Taiwania 67(3): 326–334, **2022**
DOI: 10.6165/tai.2022.67.326

Two new species of *Pentasacme* (Apocynaceae, Asclepiadoideae) from Yunnan, China

Cheng LIU[1], Xiao-Jian HU[1], Jin-Ping ZHANG[1], Wen-Bin YU[2,3,*], Yun-Hong TAN[2,3,*]

1. *Germplasm Bank of Wild Species, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, Yunnan, China.* ***2.*** *Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences & Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla 666303, Yunnan, China.* ***3.*** *Center of Conservation Biology, Core Botanical Gardens, Chinese Academy of Sciences, Mengla 666303, Yunnan, China.* **Corresponding authors' emails: YHT: tyh@xtbg.org.cn; WBY: yuwenbin@xtbg.ac.cn.*

(Manuscript received 19 January 2022; Accepted 27 May 2022; Online published 8 June 2022)

ABSTRACT: *Pentasacme malipoense* C. Liu & Y.H. Tan and *P. tubulosum* C. Liu, X.J. Hu & Y.H. Tan are two new species from Yunnan, China, which are described and illustrated in this study. Molecular phylogenies using the nrITS, *rps16* and *trnT-F* datasets support these two new species formed a clade in the genus *Pentasacme*, then as the sister to *P. caudatum*, which is the only Chinese species hitherto included in phylogenetic studies. *Pentasacme tubulosum* can be clearly distinguished from the other five recognized species of this genus by its tubular corolla and tube much longer than lobes. *Pentasacme malipoense* is characterized by having campanulate and deeply lobed corolla, tube much shorter than lobes, corolline coronas present and inverted conical style-head, which is remarkably different from its sister species *P. tubulosum*. In addition, *P. malipoense* differs from *P. caudatum* by the reddish pedicels and calyces, oblong-lanceolate corolla lobes, staminal coronas present and inverted conical style-head, and from *P. wallichii* and *P. shanense* by its lanceolate leaf blades, reddish pedicels and calyces, both corolline coronas and staminal coronas present, purple-red anther appendages and inverted conical style-head. Furthermore, for illustrating the two species, diagnostic characters, photographs, morphological descriptions, distribution, and habitat are also provided, as well as the geographical distribution and the diagnostic key to all recognized species of *Pentasacme*.

KEY WORDS: Apocynaceae, *Pentasacme caudatum*, *P. malipoense*, *P. shanense*, *P. tubulosum*, *P. wallichii*, Yunnan, China.

INTRODUCTION

Pentasacme (the corrected spelling from '*Pentasachme*') Wall. ex Wight is an Asiatic genus of the tribe Ceropegieae (Apocynaceae-Asclepiadoideae) (Endress and Bruyns, 2000; Endress *et al.*, 2014, 2018; Meve *et al.*, 2016). It originally included two species, i.e. *P. caudatum* Wallich ex Wight and *P. wallichii* Wight. Morphologically, this genus had been placed in subtribe Leptadeniinae by Meve and Liede (2004), being characterised by a corolline corona of five lobes with denticulate or lobed apical appendages, combined with the absence of a gynostegial corona and the regular formation of a single mericarp per flower. Subsequently, Surveswaran *et al.* (2014) revealed that *Pentasacme* was poorly supported as sister to the subtribe Stapeliinae. In a recent study on the origin and early evolution of Ceropegieae by Meve *et al.* (2016), *Pentasacme* was well supported as a member of subtribe Leptadeniinae.

To date, ten names have been published under the genus *Pentasacme*, including the spelling variant '*Pentasachme*'. Of the four names (*P. brachyantha* Hand.-Mazz., *P. fasciculatum* (Buch.-Ham. ex Wight) M. R. Almeida, *P. glaucescens* Decne. and *P. stauntonii* Decne.) have been transferred to the genus *Vincetoxicum* Wolf, the name *P. esquirolii* H. Lév. has been transferred to the genus *Heterostemma* Wight & Arn., and the name *P. championii* Benth. has been subsumed under the name *P. caudatum.* Therefore, the current *Pentasacme* contains four species, i.e. *P. caudatum*, *P. pulcherrima* Grierson & D.G. Long, *P. shanense* R.W. MacGregor & W.W. Sm., and *P. wallichii*, which occur from West Himalayas to South China and Southeast Asia (Tsiang and Li, 1977; Rahman and Wilcock, 1991; Li *et al.*, 1995; Surveswaran *et al.*, 2014; Tobgay *et al.*, 2019; Li, 2020). *Pentasacme* spp. are erect or decumbent rheophytic herbs, with fascicled roots, and slender and elliptic leaves. The sessile inflorescences bear a few highly visible flowers with long and slender corolla lobes. Pollinium is erect with a small translucent beak at the apex (Surveswaran *et al.*, 2014). In China, only *P. caudatum* has been recorded in Guangdong, Guangxi, Hainan, Hunan, Jiangxi, and Yunnan Provinces (Tsiang and Li, 1977; Li *et al.*, 1995; Li, 2020).

During field investigations in south Yunnan from 2012 to 2020, we collected two unique species of *Pentasacme* characterised by lateral and subsessile cymes, glandular calyx lobes and beaked pollinia. However, they were clearly distinguished from the only Chinese species *P. caudatum* in their reddish pedicels and calyces, the shapes of corolla lobes, the cup-shaped staminal coronas and shapes of the style-head. After morphological and anatomical comparisons with the other three *Pentasacme* species, we concluded that the two species are new to science. Herein, we describe and illustrate the two new species as *Pentasacme malipoense* C. Liu & Y.H. Tan and *P. tubulosum* C. Liu, X.J. Hu & Y.H. Tan.

Table 1. Voucher and GenBank accession numbers of newly generated DNA sequences.

Taxon	Voucher specimens	location	ITS	*rps16*	*trnT-F*
Pentasacme caudatum Wall. ex Wight	*Q. Chen et al. LWX70015* (KUN)	Hainan, China	ON086999	ON098124	ON098128
Pentasacme malipoense C. Liu & Y.H. Tan	*C. Liu et al. 20CS19486* (KUN)	Yunnan, China	ON087000	ON098125	ON098129
Pentasacme tubulosum C. Liu, X.J. Hu & Y.H. Tan	*C. Liu et al. 20CS19500A* (KUN)	Yunnan, China	ON087001	ON098126	ON098130
	C. Liu et al. 20CS19500B (KUN)	Yunnan, China	ON087002	ON098127	ON098131

Table 2. GenBank accession numbers for sequence data from GenBank.

Taxon	ITS	*rps16*	*trnT-F*
Conomitra linearis Fenzl	LT595671	N/A	AJ574823/AJ574824/AJ574825
Fockea multiflora K. Schum.	FM178491	LT595596	AJ431743/AJ431744/AJ431745
Heterostemma acuminatum Decne.	N/A	LT595602	AJ574826/AJ574827
Heterostemma brownii Hayata	MG818140	N/A	N/A
Heterostemma cuspidatum Decne.	N/A	LT595603	AJ574828/AJ574829
Heterostemma dalzellii Hook. f.	N/A	HG530590	HG530571
Heterostemma herbertii Elmer	N/A	LT595604	AJ574830/AJ574831
Heterostemma peperifolium King & Gamble	N/A	EF456610	EF456110
Heterostemma sp.	MT056110	N/A	MT070831/MT077999
Heterostemma tanjorense Wight & Arn.	FJ789780	N/A	N/A
Leptadenia arborea (Forssk.) Schweinf.	AM493305	LT595619	AJ574832/AJ574833/AJ574834
Leptadenia lanceolata (Poir.) Goyder	AJ310787	HG530591	AJ410055/AJ410056/AJ410057
Leptadenia pyrotechnica Decne.	MT056111	N/A	MT070832/MT078000
	N/A	N/A	HE805513
Leptadenia reticulata (Retz.) Wight & Arn.	LT595675	HG530592	HG530572/LT595689
Neoschumannia cardinea (S.Moore) Meve	AJ310790	LT595607	AJ410049/AJ410050/AJ410051
Neoschumannia kamerunensis Schltr.	AJ310791	LT595608	AJ410052/AJ410053/AJ410054
Orbea semota (N.E. Br.) L.C. Leach	KF677404	KF677563	AJ488426/AJ488427/AJ488428
Orthanthera albida Schinz	N/A	N/A	AJ410058/AJ410059/AJ410060
Orthanthera jasminiflora Schinz	AJ310794	N/A	AJ410064/AJ410065/AJ410066
	AJ310792	N/A	N/A
	AJ310793	LT595620	AJ410061/AJ410062/AJ410063
Pentasacme caudatum Wall. ex Wight	LT595676	LT595621	LT595690/LT595702

MATERIALS AND METHODS

Voucher specimens of *Pentasacme malipoense* and *P. tubulosum* were collected from Malipo County and Mojiang County, Yunnan, respectively. Photographs and phenological information were obtained during the field expeditions. Morphological observations and trait measurements of the two new species were carried out based on living plants and pressed specimens. Pollinarium features photographed using a Keyence VHX-700F Digital Microscope (Keyence, Osaka, Japan). All morphological characters are described according to the terminology presented by Rahman and Wilcock (1991) and Li *et al.* (1995).

In this study, the nuclear ribosomal internal transcribed spacer (nrITS) and two plastid regions (*rps16* and *trnT-F*) were used for phylogenetic analyses. Four samples of *Pentasacme* were newly sampled for phylogenetic analyses, including one sample for both *P. caudatum* and *P. malipoense* and two individuals for *P. tubulosum* (Table 1). Other sequences of the tribe Ceropegieae were obtained from GenBank (Table 2) and *Fockea multiflora* K. Schum. (Tribe Fockeeae) was chosen as the outgroup. Genomic DNA of new samples was isolated using a modified CTAB method (Doyle and Doyle, 1987). Purified DNAs were fragmented to approximately 350–500 bp in size for library construction following the method of Zeng *et al.* (2018). The 150 bp pair-end reads were generated using the Illumina NovaSeq 6000 System. Cleaned raw data were *de novo* assembled for the complete chloroplast genome and nuclear ribosome DNA sequences using GetOrganelle toolkit (Jin *et al.*, 2020). The nrITS, *rps16* and *trnT-F* sequences of the four new samples were extracted from the chloroplast genome and nuclear ribosome DNA sequences, respectively. Each DNA region was aligned using MAFFT (Katoh and Standley, 2013), then the three regions were concatenated into a supermatrix.

Both Maximum Likelihood (ML) and Bayesian Inference (BI) methods were used to reconstruct phylogenies. ML analysis was conducted using RAxML (Stamatakis *et al.*, 2008), with the GTR+GAMMA+I model to search for the best-scoring ML tree and 1000 bootstrap replicates to obtain support values of branches/nodes. BI tree was reconstructed using MrBayes (Ronquist and Huelsenbeck, 2003). The supermatrix was partitioned and the best-fit DNA substitution model for the three DNA regions was identified using jModeltest

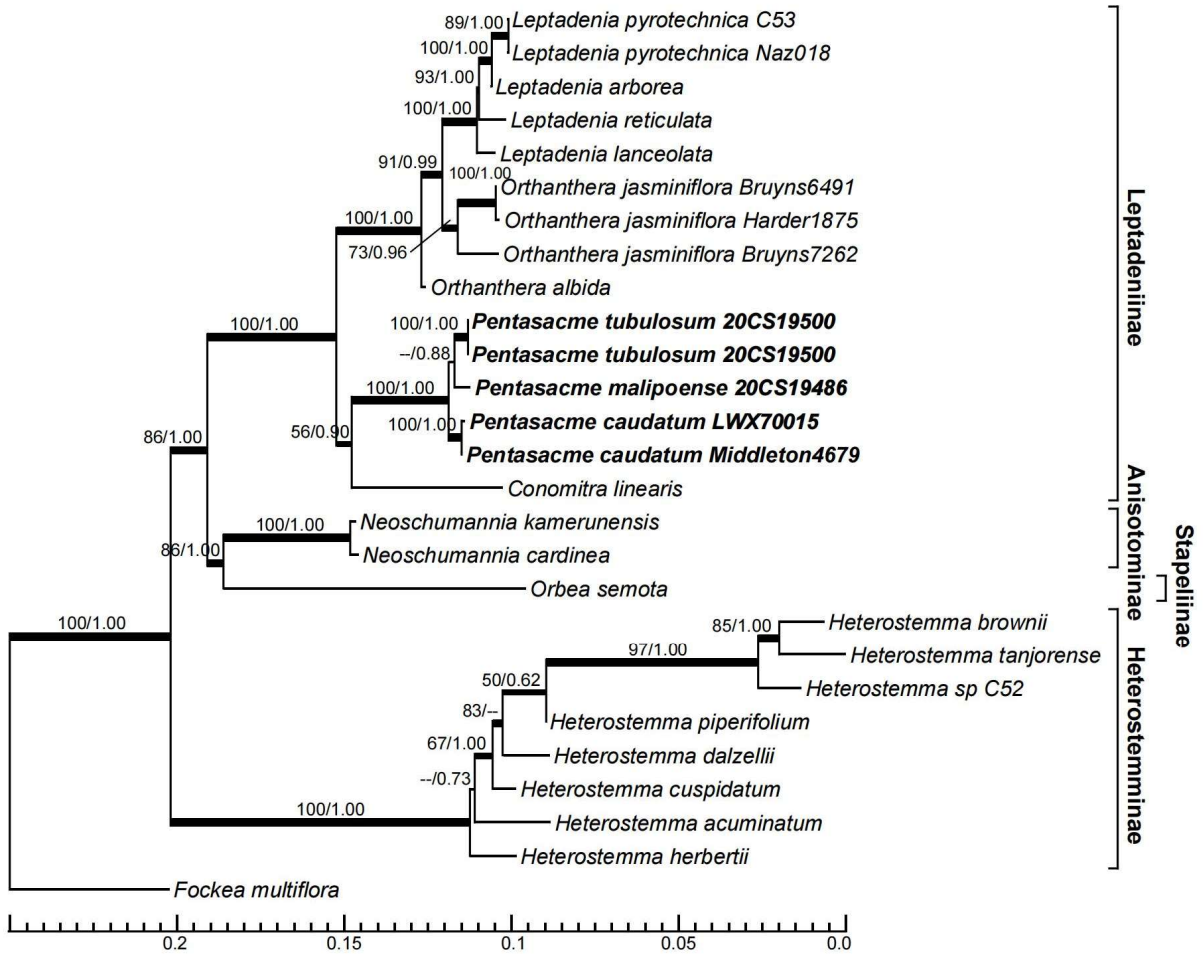

Fig. 1. Phylogeny of *Pentasacme* inferred from the combined nrITS and plastid *rps16* and *trnT-F* datasets. ML bootstrap values and BI posterior probabilities are presented above branches. The bottom scale bar represents the number of substitutions per site in the ML analysis.

(Darriba *et al.*, 2012) with the Bayesian Information Criterion (BIC). Markov Chain Monte Carlo (MCMC) analysis was performed using MrBayes for 10,000,000 generations and sampled every 1000 generations, starting with a random tree. Bootstrap support (BS) values of ≥ 70% were considered as well supported in the ML analysis and the posterior probability values (PP) ≥ 0.95 of the recovered clades were also considered as well supported in the BI analysis.

RESULTS AND DISCUSSION

Phylogenetic analyses

The nrITS matrix was 790 bp in length including 395 variable sites and 290 parsimony-informative sites; the *rps16* matrix was 930 bp in length including 116 variable sites and 48 parsimony-informative sites; and the *trnT-F* matrix was 2083 bp in length including 259 variable sites and 117 parsimony-informative sites. The best-fit BIC models of nrITS, *rps16* and *trnT-F* datasets were TrNef+G4, TPM1uf+G4 and TPM1uf+G4, respectively. The major-rule consensus ML tree with support values from both ML and BI analyses is shown in Fig. 1.

Both ML and BI analyses fully supported *Pentasacme* spp. as monophyletic (ML-BS = 100%; BI-PP = 1.00), which was the member of the subtribe Leptadeniinae with maximum support values (ML-BS = 100%; BI-PP = 1.00). Phylogenetic relationship of four subtribes was consistent with that of Meve *et al.* (2016). Within the subtribe Leptadeniinae, *Conomitra linearis* was weakly supported as the sister to the monophyletic *Pentasacme* spp. (ML-BS = 56%; BI-PP = 0.90), both of them are sister to the clade *Orthanthera* spp. + *Leptadenia* spp. Phylogenetic relationship among the three *Pentasacme* species was not fully resolved, i.e. the sister relationship between *P. malipoense* and *P. tubulosum* was weakly supported (ML-BS < 50%; BI-PP = 0.88), then they are sister to *P. caudatum*.

Of the six recognised *Pentasacme* species, *P. caudatum* was the most widely distributed from the West Himalayas to South China and Southeast Asia, *P. wallichii* and *P. pulcherrima* were found in the Himalayas

Table 3. Diagnostic character differences amongst ***Pentasacme malipoense***, ***P. tubulosum***, ***P. caudatum***, ***P. wallichii*** and ***P. shanense***.

Characters	*P. malipoense*	*P. tubulosum*	*P. caudatum*	*P. wallichii*	*P. shanense*
Leaf blades	lanceolate, 2–8 × 0.5–1.5 cm	lanceolate, 5–8 × 1–2 cm	linear-lanceolate, 6–9 × 0.8–1 cm	ovate-elliptic, 5–8 × 1.5–2.5 cm	linear, 4.5–12 × 0.3–0.8 cm
Color of pedicels and calyces	reddish	reddish	green	green	green
Corolla	campanulate, deeply lobed	tubular	campanulate, deeply lobed	campanulate, deeply lobed	campanulate, deeply lobed
Tube	ca. 1 mm, much shorter than lobes	2–3.5 cm long, much longer than lobes	less than 1 mm, much shorter than lobes	less than 1mm, much shorter than lobes	less than 1 mm, much shorter than lobes
Lobes	oblong-lanceolate, 10–15 × 3–5 mm	ovate, 5–10 × ca. 5 mm	linear-lanceolate, 6–8 × ca. 1 mm	oblong-lanceolate, 10–13 × 2–3 mm	oblong-lanceolate, 4–5 × 1.5–2 mm
Corolline coronas	reduced to five separate scales, coronal scales adnate to the corolla tube between the lobes, triangular, reddish and pubescent, margin entire	absent	reduced to five separate scales, coronal scales adnate to the corolla tube between the lobes, broadly ovate, white and glabrous, margin denticulate	reduced to five separate scales, coronal scales adnate to the corolla tube between the lobes, lanceolate, white and glabrous, margin entire	absent
Staminal coronas	cup-shaped, adnate to the base of the corolla tube, lobes triangular and split into two incurved horns	cup-shaped, adnate to the base of the corolla tube, lobes subrounded	absent	absent	cup-shaped, adnate to the base of the corolla tube, lobes rounded
Anther appendages	ovate-acuminate, purple-red	ovate-acuminate, purple-red	ovate-acuminate, purple-red	ovate-acuminate, yellow	ovate
Style-head	inverted conical	subsphaeroidal, 5-angled	conical, apex 2-cleft	conical	conical

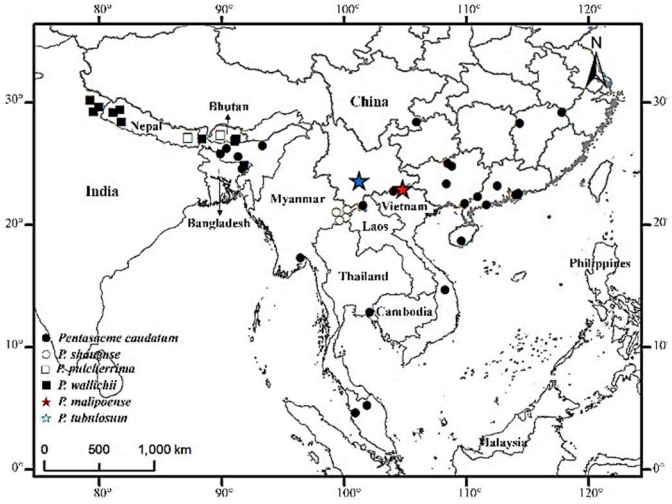

Fig. 2. Geographical distribution of the species of ***Pentasacme*** of Apocynaceae.

to Bangladesh, *P. shanense* was restricted into Myanmar, and *P. malipoense* and *P. tubulosum* were endemic to south Yunnan, China (Fig. 2). From the geographical distribution pattern, two Chinese endemic species *P. malipoense* and *P. tubulosum* tended to be independently derived from *P. caudatum* in south Yunnan, which is also supported by the phylogenetic analyses. The new findings of *P. tubulosum* and *P. malipoense* enrich the species richness of *Pentasacme* in Southwest China, thus having great significance for studying the plant diversity and conservation in this region.

Morphological comparisons

Morphological investigations revealed that the two new species belong to the genus of *Pentasacme*, characterised by their extra-axillary cymes borne on alternating sides of the axis and pollinia with small translucent beaks (Tsiang and Li, 1977; Rahman and Wilcock, 1991; Li *et al.*, 1995; Li, 2020). Both *P. malipoense* and *P. tubulosum* have lanceolate leaf blades, reddish pedicels and calyces, cup-shaped staminal coronas and purple-red anther appendages, but *P. malipoense* can be clearly distinguished from *P. tubulosum* by the campanulate and deeply lobed corolla and tube much shorter than lobes, corolline coronas present and inverted conical style-head. And both of them can also be separated from the hitherto only Chinese species *P. caudatum* by their reddish pedicels and calyces, the shapes of corolla lobes, the cup-shaped staminal coronas and shapes of the style-head (Table 3).

Additionally, *Pentasacme malipoense* is morphologically similar to *P. wallichii* (a species distributed in Bangladesh, Bhutan, India and Nepal) and *P. shanense* (a species restricted in Myanmar) in terms of the campanulate and deeply lobed corolla, tube much shorter than lobes, but it can be distinguished from *P. wallichii* and *P. shanense* by its lanceolate leaf blades, reddish pedicels and calyces, both corolline coronas and staminal coronas present, purple-red anther appendages and inverted conical style-head, geographically, there is also an obvious separation between *P. malipoense* and *P. wallichii*. Besides, *P. tubulosum* can be clearly separated from all recognized species of this genus by its tubular

corolla and tube much longer than lobes (Table 3).

Pentasacme spp. are rheophytic herbs, often inhabiting damp rock ledges in waterfalls, moist banks and stream beds. Their strongly fascicled roots make them adhere strongly to wet rocky cliffs and increase their ability to resist strong water currents; the tough and flexible stems can provide more resistance to swift-flowing streams for self-preservation and maintenance; the lanceolate, flexible and glossy willow-like leaves also may help them to adapt to the cool water, and the sessile inflorescences bearing a few showy flowers with slender petals may be attractive for pollinators.

Noteworthy, corollas of *Pentasacme* are campanulate and the length of corolla tube was shorter than that of the corolla lobes in the early recorded species (Rahman and Wilcock, 1991; Li *et al.*, 1995; Li, 2020). In this study, we found that corolla lobes joined into a long tube and the length of the tube was longer than that of free lobes in the new species *P. tubulosum*. Therefore, the generic delimitation of the taxonomic revision of *Pentasacme* needs to be updated in the future, based on comprehensive morphological and molecular evidence.

TAXONOMIC TREATMENT

Pentasacme malipoense C. Liu & Y.H. Tan, ***sp. nov.*** **Fig. 3**

***Type*:** CHINA. Yunnan Province, Malipo County, Tianbao Town, the wet cliff along the waterfall, 22°59′0″N, 104°49′34″E, 890 m a.s.l., 18 June 2020, *C. Liu, M.J. Feng, X.J. Hu, C.H. Li & B. Xiao 20CS19486* (holotype: KUN, isotypes: KUN, HITBC)

***Diagnosis*:** *Pentasacme malipoense* is morphologically similar to *P. wallichii*, but it can be distinguished from the latter by the lanceolate (vs. ovate-elliptic) leaf blades, pedicels and calyces reddish (vs. green), both corolline coronas and staminal coronas present (vs. only corolline coronas present), the coronal scales of corolline coronas triangular, reddish and pubescent (vs. lanceolate, white and glabrous), anther appendages purple-red (vs. yellow), and style-head inverted conical (vs. conical).

***Description*:** Rheophytic, perennial herb, to 40 cm tall, with fascicled roots. Stems slender and erect, glabrous, often branched at base, internodes 1–3(–7) cm long. Leaves opposite, petioles 1–2 mm, pubescent, with glands at the junction of petioles and blades; leaf blades lanceolate, 2–8 × 0.5–1.5 cm, base cuneate, apex long acuminate, margin entire and sparsely hairy, mid-rib prominent on both sides and pubescent abaxially, lateral veins 4–6 pairs, unconspicuous. Cymes subsessile, shorter than leaves, 3–6-flowered; pedicels reddish, 1–2 cm long; bracts lanceolate, 1–2 mm long, apex acute; calyx reddish and with basal glands, lobes ovate-lanceolate, 2.5–3 × 1–1.5 mm. Corolla deeply lobed, white; lobes oblong-lanceolate, 10–15 × 3–5 mm, much longer than tube. Corolline coronas reduced to five separate scales, coronal scales triangular, ca. 1 mm high and ca. 1 mm wide at base, reddish and pubescent, adnate to the corolla tube between the lobes. Staminal coronas entire, cup-shaped, fleshy, adnate to the base of the corolla tube; lobes 5, fleshy, triangular and split into two incurved horns, never exceeding the staminal column. Staminal column 1–1.5 mm long; anther appendages ovate-acuminate and purple-red, fleshy, apex membranous and inflexed on the base of style-head. Pollinia erect, ovoid, apex with a small translucent beak, attached to caudicle at middle; corpuscles oblong-lanceolate, longer than translator arms. Style-head inverted conical, membranous, 2–3 mm long, exserted above anthers. Follicle single, cylindrical-lanceolate, 5–7 cm long, ca. 3 mm in diam. Seeds oblong-spathulate, 2–3 × 1 mm, coma 1–1.2 cm.

***Phenology*:** *Pentasacme malipoense* was observed flowering from May to November and fruiting from July to the following January.

***Etymology*:** The specific epithet ‘malipoense’ is derived from the type locality, Malipo County.

***Vernacular*:** 麻栗坡石萝藦

***Distribution and habitat*:** *Pentasacme malipoense* is only found in the type locality and grows on the wet cliff along the waterfall, together with species of *Tirpitzia sinensis* (Hemsl.) Hall. (Linaceae), *Spiradiclis baishaiensis* X.X. Chen & W.L. Sha (Rubiaceae), *Begonia crystallina* Y.M. Shui et W.H. Chen (Begoniaceae), *Elatostema* spp. (Urticaceae) and some species of Poaceae, at an elevation of ca. 890 m.

***Additional specimens examined (paratypes)*:** CHINA. Yunnan Province, Malipo County, Tianbao Town, the wet slopes near the waterfall, 22°59′0″N, 104°49′34″E, 890 m a.s.l., 22 October 2020, *M.J. Feng, X.J. Hu, D.M. He & C.H. Li 20CS19486* (KUN); Ibid., 19 November 2002, *Y.M. Shui &D.G. Wang 21818* (KUN); Ibid., 13 August 2003, *Y.M. Shui et al. 32250* (IBSC, KUN, PE); Ibid., 25 May 2013, *L. Wu & X.B. Guo 3880* (BNU); Ibid., 20 October 2014, *Y.P. Chen & Y. Tong EM126* (KUN, HITBC).

***Conservation status*:** In our field investigations, *Pentasacme malipoense* is only found at the type locality with less than 100 mature individuals within an area of ca. 10,000 m^2 (100 m × 100 m). Further detailed investigation of the same habitats is also needed to give a better understanding of its natural distribution and abundance. Therefore, it is regarded at present as Data Deficient (DD) according to the IUCN Red List Categories and Criteria (IUCN, 2019).

Pentasacme tubulosum C. Liu, X.J. Hu & Y.H. Tan, ***sp. nov.*** **Fig. 4**

***Type*:** CHINA. Yunnan Province, Mojiang County, Puyehe gorge of Xinfu Town, on wet cliff along the river, 23°38′05″N, 101°15′33″E, 1370 m a.s.l., 22 June 2020, *C. Liu, M.J. Feng & X.J. Hu 20CS19500* (holotype: KUN, isotypes: KUN, HITBC)

***Diagnosis*:** *Pentasacme tubulosum* C. Liu, X.J. Hu & Y.H. Tan can be easily distinguished from all recognized

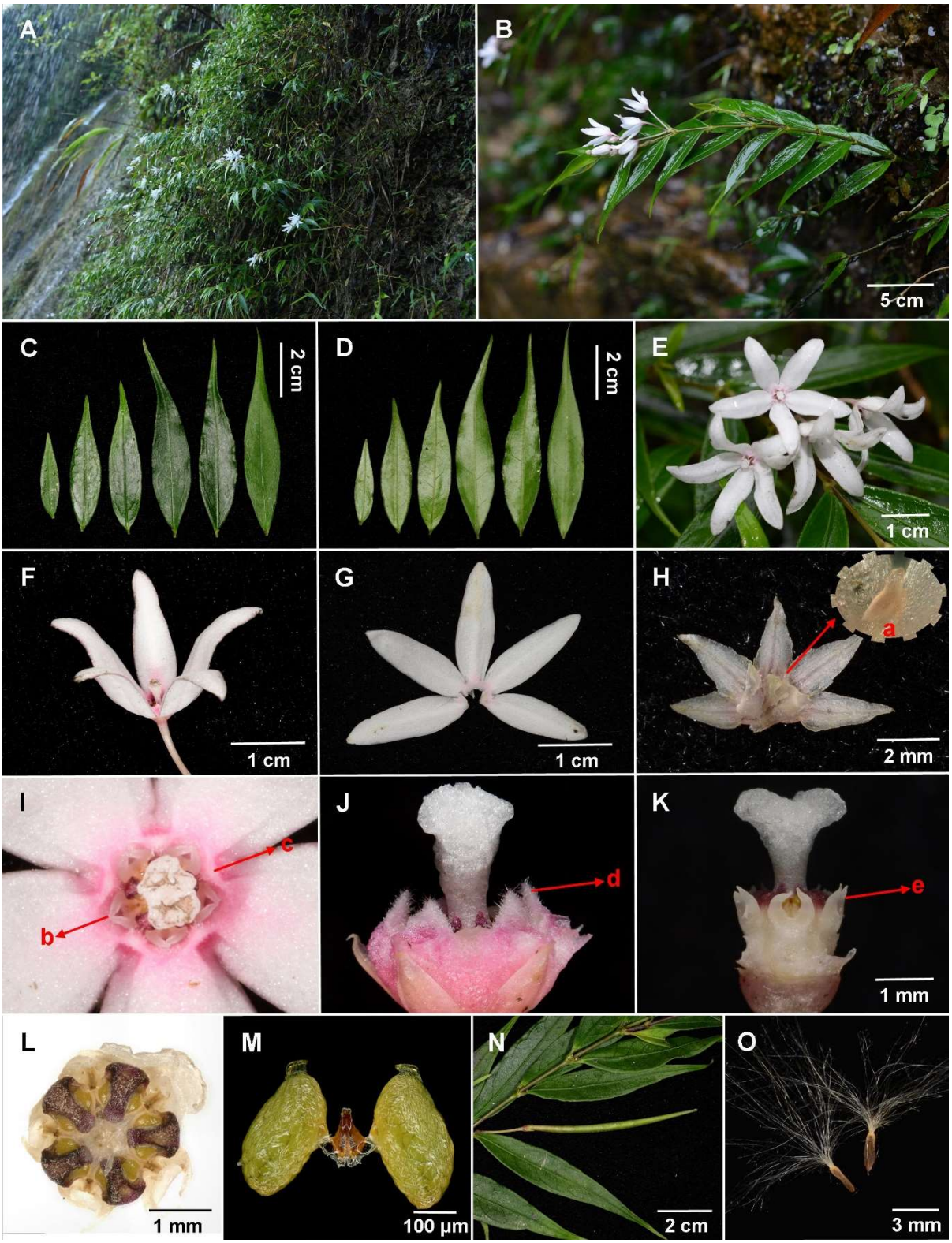

Fig. 3. Morphology of ***Pentasacme malipoense*** C. Liu & Y.H. Tan, *sp. nov*. **A:** Habitat. **B:** Habit. **C:** Adaxial leaf surface. **D:** Abaxial leaf surface. **E:** Flower, front view. **F:** Flower, lateral view. **G:** Opened corolla. **H:** Opened calyx and the basal glands (**a:** basal glands). **I:** Base of inside corolla tube, showing the position of corolline coronas and staminal coronas (**b:** staminal corona; **c:** corolline corona adnate to the corolla tube between the lobes). **J:** Lateral view of the corolline coronas adnate to the corolla tube between the lobes (**d:** corolline corona, the same as **c**). **K:** Gynostegium and staminal coronas (**e:** staminal corona, the same as **b**). **L:** Top view of the anthers. **M:** Pollinarium. **N:** Follicle. **O:** Seeds. (Photos: **A** by Lei Cai, **B–K**, **N** and **O** by C. Liu, **L** and **M** by Lian-Yi Li)

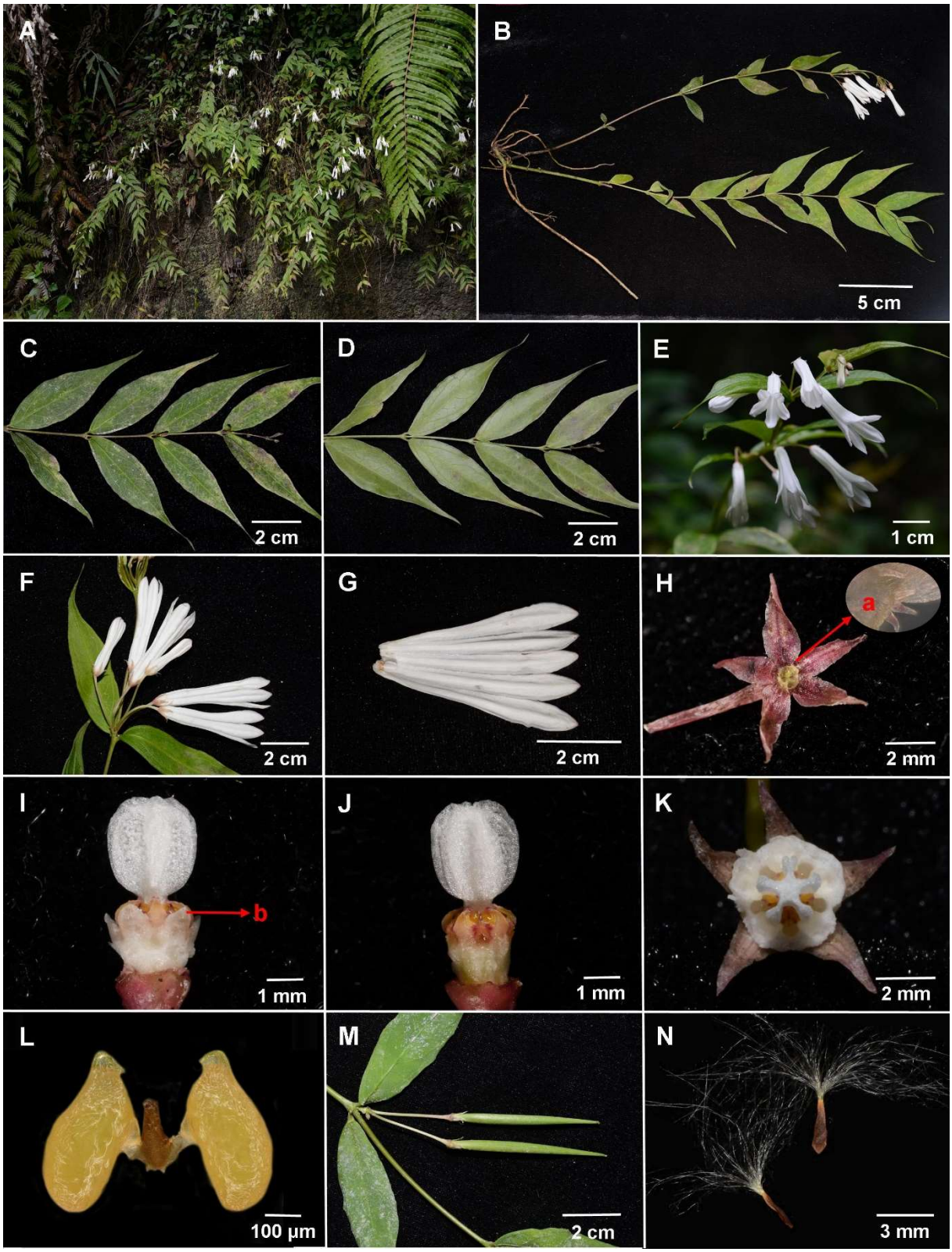

Fig. 4. Morphology of ***Pentasacme tubulosum*** C. Liu, X.J. Hu & Y.H. Tan, *sp. nov.* **A:** Habitat. **B:** Habit. **C:** Adaxial leaf surface. **D:** Abaxial leaf surface. **E:** Flower, front view. **F:** Flower, lateral view. **G:** Opened corolla. **H:** Opened calyx and the basal glands (**a:** basal glands). **I:** Gynostegium and staminal corona (**b:** staminal corona). **J:** Gynostegium without staminal coronas, and showing the lateral view of the style-head. **K:** Top view of the style-head. **L:** Pollinarium. **M:** Follicles. **N:** Seeds. (Photos: **A–K**, **M** and **N** by C. Liu, **L** by Lian-Yi Li)

species of *Pentasacme* by its tubular corolla and tube much longer than lobes.

***Description*:** Rheophytic, perennial herb, 30–80 cm tall, with strong fascicled roots. Stems slender and erect, glabrous, often branched at base, internodes 3–8 cm long, nodes pubescent. Leaves opposite, petioles 1–2 mm, pubescent, with glands at the junction of petioles and blades; leaf blades lanceolate, 5–8 × 1–2 cm, base cuneate, apex long acuminate, margin entire and sparsely hairy, mid-rib prominent on both sides and pubescent abaxially, lateral veins 4–6 pairs. Cymes subsessile, subequal or longer than leaves, 3–6-flowered; pedicels 1–2 cm long, reddish, glabrous; bracts lanceolate, 1–2 mm long, apex acute; calyx parted almost to base, reddish, with basal glands, lobes lanceolate, 3–4 × 1–1.5 mm. Corolla tubular, white; corolla lobes joined into a long tube, tube 2–3.5 cm long, ca. 5 mm in diam., much longer than free lobes; free lobes ovate, 0.5–1 × 0.5 cm. Corolline coronas absent. Staminal coronas entire, cup-shaped, fleshy, adnate to the base of the corolla tube; lobes subrounded, fleshy, never exceeding the staminal column. Staminal column ca. 1 mm long; anther appendages ovate-acuminate and purple-red, fleshy, apex membranous and inflexed on the base of style-head. Pollinia erect, ovoid, apex with a small translucent beak, attached to caudicle at middle; corpuscles oblong-lanceolate, longer than translator arms. Style-head subsphaeroidal and 5-angled, membranous, 2–2.5 mm long, like a five-pointed star from the top view, exserted above anthers. Follicle single, cylindrical-lanceolate, 5–7 cm long, ca. 3 mm in diam. Seeds oblong-spathulate, ca. 3 × 1 mm, coma 1–1.2 cm.

***Phenology*:** *Pentasacme tubulosum* was observed flowering from June to July and fruiting from July to October.

***Etymology*:** The specific epithet 'tubulosum' is derived from its tubular corolla.

***Vernacular*:** 管花石萝藦

Distribution and habitat: *Pentasacme tubulosum* grows on wet cliffs near the river in the Puyehe Gorge, together with species of *Ophiorrhiza* sp. (Rubiaceae), *Pronephrium penangianum* (Thelypteridaceae) and *Woodwardia unigemmata* (Blechnaceae), at an elevation between 1000 m and 1400 m.

Additional specimens examined (*paratypes****)*:** CHINA. Yunnan Province, Mojiang County, Puyehe Gorge of Xinfu Town, on the wet cliff along the river, 23°38′05″N, 101°15′33″E, 1370 m a.s.l., 14 October 2020, *C. Liu & L. Huang 20CS20102* (KUN); Zhenyuan County, Puyehe Gorge of Gucheng Town, 23°37′29″N, 101°14′40″E, 1150 m a.s.l., 27 July 2021, *Y.X. Gong 306* (HITBC); 23°37′1″N, 101°14′39″E, 1140 m a.s.l., 11 April 2022, *H.B. Ding & Y.X. Gong D181* (HITBC).

***Conservation status*:** So far, four small populations of *Pentasacme tubulosum* were observed from the type locality, Peyehe Gorge, and with less than 100 mature individuals in a range of ca. 200,000 m^2 (2000 × 100 m). As they are not far apart geographically, they can be considered as a single population. Further detailed investigation of the same habitats is also needed to give a better understanding of the distribution area of this species, and its abundance and threats it faces. Therefore, this is regarded at present as Data Deficient (DD) according to the IUCN Red List Categories and Criteria (IUCN, 2019).

The diagnostic key to the species of *Pentasacme*

1. Corolla tubular, tube much longer than lobes ……..... ***P. tubulosum***
- Corolla campanulate and deeply lobed, tube much shorter than lobes .. 2
2. Flowers small; corolla lobes less than 10 mm long ……..…...3
- Flowers large; corolla lobes more than 10 mm long ……..…..…4
3. Stems glabrous; leaves linear-lanceolate, pedicels of cymes 0.4–0.8 cm long; corolla lobes 6–8 mm long; corolline coronas reduced to five broadly ovate coronal scales, margin denticulate; staminal coronas absent ……..…… ***P. caudatum***
- Stems sparsely hairy at the nodes; leaves linear, pedicels of cymes 2–3 cm long; corolla lobes 4–5 mm long; corolline coronas absent; staminal coronas cup-shaped with five rounded lobes ……..... ***P. shanense***
4. Stems pubescent; corolla lobes 20–30 mm long …. ***P. pulcherrima***
- Stems glabrous; corolla lobes 10–15 mm long ……..…….. 5
5. Leaves lanceolate; pedicels and calyces reddish; coronal scales of corolline coronas triangular, reddish and pubescent; staminal coronas cup-shaped, lobes triangular and split into two incurved horns; anther appendages purple-red; style-head inverted conical ..... ***P. malipoense***
- Leaves ovate-elliptic; pedicels and calyces green; coronal scales of corolline coronas lanceolate, white and glabrous; staminal coronas absent; anther appendages yellow; style-head conical ….. ***P. wallichii***

ACKNOWLEDGMENTS

We are grateful to Mr. Bo Xiao from Malipo Forestry and Grassland Administration, Mr. De-Ming He from Wenshan Laojunshan National Nature Reserve, Mr. Rong Tian and Mr. Tian-Yang Liu from Xinfu Forestry Station of Mojiang Forestry and Grassland Administration, Mr. Chang-Hong Li, Mr. Ming-Jian Feng, Mr. Xin Li and Ms. Li Huang from Kunming Institute of Botany (KIB), Chinese Academy of Sciences for their kind help during the fieldwork; to Dr. Chun-Xia Zeng and Mr. Zhi-Rong Zhang from KIB for providing the molecular data, to Mr. Lian-Yi Li from KIB for taking morphological photographs of basal glands in the calyx and pollinarium by the Keyence VHX-700F Digital Microscope (Keyence, Osaka, Japan); to Dr. Jian-Wen Zhang from KIB for his good suggestions for the manuscript. This research was supported by grant of the Large-scale Scientific Facilities of the Chinese Academy of Sciences (2017-LSFGBOWS-02) and the National Wild Plant Germplasm Resource Center, the Shandong Provincial Agricultural Elite Varieties Project 'Research on key techniques for conservation of wild forest species in germplasm bank' (2019LZGC01801), the Project of the Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences (Y4ZK111B01) and the Biodiversity Investigation Observation and Assessment Program (2019–2023) of the Ministry of Ecology and Environment of China and the China (Yunnan) - Laos transboundary biodiversity conservation project (2021–2022).

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