

A new species and a new replacement name in *Cynanchum* (Apocynaceae: Asclepiadeae) from southwest China

Miao Liao¹, Si-Jin Zeng², Lin-Ya Zeng², Hai-Jun Yin³, Mao-Lin Yan³, Caifei Zhang⁴, and GUANG-DA TANG¹

¹South China Agricultural University

²South China Botanical Garden

³Management Office of Tongbiguan Provincial Nature Reserve

⁴Wuhan Botanical Garden Chinese Academy of Sciences

November 8, 2022

Abstract

Cynanchum pingtaoi sp. nov. (Apocynaceae), from Yunnan Province, China, is described and illustrated based on molecular and morphological evidence. Its deeply cordate to reniform leaves, campanulate and large flowers show that it is a member of former *Raphistemma* which has been included in *Cynanchum*.

A new species and a new replacement name in *Cynanchum* (Apocynaceae: Asclepiadeae) from southwest China

Miao Liao^{1,5,6,7} Si-Jin Zeng² Lin-Ya Zeng² Hai-Jun Yin³ Mao-Lin Yan³ Cai-Fei Zhang^{5,6,7} Guang-Da Tang^{1,4}

¹ College of Forestry and Landscape Architecture, South China Limestone Plants Research Center, South China Agricultural University, Guangzhou, China

² South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, China

³Tongbiguan Provincial Nature Reserve, Ruli, Yunnan, China

⁴ Henry Fok College of Biology and Agriculture, Shaoguan University, Shaoguan, China

⁵ CAS Key Laboratory of Plant Germplasm Enhancement and Specialty Agriculture, Wuhan Botanical Garden, Chinese Academy of Sciences, Wuhan, China

⁶ Sino-Africa Joint Research Center, Chinese Academy of Sciences, Wuhan, China

⁷ University of Chinese Academy of Sciences, Beijing, China

Correspondence

Guang-Da Tang, College of Forestry and Landscape Architecture, South China Limestone Plants Research Center, South China Agricultural University, China; No. 483, Wushan Road, Tianhe District, Guangzhou 510642, China.

Email: gdtang@scau.edu.cn

Abstract

Cynanchum pingtaoi sp. nov. (Apocynaceae), from Yunnan Province, China, is described and illustrated based on molecular and morphological evidence. Its deeply cordate to reniform leaves, campanulate and large flowers show that it is a member of former *Raphistemma* which has been included in *Cynanchum*.

now. It is different from the all former *Raphistemma* species (*C. hooperianum*, *C. longhushanense* and *C. pulchellum*) by the broadly ovate corolla lobe, purple-red corolla, and connivent corona tip slightly exceeding corolla throat. Its detailed morphological description and illustrations are provided. Meanwhile, *Cynanchum longhushanense* G.D.Tang & Miao Liao **nom. nov.** is proposed as the replacement name of *Raphistemma brevipedunculatum* Y. Wan which is reinstated from a synonym of *C. hooperianum* (Blume) Decne because of their significant morphological differences.

KEYWORDS

Cynanchum pingtaoi; *C. longhushanense*; New species; Replacement name; Apocynaceae

1 INTRODUCTION

Cynanchum L. is one of the largest genera of Asclepiadeae (Apocynaceae), and mainly distributed in Africa and Asia (Endress et al., 2018). It has been considered as a "dustbin genus" due to its complex morphological characteristics, generally containing a gynostegial, at least basally fused corona (Liede & Kunze, 1993). The extent and classification of *Cynanchum* are controversial. Markgraf (1972) and Ali et Khatoon (1982) supported that *Cynanchum* should be divided into *Cynanchum*, *Vincetoxicum* Wolf, etc. But this taxonomic revision was not supported by other scholars (Tsiang & Li 1977; Li et al, 1995). Woodson (1941) and Liede (1997) suggested that more than twenty allied genera were included in *Cynanchum* according to the characters of fused corona etc. More than ten genera, which included *Raphistemma* Wall., are merged into *Cynanchum* based on abundant molecular and morphological evidence recently (Khanum et al., 2016). But *Vincetoxicum* was separated from *Cynanchum* with the evidence of molecular, chemical and morphological characteristics (Qiu et al., 1989; Liede, 1996; Liede, 2001; Rapini et al., 2007). Therefore, the morphological diagnostic characters of *Cynanchum* were expanded as: corolla 3–10 (–40) mm long; gynostegial corona highly variable, usually with a ring of fused staminal and interstaminal parts, staminal parts occasionally with adaxial appendage; occasionally with additional free staminal lobe connate to ring (Endress et al., 2018).

In China, 57 species of *Cynanchum* were recorded in *Flora of China* (Li et al., 1995). According to the recent revised circumscription of *Cynanchum* and *Vincetoxicum*, 27 species of *Cynanchum* have been transferred to *Vincetoxicum*, and nine species of the allied genera have been included in *Cynanchum* which contain *Adelostemma gracillimum* (Wallich ex Wight) J. D. Hooker, *Graphistemma pictum* (Champ. ex Benth.) Benth. et Hook. f. ex Maxim., *Holostemma ada-kodien* Schultes, *Metaplexis hemsleyana* Oliv., *M. japonica* (Thunb.) Makino, *Raphistemma hooperianum* (Blume) Dec., *R. pulchellum* (Roxb.) Wall., *Sichuania alterniloba* M. G. Gilbert & P. T. Li. (Khanum et al., 2016), *Sarcostemma acidum* (Roxb.) Voigt (Liede & Kunze 2002; Liede & Täuber 2002). Recently, two new species of *Cynanchum* were reported from China (Shen et al., 2019; Xu et al., 2021). There are 41 species of *Cynanchum* recorded in China by now.

We collected an unknown species in Ruili, Yunnan during field survey in 2020. This species has many typical characters of former *Raphistemma* (included in *Cynanchum*) with large and reniform leaves, large and campanulate corolla. We are unable to match it with any recorded species after the careful examination of the specimens and literature from China and neighboring countries, and the molecular phylogenetic results strongly support that it is an independent species within *Cynanchum* also. Therefore, we describe it here as new.

2 MATERIALS AND METHODS

Morphological observation

The morphological data of the new species were based on living plants and specimens collected in the field, and the vouchers were deposited at the herbaria IBSC and KUN (acronyms according to Thiers 2021), and the morphological data for similar species refer to their protologue (Blume, 1826; Wan, 1983), revised literature (Wallich, 1831; Candolle, 1844), regional flora (Backer & Bakhuizen van den Brink, 1965) or living plants and specimens.

Phylogenetic analysis

Total genomic DNA was obtained from the fresh leaves of the *C. pingtaoi* and *R. brevipedunculatum* Y. Wan with the plant genomic DNA kit (DP305, Tiangen, Beijing, China), and then sent to Novogene (Tianjin, China) for library (350 bp) preparation for genome skimming sequencing. Paired-end (150 bp) sequencing was conducted on an Illumina HiSeq 2000, generating 10 Gb raw data of this sample. After quality controlling of the raw data by fastp v.0.23 (Chen et al. 2018), 3 Gb paired reads were extracted for plastid and nuclear ribosome assembly with GetOrganelle v.1.7 (Jin et al., 2020). The plastid genome of *Apocynum venetum* L. (MT313688) and a continuous sequence (18S-ITS1-5.8S-ITS2-26S) of the ribosome genome of *Asclepias albicans* S.Watson (JN665082), and the nrETS of *Calciophila galgalensis* (LN896997) and *Cynanchum adalinae* K.Schum. subsp. *adalinae* (LN897003) were used as the reference respectively. Geneious Prime 2019 (<https://www.geneious.com>) was employed to annotate and extract three plastid DNA markers (one spacers of *trnL-F*, and two introns of *rps16* and *trnL*) and two nuclear DNA regions (nrITS: internal transcribed spacer and nrETS: external transcribed spacer), and these data were upload to GenBank (<https://www.ncbi.nlm.nih.gov/>).

The samples of 58 species were used for molecular analysis, including 51 species of *Cynanchum*, and seven samples were taken as the out groups, including *Pentatropis madagascariensis* Decne., *P. nivalis* (J.F.Gmel.) D.V.Field & J.R.I.Wood and *Pentatropis* sp. which belonged to Tylophorinae and *Calciophila galgalensis* Liede & Meve (including two samples), *Calciophila gillettii* Liede & Meve, and *Calotropis procera* (Aiton) W.T.Aiton which belonged to Asclepiadinae (Khanum et al. 2016) (Appendix 1). The sequences of three plastid DNA markers and two nuclear DNA regions were aligned separately in MEGA v.7.0.26 using MUSCLE with manual adjustment (Kumar et al., 2016), and then concatenated into a super matrix in Geneious Prime 2019. The incomplete sequences were filled with missing data. The maximum likelihood (ML) was performed under RAxML-HPC2 8.2.12 on XSEDE (Stamatakis, 2014) through the CIPRES portal (Miller et al., 2010) by using GTRCAT model and 1 000 bootstraps, and the trees is viewed in Figtree 1.4.2 (Rambaut, 2012).

3 RESULTS

Morphological comparison

This new species is similar to *C. hooperianum*, *C. longhushanense* and *C. pulchellum*, but it is distinctly different from them by the broadly ovate corolla lobe, purple-red corolla, and connivent corona tip slightly exceeding corolla throat (Table 1).

Molecular phylogenetics

The results of phylogenetic systematic analysis show that the new species is a member of *Cynanchum*, according to the combined two nuclear DNA regions (*nr* ITS and *nr* ETS) and three plastid DNA markers (one spacers of *trnL-F*, and two introns of *rps16* and *trnL*). And it is the sister to *C. pulchellum* and *C. longhushanense* with the strong support rate (BSML= 100%, Figure 1).

4 TAXONOMIC TREATMENT

Cynanchum pingtaoi S.Jin Zeng, G.D.Tang & Miao Liao, sp. nov. Figures. 2–3

Diagnosis. *Cynanchum pingtaoi* is similar to *C. longhushanense* morphologically in having large and deeply cordate to reniform leaves, large and campanulate corolla, follicles solitary, triangulate, fusiform, with three ribs. But it differs from the latter by its broadly ovate corolla lobe (vs. oblong), outer surface greenish-white and inner surface purple-red corolla (vs. outer surface greenish-white, inner surface white, usually with purple spots on the top of corolla lobe), corona tip connivent, slightly exceeding corolla throat (vs. corona tips connivent, not exceeding the throat of the corolla)

Type. CHINA. Yunnan (云南): Dehong Dai and Jingpo Autonomous Prefecture (德宏傣族景颇族自治州), Ruili City (瑞丽市), Nongdao Town (弄岛镇), Tongbiguan Provincial Nature Reserve, 24 August 2020, Lin Ya Zeng & S.Jin Zeng. 4825 (holotype, IBSC!; isotypes, KUN!).

Description. Twining liana. White latex in stems and leaves. **Branchlets** fistulous, smooth, glabrous, slightly woody. **Leaves** opposite; petiole 6–14 cm long, smooth, sparsely white puberulent, later glabrescent,

with small yellowish-brown glands at the tip, inter petiole with small glands; leaf blade deeply cordate to reniform, 7–15 × 4–13 cm, membranous, base cordate, apex acuminate, margin entire, adaxial surface dark green, glabrous, abaxially light green, sparsely white puberulent on veins, gradually glabrescent laterly; basal veins five or seven, palmate, secondary veins three to five pairs, pinnate, tertiary veins reticulate, smooth adaxially, raised abaxially. **Inflorescences** extra-axillary, subumbellate to subracemic, 5–11 flowers; peduncle 10–12 cm long, smooth; pedicel 3.0–5.5 cm long, smooth, sparsely white puberulent near the base, base with bracteoles triangular, ca. 0.1 × 0.1 cm. **Calyx** yellowish-green, basally fused, lobe elliptic, ca. 0.6 × 0.5 cm, base with small glands, apex obtuse, margin ciliate. **Corolla** campanulate, glabrous, external surface greenish white, inner surface purplish red, 3.3–3.5 cm in diam; lobe slightly longer than tube, tube 1.2–1.4 cm, lobe broadly ovate, 1.3–1.8 × 1–1.2 cm, apex reflexed, overlapping to right. **Corona** lobe linear-subulate, white, separate, ca. 1.1 cm long, inserted at base of gynostegium, longer than gynostegium and corona tips connivent, slightly exceeding corolla throat. **Anthers** with inwardly incurved paleolae. **Stigma head** broadly rounded, slightly depressed, white. **Pollinia** 2 per pollinarium, ellipsoid, yellow, pendulous, ca. 0.13 × 0.08 cm, caudicle ca. 0.05 cm long, retinaculum ca. 0.1 cm long. **Follicles** solitary, fusiform, ca. 14.5 cm long, ca. 5 cm diam., glabrous, with a thick fibrous pericarp, triangulate, tip curved outwards; seeds ovoid, 0.8 cm × 0.6 cm, tipped with a white silky coma; coma 3.8–4.2 cm long. Flowering in September–October. Fruiting in November–December.

Etymology. The specific epithet honors the eminent botanist Ping-Tao Li (李秉滔), an expert in the Apocynaceae.

Chinese name. Bing-tao-da-hua-teng (秉滔大花藤).

Distribution. Endemic to China, only one population was found at the border of China-Myanmar in Ruili, Yunnan Province, China.

Habitat and phenology. This species occurs near open woods and climbing up trees. Flowering was observed in September to October, fruiting in November to December.

Provisional IUCN assessment. The species is known only from the type locality so far, where only a few individuals were seen. A suitable habitat exists in the proximity of the type locality. Nevertheless, as there is no reliable information on the population sizes or distribution of this species, we propose to treat it currently as Data Deficient (IUCN 2019).

Notes. *Cynanchum pingtaoi* is a distinctive species for its larger flowers. The large and reniform leaves, campanulate corolla and lanceolate corona indicate that it is close with former *Raphistemma* which has been included in *Cynanchum*. The results of molecular phylogenetic analyses also showed that *Cynanchum pingtaoi* is close to the former *Raphistemma* species. It is the sister to *C. pulchellum* (*R. pulchellum* (Roxb.) Wall.) and *C. longhushanense* (*R. brevipedunculatum* Y. Wan) (Figure 1). Although the molecular data of *C. hooperianum* (*R. hooperianum* (Blume) Decne) was absent, but it can be distinguished between *C. pingtaoi* and *C. hooperianum* by corolla outer surface greenish-white, inner surface purple-red (vs. corolla outer surface light green, inner surface white with purple spots on the top of lobe), corolla lobe broadly ovate (vs. corolla lobe ovate), corona tips connivent, slightly exceeding corolla throat (vs. corona tips not connivent, stretching reaching to the middle of the corolla lobe), calyx-segments longer (6 mm vs. 3–4 mm), and corolla-tube longer (12–14 mm vs. 8–9 mm). Thus, we would like to propose *Cynanchum pingtaoi* to be a new species.

Cynanchum longhushanense G.D.Tang & Miao Liao, **nom. nov.**, non *C. brevipedunculatum* J.Y.Shen (2019).

[?] *Raphistemma brevipedunculatum* Y.Wan, Guihaia 3(3): 197 (1983).

Type. CHINA. Guangxi (广西): Long'an county (隆安县), Longhushan Nature Reserve, open woods, 2 July 1981, *D.H. Tan 82329* (holotype: GXMS!; isotypes: CANT!).

Chinese name. Long-hu-shan-da-hua-teng (龙虎山大花藤).

Notes. Four names were recorded in *Raphistemma*. *R. ciliata* Hook.f. was treated as the synonym of *Pergularia daemia* (Forssk.) Chiov. (Goyder, 2006); *R. pulchellum* (Roxb.) Wall. was revised to *C. pulchellum* (Roxb.) Liede & Khanum (Khanum et al., 2016). *R. brevipedunculatum* Y. Wan was considered as the synonym of *R. hooperianum* (Blume) Decne without any evidence (Li et al., 1995). Geographically, *R. brevipedunculatum* was found in Guangxi, China (Wan, 1983), while *R. hooperianum*, first discovered in Java island, Indonesia, was recorded as *Oxystelma hooperianum* Blume (Blume, 1826) initially, and the later was revised as *R. hooperianum* (Candolle, 1844). However, the description of *R. hooperianum* was poor in these two works, and its type specimen was absent (Blume, 1826; Candolle, 1844). We collected and checked the more clear description of *R. hooperianum* from *Flora of Java* (Backer & Bakhuizen van den Brink, 1965). Furthermore, we collected the living samples of *R. brevipedunculatum* from type location (Longhushan Nature Reserve, Longan County, Guangxi Zhuang Autonomous Region, China.) and Jinping County, Yunnan Province, China, which very close to the former. We found that *R. brevipedunculatum* are significantly different from *R. hooperianum* by contrasting the descriptions and the living samples, the former has longer calyx (6 mm vs. 3–4 mm), longer corolla-tube (12–16 mm vs. 8–9 mm), different corolla lobe (oblong vs. ovate) and corona lobe (corona tips connivent, not exceeding the throat of the corolla vs. corona tip not connivent, stretching to the middle of the corolla lobe). *R. brevipedunculatum* is flowering in June–July (Wan 1983) and in September (*S. Jin Zeng* and *Lin Ya Zeng 4887*), but *R. hooperianum* is flowering almost all the years (Blume, 1826). So, we suggested that *R. brevipedunculatum* should be separated from *R. hooperianum* (= *C. hooperianum*) as an independent species. And we renamed it as *Cynanchum longhushanense* because the Latin word of ‘brevipedunculatum’ had been used to name another species of *Cynanchum brevipedunculatum* J. Y. Shen (Shen et al., 2019).

Other specimens examined. CHINA. Guangxi (广西), Long’an (隆安), Pingshan (屏山), 10 Oct. 1977, *Longan Investigation Team 2-040* (GXMI031735 [photo!]); Long’an (隆安), Longhushan Nature Reserve, 25 Jun. 2021, *Miao Liao 78* (IBSC!). Yunnan Province (云南). Honghe Hani and Yi Autonomous Prefecture (红河哈尼族彝族自治州), Jinping Miao and Yao Dai Autonomous County (金平苗族瑶族傣族自治县), Jinshuihe Town (金水河镇), 9 Sept. 2020, *Lin Ya Zeng & S. Jin Zeng 4887* (IBSC!).

AUTHOR CONTRIBUTIONS

Miao Liao : Data curation (Lead); Formal analysis (Lead); Investigation (Supporting); Methodology (Lead); Software (Lead); Validation (Equal); Visualization (Lead); Writing – original draft (Lead); Writing – review & editing (Equal). **Si-Jin Zeng** : Conceptualization (Supporting); Formal analysis (Equal); Investigation (Lead); Writing – review & editing (Supporting). **Lin-Ya Zeng** : Investigation (Supporting); Resources (Supporting). **Hai-Jun Yin** : Investigation (Equal). **Mao-Lin Yan** : Investigation (Equal). **Cai-Fei Zhang** : Data curation (Equal); Validation (Equal); Writing – review & editing (Supporting). **Guang-Da Tang** : Conceptualization (Lead); Data curation (Equal); Formal analysis (Supporting); Funding acquisition (Lead); Methodology (Supporting); Project administration (Lead); Resources (Supporting); Supervision (Lead); Validation (Lead); Writing – review & editing (Lead).

ACKNOWLEDGEMENTS

This work was supported by Science and Technology Program from Forestry Administration of Guangdong Province (2023KJCX001). We are thankful to Prof. **Nian-He Xia** (South China National Botanical Garden) and Dr. **Gang Yao** (South China Agricultural University) for their helpful comments and constructive suggestions, and Guangxi Longhu Mountain Provincial Nature Reserve for supporting our field work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The newly obtained sequences of *Cynanchum pingtaoi* and *C. longhushanense* have been submitted to the NCBI website, and the assigned Genbank accessions will be provided soon. The DNA sequences data

supporting the findings of this study are available within APPENDIX 1. The morphological data used in the study are included in this paper.

ORCIDGuangda Tang iD <https://orcid.org/0000-0001-5623-3928>

REFERENCES

- Ali SI, Khatoon S (1982) Genus *Vincetoxicum* von Wolf (Asclepiadaceae) in Pakistan. Pakistan. Journal of Botany 14(1): 61–68.
- Backer CA, Bakhuizen van den Brink Jr RC (1965) Flora of Java (Spermatophytes only) VOL.II (Angiospermae families 11-160). N.V.P. Noordhoff, Groningen, 713 pp.
- Blume C K L.V. (1826) Asclepiadaceae. In: Blume, C. K. L. V.(Ed)Bijdragen tot de flora van Nederlandsch Indië. Lands Drukkerij, Batavia, 1048–1066.
- Candolle A L P P (1844) Asclepiadaceae. In:Candolle, A. L. P. P.(Ed)Prodromus Systematis Naturalis Regni Vegetabilis vol. 8.Victor Masson, Paris, 490–665.
- Chen SF, Zhou YQ, Chen YR, Gu J (2018). fastp: an ultra-fast all-in-one FASTQ preprocessor. Bioinformatics 34 (17): 884–890.
- Endress ME, Meve U, Middleton DJ, Liede-Schumann, S (2018) Apocynaceae. In: Bittrich V, Kadereit JW (Eds) The families and genera of vascular plants 15. Flowering plants. Eudicots. Apiales, Gentianales (except Rubiaceae). Springer, Berlin, 207–411. https://doi.org/10.1007/978-3-319-93605-5_3
- Goyder D (2006) A revision of the genus *Pergularia* L. (Apocynaceae: Asclepiadoideae). Kew Bulletin 2006, 61: 245–256. <https://www.jstor.org/stable/20443269>
- IUCN (2019) Guidelines for using the IUCN red list categories and criteria. Version 14. prepared by the standards and petitions subcommittee of the IUCN Species Survival Commission. Jin JJ, Yu WB, Yang JB, Song Y, dePamphilis CW, Yi TS, Li DZ (2020) GetOrganelle: A fast and versatile toolkit for accurate de novo assembly of organelle genomes. Genome Biology 21(1): 241. <https://doi.org/10.1186/s13059-020-02154-5>
- Kumar S, Stecher G, Tamura K (2016) MEGA7: Molecular evolutionary genetics analysis version 7.0 for bigger datasets. Molecular Biology and Evolution 33 (7): 1870–1874. <https://doi.org/10.1093/molbev/msw054>
- Li PT, Gilbert MG, Steven WD (1995) Asclepiadaceae. In: Wu ZY, Raven PH (Eds) Flora of China, vol 16. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, Missouri, 189–270.
- Liede S (1996) *Cynanchum-Rhodostegiella-Vincetoxicum-Tylophora*(Asclepiadaceae): New considerations on an old problem. Taxon 45(2): 193–211. <https://doi.org/10.2307/1224660>
- Liede S (1997) Subtribes and genera of the tribe Asclepiadeae (Apocynaceae, Asclepiadoideae) - a synopsis. Taxon 46 (2): 233–247.<https://doi.org/10.2307/1224093>
- Liede S (2001) Subtribe Astephaninae (Apocynaceae-Asclepiadoideae) reconsidered: new evidence based on *cpDNA* spacers. Annals of the Missouri Botanical Garden 88(4): 657.
- Liede S, Kunze H (1993) A descriptive system for corona analysis in Asclepiadaceae and Periplocaceae. Plant Systematics and Evolution 185: 275–284.
- Liede S, Kunze H (2002) *Cynanchum* and the Cynanchinae (Apocynaceae – Asclepiadoideae): a molecular, anatomical and latex triterpenoid study. Organisms Diversity & Evolution 2(3): 239–269. <https://doi.org/10.1078/1439-6092-00045>
- Liede S, Tauber Angelika (2002) Circumscription of the genus *Cynanchum* (Apocynaceae-Asclepiadoideae). Systematic Botany 27(4): 789–800. <https://doi.org/10.1043/0363-6445-27.4.789>
- Liede-Schumann S, Khanum R, Mumtaz AS, Gherghel I, Pahlevani A (2016) Going west – A subtropical lineage (*Vincetoxicum*, Apocynaceae: Asclepiadoideae) expanding into Europe. Molecular Phylogenetics and Evolution 94: 436–446. <https://doi.org/10.1016/j.ympev.2015.09.021>
- Markgraf F (1972) Asclepiadaceae. In: Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (Eds) Flora Europaea, Volume 3. Diapensiaceae to Myoporaceae. Cambridge University Press, Cambridge, 70–73.
- Miller MA, Pfeiffer W, Schwartz T (2010) Creating the CIPRES science gateway for inference of large phylogenetic trees. In: Proceedings of the gateway computing environments workshop (GCE), 14 Nov. 2010, New Orleans, LA, 1–8. <https://doi.org/10.1109/GCE.2010.5676129>
- Qiu SX, Li DZ, Zhang z x, Zhou J, WU ZY (1989). Chemotaxonomy of *Cynanchum* and its allied genera with notes on the generic characteristics of *Vincetoxicum*. Acta Botanica Yunnanica 11(1): 41–50.
- Rambaut A (2012). FigTree version 1.4.0. Available from: <http://tree.bio.ed.ac.uk/software/figtree/>.
- Rapini A, van den Berg C, Liede-Schumann S (2007) Diversification of Asclepiadoideae (Apocynaceae) in the New World. Annals of the Missouri Botanical Garden 94(2): 407–422. [http://dx.doi.org/10.3417/0026-6493\(2007\)94\[407:DOAAIT\]2.0.CO;2](http://dx.doi.org/10.3417/0026-6493(2007)94[407:DOAAIT]2.0.CO;2)
- Shen JY, Ma DX, Wang WG, Shi JP (2019) *Cynanchum bre-*

FIGURE 1 The simplified maximum likelihood tree of *Cynanchum* based on combined two nuclear DNA regions (nrITS and nrETS) and three plastid DNA markers (one spacers of *trnL-F* , and two introns of *rps16* and *trnL*). The numbers on each node are bootstrap support values.

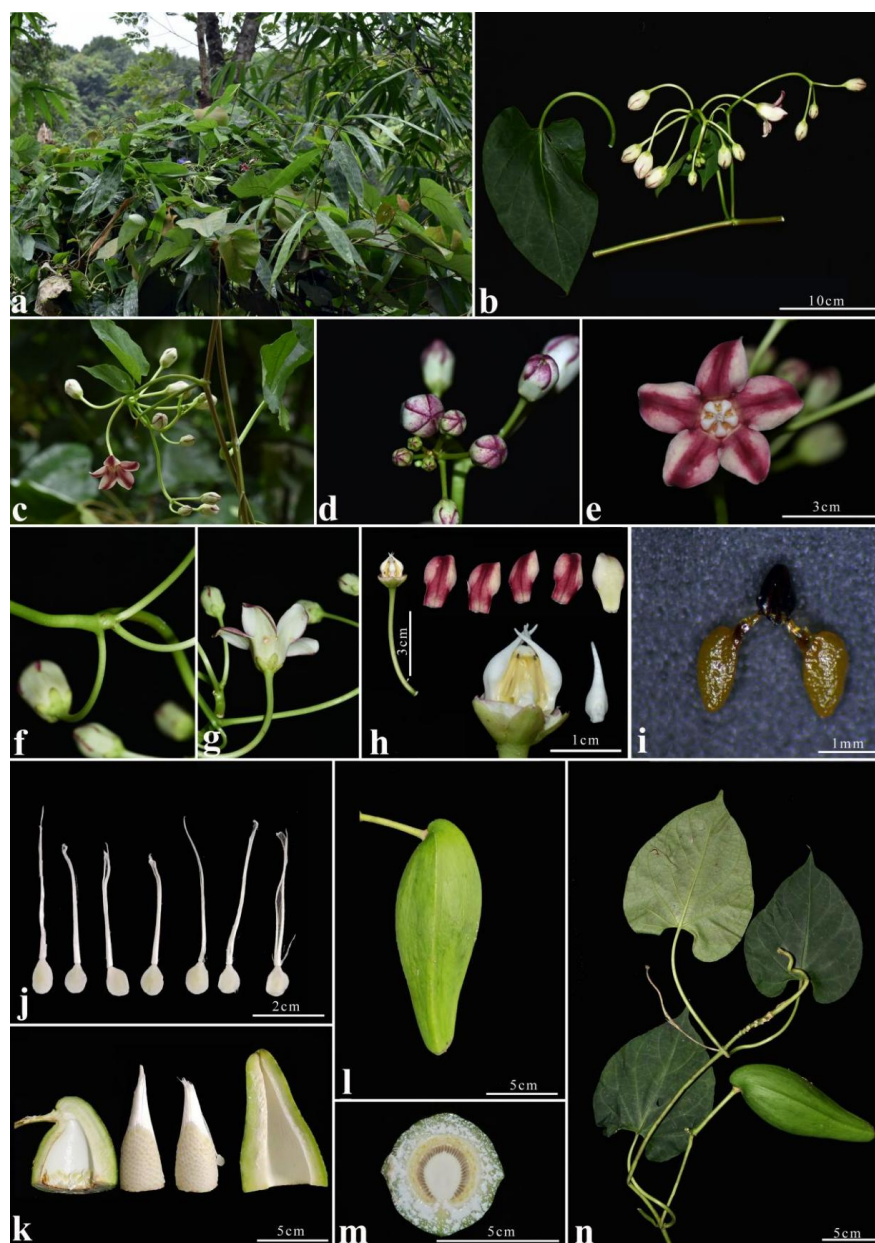


FIGURE 2 *Cynanchum pingtaoi* S.Jin Zeng, G.D.Tang & Miao Liao. **a** habitat; **b** inflorescence and leaf; **c** inflorescence; **d** front view of the flower; **e** front view of the flower; **f** bracteoles at the base of the pedicel; **g** dorsal view of flower; **h** corolla and corona separation, showing the gynostegium and corona, the inner (middle four corolla) and outer surfaces (most right corolla) of corolla lobe; **i** pollinarium; **j** young seeds; **k** arrangement of the seeds; **l** follicle; **m** transection surface of follicle; **n** follicle and leaves. Photo i by Miao Liao, other photos by Si-Jin Zeng.

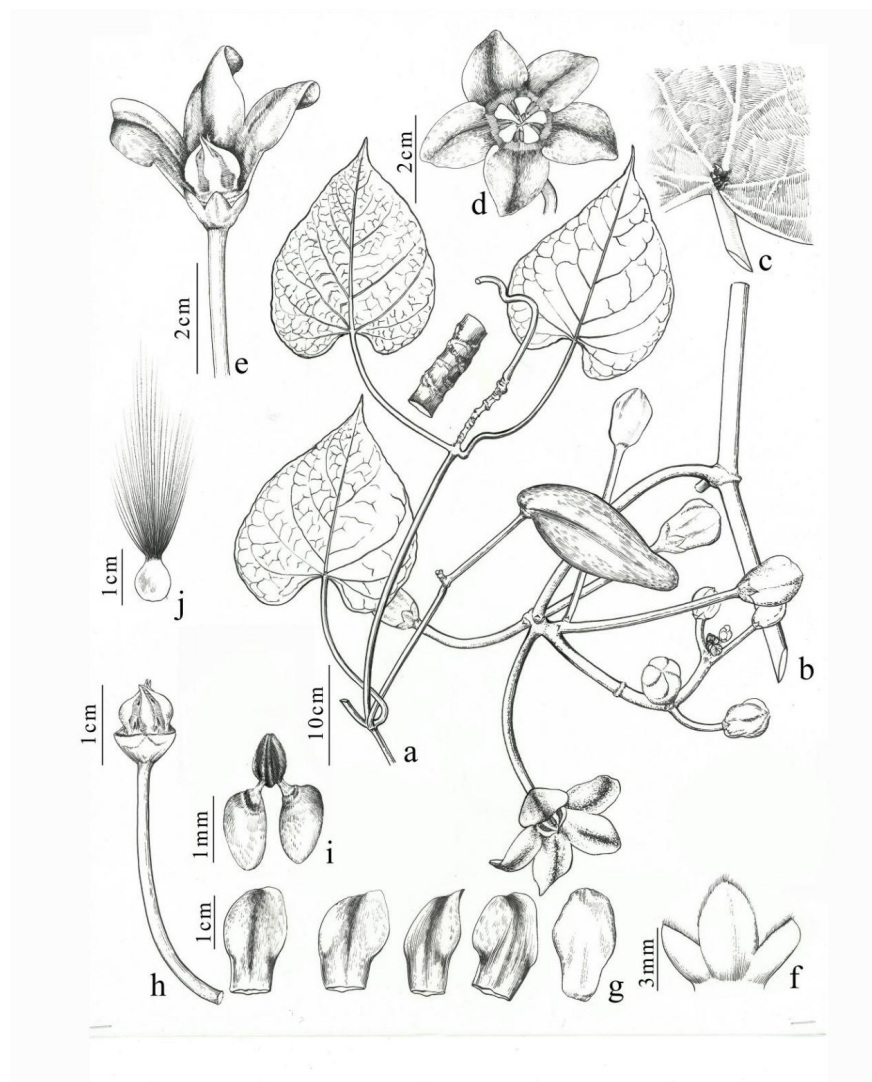


FIGURE 3 *Cynanchum pingtaoi* S. Jin Zeng, G.D. Tang & Miao Liao. **a** follicle and leaves; **b** inflorescence; **c** glands at base of leaf; **d** front view of flower; **e** ecutaway view of the flower; **f** calyx; **g** corolla lobe; **h** corolla separation, showing corona lobe, and the way pollinarium are inserted; **i** pollinarium; **j** seed. Drawn by Ding-Han Cui.

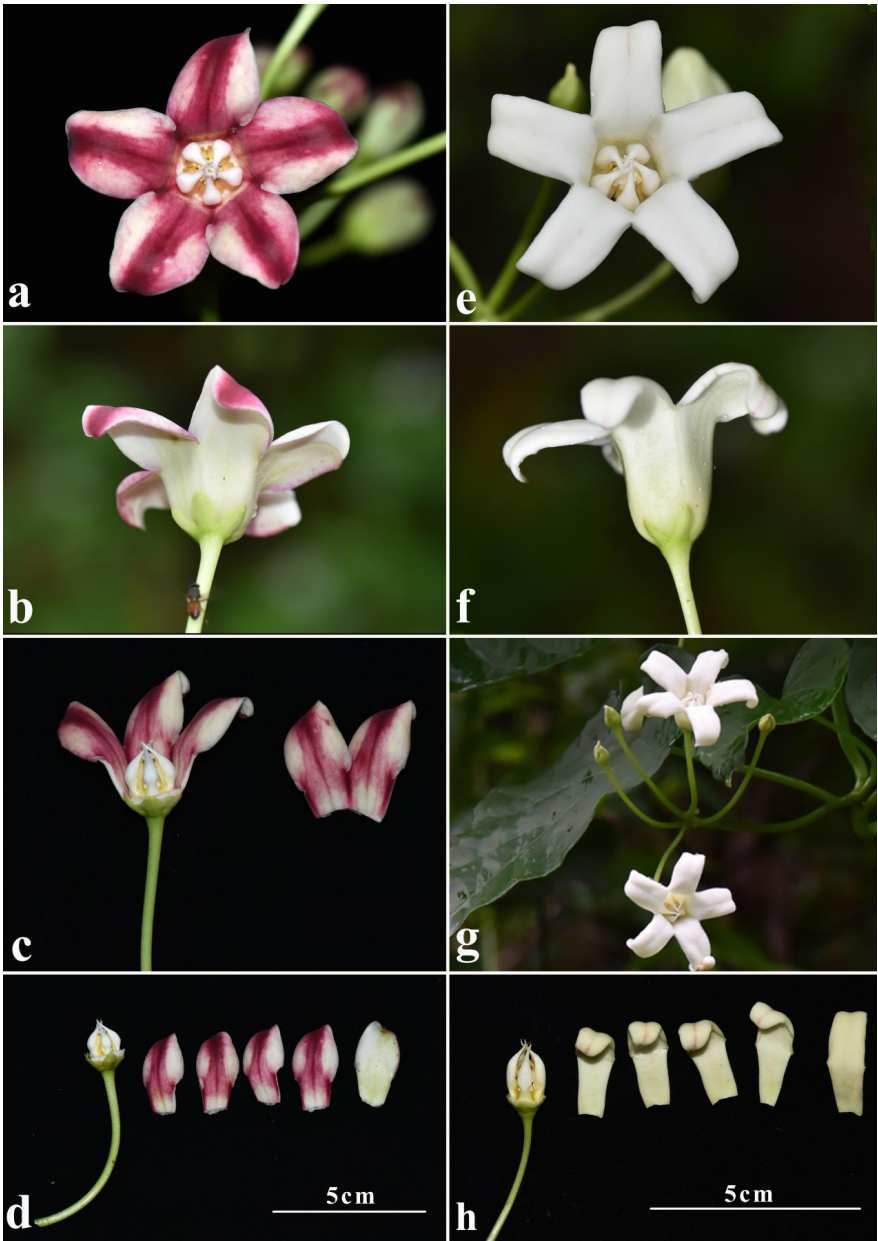


FIGURE 4 Comparison of *Cynanchum pingtaoi* and *C. longhushanense* : a–d *C. pingtaoi* e–h *C. longhushanense* a, e flowers, front view; b, f flowers, elevation view; c, g flowers, showing whether the corona exceeds the corolla tube; d, h corolla separation, showing the color of corolla lobe, corona lobe. All photos by Si-Jin Zeng.

APPENDIX 1

Sequences obtained from GenBank and sequencing for phylogenetic analysis

| Species | Origin | Voucher |
|-------------------------------------|---------------------|---------------------------|
| Asclepiadinae (Outgroups) | | |
| <i>Pentatropis madagascariensis</i> | Madagascar: Toliara | Liede & Conrad 2749 (UBT) |

Pentatropis nivalis

Pentatropis sp.

Tylophorinae (Outgroups)

Calciphila galgalensis

Calciphila galgalensis

Calciphila gillettii

Calotropis procera

Cynanchinae (Ingroups)

Cynanchum adalinae

Cynanchum africanum

Cynanchum annularium

Cynanchum blyttiioides

Cynanchum boudieri

Cynanchum crassiantherae

Cynanchum ellipticum

Cynanchum ethiopicum

Cynanchum falcatum

Cynanchum foetidum

Cynanchum formosanum

Cynanchum giraldii

Cynanchum gonoloboides

Cynanchum graphistemmatoideis

Cynanchum insipidum

Cynanchum itremense

Cynanchum laeve

Cynanchum ledermannii

Cynanchum ligulatum

Cynanchum longipes

Cynanchum maximoviczii

Cynanchum membranaceum

Cynanchum meyeri

Cynanchum montevidense

Cynanchum montevidense

Cynanchum obtusifolium

Cynanchum officinale

Cynanchum ovalifolium

Cynanchum pachycladon

Cynanchum peraffine

Cynanchum physocarpum

Cynanchum pingtaoi **sp. nov.**

Cynanchum pulchellum

Cynanchum racemosum

Cynanchum radians

Cynanchum revoilii

Cynanchum roulinioides

Cynanchum rostellatum

Cynanchum rubricorona

Cynanchum rungweense

Cynanchum sahyadricum

Cynanchum schistoglossum

Cynanchum sinoracemosu

Kenya: Kilifi

Ethiopia: Ogaden

Somalia: Bari

Somalia: Bari

Somalia: Bari

Gambia

Cameroon: Sud (Mt.Cameroon)

South Africa: Western Cape

Bhutan

Somalia: Bari

Japan: Kagoshima Pref.

Somalia: Balad

South Africa: Eastern Cape

Tanzania: Ufipa

Ethiopia: Ogaden

Mexico: Oaxaca

China: Taiwan

China: Shaanxi

Kenya: Naivasha

China: Hongkong

South Africa: Orange Free State

Madagascar: Fianarantsoa

U.S.A.: Missouri

Tanzania: Kilimanjaro

Mexico: Sonora

Ghana: Brong-Ahafo Region

Japan: Miyagi

Madagascar: Toliara

Namibia

Argentina: Salta

Brazil: Mato Grosso do Sul

South Africa: Eastern Cape

China: Anhui

Philippines: Zamboanga

Madagascar: Toliara

Mexico: Chiapas

Philippines: Mindoro

China: Yunnan

Thailand: Satun

Mexico: Tamaulipas

North Yemen: Hodeidah

Kenya: Northern Frontier

Bolivia: Chuquisaca

Japan: s.loc.

Somalia: Hiiraan / Bari

Tanzania: Rukwa

India: Maharashtra

Mozambique: Sofala

China: Yunnan

Meve 949 (UBT)

Kuchar & Abdirizak 20905 (UPS V-195021)

Thulin & Warfa 6205(K, UPS)

Thulin & al. 9433(UPS)

Thulin Dahir & Osman 10122 (UPS)

Huber s.n. (UBT)

Meve 902 (K, SCA)

Liede 2550 (MO)

Grierson & Long 2351 (E)

Thulin & al. 10681 (UPS)

Tateishi & Yamashiro 45546 (URO)

Hedberg & Warfa 90 (UPS)

Liede 2933 (UBT)

Bidgood & al. 2440 (KMWC 8418)

Kuchar & Abdirizak 21226 (UPS)

Campos 3956 (MO)

Wang & al. 02687 (L)

Zhu & al. 2323 (MO)

Liede & Newton 3157 (UBT)

Surveswaran s.n. (SUK)

Liede 2940 (UBT)

Phillipson & al. 3857 (MO)

Liede s.n. (UBT)

Hemp 4138 (UBT)

Fishbein 7461 (OKLA)

Jongkind & Schmidt 1739 (MO)

Yamashiro & Yamashiro 7578 (TUS)

Liede & al. 2765 (ULM)

Van Wyk 9030 (PRE)

Liede & Conrad 3100 (ULM)

Farinacchio & Felismino 916 (SPF)

Liede 2925 (UBT)

Liu & al. A50185 (MO)

Liede 3297 (ULM)

Liede & al. 2741 (MO, P, UBT)

Alvarez 6895 (MO)

Knauer s.n. (UBT)

Zeng & al. SJ4825 (IBSC, KUN)

Middleton & al. 5359 (E)

Liede & Conrad 2609 (ULM)

Müller-Hohenstein & Deil 1967 (UBT)

Liede & Newton 3239 (ULM)

Wood & al. 13300 (K, UBT)

ex BG Tartu (UBT)

Kuchar 16793 (K, MWC 8414)

Bidgood & al. 2525 (K)

Kamble 2122 (SUK)

Goyder & Timberlake 4093 (K)

Hemp s.n. (UBT)

| | | |
|--|---------------------|---|
| <i>Cynanchum subpaniculatum</i> | Ecuador: Napo | <i>Burnham 1611</i> (MO) |
| <i>Cynanchum taiwanianum</i> | China: Taiwan | <i>Wang & Lin 02452</i> (L) |
| <i>Cynanchum thesioides</i> | China: Neimenggu | <i>Qingru 97-81</i> (MO) |
| <i>Cynanchum toliari</i> | Madagascar: Toliara | <i>McPherson 14770</i> (MO) |
| <i>Cynanchum varians</i> | Iran: Hormoszgan | <i>Amini Rad & al. 56685</i> (IRAN) |
| <i>Cynanchum wallichii</i> | China: Yunnan | <i>Schäfer 2005-48</i> (M) |
| <i>Cynanchum longhushanense</i> nom. nov. | China: Guangxi | <i>LM78</i> (IBSC) |
| <i>Cynanchum longhushanense</i> nom. nov. | China: Yunnan | <i>Zeng & al. SJ4887</i> (IBSC) |
