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Petrocodon (Gesneriaceae) in the Limestone Karsts of Guangxi, China: Three New Species and a New Combination Based on Morphological and Molecular Evidence

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Abstract—Based on morphological and molecular data, three new species of the Old World Didymocarpoid Gesneriaceae, ***Petrocodon laxicymosus***, ***P. longgangensis***, and ***P. pseudocoriaceifolius***, are described and illustrated from Guangxi, China. The three new species are most similar to *P. coriaceifolius*, differing by their texture, size, and shape of leaves, size and pubescence of inflorescence and corolla, anther shape, and pistil length. Additionally, *Primulina guangxiensis*, one of two species included in *Primulina* before its recent recircumscription, was unexpectedly found to be nested within *Petrocodon* in our ongoing phylogenetic analyses, prompting us to make the new combination ***Petrocodon guangxiensis***. The four species of *Petrocodon* treated here are all rare, known only from a single or a few localities of limestone karsts in Guangxi.

Keywords—*Lagarosolen*, molecular taxonomy, Old World Didymocarpoid Gesneriaceae, *Primulina*, rare and endangered plants, Sino-Vietnamese limestone karst.

As traditionally defined, *Petrocodon* Hance (Gesneriaceae) is a genus of four species characterized by small, white, urceolate corollas (Hance 1883; Wang et al. 1998; Li and Wang 2004; Wei 2010; Wen et al. 2012). Recent molecular phylogenetic studies, however, show that *Petrocodon* is not monophyletic and that it is embedded within a strongly supported clade composed of the polyphyletic genus *Lagarosolen* W. T. Wang, two species of *Didymocarpus* Wall., one species of *Wentsaiboea* D. Fang & D. H. Qin, and the monotypic genera *Calcareoboea* C. Y. Wu ex H. W. Li, *Dolicholoma* D. Fang & W. T. Wang, *Paralagarosolen* Y. G. Wei, and *Tengia* Chun (Möller et al. 2011a; Wang et al. 2011; Weber et al. 2011a, 2011b). Consequently, *Petrocodon*, the oldest valid generic name with its type contained within the clade, was expanded to include all taxa of the clade (Wang et al. 2011; Weber et al. 2011a), thus echoing recent molecular-based redelimitation of genera of the Old World Didymocarpoid Gesneriaceae such as *Oreocharis* Benth. (Möller et al. 2011b; Liu et al. 2012) and *Primulina* Hance (Wang et al. 2011; Weber et al. 2011b; Xu et al. 2012b).

The redelimitation of *Petrocodon* greatly increased the extent of morphological variability in the genus. For example, the color of the corolla under the new concept can be white [*Petrocodon* s. s. and *Tengia*], white to pale-purple (*Didymocarpus*), white to purple (*Lagarosolen*), purple (*Dolicholoma* and *Wentsaiboea*), blue-purple (*Paralagarosolen*), or bright red (*Calcareoboea*), while the diversity of corolla shapes includes urceolate (*Petrocodon* s. s.), near-urceolate (*Tengia*), cylindric (*Lagarosolen*), funnel-form or salver-shaped (*Didymocarpus*), campanulate (*Wentsaiboea*), long open-tubular (*Calcareoboea*), and narrow-tubular (*Dolicholoma* and *Paralagarosolen*). The presence of these diverse corolla morphologies in the redefined *Petrocodon* suggests a high degree of evolutionary lability, presumably driven by adaptation to different pollinators (Weber et al. 2011a).

In the course of floristic surveys of limestone areas of Guangxi during the period 2006–2012, we collected three additional, previously undocumented species that are morphologically most closely allied to the species of *Petrocodon* formerly included in *Lagarosolen* (Wang et al. 1998; Wei 2010). After consulting relevant literature (Wang et al. 1998; Wei 2006, 2007, 2010; Wei et al. 2008; Xu et al. 2008, 2010; Jiang et al. 2011; Weber et al. 2011a; Wen et al. 2012) and performing molecular phylogenetic analyses, we concluded that the three new species were each assignable to the expanded concept of *Petrocodon* (Weber et al. 2011a).

Here, we describe and illustrate these three new species and make a new combination in *Petrocodon* for a fourth species, *Primulina guangxiensis* Yan Liu & W. B. Xu (Liu et al. 2011), which is nested within the expanded concept of *Petrocodon* in our phylogenetic analyses. We also present and discuss the morphological and molecular phylogenetic evidence upon which our taxonomic conclusions are based.

Materials and Methods

Materials Examined—Morphological characters of the new species were observed and measured in the field and/or from herbarium specimens. For molecular data, DNA was extracted from silica-gel dried leaves collected from the respective type localities. All voucher specimens are deposited in IBK.

Molecular Methods—DNA sequences of nuclear internal transcribed spacers (ITS) and chloroplast *trnL-F* intron-spacer region (*trnL-F*) were collected, as these two regions were employed to recircumscribe *Petrocodon* (Weber et al. 2011a) and have been used routinely in recent taxonomic and phylogenetic analyses of Old World Gesneriaceae (e.g. Li and Wang 2007; Möller et al. 2011a, 2011b; Wang et al. 2011; Weber et al. 2011a, 2011b; Xu et al. 2012a, 2012b, 2013; Chung et al. 2013). Protocols for DNA extraction, PCR amplification, and sequencing were adopted from Xu et al. (2012a).

To determine the phylogenetic affinities of the three new species and *Primulina guangxiensis*, a DNA sequence matrix was assembled following the sampling schemes of Xu et al. (2012a) for *Primulina* and Weber et al. (2011a) for *Petrocodon*. The species *Petrocodon jasminiflorus* (D. Fang & W. T. Wang) A. Weber & Mich. Möller and *P. fangianus* (Y. G. Wei) Yin Z. Wang, although included in the study of Weber et al. (2011a), were not sampled here because sequences were not available in GenBank. *Briggsia longipes* (Hemsl. ex Oliv.) Craib, *Briggsiopsis delavayi* (Franch.) K. Y. Pan, *Hemiboea ovalifolia* (W. T. Wang) A. Weber & Mich. Möller, *Hemiboea purpureotincta* (W. T. Wang) A. Weber & Mich. Möller, *Loxostigma griffithii* (Wight) C. B. Clarke, *Lysionotus pauciflorus* Maxim., and *Petrocosmea kerrii* Craib were chosen as outgroup based on the results of Möller et al. (2011a). The final matrix contained 41 ingroup taxa (*Petrocodon* and *Primulina*) and an outgroup composed of representatives from seven lineages. Appendix 1 lists all taxa sampled and corresponding GenBank DNA sequence accession numbers.

DNA sequences were aligned using the program MUSCLE implemented in the software MEGA5 (Tamura et al. 2011) with minor manual adjustments. The aligned matrix (TreeBASE study number TB2:S14036) was analyzed using maximum parsimony (MP) and maximum likelihood (ML) optimality criteria. Maximum parsimony analyses including all alignment positions were performed in MEGA5 using close-neighbor-interchange (CNI) and 200 random addition replicates. Clade support was estimated with 1,000 bootstrap replicates employing tree-bisection-reconnection (TBR). For ML analysis, the matrix was partitioned (ITS vs. *trnL-F*). Ten independent ML analyses were conducted using RAxML (Stamatakis et al. 2008) via RAxML BlackBox (http://phylobench.vital-it.ch/raxml-bb/), with the gamma model of rate heterogeneity and the proportion of invariable sites for each of the two data partitions estimated by the program.

Results

***Morphological Affinities*—**The three new species are morphologically most similar to *Petrocodon coriaceifolius* (Y. G. Wei) Y. G. Wei & Mich. Möller, differing by the texture, size, and shape of the leaves, the structure of the inflorescence, the size of the corolla, the density of the pubescence on the corolla, the shape of the anthers, and the length of the pistil (Table 1).

***Molecular Data*—**The DNA matrix includes 1,460 aligned positions (ITS: 730 bp; *trnL-F*: 730 bp), of which 527 (ITS: 407 bp; *trnL-F*: 120 bp) are variable and 300 (ITS: 257 bp; *trnL-F*: 43 bp) are parsimony informative. The best ML tree (log likelihood score = −9,167.793716) of the ten runs of RAxML analyses is depicted in Fig. 1A and is also deposited as a tree file attached to the aligned data matrix in TreeBASE. Maximum parsimony analyses resulted in 14 equally most parsimonious trees of 1,337 steps (CI = 0.59, RI = 0.69, RCI = 0.41). The 50% majority rule consensus cladogram was largely compatible with the best ML tree (Fig. 1A).

All three new species display substantial divergences from their respective sister species, as indicated by their relatively long terminal branches (Fig. 1A), thus supporting their individual recognition as distinct species. In both ML and MP analyses (Fig. 1A), the three new species and *Primulina guangxiensis* are placed in *Petrocodon* with strong support (LB = 96; PB = 82). With the exclusion of *Pri. guangxiensis*, *Primulina* is monophyletic, forming the sister group to *Petrocodon* with strong support (LB = 100; PB = 99). Within *Primulina*, phylogenetic relationships are highly congruent with previous analyses (Xu et al. 2012a). Within *Petrocodon*, the three new species and *Pri. guangxiensis* are placed in a strongly supported but internally poorly resolved clade (Fig. 1A; LB = 98; PB = 94) that also includes *P. hancei* (Hemsl.) A. Weber & Mich. Möller, *P. hechiensis* (Y. G. Wei, Yan Liu & F. Wen) Y. G. Wei & Mich. Möller, *P. coccineus* (C. Y. Wu ex H. W. Li) Yin Z. Wang, *P. ferrugineus* Y. G. Wei, *P. coriaceifolius*, *P. scopulorum* (Chun) Yin Z. Wang, *P. dealbatus* Hance, and *Lagarosolen ainsliifolius* W. H. Chen & Y. M. Shui, nom. nud., which was described and illustrated in Shui and Chen (2006) and Wei (2010) but not validly published. These same taxa minus *Pri. guangxiensis* and the three new species were similarly grouped in a strongly supported clade with low internal resolution in the analysis of Weber et al. (2011a). Interestingly, although the three new species are morphologically most similar to *P. coriaceifolius*, none of them appears to be its sister taxon (Fig. 1A).

Discussion

Based on the results of their phylogenetic study, Weber et al. (2011a) hypothesized that the current species diversity of *Petrocodon* evolved during three episodes of species radiation. Our results suggest that the four newly added species originated during the second episode (Fig. 1A). The addition of these four species to the phylogeny of *Petrocodon* does not substantially alter the basic structure recovered by Weber et al. (2011a).

The discovery of three morphologically (Table 1) and molecularly (Fig. 1A) distinct species of *Petrocodon*, plus the transfer of *Primulina guangxiensis* to *Petrocodon*, increases to 23 the number of species included in *Petrocodon*. Given the diversity of floral morphologies that exist within the genus (Fig. 1B), as well as its moderate number of species, *Petrocodon* is a promising model for investigating trends in floral evolution that may be important in other Old World Didymocarpoid Gesneriaceae. Although phylogenetic sampling is incomplete, our results suggest that salver-shaped to cylindric corollas (i.e. species formerly included in *Lagarosolen*) may be ancestral in the genus (Fig. 1A–B; Weber et al. 2011a), with more specialized corolla shapes, such as urceolate, long-salver-shaped, and open-tubular, probably having evolved later (Fig. 1B; Weber et al. 2011a). Additional field observations are needed to determine the extent to which evolutionary transformations in corolla morphology are correlated with pollinator shifts and to test competing hypothesis about how such shifts may have affected speciation.

Taxonomic Treatment

1. Petrocodon guangxiensis (Yan Liu & W. B. Xu) W. B. Xu & K. F. Chung, comb. nov. *Primulina guangxiensis* Yan Liu & W. B. Xu in Liu et al. Nordic J. Bot. 29: 682. 2012

Table 1. Morphological comparisons of *Petrocodon coriaceifolius*, *P. laxicymosus*, *P. longgangensis*, and *P. pseudocoriaeifolius*.

Characters	*P. coriaceifolius*	*P. laxicymosus*	*P. longgangensis*	*P. pseudocoriaeifolius*
Leaf texture	Coriaceous	Coriaceous	Chartaceous	Coriaceous
Leaf blade shape	Ovate-elliptic to ovate-oblong	Elliptic	Ovate or broadly ovate to elliptic	Oblong
Leaf blade size	2.5–8 × 1.7–4.5 cm	2–5 × 1.5–2.3 cm	7–15 × 4–8.5 cm	10–18 × 4–6 cm
Leaf apex	Obtuse to rounded	Acute to obtuse	Obtuse or acute	Acute to obtuse
Leaf margin	Entire	Repand to entire	Serrate	Serrate
Leaf base	Shallowly cordate	Cuneate	Cuneate, round to shallowly cordate	Cuneate
Cymes	1–3-branched	1- or 2-branched	1–3-branched	2- or 3-branched
Number of flowers	7–14	1–5	10–15	10–25
Corolla length	18–30 mm	20–30 mm	10–12 mm	20–25 mm
Corolla surface	Pubescent	Glabrous to sparsely pubescent	Brown hispidulous	Purple pubescent
Anthers	Reniform	Reniform	Reniform	Elliptic
Pistil length	ca. 16 mm	16–20 mm	5–8.5 mm	13–19 mm

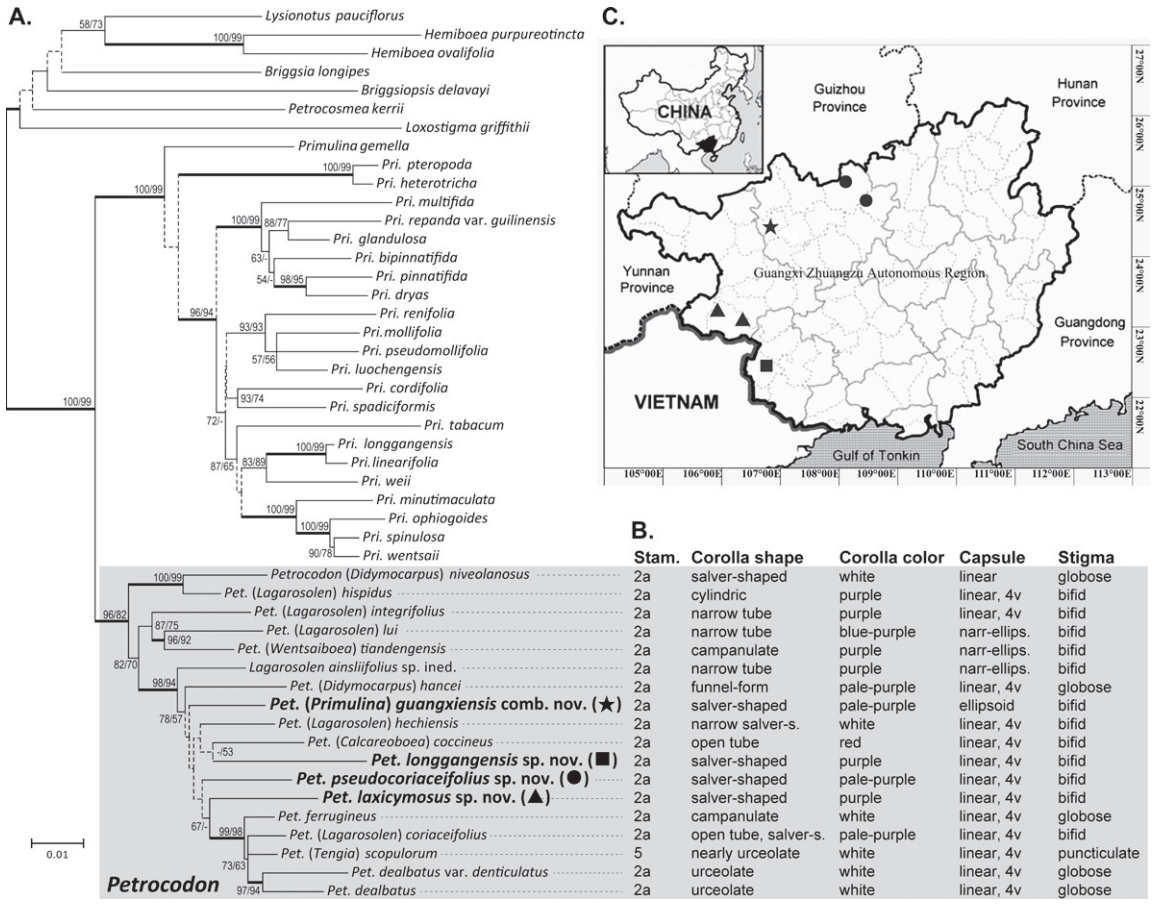

FIG. 1. A. The best-scoring ML tree from one of the ten analyses of ITS and *trnL-F* sequence data. Phylogenetic placements of *Petrocodon laxicymosus*, *P. longgangensis*, *P. pseudocoriaceifolius*, and *Primulina guangxiensis* are highlighted. Bootstrap values (LB/PB) greater than 50% are shown. Thick lines denote a strongly supported clade with LB and/or PB greater than 95%. Dashed lines indicate clades collapsed in the majority rule consensus tree of MP analyses. B. Character states of *Petrocodon* clade modified from Fig. 1 of Weber et al. (2011a). Stam.: number of fertile stamens (a, anterior pair); 4v, dehiscing into 4 valves. C. Geographic distributions of *P. laxicymosus* (triangle), *P. longgangensis* (square), *P. pseudocoriaceifolius* (circle), and *P. guangxiensis* (star).

("2011").—TYPE: CHINA. Guangxi: Fengshan County, Paoli Town, on moist limestone rock face in a karst cave, 17 Apr 2009 (fl), *Wei-Bin Xu and Yan Liu 09352* (holotype: IBK!; isotype: PE!).

2. Petrocodon laxicymosus W. B. Xu & Yan Liu, sp. nov.—TYPE: CHINA. Guangxi: Jingxi County, Ande Town, growing in evergreen broad-leaved forest on slopes of limestone hills, alt. 1,100 m, 16 Aug 2009 (fl), *Wen-Bin Xu et al. 09993* (holotype: IBK).

Herbs, perennial. Rhizome subterete, 2–9 cm × 2.5–4 mm. Leaves 5–15, basal; petiole 1.5–4.5 cm, terete, canaliculated adaxially, puberulous; leaf blade coriaceous, elliptic, 2–5 × 1.5–2.3 cm, the apex acute to obtuse, the margin repand to entire, sometimes serrate, the base cuneate, slightly oblique, with appressed pubescence on both sides; lateral veins 3–5 on each side of central vein, depressed adaxially, prominent abaxially. Cymes 3–5, axillary, 1- or 2-branched, 1–5-flowered; peduncle 5–14 cm × 1–2 mm, sparsely puberulous; bracts 2, opposite, linear-lanceolate, 6–8 × 1–1.5 mm, the margin entire, the apex acute, pubescent abaxially; bracteoles 2, opposite, linear, puberulous abaxially. Pedicel 5–10 mm long, puberulous. Calyx 5-lobed nearly to base, the lobes narrowly lanceolate to linear, 3–5 × 0.5 mm, the margin entire, puberulous externally, glabrous internally. Corolla purple, salver-shaped, 20–30 mm long, glabrous to sparsely pubescent externally, glabrous internally; tube slender, 12–20 mm long, 4–6 mm in diam. at mouth, ca. 3 mm in diam. at base; limb distinctly 2-lipped, the upper lip ca. 4 mm long, 2-lobed to near base, the lobes broadly ovate, ca. 4 × 4 mm, the lower lip ca. 8–10 mm long, 3-lobed to near the middle, the lobes broadly ovate, ca. 4 × 6 mm. Stamens 2, adnate to ca. 1.2 cm above corolla tube base; filaments erect, 6–8 mm long, linear, puberulent; anthers reniform, ca. 3 mm long, dorsifixed, the thecae confluent at apex. Staminodes 3, glabrous, adnate to ca. 7–9 mm above corolla tube base, the lateral ones ca. 2.5 mm long, the middle one 1 mm long. Disc orbicular, ca. 0.5 mm high, the margin repand. Pistil 16–20 mm long, ovary 8–10 × ca. 1.5 mm, puberulent; style 8–10 mm long, puberulent; stigmas 2, broadly ovate, ca. 1 mm, equilateral. Capsule linear, 2–4 cm × ca. 2 mm, 4-valved. Figures 2A–B, 3.

Paratypes—CHINA. Guangxi: Jingxi County, Ande Town, alt. 1,100 m, 29 May 2009, *Wei-Bin Xu et al. 09662* (IBK); same locality, 16 Aug 2009, *Wei-Bin Xu et al. 09988* (IBK); same locality, 23 Mar 2012, *Yu-Song Huang et al. Y1059* (IBK); same locality, 15 Apr 2012, *Yu-Song Huang Y1230* (IBK). Jingxi County, Wuping Town, alt. 600 m, 16 Aug 2008, *Wei-Bin Xu 08187* (IBK); the same locality, 7 Jul 2009, *Wei-Bin Xu & Bo Pan 09689* (IBK).

Phenology—The species is flowering from July to August and fruiting August to October.

FIG. 2. Photographs of the new species. A, B. *Petrocodon laxicymosus*. C, D. *Petrocodon longgangensis*. E, F. *Petrocodon pseudocoriaceifolius*.

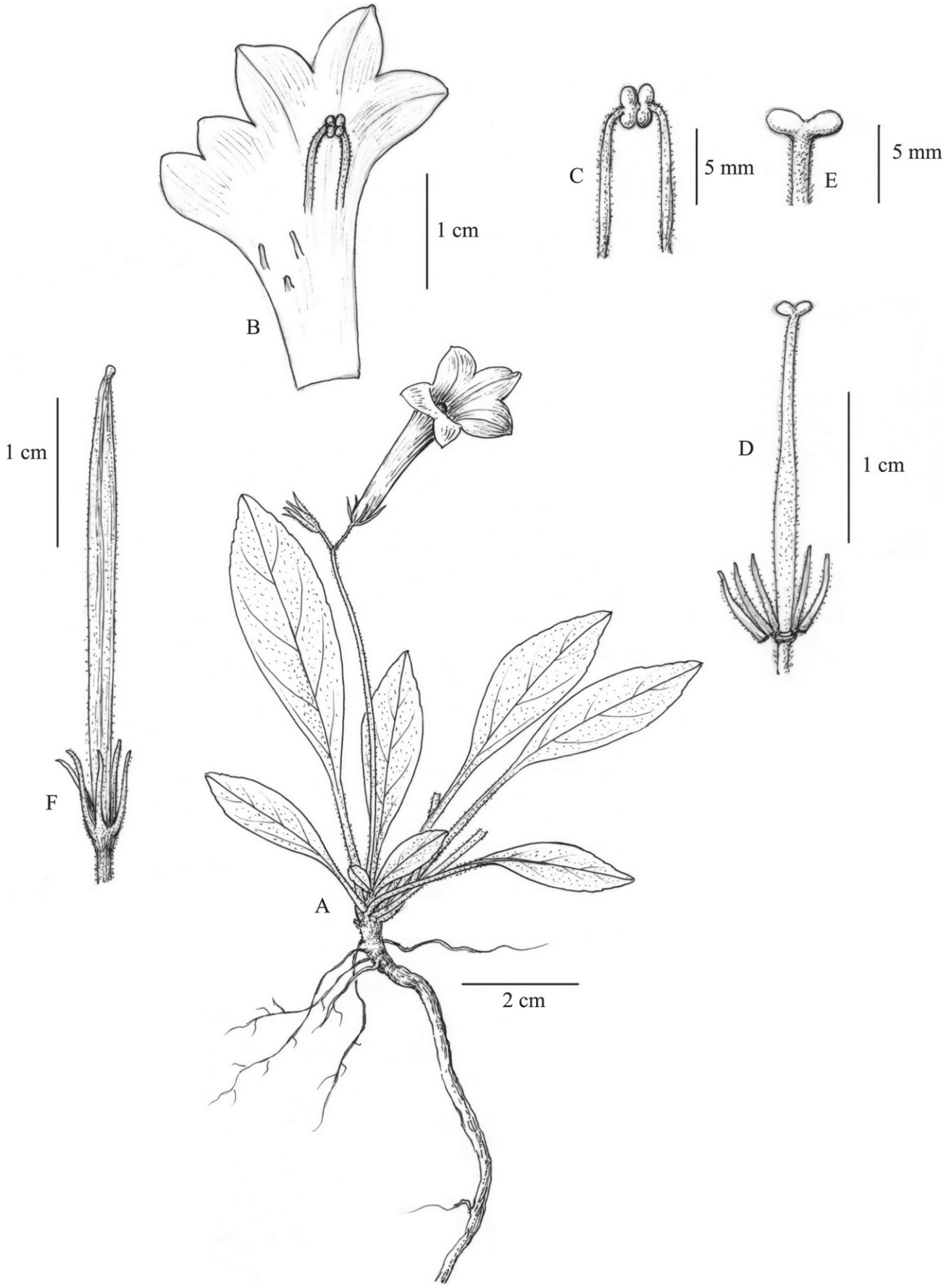

Fig. 3. *Petrocodon laxicymosus* W. B. Xu & Yan Liu (Drawn by W.-H. Lin based on holotype). A. Habit. B. Corolla opened, showing stamens and staminodes. C. Stamens. D. Calyx and pistil. E. Stigma. F. Capsule.

Etymology—The specific epithet refers to the sparse arrangement of the cymes.

Distribution and Ecology—*Petrocodon laxicymosus* is known only from the type locality in Jingxi County, Guangxi (Fig. 1C), with fewer than 250 mature individuals. It grows in evergreen broad-leaved forest on slopes of limestone hills, at 600–1,100 m elevation.

Notes—*Petrocodon laxicymosus* is similar to *P. coriaceifolius* but differs in the shape (elliptic vs. ovate-elliptic to ovate-oblong) and size (2–5 × 1.5–2.3 cm vs. 2.5–8.5 × 1.7–4.5 cm) of the leaf blade, the shape of the leaf apex (acute to obtuse vs. obtuse to rounded) and base (cuneate vs. shallowly cordate), the form of the leaf margin (repand to entire or occasionally serrate vs. always entire), the branching of the cymes (1 or 2-branched vs. 1–3-branched), and the number of flowers per cyme (1–5 vs. 7–14).

3. *Petrocodon longgangensis* W. H. Wu & W. B. Xu, sp. nov.—TYPE: CHINA. Guangxi: Longzhou County, Nonggang National Nature Reserve, growing in evergreen broad-leaved forest on slopes of limestone hills, alt. 400 m, 27 Oct 2010 (fl), *Wang-Hui Wu W0285* (holotype: IBK; isotypes: PE, IBK).

Herbs, perennial. Rhizome subterete, 1.5–3.5 cm × 4–8 mm. Leaves 5–16, basal; petiole 2.5–5 cm, terete, canaliculated adaxially, brown hispid; leaf blade chartaceous, ovate or broadly ovate to elliptic, 7–15 × 4–8.5 cm, the apex obtuse or acute, the margin serrate, the base cuneate, round to shallowly cordate, slightly oblique, appressed hirtellous on both sides; lateral veins 5–8 on each side of central vein, depressed adaxially, prominent abaxially. Cymes 2–5, axillary, 1–3-branched, 10–15-flowered; peduncle 5–10.5 cm × ca. 2.5 mm, brown hispid; bracts 2, opposite, linear-lanceolate, 6–9 × 1.5 mm, margin entire, apex acuminate, brown hispidulous; bracteoles 2, opposite, linear, 3–6 mm long. Pedicel ca. 3.5 mm, brown hispidulous. Calyx 5-lobed nearly to the base, the lobes narrowly lanceolate to linear, ca. 2 × 0.5 mm, the margin entire, brown hispidulous externally, sparsely puberulent internally. Corolla purple, salver-shaped, 10–12 mm long, brown hispidulous externally, sparsely puberulent internally; tube slender, 8–9 mm long, ca. 3.5 mm in diam. at mouth, ca. 2.5 mm in diam. at base; limb distinctly 2-lipped, the upper lip ca. 2.5 mm long, 2-lobed to near base, the lobes ovate, ca. 2 × 1.5 mm; the lower lip ca. 4 mm long, 3-lobed to above the middle, the lobes ovate, ca. 3 × 2 mm. Stamens 2, adnate to ca. 4 mm above corolla tube base; filaments erect, ca. 5 mm long, linear, puberulent; anthers reniform, black, ca. 1 mm long, dorsifixed, thecae confluent at apex. Staminodes 3, glabrous, the apex capitate, adnate to ca. 3.5 mm above corolla tube base, the lateral ones ca. 1.5 mm, the middle one 1.4 mm. Disc semiorbicular, ca. 1 mm high, the margin repand. Pistil 5–8.5 mm long, ovary 3–5.5 mm long, ca. 1 mm in diam., puberulent; style 2–3 mm long, puberulent; stigmas 2, broadly ovate, ca. 0.4 mm, bifid. Capsule linear, 3–4.5 cm long, ca. 1 mm in diam., 4-valved. Figures 2C–D, 4.

Phenology—The species is flowering from October to November and fruiting November to December.

Etymology—The specific epithet refers to the vernacular pronunciation (Longgang) of the type locality, Nonggang National Natural Reserve.

Distribution and Ecology—*Petrocodon longgangensis* is currently known only from one population with less than 250 mature individuals in Nonggang National Nature Reserve (Fig. 1C). It grows in evergreen broad-leaved forest on slopes of limestone hills, at 300–400 m elevation.

Notes—*Petrocodon longgangensis* is similar to *P. laxicymosus* but differs in the texture (chartaceous vs. coriaceous), the shape (ovate or broadly ovate to elliptic vs. elliptic) and the size (7–15 × 4–8.5 cm vs. 2–5 × 1.5–2.3 cm) of the leaf blade, the shape of leaf apex (obtuse or acute vs. acute to obtuse) and base (cuneate, round to shallowly cordate vs. cuneate), and the form of margin (serrate vs. repand to entire or sometimes serrate), the branching of the cymes (1–3-branched and 10–15-flowered vs. 1- or 2-branched and 1–5-flowered), the size (10–12 mm vs. 2–3 cm long) and the pubescence (brown hispidulous vs. glabrous to sparsely pubescent externally) of corolla, and the length of pistil (5–8.5 vs. 16–20 mm).

4. Petrocodon pseudocoriaceifolius Yan Liu & W. B. Xu, sp. nov.—TYPE**:** CHINA. Guangxi: Luocheng County, Huaiqun Town, growing in evergreen broad-leaved forest on slopes of limestone hills, alt. 320 m, 19 Apr 2009 (fl), *Wei-Bin Xu & Yan Liu 09412* (holotype: IBK; isotypes: PE, IBK).

Herbs, perennial. Rhizome subterete, 1–8 cm × 4–12 mm across. Leaves 6–12, basal; petiole 2–4 cm long, terete, canaliculated adaxially, purple puberulent; leaf blade coriaceous, oblong, 10–18 × 4–6 cm, the apex acute to obtuse, the margin serrate, the base cuneate, slightly oblique, with appressed purple pubescence on both sides; lateral veins 5–8 on each side of central vein, depressed adaxially and prominent abaxially. Cymes 2–4, axillary, 2- or 3-branched, 10–25-flowered; peduncle 5–14 cm long, ca. 3 mm across, with appressed purple pubescence; bracts 2, opposite, linear-lanceolate, 10–17 × 1.5–3 mm, margin entire, apex acute, purple pubescent externally; bracteoles 2, opposite, linear, 7–10 × 1–1.5 mm, purple pubescent externally. Pedicel 4–8 mm long, purple pubescent. Calyx 5-lobed nearly to base, the lobes narrowly lanceolate to linear, 2.5–4 × 0.5 mm, margin entire, purple pubescent externally, glabrous internally. Corolla pale purple, salver-shaped, 20–25 mm long, purple pubescent externally, sparsely puberulent internally; tube slender, 12–16 mm long, 4–4.5 mm in diam. at mouth, ca. 3 mm in diam. at base; limb distinctly 2-lipped, upper lip ca. 3 mm long, 2-lobed to near base, the lobes ovate, ca. 3 × 3 mm; lower lip ca. 8–10 mm long, 3-lobed to above middle, the lobes ovate, ca. 3 mm × 3 mm. Stamens 2, adnate to 8–9 mm above corolla tube base; filaments erect, 5–7 mm long, linear, purple puberulent; anthers elliptic, ca. 1.5 mm long, dorsifixed, thecae confluent at apex. Staminodes 3, glabrous, the apex capitate, adnate to ca. 5–7 mm above corolla tube base, lateral ones ca. 1.5 mm long, middle one 0.5 mm long. Disc orbicular, ca. 1.2 mm high, the margin repand. Pistil 13–19 mm long, ovary 6–8 mm long, ca. 1.2 mm across, purple puberulent; style 6–10 mm long, purple puberulent; stigmas 2, broadly ovate, ca. 0.5 mm, equilateral. Capsule not seen. Figures 2E–F, 5.

Paratypes—CHINA. Guangxi: Luocheng County, Huaiqun Town, alt. 320 m, 5 May 2006, *Wei-Bin Xu & Yan Liu 06046* (IBK). Huanjiang County, Mulun National Nature Reserve, alt. 575 m, 29 Apr 2011, *Yu-Song Huang et al. Y0119* (IBK); the same locality, 2 May 2011, *Yu-Song Huang et al. Y0201* (IBK); the same locality, 12 May 2011, *Wei-Bin Xu 11152* (IBK).

Phenology—The species is flowering from April to May.

Etymology—The specific epithet refers to its resemblance to *P. coriaceifolius*.

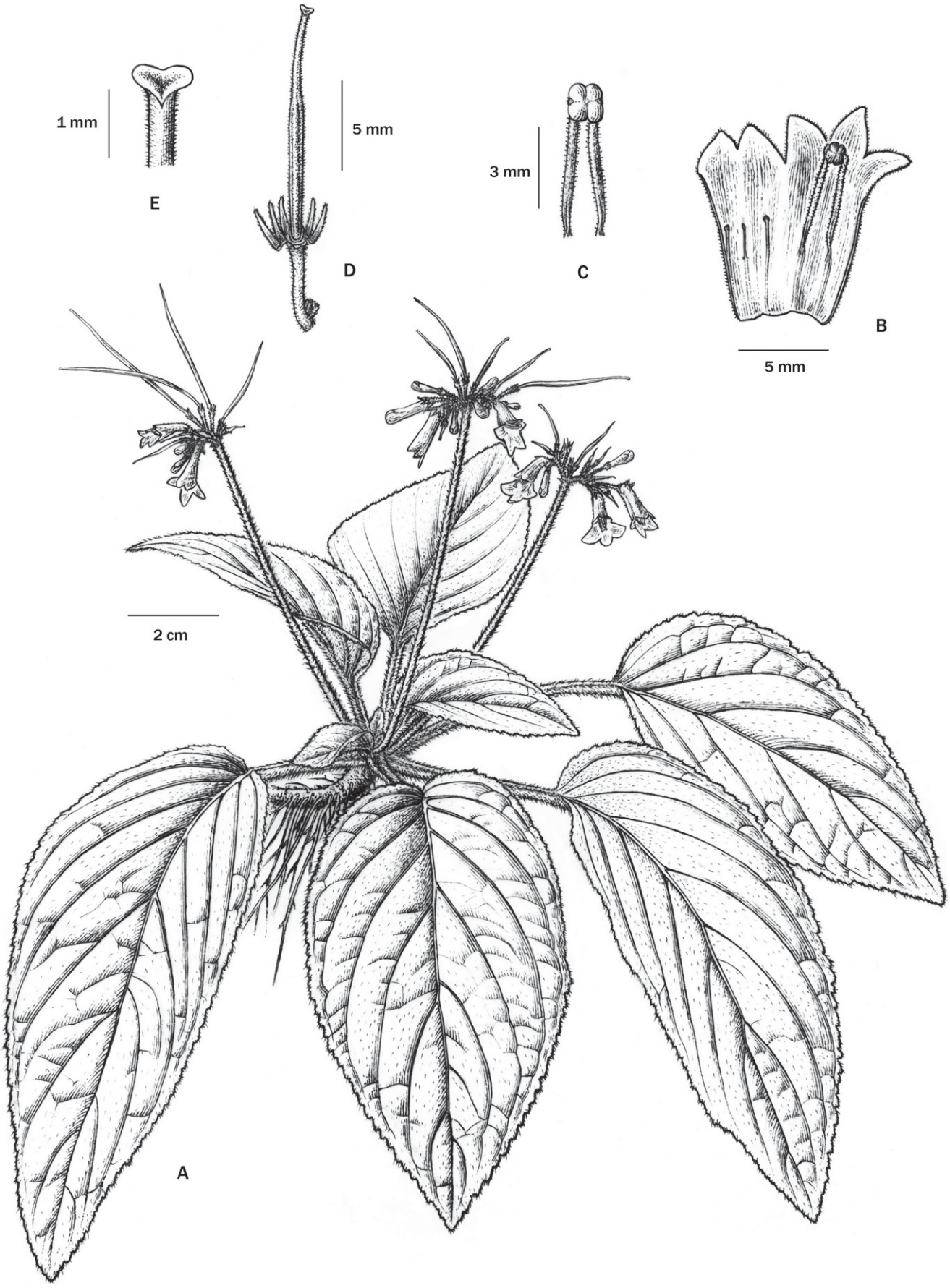

Fig. 4. *Petrocodon longgangensis* W. H. Wu & W. B. Xu (Drawn by Y.-X. Zhu based on holotype). A. Habit. B. Corolla opened, showing stamens and staminodes. C. Stamens. D. Calyx and pistil. E. Stigma.

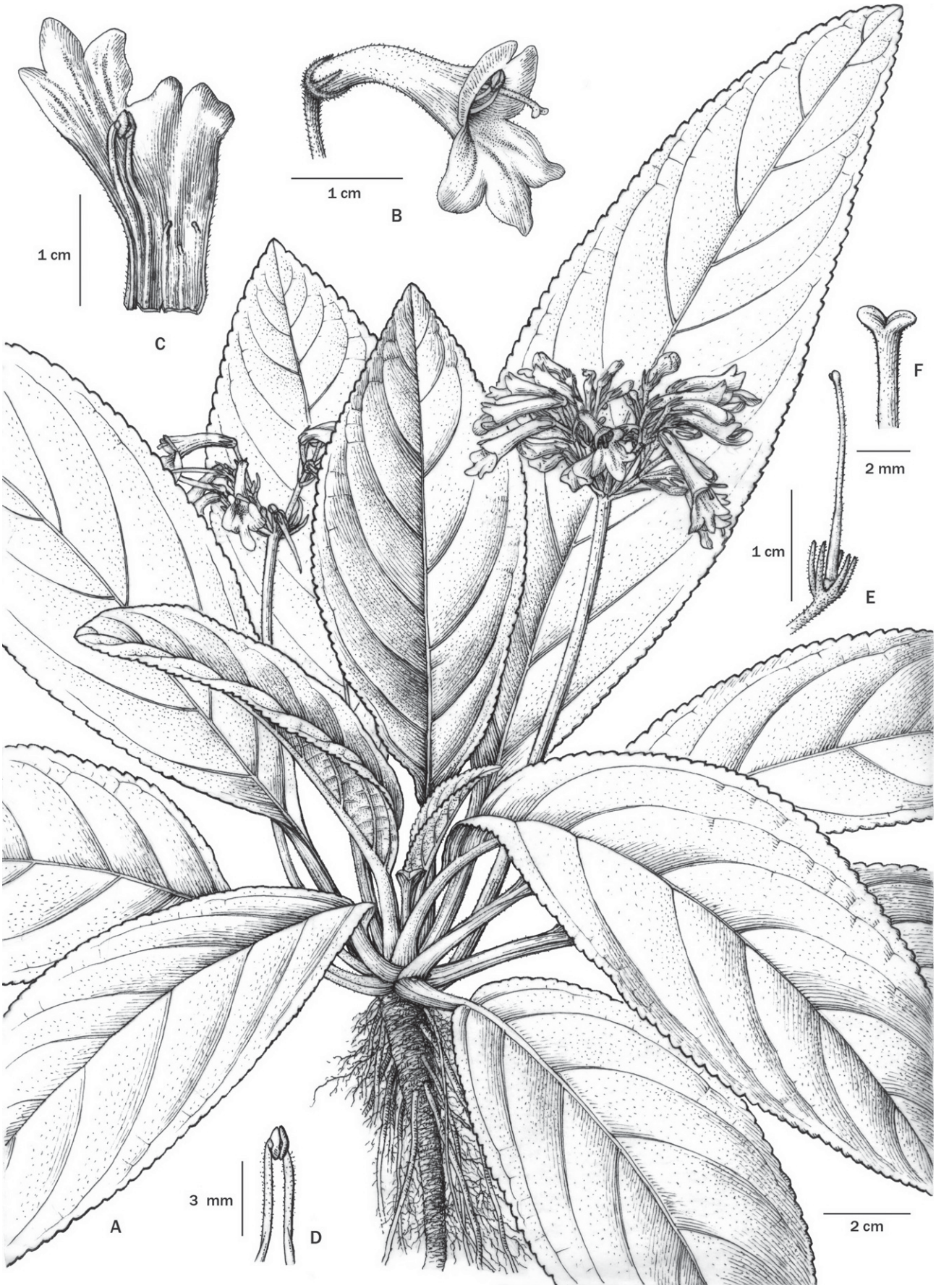

FIG. 5. *Petrocodon pseudocoriaceifolius* Yan Liu & W. B. Xu (Drawn by S.-Q. He based on holotype). A. Habit. B. Flower. C. Corolla opened, showing stamens and staminodes. D. Stamens. E. Calyx and pistil. F. Stigma.

Distribution and Ecology—*Petrocodon pseudocoriaceifolius* is known from the type locality in Luocheng County and Mulun National Nature Reserve in Huanjiang County, Guangxi (Fig. 1C). It grows in evergreen broad-leaved forests on slopes of limestone hills, at 300–600 m elevation.

Notes—*Petrocodon pseudocoriaceifolius* is similar to *P. coriaceifolius* but differs in the shape (oblong vs. ovate-elliptic to ovate-oblong) and size (10–18 × 4–6 cm vs. 2.5–8.5 × 1.7–4.5 cm) of the leaf blade, the shape of the leaf apex (acute to obtuse vs. obtuse to rounded), margin (serrate vs. entire), and base (cuneate vs. shallowly cordate), and the shape of anthers (elliptic vs. reniform).

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Appendix 1. Taxon and GenBank accession numbers. Species: (ITS/*trnL-F*). All newly acquired sequences were derived from type collection.

Briggsia longipes (Hemsl. ex Oliv.) Craib: GU350653/FJ501545; ***Briggsiopsis delavayi*** (Franch.) K. Y. Pan: GU350647/HQ632879; ***Hemiboea ovalifolia*** (W. T. Wang) A. Weber & Mich. Möller: HQ632980/HQ632883; ***Hemiboea purpureotincta*** (W. T. Wang) A. Weber & Mich. Möller: HQ632981/HQ632884; ***Lagarosolen ainsliifolius*** W. H. Chen & Y. M. Shui, nom. nud.: HQ633038/HQ632941; ***Loxostigma griffithii*** (Wight) C. B. Clarke: FJ501338/FJ501508; ***Lysionotus pauciflorus*** Maxim.: FJ501331/FJ501497; ***Petrocodon coccineus*** (C. Y. Wu ex H.W. Li) Yin Z. Wang: FJ501365/FJ501516; ***Petrocodon coriaceifolius*** (Y. G. Wei) Y. G. Wei & Mich. Möller: HQ633040/HQ632943; ***Petrocodon dealbatus*** Hance: FJ501358/FJ501537; ***Petrocodon dealbatus*** var. ***denticulatus*** (W. T. Wang) W. T. Wang: JF697578/JF697590; ***Petrocodon ferrugineus*** Y. G. Wei: HQ633043/HQ632946; ***Petrocodon guangxiensis*** (Yan Liu & W. B. Xu) W. B. Xu & K. F. Chung: JX506899/JX506791; ***Petrocodon hancei*** (Hemsl.) A. Weber & Mich. Möller: HQ633041/HQ632944; ***Petrocodon hechiensis*** (Y. G. Wei, Yan Liu & F. Wen) Y. G. Wei & Mich. Möller: HQ633039/HQ632942; ***Petrocodon hispidus*** (W. T. Wang) A. Weber & Mich. Möller: HQ633036/ HQ632939; ***Petrocodon integrifolius*** (D. Fang & L. Zeng) A. Weber & Mich. Möller: HQ633037/HQ632940; ***Petrocodon laxicymosus*** W. B. Xu & Yan Liu: KC765115/KC765117; ***Petrocodon lui*** (Yan Liu & W. B. Xu) A. Weber & Mich. Möller: HQ633035/ HQ632938; ***Petrocodon niveolanosus*** (D. Fang & W. T. Wang) A. Weber & Mich. Möller: JF697576/JF697588; ***Petrocodon longgangensis*** W. H. Wu & W. B. Xu: KC765114/KC765116; ***Petrocodon pseudocoriaceifolius*** Yan Liu & W. B. Xu: JX506852/JX506741; ***Petrocodon scopulorum*** (Chun) Yin Z. Wang: GU350637/GU350669; ***Petrocodon tiandengensis*** (Yan Liu & B. Pan) A. Weber & Mich. Möller: HQ633042/HQ632945; ***Petrocosmea kerrii*** Craib: FJ501334/FJ501502; ***Primulina bipinnatifida*** (W. T. Wang) Yin Z. Wang: DQ872842/DQ872806; ***Primulina cordifolia*** (D. Fang & W. T. Wang) Yin Z. Wang: DQ872845/DQ872803; ***Primulina dryas*** (Dunn) Mich. Möller & A. Weber: FJ501348/ FJ501524; ***Primulina gemella*** (D. Wood) Yin Z. Wang: FJ501345/FJ501523; ***Primulina glandulosa*** (D. Fang, L. Zeng & D. H. Qin) Yin Z. Wang: DQ872841/DQ872804; ***Primulina heterotricha*** (Merr.) Yin Z. Wang: (DQ872826/DQ872816); ***Primulina linearifolia*** (W. T. Wang) Yin Z. Wang: DQ872834/DQ872810; ***Primulina longgangensis*** (W. T. Wang) Yin Z. Wang: FJ501347/AJ492290; ***Primulina luochengensis*** (Yan Liu & W. B. Xu) Mich. Möller & A. Weber: HQ633046/HQ632949; ***Primulina minutimaculata*** (D. Fang & W. T. Wang) Yin Z. Wang: DQ872828/DQ872815; ***Primulina mollifolia*** (D. Fang & W. T. Wang) Yin Z. Wang: JX506866/JX506755; ***Primulina multifida*** B. Pan & K. F. Chung: JX507031/JX506756; ***Primulina ophiopogoides*** (D. Fang & W. T.

Wang) Yin Z. Wang: DQ872829/DQ872814; ***Primulina pinnatifida*** (Hand.-Mazz.) Yin Z. Wang: FJ501350/FJ501527; ***Primulina pseudomollifolia*** W. B. Xu & Yan Liu: JX506869/JX506759; ***Primulina pteropoda*** (W. T. Wang) Yan Liu: DQ872827/DQ872817; ***Primulina renifolia*** (D. Fang & D. H. Qin) Yin Z. Wang: JX506737/JX506851; ***Primulina repanda*** var. ***guilinensis*** (W. T. Wang) Mich. Möller & A. Weber: DQ872846/DQ872808; ***Primulina spadiciformis*** (W. T. Wang) Mich. Möller & A. Weber: FJ501346/AJ492291; ***Primulina spinulosa*** (D. Fang & W. T. Wang) Yin Z. Wang: DQ872830/DQ872813; ***Primulina tabacum*** Hance: FJ501352/AJ492300; ***Primulina weii*** Mich. Möller & A. Weber: DQ872832/ DQ872811; ***Primulina wentsaii*** (D. Fang & L. Zeng) Yin Z. Wang: DQ872831/DQ872812.