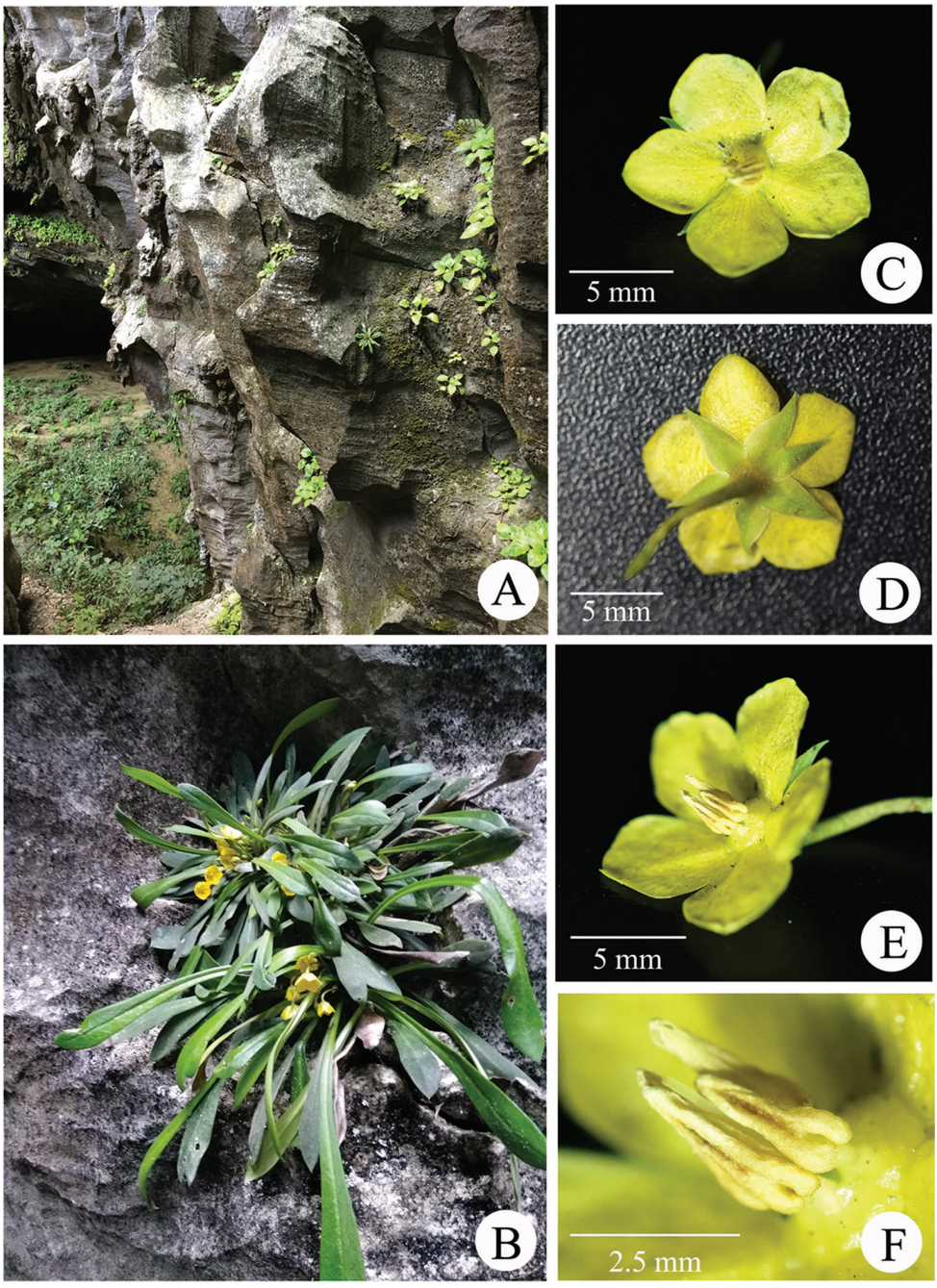

Figure 3. *Lysimachia fanii*. **A** Habitat **B** habit **C** flower, frontal view **D** flower, back view **E** flower, lateral view **F** stamens.

apex without stolons from the base, leaf blade glabrous adaxially and glandular abaxially, basifixed anthers which open by apical pores. *L. fanii* is also similar to *L. rupestris* F.H.Chen & C.M.Hu from limestone areas distributed in south-western China and northern Vietnam (Tong et al. 2017), but it can be distinguished from the latter by its rhizome which is branched at the apex and without stolons from the base, leaf blade spatulate to narrowly oblanceolate and glabrous adaxially, lateral veins invisible on both sides. A comparison of the main characters of the four species is shown in Table 2.

Table 2. Comparison of characters amongst *Lysimachia fanii*, *L. verbascifolia*, *L. rupestris* and *L. alpestris*.

Morphological traits	*L. fanii*	*L. verbascifolia*	*L. rupestris*	*L. alpestris*
Rhizome	6–8 cm long, branched at the apex	4–10 cm long, geniculate at the base	2–5 cm long, with stolons from the base	1–4 cm long, with stolons from the base
Leaf blade	spatulate to narrowly oblanceolate, 6–21 × 0.6–2.0 cm	elliptic to broadly elliptic, 7–17 × 3.5–8.0 cm	elliptic-oblance-olate, 3–6.5 × 1.2–2.2 cm	spatulate to narrowly oblanceolate, 3–6 × 0.6–1.5 cm
Leaf indumentum	glabrous adaxially, glandular abaxially	greyish villous on both sides	minutely glandular on both sides	dense long coarse greyish hairs on both sides
Lateral veins	invisible on both sides	obvious, densely greyish villous	prominent abaxially	invisible on both sides
Inflorescence	flowers solitary	subumbellate	flowers solitary	flowers solitary
Corolla	yellow, deeply parted, tube 0.5–1.0 mm	pale yellow, divided nearly to the base	yellow, divided nearly to the base	yellow, deeply parted, tube 1–1.5 mm
Filaments	ca. 1.5 mm long, lower 0.5 mm connate into a tube	ca. 3 mm long, connate basally into a ring	ca. 1 mm long, connate basally into a ring	ca. 3 mm long, lower 1.5 mm connate into a tube
Anthers	3-3.5 mm long, basifixed, opening by apical pores	ca. 5 mm long, basifixed, opening by apical pores	4–5 mm long, basifixed, opening by apical pores	ca. 2 mm long, dorsifixed, opening by lateral slits
Flower	May to June	June to October	April to May	April

Figure 4. The distribution of *Lysimachia fanii* in Guangxi, China.

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The authors are grateful to Mr. Xincheng Qu (Guangxi Institute of Chinese Medicine & Pharmaceutical Sciences) for the fine line drawings, to Mr. Xiaomao Huang and Mr. Wanlong Wei for their help in the field, to Dr. Mark Hughes (Royal Botanic Garden, Edinburgh) for his helpful comments. This study was supported by Science & Technology Basic Resources Investigation Program of China (Grant no. 2017FY100100) and also in part by The Chinese Medicine Public Health Service Subsidy Special "National Chinese Medicine Resources Census Project" (CS 2017, No. 6) and the Construction of a Joint Laboratory for Quality Research of Traditional Chinese Medicine in Guangxi and Macao (GuiKe AD17195002).

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RESEARCH ARTICLE

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Marsdenia yarlungzangboensis (Apocynaceae, Asclepiadoideae), a new species from Xizang, China

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Abstract

Marsdenia yarlungzangboensis (Apocynaceae, Asclepiadoideae), a new species from Motuo County, southeastern Xizang of China, is described and illustrated. It is morphologically similar to *M. medogensis*, *M. tenii* and *M. yuei*, the major differences between the new species and the morphological relatives are outlined and discussed. A diagnostic key to the new species and its closely related species in China is provided.

Keywords

Marsdenia, *Marsdenia yarlungzangboensis*, new species, China

Introduction

Marsdenia R. Brown (1810: 460) (Apocynaceae, Asclepiadoideae, Marsdenieae) (Endress and Bruyns 2000, Endress et al. 2014) was established in 1810 and was named in honor of the plant collector William Marsden (1754–1836), who was the Secretary of the Admiralty from 1795. The genus comprises around 100 species, mainly from tropical and subtropical regions, particularly in Asia, Africa and the Americas (Tsiang and Li 1977, Li et al. 1995, Stevens and Juárez-Jaimes 1999, Endress and Bruyns 2000, Stevens 2009). In the revision of *Marsdenia* in Asia, Malesia, Australia and Papuasia (Forster 1995a, 1995b), some species of *Dregea* E. Meyer, *Gymnema* R. Brown, *Dischidanthus* Tsiang and *Jasminanthes*

Blume are subsumed into *Marsdenia*. However, these taxonomic treatments are not fully supported by the current molecular phylogenies (Endress et al. 2014). Some new taxa of this genus have been discovered and described in recent years (Stevens and Juárez-Jaimes 1999, Juárez-Jaimes and Alvarado-Cárdenas 2010, Rapini and Pereira 2011, Fernando and Rodda 2013, Jaimes 2015, Jaimes and Pérez 2015, Jaimes and Saynes 2015, Carnevali et al. 2016, Stevens et al. 2016, Santo et al. 2018a, 2018b). According to the treatment of *Marsdenia* in Flora of China, there are 25 species recognized in China and mainly distributed in the east, south and southwest provinces (Tsiang and Li 1977, Li et al. 1995).

In 2016, we collected an unknown species of Apocynaceae during fieldwork in Motuo County, southeastern Xizang, China. This species was identified as a member of *Marsdenia* by characterizing woody vines with umbelliform inflorescences, campanulate corollas with fleshy corona attached to gynostegium and the erect pollinia attached to the caudicles at the base (Tsiang and Li 1977, Li et al. 1995). After careful comparisons of diagnostic morphological and anatomical features of the closely related species from China and adjacent regions (Hooker 1885, Yoganarasimhan and Subramanyam 1976, Tsiang and Li 1977, Li et al. 1995, Forster 1995a, 1995b, Fernando and Rodda 2013), we concluded that the species is new to science and thus describe and illustrate it hereby. Its morphological characters are compared with the closely related species including *M. medogensis* P. T. Li (1985), *M. tenii* M. G. Gilbert & P. T. Li (Gilbert et al. 1995), *M. yuei* M. G. Gilbert & P. T. Li (Gilbert et al. 1995).

Materials and methods

Vouchers of *Marsdenia yarlungzangboensis* were collected from Motuo County, Xizang of China. The photographs and phenology data were obtained during the field expeditions.

Morphological observations and measurements of the new species were carried out based on living plants and dry specimens. The morphology of opened corolla, opened calyx, gynostegium and staminal corona, pistil, pollinarium were observed by using a Keyence VHX-700F Digital Microscope (Keyence, Osaka, Japan) and based on dry specimens. All morphological characters are described according to the terminology presented by Li et al. (1995).

Taxonomic treatment

Marsdenia yarlungzangboensis **C.Liu, J.D.Ya & Y.H.Tan, sp. nov.**
urn:lsid:ipni.org:names:77201389-1
Figs 1, 2

Diagnosis. *Marsdenia yarlungzangboensis* is morphologically similar to *M. medogensis*, *M. tenii* and *M. yuei*, but differs from *M. medogensis* in inflorescences pubescent; sepals suborbicular; corolla yellow, throat red and densely pilose, shorter lobes and reddish

outside, apex emarginate, margin reddish and ciliate; corona lobes triangular, to base of anthers; stigma head hemispherical; and differs from *M. tenii* in leaf blades elliptic; sepals suborbicular; corolla yellow, throat red, lobes reddish outside, margin reddish; stigma head hemispherical, conspicuously exserted from anther appendages and corolla tube; and also differs from *M. yuei* in leaf blades elliptic; inflorescences unbranched and pubescent; sepals suborbicular; corolla yellow, throat red and densely pilose; lobes ovate, apex emarginate; corona lobes to base of anthers.

Type. CHINA. Xizang: Motuo County, Renqinbeng, on margins of the subtropical evergreen broad-leaved forest, 29°20'08.59"N, 95°21'38.42"E, 1848 m a.s.l., 15 Nov 2016, in flowering, *C. Liu, J.D. Ya, H.J. He & C.H. Li 16CS11914* (holotype: KUN!, isotype: KUN!)

Description. Lianas woody, up to 10 m. Stems pale gray, sap white. Branchlets glabrous or distal parts minutely puberulent. ***Leaves*** opposite, petiole 1.5–2.5 cm, puberulent; blades elliptic, 7–12 × 3.5–6 cm, papery, glabrescent or sparsely hairy and denser along veins adaxially, base rounded or shallowly cordate, apex acuminate, margin entire, revolute, abaxially pale; lateral veins 4 or 5 pairs. ***Inflorescences*** umbel-like or with several umbel-like cymules along unbranched rachis, 3–7 cm, rachis at least 1.5 cm; peduncle 1.5–6 cm, pubescent; pedicel 5–7 mm, pubescent. ***Sepals*** suborbicular, pubescent outside, ca. 4 × 3–4 mm, ciliate, basal glands 5. ***Corolla*** yellow, campanulate, 1–1.5 cm in diam., glabrous outside, pubescent inside; tube ca. 5 mm, glabrous outside; throat red and densely pilose; lobes ovate and reddish outside, twisted to the right, 5–6 × 3–4 mm, apex emarginate, margin reddish and ciliate. ***Corona*** lobes triangular, fleshy, to base of anthers, almost flat. Anther appendages oblong, apex membranous; ***Pollinia*** 2 per pollinarium, erect, reniform. Ovary glabrous, ca. 2 mm, 2-carpelled, free. Stigma head hemispherical, conspicuously exserted from anther appendages and corolla tube. Follicles and seeds not seen.

Phenology. Flowering from November to December.

Distribution and habitat. *Marsdenia yarlungzangboensis* grows at the margins of subtropical evergreen broad-leaved forest with main community types of *Castanopsis echinocarpa* J. D. Hooker & Thomson ex Miquel and *Quercus gambleana* A. Camus, Renqinbeng, Motuo County, Xizang, China, at an elevation of 1800–2100 m.

Etymology. The specific epithet 'yarlungzangboensis' is derived from the type locality, Yarlung Zangbo Grand Canyon, Motuo County, southeast Xizang, China.

Vernacular name. Yǎ Lǔ Zàng Bù Niú Nǎi Cài (Chinese pronunciation); 雅鲁藏布牛奶菜 (Chinese name).

Discussion. Based on the larger gynandrium, corolla tube almost equal in length to gynostegium and with umbel-like cymules along unbranched rachis, *Marsdenia yarlungzangboensis* belongs to *Marsdenia* sect. *Ruehssia* (Karst.) Fourn. (Tsiang and Li 1977). Morphologically, it is similar to *M. medogensis*, *M. tenii* and *M. yuei* in terms of habit and floral morphology, but can be distinguished from *M. medogensis* in inflorescences pubescent (vs. glabrous); sepals suborbicular (vs. ovate); corolla yellow (vs. white), throat red and pilose (vs. glabrous), apex emarginate (vs. rounded), margin reddish and ciliate; corona lobes triangular (vs. oblong), to base of

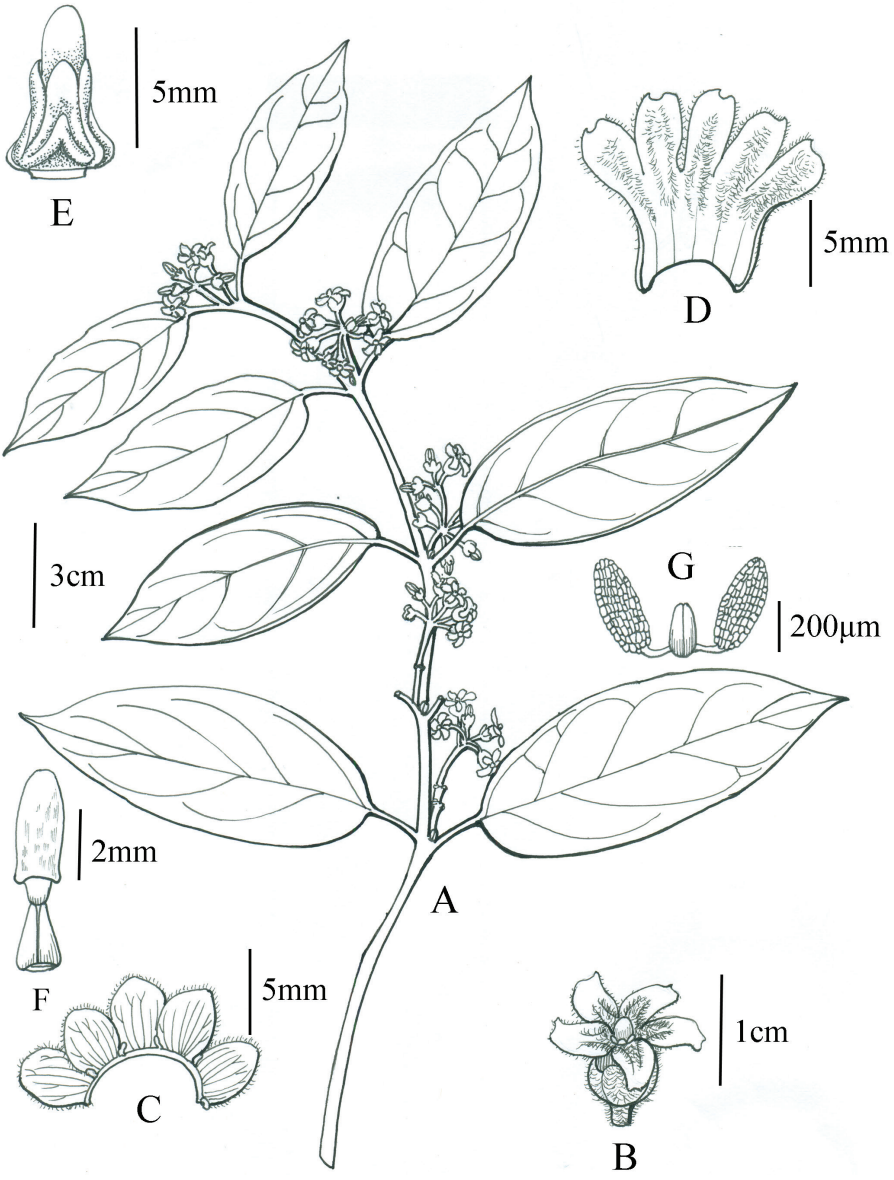

Figure 1. *Marsdenia yarlungzangboensis* C.Liu, J.D.Ya & Y.H.Tan **A** habit **B** flower (lateral view) **C** opened calyx **D** opened corolla **E** gynostegium and staminal corona **F** pistil **G** pollinarium.

anthers (vs. as long as anther appendages); stigma head hemispherical (vs. discoid, convex). It also differs from *M. tenii* in its stems glabrous or distal parts minutely puberulent (vs. densely yellow-brown tomentose); leaf blades elliptic (vs. oblong-ovate); sepals suborbicular (vs. elliptic); corolla yellow, throat red and pilose, lobes reddish outside (vs. yellowish white, throat pilose with retrorse hairs); stigma head hemispherical (vs. 2-cleft, conical), conspicuously exserted from anther appendages

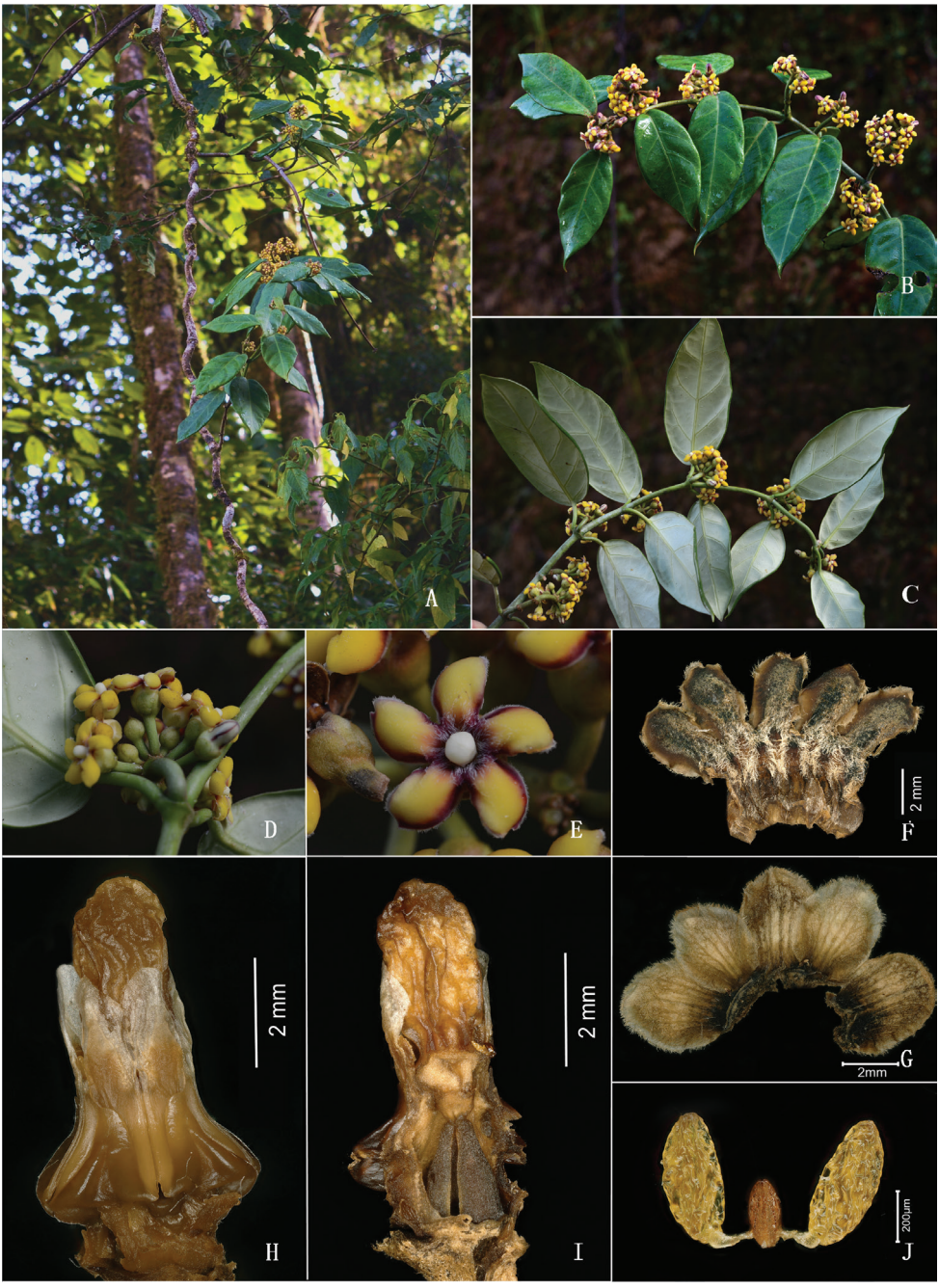

Figure 2. *Marsdenia yarlungzangboensis* C.Liu, J.D.Ya & Y.H.Tan **A** habit **B** inflorescences and adaxial leaf surface **C** abaxial leaf surface **D** flower (lateral view) **E** flower (front view, showing hairy throat) **F** opened corolla **G** opened calyx **H** gynostegium and staminal corona **I** pistil **J** pollinarium. Photo credit: Cheng Liu (**A–E**) and Lian-Yi Li (**F–J**).

Table 1. Diagnostic character differences amongst *Marsdenia yarlungzangboensis*, *M. medogensis*, *M. tenii* and *M. yuei.*

Character	*M. yarlungzangboensis*	*M. medogensis*	*M. tenii*	*M. yuei*
Stems	stems pale gray, glabrous or distal parts minutely puberulent	stems pale gray, nodes pilose	stems densely yellow-brown tomentose	stems glabrous except for flowers
Leaves	petiole 1.5–2.5 cm; blades elliptic, 7–12 × 3.5–6 cm, base rounded or shallowly cordate, abaxially pale, lateral veins 4 or 5 pairs	petiole 1–1.6 cm; blades oblong, 10–11 × 2–3 cm, base rounded, lateral veins 7 or 8 pairs	petiole to 4 cm; blades oblong-ovate, to 12.5 × 7.5 cm, base cordate, lateral veins ca. 5 pairs;	petiole ca. 4 cm; blades ovate, ca. 9.5 × 5.8 cm, base shallowly cordate, lateral veins 4 or 5 pairs
Inflorescences	with several umbel-like cymules along unbranched rachis, pubescent; rachis to at least 1.5 cm	umbel-like, glabrous 4–8–flowered	with several umbel-like cymules along unbranched rachis; rachis to at least 2 cm	umbel-like, up to 9–flowered
Peduncle and Pedicel	peduncle 1.5–6 cm, pedicel 5–7 mm, pubescent	peduncle 4–4.5 cm, pedicel 2–2.5 cm, glabrous	peduncle to 3 cm, pedicel ca. 5 mm	peduncle ca. 1.5 cm, pedicel to 9 mm
Sepals	suborbicular, pubescent outside, ca. 4 × 3–4 mm, basal glands 5	ovate, ca. 4 × 2 mm	elliptic, ca. 3 × 2 cm	rounded, ca. 3 × 2.5 mm, finely appressed puberulent
Corolla	yellow, ca. 1–1.5 cm in diam., throat red and densely pilose; lobes ovate, ca. 5–6 × 3–4 mm, apex emarginate, margin reddish and ciliate	white, 1.5–2 cm in diam., throat glabrous; lodes broadly ovate, ca. 9 × 9 mm, apex rounded	yellowish white, ca. 6 mm, throat pilose with retrorse hairs, lobes ca. 3.5 × 2.5 mm, lobes densely appressed tomentose in center	white, glabrous except for sparsely ciliate margin, lobes oblong-obovate, ca. 5.5 × 2.5–3.2 mm, apex rounded
Corona lobes	triangular, to base of anthers	oblong, as long as anther appendages	to base of anthers	narrowly triangular, as long as anther appendages
Stigma head	hemispherical, conspicuously exserted from anther appendages and corolla tube	discoid, convex, slightly exserted from anther appendages	2-cleft, conical, equalling anther appendages	hemispherical, conspicuously exserted from anther appendages and corolla tube

and corolla tube (vs. equalling anther appendages). Beyond that, it can be distinguished from *M. yuei* in leaf blades elliptic (vs. ovate); inflorescences unbranched, pubescent (vs. branched, glabrous); sepals suborbicular (vs. rounded); corolla yellow (vs. white), throat red and densely pilose (vs. glabrous); lobes ovate, apex emarginated (vs. oblong-obovate, apex rounded); corona lobes to base of anthers (vs. as long as anther appendages). The detailed characters amongst the three related species are provided in Table 1.

According to field surveys, this new species is only found in the type locality Renqinbeng, Motuo County, Xizang. This area is one of China's biodiversity hotspots and consists of a diverse series of ecosystems from subtropical broad-leaved forests to alpine meadows above the tree line with an altitudinal range of 150–6000 m above sea level. Plant diversity is also poorly studied in this area, and some new taxa have been discovered in recent years. In order to better understand and conserve the biodiversity in this area, more extensive investigations are needed in the future.

A diagnostic key to the new species and its closely related species in China

1a Corolla tube longer than lobes ..... ***M. sinensis***
1b Corolla tube shorter than lobes **2**

2a Corolla lobes 9–12 mm **3**
3a Leaf blade 5.5–10 cm wide; inflorescences 7–15 cm; corolla interior pubescent; sepals ca. 8 × 6 mm ..... ***M. koi***
3b Leaf blade 2–3 cm wide; inflorescences 4–4.5 cm; corolla glabrous; sepals 3–4 × 2–2.5 mm..... ***M. medogensis***
2b Corolla lobes 3–7 mm **4**
4a Base of leaf blade rounded to truncate; inflorescences unbranched..... **5**
5a Plants tomentose; corolla white, 6–8 mm, stigma head 2-cleft, conical, equalling anther appendages..... ***M. tenii***
5b Plants puberulent; corolla yellow, 1–1.5 cm, stigma head hemispherical, conspicuously exserted from anther appendages and corolla tube ..... ***M. yarlungzangboensis***
4b Base of leaf blade cordate; inflorescences usually obviously branched **6**
6a Peduncle to 16 cm; corolla interior pilose; corona lobes shorter than corolla tube ..... ***M. hainanensis***
6b Peduncle ca. 1.5 cm; corolla interior glabrous; corona lobes longer than corolla tube ..... ***M. yuei***

Acknowledgements

We are grateful to Chang-Hong Li, Hai-ping Wei, Ma Ni, Duo-Jie Sanjie for their kind help in the fieldwork; to Lian-Yi Li for taking morphological photographs of opened corolla, opened calyx, gynostegium and staminal corona, pistil, pollinarium by Keyence VHX-700F Digital Microscope (Keyence, Osaka, Japan); and to Ling Wang for the line drawing. This research was supported by the programme of Germplasm Bank of Wild Species, National Science & Technology Infrastructure and the Large-scale Scientific Facilities of the Chinese Academy of Sciences (2017-LSFGBOWS-02).

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RESEARCH ARTICLE

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The taxonomic revision of Asian *Aristolochia* (Aristolochiaceae) V: two new species from Yunnan, China

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Abstract

Aristolochia pseudoutriformis X.X.Zhu & J.S.Ma, **sp. nov.** and *A. yangii* X.X.Zhu & J.S.Ma, **sp. nov.**, two new species from Yunnan, China, are described and illustrated here. The former is morphologically similar to *A. utriformis* and *A. forrestiana* and the latter is similar to *A. cucurbitoides* and *A. forrestiana*. According to Ma's (1989a) classification, both new species belong to *Aristolochia* subgenus *Siphisia* on the basis of the 3-lobed gynostemium and oblong anthers that are adnate in pairs, opposite the gynostemium lobes. Meanwhile, the two new species are assessed as Vulnerable (VU D2) according to IUCN Red List criteria.

Keywords

Aristolochia, Baoshan, field expedition, morphology, taxonomy

* These authors contributed equally to this work

Introduction

Aristolochia L. consists of about 550 species (González 2012) and is the largest genus in Aristolochiaceae (Hwang et al. 2003). Most species are distributed in the tropics and subtropics (Ma 1989a; Wanke et al. 2006). Three subgenera: subgenus *Aristolochia*, subgenus *Siphisia* and subgenus *Pararistolochia* are recognised based on morphological and molecular data (Wanke et al. 2006). China has 69 species according to Zhu et al. (2018). A key to the subgenera and a useful key to Asian species of *Aristolochia* subgenus *Siphisia* are provided by Do et al. (2015a).

During five field expeditions to Hundred Flowers Ridge in Longyang District, Baoshan, western Yunnan, two unknown species of *Aristolochia* were collected. Careful studies of the genus were undertaken, particularly the floral characteristics of those species in the adjacent regions, as well as morphological comparisons of the two unknown species with their related species. Meanwhile, through extensive fieldwork, careful examination of numerous specimens and colour photos and consultation of related publications, we confirm that they are two new species of *Aristolochia* which are described and illustrated in this study.

Taxonomy

***Aristolochia pseudoutriformis* X.X.Zhu & J.S.Ma, sp. nov.**
urn:lsid:ipni.org:names:77201390-1
Figures 1, 2, 3, 7A–C

Type. CHINA. Yunnan: Baoshan, Longyang District, Hundred Flowers Ridge, 98°47.38'E, 25°18.00'N, 1891 m a.s.l., 13 May 2018, X.X.Zhu ZXX18074 (holotype: CSH [CSH-0153653!]; isotypes: CSH!, KUN!).

Diagnosis. Similar to *Aristolochia utriformis* S.M.Hwang (Hwang 1981) and *A. forrestiana* J.S.Ma (Ma 1989b), but differs from the former in its lamina ovate to narrowly ovate (vs. ovate-lanceolate in *A. utriformis*), limb cylinder, forming obtuse angle with upper tuber, inside dark red, dense processes (vs. limb ovoid, straight extended from upper tube, inside black purple, sparse processes in *A. utriformis*) and throat ca. 6 mm in diam. (vs. ca. 1 mm in diam. in *A. utriformis*) and differs from the latter in its flower light yellow (vs. light brown or purple in *A. forrestiana*), limb slightly asymmetric, 2–3 × 1–1.7 cm; 3-lobed, lobes triangle or wide triangle; inside dark red (vs. asymmetric, 6–8 × 1.5–2 cm; 3-lobed, lobes lanceolate; inside black purple in *A. forrestiana*), as well as throat ca. 6 mm in diam. (vs. ca. 3mm in diam. in *A. forrestiana*). Detailed morphological comparisons are shown in Table 1 and Figure 7.

Description. Semi-deciduous climbing shrubs. Stems terete. Petioles 2–5 cm long, densely pubescence; laminas ovate to narrowly ovate, 10–22 × 7–13 cm, adaxially sparsely pubescence, abaxially densely pubescence, base cordate, margin entire, apex acute; veins palmate, 2–3 pairs from base, lateral veins 3–5-paired. Flowers axillary, sometimes on stems, solitary or paired; pedicels 1.8–5 cm, densely brown villous; bractlets 1 or 2,

Table 1. Morphological comparisons amongst *Aristolochia pseudoutriformis*, *A. utriformis* and *A. forrestiana*.

Characters	*A. pseudoutriformis*	*A. utriformis*	*A. forrestiana*
Lamina	ovate to narrowly ovate	ovate-lanceolate	ovate to narrowly ovate
	10–22 × 7–13 cm	10–17 × 3–4 cm	7–21 × 3–10.5 cm
Calyx	light yellow	light yellow	light brown or purple
Limb	cylinder, slightly asymmetric, 2–3 cm long, forming obtuse angle with upper tuber, inside dark red, dense processes, 3-lobed, lobes triangle or wide triangle	ovoid, slightly asymmetric, 1–2 cm long, straight extended from upper tube, inside black purple, sparse processes, 3-lobed, lobes ovate-deltate	cylinder, asymmetric, 6–8 cm long, forming right angle with upper tuber, inside black purple, dense processes, 3-lobed, lobes lanceolate
Throat	ca. 6 mm in diam.	ca. 1 mm in diam.	ca. 3 mm in diam.

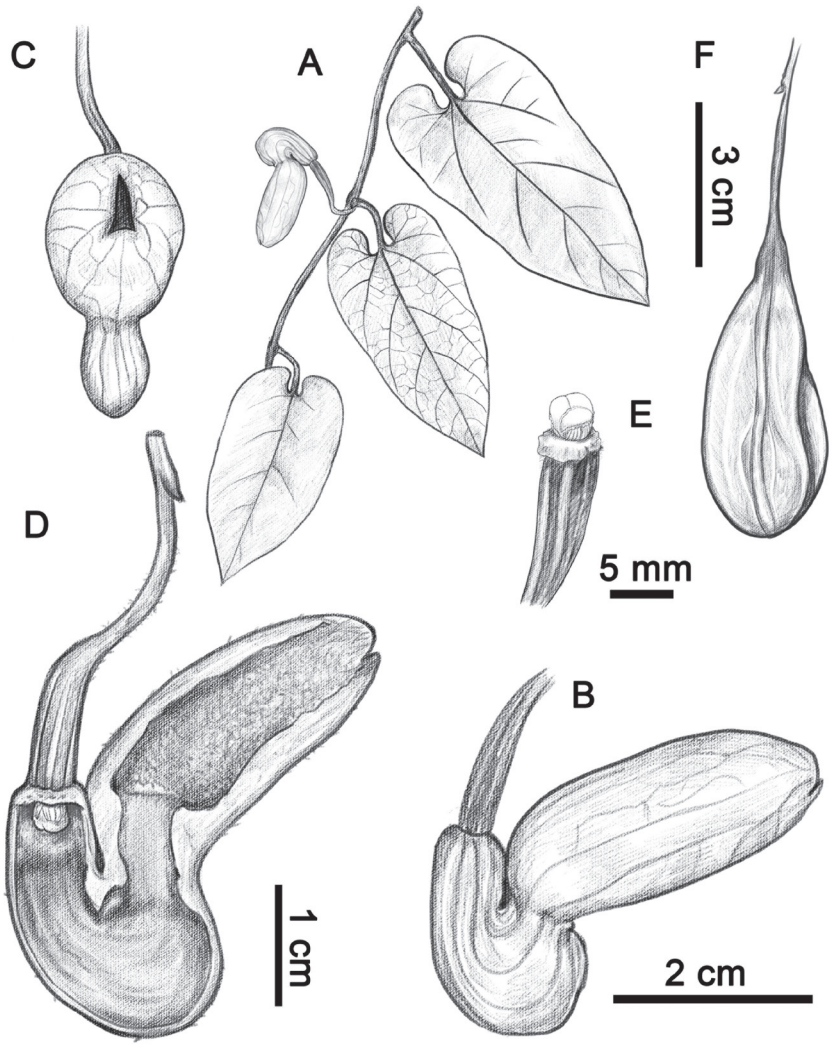

Figure 1. *Aristolochia pseudoutriformis* X.X.Zhu & J.S.Ma, sp. nov. **A** habit **B** flower (lateral view) **C** flower (front view) **D** opened flower (showing the inside structure) **E** anthers and gynostemium **F** fruit. Illustration by Shizhen Qiao.

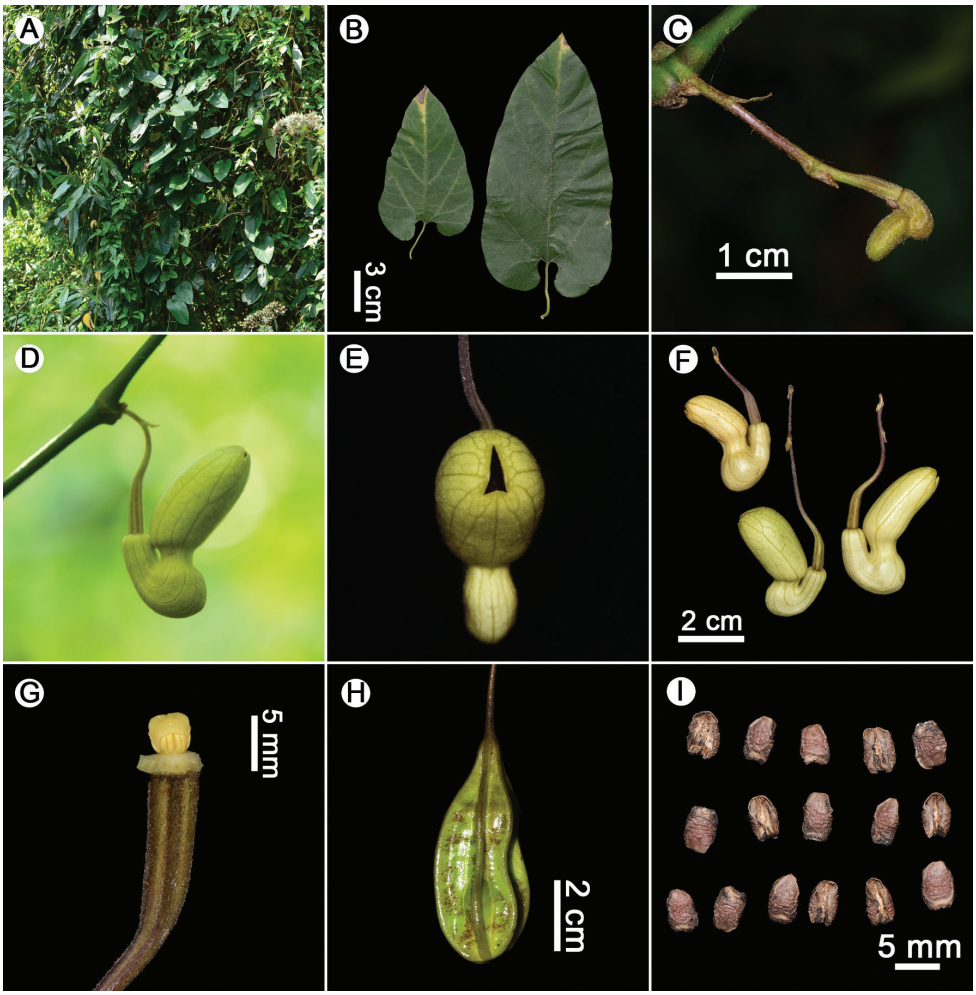

Figure 2. *Aristolochia pseudoutriformis* X.X.Zhu & J.S.Ma, sp. nov. **A** habit **B** leaves **C** flower bud **D** flower (lateral view) **E** flower (front view) **F** flowers **G** anthers and gynostemium **H** fruit **I** seeds. Photographed by Xinxin Zhu.

ovate, 3–5 mm long, adaxially glabrous, abaxially densely villous. Calyx tube geniculately curved, light yellow, abaxially sparsely villous; basal tube 1.8–2.5 cm long, inside black purple at base, dark red above base, upper tube 1.2–1.8 cm long, inside dark red; limb saccate, cylinder, slightly asymmetric, 2–3 × 1–1.7 cm, forming obtuse angle with upper tuber, inside dark red, densely processes, 3-lobed, lobes triangle or wide triangle; throat ca. 6 mm in diam.. Anthers 6, oblong, ca. 1.5 mm long, adnate in 3 pairs to base of gynostemium, opposite to lobes. Gynostemium ca. 3 mm long, 3-lobed. Ovary terete, ca. 12 mm long, densely brown villous. Fruit stem ca. 4.5 cm long, sparsely puberulous. Capsule obovate-elliptic, distinctly 6-angled, sparsely puberulous on angles, ca. 6 × 2.5 cm (ca. 5 × 2.5 cm in dry specimens). Seeds ellipse, 5–6 × 3–4 mm, not winged, the adaxial surface deeply concave and the abaxial surface convex, wrinkled, both surfaces glabrous.

Figure 3. Holotype of *Aristolochia pseudoutriformis* X.X.Zhu & J.S.Ma, sp. nov. (CSH-0153653).

Phenology. Flowering from March to May and fruiting from July to August.

Etymology. The specific epithet refers to the similarity between the new species and *A. utriformis* in the morphology of flowers. The Chinese name is given as "拟囊花马兜铃".

Distribution and habitat. The new species is currently known to Longyang District, Baoshan, Yunnan, China. It grows in forests at an elevation of between 1890 m

and 2260 m, together with *Castanopsis* ssp. (Fagaceae), *Disporum* sp. (Colchicaceae), *Elytranthe albida* (Bl.) Bl. (Loranthaceae), *Nervilia tahanshanensis* T.P.Lin & W.M.Lin (Orchidaceae), *Rubus* sp. (Rosaceae), etc.

IUCN Red List Category. *Aristolochia pseudoutriformis* is known from only two populations, with fewer than five individuals at each site. Therefore, the new species is assigned a preliminary status of Vulnerable (VU D2) according to IUCN Red List Criteria (IUCN 2012), indicating a population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer).

Specimens Examined. CHINA. Yunnan: Baoshan, Longyang District, Hundred Flowers Ridge, 30 Mar 2015, X.X.Zhu & Z.X.Hua ZH026 (CSH); 20 Apr 2017, X.X.Zhu ZXX17050 (CSH); 11 Aug 2018, X.X.Zhu & J.Wang ZXX18241 (CSH, KUN).

***Aristolochia yangii* X.X.Zhu & J.S.Ma, sp. nov.**
urn:lsid:ipni.org:names:77201391-1
Figures 4, 5, 6, 7J–L

Type. CHINA. Yunnan: Baoshan, Longyang District, Hundred Flowers Ridge, 98°47.38'E, 25°18.00'N, 1890 m a.s.l., 13 May 2018, X.X.Zhu ZXX18073 (holotype: CSH [CSH-0153654!]; isotypes: CSH!, KUN!).

Diagnosis. Similar to *Aristolochia cucurbitoides* C.F.Liang (Liang 1975) and *A. forrestiana* J.S.Ma (Ma 1989b), but differs from the former in its flower larger, basal tuber 2.5–3.5 cm long; limb 3.3–4.7 cm long; deeply 3-lobed, lobes ovate-deltoid, 1.6–2.4 cm long (vs. flower smaller, basal tuber ca. 2 cm long; limb ca. 2 cm long; shallowly 3-lobed, lobes lanceolate-acuminate, 0.5–0.7 cm long in *A. cucurbitoides*) and differs from the latter in its lamina lanceolate to hastate, 8–24.5 × 1.2–5.5 cm, base auriculate to cordate (vs. lamina ovate to narrowly ovate, 7–21 × 3–10.5 cm, base cordate in *A. forrestiana*), calyx yellowish-white (vs. light brown or purple in *A. forrestiana*), as well as limb symmetric, 3.3–4.7 cm long, straight extended from upper tube and parallel to it; deeply 3-lobed, lobes ovate-deltoid; inside pinkish or ochre without processes (vs. asymmetric, 6–8 cm long, forming right angle with upper tuber; 3-lobed, lobes lanceolate; inside black purple with dense processes in *A. forrestiana*). Detailed morphological comparisons amongst the three species are summarised in Table 2 and comparisons between *A. pseudoutriformis* and *A. forrestiana* are also shown in Fig. 7.

Description. Semi-deciduous climbing shrubs. Stems terete. Petioles 1–4 cm long, densely pubescence; laminas lanceolate to hastate, 8–24.5 × 1.2–5.5 cm, adaxially glabrous or sparsely pubescence along medial vein, abaxially densely pubescence, base auriculate to cordate, margin entire, apex acute; veins palmate, 2–3 pairs from base, lateral veins 6–15-paired. Cymes on old woody stems or axillary, 1–2-flowered, in clusters of 1 to numerous; pedicels 5–7 cm long, sparsely pubescence; bractlets 1 or 2, ovate-lanceolate, 3–5 mm long, adaxially glabrous, abaxially densely brown villous. Calyx tube geniculately curved, yellowish-white with distinct purple stripe, abaxially subglabrous or sparsely villous; basal tuber 2.5–3.5 cm long, inside black purple at base, white mix

Table 2. Morphological comparisons amongst *Aristolochia yangii*, *A. cucurbitoides* and *A. forrestiana*.

Characters	*A. yangii*	*A. cucurbitoides*	*A. forrestiana*
Lamina	lanceolate to hastate, 8–24.5 × 1.2–5.5 cm, base auriculate to cordate	trullate-lanceolate, ovate-lanceolate, or lanceolate, 12–22 × 2.5–4.5 cm	ovate to narrowly ovate, 7–21 × 3–10.5 cm
Calyx	Yellowish-white; inside of basal tuber black purple at base, white mix with more or less reddish-violet above base, inside of upper tube white mix with reddish-violet	undocumented	light brown or purple; inside of tuber black purple
Limb	3.3–4.7 cm long symmetric, straight extended from upper tube and parallel to it, inside pinkish or ochre, smooth, deeply 3-lobed, lobes ovate-deltoid, 1.6–2.4 cm long	ca. 2 cm long, slightly asymmetric, straight extended from upper tube, inside undocumented, shallowly 3-lobed, lobes lanceolate-acuminate, 0.5–0.7 cm long	6–8 cm long, asymmetric, forming right angle with upper tuber, inside black purple with dense processes, 3-lobed, lobes lanceolate, ca. 2.5 cm long

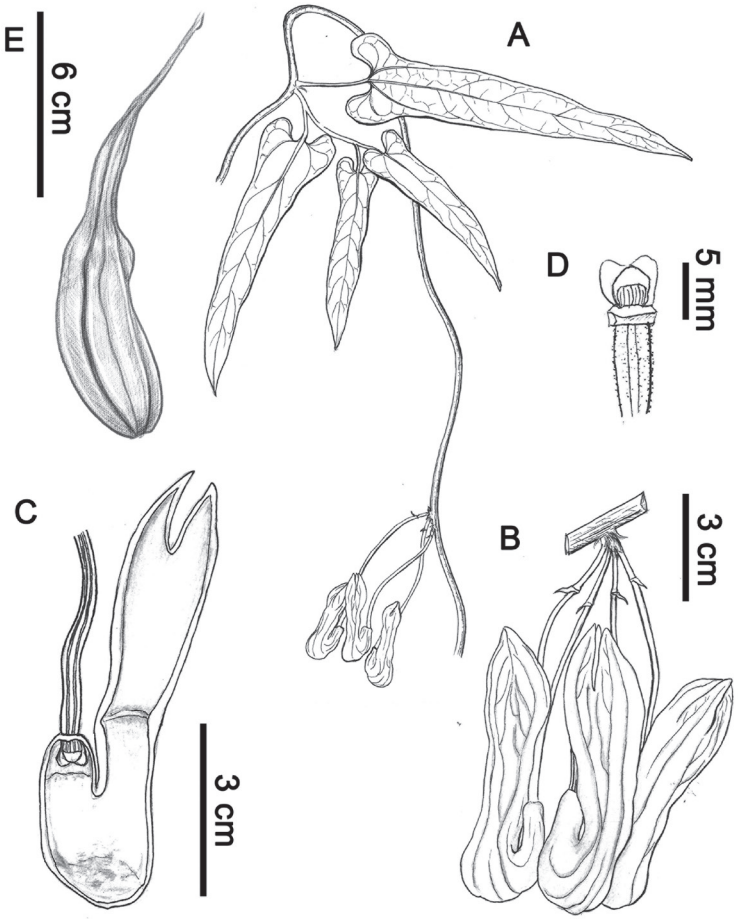

Figure 4. *Aristolochia yangii* X.X.Zhu & J.S.Ma, sp. nov. **A** habit **B** inflorescence **C** opened flower (showing the inside structure) **D** anthers and gynostemium **E** fruit. Illustration by Manhua Lin (**A**–**D**); Illustration by Shizhen Qiao (**E**).

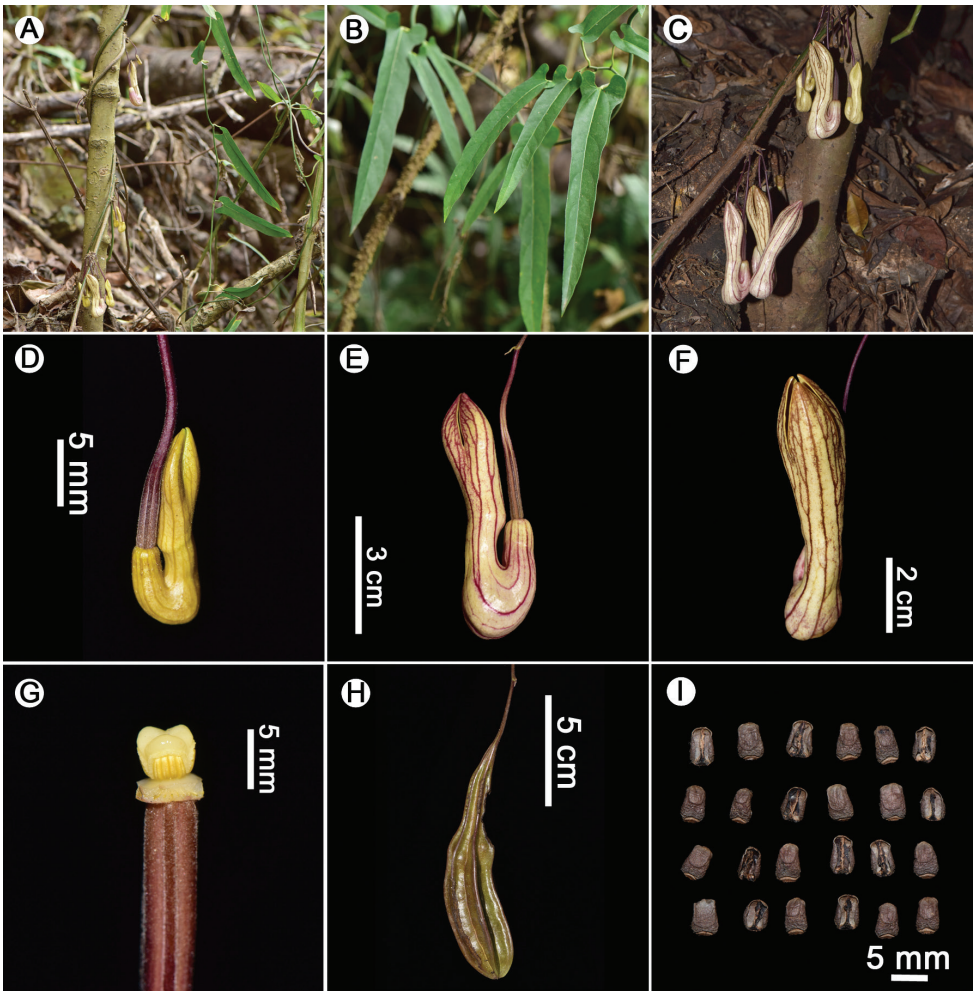

Figure 5. *Aristolochia yangii* X.X.Zhu & J.S.Ma, sp. nov. **A** habit **B** leaves **C** inflorescence **D** flower bud **E** flower (lateral view) **F** flower (front view) **G** anthers and gynostemium **H** fruit **I** seeds. Photographed by Xinxin Zhu.

with more or less reddish-violet above base, upper tube 2.5–3.5 cm long, inside white mix with reddish-violet, limb cylindric, symmetric, 3.3–4.7 cm long, straight extended from upper tube and parallel to it, inside pinkish or ochre, deeply 3-lobed, lobes ovate-deltoid, 1.6–2.4 cm long; throat ca. 7 mm in diam. Anthers 6, oblong, ca. 2 mm long, adnate in 3 pairs to base of gynostemium, opposite to lobes. Gynostemium ca. 3.5 mm long, 3-lobed. Ovary terete, 15–25 mm long, densely brown villous. Fruit stem purple red, ca. 6.5 cm long, sparsely puberulous. Capsule narrowly obovate-elliptic, distinctly 6-angled, nearly glabrous, ca. 10.5 × 2.5 cm (ca. 8.5 × 2 cm in dry specimens). Seeds ovate-elliptic, 5–5.5 × 3.5–4 mm, not winged, the adaxial surface deeply concave and the abaxial surface convex, wrinkled, both surfaces glabrous.

Figure 6. Holotype of *Aristolochia yangii* X.X.Zhu & J.S.Ma, sp. nov. (CSH-0153654).

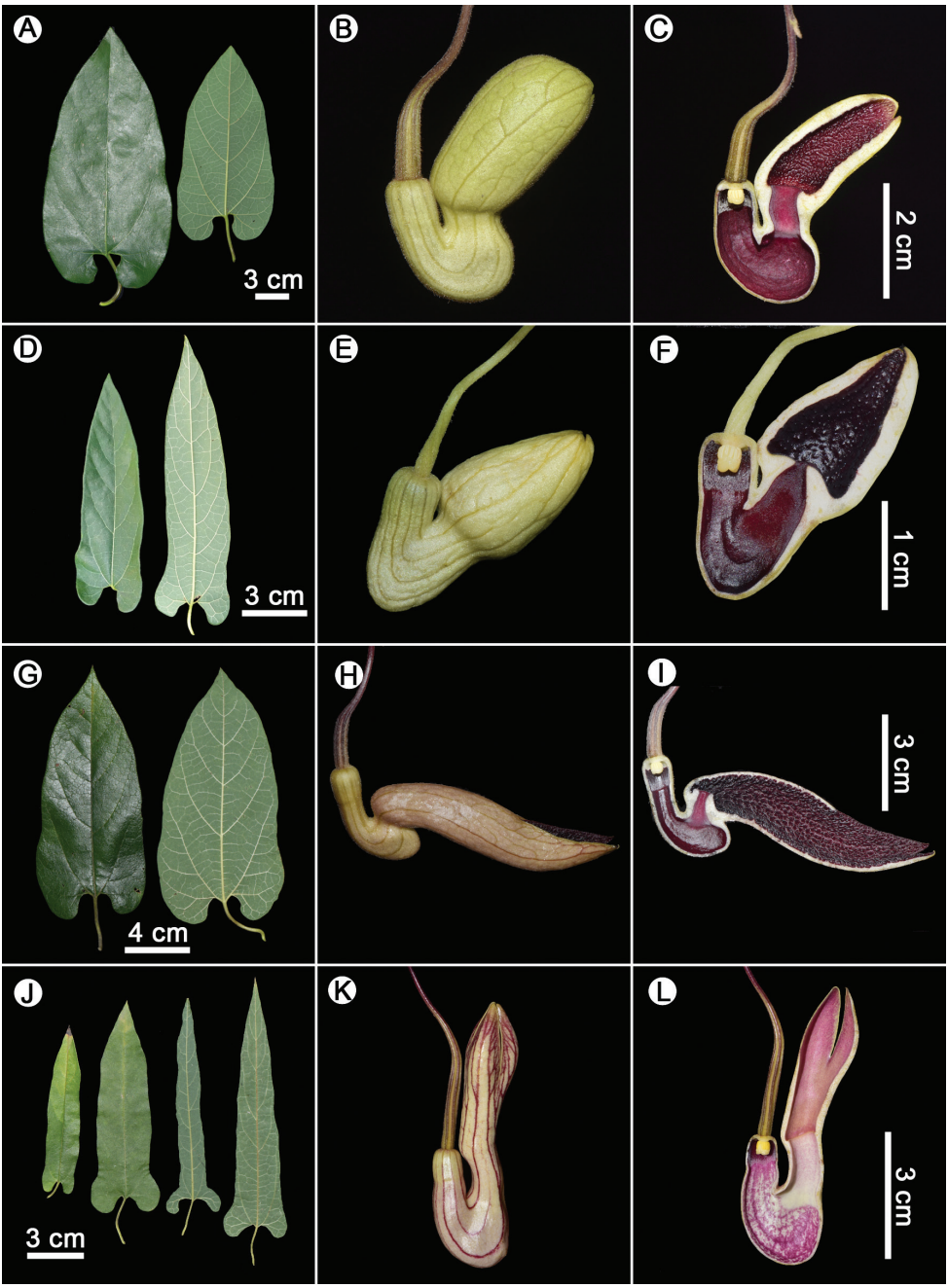

Figure 7.A–C *Aristolochia pseudoutriformis* X.X.Zhu & J.S.Ma, sp. nov. **A** leaves **B** flower (lateral view) **C** opened flower (showing the inside structure). **D–F** *A. utriformis* S.M.Hwang **D** leaves **E** flower (lateral view) **F** opened flower (showing the inside structure). **G–I** *A. forrestiana* J.S.Ma **G** leaves **H** flower (lateral view) **I** opened flower (showing the inside structure). **J–L** *A. yangii* X.X.Zhu & J.S.Ma. **J** leaves **K** flower (lateral view) **L** Opened flower (showing the inside structure). Photographed by Xinxin Zhu (**A–C**, **G–L**); Photographed by Lei Cai (**D–F**).

Phenology. Flowering May and fruiting from July to August.

Etymology. The new species is named after Zhiguang Yang, who first discovered this rare species and who accompanied us on a number of subsequent field expeditions in Hundred Flowers Ridge, Baoshan, Yunnan. The Chinese name is given as "杨氏马兜铃".

Distribution and habitat. The new species is currently known to Longyang District, Baoshan, Yunnan, China. It grows in forests at an elevation of between 1880 m and 2130 m, together with *Castanopsis* ssp. (Fagaceae), *Disporum* sp. (Colchicaceae), *Elytranthe albida* (Bl.) Bl. (Loranthaceae), *Nervilia tahanshanensis* T.P.Lin & W.M.Lin (Orchidaceae), *Rubus* sp. (Rosaceae), etc.

IUCN Red List Category. *Aristolochia yangii* is known from only three populations, with fewer than ten individuals seen at each site. Therefore, the new species is assigned a preliminary status of Vulnerable (VU D2) according to IUCN Red List Criteria (IUCN 2012), indicating a population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer).

Specimens Examined. CHINA. Yunnan: Longyang District, 30 Mar 2015, X.X.Zhu & Z.X.Hua ZH028 (CSH); 4 June2017, X.X.Zhu ZXX17074 (CSH); 11 Aug 2018, X.X.Zhu & J.Wang ZXX18242 (CSH).

Discussion

Aristolochia pseudoutriformis is morphologically similar to *A. utriformis* (Figs. 7D–F) in the shape and colour of flower, but they can be distinguished by the morphology of lamina and limb and the size of throat. It is also similar to *A. forrestiana* (Figs. 7G–I) in the morphology of lamina, whereas they differ in the shape and colour of flower, the morphology of limb, as well as the size of throat (see Table 1 and Fig. 7)

Aristolochia yangii is similar to *A. cucurbitoides* in the shape of lamina, but they can be distinguished by the morphology of flower. It is also similar to *A. forrestiana* (Figs. 7G–I) in the size of flower, whereas they differ in the shape and colour of flower, the morphology of limb, as well as the shape of lamina (summarised in Table 2 and comparison of *A. pseudoutriformis* and *A. forrestiana* is also shown in Fig. 7).

Both two new species with horseshoe-shaped perianth, the 3-lobed gynostemium and each lobe consisting of one pair oblong stamens belongs to *Aristolochia* subgenus *Siphisia* (Ma 1989a). These new discoveries, along with many new species recently described from China and neighbouring countries (Phuphathanaphong 2006; Liu and Deng 2009; Xu et al. 2011; Yao 2012; Huang et al. 2013, 2015; Wu et al. 2013; Do et al. 2014, 2015a, 2015b, 2015c, 2015d, 2017; Huong et al. 2014; Lu and Wang 2014; Ohi-Toma et al. 2014; Ravikumar et al. 2014; Zhu et al. 2015, 2016, 2017a, 2017b, 2018; Gong et al. 2018; Yang et al. 2018) provide evidence that the genus *Aristolochia* and especially *Aristolochia* subgenus *Siphisia* is very diverse in South-East Asia. We predict that more new species of *Aristolochia* will be found after extensive investigations in this region.

Acknowledgements

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RESEARCH ARTICLE

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Two new species of *Cylindrolobus* (Orchidaceae) from the eastern Himalayas

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Abstract

Two new species, *Cylindrolobus motuoensis* and *C. glabriflorus* (Orchidaceae), from Southwestern China and north of Myanmar are described and illustrated with detailed photos. *Cylindrolobus motuoensis* is morphologically similar to *C. gloensis* and *C. foetidus,* but can be distinguished from them by having amplexicaul sterile bracts, dark red floral bracts, white flowers, falcate-lanceolate lateral sepals and central keel of lip running from base to the tip of mid-lobe. *Cylindrolobus glabriflorus* is similar to *C. hegdei* and *C. tenuicaulis* but differs from them by having longer and wider leaves, obovate bracts, and the reddish brown central papillate keel of lip.

Keywords

Taxonomy, Orchidaceae, *Cylindrolobus*, new species, China

Introduction

The genus *Cylindrolobus* Blume consists of 60−70 species, distributed in the tropical region from East Himalaya, China, Southeast Asia to New Guinea (Chen et al. 2009, Ormerod 2014, Ng et al. 2018). *Cylindrolobus* was originally proposed as a section of *Eria* Lindl., Pridgeon et al. (2005) suggested that *Cylindrolobus* should be subsumed into *Callostylis* Blume. Recent molecular and morphological studies suggest that *Cylindrolobus* is a distinct genus, characterized by a multi-noded stem with leaves at apex, short inflorescences with one to several flowers and conspicuous and colorful bracts (Chen et al. 2009, Ng et al. 2018).

Materials and methods

Living plants were collected from Xizang (Tibet) Autonomous Region of China and north of Myanmar during the botanical expeditions in 2016 and in 2018. The shapes, colors of flowers and other details of the plants observed, measured and photographed, as well as specimens collected, were based on living materials from 2017 to 2019. Morphological photographs of the lip, column and pollinia were taken using an Olympus SZX16. All voucher specimens were deposited in KUN (Herbarium of Kunming Institute of Botany, Chinese Academy of Sciences).

Taxonomic treatment

Cylindrolobus motuoensis **X.H.Jin & J.D.Ya, sp. nov.**
urn:lsid:ipni.org:names:60479344-2
Figures 1, 3A

Diagnosis. *Cylindrolobus motuoensis* is similar to *C. gloensis* (Ormerod & Agrawala) Schuit., Y.P. Ng & H.A. Pedersen, and *C. foetidus* (Aver.) Schuit., Y.P. Ng & H.A. Pedersen in terms of morphological structure and shape of the flowers (Hu et al. 2010, Agrawala and Ormerod 2014, Ng et al. 2018). The new species can be distinguished from *C. gloensis* by the smaller flowers, elliptic and concave bracts, and ovate lip with three keels, mid-lobe thickened and papillate on margin. The new species can be distinguished from *C. foetidus* with longer and wider leaves, dark red and elliptic floral bracts, white flowers and falcate-lanceolate lateral sepals.

Type. CHINA. Xizang Autonomous Region: Motuo, subtropical evergreen broad-leaved forest, alt. 2000 m, 26 Feb 2017, *Ji-Dong Ya, Cheng Liu, Hua-Jie He 17HT0073* (holotype: KUN!).

Additional specimen examined. CHINA. Xizang Autonomous Region: Motuo, subtropical, evergreen broad-leaved forest, 26 Feb 2017, *Xiao-Hua Jin, Ji-Dong Ya, 17HT1088* (paratype: KUN!)

Description. Epiphytic herb. Roots terete, slender, pubescent, *ca.*1.0−1.5mm thick. Rhizome creeping, to 3−4 mm thick. Stem terete, slender, 3(2) leaved apically, covered by close-fitting sheaths, 18−24 cm long, 3−6 mm thick. Leaves ligulate-lanceolate, acuminate, 10−13 cm long, 1.5−2.0 cm wide. Inflorescences axillary, pubescent, borne on near the apical of the stem, 2−3 cm long, 2 flowered; peduncle 1.0−1.5 cm long; 2 sterile bracts, smaller, amplexicaul; rachis 0.2 cm long, floral bracts dark red, elliptic, acute, concave, sparsely tomentum, 7 mm long, 3 mm wide. Flowers white, sepal externally with brown tomentum, peduncle and ovary ca. 1.0−1.5 cm long, densely brown tomentum. Dorsal sepal lanceolate, acute, 5 veined, 11 mm long, 4 mm wide; lateral sepals falcate-lanceolate, acute, 5 veined, 9 mm long, 5 mm wide, base adnate to column foot form a subglobose and obtuse mentum; petals lanceolate, slightly oblique, acute, 3 veined, 10 mm long, 3 mm wide; labellum ovate in outline, 3-lobed, base hinged to the apex of the column foot, apex obtuse and emarginate,

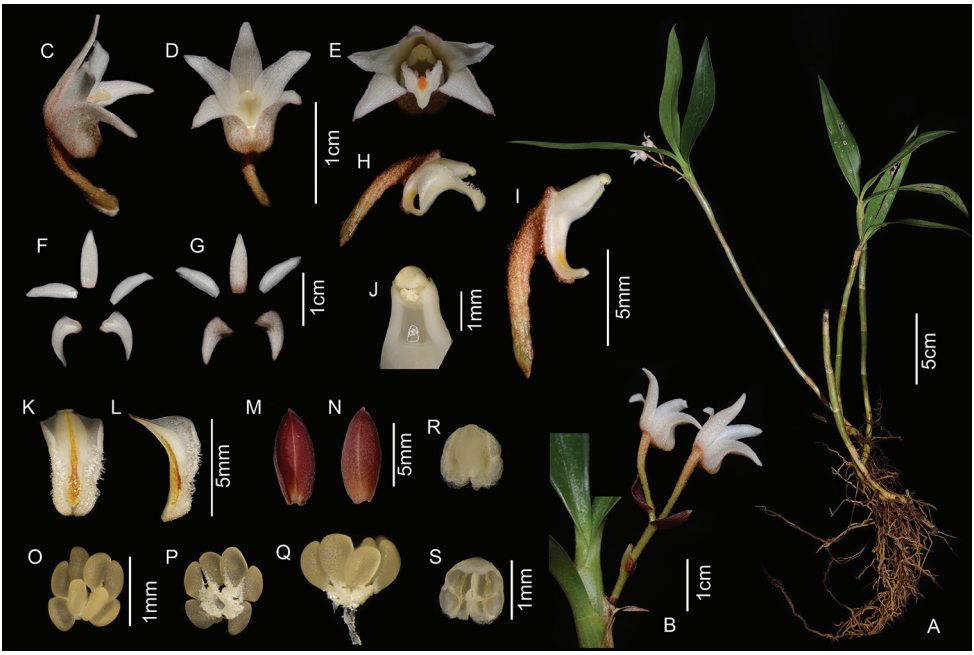

Figure 1. *Cylindrolobus motuoensis* X.H.Jin & J.D.Ya. **A** Plant **B** Inflorescence **C** lateral view of flower **D** ventral view of flower **E** front view of flower **F** adaxial sepals and petals **G** abaxial sepals and petals **H** lateral view of column and lip **I** lateral view of column **J** front view of column **K** front view of labellum **L** lateral view of labellum (rip cutting) **M** adaxial bract **N** abaxial bract **O** polar view of pollinarium **P** ventral view of pollinarium **Q** lateral view of pollinarium **R** adaxial anther cap **S** abaxial anther cap (Photographed by J.-D. Ya).

curved, *c.* 6 mm long, 3 mm wide; lateral lobes suberect, subovate, apex slightly introvert; mid-lobe ligulate, ca. 3 × 3 mm, thickened and papillate on margin, apex emarginate; disk with 3 keels, central keel longitudinal thickened, with orange papilla, running from base to the tip of mid-lobe, lateral keels glabrous, running from base to middle of mid-lobe. Column semiterete, ca. 4 mm long, broad winged at ventrally; foot incurved, ca. 3.5 mm. Anther cap ovate, ca. 1 mm × 1 mm, pollinia 8, yellowish white, compressed rectangular, anterior ca. 0.5 mm × 0.4 mm × 0.2 mm, posterior 4 smaller. Fl. February-March.

Etymology. The new species is named after Motuo, Xizang Autonomous Region of China, where it was discovered in a subtropical evergreen broad-leaved forest.

Vernacular name. Mo Tuo Zhu Lan (墨脱柱兰).

***Cylindrolobus glabriflorus* X.H.Jin & J.D.Ya, sp. nov.**
urn:lsid:ipni.org:names:60479345-2
Figures 2, 3B

Diagnosis. *Cylindrolobus glabriflorus* is similar to *C. hegdei* (Agrawala & H. J. Chowdhery) A. N. Rao and *C. tenuicaulis* (S. C. Chen & Z. H. Tsi) S. C. Chen & J. J. Wood

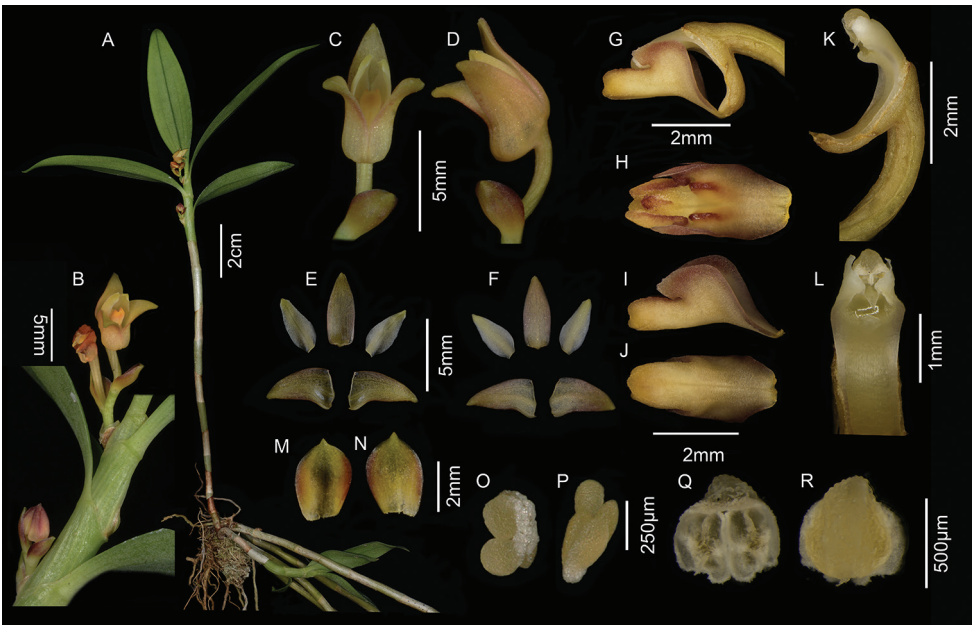

Figure 2. *Cylindrolobus glabriflorus* X.H.Jin & J.D.Ya. **A** Plant **B** inflorescence **C** ventral view of flower **D** lateral view of flower **E** adaxial sepals and petals **F** abaxial sepals and petals **G** lateral view of column and lip **H** front view of labellum **I** lateral view of labellum **J** ventral view of labellum **K** lateral view of column **L** front view of column **M** adaxial bract **N** abaxial bract **O** lateral view of pollinarium **P** polar view of pollinarium **Q** abaxial anther cap **R** adaxial anther cap (Photographed by J.D. Ya).

(Agrawala and Chowdhery 2008, Chen et al. 2009). The new species can be distinguished from *C. hegdei* by the longer and wider leaves, glabrous inflorescence, smaller and yellow flowers, yellowish green and obovate bracts and reddish brown central papillate keel of lip. It differs from *C. tenuicaulis* by having longer and wider leaves, longer inflorescence, yellowish green and obovate bracts, longer lip with three calli, lateral margins of mid-lobe thickened and erect.

Type. MYANMAR. Kachin State: Putao Township, Hponkanrazi Wildlife Sanctuary, subtropical, evergreen, broad-leaved, humid montane forest, alt. 2200 m, 12 Apr 2018, *Xiao-Hua Jin, Ji-Dong Ya 18HT1618* (holotype: KUN!).

Additional specimen examined. CHINA. Xizang Autonomous Region: Motuo, subtropical, evergreen broad-leaved forest, alt. 1796 m, 2 Apr 2019, *Ji-Dong Ya, Cheng Liu, 18HT2586* (paratype: KUN!). CHINA. Xizang Autonomous Region: Motuo, subtropical, evergreen broad-leaved forest, alt. 1750 m, 7 Apr 2018, *Hong Jiang, Weiping Zhang, Zhou-dong Han 07336* (paratype: YAF!).

Description. Epiphytic herb. Roots terete, slender, pubescent, *ca.*0.8−1.0 mm thick. Rhizome inconspicuous. Stem clustered, terete, slender, 4-leaved apically, covered by close-fitting sheaths, 13−25 cm long, 3−4 mm thick. Leaves lanceolate, acuminate, 4.5−6.5 cm long, 0.8−1.5 cm wide. Inflorescences axillary, glabrous, arising from the apical of the stem, 1.3 cm long, 2-flowered; peduncle 0.5 cm long; sterile bracts

Figure 3. Holotype. **A** *Cylindrolobus motuoensis* X.H.Jin & J.D.Ya. **B** *Cylindrolobus glabriflorus* X.H.Jin & J.D.Ya.

1–2, smaller. Flowers yellow, sepal externally reddish yellow, 7–8mm long; floral bracts yellowish green with red brown edges, obovate, mucronate, concave, glabrous, 4 mm long, 2.5 mm wide; peduncle and ovary ca. 4–6 mm long. Dorsal sepal lanceolate, obtuse, 3 veined, 6 mm long, 2 mm wide; lateral sepals falcate-ovate, obtuse, 3-veined, 5 mm long, 3.5 mm wide, base adnate to column foot form a subglobose and obtuse mentum; petals oblong-ovate, slightly oblique at base, obtuse, 1 veined, 5 mm long, 2 mm wide; labellum oblong in outline, 3-lobed, base hinged to the apex of the column foot, apex emarginate, ca.3.5 mm long, 1.5 mm wide; lateral lobes suberect, subovate, apex slightly introvert, disk with 2 reddish brown calli; mid-lobe sub-square, ca. 3.3 mm × 2 mm, lateral margins thickened and erect, with a central papillate keel, reddish brown, ca. 0.5 mm high; apex emarginate. Column semiterete, ca. 3.5 mm long, narrow winged at ventrally; rostellum triangle, 0.2 mm, a hook-like protrusion under the stigma; foot incurved, ca. 4 mm; cap subrotund, ca. 0.6 mm × 0.6 mm, papillate and protrude in front; pollinia 8, yellowish white, compressed subrotund from the lateral view, anterior 4 ca. 0.2 mm × 0.2mm × 0.1mm, posterior 4 smaller. Fl. April-May.

Etymology. The specific epithet "*glabriflorus*" refers to glabrous flowers of this new species.

Vernacular name. Zhong Mian Zhu Lan (中缅柱兰).

Discussion

The generic delimitation of Podochileae Pfitzer has long been confused (Pridgeon et al. 2005, Ng et al. 2018). Recent molecular and morphological evidence reveals that *Eria s.l.* should be split into 21 genera, including *Cylindrolobus* which is morphologically characterized by fleshy and elongate stems, lateral inflorescences, conspicuous and colorful bracts.

These two new species are distributed in a narrow area in the border region between China and Myanmar. We found there are many populations of each species and abundant individuals per population during our botanical expeditions. As the habitats of these two species are in a remote location and the border area has restricted access, the effect of human interference and climate change on them is little known. For the time being, these two species are considered as Least Concern (LC) according to current information on these species and the IUCN Red List category (IUCN 2012).

Located at the margin of Qinghai-Tibet Plateau, Motuo is famous for its vertical vegetation system from tropical forest to permanent glacier with elevation approximately 7000 m, which allow the thriving and diversification of plant diversity. In addition, there are many biodiversity hotspots in the eastern Himalayas, e.g. the north of Myanmar, however the species diversity of this region is poorly known. Hence, the species diversity of these border regions requires solid investigations (Liu et al., 2019) and timely conservation action plans in this region, in order to mitigate increasing anthropogenic disturbance and destruction.

The two new species described here increased the members of *Cylindrolobus* in China to seven species (Chen et al. 2009, Hu et al. 2010, Liu et al. 2013, Ng et al. 2018), the key to Chinese species of *Cylindrolobus* are developed here.

Key to Chinese species of *Cylindrolobus*

1 Stems stout, clavate **2**
– Stems slender, terete **4**
2 Lip yellow ..... ***C. cristatus***
– Lip lateral lobes with purple edges, mid-lobe with lighter purple edges and patch **3**
3 Inflorescence glabrous, the lateral lobes bigger than mid-lobe ..... ***C. clavicaulis***
– Inflorescence pubescent, the lateral lobes smaller than mid-lobe ..... ***C. marginatus***
4 Inflorescence glabrous **5**
– Inflorescence pubescent **6**
5 lip mid-lobe thickened and papillate on margin ..... ***C. tenuicaulis***
– lip mid-lobe not thickened and smoothly on margin ..... ***C. glabriflorus***
6 Flowers yellow ..... ***C. foetidus***
– Flowers white ..... ***C. motuoensis***

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RESEARCH ARTICLE

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Two out of one: revising the diversity of the epiphytic fern genus *Scleroglossum* (Polypodiaceae, Grammitidoideae) in southern China

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Abstract

Our understanding of the flora of China has greatly improved during the last 100 years but effective management of the rich biodiversity and unique natural resources requires resolving the taxonomic limitations of existing treatments. Here, we focus on the epiphytic genus *Scleroglossum* with special emphasis on the occurrences in Hainan and Yunnan of mainland China. By combining fieldwork, herbarium studies, and DNA barcoding we test the hypothesis that this genus is represented by more than one species in China. Our integrative results show the Yunnan accessions are distinct from those in Hainan in both phenotypic and genotypic variation. The Yunnan accessions belong to *S. pusillum*, whereas the Hainan accessions represent a distinct species displaying the morphological characteristics of *S. sulcatum*. Genotypic evidence suggests the occurrence of cryptic diversity among accessions with the morphology of *S. sulcatum*. In summary, the study contributes to the crucial assessment of the plant diversity in Yunnan and illustrates the importance of integrating collection efforts and DNA barcoding approaches to enable effective assessment of the epiphytic diversity of Yunnan.

Keywords
Cryptic speciation, DNA barcoding, grammitid ferns, Yunnan

Introduction

Grammitid ferns (Grammitidoideae, Polypodiaceae) are with ca. 911 species one of the most species rich lineages of ferns (PPG1 2016). These ferns are distributed throughout wet tropical habitats but their ranges expand into wet subtropical and temperate climate zones (e.g. Parris 2003, Ranker et al. 2004, Sundue et al. 2014, Bauret et al. 2017). Most grammitid ferns grow as epiphytes but some species prefer saxicolous or rheophytic habitats. The classification and taxonomy of these ferns have been challenging with the consequence that recent research integrating phylogenetic approaches resulted in a remarkable transformation of the generic classification of these ferns (e.g. Ranker et al. 2004, Sundue et al. 2014, Bauret et al. 2017, Parris 2018). A major challenge is the assessment of local species diversity as a consequence of a combination of factors including the frequent occurrence in remote areas, often restricted and disjunct distribution ranges, and homoplasy in many key-characteristics used to identify these plants (e.g. Parris 2003, 2018, Ranker et al. 2004). The mostly elusive morphological differentiation between closely related grammitid ferns requires careful investigation of the often few available specimens by researchers with special taxonomic expertise. Thus, assessing the threats to the grammitid fern diversity is a challenging but crucial task to enable the conservation of these unique ferns despite the rapid environmental changes of their habitats as a consequence of deforestation and global climate change. The application of DNA-barcoding approaches holds the promise to resolve the species identification issues but very little attention has yet been given to the application of these methods to assess and monitor the occurrences of these ferns. Several studies demonstrated successful application of DNA barcoding to clarify the distribution/ecology of ferns (e.g. de Groot et al. 2011, Nitta et al. 2017) and species taxonomy (Shu et al. 2017) as long as reticulate evolution is taken into account (e.g. Wang et al. 2016, Liu et al. 2018). As a crucial step towards the application of DNA barcoding to monitor the grammitid diversity throughout China, we are required to re-assess the known occurrences and species diversity of these ferns in China.

Similar to other plant groups, our understanding of grammitid ferns diversity of China has been steadily improved. The treatment of these ferns in the Flora Reipublicae Popularis Sinicae (FRPS, Zhang 2000) recognized 22 species, whereas the Flora of China (FOC, Zhang et al. 2013) accepted 31 species. A recent study with special emphasis on Taiwan (Knapp and Hsu 2017) increased the number of species occurring in China to 35 species (see Table 1). Differences between the treatment provided in FRPS and FOC are not only restricted to the number of species recognized (9 species; 29%) and their generic classification but also to the improved understanding of the species identity with several species previously recorded using either synonyms (4 species; 13%) or wrongly applied names (5 species; 16%). However, some conflicts may require further attention. For example, treatments in both FRPS and FOC, agreed on a single species of the mainly tropical Asian genus *Scleroglossum* Alderw. oc-

curring in China but differ about the accepted name. *Scleroglossum pusillum* (Blume) Alderw. was the name recorded for the Chinese occurrences (e.g. Zhang 2000) until the FOC treatment recognized instead *Scleroglossum sulcatum* (Kuhn) Alderw. and the authors argued the misidentification in FRPS (Moore and Parris 2013). These two species are morphologically distinct but frequently confused in older treatments. Both species show a wide distribution range in tropical SE Asia. The most recent treatment of this genus for Vietnam included the two above mentioned species as well as *S. pyxidatum* Alderw. (Parris et al. 2015). Besides, the two treatments (FRPS and FOC) differ in the reported distribution of the genus in China. The FOC treatment reported only Taiwan and Hainan as occurrences, whereas the FRPS treatment accepted a wider range of this species in southern China. Besides Hainan (Mt. Wuzhishan, Mt. Yinggeling) and Taiwan (North), the genus *Scleroglossum* was previously recorded to occur in the Nanling Mountains of Guangdong (Yan et al. 2007, Zhang and Li 2011), Daming Mountain and Shangsi County in Guangxi (Zhou and Li 1993, Qin and Liu 2010, Jiang and Liu 2014), and Mt. Laojunshan in Yunnan (Lu and Zhang 1994). Consequently, the Species Catalogue of China Vol. 1 (Yan et al. 2016) recorded one species of *Scleroglossum*, namely *S. sulcatum*, to occur in Guangdong, Guangxi, Hainan, Taiwan, and Yunnan.

Here, we test the hypothesis that conflicting species identity of the Chinese occurrences of *Scleroglossum* reflects the occurrence of two instead of one representative of this genus in mainland China. Both species considered to occur in China, namely *S. pusillum* and *S. sulcatum*, occur throughout tropical Asia, Malay Archipelago, and the Pacific Islands (Parris et al. 2015, Parris 2018). Their reported range includes Thailand (Lindsay et al. 2009) and Vietnam (Parris et al. 2015). To address this question, we studied living materials of this taxon collected from Hainan and Yunnan. We also compared existing herbarium specimens of known occurrences in Guangdong, Guangxi, Hainan, and Yunnan. Several herbarium collections of *Scleroglossum* from Vietnam were also checked carefully. The comparisons were carried out to detect both phenotypic (morphology) and genotypic (DNA sequences) differentiation between the sampling accessions to recover evidence to support or reject the proposal of two species instead of a single species in mainland China.

Methods

Previous collections of *Scleroglossum* in China were explored by studying digital images available through the online resources of Chinese herbaria [http://www.cvh.ac.cn] and by visiting the herbaria of Kunming Institute of Botany, Chinese Academy of Sciences (KUN), Yunnan University (PYU), and the South China Botanical Garden, Chinese Academy of Sciences (IBSC). All specimens were re-identified using published identification keys (Parris et al. 2015) and comparison with digital images of types available via Global Plants on JSTOR [https://plants.jstor.org]. We also studied published descriptions and images in floristic treatments recording *Scleroglossum* in China (e.g. Ching et al. 1964, Zhang 2000, Knapp 2011, Zhang 2012, Jiang and Liu 2014, Yan and Zhou 2018).

Table 1. Summary of the grammitid ferns (Grammitidoideae, Polypodiaceae) diversity of China (Chinese species printed in bold). Columns report: "Genus" recorded genera according to PPG 1 (2016); "Species" recorded species occurring in China according to the most recent publications; "2000" species reported in Zhang (2000); "2013" species recorded in Zhang et al. (2013); "2016" species recorded in Yan et al. (2016); "2017" species recorded in Yan et al. (2016) plus Knapp and Hsu (2017) ; "TaxCon" consistency of species names used in the different taxonomic records (CO = same name used throughout, MI = misapplied species names in older treatments, NA = not applicable; SY = synonyms used in older publications); "PhyRes" species represented in the *rbcL* dataset (0 = absent, 1 = present)). The following columns report present (1) or absence (0) in Chinese provinces with grammitid records. ChPrSp reports the number of provinces in which each grammitid species has been recorded. The final column "Vietnam" reports occurrences in Vietnam.

Genus	Species	2000	2013	2016	2017	TaxCon	PhyRes	Anhui	Fujian	Jiangxi	Zhejiang	Guangdong	Guangxi	Guizhou	Hunan	Sichuan	Xizang	Yunnan	Hainan	Taiwan	ChPrSp	Vietnam
***Acrosrous* Copel.**	*A. friderici-et-pauli* (Christ) Copel.	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
***Calymmodon* C.Presl**	***C. asiaticus* Copel.**	1	1	1	1	CO	1	0	0	0	0	0	1	0	0	0	0	0	1	0	2	1
	C. concinuus Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***C. gracilis* (Fee) Copel.**	1	1	1	1	CO	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	***C. oligotrichus* T.C.Hsu**	0	0	0	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	***C. ordinatus* Copel.**	0	1	1	1	CO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
***Chrysogrammitis* Parris**	***C. glandulosa* (J.Sm.) Parris**	1	1	1	1	SY	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
***Ctenopterella* Parris**	***C. blechnoides* (Grev.) Parris**	1	1	0	1	SY	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	C. nhatrangensis (Baker) Parris	0	0	1	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
***Dasygrammitis* Parris**	*D. brevivenosa* (Alderw.) Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***D. mollicoma* (Nees & Blume) Parris**	1	1	1	1	CO	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
***Micropolypodium* Hayata**	***M. okuboi* (Yatabe) Hayata**	1	1	1	1	CO	1	0	1	0	1	1	1	1	1	0	0	0	1	1	8	1
	***M. sikkimense* (Hieron.) X.C.Zhang**	1	1	1	1	CO	1	0	0	0	0	0	1	1	1	1	1	1	0	0	6	0
***Oreogrammitis* Copel.**	***O. adspersa* (Blume) Parris**	1	1	1	1	CO	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0
	***O. congener* (Blume) Parris**	1	1	1	1	CO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	***O. dorsipila* (Christ) Parris**	1	1	1	1	CO	1	0	1	1	1	1	1	0	0	0	0	0	0	0	5	1
	***O. hainanensis* Parris**	0	1	1	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

Genus	Species	2000	2013	2016	2017	TaxCon	PhyRes	Anhui	Fujian	Jiangxi	Zhejiang	Guangdong	Guangxi	Guizhou	Hunan	Sichuan	Xizang	Yunnan	Hainan	Taiwan	ChPrSp	Vietnam
***Oreogrammitis* Copel.**	***O. nuda* (Tagawa) Parris**	1	1	1	1	CO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	***O. orientalis* T.C.Hsu**	0	0	0	1	NA	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0
	O. parvula Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***O. reinwardtii* (Blume) Parris**	1	1	1	1	CO	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	***O. sinohirtella* Parris**	0	1	1	1	NA	0	0	1	1	1	1	1	1	1	0	0	0	0	0	7	1
	O. subevenosa (Baker) Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
***Prosaptia* C.Presl**	*P. alata* (Blume) Christ	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***P. barathrophylla* (Baker) M.G.Price**	1	1	1	1	MI	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	***P. celebica* (Blume) Tagawa & K.Iwatsuki**	0	1	1	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	***P. contigua* (G.Forster) C.Presl**	1	1	1	1	CO	1	0	0	0	0	1	0	0	0	0	0	1	1	1	4	0
	***P. formosana* (Hayata) T.C.Hsu**	0	0	0	1	NA	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	0
	***P. intermedia* (Ching) Tagawa**	1	1	1	1	MI	0	0	0	0	0	1	1	0	0	0	0	0	1	1	4	1
	***P. nutans* (Blume) Mett.**	0	1	1	1	NA	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
	***P. obliquata* (Blume) Mett.**	1	1	1	1	CO	1	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1
	P. pectinata T.Moore	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***P. urceolatis* (Hayata) Copeland**	0	1	1	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
***Radiogrammitis* Parris**	***R. alepidota* (M.G.Price) Parris**	0	1	1	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	R. beddomeana (Alderw.) Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***R. ilanensis* T.C.Hsu**	0	0	0	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	R. jagoriana (Mett. Ex Kuhn) Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***R. moorei* Parris & Ralf Knapp**	0	1	1	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
***Radiogrammitis* Parris**	***R. setigera* (Blume) Parris**	1	1	1	1	SY	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	***R. subnervosa* T.C.HSu**	0	0	0	1	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	***R. taiwanensis* Parris & Ralf Knapp**	1	1	1	1	MI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Genus	Species	2000	2013	2016	2017	TaxCon	PhyRes	Anhui	Fujian	Jiangxi	Zhejiang	Guangdong	Guangxi	Guizhou	Hunan	Sichuan	Xizang	Yunnan	Hainan	Taiwan	ChPrSp	Vietnam
***Scleroglossum* Alderw.**	***S. pusillum* (Blume) Alderw.**	1	0	0	0	NA	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	S. pyxidatun Alderw.	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***S. sulcatum* (Kuhn) Alderw.**	0	1	1	1	MI	1	0	0	0	0	1	1	0	0	0	0	0	1	1	4	1
***Themelium* (T.Moore) Parris**	***T. blechnifrons* (Hayata) Parris**	1	1	1	1	MI	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	T. halcoense (Copel.) Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	***T. tenuisectum* (Blume) Parris**	1	1	1	1	CO	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
***Tomophyllum* (E.Fournier) Parris**	***T. donianum* (Spreng.) Fraser-Jenk.**	1	1	1	1	MI	0	1	0	0	0	0	0	1	1	1	1	1	0	0	6	1
	T. repandulum (Mett.) Parris	0	0	0	0	NA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
***Xiphopterella* Parris**	***X. devolii* S.J.Moore, Parris, W.L.Chiou**	0	1	1	1	NA	1	0	1	0	1	1	1	0	0	0	0	0	0	1	5	0
	X. parva Parris	0	0	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Species per provinces		22	31	31	36		18	1	4	2	4	8	9	4	4	2	2	4	10	28		
Proportion of species diveristy							46%	3%	11%	5%	11%	22%	24%	11%	11%	5%	5%	11%	27	76%		

Fieldwork was carried out to obtain new collections from known localities in Hainan (Mt. Yinggeling) and SE Yunnan. Potential new localities in western Yunnan (Tongbiguan) besides previous reported occurrences were explored to assess the real current distribution range in mainland China (Mt. Laojunshan, Yunnan and Mt. Yinggeling, Hainan). Together with samples from different herbaria, these specimens were studied to determine the phenotypic variation and to re-identify the accessions using determination keys (Parris et al. 2015). Morphological observations were carried out using a microscope for some detailed observations.

Genomic DNA was extracted from the newly collected accessions (Hainan and Yunnan) as well as some herbarium specimens including collections from Vietnam, Guangxi, Guangdong and Yunnan using standard DNA extraction protocols (Liu et al. 2007, Liu 2016). Given the available amount of *rbcL* sequences of grammitid ferns in GenBank (www.ncbi.nlm.nih.gov) and the initial analyses of the variation among available sequences of *Scleroglossum*, we restricted our analyses to the *rbcL* component of the CBOL barcode of land plants (CBOL Plant Working Group 2009). The sequences were obtained using primers and protocols used for grammitid ferns in the past (Ranker et al. 2004). All *rbcL* sequences of grammitid ferns available in GenBank till October 2018 were downloaded and integrated in a single alignment using Mesquite 3.04 (Maddison and Maddison 2018). Newly generated sequences were assembled and then incorporated into the global alignment. The alignment included three species of *Scleroglossum* previously studied, namely the GenBank accessions of *S. pusillum* (KM218812, KY712079 from Malay Peninsula and Thailand respectively), *S. sulcatum* (AY460664, AY460665,

KY099861 from Pohnpei and Moorea), and *S. wooroonooran* (F.M.Bailey) C. Chr. (KM218809, KM218810 from Australia) plus newly generated sequences of the Hainan Accession (one location, two specimens) and Yunnan Accession (one location, one specimen). Besides, we obtained sequences of two accessions collected in Vietnam that were deposited at KUN. Unfortunately, most of the herbarium specimens were failed in sequence generation. Appendix 1 provides the information on all newly generated accessions including herbarium voucher, area of origin, and GenBank accession number.

The genetic variations among the *rbcL* sequences were compared pairwise among all available and newly generated accessions of *Scleroglossum* (Table 2) by recording sequence similarity in % and number of substitution events. The phylogenetic relationships were reconstructed using maximum likelihood via PhyML 3.0 (Guindon and Gascuel 2003, Guindon et al. 2010) and Bayesian inference via MrBayes 3.2 (Ronquist et al. 2012). The substitution model was determined using jModeltest 2 (Darriba et al. 2012) with the Bayesian Information Criterion (BIC; Schwarz 1978). The number and kind of parameters (mutation type, gamma and invariable sites) were set as the default in the phylogenetic analyses but the parameter values estimated empirically during the phylogenetic analyses (model selected: GTR+I+G). TRACER 1.5 (Rambaut and Drummond 2009) and FIGTREE 1.4.2 (Rambaut 2014) were used to summarize and visualize the results.

The biogeography of the Chinese grammitid ferns (Table 1) was assessed based on existing records reported in recent treatments combined with herbaria records. The distribution was then explored using neighbor-joining cluster analyses reconstructed with Jaccard distances. The dataset was also used to assess the conservation status based on the IUCN Red List Categories and Criteria (IUCN 2012). All statistical analyses were carried out using R version 3.5.1 (R Development Core Team 2018). The IUCN assessment was assisted by the ConR package (Dauby et al. 2017).

Results

Phenotypic differentiation

New locality in Yunnan is occurred in Tongbiguan Provincial Nature Reserve (Dehong, 24°19'55.68"N, 97°43'45.51"E, alt., 1443m). The Yunnan accession (Fig. 1A–E) shared with the Hainan accession (Mt. Yinggeling, 19°24'15.9"N, 109°32.07'E, alt., 1749m; Fig. 1F–H) the characters of short, erect, radial rhizome (Fig. 1C, 1F), non-articulated leaves with simple lamina and short petioles, concolorous and glabrous rhizome scales, free veins, absence of hydathodes, branches hairs attached to the lamina (Fig. 1D, 1G), and coenosori arranged in parallel to the margins (Fig. 1E, 1H). However, the Yunnan accession differed from the Hainan accession in the lamina texture and positioning of the coenosori. The Yunnan accession (YunAcc) has a thick lamina margin with the coenosori arranged in submarginal grooves (Fig. 1E), whereas the Hainan accession (HaiAcc) shows a thin lamina margin with the coenosori arranged in grooves on the abaxial surface of the lamina (Fig. 1H). Compared with the established species differentiation in the ge-

nus *Scleroglossum*, the Hainan accession should be identified as *S. sulcatum*, whereas the Yunnan accession should be identified as *S. pusillum*. The Yunnan accession differs from *S. pyxidatum* because the lamina was not narrowed below the sori and wider than 2 mm.

Genotypic differentiation

Pairwise comparisons of the *rbcL* sequences of the seven distinct *Scleroglossum* sequences recovered a sequence variation between 99.7% and 100% (Table 2). The two accessions of *S. wooroonooran* (KM218809, KM218810) showed a similarity of 99.4%, whereas the accessions of *S. pusillum* from Malay Peninsula (KM218812) and Thailand (KM211812) showed a similarity of 99.4%. The accession obtained in Yunnan (YunAcc in Table 2) showed a similarity of 99.9% with the *S. pusillum* from Thailand and a 99.3% similarity with *S. pusillum* of the Malay Peninsula. The Hainan accession (HaiAcc) and Yunnan accession (YunAcc) showed a similarity of 98.9%. Accessions of *S. sulcatum* obtained from Pacific Islands and Vietnam showed a similarity between 100% and 99.5%. The Yunnan accession and Hainan accession showed similarities to accessions of *S. sulcatum* below 99.0% (Table 2).

The phylogenetic reconstruction recovered the Yunnan accessions to be nested in clade comprising the two *Scleroglossum pusillum* accessions (Fig. 2), whereas the Hainan accessions formed an independent lineage that was part of the polytomy involving the *S. pusillum* and *S. wooroonooran*. The Vietnam accessions nested together with previously obtained accessions of *S. sulcatum* occurring on the Pacific Islands (Moorea, Pohnpei).

Table 2. RbcL sequence variation among *Scleroglossum* samples studied. GenBank accession numbers are given for those available in GenBank, whereas specimens accessions are given for newly obtained sequences, namely YunAcc = Yunnan population, HaiAcc = Hainan populations (all sequences obtained for this population were identical), and two Vietnam accessions (VieAcc1 and VieAcc2). Sequence variation are given as pairwise similarity (upper-right corner, in %) and number of substitution events (lower-left corner). Sequence pairs with a similar >99% are marked in Bold.

	YunAcc	**HaiAccA&B**	**KY712079**	**KM218812**	**VieAcc1**	**VietAcc2**	**AY460664**	**AY460665**	**KY099861**	**KM218809**	**KM218810**
YunAcc	–	98.9	**99.9**	**99.3**	98.5	98.5	98.4	98.5	98.5	98.4	98.5
HaiAccA&B	13	–	99	98.7	98.1	98.1	98.1	98.3	98.3	98.1	98.3
KY712079	1	12	–	**99.4**	98.6	98.7	98.5	98.7	98.7	98.4	98.6
KM218812	9	16	8	–	98.5	98.6	98.6	98.7	98.7	98.1	98.4
VieAcc1	19	24	17	18	–	**99.9**	**99.5**	**99.8**	**99.8**	97.7	97.8
VieAcc2	18	23	16	17	1	–	**99.7**	**99.8**	**99.8**	97.7	98
AY460664	20	23	18	17	6	4	–	**99.8**	**99.8**	97.7	98
AY460665	18	21	16	15	3	2	2	–	**100**	97.8	98.1
KY099861	18	21	16	15	3	2	2	0	–	97.8	98.1
KM218809	20	24	20	24	29	29	29	27	27	–	**99.4**
KM218810	18	21	17	20	27	26	26	24	24	7	–

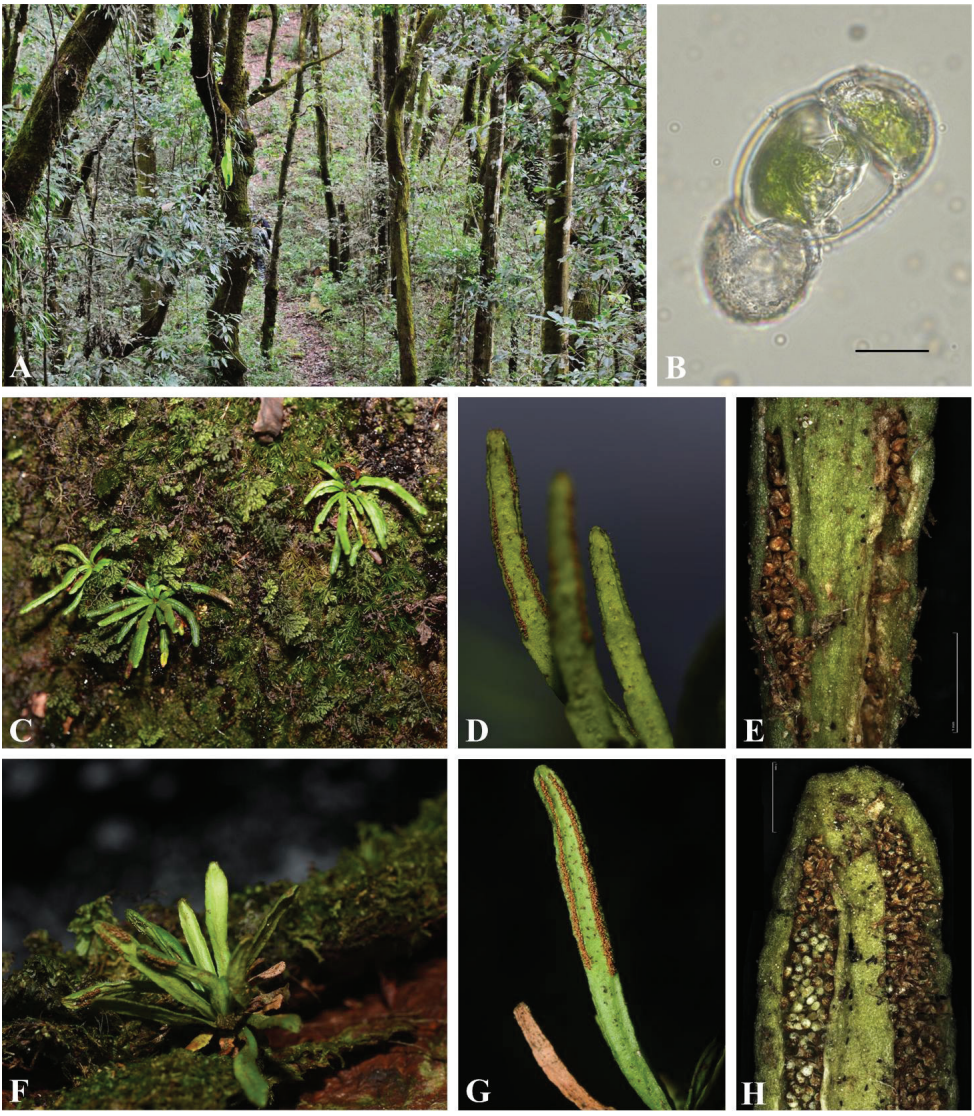

Figure 1. The grammitid genus *Scleroglossum* in China. **A–E** *Scleroglossum pusillum* in Yunnan (YunAcc) and **F–H** *Scleroglossum sulcatum* in Hainan (HaiAcc). **A** habitat of *S. pusillum* occurrences in Yunnan **B** germinated green spore recovered from opened mature sporangia of *S. pusillum*. The remains of the spore wall are visible at the lower part of the larger of the two cells that both contain mature chloroplasts. The smaller cell is the first daughter cell formed by the first cell division **C** habit of *S. pusillum* **D** close up of the dorsal surface of the simple leaves showing the location of the submarginal sori and the occurrences of brown branched hairs of *S. pusillum* **E** close up of the sorus structure showing the placement at the submargin of the leaves in *S. pusillum*. **F** habit of *S. sulcatum* **G** close up of the dorsal surface of the simple leaves showing the location of the not submarginal sori and the occurrences of brown branched hairs of *S. sulcatum* **H** close up of the sorus structure showing the placement of the sori in dorsal grooves and a distinct lamina margin in *S. sulcatum*. Scale bars: 0.02 mm (**B**); 1 mm (**E, H**).

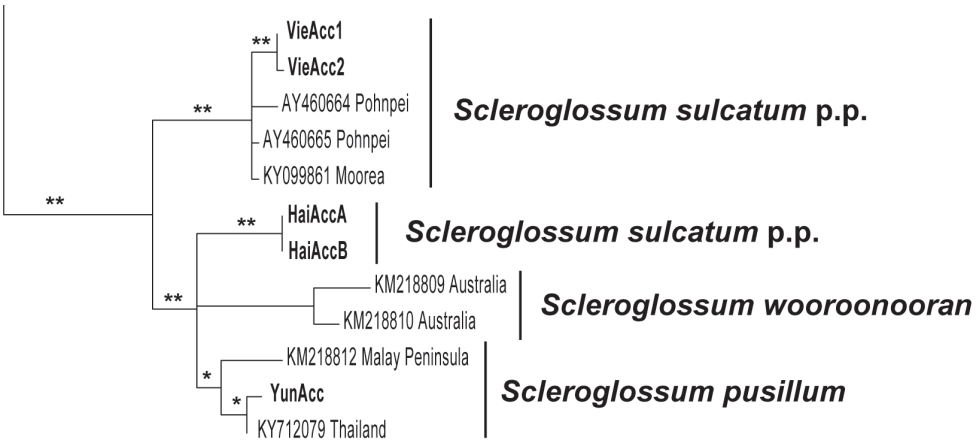

Figure 2. Reconstruction of the phylogenetic relationships of *Scleroglossum* species occurring in China including all accessions available in GenBank (October 2018). Newly generated accessions are printed in bold: HaiAcc = Hainan Accessions, two sequences obtained from individual A and B; YunAcc = Yunnan Accessions; VieAcc1 and VieAcc2 = two accessions obtained from the herbaria collections at KUN representing two independent collections (see Suppl. material 1: Table S1). The areas of origin are given for *Scleroglossum* GenBank accessions. The presented consensus phylogram is based on a Bayesian inference of Phylogeny including 690 accessions represented by *rbcL* sequences. Clades composed by non-*Scleroglossum* accessions were pruned. Two stars mark clades with a posterior confidence of p = 1.00 whereas one star marks clade with a posterior confidence p ≥ 0.95 and < 1.00. p.p. = pro parts to indicate the polyphyly of *S. sulcatum.*

Discussion

Species identity

The Hainan and Yunnan accession are distinct in both phenotype and genotype. Thus, two instead of one species of *Scleroglossum* occur in mainland China. Both genotypic and phenotypic evidence support the conclusion that the Yunnan accessions belong to *S. pusillum*. This is consistent with the original report of this taxon in Yunnan (Lu and Zhang 1994). Phylogenetic analyses supported *S. pusillum* occurring in Thailand as the closest relative of the Yunnan occurrences. In contrast, the taxonomic treatment of the Hainan accession is less clear. Phenotypic evidence supports the treatment as *S. sulcatum*, as established previously in the FOC treatment (Moore and Parris 2013). However, the genotypic evidence did not support this conclusion because the Hainan accessions were distinct from all other accessions obtained so far for *Scleroglossum* including not only *S. pusillum* (KM218812; KY712079) and *S. wooroonooran* (KM218809, KM218810), but also *S. sulcatum*. The phylogenetic analyses recovered a clade comprising accessions with the *S. sulcatum* morphology collected in the Pacific Islands of Moorea (KY099861) and Pohnpei (AY40664, AY40665) as well as the two newly obtained accessions from Vietnam. Thus, the Hainan accession may represent a new species which is morphological distinct from the Yunnan accession but not from the *S. sulcatum* accessions from Vietnam. Morphological evidence supports the occurrence of the *S. sulcatum* morpho-

type also in Guangxi, Guangdong, and Taiwan. However, we currently lack genotypic evidence to assign these specimens to the genotypic differentiated forms of *S. sulcatum*.

Taxonomic treatment

Species of *Scleroglossum* occurring in mainland China can be identified using the morphological key presented for Vietnam species (Parris et al. 2015). However, we encountered a conflict between the phenotypic and genotypic variation because *S. sulcatum* was recovered as polyphyletic (Fig. 2). This conflict may be explained as a consequence of cryptic speciation (Bickford et al. 2007). Conflicting results between genotype- and phenotype- based species recognition have been reported for several recent diverging fern lineages (Paris et al. 1989) and epiphytic liverworts colonizing similar habitats as *Scleroglossum* (Yu et al. 2013). However, the taxonomic treatment of cryptic or semi-cryptic species is challenging as a consequence of theoretical and practical issues (Jörger and Schrödl 2013). Given the small sample size, we recommend a treatment that is based on the phenotypic variation, meaning *S. sulcatum*, until more evidence will be obtained. This approach avoids unstable taxonomic solutions which are important especially given the lack of evidence concerning the genotype of the type collection of this widespread species. The type was collected on the island of Sri Lanka (lectotype: Thwaites 3807; see Parris et al. 2015) however none of the currently available *rbcL* sequences of this species has been obtained from Sri Lanka. Given the cryptic phenotypic differentiation of the two genotypes, we cannot conclude to which the type may belong. Thus, the introduction of a new name may create more confusion but we must stress that the taxonomic status of the populations currently treated as *S. sulcatum* require further study.

DNA barcoding

Besides this problem, DNA barcoding using the *rbcL* region appears to be sufficient to resolve the DNA based identification of grammitid ferns in China with all species included having a distinct *rbcL* sequence. However, several species such as the Hainan endemic *Oreogrammitis hainanensis* Parris require to be studied to confirm that this conclusion is true for all grammitid ferns occurring in China. So far, *rbcL* sequences have been obtained for only 45.9% of the Chinese grammitid species. Representatives of the four genera including more than one species in China that were presented with at least two species – namely *Calymmodon* C. Presl, *Micropolypodium* Hayata, *Oreogrammitis* Copel., and *Prosaptia* C. Presl – were distinct from each other in our dataset. Some of the Chinese species were not clearly distinct from closely related non-Chinese species, e.g. *P. contigua* and *P. obliquata*. A further limitation of *rbcL* based barcoding is the problem differentiating some of the proposed generic concepts, such as *Oreogrammitis* Copel., *Radiogrammitis* Parris, and *Theme-*

lium (E. Four.) Parris (see also Sundue et al. 2014). The generic concept of these ferns requires arguably further attention besides the urgent need to focus more on the species taxonomy.

In turn, the application of DNA barcoding recovered a conflict between taxonomic treatments based exclusively on phenotypic evidence with the genotypic evidence. This is consistent with the hypothesis that the frequent employment of these approaches will not only help to resolve conflicting interpretations of phenotypic differentiation (see Yu et al. 2013, Zhou et al. 2016) but also recover more cases of cryptic/ semi-cryptic species differentiation (Pickford et al. 2006). Given the species richness of the fern floras of the southern provinces of China, future studies integrating phenotypic and genotypic evidence may recover more instances of cryptic or semi-cryptic taxa. Some of these taxa may turn out to be the consequence of hybrid-speciation (e.g. Liu et al. 2018) but other processes such as limitations to the accessible morphospace may contribute also to the accumulation of cryptic fern diversity (see Schneider 2016). The genus *Scleroglossum* as well as other grammitid ferns is arguably well suited to explore the role of rapid diversification and ecological conservatism in the decoupling of the accumulation of species diversity and morphological disparity (Schneider 2016). As shown by Liu et al. (2018), the interpretation of DNA barcode based species identification may result in misleading species assessment if the ploidy level has not been assessed. However, relatively little attention has been given to the study of polyploidy in grammitid ferns so far. About 23% of the published 43 chromosome counts of grammitid ferns indicate the occurrence of polyploidy (Schneider unpublished), which is substantially lower than the frequency of polyploidy in *Asplenium* (Schneider et al. 2017). However, no chromosome counts have been published for the genus *Scleroglossum* yet.

The recovered success of DNA based identification of *Scleroglossum* species may enable future studies to report not only the distribution of the sporophytic generation but also the distribution of the gametophytic stage of the life cycle. A recent study provides distinct distribution patterns observed for fern gametophyte and sporophyte generations of the same species on the Pacific island of Moorea (Nitta et al. 2017). This is especially important to studies focusing on grammitid ferns because this fern lineage includes gametophytes reproducing independently of their sporophytes in geographically disjunct populations (Farrar 1967; Dassler and Farrar 2001).

Biogeography of Chinese grammitid ferns

Given the global distribution of grammitid ferns (see Sundue et al. 2014; Bauret et al. 2017), Chinese grammitid ferns occur mainly in the two larger islands namely Hainan (10 spp., 27% of the Chinese species diversity) and Taiwan (28 spp., 76% the Chinese diversity) and preferably in the southern provinces of Guangdong (8 spp., 22% the Chinese diversity) and Guangxi (9 spp., 24% the Chinese diversity). The remaining provinces with wet subtropical to tropical climate house four (Fujian, Guizhou,

Hunan, Yunnan, Zhejiang), two (Jiangxi, Sichuan, Xizang), or one (Anhui) species (Table 1). The low number of grammitid species recorded until now in Yunnan is a bit surprising given the remarkable fern richness of this province especially in the tropical southern parts (Zhou et al. 2016).

Analyses focusing on the similarities among the grammitid floras of Chinese provinces recovered similarities (Fig. 3) between the grammitid rich islands of Hainan (10 spp.) and Taiwan (28 spp.) and the two southern provinces Guangdong (8 spp.) and Guangxi (9 spp.). The East China provinces Fujian (4 spp.), Zhejiang (4 spp.), and Jiangxi (2 spp.) formed together a cluster (Fig. 3), whereas Anhui (1 spp.) was nested in cluster including Southwest China provinces, namely Sichuan (2 spp.), Xizang (2 spp.), Yunnan (4 app.), Guizhou (2 spp.), and Hunan (2 spp.). These results are consistent with the prediction that the grammitid diversity is mainly shaped by differences in the climatic conditions but this requires further analyses.

Conservation of *Scleroglossum* in China

Several species of grammitids including *Scleroglossum sulcatum* were listed in the Red List of Chinese Plants (Qin et al. 2017), but none of the Chinese species have been listed in the list of rare and threatened species of Asia (Ebihara et al. 2012). Furthermore, the more recent list did not mention any species of *Scleroglossum* as rare or threatened. This difference is arguably the consequence of the context differences of a national (Qin et al. 2017) and a global (Ebihara et al. 2012) focus of the assessment. As a consequence of our results, the Red List of Chinese Plants needs some changes. In 2017, *S. sulcatum* was listed as VU D1+2 (Qin et al. 2017), but this assessment is likely based on the assumption of a single species with occurrences in five provinces of China (Yan et al. 2016). Given the recognition of the Yunnan occurrences as *S. pusillum*, the range of *S. sulcatum* has been reduced from five to four provinces of China. However, the current range is sufficient to maintain the status reported (Qin et al. 2017). In contrast, the Chinese populations of *S. pusillum* may be highly vulnerable but further assessments are needed. We recorded this species for the first time to occur in western Yunnan namely Mt. Tongbiguan, Dehong but were unable to confirm the previous records in southeastern Yunnan namely Mt. Laojunshan, Malipo. However, both species are considered as least concern (LC) considering the distribution range comprising most of tropical Asia and some islands in the Pacific and Indian Oceans.

In our study, we are able to confirm the occurrences in both Yunnan and Hainan. As mentioned above we obtained a new record from western Yunnan but failed to reconfirm the occurrence in southeastern Yunnan. During fieldwork we confirmed the occurrence of these ferns in one of the two locations recorded in Hainan namely the Mt. Yinggeling population but did not recollect the Mt. Wuzhishan population. The Guangxi and Guangdong occurrences have been surveyed in recent years (Zhou and Li 1993, Yan et al. 2007, Zhang and Li 2011, Jiang and Liu 2014). Thus, all recorded populations of these ferns in China are arguably stable despite the restriction to isolated localities result

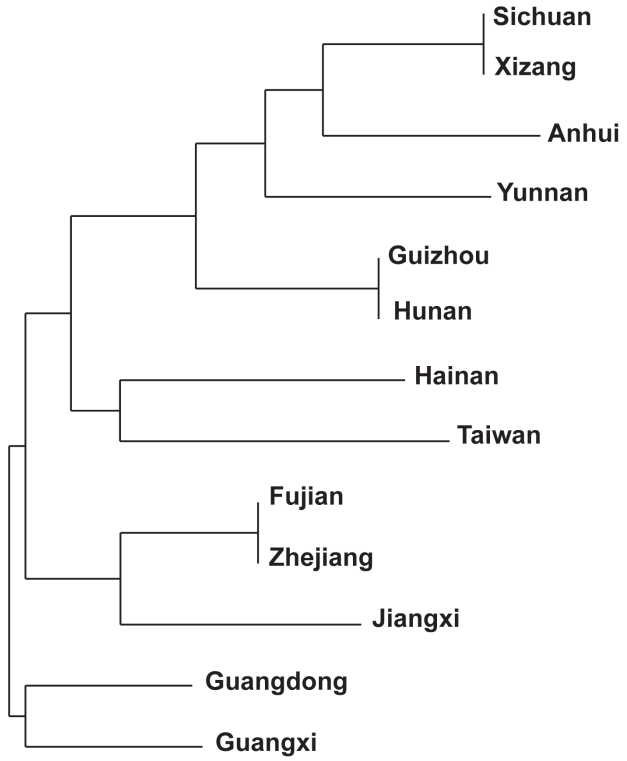

Figure 3. Similarity clustering of the Chinese provinces that are home to at least one grammitid ferns. The clustering analysis was carried out using Jaccard distances and the NJ-tree building algorithm. The underlying scoring (Table 1) was carried out as absence (0) and presence (1).

in local threats. All known Chinese occurrences are within national parks that will arguably enable effective protection of these populations. However, we still recommend that the number of individuals need to be regularly assessed. At the current stage, the IUCN red list assessment are based on species identification using the phenotypic differentiation only and thus they are arguably misleading for lineages including cryptic- or semi-cryptic species as recovered in *S. sulcatum* (see above). Thus, assessments of the distribution of *S. sulcatum* are arguably inaccurate. Furthermore, very little information exists about the number of individuals per site which limits any assessment of the potential dynamics of population size shrinking or expansion. Finally, the distribution of the two *Scleroglossum* species throughout tropical SE Asia and Pacific Islands may lack the accuracy requested to enable reliable IUCN assessments. Many older collections of these species lack detailed information about the collecting sites and several putative occurrences require to be re-confirmed by recollecting.

Conclusions

Our study on the grammitid fern *Scleroglossum* in China illustrated the importance of combining field assessments together with traditional morphological (phenotype) and DNA barcoding (genotype) approaches to improve our knowledge of the distribution of plants occurring in remote wet forest habitats of southern China. The assessment and conservation of these local rare species is challenging but the usage of DNA barcoding approaches may enable reliable surveys that do not require the involvement of the few taxonomic experts. In turn, these assessments may also provide crucial information to improve existing taxonomic treatments by providing evidence to test taxonomic concepts that may be challenged by the occurrence of cryptic species.

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Supplementary material 1

Table S1

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RESEARCH ARTICLE

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Yushania tongpeii (Poaceae, Bambusoideae), a new bamboo species from north-eastern Yunnan, China

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Abstract

Yushania tongpeii D.Z.Li, Y.X.Zhang & E.D.Liu, a new species of the temperate bamboo tribe Arundinarieae (Poaceae: Bambusoideae), is described and illustrated from north-eastern Yunnan, China. *Yushania tongpeii* is characterised by taller branching from nodes 1–2 m above the ground, usually three branches at the node, sparse purple spots and thin white powder on the internode, densely purple-spotted culm sheaths, glabrous margins of culm sheaths and tomentose leaf ligules. Based on the morphological features, this new species is assigned to section *Yushania*.

Keywords

New species, north-eastern Yunnan, temperate woody bamboos, *Yushania* sect. *Yushania*

Introduction

Yushania P.C.Keng, (1957) is one of the largest genera of the tribe Arundinarieae (i.e. the temperate woody bamboos) (Poaceae, Bambusoideae). It consists of more than 80 species, which are mainly distributed in the mid-elevation mountains and

subalpine areas (1000–3800 m alt.) of East and Southeast Asia, with the centre of diversity situated in south-western and south-eastern China (Keng 1957, Keng and Wang 1996, Ohrnberger 1999, Li et al. 2006, Vorontsova et al. 2017, Yi et al. 2008, 2017), especially the biodiversity hotspot Mountains of Southwest China. These bamboos are dominant elements for the understorey vegetation of the forest ecosystem. More than 70 species of *Yushania* have been described in China (Yi et al. 2008, 2017), some of which are the staple food of the giant panda (Yi and Jiang 2010).

Species of *Yushania* are characterised by the long-necked rhizomes, diffuse culms, one to many branches at the node, semelauctant and paniculate inflorescence and three stamens (Li et al. 2006). Most taxa of this genus were described without reproductive features due to infrequent flowering. Only 11 species have inflorescence information in *Flora Reipublicae Popularis Sinicae* (Keng and Wang 1996) and *Flora of China* (Li et al. 2006). The genus *Yushania* is divided into two sections, i.e. *Y.* sect. *Brevipaniculatae* T.P. Yi and *Y.* sect. *Yushania*, based mainly on the culm height and branch number at the node (Yi 1986, 1995). Sect. *Brevipaniculatae* is distinguished by taller culms, many and subequal branches at each node and terminal panicles or racemes; while species of sect. *Yushania* are usually shorter and have 1 branch at the mid-culm node or 1 branch at the lower part of the culm and 3–8 branches at the upper part of the culm and terminal panicles.

During a botanical survey to Sanjiangkou, Wumengshan National Nature Reserve, Daguan County, Yunnan, China in 2016, specimens and relevant DNA samples of several bamboo species were collected. One of them has long-necked rhizomes, usually three branches at the node and occurs at elevations around 2300 m. These characters are typical of the genus *Yushania*. After comparison with specimens of *Yushania* deposited at KUN and some literature (e.g. Keng and Wang 1996, Li et al. 2006, Yi et al. 2008, 2017), we concluded that it did not match any described species of *Yushania*. In order to know more about its habitat, distribution range and morphological features, we revisited Sanjiangkou, Wumengshan National Nature Reserve in September 2018 and more specimens were collected. In this paper, we described it as a new species, i.e. *Yushania tongpeii* D.Z.Li,Y.X.Zhang & E.D.Liu.

Materials and methods

Observation and measurement of morphological characters of the new species were carried out in the field and the herbarium, based on living plants and specimens. Some characters were observed by stereomicroscope (Leica S6E). Morphological features of the related species (*Yushania oblonga* T.P.Yi, *Y. pingshanensis* T.P.Yi and *Y. straminea* T.P.Yi) were obtained from literature (Keng and Wang 1996, Li et al. 2006, Yi et al. 2008) and specimens deposited at KUN.

Taxonomy

***Yushania tongpeii* D.Z.Li, Y.X.Zhang & E.D.Liu, sp. nov.**
urn:lsid:ipni.org:names:60479346-2
Figures 1, 2

Diagnosis. *Yushania tongpeii* is morphologically similar to *Y. oblonga*, *Y. pingshanensis* and *Y. straminea*, but can be easily distinguished by having taller branching from nodes 1–2 m above the ground, sparse purple spots on the internode, densely purple spotted culm sheaths, glabrous margins of culm sheaths and tomentose leaf ligules.

Type. CHINA. Yunnan: Daguan County, Wumengshan National Nature Reserve, Sanjiangkou, 28°13'16"N, 103°54'1"E, 2260 m alt., 29 September 2018, *Y.X. Zhang* et al. *18180* (holotype: KUN!; isotype: KUN!).

Description. Rhizomes pachymorph, rhizome neck 17–41 cm long, 0.4–0.6 cm in diameter, solid. Culms 2–5 m tall, 0.8–1.5 cm in diameter; internodes terete, 15–38 cm long, initially sparsely purple-spotted, thinly white powdery, densely below nodes, glabrous; culm wall 2–4 mm thick; nodes inconspicuous; sheath scar prominent, with persistent remains of sheath base. Branching from nodes 1–2 m above the ground, branches usually 3, the base appressed to the culm. Culm sheaths tardily deciduous, oblong, leathery, 1/3 to 1/2 as long as internodes, densely purple-spotted, sparsely setose or glabrous abaxially, margins glabrous; auricles narrowly falcate; oral setae radiate; ligules 1–3 mm tall, truncate, margins entire or shallowly serrate; blades erect or recurved, lanceolate. Foliage leaves 3–5 per ultimate branch, sometimes a slender branchlet with 3–5 foliage leaves extending from the apex of the ultimate branch; sheaths initially sparsely setose and white powdery, glabrescent, green or purple, margins glabrous; auricles narrowly falcate, deciduous; oral setae several, radiate, deciduous; ligules truncate or a little arched, 2–3 mm tall, tomentose abaxially; petiole puberulous, initially white powdery; blades 9.5–21 × 1.2–3 cm, shallowly wavy when dry, glabrous, glaucous abaxially, secondary veins 4–6 pairs, transverse veins conspicuous, apex tapering, margins serrate. Inflorescence unknown.

Phenology. New shoots May to July.

Distribution and habitat. This new species is only found in Daguan County, north-eastern Yunnan, China. It occurs above the upper limit of distribution of *Chimonobambusa tumidissinoda* Hsueh&T.P.Yi ex Ohrnberger in this area, and grows under the evergreen broadleaved forests at an altitude between 2200–2400 m.

Etymology. The specific epithet refers to Professor Tong-Pei Yi (1933–2016), who made great contributions to the taxonomy of the alpine bamboos (particularly in *Fargesia* Franchet and *Yushania* P.C. Keng) in China.

Additional specimens examined (paratypes). CHINA. Yunnan: Daguan County, Wumengshan National Nature Reserve, Sanjiangkou, 28°14'11"N, 103°54'21"E, 2390 m alt., 24 May 2016, *E.D. Liu* et al. *4760* (KUN!), ibid., 28°13'44"N, 103°54'53"E, 2230 m alt., 28 September 2018, *Y.X. Zhang* et al. *18176*, *18177* (KUN!).

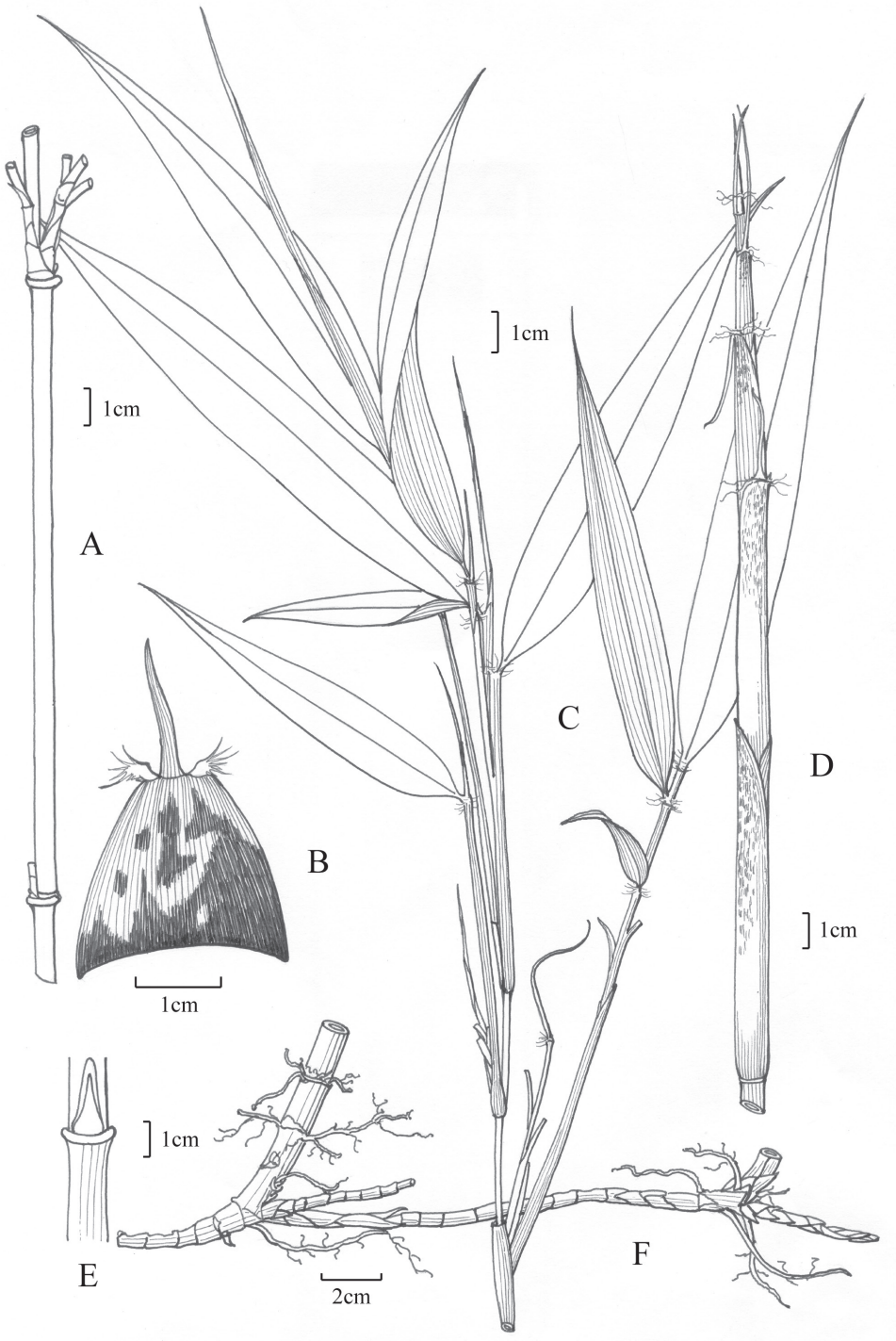

Figure 1. *Yushania tongpeii* D.Z.Li., Y.X.Zhang & E.D.Liu. **A** internode and branches **B** part of the culm sheath, denoting auricles and the blade **C** young leaves **D** new shoot **E** culm bud **F** long-necked rhizome.

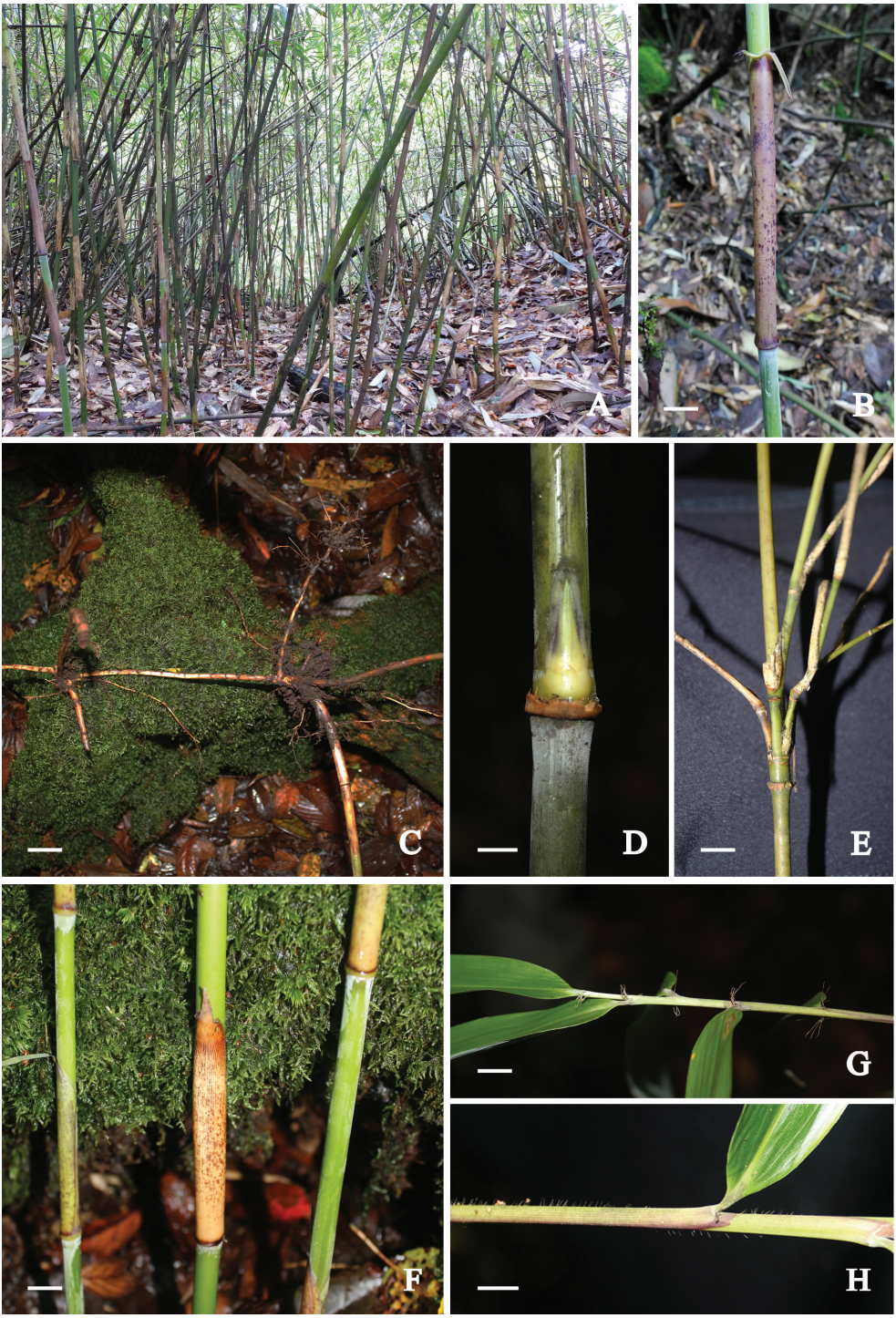

Figure 2. *Yushania tongpeii* D.Z.Li., Y.X.Zhang & E.D.Liu. **A** habitat **B** culm sheath **C** rhizome **D** culm bud **E** branches **F** young culms with culm sheaths **G** foliage leaves **H** leaf sheath. Scale bars: 5 cm (**A**); 2.5 cm (**C**); 2 cm (**B**); 1 cm (**D–G**); 5 mm (**H**).

Table 1. Morphological comparison of *Yushania tongpeii* and related species.

	Y. tongpeii	*Y. oblonga*	*Y. pingshanensis*	*Y. straminea*
Culm height	2–5 m	3–4.5 m	1.2–2 m	2–4 m
Culm diameter	0.8–1.5 cm	1–2 cm	0.5–0.75 cm	0.6–1 cm
Internode	15–38 cm long, thinly white powdery, densely below nodes, glabrous	28–40 cm long, initially white powdery, densely below nodes, glabrous	13–35 cm long, a ring of white powder below nodes, glabrous	18–29 cm long, thinly white powdery, densely below nodes, glabrous
Branch complement	Usually 3	1–3 (5)	1–3	1–3
Nodal sheath scar	Prominent	Prominent	Prominent	Prominent, initially retrorsely setose
Culm sheath	Tardily deciduous, densely purple-spotted, sparsely setose or glabrous abaxially, margins glabrous	Persistent, white powdery, glabrous, margins densely yellow setulose	Persistent, densely light yellow verrucose setose abaxially, margins densely ciliate	Persistent, densely setose, margins densely ciliate
Culm sheath auricle	Narrowly falcate	Falcate	Oblong or falcate	Falcate
Culm sheath blade	Erect or recurved, lanceolate	Erect, linear-lanceolate	Recurved, triangular-linear or linear-lanceolate	Erect or recurved, oblong-triangular or elliptic-lanceolate
Leaf number of the ultimate branch	3–5	5–7	5–9	4–9
Leaf sheath	Initially sparsely setose and white powdery, glabrescent, margins glabrous	Glabrous, initially white powdery, margins glabrous	Glabrous, margins glabrous	Glabrous, usually white powdery, margins glabrous
Leaf ligule	Truncate or a little arched, tomentose abaxially	Truncate, glabrous	Truncate, glabrous	arcuate
Petiole	Puberulous, initially white powdery	White powdery	Purple	Puberulous, initially white powdery
Leaf blade	9.5–21 × 1.2–3 cm, glabrous	14–17 × 3.6–4 cm, glabrous	9–17 × 1.3–2.2 cm, glabrous	7–19 × 1.6–2.6 cm, basally grey hairy

Discussion

The vegetative characters of *Yushania tongpeii*, such as three branches at the upper part of the nodes and medium height culms, are similar to the species of section *Yushania*, particularly the three species listed in Table 1. All these three species have less than five branches at the node, white powder on the internode or below the node, prominent nodal sheath scar, falcate culm sheath auricles and white powdery petioles (except for *Y. pingshanensis*). However, some subtle features make *Y. tongpeii* distinctive, including sparse purple spots on the internode, densely purple-spotted culm sheaths, glabrous margins of culm sheaths and tomentose leaf ligules. Therefore, this new species should be assigned to section *Yushania* on the basis of morphology.

Some researchers analysed the diversity and the distribution patterns of endemic seed plants in China (Huang et al. 2014, Huang et al. 2016). The Central Yunnan Plateau Subregion, one of the floristic units in China (Wu et al. 2010), is one of the two centres of Chinese endemic flora (Huang et al. 2016). Wumengshan National Nature Reserve is located at the east edge of the Central Yunnan Plateau Subregion. Therefore, the discovery of *Yushania tongpeii*, which is endemic to Wumengshan National Nature Reserve, gives meaning for studying the diversity of endemic species in this area.

Acknowledgements

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RESEARCH ARTICLE

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Dendrocalamus menghanensis (Poaceae, Bambusoideae), a new woody bamboo from Yunnan, China

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Abstract

Dendrocalamus menghanensis P.Y.Wang & D.Z.Li, a new species of woody bamboos endemic to south Yunnan, China, is described and illustrated. The new species is morphologically similar to *D. semiscandens* and *D. birmanicus* but differs in having a reflexed culm sheath blade, 10 mm high culm sheath ligule, 1 mm high leaf sheath ligule, 4 florets and 1 glume.

Keywords

Dendrocalamus, woody bamboo, Poaceae, Yunnan, taxonomy

Introduction

The genus *Dendrocalamus* was described by Nees von Esenbeck (1835) and currently comprises of more than 50 species in tropical and subtropical regions of Asia (Ohrnberger 1999, Bamboo Phylogeny Group 2012). Several new species in this genus have been continuously described in recent years (Yang et al. 2016, Wang et al. 2016, Nguyen et al. 2017a, 2017b). There are about 30 species of *Dendrocalamus* distributed in China (including new species described in recent years) (Li et al. 2006). It is a typical paleotropical woody bamboo genus belonging to the subtribe Bambusinae Presl (1830)

of tribe Bambuseae Kunth ex Dumortier (1829). Within this subtribe, the three major genera are *Bambusa* (von Schreber 1789), *Dendrocalamus* and *Gigantochloa* Kurz ex Munro (1868). They formed a clade known as the BDG complex (Goh et al. 2010, 2013), also named "core Bambusinae", but the long-standing problems for taxonomic delimitation and evolutionary relationships within the BDG complex have not been satisfactorily resolved (Goh 2012, Chokthaweepanich 2014, Zhou et al. 2017).

Most of the species of *Dendrocalamus* can be recognised by their thick-walled culms, swollen nodes reflexed culm sheath blade and aerial roots at the lower nodes. The species usually have white, blackish or light-brown hairs on the culm sheaths (Dransfield 1980). Compared to *Dendrocalamus*, it is easy to classify the *Bambusa* species by the erect culm sheath blade and conspicuous auricles and *Gigantochloa* by connate filaments. While checking the bamboos cultivated in Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences (CAS), we discovered an extraordinary *Dendrocalamus* species. The floret of this species has no lodicule, one plumose stigma, six stamens and completely separate filaments, indicating that it belongs to *Dendrocalamus* rather than to *Gigantochloa* or *Bambusa* (Li and Hsueh 1988a, 1988b, Dransfield and Widjaja 1995, McClure 1966, Wong 1995, Li et al. 2006, Clayton et al. 2008, Sungkaew 2008).

This new species resembles *D. semiscandens* (Li and Hsueh 1989) and *D. birmanicus* Camus (1932) in some morphological characters as discussed below (see Table 1). It was introduced in XTBG from Menghan Township, Jinghong, Yunnan, China in 1980.

Material and methods

All measurements of the new *Dendrocalamus* species were taken from dried herbarium specimens and living individuals at XTBG, Menglun, Mengla, Yunnan province. For morphological characterisation, vegetative parts of plant material were measured using the living plants and the reproductive parts were analysed under an automated digital microscope (ZEISS Smartzoom 5) linked with a computer in Xishuangbanna Station for Tropical Rainforest Ecosystem Studies of XTBG, CAS. The morphological terminology followed McClure (1966).

Table 1. Morphological differences amongst *Dendrocalamus menghanensis*, *D. semiscandens* and *D. birmanicus*.

Characters	*D. menghanensis*	*D. semiscandens*	*D. birmanicus*
Diameter of culm	4–8 cm	6–15 cm	ca. 8 cm
Culm sheath blade	reflexed	erect	reflexed
Number of florets	4	4–5	2–3
Culm sheath	covered with dense brownish-black hairs	covered with dark brown hairs	covered with dark brown hairs
Culm sheath ligule	10 mm	1 mm	3–4 mm
Leaf sheath ligule	1 mm	3–5 mm	1 mm
Glume	1	1–3	2
Anther	6 mm, yellow	3.7 mm, yellow, anther tip purple	3–4 mm

Taxonomy

***Dendrocalamus menghanensis* P.Y.Wang & D.Z.Li, sp. nov. "勐罕龙竹" (Meng Han Long Zhu)**
urn:lsid:ipni.org:names:60479347-2
Figures 1, 2

Type. CHINA. Yunnan: Xishuangbanna, Menglun, 21°55.949'N, 101°15.139'E, 570 m alt., 18 November, 2010, *P.Y. Wang C130022* (holotype: HITBC!; isotype: KUN!).

Diagnosis. *Dendrocalamus menghanensis* is morphologically similar to *D. semiscandens* and *D. birmanicus*, but can be easily distinguished from them by having a reflexed culm sheath blade, 10 mm high culm sheath ligule, 1 mm high leaf sheath ligule, 4 florets and 1 glume.

Description. Arborescent bamboo, perennials; rhizomes pachymorph, short necked. Culms apically pendulous, 8–12 m tall, 4–8 cm in diam.; culms terete, with a ring of white tomenta below sheath scars, internodes 20–40 cm long, wall 1–3.5 cm thick and almost solid at the base of culms; culm surface initially densely covered with white hairs and becoming glabrous later; culm sheaths deciduous, thickly leathery, 1/2 as long as the internodes, covered with dense brownish-black hairs, pale green initially, later becoming yellowish-brown with age; blades lanceolate, reflexed; auricles small inconspicuously lobed, oral setae absent; ligules ca. 10 mm high, dentate. Branching from lower nodes ca. 0.5–1.0 m above ground, branches several, usually subequal, sometimes 1 dominant; ultimate branchlets with 10–16 leaves, usually 12 leaves. Foliage leaves lanceolate, 11–30(-35) cm × 2–4.5(-6) cm, adaxial surface green and glabrous, abaxial surface pale green and pubescent, margins serrulate, secondary veins 7–11 pairs, usually 10 pairs, petioles 2–5 mm; leaf sheaths initially white hairy and later glabrous; auricles inconspicuous, ligules ca. 1 mm high, entire. Flowering branches pendulous, leafless, with clusters of 3 to 15(-60) pseudo-spikelets at each node; clusters 1–3.5 cm in diam.; pseudo-spikelets ovate-lanceolate, pale green, apically acute and light purple, 12–16 × 3–4 mm; fertile florets usually 4 per pseudo-spikelet; glumes 1, broadly ovate, 5–7 × 4–6 mm, margins ciliate at upper half; lemma ovate, 8–12 × 4–7 mm, pubescent, many-veined, apex mucronate, margins ciliate; palea oblanceolate, 2-keeled, 7–11 × 1–2 mm, keels and margins long ciliate; lodicules absent; stamens 6, ca. 6 mm long, ovary ovoid, pistil ca. 16 mm long, anthers yellow, filaments free, ca. 14 mm long; stigma 1, purple, plumose. Fruit unknown.

Distribution. *Dendrocalamus menghangensis* is only known from Menghan Township, Jinghong, Yunnan, China.

Conservation status. As a great many forests have been destroyed by local people in the last 30 years, we did not find the new species at the locality where it was introduced. Further investigation is required to find more distribution localities and determine the conservation status of the new species. At present, we consider it as DD (Deficient Data) according to the IUCN parameters (IUCN 2012).

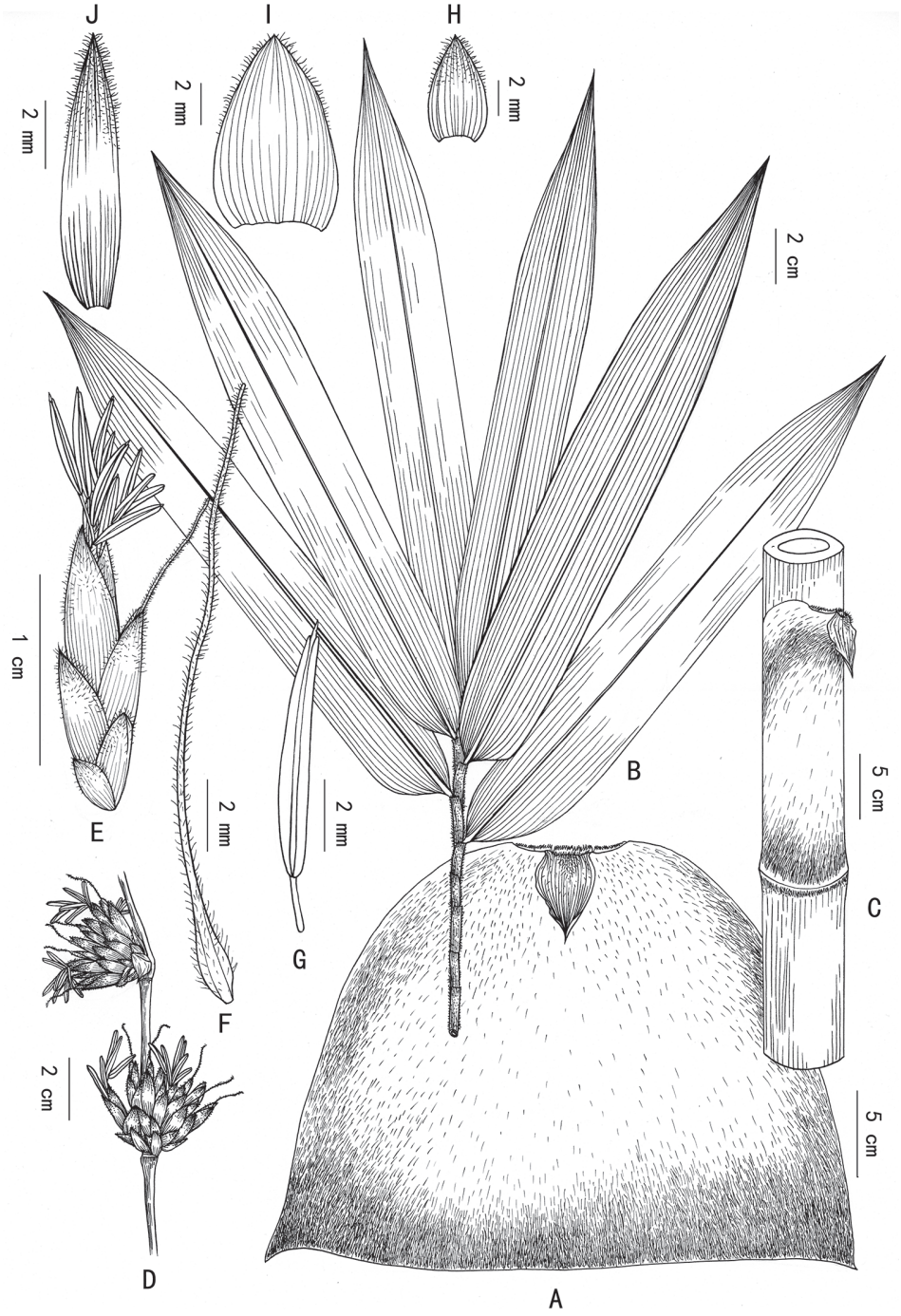

Figure 1. *Dendrocalamus menghanensis* P.Y. Wang & D.Z. Li. **A** Culm sheath (abaxial view) **B** ultimate branchlet with leaves **C** portion of young culm with culm sheath **D** portion of flowering branch **E** pseudo-spikelet **F** pistil **G** stamen **H** glume **I** lemma **J** Palea. Drawn from the holotype.

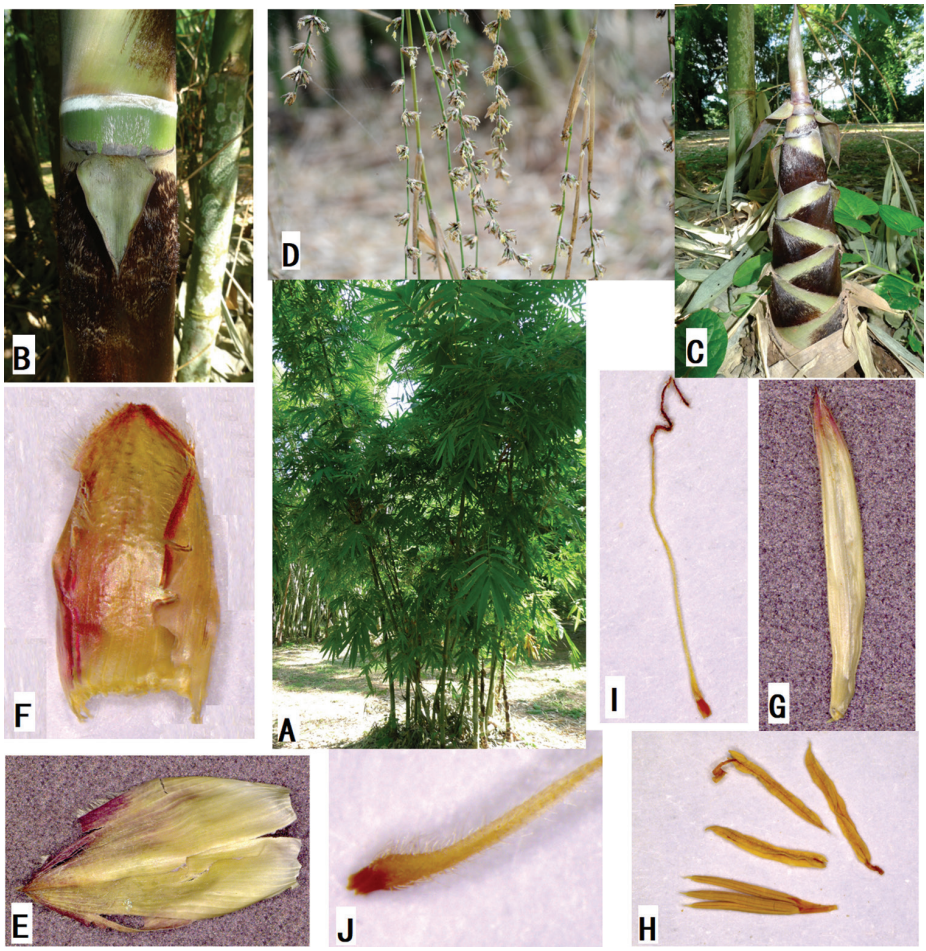

Figure 2. *Dendrocalamus menghanensis* P.Y.Wang & D.Z.Li. **A** Clump **B** portion of young culm with culm sheath **C** new shoot **D** flowering branches **E** glume **F** lemma **G** palea **H** floret **I** pistil **J** ovary.

Etymology. The specific epithet refers to the original place of the new species, i.e. Menghan Town, Xishuangbanna, south Yunnan, China.

Phenology. Shooting from July to October and flowering from December to May of the next year.

Additional specimens examined (paratype). CHINA. Yunnan, Xishuangbanna, Menglun, 21°55.949'N, 101°15.139'E, 570 m alt., 7 December, 2010, *P.Y. Wang* C130051 (paratype: HITBC!, KUN!)

Discussion

Dendrocalamus menghanensis is morphologically similar to *D. semiscandens* and *D. birmanicus*. However, the new species differs from them by having a reflexed culm sheath

blade, 10 mm high culm sheath ligule, 1 mm high leaf sheath ligule, 4 florets and 1 glume. The major differences amongst these species are listed in Table 1. This new species is only found in Xishuangbanna which is located in one of the world's biodiversity hotspots (Indo-Burma) (Myers et al. 2000). Many forests have been destroyed because of the plantation of rubber trees in this region in the past 30 years. Many species may become extinct before we know that they exist in Xishuangbanna. More field investigations need to be conducted in this region in future.

Acknowledgements

This study was supported by grants from the National Natural Science Foundation of China (31700560) and Natural Science Foundation of Yunnan Province (2018FB043). We thank Dr. Wen-Bin Yu from Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences for improving the manuscript. We also appreciate the Xishuangbanna Station for Tropical Rainforest Ecosystem Studies and Herbarium of Xishuangbanna Tropical Botanical Garden (HITBC) for their support during the examination of specimens.

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RESEARCH ARTICLE

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Two new species of *Henckelia* (Gesneriaceae) from Southeastern Yunnan, China

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Abstract

Two new species of Gesneriaceae, *Henckelia nanxiheensis* Lei Cai & Z.L.Dao, **sp. nov.** and *H. multinervia* Lei Cai & Z.L.Dao, **sp. nov.** from southeastern Yunnan, China, are described with color photos. The diagnostic characters of the two new species, together with photographs, detailed descriptions, distribution and habitat, as well as comparisons with morphologically similar species, are also provided.

Keywords

Gesneriaceae, *Henckelia*, new taxon, China, flora of Yunnan

Introduction

The circumscription of the genus *Henckelia* Spreng. (Gesneriaceae) has been redefined by Weber et al. based on molecular and morphological evidence (Weber and Burtt 1998; Weber et al. 2011). *Henckelia s.l.* consists of more than 60 species, mainly distributed across south and east Asia and the adjacent Himalayan regions (Weber et al. 2011; Manudev et al. 2012; Janeesha and Nampy 2015; Sinha and Datta 2016; Ranasinhe et al. 2016; Krishna and Lakshminarasimhan 2018; Sirimongkol et al. 2019).

Southwest China harbors a high diversity of *Henckelia*, and more than 20 species of *Henckelia*, which were originally described under the names of *Hemiboeopsis* W.T. Wang and *Chirita* Buch.-Ham. ex D. Don, are recorded from China (Wang et al. 1990, 1998; Weber et al. 2011; Li and Wang 2005; Möller et al. 2016; Xu et al. 2017).

During our field investigation in southeastern Yunnan in 2016, several unusual species of Gesneriaceae caught our attention. After careful study of relevant specimens and taxonomic publications from the adjacent regions (Wang et al. 1990, 1998; Li and Zhu 2010; Weber et al. 2011; Middleton et al. 2013; Möller et al. 2016; Xu et al. 2017; Sirimongkol et al. 2019), we concluded that these plants represent two new members of *Henckelia*. Descriptions and illustrations of the new species are presented here; the morphological characters are also compared with those of closely related species.

Taxonomic treatments

Henckelia nanxiheensis **Lei Cai & Z.L.Dao, sp. nov.**
urn:lsid:ipni.org:names:60479349-2
Figures 1, 2

Diagnosis. *Henckelia nanxiheensis* is morphologically similar to *H. auriculata* (J.M. Li & S.X. Zhu) D.J. Middleton & Mich. Möller in the shape, color and size of the flower; it also resembles *H. ceratoscyphus* (B.L. Burtt) D.J. Middleton & Mich. Möller in the indumentum characteristics of the whole plant and hornlike apex of the calyx, but differs from them both in the shape of leaf blade, calyx lobes, size of corolla, indumentum of pedicel and pistil.

Type. China. Yunnan: Pingbian County, Baiheqiao Town, Dujiao, 22°55'N, 103°51'E, 255 m a.s.l., on the surface of rocks in the shaded valleys, in flower, 18 Mar 2017, *Lei Cai CL035* (holotype: KUN!, isotypes: KUN!).

Description. Perennial; stem extremely short, usually less than 1 cm. Rhizome 0.5–1.0 cm long, internodes inconspicuous. Leaves basal, opposite; petiole 2–11 cm long, ca. 1 mm in diameter, base 3 mm wide, densely pubescent; leaf blade oblong to oval, 4–20 × 1.5–5.5 cm, herbaceous, adaxially densely puberulent, eglandular, abaxially puberulent and densely along veins, base oblique or asymmetrical, margin serrate, apex acute; lateral veins 5–12 on each side of midrib, conspicuous on both sides. Cymes 3–10 per plant, each 1–4-flowered; peduncle 1–2 cm long, pubescent; bracts 2, free, ovate to oval, ca. 3–5 × 2–3 mm, pubescent both sides, margin entire, apex acute. Pedicel 0.8–2.5 cm long, pubescent. Calyx 8–10 mm long, 5-parted to 3/4 of the length; lobes equal, lanceolate to long-triangular, 6–8 mm long, outside pubescent, inside glabrous, apex attenuate, horn-like 3–5 mm long. Corolla ca. 2 cm long, white to pale blue, with light purple stripes inside, abaxial lips purple, outside sparsely puberulent, inside glabrous; tube slightly curved, narrow at base, ca. 10–13 × 2.0–4.5 mm; adaxial lobes 2, orbicular, ca. 4 mm in diameter; abaxial lobes 3, orbicular, ca. 5 mm in diameter. Stamens 2, anthers adaxially fused, ca. 1.5 mm long, sparsely puberulent; filaments ca.

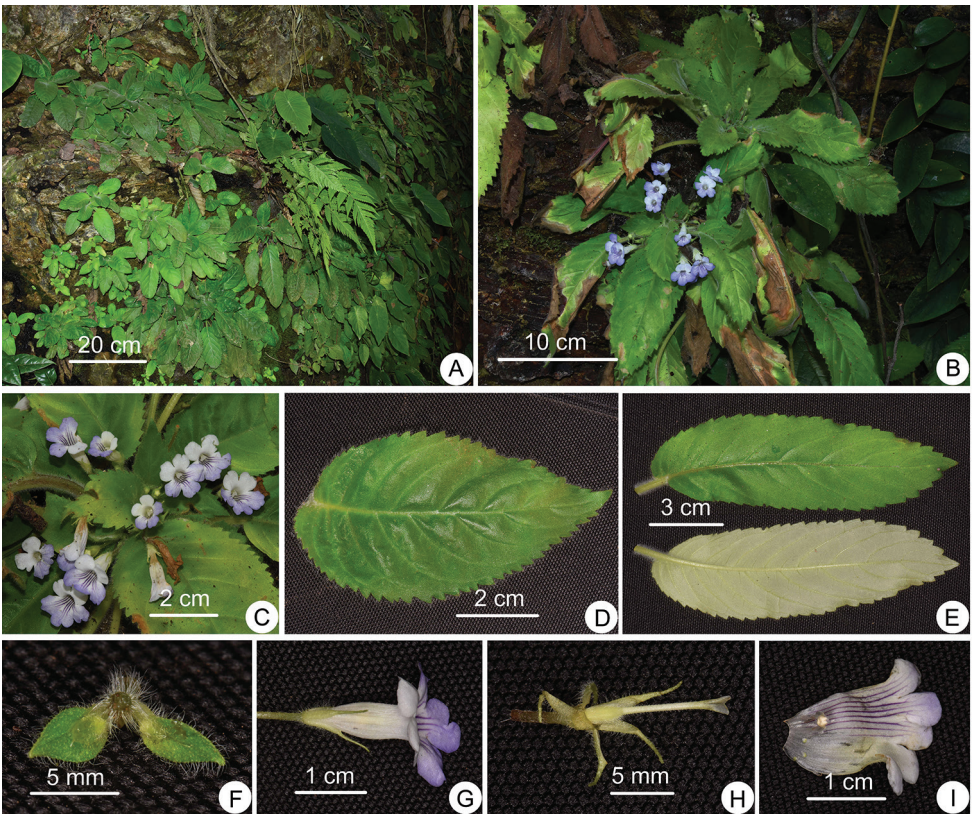

Figure 1. *Henckelia nanxiheensis* Lei Cai & Z.L.Dao, sp. nov. **A** Habitat **B** plants with flowers **C** front view of flowers **D** adaxial leaf surface **E** adaxial and abaxial leaf surfaces **F** bracts **G** side view of flower **H** pistil, disc and calyx **I** opened corolla. All photographs by Lei Cai.

4.5 mm long, S-shaped, inserted ca. 2.5 mm from the base, glabrous below, extremely sparsely glandular-puberulent apically; staminodes 3, green, ca. 0.5 mm long, inserted ca. 3 mm from base. Disc ca. 0.5 mm high, inconspicuous. Pistil 1.1–1.3 cm long; ovary long-elliptic, 3–4 mm long, densely pubescent; style linear, ca. 8 mm long, glandular puberulent; stigma flabellate, ca. 2 mm long, 2-lobed. Fruit unknown.

Phenology. Flowering from March to April.

Etymology. The specific epithet '*nanxiheensis*' refers to the type locality in the regions near the Nanxi River, which is a tributary of the Red River.

Vernacular name. The Chinese mandarin "nan xi he han ke ju tai" (南溪河汉克苣苔)

Distribution and habitat. The new species is currently known only from the type locality with a small population of ca. 150 individuals growing on moist rocks of the entrance to the valley near the banana plantation. The population of *Henckelia nanxiheensis* was first discovered in 2014 (without flowers) by Lei Cai; individuals in blossom were collected in 2017. The disturbance of the population has been observed

Figure 2. Holotype of *Henckelia nanxiheensis* Lei Cai & Z.L.Dao (KUN-1443557).

with ca. 15% loss of the original habitat, due to human activities which are not limited to the expansion of banana plantations. An urgent preservation scheme is required to rescue this species from further disturbances or wipe-out from the type locality.

Notes. This new species most closely resembles *Henckelia auriculata* in the shapes of the flower and calyx. However, it differs from the latter in the oblong to oval leaf blade with oblique base and serrate margin (vs. rotund to elliptical with auriculate base and shallowly serrate to coarsely dentate margin); the calyx divided 3/4 of the length of calyx (vs. calyx parted to base); the flower lips white to pale blue adaxially and purple abaxially (vs. entirely white); the ovary densely pubescent and the style glandular puberulent (vs. densely but eglandulate hairy pistil). It is also similar to *H. ceratoscyphus* in the indumentum characteristics and hornlike apex of the calyx, but differs from having leaf blade oblong to oval (vs. narrowly to broadly elliptic), smaller corolla ca. 2.2 cm long (vs. 4.5 cm long), slightly curved tube (vs. tube funnelform), equal size of 3 staminodes ca. 0.5 mm long (vs. central one ca. 1.5 mm long, laterals ca. 6 mm long); the ovary densely pubescent and the style glandular puberulent (vs. puberulent pistil).

Henckelia multinervia **Lei Cai & Z.L.Dao, sp. nov.**
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Figures 3, 4

Diagnosis. *Henckelia multinervia* is similar to *H. ceratoscyphus* (B.L. Burtt) D.J. Middleton & Mich. Möller in the shape, color and size of the flower, the indumentum of leaf blade and the horn-like calyx apex, but it can easily be distinguished from the latter by the shape of leaf blade and distinct venation pattern, smaller horn-like calyx apex, the indumentum of corolla and style and smaller stigma.

Type. China. Yunnan: Hekou County, Laofanzhai Town, Jinzhuliang village, Shiqiao, 22°47'N, 103°49'E, 442 m a.s.l., on moist rocks in rainforest valley along the bank of the stream, in flower, 3 Apr 2018, *G.L. Zhang CL2018008* (holotype: KUN!, isotypes: KUN!).

Description. Perennial, stem extremely short, usually less than 1 cm. Rhizome 0.8–5.0 cm long, internodes inconspicuous. Leaves basal, opposite; petiole 2–16 cm long, ca. 1 mm in diameter, densely pubescent; leaf blade long-elliptic to broadly lanceolate, 4–34 × 2–8 cm, herbaceous, adaxially densely puberulent, eglandular, abaxially puberulent and densely puberulent along veins, base oblique, cuneate on both sides, margin serrate, apex acute; lateral veins 12–22 on each side of midrib, conspicuous on both sides. Cymes 2–5 per plant, each 1–3-flowered; peduncle 1.2–2.5 cm long, pubescent; bracts 2, free, lanceolate, ca. 8–10 × 3–5 mm, pubescent both sides, margin entire, apex acute. Pedicel 1.5–2.5 cm long, pubescent. Calyx 1.2–2.0 cm long, 5-divided to near base; lobes equal, lanceolate to oblong, 1.2–2.0 cm long, outside pubescent, inside glabrous, apex attenuate, horn-like, 4–6 mm long. Corolla blue-purple, with two yellow stripes and several purple stripes on the abaxial lip, 3.5–5.0 cm long, outside glandular pubescent, inside glabrous; tube funnelform, outside white, ca.

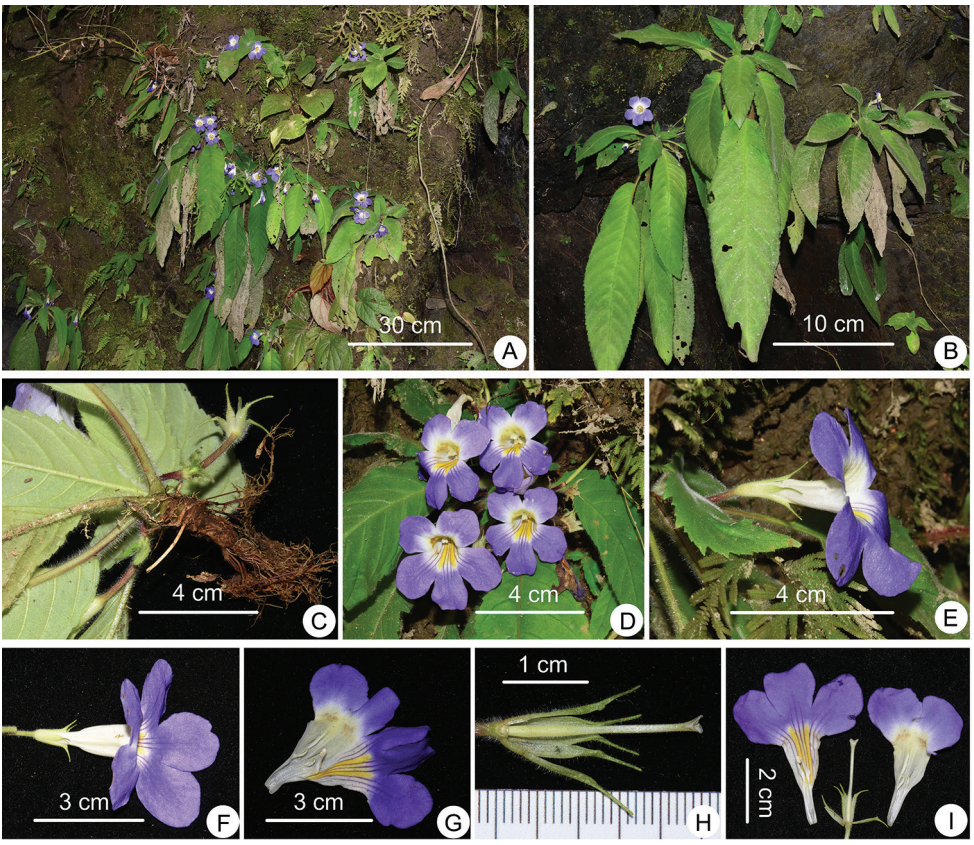

Figure 3. *Henckelia multinervia* Lei Cai & Z.L.Dao, sp. nov. **A** Habitat **B** plants with flowers **C** rhizome, petiole and abaxial leaf surface **D** front view of flowers and adaxial leaf surface **E, F** side view of flowers **G** opened corolla **H** pistil, disc and calyx **I** opened corolla and pistil with calyx. All photographs by Lei Cai.

2.8–4.0 × 0.2–1.5 cm; adaxial lobes 2, orbicular, ca. 1.5 cm in diameter; abaxial lobes 3, orbicular, ca. 1.8 cm in diameter. Stamens 2, anthers adaxially fused, ca. 2 mm long, puberulent; filaments 6–8 mm long, inserted ca. 1.2 cm from base, glabrous below, sparsely glandular puberulent apically; staminodes 3, central one ca. 1.5 mm long, laterals ca. 4 mm long, inserted ca. 1.3 cm from base. Disc ca. 1 mm high, shallowly 5-lobed. Pistil 2.4–2.8 cm long; ovary long elliptic, 8–10 mm long, densely pubescent; style linear, 1.5–1.8 cm long, glandular puberulent; stigma flabellate, ca. 2 mm long, 2-lobed. Old capsule (from the previous year) ca. 3.2 cm long.

Phenology. Flowering from March to April; fruiting from April to May.

Etymology. The specific epithet '*multinervia*' is Latin, and refers to the relatively large number veins of this species.

Vernacular name. The Chinese mandarin "duo mai han ke ju tai" (多脉汉克苣苔)

Distribution and habitat. This species is currently known only from the type locality, where ca. 80 individuals were found on moist rocks beside a river in a rainforest valley. More field work is required to assess the conservation status.

Figure 4. Holotype of *Henckelia multinervia* Lei Cai & Z.L.Dao (KUN-1443559).

Additional specimens examined. China. Yunnan: Hekou Couty, Laofanzhai Town, Jinzhuliang village, Shiqiao, 22°47'N, 103°49'E, 442 m a.s.l., on moist rocks in rainforest valleys along stream, in flower, 11 Apr 2018, *Lei Cai et al. CL084* (KUN!); Hekou County, Laofanzhai Town, Jinzhuliang village, Shenchong, 22°47'N, 103°49'E, 485 m a.s.l., on moist rocks in the rainforest valley along streamsides, in flower, 8 Mar 2017, *G.L. Zhang ZhangGL222* (KUN!).

Notes. The new species is most similar to *H. ceratoscyphus* in its habitat and floral characteristics, but can easily be distinguished from the latter by having long-elliptic to broadly lanceolate leaf blade (vs. narrowly to broadly elliptic); more lateral veins up to 12–22 pairs (vs. 7–11 pairs); the horn-like apex up to 1/4–1/3 of the length of calyx (vs. 1/2–2/3 of the length of calyx); the corolla glandular pubescent outside (vs. sparsely puberulent outside), the glandular pubescent style (vs. puberulent); and the ca. 2 mm long stigma (vs. ca. 6 mm long).

Discussion

Based on the field observation and field notes of historical herbarium collections of *Henckelia*, most species of *Henckelia* were found on soil and rocks (non-limestone), with only four species, *H. auriculate*, *H. dimidiata* (Wall. ex C.B. Clarke) D.J. Middleton & Mich. Möller, *H. campanuliflora* Sirim. and *H. candida* Sirim. (Sirimongkol et al. 2019) were recorded from limestone areas. We believe that the habitat driven speciation is worthy of further investigation. Although a large number of new species of Gesneriaceae have been reported from China in recent years, until now, no new members of *Henckelia* have been published after the revision (Weber et al. 2011) from China, and a few new species of the genus have been described from India, Sri Lanka, Myanmar and Thailand (Manudev et al. 2012; Janeesha and Nampy 2015; Ranasinhe et al. 2016; Krishna and Lakshminarasimhan 2018; Sirimongkol et al. 2019). The two new species in this paper were all discovered in Dawei Mountain area, a locality with several different vegetation types and abundant plant diversity; therefore, we will continue to pay more attention to the Gesneriaceae species diversity in this area and adjacent region.

According to the first-hand field investigation, the two new species described here also fit the criterion of Plant Species with Extremely Small Populations (Ma et al. 2013), with unique topography and habitat, extremely limited distribution range, the population and the habitat being susceptible to human activities, e.g. collection, crop planting or deforestation. The development of a conservation strategy and action plan is urgently needed to protect the two new species.

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RESEARCH ARTICLE

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Validation of *Gastrochilus prionophyllus* (Vandeae, Orchidaceae), a new species from Yunnan Province, China

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Abstract

Gastrochilus prionophyllus, which was previously not validly published, is here validated. The species is described along with illustration and photos. Morphologically, the long and pendulous stem and distichous leaves of this new species indicate that it belongs to the sect. *Microphyllae*. It is unique in having thick fleshy leaves and margin significantly serrate, small flowers, reniform epichile and margin with dentations, thickened cushion on the central epichile and subconic hypochile. Meanwhile, a preliminary conservation status assessment according to IUCN Red List categories and criteria is given to the new species.

Keywords

Orchidaceae, section *Microphyllae*, *Gastrochilus*, taxonomy, Yunnan

Introduction

The genus *Gastrochilus* D. Don was established in 1825 (Epidenroideae; Vandeae; Aeridinea), which includes more than 62 species collectively distributed from India and Sri Lanka throughout Indochinese Peninsula, extending southwards to Indonesia and east-

wards from China to Southern Japan (Chen et al. 2009; Kumar et al. 2014; Govaerts et al. 2016; Raskoti 2016; Averyanov et al. 2018; Liu et al. 2016, 2019; Liu and Gao 2018,). Some studies had speculated that *Gastrochilus* spread from tropical regions to temperate alpine regions (Fan et al. 2009; Liu et al. 2019). China is the diversity center of *Gastrochilus* and contains 42 species, of which 22 species are recognized as endemic to China, mainly in the Southern and the Southwestern parts of the country (Tsi 1996; Chen et al. 2009; Kumar et al. 2014; Liu et al. 2016, 2019; Liu and Gao 2018).

During our field investigation in the limestone forest of Southeast Yunnan Province, a species of *Gastrochilus* with serrate leaf was collected. After reviewing the relevant literature, two of the authors agreed the collection shares an identical morphology and provenance to the species presented and named previously as *G. prionophyllus* in The Wild Orchid in Yunnan (Xu et al. 2010). But it was never validly published, as neither provided a description nor cited the type specimen according to the *International Code of Nomenclature for algae, fungi and plants* (Shenzhen Code) (Turland et al. 2018). Here, the name of *Gastrochilus prionophyllus* is validly published. In addition, an illustration, a note on distribution, and affinities with other closely resembling species and IUCN conservation status are provided.

Materials and method

Morphological observations of the new species were based on living plants (five individuals) and dried herbarium specimens (three specimens kept in the herbaria of HITBC) from two flowering seasons (2015 to 2016). All morphological characters were measured by using the vernier caliper. Both herbarium specimens and fresh material of *G. distichus* and *G. corymbosus* were examined. 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

Gastrochilus prionophyllus **H.Jiang, D.P.Ye & Q.Liu, sp. nov.**
urn:lsid:ipni.org:names:60479348-2
Figs 1, 2, 3C-1, C-2

Gastrochilus prionophyllys H. Jiang & D.P. Ye (2010: 475, Photos 694 a & b), *nom. inval.*

Diagnosis. *Gastrochilus prionophyllus* is similar to *G. distichus* and *G. corymbosus*, but could be distinguished by having thick fleshy leaves and distinct serrate at the leaf margin, smaller flowers, reniform epichile with dentations at the margin and thickened cushion on the central epichile, and subconic hypochile.

Type. CHINA. Yunnan Province: Malipo County, Xia jinchang town, limestone forest, 1550–1650 m a.s.l., epiphytic on tree trunks or on rocks, 15 Mar. 2016, Qiang Liu *359* (holotype, HITBC!)

Description. Epiphytic herbs, stem pendulous, 10–15 cm long, ca. 1.25 mm in diameter, slender, unbranched with tiny red-purple spots. Leaves alternate, distichous, ovate, 0.9–1.3 × 0.3–0.5 cm, margin significantly serrate; leaf apex acuminate with 2 unequally awns; abaxial leaves with purple spots and sometimes on the adaxial leaves. Inflorescences several, opposite to leaves, subumbellate, 2–3-flowered; peduncle 0.9–1.1 cm, slender, upper part enlarged, lower part with 2 cupular sheaths; floral bracts ovate-lanceolate, 1.0–1.2 mm; pedicel and ovary 0.9–1.1 cm. Flower yellow-green, with reddish brown spots. Dorsal sepal concave, oblong-elliptic, 3.4–3.7 × 2.3–2.6 mm, apex obtuse; lateral sepal concave, oblong-elliptic, 3.6–4.2 × 2.6–3.0 mm, apex obtuse; petals subobovate, 3.5–4.1 × 2.3–2.5 mm, apex obtuse. Lip with an epichile and a saccate hypochile; epichile nearly reniform, 2.8–3.3 × 4.9–5.3 mm, adaxially glabrous, with a thicken central cushion and 2 conic calli near base, margin irregularly denticulate; hypochile subconic, laterally compresses, 5.0–5.7 mm tall, 4.5–5.0 mm in diameter, apex rounded. Column stout, ca. 2.5 mm long; anther cap narrowed into a beak toward apex; rostellum bilobed with acuminated tip, and arising a horn-like awn from the center of each lobe (obvious in the lateral view).

Etymology. The specific epithet refers to the significantly serrate margin of leaf blades.

Distribution and habitat. At present, the new species is only to be found in Malipo town, Yunnan, China. It was also recorded in Ha Giang province of North Vietnam according to Prof. L.V. Averyanov's comment. *Gastrochilus prionophyllus* was found on the tree trunks at altitudes from 1550 to 1650 m in the limestone broad-leaved forests, which is dominated by *Quercus marlipoensis* Hu & W. C. Cheng (Fagaceae), *Q. utilis* Hu & W. C. Cheng (Fagaceae), *Platycarya strobilacea* Siebold & Zuccarini (Juglandaceae), *Manglietia grandis* Hu & W. C. Cheng (Magnoliaceae), *Eriobotrya japonica* (Thunberg) Lindley (Rosaceae) and *Podocarpus macrophyllus* (Thunberg) Sweet (Podocarpaceae), as well as an abundance of other orchid species, including *Eria coronaria* (Lindley) H. G. Reichenbach (Orchidaceae), *Paphiopedilum malipoense* S. C. Chen & Z. H. Tsi (Orchidaceae) and *Habenaria fordii* Rolfe (Orchidaceae).

Phenology. *Gastrochilus prionophyllus* was observed in flowering from March to April in the wild.

Chinese name. ju ye pen ju lan (锯叶盆距兰)

Additional specimens examined. CHINA. Yunnan: Malipo County, Xia jinchang town, limestone forest, 1600m a.s.l., 4 Mar. 2016, Qiang Liu *214* (paratype, HITBC!); China. Yunnan. Malipo County, Babu village, limestone forest, 1650m a.s.l., 16 Jul. 2016, Qiang Liu *376* (HITBC!)

Conservation status. At present, *Gastrochilus prionophyllus* is only known from two sites (Malipo County: Xia jinchang town and Babu village), around 50 individuals were discovered based on two years of botanical surveys. Although limestone forests have been seriously threatened by modern destructive human activities, not limited to quarrying and rubber plantation expansion (Sodhi and Brook 2006; Liu et al. 2015),

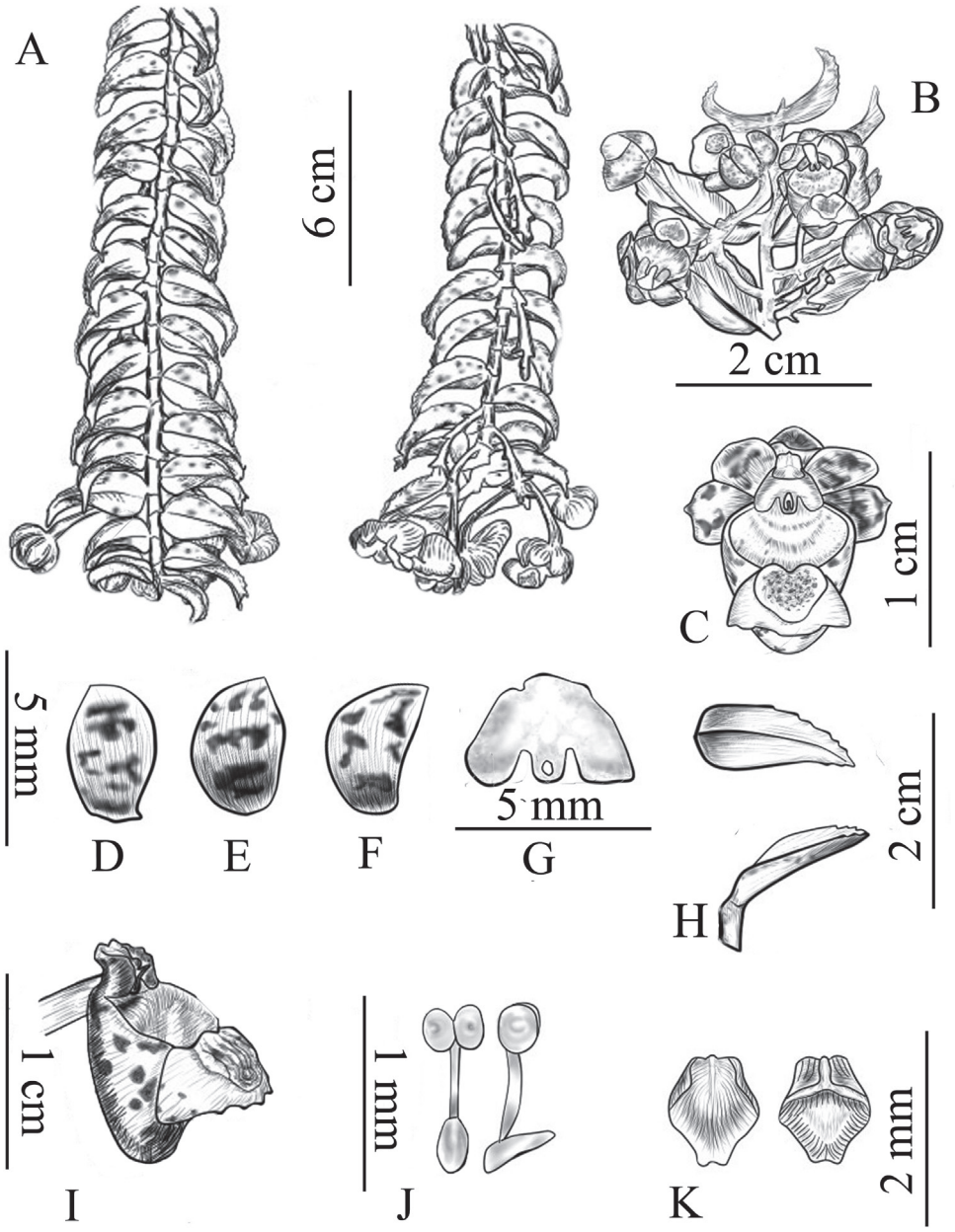

Figure 1. *Gastrochilus prionophyllus*. **A** Adaxial view and abaxial view of plant **B** inflorescence **C** front view of flower **D** lateral sepal **E** petal **F** dorsal sepal **G** front view of column **H** margin of leaf **I** lateral view of labellum and column **J** pollinarium **K** abaxial and adaxial anther cap. All from the type collection (Qiang Liu, *359*) and drawn by Bo Pan.

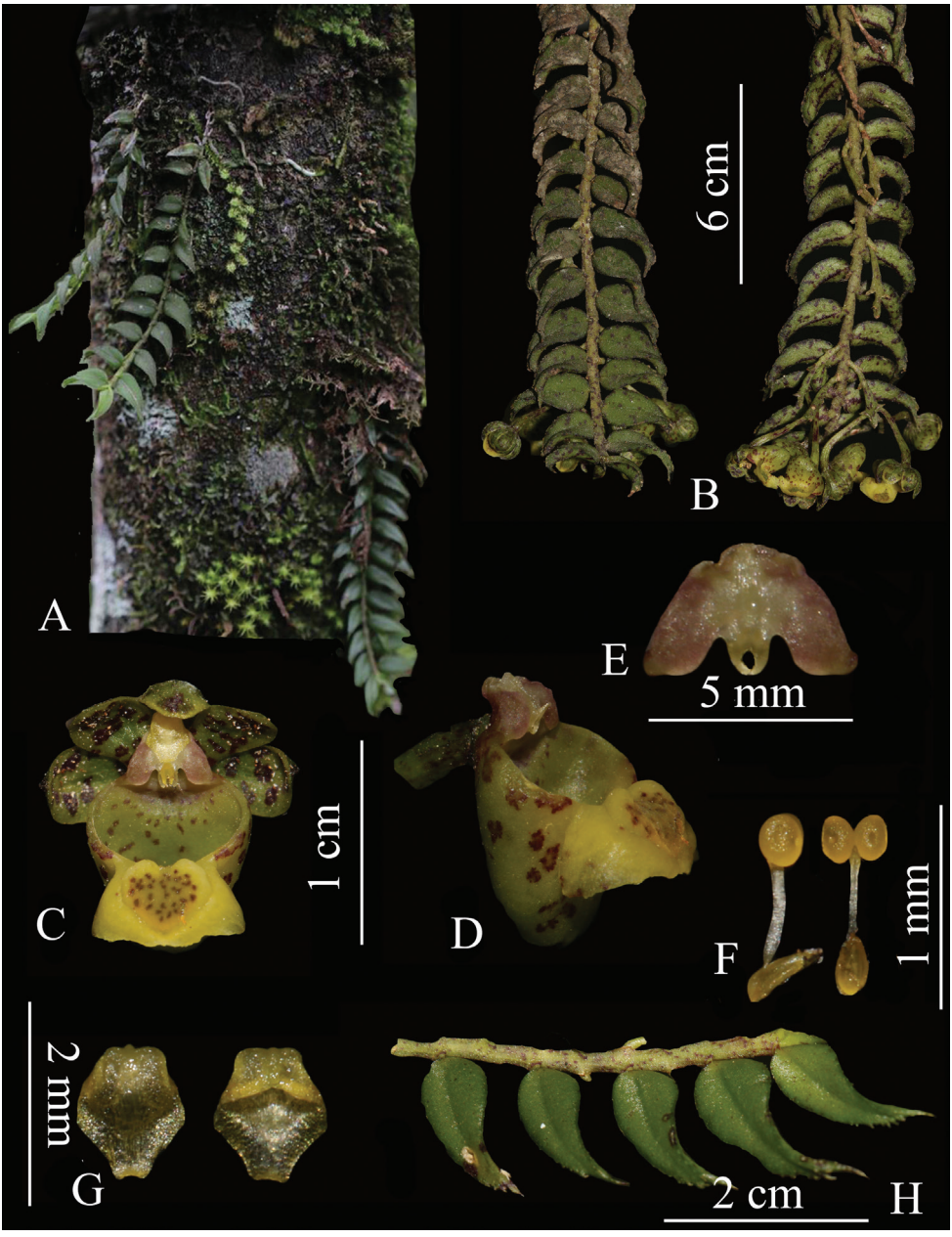

Figure 2. *Gastrochilus prionophyllus.* **A** Plant habit **B** plant **C** front view of flower **D** lateral view of labellum and column **E** front view of column **F** pollinarium **G** anther cap **H** variation of leaf margin (Photographed by Q. Liu).

the distribution of the new species lies in the landmine zone, a legacy from the Sino-Vietnamese War and the restricted zone keeps the habitat of limestone forest intact in Malipo county. Therefore, we expect that more individuals could be found in the adjacent forests extending along the China-Vietnam border. We suggest that the current conservation status of this new species is Data Deficient (IUCN 2017).

Key to the species of *Gastrochilus* sect. *Microphyllae*

1 Thick fleshy leaves and margin significantly serrate, epichile reniform and margin with dentation, and hypochile subconic ..... ***G. prionophyllus***
– Fleshy leaves and margin without serrate, epichile suborbicular or rhomboid and margin without dentation, and hypochile cupular **2**
2 Epichile with thickened cushion on the center **3**
– Epichile without cushion on the center **4**
3 Subumbellate inflorescence, orbicular cushion on the central epichile ..... ***G. distichus***
– Corymb inflorescence, diamond cushion on the central epichile ..... ***G. corymbosus***
4 Hypochile narrower than epichile **5**
– Hypochile broader than epichile **6**
5 Epichile with two ridges ranging from base to apex ..... ***G. affinis***
– Epichile membranous with longitudinal ridges centrally ..... ***G. alatus***
6 Inflorescence 1 or 2-flowered; leaves without awns at apex ..... ***G. fuscopunctatus***
– Inflorescence 5 or 6-flowered; leaves with 1–3 short awns at apex **7**
7 Epichile cordiform and without papillate ..... ***G. kadooriei***
– Epichile subobucular and with palillate ..... ***G. pseudodistichus***

Note: The long and pendulous stem of this new species indicate that it belongs to the sect. *Microphyllae* (Tsi, 1996), and these species are easily confused by having similarly vegetative and floral characters, especially between *G. distichus* and *G. pseudodistichus.* Such as the specimens of *G. distichus*: QTT *73-896* (KUN!), ETM *4115* (KUN!) and Wang *63369* (AMES!) all were misidentified as the *G. pseudodistichus*. Although the new species is similar to *G. distichus* and *G. corymbosus* in vegetative and floral characters, it differs from *G. distichus* by having thick fleshy leaves with significant serrates margin, smaller flowers and sepals size less than 4 mm, and thickened cushion on the central epichile (vs fleshy leaves and margin entire, flowers large and sepals size more than 5 mm, and slightly thickened cushion on the central epichile in *G. distichus*) (Chen et al. 2009) (see Table 1 and Figure 3); differs from *G. corymbosus* by subumbellate inflorescence, reniform epichile and margin with dentations, orbicular central cushion on the epichile and subconic hypochile (vs corymb inflorescence, suborbicular epichile and margin entire, diamond-shaped cushion on the epichile and subcupular hypochile in *G. corymbosus*) (Das and Chanda 1988) (see Table 1 and Figure 3).

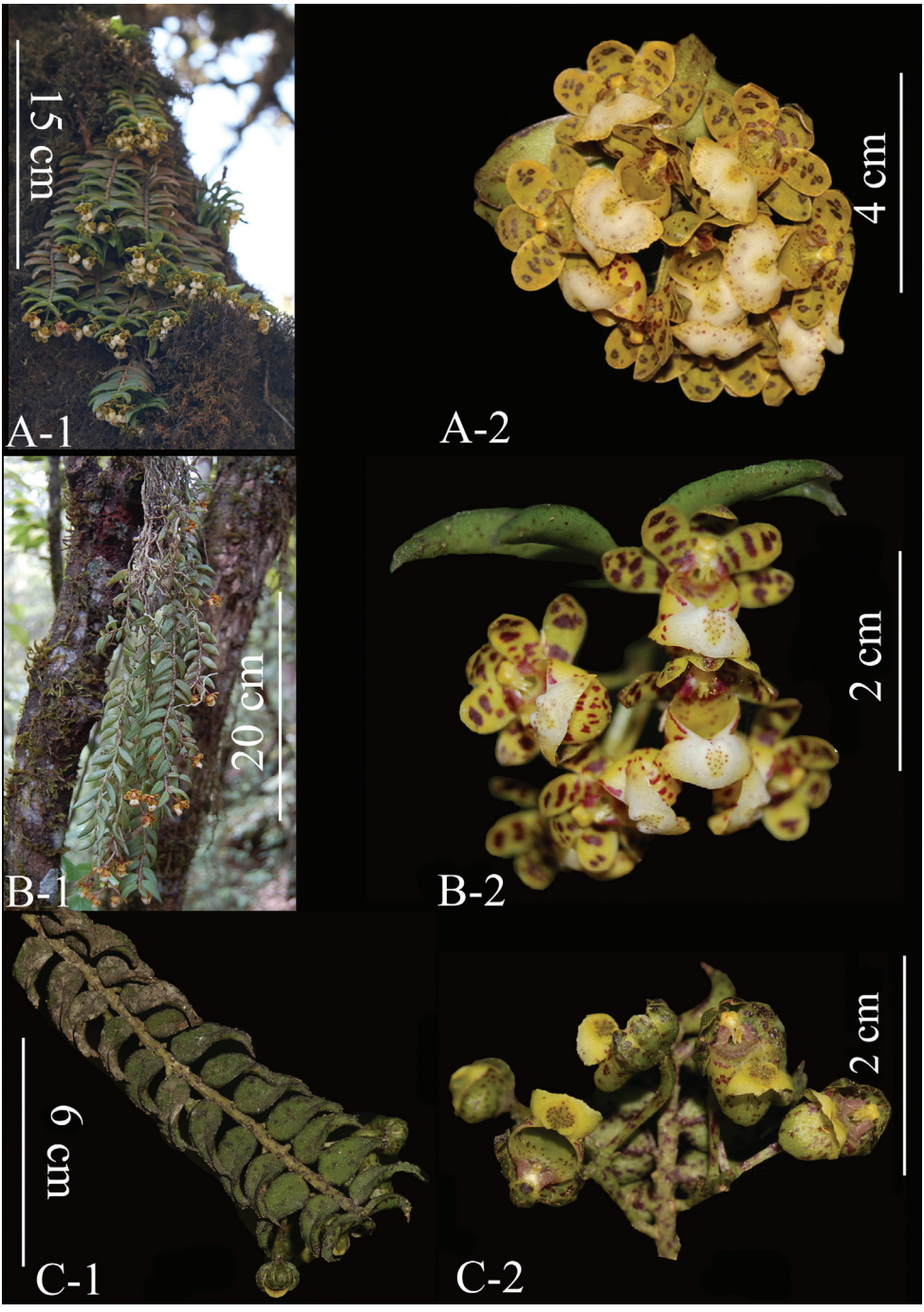

Figure 3. A *Gastrochilus corymbosus* (**A-1** Plant **A-2** Inflorescence and flowers) **B** *G. distichus* (**B-1** Plant **B-2** Inflorescence and flowers) **C** *G. prionophyllus* (**C-1** Plant **C-2** Inflorescence and flowers) (Photographed by Q. Liu).

Table 1. Morphological comparison of *Gastrochilus prionophyllus* and its closely related species.

Character	*G. prionophyllus*	*G. corymbosus*	*G. distichus*
Habitat	Limestone forest	Subalpine rhododendron forest	Monsoon evergreen broad leaved forest
Plant length	10–15 cm	10–15 cm	10–30 cm
Leaf	Ovate, acuminate with 2 awns, margin serrate	Ovate, acuminate, without awn, margin entire	Lanceolate, acuminate with 2–3 awns, margin entire
Inflorescence	Subumbellate, peduncle 1.0 cm in length, 2–3 flowers	Corymb, peduncle1.3 cm in length, 4 flowers	Subumbellate, peduncle 2.5–3.0 cm in length, 2–4 flowers
Epichile	Reniform, with thickly and orbicular central cushion, and margin with dentations	Rhomboid, with diamond-shaped central cushion, and margin entire	Suborbicular, with orbicular central cushion, and margin entire
Hypochile	Subconic	Cupular	Subcupular
Flower period	March– April	October–November	January–May

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RESEARCH ARTICLE

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Primula dongchuanensis (Primulaceae), a new species from northern Yunnan, China

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Abstract

Primula dongchuanensis Z.K.Wu & Yuan Huang, a new species of Primulaceae from Dongchuan of northern Yunnan, China, is described and illustrated. Both morphological and molecular evidence support *P. dongchuanensis* as a member of the sect. *Proliferae*. It is similar to *P. aurantiaca* W.W.Smith & Forrest, but is distinguished by having unique raceme inflorescences. Its distribution, phenology and conservation status are also provided.

Keywords

Primulaceae, *Primula dongchuanensis*, new species, Yunnan, China

Introduction

Primula Linn. is one of the largest genera of Primulaceae, including about 500 species worldwide. Most *Primula* species are indigenous to the north temperate zone, with only a few outliers on some mountains of Africa (Ethiopia), tropical Asia (Java and Sumatra) and South America (Hu 1994, Hu and Kelso 1996, Mast et al. 2001). The modern center of diversity of *Primula* is in southwestern China, with ca 300 species

of 24 sections, most of which occur in western Sichuan, eastern Xizang, and northwestern Yunnan (Hu 1994, Hu and Kelso 1996). Increased exploration across this region results to the discovery and description of new *Primula* species in the past 15 years (Hu and Geng 2003, Wu et al. 2013, Xu et al. 2017a, 2017b, Yang et al. 2017, Ju et al. 2018)

Section *Proliferae* Pax (10:217, 1889) of the genus *Primula* comprises more than 20 species, mainly distributed in Eastern Himalaya and Hengduan Mountain in China. Most species in this section are horticulturally important plants. Morphologically, sect. *Proliferae* shows the distinct character of several whorls of flowers in superimposed umbels and is recognized as a 'natural' group in this genus. Previous studies presumed that the sect. *Proliferae* may represent the most primitive group of *Primula* alive today, and take a central position with respect to subsequent evolution and geographical migration in the genus (Richards 1993, 2002). However, molecular phylogenetic evidence posited the opposite conclusion and indicated that the sect. *Proliferae* represents relatively advanced members of *Primula* that exist today (Mast et al. 2001, 2004, Yan et al. 2015).

During the field investigation in the Jiaozi Snow Mountain in Dongchuan of Yunnan, southwestern China in 2011, we found a peculiar population of *Primula* in its vegetative stage on a small patch of alpine meadow near the mountain top. We transplanted some living individuals to Lijiang Alpine Botanical Garden (at elevation of ca. 3200m), northwest of Yunnan and they regained their bloom in subsequent years. The plant has a short rootstock and robust fibrous roots, obovate-oblong to oblanceolate leaves forming a dense rosette and flowers showed great similarity to the species of sect. *Proliferae*, except the inflorescences with obsolete scapes at early anthesis, then elongating to forming raceme at late flowering. We presumed the unusual inflorescence springs from abnormal variations of plant response to a different climate zone and soil type after translocation. After the field investigations in the same locality in 2016 and in 2019, we confirmed that the inflorescences we observed from the translocated individuals are morphologically consistent with those of the wild population. Further molecular phylogenic analysis revealed it is an undescribed taxon of sect. *Proliferae*. We concluded that the species is new to science and describe it here.

Materials and methods

Morphological descriptions and comparisons were based on living plants from the Lijiang alpine botanical garden and in the field, specimens from the herbarium of Kunming Institute of Botany, Chinese Academy of Sciences (KUN), and literatures (Chen and Hu 1990, Hu and Kelso 1996). All morphological characters of *P. dongchuanensis* and its morphological similar species *P. aurantiaca* were measured using a vernier caliper. The conservation status of *P. dongchuanensis* was assessed according to the IUCN Red list Categories and Criteria (IUCN 2017).

Genomic DNA was isolated from silica gel-dried leaves using a modified Cetyl Trimethyl Ammonium Bromide (CTAB) protocol (Doyle and Doyle 1987). The nrDNA and two chloroplast *matK* and *trnH-psbA* regions of *P. dongchuanensis* were amplified and sequenced using previously published universal primers (White 1990, Taberlet et al. 1991, Kress and Erickson 2007, Yang et al. 2012). Sequences of the relatives of *P. dongchuanensis* were downloaded from NCBI (https://www.ncbi.nlm.nih.gov/) (Appendix 1). Sequences for each region were aligned with CLUSTALX (Thompson et al. 1997) and then manually adjusted in BIOEDT 7.0 (Hall 1999). Maximum likelihood (ML) methods for phylogenetic estimation were conducted using IQ-TREE v. 1.6.10 under the GTR+G model (Nguyen et al. 2015). Clade supports were evaluated by 10000 bootstrap replicates of nonparametric approximate likelihood-ratio test (SH-alRT) and ultrafast bootstrap approximation approach (UFBoot) (Guindon et al. 2010; Hoang et al. 2018). Pairwise genetic distances among *P. dongchuanensis* and its closest relatives revealed by phylogenetic analyses were calculated using the Kimura 2-parameter method (Kimura 1980).

Taxonomic treatment

***Primula dongchuanensis* Z.K.Wu & Yuan Huang, sp. nov.**
urn:lsid:ipni.org:names:77201399-1
Figs 1, 2, 3A

Diagnosis. The new species most resembles *P. aurantiaca*, sharing a similar flower color, leaf shape, efarinose and glabrous, and long calyx parted below the middle. But it can be distinguished by having much smaller statue, inflorescence raceme, scapes nearly obsolete at early anthesis and deep yellow flowers. The main morphological differences between *P. dongchuanensis* and *P. aurantiaca* are summarized in Table 1.

Type. CHINA. Yunnan: Jiaozi Snow Mountain, Dongchuan district, ca. 3860 m, 102°55.75'E, 26°9.45'N, July 2016, *Z. K. Wu & Yuan Huang, ZKWu2016060* (holotype: KUN!; isotype: KUN!).

Table 1. Morphological and phenological comparisons between *Primula dongchuanensis* and *P. aurantiaca*.

Characters	*P. dongchuanensis*	*P. aurantiaca*
Leaf blade	3–6 × 2.0–3.5 cm	4–15 × 1.8–5.0 cm
Scape	scape nearly obsolete at early anthesis, elongating to 10 cm at late flowering	scape 4.5–15 cm at anthesis, elongating to 30 cm in fruit
Inflorescence	inflorescences 6–20-flowered arising from leaf rosette at early anthesis, elongating to 10 cm with 2–8 flowers forming solitary racemes at late flowering	umbels 2–4(–6), superimposed, 6–15-flowered
Pedicels	pedicel green, 1–3 cm long, glabrous	pedicel reddish, 0.3–1.0 cm long, glabrous
Bracts	1–2, linear	1, linear
Flower color	deep yellow	deep reddish orange
Flowering time	late April to early June	late May to early July

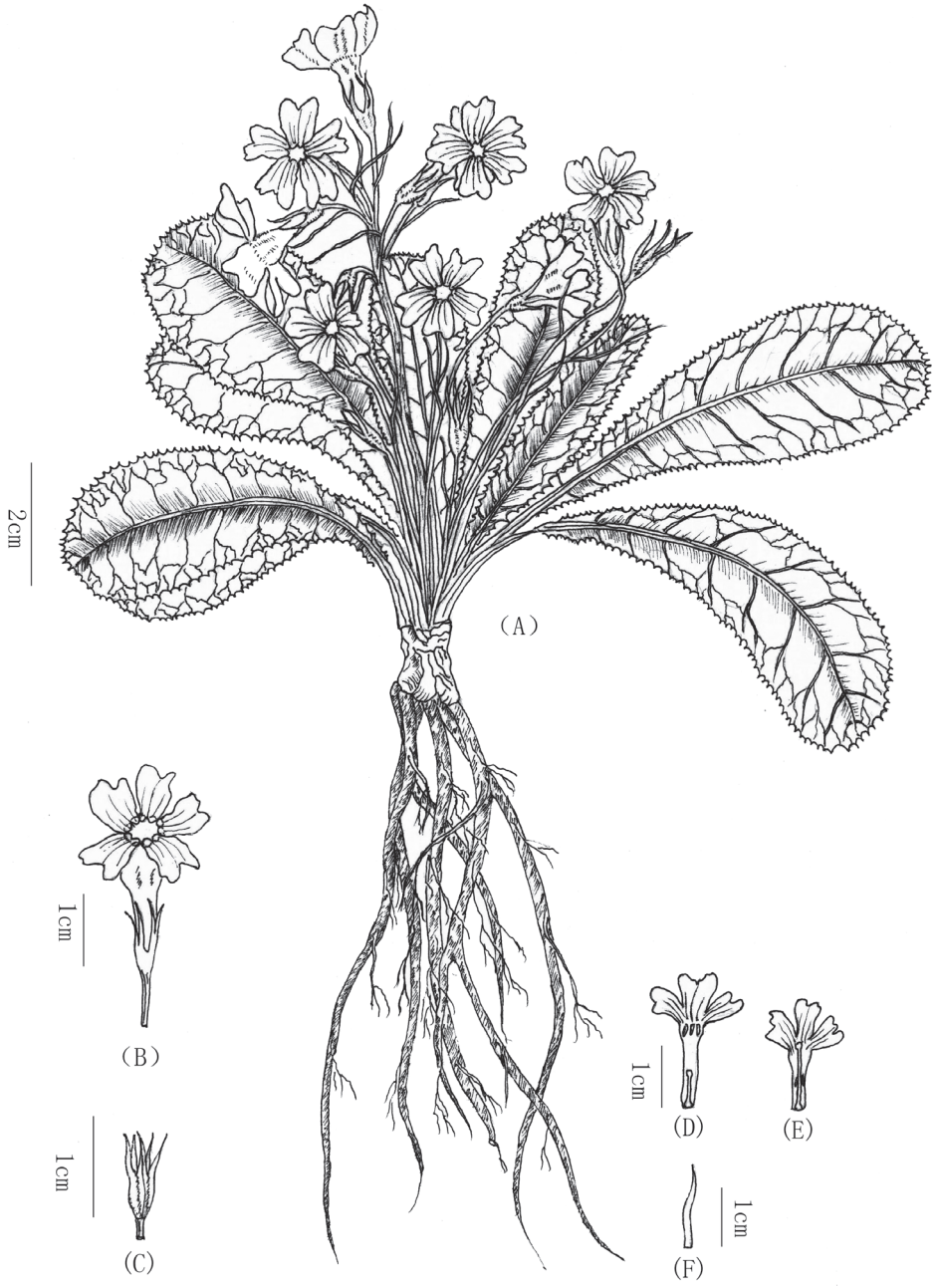

Figure 1. *Primula dongchuanensis* sp. nov. **A** Habit **B** Calyx and corolla **C** Calyx **D** Thrum flower **E** Pin flower **F** Bract.

Description. Perennial efarinose herb, glabrous, with a short root stock and 5–10 robust fibrous roots. Leaves forming a dense rosette, leaf blade obovate-oblong to oblanceolate, 3–6 × 2.0–3.5 cm, base attenuate, decurrent to petiole, margin erose-denticulate, apex rounded, petiole slightly differentiated to 1/3 as long as leaf blade;

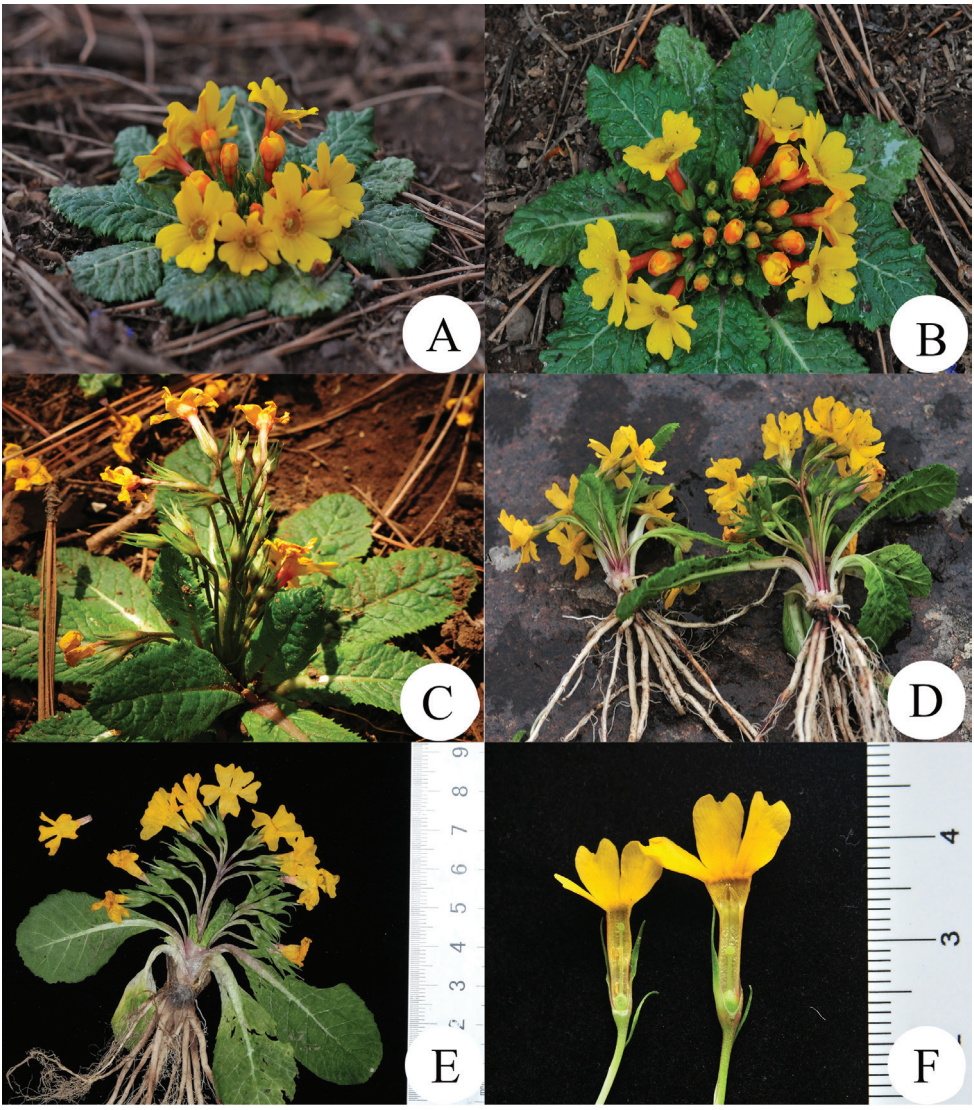

Figure 2. *Primula dongchuanensis* sp. nov. **A, B** Habit in early flowering **C, D** Habit in late flowering **E** specimen of late flowering **F** dissected corolla showing the anthers and stigma, pin flower (left) and thrum flower (right).

Scapes nearly obsolete with "compressed" 6–20-flowered inflorescences arising from leaf rosette at early anthesis, elongating up to 10 cm with 2–8 flowers forming solitary racemes at late flowering; bracts 1–2, linear, 1.0–1.8 cm long, glabrous. Pedicel 1–3 cm, glabrous. Flowers heterostylous. Calyx tubular-campanulate, 6–9 mm long, lobed to 1/2 of its length; lobes lanceolate, each with one prominent midvein, acuminate at apex. Corolla deep yellow; limb 1.2–1.8 cm wide; lobes oblong-obovate, emarginate. Pin flowers: corolla tube 0.8–1.2 cm long; stamens ca. 5 mm above base of corolla tube; style ca. 9 mm. Thrum flowers: corolla tube 0.9–1.4 cm long; stamens ca.

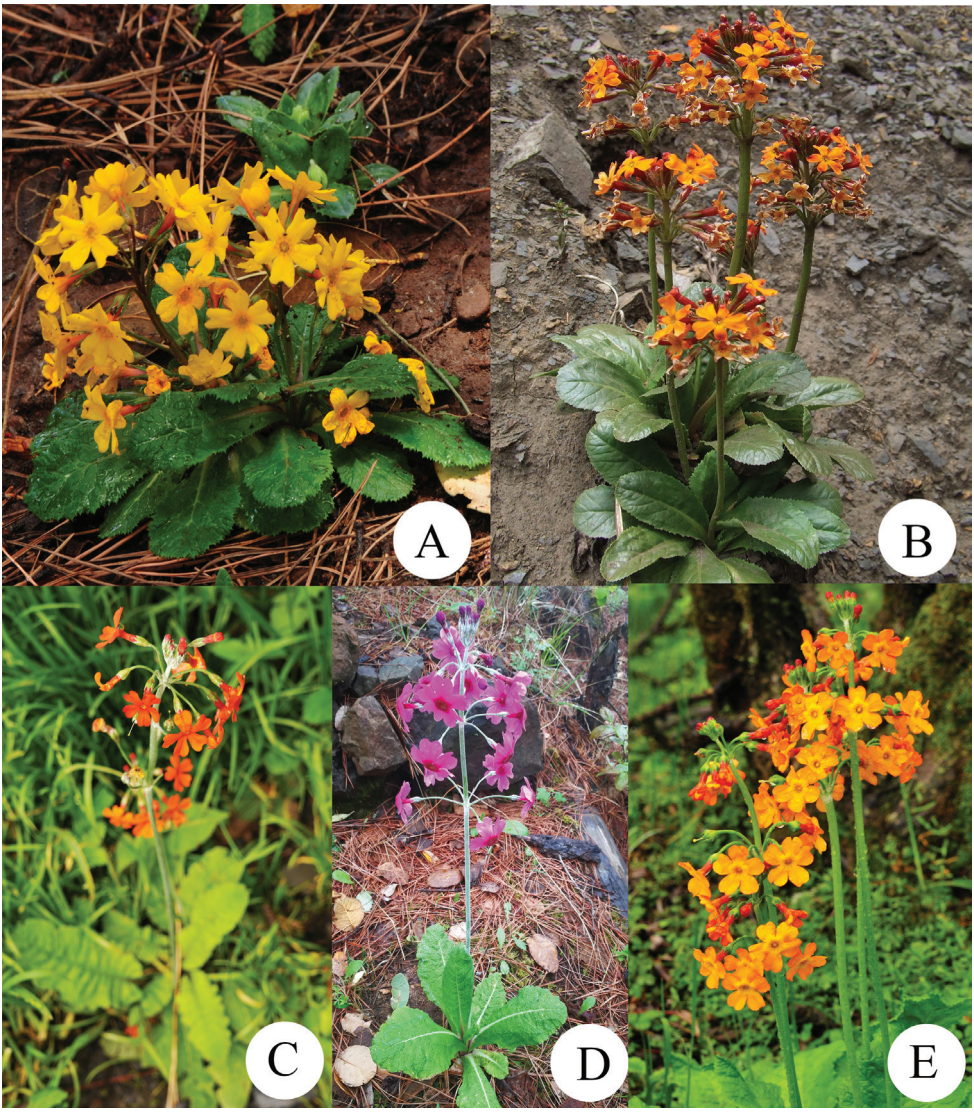

Figure 3. *P. dongchuanensis* and four of its close species **A** *P. dongchuanensis* **B** *P. aurantiaca* **C** *P. cockburniana* **D** *P. chungensis* **E** *P. pulverulenta*.

1.2 cm above base of corolla tube; style ca. 5 mm. Capsule subglobose, ca. 4 mm in diameter, ca. as long as calyx.

Phenology. Flowering occurs from late April to early June; fruiting from July to August.

Distribution and ecology. *P. dongchuanensis* is only known from the type locality in northern Yunnan, China. The plant has been found on alpine meadow and forest margin at elevation of ca. 3800–4000 m (Fig.2), associated with *Sibbaldia purpurea*

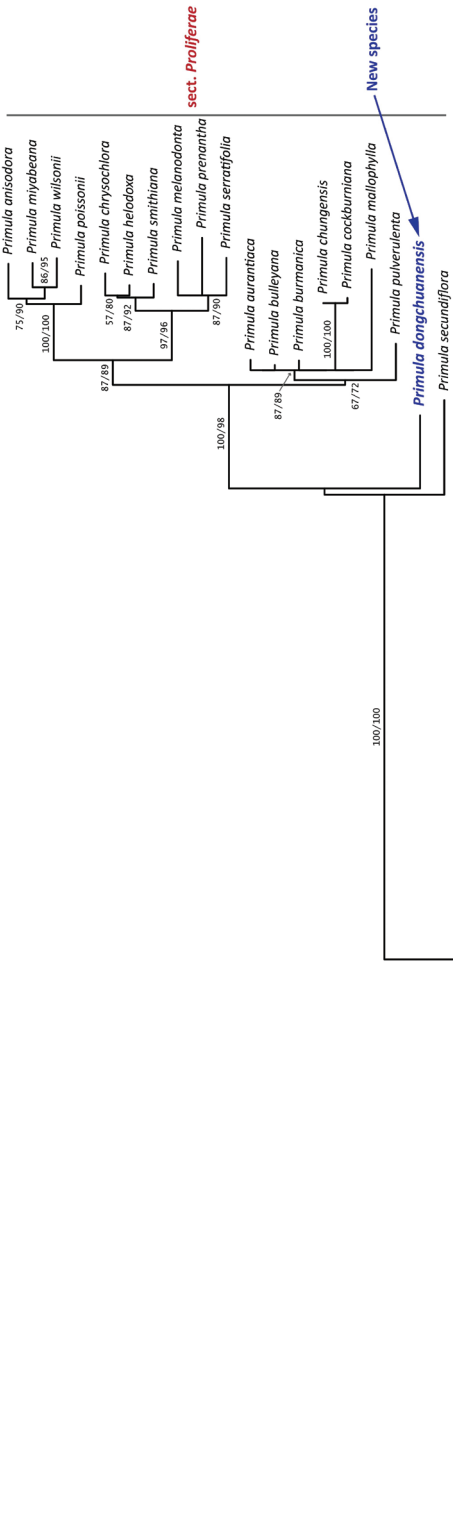

Figure 4. Maximum likelihood tree of new *Primula* species and other *Primula* species based on nuclear ITS, chloroplast *matK* and *trnH-psbA* combined sequenced data, constructed by IQ-TREE under the GTR+G model, clade supports were reported as Shimodaira-Hasegawa approximate Likelihood Ratio Test (SH-aLRT)/ Ultrafast Bootstrap Approximation (UFBoot), each estimated by 10000 replicates, and only support value more than 50% were reported.

var. *macropetala* (Murav.) T.T.Yu & C.L.Li, *Oxygraphis glacialis* (Fisch. ex DC) Bunge, *Androsace rigida* Hand.-Mazz. and *Primula faberi* Oliv.

Etymology. The epithet of the new species is derived from the name of Dongchuan in northern Yunnan, where the new species was discovered and collected.

Vernacular name. Chinese mandarin: dong chuan bao chun (东川报春)

Molecular evidence. The phylogenetic tree obtained from ML analysis is shown in Figure 4. Phylogenetic analysis showed that the new species clustered with other sampled species of sect. *Proliferae* and together formed monophyletic clade with a strong support (UFBoot value = 100%, SHaLRT value = 100%), which indicates it is a member of sect. *Proliferae*, and the tree shows that *P. dongchuanensis* is well differentiated from its close relatives; this is consistent with its special morphological characters in sect. *Proliferae*.

Conservation status. Currently, *P. dongchuanensis* is only known from the top of Jiaozi Snow Mountain in a single population with fewer than 1000 individuals on ca. 2000 m^2 occupancy along the alpine meadow. Although there is no obvious population change observed, the original habitat suffered severely from over-grazing based on three field expeditions conducted in 2011, 2016 and 2019. Living collections introduced to Lijiang alpine botanical garden in 2011 were able to flower and set seeds in the following two years, but no individuals were flowering after the fourth year. Other ex-situ conservation actions, such as seed banking, may apply to secure conservation of this unique *Primula* species. According to the guideline of IUCN red list criteria (IUCN 2017), this new species is assessed as 'Vulnerable' (VU D1).

Discussion

Sect. *Proliferae* Pax is a taxonomically well-known group in *Primula*, characterized by numerous whorls of flowers resembling candelabra (Fig. 3) (Chen and Hu 1990). Phylogenetic analyses by using DNA barcoding confirmed the monophyly of sect. *Proliferae* which could be used in narrowing the scope of identification in *Primula* (Yan et al. 2015). Preliminary molecular phylogenetic analyses in this study supports the view that *P. dongchuanensis* is a member of sect. *Proliferae*, but its molecular closed relatives are not clear yet. Further research is required to clarify the phylogenetic relationship by using enhanced molecular markers with a wider sampling in this section.

Morphologically *P. dongchuanensis* has unique inflorescences architecture compared to other members of sect. *Proliferae*. The racemose inflorescence appears in some *Primula* species, but no report in the sect. *Proliferae* till the addition of *P. dongchuanensis*, which extended the delimitation of sect. *Proliferae* and increased our knowledge of the *Primula* diversity in China. Compared to other species of the sect. *Proliferae* with bigger and upright inflorescences when anthesis begins, *P. dongchuanensis* keeps the racemes in a condensed and short form. This could flow from adaptation to the harsh habit of the mountain top where it is usually very windy and insufficient water in late April and May when it starts anthesis, and the other species of sect. *Proliferae* are usually found in the open and wet alpine meadow and have a late bloom time.

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Appendix 1

asd Information of samples used for phylogenetic inference in this study.

Species	Section	GenBank accession No.			Voucher details
		matK	*trnH-psbA*	ITS	
Primula sinensis Sabine ex Lindl.	Section Auganthus	JF955776	JN046584	JF978054	Y2010045
Primula chapaensis Gapnep.	Section Carolinella	JF955683	JN046494	JF977966	GBOWS681
Primula partschiana Pax	Section Carolinella	JF955748	JN046558	JF978028	Zeng Q.W. s.n.
Primula rugosa Balakr.	Section Carolinella	JF955764	JN046574	JF978044	Hao 662
Primula wangii Chen et C. M. Hu	Section Carolinella	JF955791	JN046599	JF978067	Hao 666
Primula heucherifolia Franch.	Section Cortusoides	JF955715	JN046526	JF977995	Y2010035
Primula polyneura Franch.	Section Cortusoides	JF955749	JN046559	JF978029	GLM103026
Primula septemloba Franch.	Section Cortusoides	JF955767	JN046575	JF978045	Hao & Yan 989
Primula blattariformis Franch.	Section Malvacea	JF955666	JN046477	JF977949	Zhao Y.J. 029
Primula malvacea Franch.	Section Malvacea	JF955720	JN046530	JF978000	Zhao Y.J. 069
Primula oreodoxa Franch.	Section Obconicolisteri	JF955740	JN046550	JF978020	Hao 710
Primula dongchuanensis	Section Proliferae	MN181436	MN181434	MN181435	ZKWu2016060
Primula anidosora Balf. f. et Forr.	Section Proliferae	KP638609	KP638689	KP638569	Y2013062
Primula aurantiaca W. W. Smith et Fletcher	Section Proliferae	HM018224	HM018469	HM018175	Hao 536
Primula bulleyana Forr.	Section Proliferae	HM018235	HM018480	HM018186	Wu Z.K. 2004018
Primula burmanica Balf. f. et Word	Section Proliferae	KP638614	KP638694	KP638574	Y2013010
Primula chrysochlora Balf. f. et Word	Section Proliferae	KP638616	KP638696	KP638576	Y2011005
Primula chungensis Balf. f. et Word	Section Proliferae	HM018226	HM018471	HM018177	Hao 465
Primula cockburniana Hemsl.	Section Proliferae	KP638621	KP638701	KP638581	Hao 1037
Primula helodoxa Balf. f.	Section Proliferae	HM018228	HM018473	HM018179	Wu Z.K. 2005034
Primula mallophylla Balf. f.	Section Proliferae	KP638624	KP638704	KP638584	Y2011084
Primula melanodonta W. W. Smith	Section Proliferae	KP638626	KP638706	KP638586	Y2011070
Primula miyabeana Ito et Kawakami	Section Proliferae	HM018222	HM018467	HM018173	H280
Primula poissonii Franch.	Section Proliferae	HM018241	HM018486	HM018192	Wu Z.K. 2004011
Primula prenantha Balf. f. et W. W. Smith	Section Proliferae	KP638632	KP638712	KP638592	GLM092452
Primula pulverulenta Duthie	Section Proliferae	HM018219	HM018464	HM018170	Hao 230
Primula secundiflora Franch.	Section Proliferae	HM018254	HM018499	HM018205	Ge & Yuan 2003T-5
Primula serratifolia Franch.	Section Proliferae	HM018221	HM018466	HM018172	Hao 484
Primula smithiana Craib	Section Proliferae	HM018220	HM018465	HM018171	Hao 640
Primula wilsonii Dunn	Section Proliferae	KP638643	KP638723	KP638603	Y2013004
Primula pycnoloba Bur. et Franch.	Section Pycnoloba	JF955759	JN046569	JF978039	Hao 766
Omphalogramma delavayi (Franch.) Franch.		KP638606	KP638686	KP638566	Y2013044

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RESEARCH ARTICLE

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Four new species of Gesneriaceae from Yunnan, Southwest China

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Abstract

Four new species of Gesneriaceae from Yunnan, southwest China, are described and illustrated. They are *Petrocosmea rhombifolia*, *Petrocosmea tsaii*, *Didymocarpus brevipedunculatus*, and *Henckelia xinpingensis*. Diagnostic characters between the new species and their morphologically close relatives are provided. Their distribution, ecology, phenology, and conservation status are also described.

Keywords

China, Gesneriaceae, taxonomy, *Petrocosmea*, *Didymocarpus*, *Henckelia*

Introduction

Gesneriaceae (Lamiales) consists of ca. 150 genera and around 3500 species of perennial herbs, shrubs or small trees, with the main distribution in the tropics and subtropics (Weber et al. 2013; Möller et al. 2016a; Middleton et al. 2018). In China, there are >600 species in 44 genera (Möller et al. 2016a, b; Xu et al. 2017). Major taxonomic changes have been implemented in accordance with phylogenetic evidence affecting the classification of Chinese Gesneriaceae, so many morphologically defined

* These authors contributed equally to this work.

genera have been split or merged, or new genera described (reviewed in Möller et al. 2016a). Southern China harbours most species of Gesneriaceae, and Guangxi, Yunnan, Guizhou and Guangdong are species richness regions in Gesneriaceae (Xu et al. 2017).

During botanical surveys from 2012 to 2018 in Yunnan, several specimens of Gesneriaceae were collected. From the vegetative forms and flower characters, they were identified as members of *Petrocosmea* Oliv. (Oliver 1887), *Didymocarpus* Wall. (Wallich 1819), and *Henckelia* Spreng. (Sprengel 1817), respectively. *Petrocosmea* has more than 50 known species distributed in China, Vietnam, Thailand and India (Han et al. 2018b); *Didymocarpus* has approximately 70 species range from northwest India, eastwards through Nepal, Bhutan, northeast India, 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. 2016a; Hong et al. 2018); *Henckelia* has 64 known species found in Sri Lanka, southern and north-eastern India, Nepal, Bhutan, southern China, northern Laos, northern Vietnam and northern Thailand (Weber et al. 2011; Sirimongkol et al. 2019). After thorough comparisons of diagnostic morphological, anatomical features and herbarium specimens available at BM, E, HITBC, K, KUN, NYBG and P with similar taxa of *Petrocosmea*, *Didymocarpus*, and *Henckelia*, and consulting the relevant literature for *Petrocosmea* (Wang 1985; Wang et al. 1990, 1998; Burtt 1998a; Li and Wang 2004; Wei and Wen 2009; Gou et al. 2010; Middleton and Triboun 2010; Zhao and Shui 2010; Shaw 2011; Xu et al. 2011; Qiu and Liu 2015; Qiu et al. 2011, 2012, 2015a, 2015b; Wang et al. 2013; Zhang et al. 2013; Han et al. 2017, 2018a, 2018b), *Didymocarpus* (Wang et al. 1998; Burtt 1998b, 1999, 2001; Weber et al. 2000; Hilliard 2001; Li and Wang 2004; Nangngam and Maxwell 2013; Wen et al. 2013; Li and Li 2014; Nangngam and Middleton 2014; Phuong et al. 2014; Li and Wang 2015; Cai et al. 2016; Joe et al. 2016; Hong et al. 2018), and *Henckelia* (Wang et al. 1998; Weber and Burtt 1998; Burtt 2001; Weber et al. 2011; Middleton et al. 2010; Ranasinghe et al. 2016; Sirimongkol et al. 2019) from China and adjacent regions, it was confirmed that the four species were new to science. Here, they are described and illustrated with photographs and drawings.

Material and methods

Morphological observations were carried out on living plants in the field and greenhouse, as well as dried specimens. All morphological characters were measured under a dissecting microscope and descriptions were made following the terminology presented by Wang 1985 and Wang et al. 1998. Literature studies included all relevant monographs of *Petrocosmea*, *Didymocarpus*, and *Henckelia*, and recently published papers (see introduction), and also similar taxa, i.e. *Petrocosmea rosettifolia* C. Y. Wu ex H. W. Li (Li 1983, Wang et al. 1998, Zhao and Shui 2010), *P. kerrii* Craib var. *kerrii* (Craib 1918, Wang 1985, Wang et al. 1998), *P. menglianensis* H. W. Li (Li 1983, Wang 1985, Wang et al. 1998), *Didymocarpus purpureobracteatus* W.W. Smith (Smith 1912, Wang et al. 1998), and *Henckelia pumila* (D. Don) A. Dietr. (Dietrich 1831, Wang et al. 1998, Weber et al. 2011). Specimens

at BM, E, HITBC, K, KUN, NYBG, P, and PE were checked and the images of type specimens were also obtained from the Chinese Virtual Herbarium (CVH, http://www.cvh.ac.cn), KUN (http://kun.kingdonia.org) and JSTOR Global Plants (http://plants.jstor.org/). Species Conservation Assessment was undertaken using the IUCN methodology (IUCN 2012; IUCN Standards and Petitions Subcommittee 2016).

Taxonomic treatments

1. *Petrocosmea rhombifolia* Y.H.Tan & H.B.Ding, sp. nov.
urn:lsid:ipni.org:names:60479351-2
Figures 1, 2

Diagnosis. *Petrocosmea rhombifolia* is similar to *P. rosettifolia*, but differs from the latter in having rhombic leaf blades (vs. broadly ovate to orbicular or broadly elliptic) and much longer petiole to 15 cm long (vs. to 4 cm long); the flowers have upper white lip (vs. purple-blue flowers throughout), corolla adaxial lip 14–15 × 9–10 mm (vs. ca. 5 mm), abaxial lip 27–28 × 12–14 mm (vs. ca. 7–8 × 6–8 mm), and flowering March-April (vs. October).

Type. CHINA. Yunnan Province: Lancang County, Laba village, 22°36'42.52"N, 99°42'57.10"E, a.s.l. 1900 m, 1 April 2017, Y.H. Tan & H.B. Ding, *T0119* (holotype: HITBC!).

Description. Perennial herb with short rhizomatous stem and crowded fibrous roots. **Leaves** 14 to 25, all in basal rosette; petioles 0.5–15 cm long, densely white pubescent to sericeous; leaf blades ovate or ovate to rhombic, 1.5–5.3 × 1.3–2.8 cm, rounded or cuneate at base, with nearly entire or slightly repand margins and acute or obtuse apex, densely pubescent to sericeous on both surfaces; lateral veins abaxially conspicuous, 2–3 on each side. **Inflorescences** 1–flowered, 4–6 cm long; **Peduncles** 2.5–3.2 cm long, pedicels 1.6–2.0 cm, densely pubescent to sericeous; **Bracts** 2, opposite, subulate, 2–3 mm. **Calyx** actinomorphic, equally divided into 5 lobes from base, lobes lanceolate, 4–5 mm, sparsely pubescent inside, densely sericeous outside. **Corolla** light blue, sparsely pubescent to puberulous outside, sparsely puberulent or subglabrous inside; tube 5–6 mm, sometimes with 2 ovate brown spots inside below the stamens; throat light blue or whitish blue with 2 oblong deep blue blotches; adaxial lip ca. 14–15 × 9–10 mm, semi-orbicular, light blue or whitish blue, distinctly 2-lobed, lobes reflexed, with rounded apex and repand margin; abaxial lip ca. 27–28 × 12–14 mm, blue, 3-lobed to or over the middle, with sub-orbicular to obovate lobes, lobes with rounded apex and repand to slightly crenate margin. **Stamens** 2, about 6 mm long, adnate to the base of the corolla tube; filaments about 3 mm long, sparsely pubescent; anthers ovate, about 3 mm long, dehiscence poricidal, glabrous, dorsifixed, coherent at apex. **Staminodes** 3, ca. 2 mm, adnate to the corolla tube at the base, subglabrous. **Pistil** ca. 1.1 cm; ovary densely villous, oblate, ca. 3 mm; style ca. 8 mm, sparsely pubescent near base; stigma capitate. **Fruit** a short capsule, 8–10 mm long.

Etymology. The new species is named after its rhombic leaf blades.

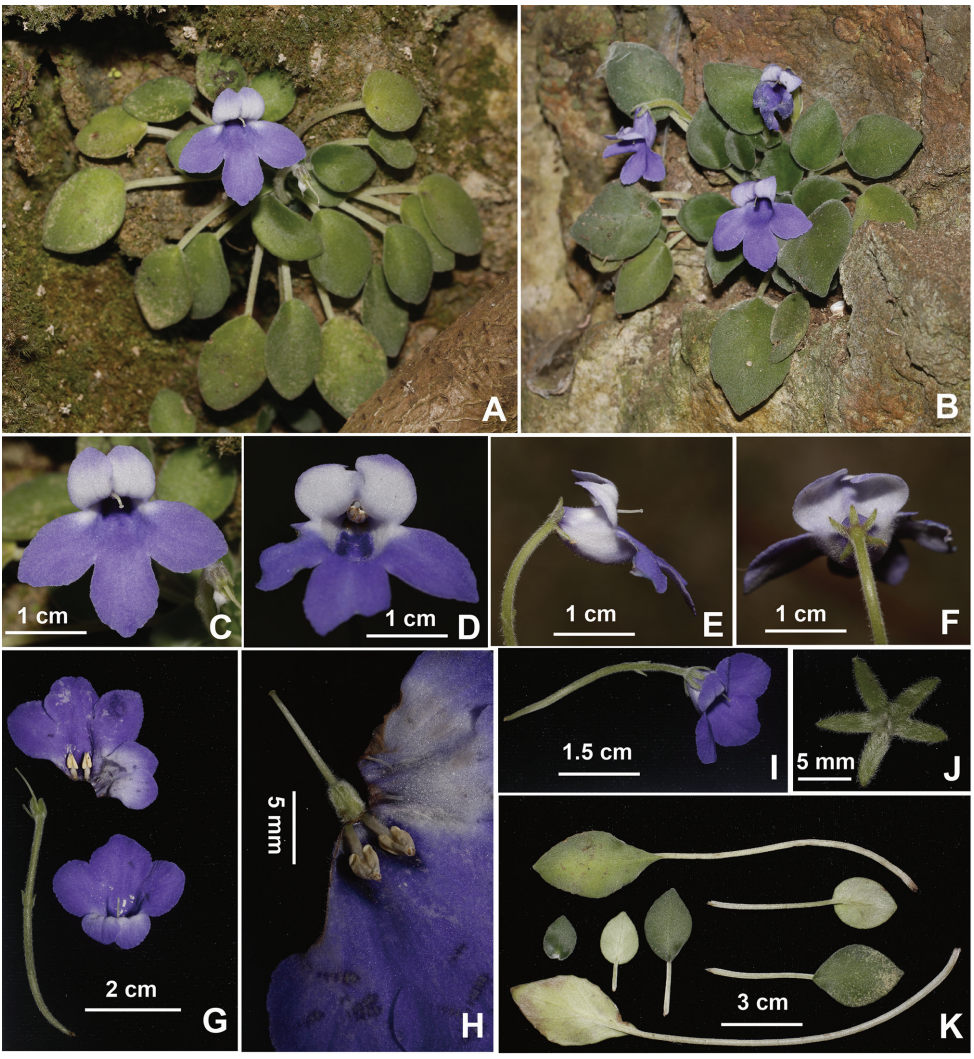

Figure 1. *Petrocosmea rhombifolia* Y.H.Tan & H.B.Ding, sp. nov. **A, B** Habit **C, D** flower in front view **E** flower in side view **F** flower in back view **G** flower **H** dissected corolla (showing pistil and stamens) **I** cyme **J** calyx in abaxial view **K** leaves. Photographed by H.B. Ding.

Vernacular name. Chinese mandarin: ling ye shi hu die (菱叶石蝴蝶).

Phenology. Flowering March-May and fruiting April-June.

Distribution and habitat. *Petrocosmea rhombifolia* grows on moist rock faces in limestone forest, at elevation ca. 1900 m in Laba, Lancang County.

Conservation status. *Petrocosmea rhombifolia* has hitherto only been found at its type locality in Laba, Lancang County. There is very limited information about its natural distribution; a further detailed investigation of the same habitats will help to identify additional populations and individuals of this new species. The lack of sufficient data currently does not allow a risk evaluation and the species can be regarded at present as Data Deficient (DD) according to the IUCN Red List Categories and Criteria (IUCN 2012).

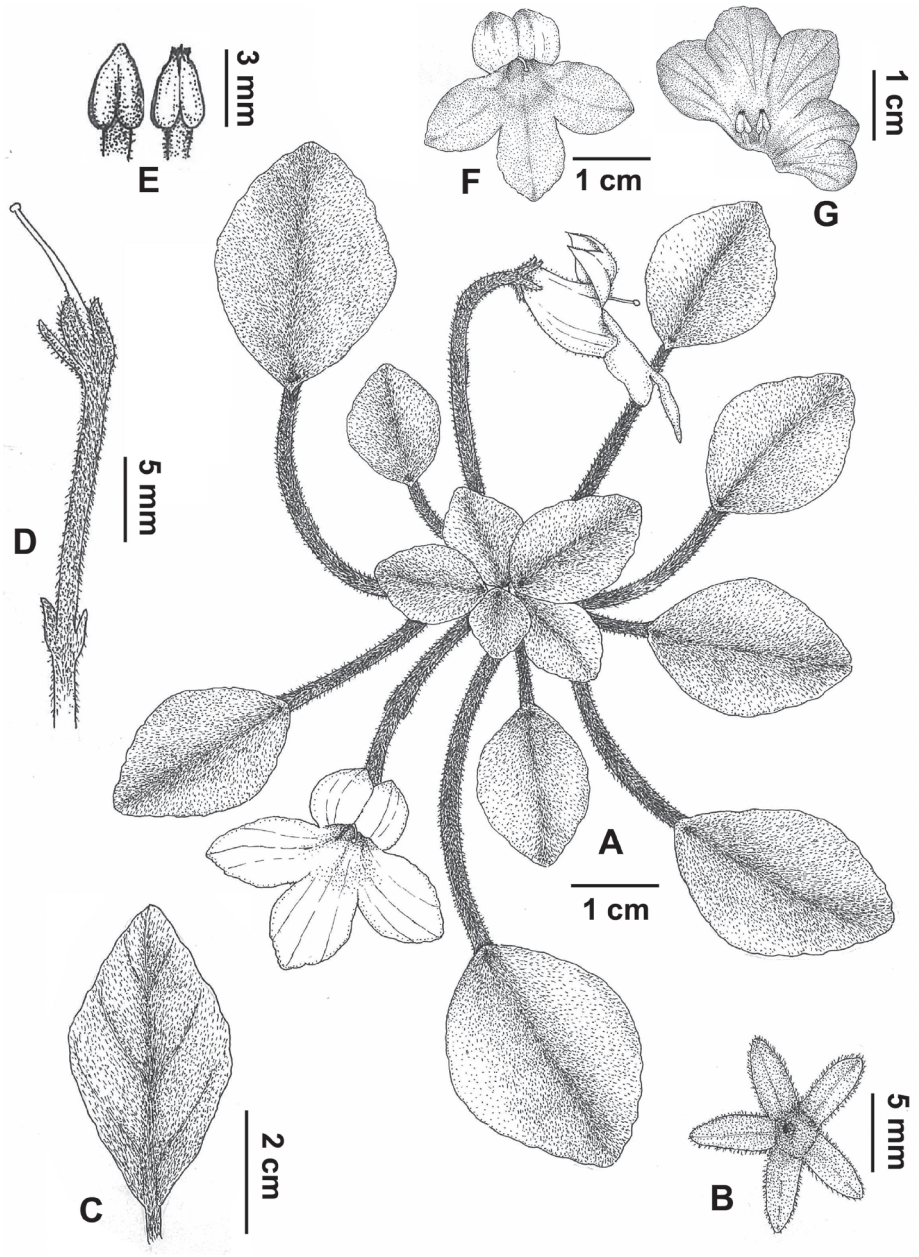

Figure 2. *Petrocosmea rhombifolia* Y.H.Tan & H.B.Ding, sp. nov. **A** Habit **B** calyx in adaxial view **C** leaf blade in abaxial view **D** pedicel with calyx and pistil **E** anthers **F** corolla in front view **G** dissected corolla. Drawn by Zhen-Meng Yang.

Note. *Petrocosmea rhombifolia* has ovate leaf blades with pubescence on the surfaces that are similar to *P. rosettifolia*, but mainly different from the leaf blade and flower characters. A comparative list of diagnostic characters of the new species and *P. rosettifolia* is given in Table 1.

Table 1. Morphological comparison between *Petrocosmea rhombifolia* sp.nov. and *P. rosettifolia* C. Y. Wu ex H. W. Li.

Characters	*P. rhombifolium*	*P. rosettifolia*
Leaf blade		
Shape and size	ovate or ovate to rhombic, 1.5–5.3 × 1.3–2.8 cm	broadly ovate to orbicular or broadly elliptic, 0.5–4.0 × 0.4–3.0cm
Margin	nearly entire or slightly repand	entire to crenulate-serrulate toward apex
lateral veins	conspicuous, 2–3 pairs	inconspicuous
Base	rounded or cuneate	broadly cuneate to cuneate
Apex	acute or obtuse	broadly acute
indumentum	densely white pubescent to siliceous	densely appressed puberulent or sericeous to tomentose
Petiole	to 15 cm long	to 4 cm long
Cymes	1-flowered	1-flowered
Corolla		
Calyx	actinomorphic, equally divided into 5 lobes from base	actinomorphic, equally divided into 5 lobes from base
colour and indumentum	light blue, upper lip white, outside sparsely pubescent to puberulous, inside sparsely puberulent or subglabrous	purple-blue throughout, outside sparsely puberulent, inside glabrous
adaxial lip	14–15 × 9–10 mm, distinctly 2-lobed with the two lobes reflexed	ca. 5 mm, distinctly 2-lobed
abaxial lip	27–28 × 12–14 mm	ca. 8 × 7 mm
Throat	whitish light blue or somewhat light blue with 2 oblong deep blue blotches	white
Tube	5–6 mm	ca. 5 mm
Stamens		
filaments	ca. 3 mm, sparsely pubescent	ca. 3 mm, minutely hispid
anthers	ca. 3 mm	ca. 1 mm, beakless
Pistil	ca. 1.1 cm	ca. 1 cm
Ovary	oblate, densely villous	elliptic-ovoid, appressed puberulent
Style	ca. 8 mm, sparsely pubescent near base	5–7 mm, sparsely puberulent near base
Flowering time	March to May	October

2. *Petrocosmea tsaii* Y.H.Tan & JianW.Li, sp. nov.

urn:lsid:ipni.org:names:60479352-2
Figures 3, 4

Diagnosis. *Petrocosmea tsaii* is similar to *P. kerrii* var. *kerrii* and *P. menglianensis* in having elliptic leaf blade, oblique and rounded leaf base, acute leaf apex, ellipsoid anthers with brevirostrate apex; but it can be easily distinguished from the two similar taxa by its bluish purple corolla (vs. white) and much longer inflorescences. *Petrocosmea tsaii* also differs from *P. kerrii* var. *kerrii* by having actinomorphic calyx (vs. zygomorphic), and differs from *P. menglianensis* by its leaf blade abaxially densely villous (vs. pubescent along midrib and lateral veins).

Type. CHINA. Yunnan Province: Mengla county, Menglun, Mengxing, 21°49'N, 101°23'E, a.s.l. 1200 m, 13 Sep. 2016, *Jian-Wu Li 4577* (holotype: HITBC!).

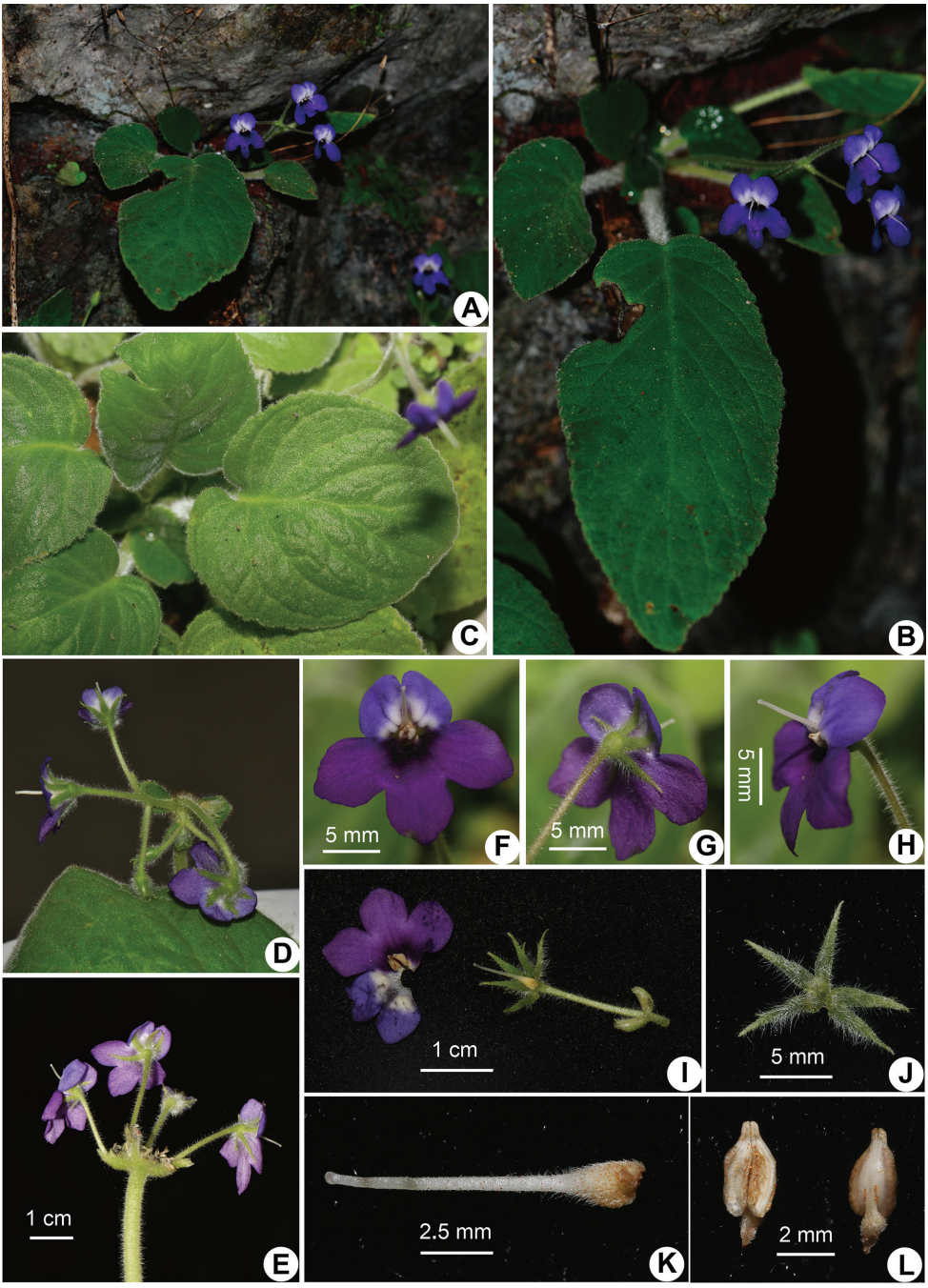

Figure 3. *Petrocosmea tsaii* Y.H.Tan & JianW.Li, sp. nov. **A, B** Habit **C** leaves **D, E** inflorescence **F** flower in front view **G** flower in back view **H** flower in side view **I** dissected flower **J** calyx in abaxial view **K** pistil **L** stamens. Photographed by J.W.Li, Y.H.Tan & H.B.Ding.

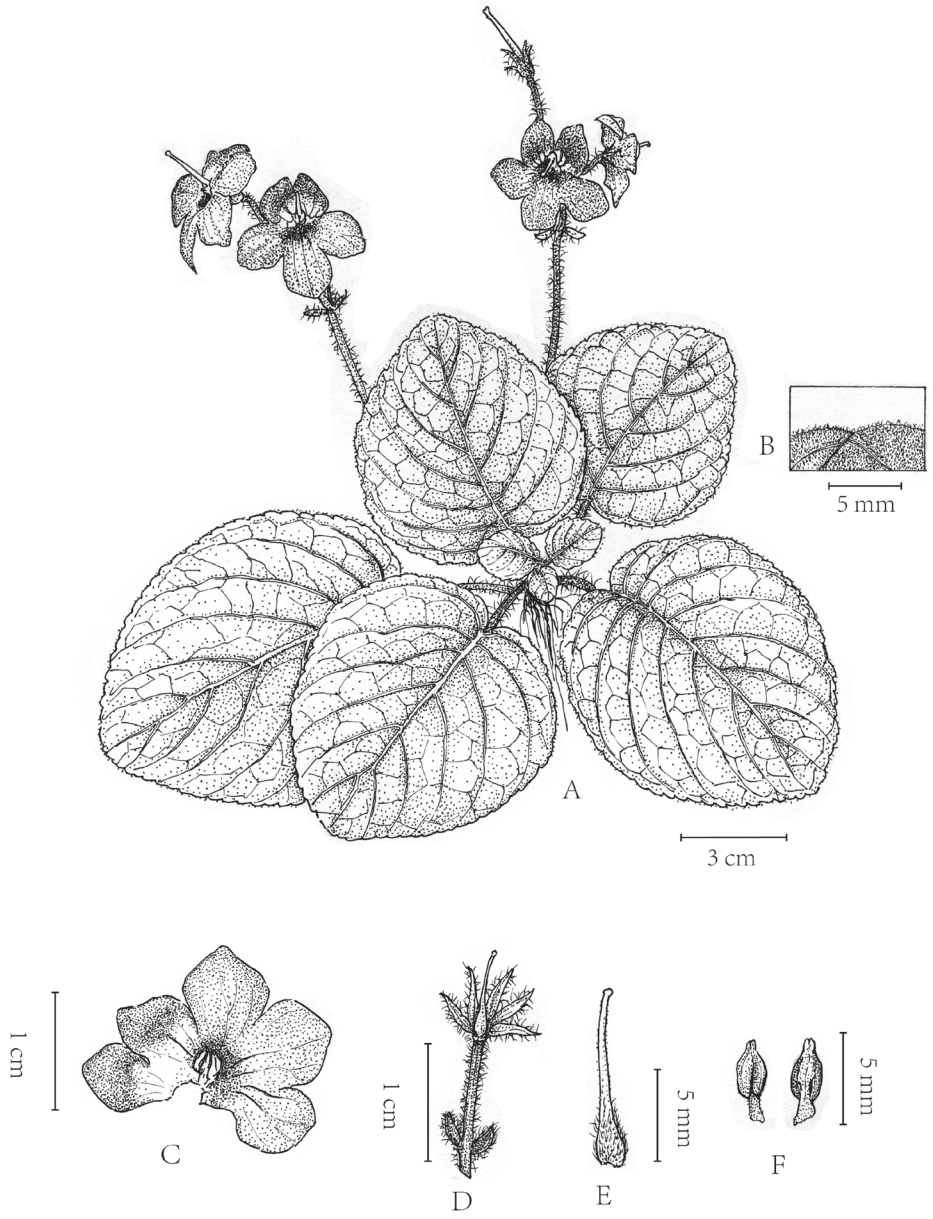

Figure 4. *Petrocosmea tsaii* Y.H.Tan & JianW.Li, sp. nov. **A** Habit **B** adaxial Leaf surface indumentum **C** corolla (Dissected) **D** pedicel with bracteoles, calyx and pistil **E** pistil **F** stamens. Drawn by Zhengmeng Yang.

Description. Perennial herb with short rhizomatous stem. **Leaves** 8–15, in basal rosette; inner leaves with petioles short or absent, ovate or suborbicular; outer leaves with long petioles, elliptic or ovate to widely ovate; 1.5–10.5 × 1.2–8.2 cm, apex acute to rounded, base rounded to subcordate, sometimes oblique, margin crenate, densely

villous on abaxial surfaces, sparsely pubescent to puberulous on adaxial surface; **lateral veins** 4–10 on either side of midrib, adaxially impressed, abaxially conspicuous; **petioles** up to 10 cm long, densely white villous. **Inflorescences** 6.0–14.5 cm long; Peduncles 3.5–11.0 cm long, 2.0–2.5 mm in diam., densely villous and with glandular hairs; **bracts** 2–3, ovate to broadly ovate, or somewhat leaf like, with 4–5 lateral veins on side, ovate-elliptic, 8–19 × 6–18 mm; **cymes** usually 3–6(–8)-flowered, **hypopodium** 0.5–3.5 cm, **pedicels** 1.2–2.3 cm, villous and with glandular hairs; **bracteoles** 2, opposite, linear-lanceolate, 3.5–8.3 × 1.5–2 mm. **Calyx** actinomorphic, equally divided into 5 lobes from base, lobes linear-lanceolate, 6–7 × 1–1.5 mm, internally sparsely with glandular hairs, externally villous and with glandular hairs, margin with 1–3 linear teeth above middle. **Corolla** 10.5–12 mm long, externally sparsely puberulous to glabrous, internally glabrous; tube 4–4.5 mm; throat dark bluish purple; adaxial lip ca. 7–9 × 10–12 mm, indistinctly 2-lobed with the two lobes reflexed, lobes semi-orbicular, with rounded apex and entire margin, base white; abaxial lip ca. 16–20 × 9–11 mm, 3-lobed to the middle, lobes semi-orbicular, with rounded to obtuse apex, bluish purple. **Stamens** 2, 4–4.5 mm long, adnate to the base of the corolla tube; anthers adnate face to face; filaments 1.5–2 mm long, with short glandular hairs near base; anther ovoid to ellipsoid, 3–3.5 mm long, with brown capitate-glandular hairs, dorsifixed, apex brevirostrate. **Staminodes** 2–3, ca. 1 mm, adnate to the corolla tube at the base, linear, glabrous. **Pistil** 11–12 mm; ovary 3–3.5 mm long, narrowly ovoid, sparsely pubescent and with yellow glandular hairs; style 7.5–9 mm, sparsely with yellow glandular hairs at base, upper part glabrous; stigma capitate. **Fruit** a short capsule, 10–12 mm long.

Etymology. The specific epithet commemorates the late Prof. Cai Xitao (Tsai Hse-Tao), who was the founder of Xishuangbanna Tropical Botanical Garden (XTBG) and devoted all his life to the study of Chinese plants.

Vernacular name. Chinese mandarin: Cai Shi Shi Hu Die (蔡氏石蝴蝶)

Phenology. Flowering September-October and fruiting October-November.

Distribution and habitat. The species grows on moist rock faces in limestone forests, Mengla County, Yunnan, China.

Conservation status. Due to insufficient field surveys so far, very few details about its natural distribution and population status are currently known. The lack of sufficient data does not allow a risk evaluation and the species can be regarded at present as Data Deficient (DD) according to the IUCN Red List Categories (IUCN 2012).

Note. A comparison of the diagnostic characters of the new species and *P. kerrii* var. *kerrii*, *P. menglianensis* is given in Table 2.

3. *Didymocarpus brevipedunculatus* Y.H.Tan & Bin Yang, sp. nov.

urn:lsid:ipni.org:names:60479353-2
Figures 5, 6

Diagnosis. *Didymocarpus brevipedunculatus* is similar to *D. purpureobracteatus* in bracts ovate to orbicular and calyx tubular, but it can be easily distinguished from the latter by

Table 2. Morphological comparison among *Petrocosmea tsaii* sp. nov., *Petrocosmea kerrii* Craib var. *kerrii* and *Petrocosmea menglianensis* H. W. Li.

Characters	*P. tsaii*	*P. kerrii* var. *kerrii*	*P. menglianensis*
Leaf blade			
shape and size	elliptic or ovate to widely ovate; 1.5–10.5 × 1.2–8.2 cm	elliptic to rhombic-elliptic or ovate, 1.8–13.5 × 1.2–8.5 cm	elliptic to elliptic-ovate, 7.5–8.5 × 5–6 cm
margin	crenate	dentate	irregularly dentate
Base	sometimes oblique, rounded to subcordate,	usually oblique, broadly cuneate to rounded	oblique, rounded to cuneate
Apex	acute to rounded	broadly acute to obtuse, rarely rounded	broadly acute to obtuse
indumentums	adaxially sparsely pubescent to puberulous, abaxially densely villous	adaxially and abaxially densely hirsute to densely puberulent	adaxially rust-brown pubescent, abaxially rust-brown pubescent along midrib and lateral veins
Bracts	ovate to broadly ovate, or somewhat leaf like, 8–19 × 6–18 mm	lanceolate, ca. 2.0 × 0.5 mm	subulate to lanceolate, 3–4 × 1.0–1.5 mm
Calyx	actinomorphic	zygomorphic	actinomorphic
Corolla colour	bluish purple	white	white
Throat of corolla	dark bluish purple	white with yellow blotches	blackish
Filaments	1.5–2.0 mm, with short glandular hairs near base	ca. 1.2 mm, puberulent	ca. 1 mm, puberulent
Anthers	ovoid to ellipsoid, 3.0–3.5 mm long, apex brevirostrate	ellipsoid, ca. 3 mm, apex brevirostrate	broadly ellipsoid, ca. 3 mm, apex brevirostrate
Ovary	sparsely pubescent and with yellow glandular hairs	sparsely puberulent	minutely villous
Style	sparsely with yellow glandular hairs at base	sparsely puberulent near base	glabrous
Flowering	September to October	April to May	August to October

its leaf base extremely obliquely cordate (vs. leaf base sometimes oblique, cuneate to cordate), inflorescence gracile, pendulous (vs. erect), inflorescence much shorter than leaf (vs. inflorescence much longer than leaf), peduncles (4.0–5.5 cm vs 4.0–10 cm long), flowers white with purplish to deep red longitudinal stripes (vs. purple to pinkish purple with darker stripes), and peduncles villous with eglandular, multicelluar hairs (vs. glabrous).

Type. CHINA. Yunnan: Ximeng, Mengsuo, grows on rock surfaces along a seasonal waterfall or moist and shade places in evergreen forest, 22°38'04.83"N, 99°35'34.17"E, a.s.l. 1200 m, 8 September 2012, *Yun-Hong Tan 6930* (holotype: HITBC! Isotype: HITBC!).

Description. Deciduous, perennial, epilithic herb, 30–40 cm tall, stem 4–6 mm in diameter. ***Dry season*** juvenile leaves distinct, blades symmetrically ovate, c. 1.5 × 1 cm, with much denser indumentum than when mature. ***Rainy season*** **stems** succulent, erect, green, densely and finely villous with multicellular eglandular hairs; pigment glands absent. **Leaves** 4–6 arranged in opposite, decussate, anisophyllous pairs; blades asymmetrically ovate, thin, papery when dry, upper surface dull dark green and drying medium brown, densely villous with eglandular, multicellular hairs, lower side pale light green and drying light brown, densely villous with eglandular, multicellular

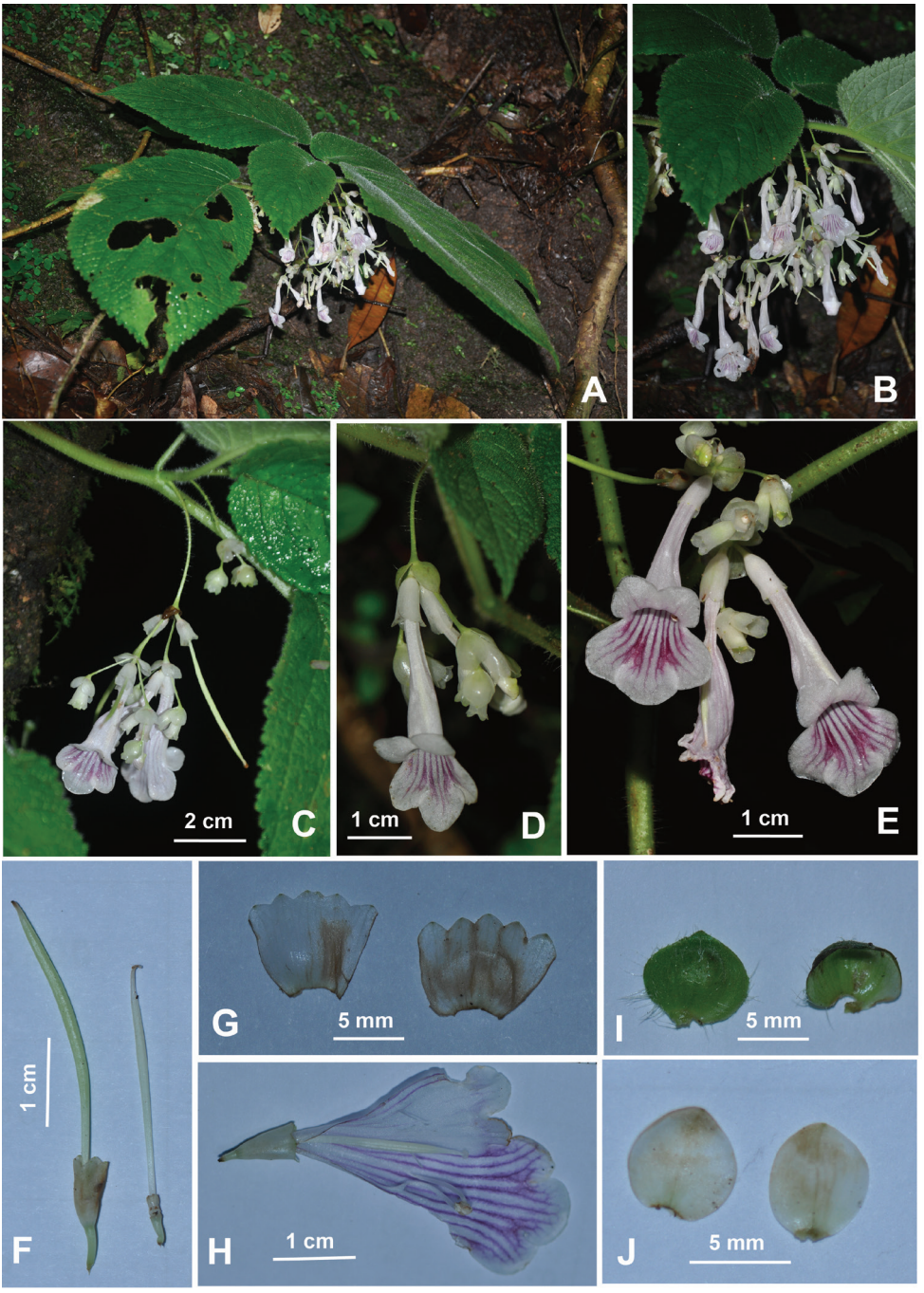

Figure 5. *Didymocarpus brevipedunculatus* Y.H.Tan & Bin Yang, sp. nov. **A, B** Habit **C, D** inflorescence **E** flowers **F** young capsules **G** dissected calyx **H** dissected corolla **I** bracts **J** bracteoles. Photographed by Y.H. Tan.

hairs along veins, 10–25 cm long, 6.5–15.5 cm wide, apex attenuate to acuminate, base extremely obliquely cordate, margins serrate, often irregularly so, or doubly serrate, midrib with 9–11 arching secondary veins on each side, distinct on both surfaces, finer venation reticulate; petioles 4.5–12.0 cm long, with indumentum as on the stems. **Inflorescence** solitary per axil, cymose, gracile, pendulous, 7–12 cm long, villous with eglandular, multicellular hairs, laxly cymose, axes succulent, light green to green; **Peduncles** 4.0–5.5 cm long, densely villous with eglandular, multicellular hairs; **Hypopodium** 1.0–2.0 cm long, glabrous or sparsely villous; **Pedicels** 3–5 mm long, glabrous or sparsely villous. **Bracts** paired; green to light green, sparsely villous with eglandular, multicellular hairs, orbicular to ovate, 5.5–6.0 mm long and wide. **Bracteoles** paired, whitish to light green, glabrous or sparsely villous, orbicular to ovate, 4.0–5.5 mm long and wide. **Flowers** numerous. **Calyx** campanulate, glabrous, often light green on both side, sometimes purplish outside; tube c. 6 mm long; lobes ovate, subequal to equal, 5(6) lobed, apices obtuse to rounded; 0.5–1.0 mm long. **Corolla** funnelform, 4.0–4.5 cm long, glabrous, white, inside with 9 purplish to deep red longitudinal stripes, 3 per lobe in the lower lip; tube 3.2–3.5 cm long, gradually widening from the base to the throat, 0.8–1.0 cm wide at base, 1.8–2.0 cm at throat; lobes ovate to suborbicular, broadly rounded; anterior (lower or abaxial) lip 3-lobed, 6–7 mm long, 7–8 mm wide apices rounded, posterior (upper or adaxial) lip 2-lobed 5–6 mm long, 7–8 mm wide, apices rounded. **Fertile stamens** 2, inserted at c. 2 cm above the base of the corolla; filaments 0.9–1.0 cm long, glabrous; anther locules oblong, c. 2 × 1 mm, tips and bases rounded, white-bearded, cream; **Staminodes** 3, inserted slightly below the stamens, lateral ones 5 mm long, the other one 3 mm long, glabrous. **Disc** ring-like, thickened, glabrous, margin entire or slightly lobed, 2–3 mm high, persistent in fruit. **Ovary** cylindric, slightly stipitate, glabrous, light green, c. 2.5–3.0 cm long, 1 mm wide; style continuous with the top of the ovary, c. 5 mm long, glabrous, whitish or light green; stigma discoid, concave medially, whitish, 1 mm diameter. **Capsules** cylindric, slightly stipitate, erect, straight, light green, when maturing light brown, 4.5–5 cm long and 2.5 mm wide. **Seeds**, numerous, elliptic, appendage absent, cell ornamentation straight, cell faces finely verrucate.

Etymology. The new species is named after its axillary relatively short peduncles.

Vernacular. Chinese mandarin: Duan Xu Chang Shuo Ju Tai (短序长蒴苣苔)

Phenology. Flowering August-September and fruiting September-October.

Distribution and habitat. The new species was found in south Yunnan, Ximeng and Cangyuan Counties. It grows on rock surfaces along a seasonal waterfall or in moist and shady places in evergreen forests, altitude 1000–1200 m.

Conservation status. The localities of this new species, in Ximeng and Cangyuan, are both part of protected areas, and a total of more than one hundred individuals were found in the wild; a further inventory is needed to clarify the habitats and populations. At present, the species is therefore assigned a preliminary status of Endangered (EN D) according to the IUCN Red List Categories and Criteria (IUCN 2012).

Note. A comparative list of diagnostic characters of the new species and *D. purpureobracteatus* is given in Table 3.

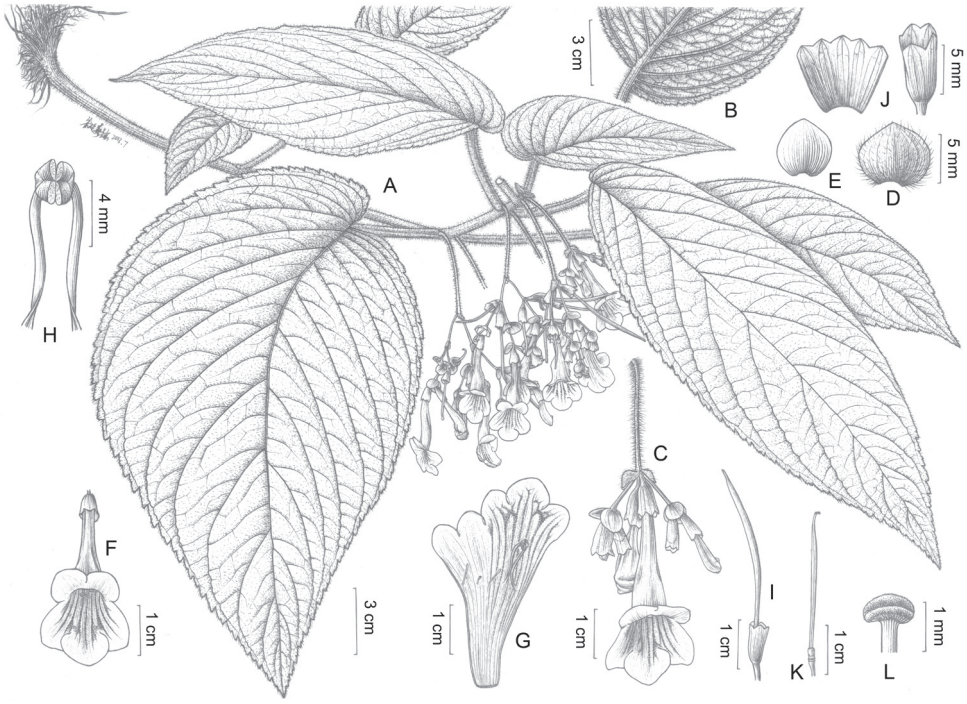

Figure 6. *Didymocarpus brevipedunculatus* Y.H.Tan, sp. nov. **A** Habit **B** leaf base in abaxial view **C** inflorescence **D** bract in abaxial view **E** bracteole **F** flower in front view **G** dissected corolla **H** stamens **I** young capsule **J** calyx **K** pistil **L** stigma. Drawn by Yun-xi Zhu.

Table 3. Morphological comparison of *Didymocarpus brevipedunculatus* and its closely related species.

Characters	*D. brevipedunculatus*	*D. purpureobracteatus*
Shape of leaf Blade	asymmetrically ovate, base extremely obliquely cordate, apex attenuate to acuminate	symmetrically ovate to elliptic or obovate, base oblique, cuneate, to cordate, apex acute to acuminate
Leaf indumentum	upper surface densely villous with eglandular, multicellular hairs, lower side densely villous with eglandular, multicellular hairs along veins	adaxially sparsely appressed puberulent to nearly glabrous along veins, sparsely glandular
Petiole	4.5–12.0 cm long, densely villous with eglandular, multicellular hairs	0.3–11.0 cm long, puberulent, sparsely glandular
Bracts	orbicular to ovate, green to slightly green, sparely villous with eglandular, multicellular hairs	ovate to elliptic-ovate, sometimes connate at the base, galeate, covering calyx when flowering, glabrous
Calyx	6–7mm long, tubular campanulate, glabrous, lobe ovate to semiorbicular	10–12 mm long, tubular campanulate, glabrous, lobes semiorbicular
Inflorescence	gracile, pendulous, much shorter than leave	erect, much longer than leave
Peduncle	4.0–5.5 cm long	4.0–10.0 cm long
Corolla	white, inside with purplish to deep red longitudinal stripes	purple to pinkish purple with darker stripes, glabrous, corolla tube funnelform
Filaments	0.9–1 cm long, glabrous	ca. 1 cm, glabrous
Staminode	three, 1.0–3.0 mm long	two, 1.5–3.0 mm long

4. *Henckelia xinpingensis* Y.H.Tan & Bin Yang, sp. nov.
urn:lsid:ipni.org:names:60479354-2
Figures 7, 8, 9 (A1–A4)

Diagnosis. *Henckelia xinpingensis* is similar to *H. pumila* in having elliptic leaf blades sometimes with purple spots abaxially, appearing brown-green adaxially, and funnel form corolla, but differs in having intensive yellow (vs. white to purple) corollas, stigma undivided or slightly 2-lobed (vs. conspicuous 2-lobed), calyx from base to below the middle (vs. 5-lobed from below to above middle); leaf blade symmetrical, base rounded to cordate (vs. asymmetrical, base oblique) and producing slender stolons.

Type. CHINA. Yunnan Province: Xinping county, Yubaiding, 24°09.32'N, 102°07.71'E, a.s.l. 1500 m, 17 Aug. 2018, Y.H. Tan, B. Yang, H.B. Ding & X.D. Zeng *Y0130* (holotype: HITBC!).

Description. Annual herbs, usually producing slender stolons from stem base, leaf axils or occasionally bract axils, stolons 10–25 cm, pubescent. **Stems** erect, 5–25 cm, pubescent to sparsely pilose. **Leaves** 4–6, opposite, widely spaced nodes; petiole 0.5–3.5 cm; blade symmetrical, ovate-elliptic to elliptic, 2–15 × 1.2–8.0 cm, herbaceous, puberulous to sparsely pilose, eglandular, abaxially sometimes with purple spots, adaxially appearing brown-green, base rounded to cordate, margin repand to entire, apex acute or obtuse; lateral veins 5–9 on each side of midrib, conspicuous. **Cymes** 1–4-flowered; **Peduncle** 0.5–3.5 cm, sparsely pilose; **Bracts** 2, free, linear to lanceolate, 3–6 mm long. **Pedicel** 2.5–5.0 cm, sparsely pilose. **Calyx** 1.2–1.7 cm, narrowly bell-shaped, divided into 5 lobes from base to below the middle; tube 3.5–4 mm; lobes subequal, lanceolate, 12–14 × 2–3 mm, outside sparsely pilose, inside glabrous, margin entire, apex subulate-attenuate. **Corolla** intensive yellow with two yellow-orange stripes on the abaxial lip, 3.7–4.2 cm long, outside sparsely glandular pilose, inside glabrous; tube narrowly funnelform, 3.4–3.8 × 0.9–1.2 cm; adaxial lip 1.9–2.3 × 0.8–1.0 cm, 2-lobed, abaxial lip 2.5–3.0 × 0.9–1.2 cm, 3-lobed, all lobes semi-orbicular, with rounded apex. **Stamens** 2, 1.3–1.5 cm long, adnate to the corolla tube below middle; filaments 1.1–1.3 cm long, sparsely puberulent to glabrous, bending in the middle, with knee; anthers fused by entire adaxial surfaces, ca. 3.5 mm, glabrous, dediscence; **Staminodes** 3, 2.5–6.0 mm. **Pistil** 2.5–2.8 cm, sparsely puberulent to puberulous, with short glandular hairs near apex; ovary 2.2–2.5cm; style 3–6 mm long, sparsely glandular puberulent. **Stigma** flabellate, 2–3 mm, undivided or slightly 2-lobed. **Capsule** sub-erect, 5–10 cm, loculicidal dehiscence .

Etymology. The new species is named after its type locality Xinping County.

Vernacular name. Chinese mandarin: Xin Ping Chun Zhu Ju Tai (新平唇柱苣苔).

Phenology. Flowering in August and fruiting from August to September.

Distribution and habitat. This species is only known from Xinping county, but is relatively common there growing in moist areas near stream sides and roadsides under the subtropical broad leaf forests.

Additional specimens examined (paratypes). CHINA. Yunnan Province: Xinping, Dapingzhang, 102°04.435'E, 24°04.672'N, a.s.l. 580 m, 16 Aug. 2018, Y.H. Tan, B. Yang *Y0115* (HITBC!); Ibid., 16 Aug. 2018, Y.H. Tan & B. Yang *Y0118* (HITBC!).

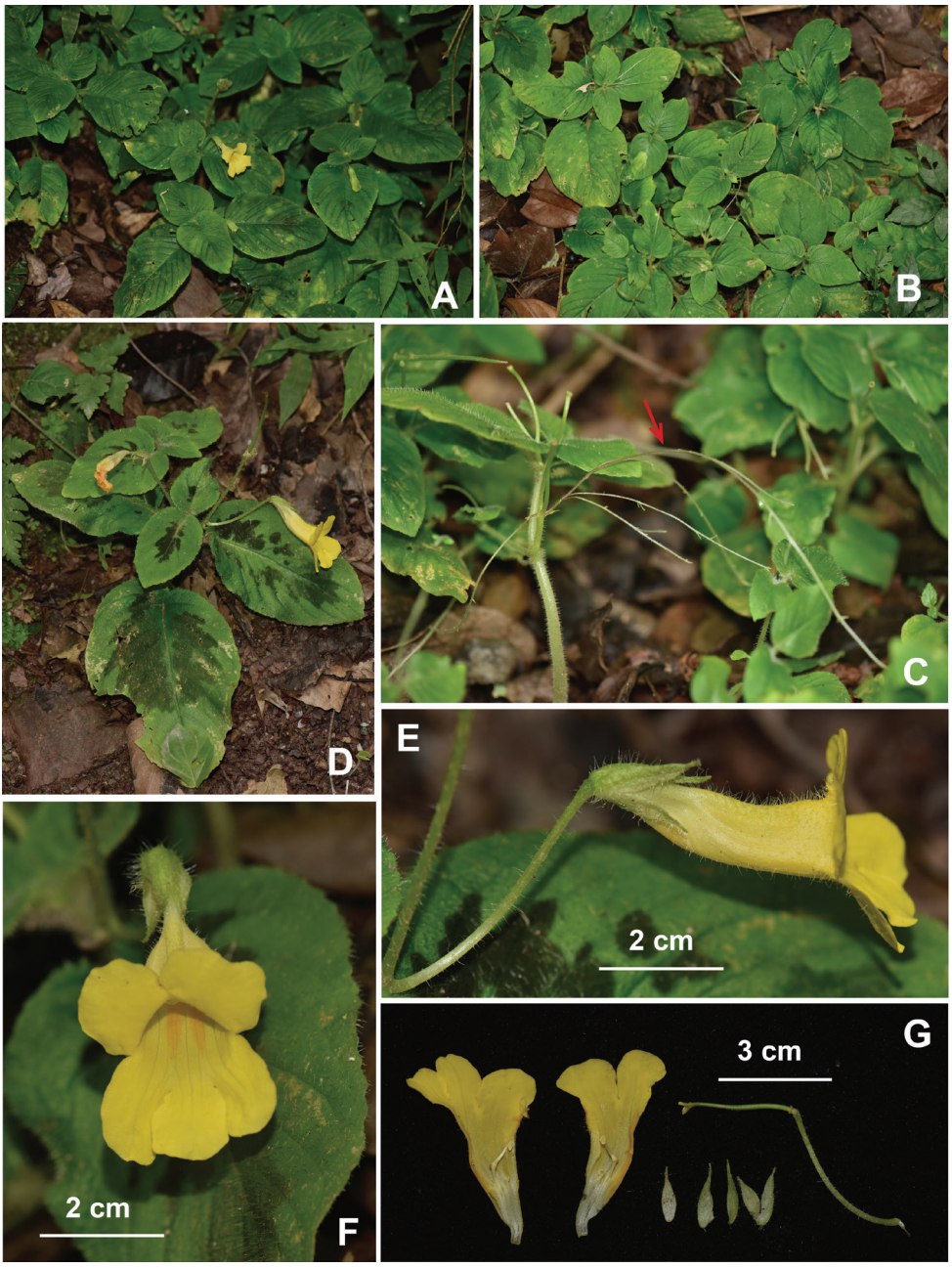

Figure 7. *Henckelia xinpingensis* Y.H.Tan & Bin Yang, sp. nov. **A, B, D** Habit **C** habit (showing stolons) **E** flower in side view **F** flower in front view **G** dissected flower. Photographed by B.Yang.

Conservation status. According to our field observations, more than ten populations have been observed around an area of 20 hectares and each population of the new species has more than 100 individuals. The species is therefore assigned a preliminary status of Least Concern (LC) according to the IUCN Red List Categories and Criteria (IUCN 2012).

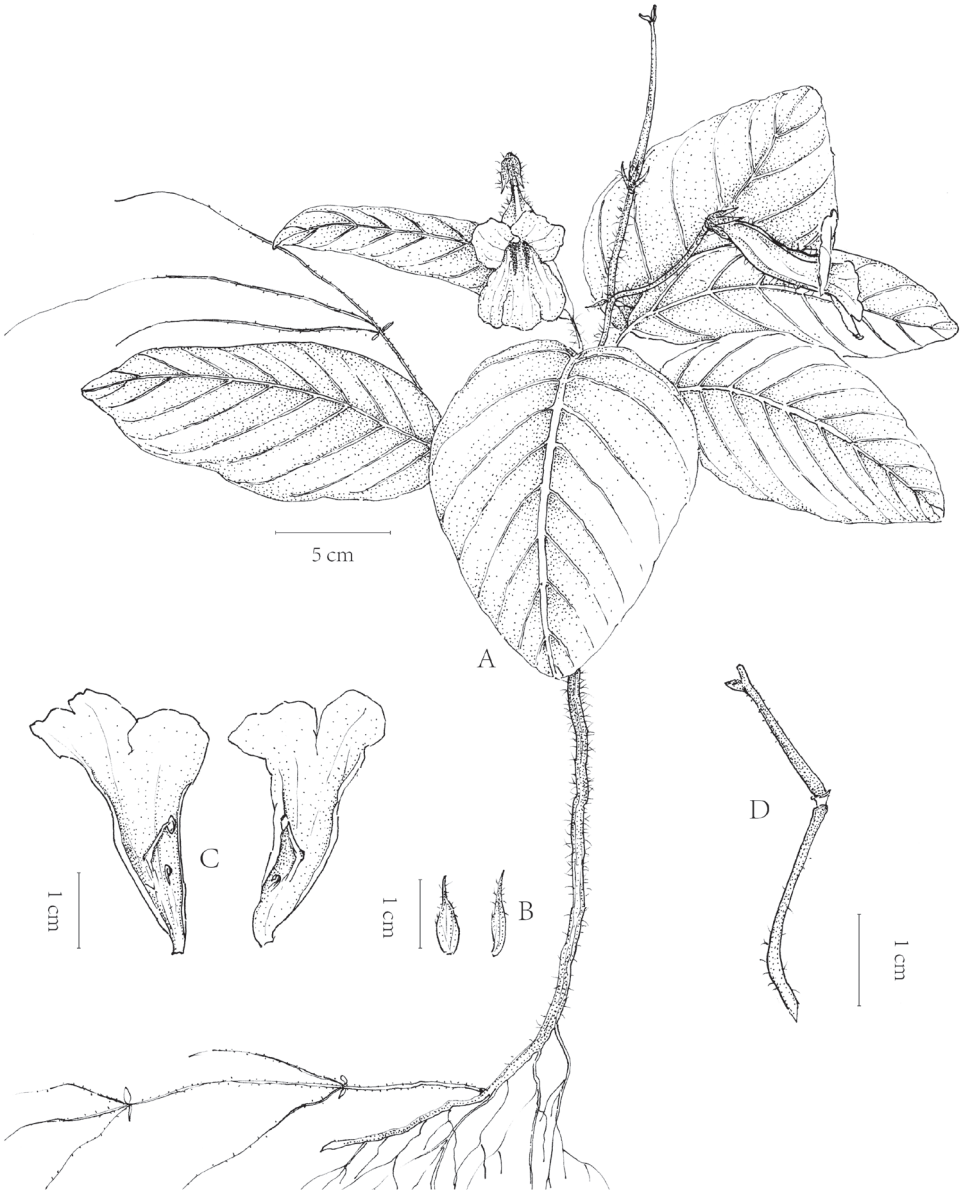

Figure 8. *Henckelia xinpingensis* Y.H.Tan & Bin Yang, sp. nov. **A** Habit **B** calyx lobes **C** corolla (Dissected) **D** pedicel with pistil. Drawn by Zheng-meng Yang.

Note. *Henckelia xinpingensis* has elliptic leaf blades with a pilose indumentum similar to *H. pumila*. A comparative list of diagnostic characters of the new species and *H. pumila* is given in Table 4.

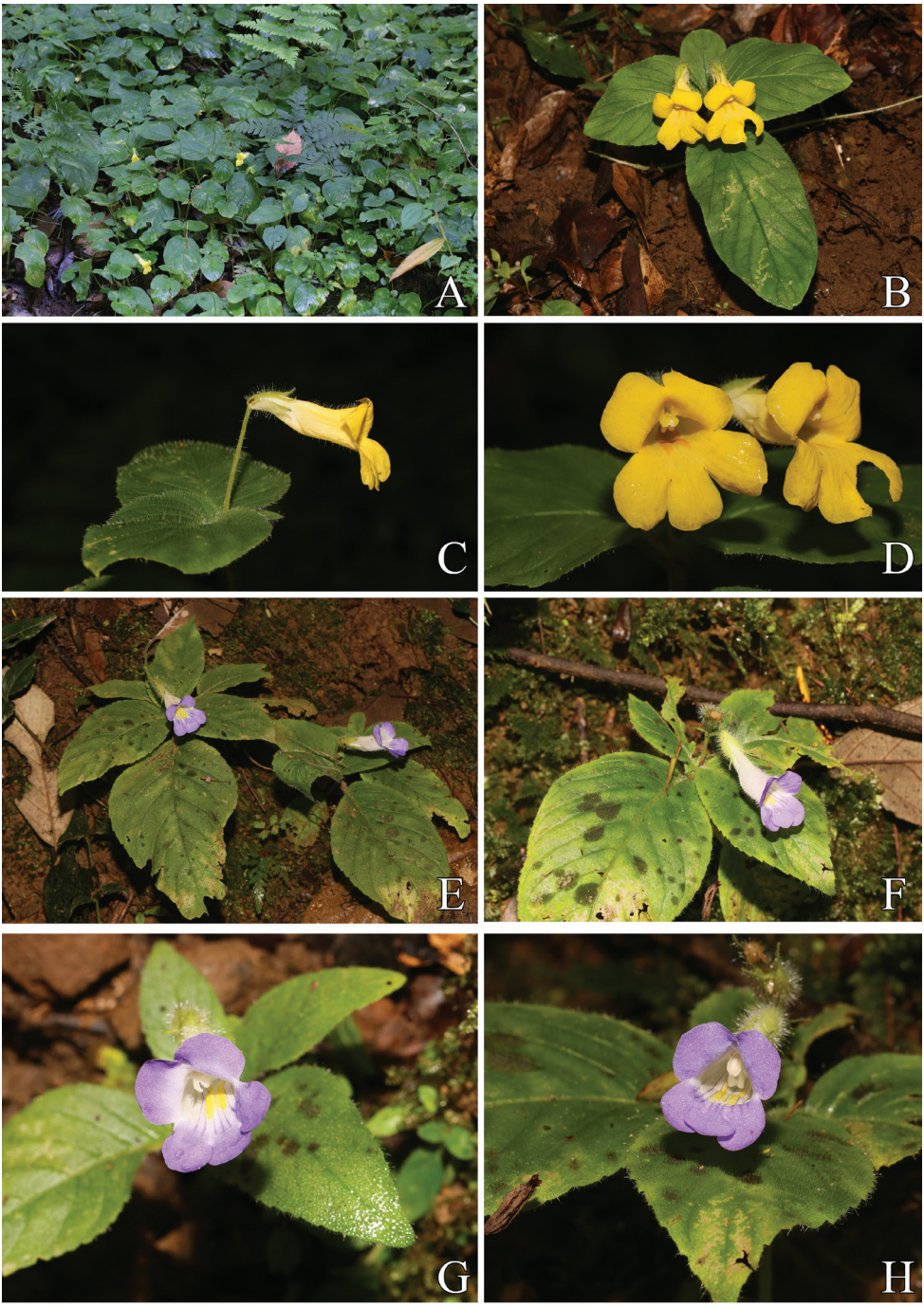

Figure 9. *Henckelia xinpingensis* Y.H.Tan & Bin Yang, sp. nov. (**A–D**) **A, B** Habit **C** flower (side view) **D** flower (front view); *Henckelia pumila* (D. Don) A. Dietr. (**E–H**) **E, F** habit **G, H** flower (front view). Photographed by H.B. Ding.

Table 4. Morphological comparison of *Henckelia xinpingensis* and its closely related species.

Characters	*H. xinpingensis*	*H. pumila*
Habit	producing slender stolons	not stolons
Leaf blade	symmetrical, base rounded to cordate, ovate-elliptic to elliptic, 2–15 × 1.2–8.0 cm	asymmetrical, base oblique, lanceolate to ovate or elliptic, 2–17 × 1.2–5.5(–8.0) cm
Leaf margin	repand to entire	denticulate to serrulate
Cymes	1–4-flowered	(1 or) 2–7 -flowered
Peduncle	0.5–3.5 cm	2.8–10.0 cm
Bracts	2, free, linear to lanceolate, 3–6 × 1–3 mm	2, free, ovate to lanceolate or obovate, 5–18 × 1–4 mm
Pedicel	2.5–5.0 cm	0.3–2.0 cm
Calyx	1.2–1.7 cm, 5-lobed nearly to base or below the middle; tube 0.5–4.0 mm	0.9–1.8 cm, 5-lobed to middle or slightly below; tube 4–10 mm
Calyx lobes	subequal, lanceolate, 12–14 × 2–3 mm, apex subulate-attenuate	slightly unequal, narrowly triangular to ovate, 4–10 × ca. 2 mm, apex subulate-acuminate, hornlike, spreading
Corolla	intensive yellow, outside glandular pilose	white to purple, outside puberulent to pilose,
Pistil	2.5–2.8 cm long, with short glandular hairs near apex	2.5–3.8 cm long, glabrous to puberulent
Stigma	labellate, 2–3 mm, undivided or slightly 2-lobed	flabellate, ca. 3 mm, conspicuous 2-lobed
Capsule	5–10 cm	6–12 cm

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Taxonomic and nomenclatural notes on *Pedicularis* (Orobanchaceae): I. One new species from northwest Yunnan, China

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Abstract

Pedicularis multicaulis W.B.Yu, H.Wang & D.Z.Li (series *Oliganthae* Prain) is a new species described and illustrated herein. This new species is endemic to northwest Yunnan and only two populations were found in Weixi county. Phylogenetic analyses support *P. multicaulis* as a new species, sister to *P. taihaiensis* Bonati and *P. macilenta* Franch. Morphological comparisons between *P. multicaulis* and *P. macilenta* and *P. taihaiensis* also support *P. multicaulis* as a new species to science.

Keywords

Orobanchaceae, *Pedicularis multicaulis*, Mountains of Southwest China, phylogenetic analysis

Introduction

Pedicularis Linn., with around 600 species, is the largest genus of Orobanchaceae and widely distributed throughout the North temperate region (Fischer 2004, Stevens 2001, Yu et al. 2015). More than 350 species have been recognised in China (Yang

et al. 1998). Of them, about two-thirds of the species are restricted in the Hengduan Mountains, which belongs to the Mountains of Southwest China hotspot (Wang 2006, Wang and Wu 1994). Due to the previously limited accessibility of the Mountains of Southwest China before the 21st century, several new species of *Pedicularis* have subsequently been discovered and described in the 2000s, owing to the construction of a road system under China's Great Western Development Strategy (Liu and Yu 2015, Yang et al. 2003, Yu et al. 2010, Yu et al. 2018).

According to the phylogeny of the *Pedicularis* species with well-represented samples from the Hengduan Mountains region, 18 taxa were not categorised as any recognised species, based on both molecular and morphological data (Yu et al. 2015), which could be potential new species or new records to China. Of them, two taxa had been described as new species, *P. wanghongiae* M.L.Liu & W.B.Yu (Liu and Yu 2015) and *P. millina* W.B.Yu, D.Z.Li & H.Wang (Yu et al. 2018). In this study, we described and illustrated another new species, *P. multicaulis* W.B.Yu, H.Wang & D.Z.Li, from the remaining 16 taxa after carefully examining morphological characters and in comparisons with herbarium specimens of the close relatives, *P. taihaiensis* Bonati and *P. macilenta* Franch. (Yu et al. 2015). *Pedicularis multicaulis* is strongly supported as a new species, based on the revised phylogenetic analyses. Meanwhile, the pollen morphology of *P. multicaulis* was investigated using a scanning electron microscope (SEM).

Material and methods

The fresh specimens of the new species were collected from Pantiange and Lidiping in Weixi county, northwest Yunnan, China. Pollen samples were collected from the type specimens, then observed under SEM (ZEISS EVO LS10, Germany). For the morphological comparisons, we examined specimens or specimen images of the closest relatives from the herbaria E, K, KUN, LA, P and PH. Selected type specimens of *P. macilenta* and *P. taihaiensis* are presented in Suppl. material 1: Figures S1 and S2.

According to the published phylogeny of *Pedicularis* (Yu et al. 2015), *P. multicaulis*, *P. macilenta* and *P. taihaiensis* were chosen as ingroups and *P. cephalantha* Franch. ex Maxim. and other species from series *Oliganthae* Prain, *Strobilaceae* Tsoong and *Amplitubae* Li were also included (Table 1). *Pedicularis axillaris* Franch. ex Maxim. was specified as the outgroup. In this study, we had two samples of the new species from Pantiange (*W.-B. Yu et al. 2014102*) and Lidiping (*W.-B. Yu et al. 2014096*), respectively, two samples of *P. tahaiensis* from Luquan (*C.-L. Xiang et al. HP9544*) and Huize (*W.-B. Yu et al. HW10369*), respectively and one sample of *P. macilenta*. Four DNA regions (nrITS, *matK*, *rbcL* and *trnL-F*) were used and the new sequences generated following Yu et al. (2011). Bayesian Inference (BI), Maximum Likelihood (ML) and Maximum Parsimony (MP) methods were used to reconstruct the phylogenies. The BI analysis was performed using MrBayes 3.26 (Ronquist and Huelsenbeck 2003). The total dataset was partitioned (see Suppl. material 2: Dataset 1) and the DNA substitution model of Bayesian Information Criterion (BIC) for four DNA regions was estimated using jModeltest 2 (Darriba et al. 2012). The ML analysis was conducted with RAxML

Table 1. Voucher information and GenBank accessions of samples used in phylogenetic analyses.

Taxon	Source	Voucher information	ITS	*matK*	*rbcL*	*trnL-F*
P. amplituba H.L. Li	Yunnan: Luquan	Yu et al., LIDZ1519A (KUN)	JF977469	JF955063	JF942952	KF277605
P. axillaris Franch. ex Maxim. (3)	Yunnan: Dali	Yu et al., YWB2014097 (KUN)	KT022428	KT022531	KT022705	KT022883
P. cephalantha Franch. ex Maxim.	Yunnan: Lijiang	W. Jiang, 08727 (KUN)	JF977493	JF955087	JF942976	KF277613
P. cephalantha affinis	Yunnan: Eryuan	Yu et al., YWB2014063	KT022501	KT022661	KT022841	KT022967
P. dissectifolia H.L. Li	Yunnan: Shangeri-La	Yu et al., HW10133 (KUN)	KF277539	KR707763	KF277641	KF277641
P. fengii H.L. Li (1)	Yunnan: Shangeri-La	Yu et al., HW10102 (KUN)	JF977553	JF955146	JF943036	KT022910
P. fengii H.L. Li (2)	Yunnan: Shangeri-La	Yu et al., Yu606 (KUN)	JF977564	JF955157	JF943047	KF277646
P. gracilicaulis H.L. Li	Xizang: Chayu	Jin et al., STET0522 (PE)	KF277547	no data	no data	KF277654
P. macilenta Franch. ex Forbes ex Hemsl.	Yunnan: Zhaotong	Li et al., 8484 (KUN)	KF277558	KT022606	KT022780	KF277680
P. multicaulis W.B.Yu, H.Wang & D.Z.Li	Yunnan: Weixi	Yu et al., YWB2014096	KT022502	KT022662	KT022842	KT022968
P. multicaulis W.B.Yu, H.Wang & D.Z.Li	Yunnan: Weixi	Yu et al., YWB2014102	MK983380	MK983381	MK983382	MK983383
P. strobilacea Franch.	Yunnan: Shangeri-La	Cai et al., 11CS3261 (KUN)	KT022508	KT022673	KT022852	KT022977
P. pseudocephalantha Franch.	Xizang: Linzhi	Gao et al., GLM123906 (KUN)	KR707794	KR707760	KR707780	KR707807
P. tachanensis Bonati	Sichuan: Mianning	Yu et al., LIDZ1062 (KUN)	JF977743	JF955333	JF943226	KF277740
P. tahaiensis Bonati	Yunnan: Luquan	Xiang et al., HP9544 (KUN)	JF977552	JF955145	JF943035	KF277741
P. tahaiensis Bonati	Yunnan: Huize	Yu et al., HW10369 (KUN)	JF977563	JF955156	JF943046	no data

8.2.10 (Stamatakis et al. 2008). The MP analysis was carried out using PAUP* 4.a165 (Swofford 2003). Parameters for the three analyses followed the previous studies (Yu et al. 2013, Yu et al. 2015).

The conservation status of *P. multicaulis* was assessed in accordance with IUCN Red List Criteria (IUCN 2012).

Taxonomy

***Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li, sp. nov.**
urn:lsid:ipni.org:names:77201400-1
Figures 1, 2A–F and 3

Vernacular name. Duo Jing Ma Xian Hao (多茎马先蒿) (Chinese).

Type. CHINA. Yunnan: Weixi, Lidiping, wet meadow, alt. 3180 m, 27°9'16.06"N, 99°24'48.70"E, 30 Aug 2014, *W.-B. Yu, X.-L. Yang & H. Tang 2014096* (holotype: HITBC! (accession no. 169315); isotypes: HITBC!, KUN!).

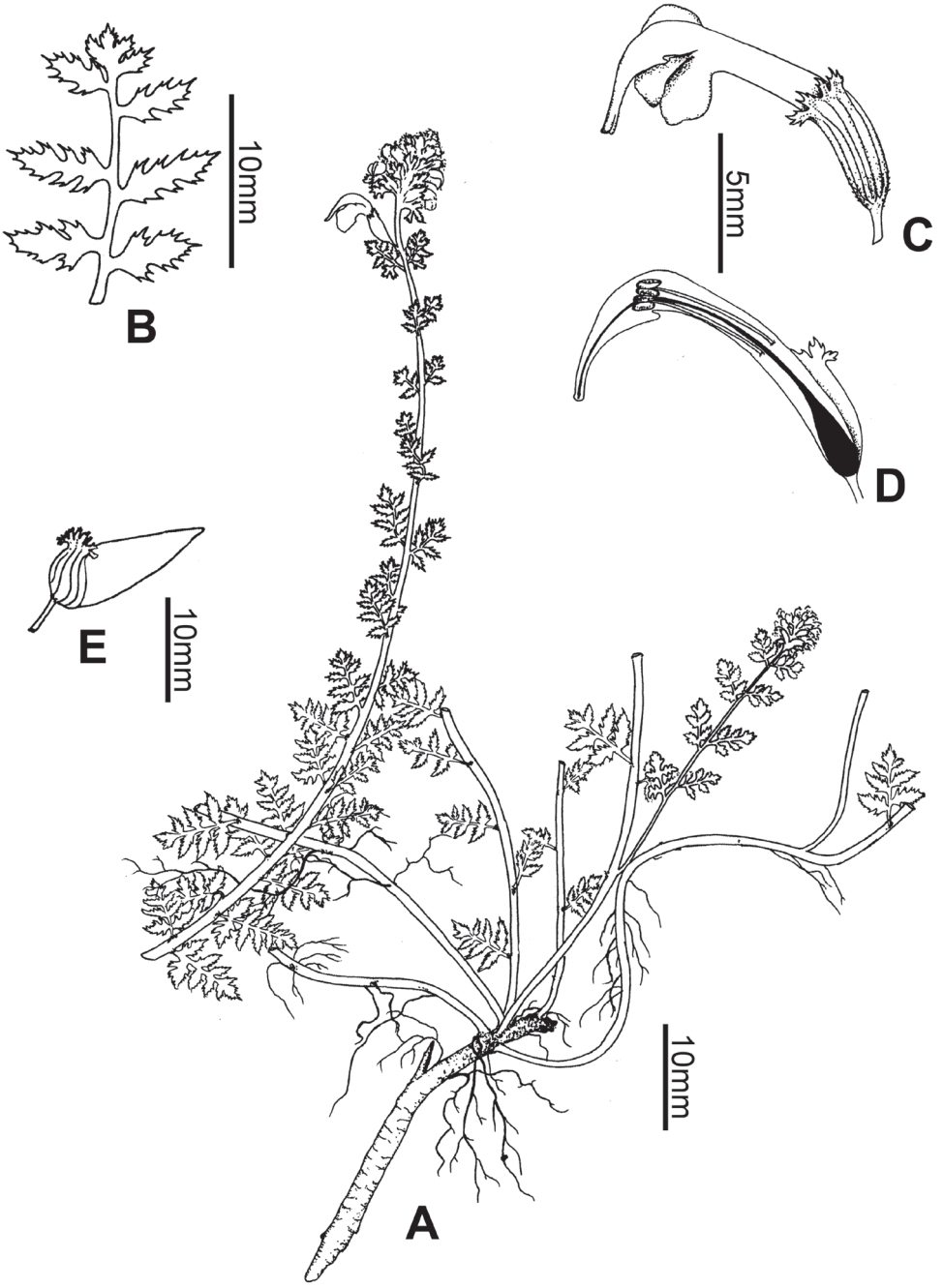

Figure 1. Line drawing of *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li **A** habit **B** leaf **C** flower **D** open flower showing the anthers and style **E** fruit. Drawn by Zhen-Long Liang from the holotype (**A–D**) and an isotype (**E**), *W.-B. Yu, X.-L. Yang & H. Tang 2014096* (KUN).

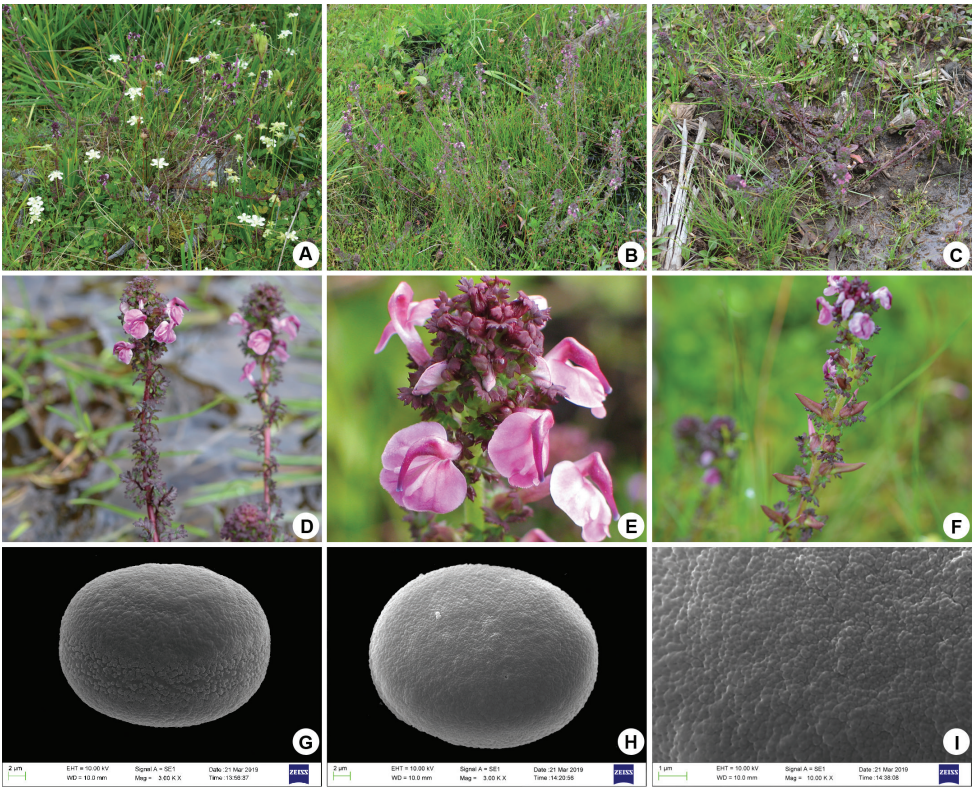

Figure 2. Field photos and pollen of *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li **A–C** overview of habitat and plants **D** inflorescence **E** flowers **F** infructescence **G** equatorial view of pollen **H** polar view of pollen **I** exine ornamentation.

Diagnosis. *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li is distinguished from *P. macilenta* and *P. taihaiensis* in having taller and more ascending stems, partially crawling stems with fibrous roots, shorter petiole and leaf blade of cauline leaves in middle and upper parts and smaller corollas with a shorter beak.

Description. Herbs perennial, 20–50 cm tall, glabrescent, drying slightly black; taproots slender, fusiform; stems caespitose, mostly (3) 5 to 9 (12) from a caudex, ascending or partially crawling (with fibrous roots) and branchlets (0) 1–3 (10), glabrescent or sparely pubescent along the lines. Basal leaves absent. Cauline leaves alternate; petiole up to 10 mm long or distal ones sessile or subsessile, glabrescent; leaf blade ovate-elliptic or oblong, 5–30 mm × 7–15 mm, glabrous on both surfaces, pinnatisect; segments 2 to 5 pairs, ovate to lanceolate-oblong, incised-pinnatifid or double dentate. Inflorescences racemose, up to 30 cm long; bracts leaflike, distal ones shorter than flowers. Pedicel 1.0–2.5 mm long. Calyx tube ca. 5 mm long, glabrescent, 1/3 cleft anteriorly; lobes 3, unequal, posterior one acicular, lateral pair larger, leaf-like and toothed. Corolla rose, 10–14 mm long; tube erect, ca. 8–10 mm long ; galea ±falcate, not crested, not twisted, with 1 distinct reflexed marginal tooth on one side; beak straight, ca. 3 mm,

Figure 3. The holotype of *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li (*W.-B. Yu, X.-L. Yang & H. Tang 2014096*, HITBC, accession no. 169315).

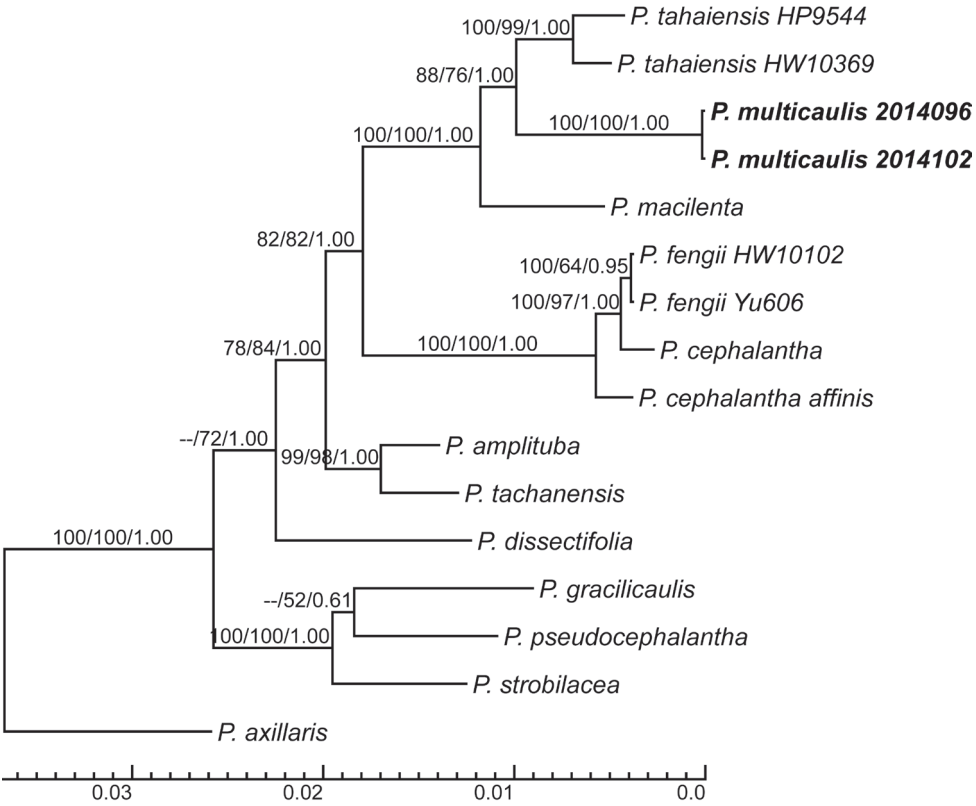

Figure 4. The major-rule consensus tree of Bayesian Inference analysis using the total data by concatenating four DNA regions (nrITS, *matK*, *rbcL* and *trnL-F*). Bootstrap values of Maximum Likelihood/ Parsimony and posterior probability values of Bayesian Inference are presented above branches. The bottom scale bar represents the number of substitutions per site.

slightly 2-cleft at apex, not ciliate; lower lip 5–6 mm × 6–8 mm, sparely ciliate, lobes 3 unequal; middle lobes apex slightly cucullate. Filaments 4 glabrous, equal length, ca.13 mm long, inserted in the middle of corolla. Ovary long ovoid, ca. 3 mm long; Capsule lanceolate-oblong, 10–15 mm × 4–5 mm. Seeds narrowly ovoid, ca. 1.0–1.2 mm.

Etymology. The specific epithet "*multicaulis*" refers to the new species having many ascending stems that are branched in the middle and upper parts.

Phenology. This new species was found in flowering from middle June (in a field trip in 2006) to August and in fruiting from July to September.

Pollen morphology. Pollen grains are radially symmetrical, isopolar, spheroidal and medium in size (polar length: 23.71–25.47 μm × equatorial diameter: 18.86–20.29 μm). Pollen apertures are bisyncolpate (Figures 2G and H) and the colpi are usually wide and sunken (Figure 2G); exine ornamentation is perforated tectum with microfoveolate ornamentation (Figure 2I).

Phylogenetic analyses. All analyses strongly supported *P. taihaiensis* as sister to *P. multicaulis* (ML/MP/BI = 88/76/1.00, Figure 4) and the two samples of *P. multicaulis*

(ML/MP/BI = 100/100/1.00) and of *P. taihaiensis* (ML/MP/BI = 100/99/1.00) are monophyletic, respectively. Then, *P. macilenta* is sister to *P. taihaiensis* + *P. multicaulis* (ML/MP/BI = 100/100/1.00).

Distribution. *Pedicularis multicaulis* was only found in two populations in Weixi county, northwest Yunnan (Figure 5). It occurs in wet meadow or the margin of wetland between 2900 m and 3200 m a.s.l.

Conservation assessment. To date, we only collected this new species from two populations in Weixi county, northwest Yunnan. There are around 100 and 300 individuals in Pantiange and in Lidiping, respectively. It is restricted to wet meadow, which is likely to be threatened by grazing in these areas. According to IUCN Red List Criteria (IUCN 2012), *P. multicaulis* can be classified as Vulnerable (VU).

Additional examined specimens. *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li. CHINA. Yunnan: Weixi, Pantiange, wet grassland, alt. 2930 m, 27°20'39.48"N, 99°16'59.30"E, 27 Aug 2014, *W.-B.Yu, X.-L.Yang & H.Tang 2014102* (KUN!). *Pedicularis macilenta* Franch. CHINA. Yunnan: Eryuan (Mountain Yentzehay), in humid localities on the slopes, 8 Aug 1888, *Delavay 3698* (types, P!, PH!, LA!); Yunnan: Zhaotong, Dashanbao, Dahaizi reservoir, alt. 3044 m, 27°44'89.2"N, 103°31'94"E, 7 Aug 2008, *H.Li et al. 8078* (KUN!). *Pedicularis taihaiensis* Bonati. CHINA. Yunnan:

Figure 5. Distribution map of *Pedicularis multicaulis* W.B.Yu, H.Wang & D.Z.Li and related taxa.

Huize, Dahai, Jul 1913, *E.E. Maire 678* (holotype: E [E00284020]!); ibid. 30 Jul 2010, *W.-B.Yu et al. HW10369* (KUN!); Yunnan: Luquan, Wumeng Mountains, alt. 3700 m, 2 Jul 1990, *R.Z.Fan & Z.W.Lyv 061* (KUN!); Yunnan: Luquan, Jiaozi Mountain. 8 Jul 2008, *C.L.Xiang et al. HP9544* (KUN!).

Discussion

The galea of *P. multicaulis* bears one pair of distinct reflexed marginal teeth on both sides, which is the key character of series *Oliganthae* Prain. Phylogenetic analyses did not support series *Oliganthae* as monophyletic (Yu et al. 2015). The previous study indicated that *P. macilenta* and *P. taihaiensis* formed a weakly supported clade, then sister to *P. multicaulis* (= *Pedicularis* sp. (9)) by using one sample of each species. In this study, both *P. multicaulis* and *P. taihaiensis* had two samples from different populations and our results showed that *P. multicaulis* and *P. taihaiensis* formed a strongly supported clade, then sister to *P. macilenta*. The relationship amongst the three species was well resolved. Therefore, population level sampling is very important for species delimitation and phylogeny of recently derived lineage.

Morphological characters differentiate *P. multicaulis* from the two most closely related species (Table 2). The key diagnostic characters of *P. multicaulis* are having taller and more branched stems, partially crawling stems with fibrous roots, shorter petiole of cauline leaves and smaller corollas with a short beak. The three species are also isolated geographically (Figure 5). According to herbarium records, *P. taihaiensis* occurs in Luquan and Huize, north Yunnan and *P. multicaulis* is only found in Weixi, northwest Yunnan. The distribution of *P. macilenta* is disjunct, with one population in Eryuan, northwest Yunnan and another in Zhaotong, northeast Yunnan. As all three species were mainly confined to the habitat of wet meadow, we assume that geographical isolation may play an important role in species divergence in this lineage.

Table 2. Morphological comparison amongst *Pedicularis multicaulis*, *P. macilenta* and *P. taihaiensis*.

Characters	*P. multicaulis*	*P. macilenta*	*P. taihaiensis*
Plant height (cm)	20–50	20–30	15–30
Rooting stems	Yes	No	No
Stems	(3) 5-9 (12)	1–5	2–4
Branchlets per stem	(0) 1-3 (10)	1–3	1–3
Leaf bade size (mm)	5–20 × 7–15	30–50 × 10–15	15–30 × 8–11
Petiole length (mm)	3–11	5–20	8–25
Leaf lobes (pairs)	2–5	5–7	5–7
Leaf lobe size (mm)	3–8 × 2–4	3–7 × 2–5	3–6 × 1–4
Calyx length (mm)	4–5	6–7	5–7
Corolla colour	Rose	White with purple beak	Rose
Corolla length (mm)	10–14	11–13	17–20
Corolla tube length (mm)	8–10	6–7	11–15
Beak length (mm)	3	3–4	4–5
Galea	Not crested	Slightly crested	Not crested

Acknowledgements

We are grateful to Hui Tang and Xiu-Long Yang for their kind help in the field; to Zhen-Long Liang for the line drawing; to Ting Tang and Yin Zhao for preparing SEM investigation; and to the curators of the herbaria K, KUN, LA, P and PH for making specimens available for access in the herbarium or online database. This study was supported by grants from the Large-scale Scientific Facilities of the Chinese Academy of Sciences (2017-LSFGBOWS-02), Chinese Academy of Sciences Strategic Priority Research Program of the Chinese Academy of Sciences (XDB31000000) and the National Natural Science Foundation China (31470323, 31870196).

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Supplementary material 1

Figures S1 and S2

Authors: Xin Li, Hong Wang, De-Zhu Li, Wen-Bin Yu

Data type: Specimen photos.

Explanation note: Figure S1. A syntype of *Pedicularis macilenta* Franch. (Delavay 3698, P [P02981467]); Figure S2. The holotype of *Pedicularis taihaiensis* Bonati (E.E. Maire 678, E [E00284020]).

Link: https://doi.org/10.3897/phytokeys.130.35258.supplS1

Supplementary material 2

Dataset 1

Authors: Xin Li, Hong Wang, De-Zhu Li, Wen-Bin Yu

Data type: DNA matrix

Explanation note: DNA sequence matrix of the four DNA markers with the best-fit BIC models . The matrix is partitioned by regions.

Link: https://doi.org/10.3897/phytokeys.130.35258.supplS2

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RESEARCH ARTICLE

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Spiradiclis tubiflora (Rubiaceae), a new cave-dwelling species from southern China

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Abstract

Spiradiclis tubiflora, a new Rubiaceae species, is described from a limestone area of southern China. It is similar to *Spiradiclis glandulosa* and *S. umbelliformis*, but differs from the latter two in its linear stipule, short peduncle and tubular-funnelform corolla with a distinctively enlarged tube. The colour photograph, illustrations, detailed descriptions and conservation status of the new species are provided.

Keywords

Rubiaceae, taxonomy, Guangdong, limestone

Introduction

Caves are considered to be extreme and exceptional habitats that usually provide insufficient resources, especially lack of light, water and soil for plants to survive (Whitten 2009). Most caves are isolated environments which lead to the limitation in dispersal or movement of species and provide great possibilities for speciation and radiation (Biswas 2009, Chung et al. 2013). Many cave-dwelling species, especially those from karst

areas, are highly localised (Chen 2006, Whitten 2009). Recently, the number of newly discovered and described plant species with unique characters from China's karst caves is increasing dramatically, including *Begonia* L. (Begoniaceae, e.g. Peng et al. 2012), *Chiritopsis* W. T. Wang (Gesneriaceae, e.g. Wu et al. 2011), *Elatostema* J.R.Forster & G.Forster (Urticaceae, e.g. Fu et al. 2017), *Lagarosolen* W. T. Wang (Gesneriaceae, e.g. Xu et al. 2011), *Pilea* Lindl. (Urticaceae, e.g. Monro et al. 2012) and *Polystichum* Roth (Dryopteridaceae, e.g. Han et al. 2016). *Spiradiclis* Blume also exhibits a great diversity in cave habitat with six newly published species from karst caves (Deng et al. 2014, Wen et al. 2015, Wu et al. 2015a, 2015b, 2016, Liu et al. 2018).

There are approximately 53 *Spiradiclis* species worldwide, most representatives being herbs and occurring in limestone areas (Chen and Taylor 2011, Deng et al. 2014, Wang et al. 2015, Wen et al. 2015, Wu et al. 2015a, 2015b, 2016, 2019, Wang 2016a, 2016b, Pan et al. 2016, 2019, Liu et al. 2018). China is the diversity centre of *Spiradiclis* with 47 species being recorded and most of them distributed in Guangxi and Yunnan provinces of south-western China (Lo 1999, Chen and Taylor 2011, Liu et al. 2018, Pan et al. 2019).

Spiradiclis is a taxonomically difficult genus and most similar to *Ophiorrhiza* L. (Chen and Taylor 2011), some specimens of *Spiradiclis* and *Ophiorrhiza* with flowers have even been frequently misidentified with each other (Wu et al. 2015a). However, *Spiradiclis* can be distinguished from *Ophiorrhiza* by its linear-oblong or subglobose capsules with two or four valves when mature (vs. obcordate and compressed capsules with two valves when mature) (Lo et al. 1983, Robbrecht 1988, Lo 1999, Chen and Taylor 2011). The genus was split into two subgenera: subgenus *Spiradiclis* characterised by ellipsoid to linear-oblong capsules with twisted valves when mature and subgenus *Sinospiradiclis* H.S.Lo characterised by subglobose capsules with untwisted valves (Lo 1998).

During a field investigation of the karst cave in Guangdong Province, southern China in 2009, a peculiar species of Rubiaceae was found. The plant has subglobose capsules, dehisces with four valves and many small, granulate seeds when mature (Figs 1F, 2I) which clearly indicated it belongs to *Spiradiclis*. After re-collections of flowers and fruit materials and further comparison of the known *Spiradiclis* species, we confirmed that it is an unpublished species and report it here.

Material and methods

Materials are deposited at the herbarium of forest plants in Central South University of Forestry and Technology (CSFI), Guangxi Institute of Botany, Guangxi Zhuang Autonomous Region and Chinese Academy of Sciences (IBK). Morphological observations and measurements of the new species are based on living material in the field, as well as dry specimens. The conservation status of the new species is evaluated, based on field observations in accordance with IUCN guidelines (2016).

Taxonomic treatment

Spiradiclis tubiflora **L.Wu, B.M.Wang & B.Pan, sp. nov.**
urn:lsid:ipni.org:names:60479355-2
Figs 1, 2A–I

Diagnosis. This species is similar to *Spiradiclis glandulosa* and *S. umbelliformis* by having procumbent to creeping habit. It is, however, easily distinguished from the latter two by its linear stipule, short peduncle and tubular-funnelform corolla with distinctively enlarged tube.

Type. China. guangdong: Yingde city, Jiulong town, on the wall near the mouth of a karst cave, 460 m alt., 24°17'N, 112°36'E, 18 Oct 2016 (flower), B. Pan GX-IBPB2016023 (holotype: IBK!; isotype: CSFI!)

Description. Herbs to 5 cm in height, perennial, procumbent to creeping; stems glabrous or subglabrous. Petiole 0.3–1.8 cm, sparsely pubescent; leaf blade drying papery, adaxially green, abaxially pale, ovate to elliptic, 4.5–25.5 × 4.0–14.5 mm, both surfaces pubescent, abaxially with densely yellow glandule-like spots, base rounded to obtuse, sometimes decurrent, apex acute to rounded; secondary veins 3–5 pairs; stipules usually caduceus, pubescent, narrowly linear, 3–5 mm long. Inflorescences cymose, umbelliform to subcapitate, 2–5-flowered; peduncles 1.2–1.5 cm long, densely pubescent; bracts subulate, densely pubescent, 1.8–3.0 mm long; pedicels 1.5–2.0 mm long. Calyx densely pubescent; hypanthium portion subglobose, 1.4–1.6 mm long; lobes triangular, 1.4–1.6 mm long. Corolla white, tubular-funnelform, subglabrous outside; tube 14–16 mm long, ca. 2 mm in diameter at the base, while 3.8–4.5 mm in diameter at the middle of corolla tube, inside densely pubescent near base; lobes ovate to ovate-triangular, 3.5–4.5 × 2.5–3.0 mm. Stamens 5, inserted at the middle of corolla tube; filaments 0.5–1.5 mm long; anthers dorsifixed, linear. Ovary 2-celled, ovules numerous in each cell on peltate axile placentas, attached to the middle of the septum; stigmas 2-lobed, appearing near the throat of corolla tube. Capsules subglobose, ca. 2 mm in diam., densely pubescent, valves 4. Seeds many, dark brown, granular, 0.22–0.28 mm long.

Distribution and ecology. The new species is only known from the type locality. Plants on the wall or large stones inside or at the mouth of the cave, usually wet and covered with calcareous soil. Flowering from August to October, occasional few individuals in March to May, fruiting from September to December.

Etymology. The specific epithet refers to the corolla shape of the new species. The Chinese name is given as “cu-tong-luo-xu-cao (粗筒螺序草)”.

Preliminary conservation status. Up to now, only one population with 360 individuals have been found in the type locality. Although five field investigations have been carried out in the surrounding area of the type locality in the past five years since the new species was discovered, no additional populations have been found. The individuals are occurring in places with thick calcareous soil and thriving in low-light conditions. Karst caves are known for their spectacular landscape and nature which

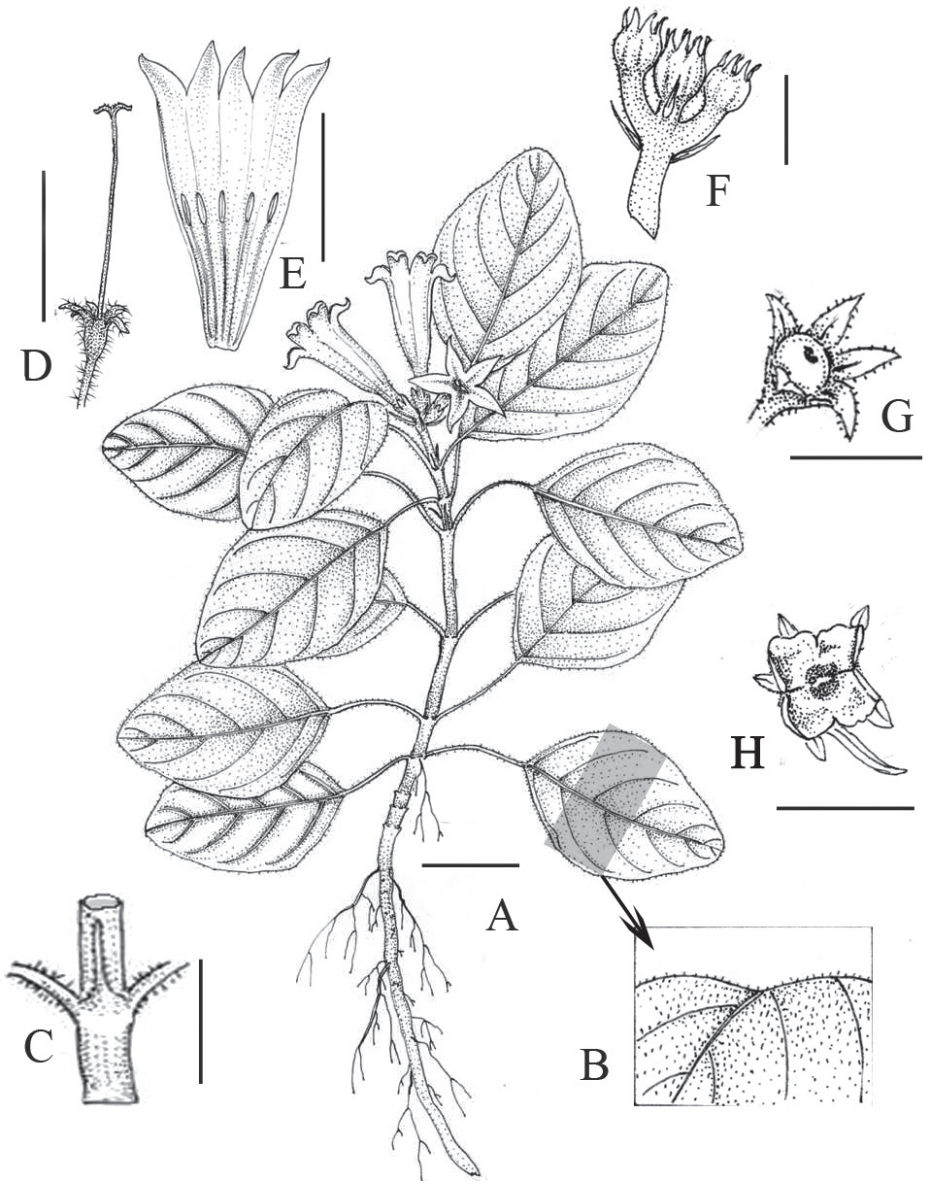

Figure 1. *Spiradiclis tubiflora*. **A** Habit **B** Enlarged leaf blade (adaxial) **C** Stipule **D** Style **E** Opened corolla **F** Infructescence, lateral view **G** Capsule before dehiscence **H** Matured capsules split into four valves. Scale bars: 1 cm (**A, D, E**); 3 mm (**C, F–H**). Drawn from the holotype by Zheng-Meng Yang.

attract tourists. Many karst caves in China played an important role in stimulating the local economy and were exploited for tourism. The cave where the new species occurred has not been spared and the cement road has been built directly leading into the cave, despite this cave being located far away from human settlements. According to the IUCN (2016) Red List Categories and Criteria, *Spiradiclis tubiflora* should be assigned as Critically Endangered (B2ab(iii,iv,v) & D).

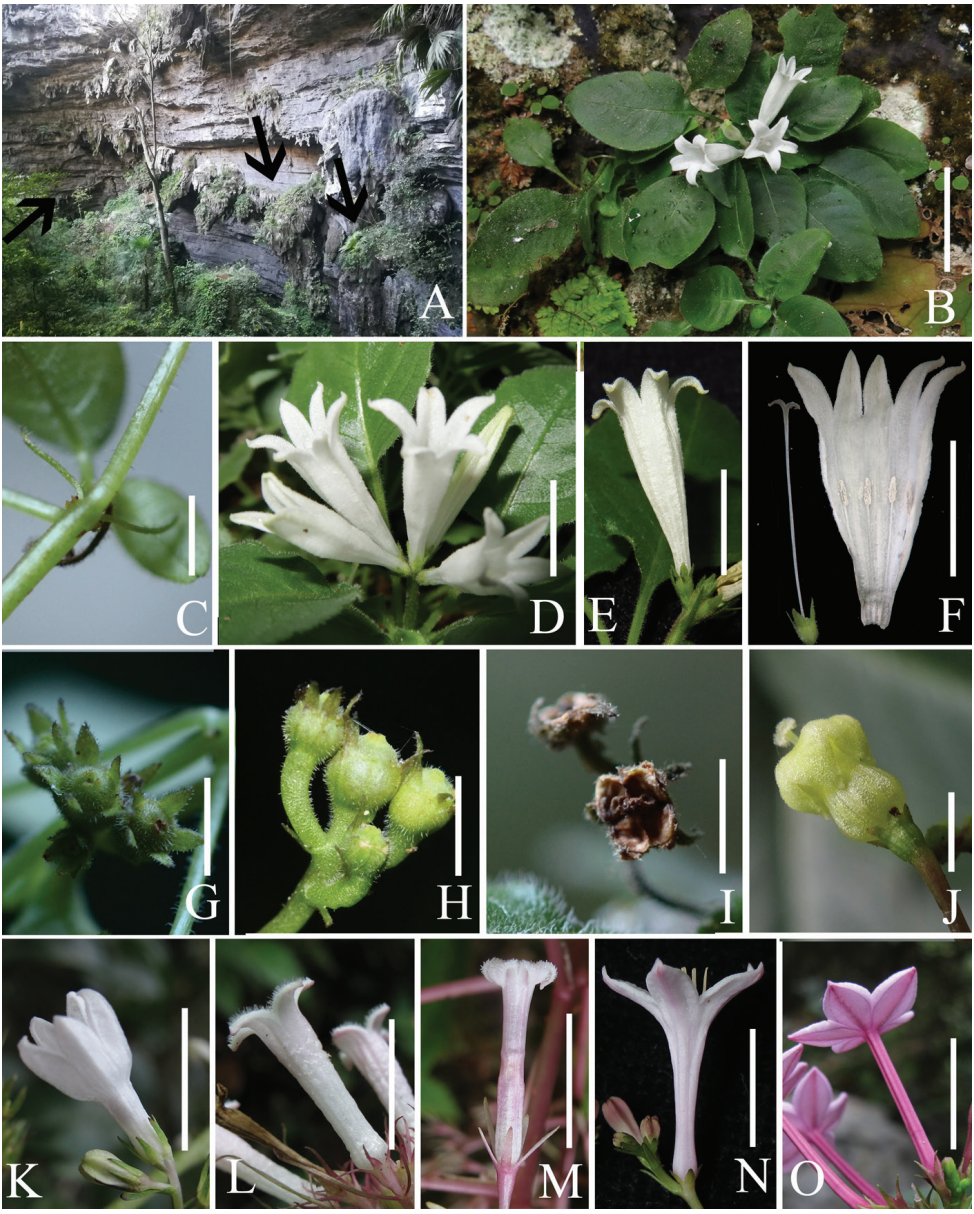

Figure 2. *Spiradiclis tubiflora*. **A** Habitat (the arrow shows the place of growth) **B** Habit **C** Stipule **D** Inflorescence, lateral view **E** Flower, lateral view **F** Corolla opened to show floral parts **G** Capsules, frontal view **H** Capsules, lateral view **I** Matured capsules with four valves. Flowers of selected Spiradiclis species, lateral views: **J** *S. longipedunculata* **K** *S. fusca* **L** *S. malipoensis* **M** *S. baishaiensis* **N** *S. glabra* **O** *S. coccinea*. Scale bars: 1 cm (**B, D, E, F, K, L, M, N, O**); 3 mm (**C, G, H, I, J**). Photos by Bo Pan, Jing Liu and Lei Wu.

Discussion. The corolla character of *Spiradiclis* shows great diversity (Fig. 2J–O). The corolla tube of the genus ranges from 2.5 to 24 mm (Chen and Taylor 2011), the corolla colour appears in white, pink or purple-reddish and the corolla shape varies

Table 1. Morphological comparison of *Spiradiclis tubiflora*, *S. glandulosa* and *S. umbelliformis*.

	Spiradiclis tubiflora	***S. glandulosa***	***S. umbelliformis***
Stipule	narrowly linear, usually caduceus	deeply 2-parted, persistent	deeply 2-parted, persistent
Peduncle	1.2–1.5 cm long	2–5 cm long	2–7 cm long
Calyx lobe	triangular, 1.4–1.6 mm long	oblong-lanceolate, ca. 4–6 mm long	ovate-triangular, ca. 0.6 mm long
Corolla	tubular-funnelform	funnelform	funnelform to tubular-funnelform
Corolla tube	14–16 mm long, enlarged distinctly, 3.8–4.5 mm in diam. at middle	16–18 mm long, slender, ca. 1.8 mm in diam. at middle	17–18 mm long, slender, ca. 1.5 mm in diam. at middle

from urceolate-tubular (*Spiradiclis longipedunculata* S. Y. Liu & S. J. Wei, Fig. 2J), tubular (*S. malipoensis* H. S. Lo, Fig. 2L and *S. baishaiensis* X. X. Chen & W. L. Sha, Fig. 2M), funnelform (*S. fusca* H. S. Lo, Fig. 2K and *S. glabra* L. Wu & Q. R. Liu, Fig. 2N) to salverform (*S. coccinea* H. S. Lo, Fig. 2O). Although the corolla shape of *Spiradiclis tubiflora* is tubular-funnelform, its corolla tube enlarges distinctly from near the base to the throat of the corolla which currently is unique in all the known *Spiradiclis* species (Fig. 2D, E). *Spiradiclis tubiflora* is morphologically most similar to *S. glandulosa* L. Wu & Q. R. Liu and *S. umbelliformis* H. S. Lo by having procumbent to creeping habit, but it can be distinguished from the latter two species (Table 1). According to Lo (1998), this new species belongs to subg. *Sinospiradiclis* on the basis of its subglobose capsules with four untwisted valves (Figs 1E–G, 2G–I).

Based on our field investigations of *Spiradiclis* in China and careful studies of relevant literature and specimens, about 94% of the known *Spiradiclis* species are confirmed to be distylous plant, of which more than 30 species have been observed with both long- and short-styled flowers in the same population. It is known that being distylous is a unique phenotype in plants to ensure reproduction by avoiding self-pollination and to increase male fitness and outcrossing rates by reducing sexual interference between male and female functions (Watanabe et al. 2017). In this study, however, all the individuals with observed flowers are with stamens inserted at the middle of the corolla tube and stigmas located near the throat of the corolla tube, this being the long-styled form. This phenomenon could be interpreted from two aspects currently: 1) both styled flowers are present in the population but only few individuals are short-styled rather than long-styled and they could be overlooked during the investigations; 2) this population is a monomorphic population with all individuals having long-styled flowers which is not rare and was reported from other groups such as *Eichhornia* Kunth and *Luculia* Sweet (Barrett 1989, Zhou and Wang 2009). Further studies on the reproductive and pollination biology of the new species are needed.

Specimens examined (Paratypes). CHINA. Guangdong: the type locality, 27 Nov 2016 (fruit), L. Wu & B. M. Wang 5610 (CSFI!), 13 Oct 2017, L. Wu & B. M. Wang 6236 (CSFI!).

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