# Two new species of *Primulina* (Gesneriaceae) from limestone karsts of China (#23971)



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# Two new species of *Primulina* (Gesneriaceae) from limestone karsts of China

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**ABSTRACT**

The limestone karst area of South China is a major biodiversity hotspot of global terrestrial biomes. During the extensive field work on the Guangxi limestone formations ~~in last ten years~~, two unknown species of Gesneriaceae were collected. After conducting a comprehensive study of the literature and herbarium specimens, *Primulina davidioides* and *P. hiemalis* are recognized as two new species to science, and described and illustrated here. *P. davidioides* is morphologically close to *P. lunglinensis* based on the shape of leaf and flower, but it can be easily distinguished by shape of bracts, calyx, corolla and stigma, indumentum of peduncles, pedicels and pistil, number of staminodes. *P. hiemalis* is closely relate to *P. luzhaiensis* in vegetative appearance, but differs in shape of calyx and stigma, number of bracts and staminodes, indumentum of leaf blade and peduncle, position of stamens in corolla tube. The conservation status of *P. davidioides*, *P. hiemalis* was assessed as "Critically Endangered" (CR) and Near Threatened (NT) according to IUCN Red List Category and Criteria, respectively.

**Keywords**

Karst region, Didymocarpinae, *Primulina davidioides*, *Primulina hiemalis*.

## INTRODUCTION

The karst habitats of Sino-Vietnamese limestone regions are renowned because of their very rich biodiversity and high endemism in the tropical and subtropical flora of the world (Myers et al. 2000; Clements et al. 2006; Hou et al. 2010). Karst areas in south China offer a multitude of ecological niches for plant diversification and speciation (Ai et al., 2015), with about half of all endemic genera of flowering plants in China (Ying & Zhang 1994), ~~such as *Aspidistra*, *Begonia*, *Elatostema*, *Impatiens* and also several genera of Gesneriaceae (Xu 1994; Xu et al., 2017).~~ Among these, Gesneriaceae form the most abundant part with 28 genera, amounting to 90% of all endemic genera of the family in China (Wang et al. 1990, 1998; Li & Wang 2004).

*Primulina* Hance was enlarged from the ~~originally monotypic~~ to a medium-sized genus based on ~~recent~~ molecular phylogenetic analyses (Wang et al. 2011, Weber et al. 2011). In recent years, the newly revised *Primulina* has attracted much more attention from botanists, and over 50 new species have been described after the generic recircumscription (Yang et al. 2017). Currently it becomes one of the most interesting genera of the Old World Gesneriaceae comprising more than 170 species ~~(Möller et al. 2016),~~ widely distributed throughout the Karst regions of S & SW China and N Vietnam (~~Wang et al. 2011; Möller et al., 2011~~). The limestone regions of southwestern China possess the highest biodiversity and differentiation of *Primulina* with about 80% species founded ~~there~~ (Wei et al. 2010) (Fig. 1). It displays a high degree of edaphic habitat specialization and also high endemism, i.e. majority of species of the calcipholous genus have a narrowly restricted distribution only in karst towers and caves (Wang

et al. 1990, 1998; Li & Wang 2004; Wei et al. 2010, Ai et al., 2015).

During our continuous floristic surveys for limestone karsts flora in recent years, we have revealed an additional two species of *Primulina* ~~and~~ not known previously in 2009 and 2010. Further fieldwork was conducted at the same locality, and ~~the~~ flowering specimens ~~were~~ collected. Available information suggested that these two species are rare and usually occur only at one or two localities. After comprehensive literature analysis (Wang et al. 1998, Wang & Li 2004, Wei et al. 2010), as well as herbarium specimens of E, GH, HITBC, HN, IBK, IBSC, K, MO, KUN, PE and US (herbarium acronyms according to Index Herbariorum; Thiers 2017), they were identified as two new taxa of *Primulina* based on results of detailed examination of morphological anatomical features, which we hereby describe and illustrate.

## MATERIALS AND METHODS

### Ethics statement

All the collecting locations of the new species reported in this study are not in any natural conservation area and no specific permissions were required for these locations. Since ~~this species is~~ currently undescribed, inevitably, it is not currently included in the China Species Red List (Wang & Xie 2004). And our field studies did not involve any endangered or protected species. No specific permits are required for the present study.

### Nomenclature

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(ICN), and hence the new names contained in the electronic version are effectively published under that Code from the electronic edition alone. In addition, new names contained in this work which have been issued with identifiers by IPNI will eventually be made available to the Global Names Index. The IPNI LSIDs can be resolved and the associated information viewed through any standard web browser by appending the LSID contained in this publication to the prefix "http://ipni.org/". The online version of this work is archived and available from the following digital repositories: PeerJ, PubMed Central, and CLOCKSS.

**Material collection**

These two species were collected and examined during the floristic surveys field works. In addition, the plants were monitored in the field and nursery in the Gesneriad Conservation Center of China (GCCC) by the authors over the past eight years. All specimens and tissue samples were deposited in the Anhui University Museum (AHU) and herbarium of Guangxi Botanical Garden (IBK).

**Morphological observations and specimens examined**

An overview of the genus *Primulina* from S China and adjacent areas of N Vietnam was prepared. All available specimens of *Primulina* stored in the following herbaria were carefully examined: E, GH, HITBC, HN, IBK, IBSC, K, MO, KUN, PE and US. The images of type specimens were also obtained from Tropicos (http://www.tropicos.org), JSTOR Global Plants (http://plants.jstor.org) and the International Plant Names Index (http://www.ipni.org). Morphological description of the new species was based on examination of fresh and pressed specimens. All morphological characters, particularly the details of the flowers, were studied

under a stereomicroscope (MD-90, Olympus, Tokyo, Janpan), and are described using the terminology presented by Wang et al. (1998). The morphological comparison with other species was based on study of live plants in the field and in cultivation in GCCC, herbarium specimens, and also information gathered in the literature searches.

## RESULTS

***Primulina davidioides*** F. Wen & Xin Hong sp. nov. (Figs 1, 3)

**IPNI:**

**Type**. China. Guangxi: Donglan County, Donglan Town, Dayou village, growing in rocky crevices and tufa surface on the bottom of a limestone hill, elevation ca. 350 m, 05 May 2012 (fl.), *F. Wen & Xin Hong 201205005* (holotype: IBK!; isotype: AHU!).

**Paratypes.** China: Guangxi: Donglan County, Donglan Town, Dawen Village, ca. 350 m, 12 May 2009, *F. Wen 0905012* (IBK!); ibid., 350 m, 28 May 2011, *Xin Hong 201209030* (AHU!).

**Diagnosis.** *Primulina davidioides* is morphologically close to *P. lunglinensis* based on the shape of leaf and flower, but it can be easily distinguished by peduncles puberulent; bracts cordate to suborbicular, base subtruncate, 4–6 × 4–5 cm, thick chartaceous; pedicels glandular and eglandular–pubescent, triangle calyx, corolla ca. 6 cm long, tubular, staminodes 3, pistil c. 3.7 cm long, densely puberulent with both glandular and eglandular hairs, stigma narrowly obtrapeziform, apex retuse (see Table 1).

**Description.** Perennials, ~~acaulescent~~. Rhizome terete, 2–6 cm long, 1–2 cm in diameter. Leaves ~~basal,~~ 4–10, opposite; pachyphyllous, rigid coriaceous when dry, densely pubescent on both surfaces; petiole flattened, 1–2 cm long, 6–10 mm wide, densely pubescent; blade elliptical to

broadly ovate, (5–) 11–12.5 cm, 5–10 cm wide, apex somewhat obtuse, base obliquely cuneate, margin shallowly serrate; lateral veins 3–5 on each side, impressed adaxially and prominent abaxially. Cymes 1–3, 5–9 (11)-flowered; peduncles 5–9 (12) cm, 4–8 mm in diameter, pubescent; pedicels ca. 1.4 cm long, glandular and eglandular-pubescent; bracts 2, opposite, free, cordate to suborbicular, thick chartaceous, slightly fleshy, leathery when dry, white when flowering, with crinkled and virescent margin, 4–6 cm long, 4–5 cm wide, base subtruncate, apex acute, outside densely puberulent with sparsely strigillose, inner surface glandular-puberulous. Calyx membranous, white to subtranslucent, ca. 7 mm, 5-sect; segments equal, ~~triangle,~~ 2–3 mm wide, margin ~~with~~ obscurely serrated from the middle, apex acute, outside densely puberulent. Corolla ca. 6 cm long, purple, with dark purple lines inside and two yellow-white streaks in the throat, outside glandular and eglandular–pubescent, inside pubescent near base; tube ~~tubular;~~ ca. 4.5 cm long, ca. 1 cm diameter at mouth, c. 0.5 cm in diameter at base; limb distinctly 2-lipped, adaxial lip 2-parted to the base, lobes ovate, c. 6 × 5 mm, 3-lobed from near the middle, lobes oblong, 10–15 × 4–6 mm. Stamens 2, abaxial, adnate to ca. 1.7 cm above corolla base; filaments ca. 1.1 cm, strongly geniculate near the base, ca. 1 mm wide, sparsely short glandular–puberulous; anthers pale yellow, reniform–oblong, ca. 3 mm, ca. 2 mm wide, fused face to face, bearded on the back. Staminodes 3, adaxial, linear, apex capitellate, lateral ones ca. 7 mm long, adnate to ca. 1.5 cm above corolla base, central one ca. 4.5 mm long, adnate to ca. 0.9 cm above corolla base, sparsely glandular-puberulous. Disc ring-shaped, ~~obscurely~~ lobed, 0.5–0.8 mm high, glabrous. Pistil ~~ovary~~ linear, c. 3.7 cm long, green, densely puberulent with both glandular and eglandular hairs; ovary c. 2.0 cm, ca. 1.5 mm wide. Lower lip of stigma

narrowly obtrapeziform, apex retuse, translucent to green, ca. 3 mm long, recurved. Capsule ca. 5 cm long, brownish.

**Distribution, Habitat and Ecology.** *Primulina davidioides* is rare, only found in the type locality, i.e. a ~~nameless~~ limestone hill, ca. 20 km west of Donglan Town, Donglan County, in northern Guangxi of southern China. It grows in rocky crevices and tufa surface on the bottom of a limestone hill, at an elevation of 350 m a.s.l. The average temperature of Donglan County is 18.7 ℃, the average annual precipitation has been calculated with ca. 1660 mm. The forest where *P. davidioides* occurs is subtropical evergreen broad-leaved forest. Flowering in May.

**Etymology.** The specific epithet is derived from its cordate to suborbicular bracts with subtruncate base. The shape of bracts looks similar the bracts of *Davidia involucrate* Baill., ~~is~~ native to China.~~.~~

***Primulina hiemalis*** Xin Hong & F. Wen sp. nov. (Figs 2, 4)

**Type**: China, Guangxi, Yongfu county, Baishou Town, Chuanyan village, on the moist rock face at the entrance of limestone caves, 526 m a.s.l., 09 December 2010, F. Wen & L.F. Fu WFBCJT101209-01 (holotype: IBK!; isotype: AHU!).

**Additional collections.** China, Guangxi, Yongfu county, Baishou Town, Baishouyan, on the moist rock face at the bottom of limestone hills, 511 m a.s.l., 15 December 2011, F. Wen WFBCJT111215-01 (IBK)

**Diagnosis.** *Primulina hiemalis* is closely relate to *P. luzhaiensis* in vegetative appearance, but differs in indumentum of leaf blade and peduncle (puberulent), bracts 3, longer calyx, c. 1.5 cm

long, stamens adnate to c. 2 cm above the corolla tube base, staminodes 2, stigma ligulate, lobes linear (shown in Table 2).

**Description.** Perennials, ~~acaulescent.~~ Rhizome subterete, c. 1.0–2.5 × 0.5–2.0 cm wide, internodes inconspicuous. Leaves ~~basal,~~ 6–8, opposite; petiole 0.5–3.5 × 0.4–0.6 cm; leaf blade thick chartaceous, markedly obliquely ovate or oblong, 5.5–9.5 × 3.5–5.0 cm, apex obtuse, base obviously oblique, cuneate–attenuate, margin crenate, obviously serrated from the base; densely puberulent on both surfaces, lateral veins 4–5 on wider side of midrib, lateral veins 3–4 on narrower side of midrib inconspicuous. Cymes 2–4, 1–3-flowered; peduncle 1.5–3.0 cm, densely puberulent; bracts 3, free, narrowly lanceolate, lateral ones c. 20 × 2–2.5 mm, the central one c. 5 × 0.8–1 mm, puberulent, margin entire, apex acute. Pedicel 0.5–1.0 cm, densely puberulent. Calyx 5-sect from base; segments equal, lanceolate-ovate, c. 15 × 6 mm, puberulent, margin entire, apex acute. Corolla purple, 4–6 cm, outside puberulent, inside glabrous; tube tubular, 2.5–4.8 cm long, base c. 3–5 mm in diameter, top 12–16 mm in diameter; limb distinctly 2-lipped, adaxial lip 2-parted to the base, lobes ovate, c. 10 × 8 mm, 3-lobed over the middle, lateral ones ovate, central one oblong, obtuse to truncate at apex, 12–15 × 8–10 mm. Stamens 2, adnate to c. 2 cm above the corolla tube base, filaments c. 1 cm long, geniculate near the base, glabrous; anthers fused by their entire adaxial surfaces, elliptic, c. 2.5 mm long, glabrous; staminodes 2, linear, 6–7 mm, glabrous. Pistil c. 3 cm, densely puberulent with both glandular and eglandular hairs; ovary c. 2.0 cm, glandular-puberulent. Stigma ligulate, lobes linear, 2–2.5 mm long. Capsule 2.5–3.0 cm long.

**Distribution, Habitat and Ecology**. *Primulina hiemalis* is locally abundant, narrow endemic

and only known from the type locality, i.e. Chuanyan village, Baishou Town, Yongfu county, Guangxi province. It grows on moist shady cliffs at the entrance of a limestone cave, at an elevation of 530 m a.s.l. The average temperature is 18.8℃, the average annual precipitation has been calculated with c. 2, 000 mm. The forest where is subtropical evergreen broad–leaved forest. Flowering in November.

**Etymology.** The flowering time of this new species is in December. Thus the specific epithet is derived from its winter ~~florescence,~~ The Latin word, "hiemalis", is an adjective. ~~The word~~ meaning is "to belong to winter", and hints the flowering time of the new taxon is in winter (from December to January).

## DISCUSSION

The tropical and subtropical karst landforms of southern and southwestern China represent an unrivalled biodiversity-rich landscape and, therefore, have long been regarded as ideal natural laboratories for studying processes of population divergence and speciation of terrestrial plants (Davis et al., 1995). China is a significant centre of diversity of Old World Gesneriaceae, which consists of ~~59 genera and more than 442 species (Wang et al., 1998~~), with 28 endemic genera (Ying et al., 1994), and 75% of all species endemic to this region before 2011 (Gao et al., 2015). ~~Without a doubt,~~ Gesneriaceae is one of the most endemic plant groups found in China ~~(Möller et al., 2016),~~ with most ~~of~~ taxa found in the limestone karst landforms in S & SW China. The genus, *Primulina*, is one of the ~~largest~~ genus in Old World Gesneriaceae with more than 150 species distributed in the karst area of southern and southwestern China and northern Vietnam

(Möller et al., 2016; Yang et al., 2018). This group shows high levels of endemism and ecological specialisation (Hao et al., 2015), with narrow, island distributions (Wang et al., 1998, Li & Wang, 2004, Wei et al., 2010). Many *Primulina* species pairs can successfully interbreed through artificial experiments (Wen 2008; Zhang et al., 2017), suggesting *Primulina* is probably a genus under recent or ongoing speciation and differentiation (Gao et al., 2015).

~~Pollination syndrome represents the combination of pollinator-related traits to which flowers of different species pollinated by functionally similar pollinators converge (Faegri & van der Pijl, 1979; Fenster et al., 2004; Rosas-Guerrero et al., 2014). During flower evolution in animal-pollinated species, the primary targets of selection is how to attract of pollinators and transfer pollen successfully, which also lead to repeated evolutionary shifts between pollinators, and consequently to the diversification of floral forms (Harder & Barrett 2006, Alcantara & Lohmann 2010). So, in angiosperms, which rely on pollination to reproduce, the floral morphology that affects individual reproductive success may lead to evolutionary divergence and speciation (Herrera 1990). In Gesneriaceae, most neotropical species studied to date exhibit functional specialization in pollination systems (SanMartín-Gajardo & Sazima 2005; Martén-Rodríguez et al. 2015), but species in different genera also have floral traits that correspond to more than one pollination syndrome (Perret et al. 2001; Martén-Rodríguez et al. 2009). In addition, pollination syndromes have been detected as patterns of convergent evolution associated with pollinator shifts in the family (Ramírez-Aguirre et al., 2016). Therefore, pollination syndrome is a set of very dynamic and rapidly evolving characters and offers classic examples of convergent evolution in many groups (Perret et al., 2007; Martén-Rodríguez et al.,~~

2010).

However, in contrast to its high species diversity, the morphological variation of *Primulina* is relatively limited compared to other genera (Möller et al. 2016). Especially, the corolla morphology is relatively monotonous, and most species possess straightly infundibuliform corolla, with the salverform (e.g. *Primulina tabacum*), campaniform (e.g. *P. dichroantha*, *P. mollifolia*, *P. hezhouensis*, and *P. renifolia*, which is belong to old *Wentsaiboea*), and also *P. curvituba* showing the strongly curved tube shape. But corolla size of this genus shows great variation and had been used as an important character for the description of new species and also to establish the old *Chiritopsis* (Wang 1981). However, there is a lot of overlap in morphology between former *Chiritopsis* and *Chirita*. Recently, the molecular studies also showed that *Chiritopsis* and *Chirita* sect. *Gibbosaccus* together from same clade (Li & Wang 2007, Möller 2009). The presence of great variation exists in corolla size suggests a high degree of evolutionary lability, presumably driven by adaptation to different size of pollinators (Weber et al., 2011).

Floral morphology is well known to affect the attractiveness of the plant to pollinators and the efficiency of pollen removal and deposition during pollinator visits (Stephenson 1979, Ehlers et al. 2002, Syafaruddin et al. 2006), inflorescence structure of this genus also plays an import role here. The pair-flowered cyme is the basic type of the inflorescence in the Old World Gesneriaceae (Weber 1978, 1982), but it is highly variable between species and even within an individual (Weber 2013). The inflorescences in *Primulina* are usually dichotomous cymes with few flowers (large corolla, e.g. species of former *Chirita* sect. *Gibbosaccus*) to many flowers

~~(small corolla, e.g. species of former *Chiritopsis*) (Li & Wang 2004; Wang et al. 1998; Wei et al. 2010).~~ In addition, *Primulina* also shows a wide range of diversity of involucral bracts, which is also one of important characteristics for the taxonomy of this group. The two opposite bracts are brightly white when flowering time and serve the function of attracting pollinators, like: *Primulina eburnea*, *P. lutea*, *P. xiziae*, *P. lungzhouensis*, *P. lunglinensis*, *P. beiliuensis* var. *beiliuensis* and *P. beiliuensis* var. *fimbribracteata* and this new species, *P. davidioides*. The development of cymes in these species shows that two lateral paraclades of pair-flowered cyme is reduced, so all flowers clustered together. While flowers of these species always blossom in a short time (Hong 2016), the large white bracts and central flower cluster make the inflorescence may look superficially like a single flower, and attract pollinators.

## CONSERVATION ASPECTS

A clear understanding of speciation and diversification in karst landscapes is particularly important, as these habitats are disproportionately threatened by climate change and anthropogenic deforestation (Clements et al., 2006). *Primulina davidioides* is currently known with certainty only from its type locality. *P. davidioides* belongs to one of stenochoric plants, which it is only grown in limestone area. Currently there is insufficient information concerning the distribution and population status of this new species. Obviously, further field study is needed in northwestern Guangxi as its geographic range may well be more extensive than presently know. At present only one known population with less than survived seventy individuals (including the mature and young ones) was found in Guangxi. *Primulina hiemalis*

has two known populations in Baishou town, Yongfu county. Its Near Threatened status is based on its localised and patchy distribution on this town. The species flowers abundantly from December to January in the winter. Thus the new taxon faces the risk is over-collecting by tourists and local people because of their beautiful flowers.

Based on IUCN red list categories (IUCN, 2016), ~~The Proposed IUCN Red List Category of~~ *Primulina davidioides* can be assessed as "Critically Endangered, CR A1abcd+C2a (i, ii)" because the number of mature individuals known is less than fifty. *Primulina hiemalis* can be assessed as Near Threatened (NT). We ~~had~~ cultivated about ten young plants from leaf cuttings of each new species for *ex situ* conservation in Genseriad Conservation Center of China (GCCC), Guilin Botanical Garden so that we can preserve the germ plasma resources of ~~this~~ rare species.

## CONCLUSIONS

During our continuous floristic surveys for limestone karsts flora in recent years, two unknown species of Gesneriaceae were collected. After conducting a comprehensive study of the literature and herbarium specimens, *Primulina davidioides* and *P. hiemalis* are recognized as two new species to science based on results of detailed examination of morphological anatomical features. Available information suggested that these two species are rare and usually occur only at one or two localities. The conservation status of *P. davidioides*, *P. hiemalis* was assessed as "Critically Endangered" (CR) and Near Threatened (NT) according to IUCN Red List Category and Criteria, respectively.

**ACKNOWLEDGEMENTS**

The authors are grateful to The Gesneriads Society and The African Violet Society of America for their support and help. We also express our appreciation to the corresponding curators of the botanical collections for facilitating our access to examined specimens. We thank Long-Fei Fu and Jia Dong provided access for the study and measurement of comparative material, Zheng-Long Li, Fu-Zhuan Pan, Shu Li and Zi-Bing Xin helped conduct fieldwork and with logistics. Thanks are also due to Miss Xiao-Ming Xu and Miss Wen Ma for the beautiful hand-drawing.

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## Tables

**Table 1**. Diagnostic character differences between *Primulina davidioides* sp. nov. and its close relatives *P. lunglinensis*.

**Table 2**. Diagnostic character differences between *Primulina hiemalis* sp. nov. and its close relatives *P. luzhaiensis*.

## Figure captions

**Figure 1**. ***Primulina davidioides* sp. nov.** (A) habit in flowering period; (B) dissection of a flower showing stamens and staminodes; (C) anthers, showing beard; (D) pistil; (E) stigma; (F) ovary and calyx; (G) calyx. (Xiao-Ming Xu drawn from the holotype.)

**Figure 2**. ***Primulina hiemalis* sp. nov.** (A) habit in flowering period; (B) dissection of a flower showing stamens and staminodes; (C) calyx and pistil; (D) calyx, showing puberulent. (Wen Ma drawn from the holotype.)

**Figure 3**. ***Primulina davidioides*** sp. nov. — A: habitat; B: population; C: the flower bud; D: plant in flowering plant with cymes; E—H: Cymes (E: showing adaxial bracts F: showing abaxial bracts G: frontal view of cymes; H: Top view of cymes); I: Lateral view of corolla; J: young fruit; K: Top view of corolla; L: upward view of corolla; N: Opened corolla, pistils without corolla and calyx lobes; O: dissection of a flower showing staminodes; P—Q: stamens (P: the reverse side, showing beard; Q: the frontal side, showing the anthers); R: capsules (Photographs by Fang Wen and Xin Hong).

**Figure 4.** ***Primulina hiemalis*** sp. nov. — A: habitat; B: Plant; C—F: corolla (C: frontal view; D: right side view; E: Top view; F: left side view); G: calyx; H: pistils with calyx lobes, shoeing the stigma; I: opened corolla (Photographs by Fang Wen).

## Table 1 (on next page)

Table 1. Diagnostic character differences between *Primulina davidioides* sp. nov. and its close relatives *P. lunglinensis*.

**Table 1**. Diagnostic character differences between *Primulina davidioides* sp. nov. and its close relatives *P. lunglinensis*.

| Characters | *P. davidioides* | *P. lunglinensis* |
|---|---|---|
| Indumentum of peduncles | puberulent | glandular puberulent |
| Bracts | cordate to suborbicular, base subtruncate, 4–6 × 4–5 cm | elliptic to broadly ovate, base attenuate, 0.6–3.8 × 0.4–2.7 cm |
| Indumentum of Pedicel | glandular and eglandular pubescent | glandular puberulent |
| Shape of Calyx | triangle | narrowly lanceolate to narrowly triangular |
| Corolla size | ca. 6 cm long | 3–3.8 cm long |
| Number of staminodes | 3 | 2 |
| Pistil | ca. 3.7 cm long, densely puberulent with both glandular and eglandular hairs | ca. 2.7 cm, puberulent |
| Shape of Stigma | narrowly obtrapeziform, apex retuse | cuneate |

## Table 2 (on next page)

Table 2. Diagnostic character differences between *Primulina hiemalis* sp. nov. and its close relatives *P. luzhaiensis*.

**Table 2**. Diagnostic character differences between *Primulina hiemalis* sp. nov. and its close relatives *P. luzhaiensis*.

| Characters | *P. hiemalis* | *P. luzhaiensis* |
|---|---|---|
| Indumentum of of leaf blade | puberulent on both surfaces | villous and pubescent adaxilly |
| Cymes | each inflorescence with 1–3-flowered | each inflorescence with 1–10-flowered |
| Indumentum of peduncle | densely puberulent | densely villous |
| Bracts | 3, lateral ones ca. 2 cm long, the central one ca. 0.5 cm long, | 2, 0.2–0.8 mm long |
| Calyx size | ca. 1.5 cm long, | 0.5–1 cm long |
| The location of stamens | adnate to ca. 2 cm above the corolla tube base | adnate to 1.4–1.7 mm above the corolla tube base |
| Number of staminodes | 2 | 3 |
| Shape of stigma | ligulate, 2-lobed, lobes linear | obtrapeziform, apex retuse |

## Figure 1(on next page)

Hand-drawing of Primulina davidioides

(A) habit in flowering period; (B) dissection of a flower showing stamens and staminodes; (C) anthers, showing beard; (D) pistil; (E) stigma; (F) ovary and calyx; (G) calyx.

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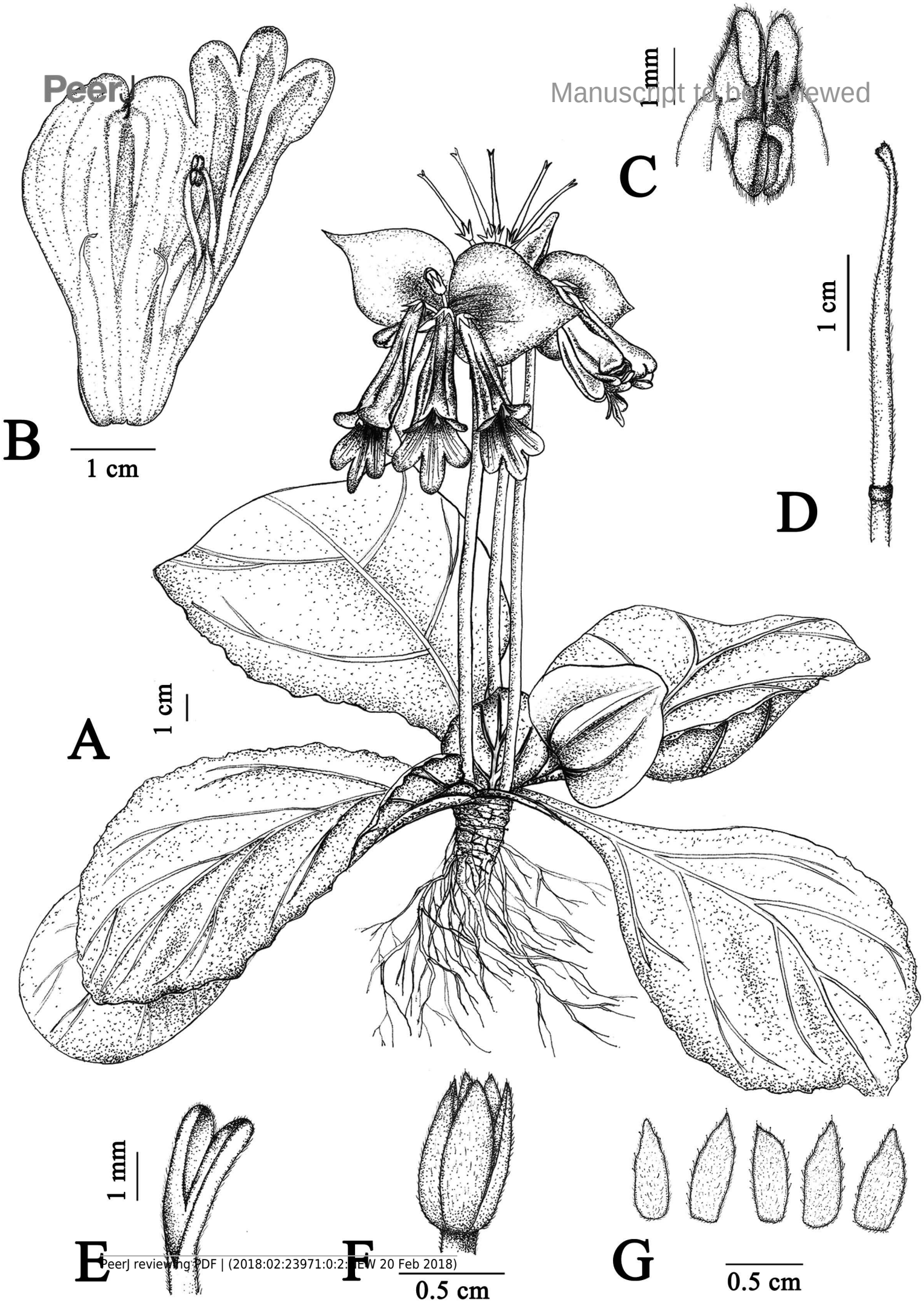
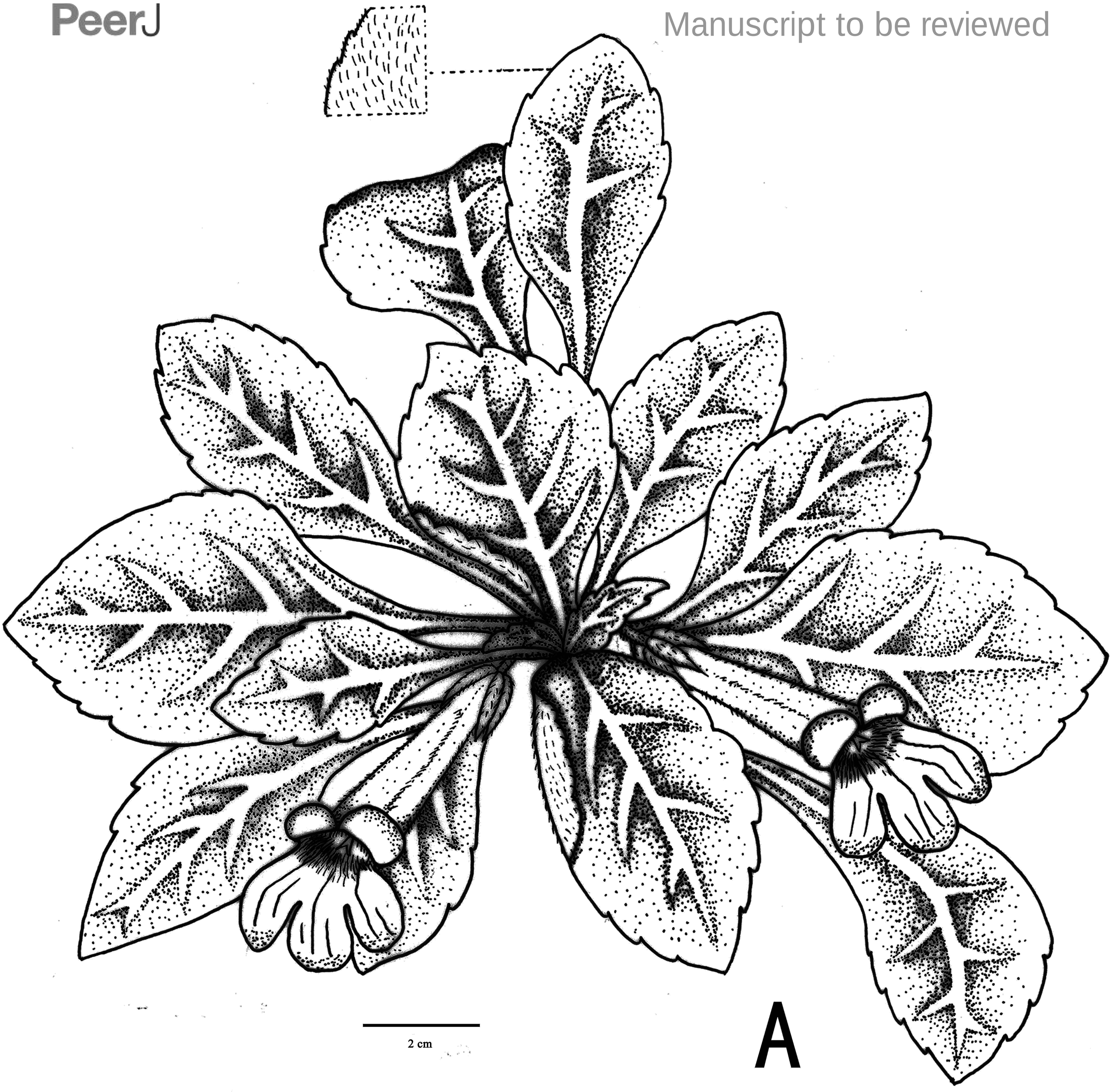


## Figure 2(on next page)

Hand-drawing of *Primulina hiemalis* sp. nov.

(A) habit in flowering period; (B) dissection of a flower showing stamens and staminodes; (C) calyx and pistil; (D) calyx, showing puberulent.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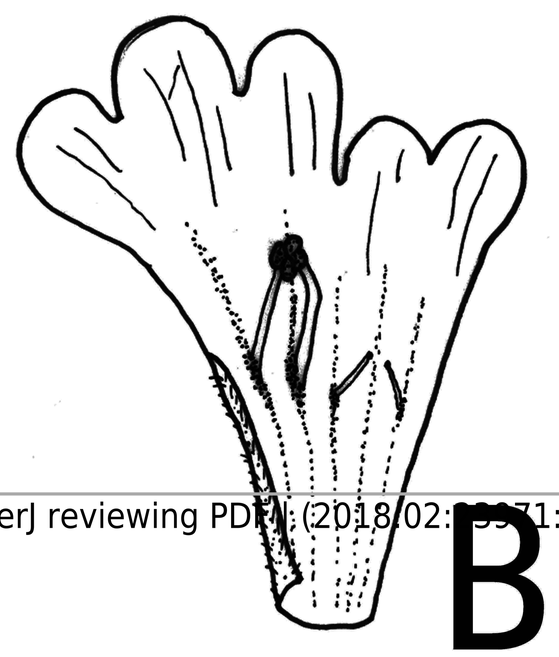
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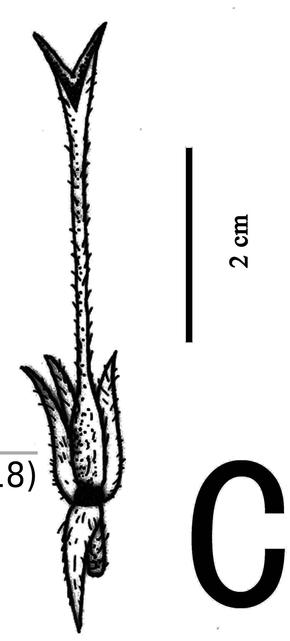
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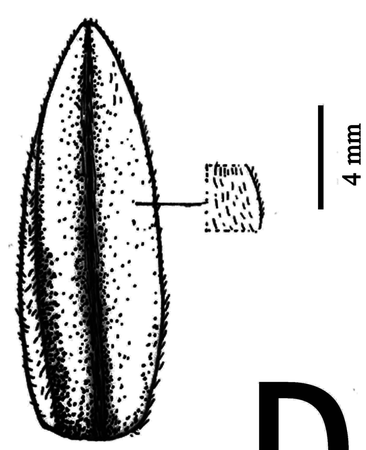
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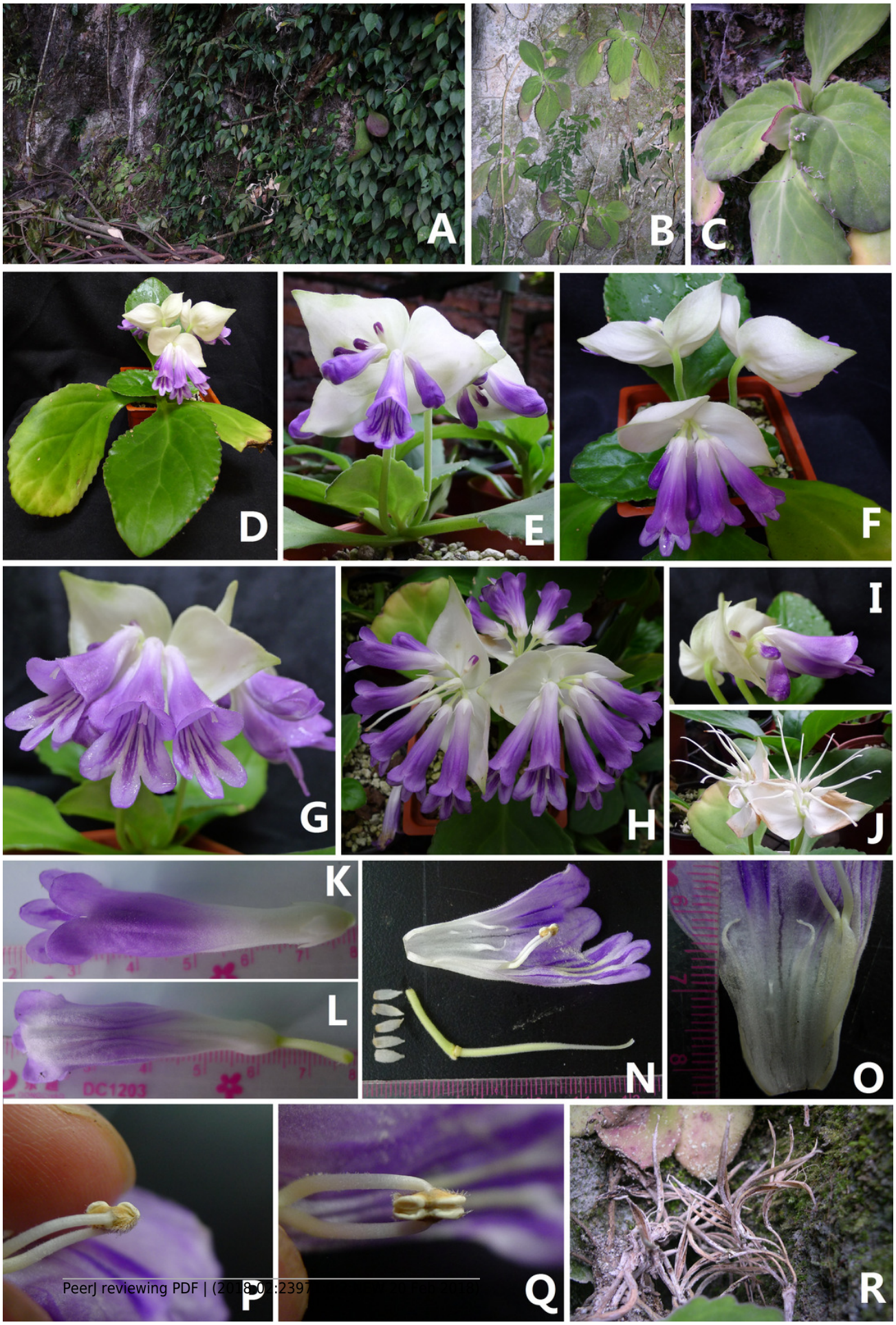
# Figure 3

Photos of *Primulina davidioides* sp. nov.

A: habitat; B: population; C: the flower bud; D: plant in flowering plant with cymes; E—H: Cymes (E: showing adaxial bracts F: showing abaxial bracts G: frontal view of cymes; H: Top view of cymes); I: Lateral view of corolla; J: young fruit; K: Top view of corolla; L: upward view of corolla; N: Opened corolla, pistils without corolla and calyx lobes; O: dissection of a flower showing staminodes; P—Q: stamens (P: the reverse side, showing beard; Q: the frontal side, showing the anthers); R: capsules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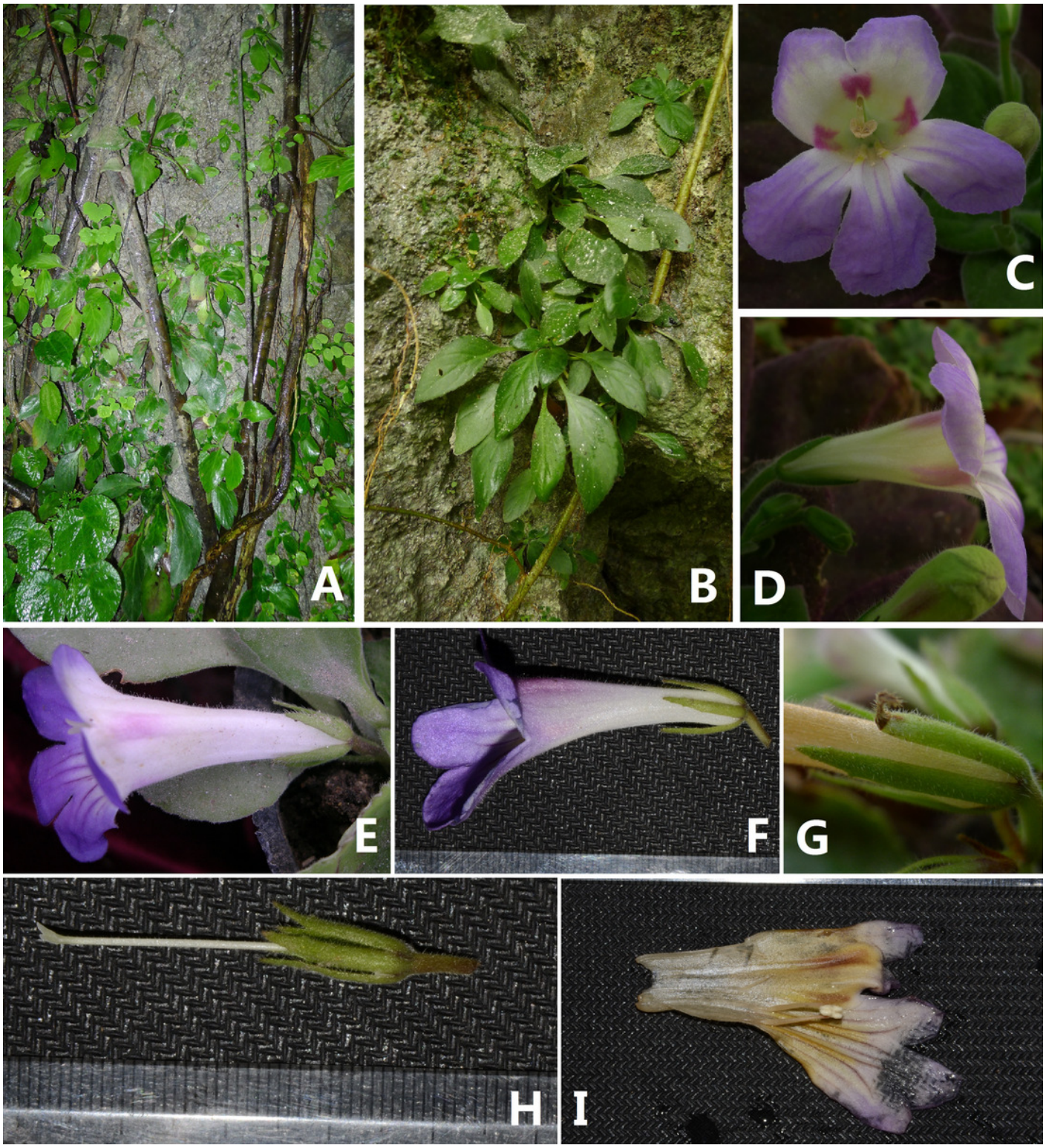
# Figure 4

Photos of *Primulina hiemalis* sp. nov.

A: habitat; B: Plant; C—F: corolla (C: frontal view; D: right side view; E: Top view; F: left side view); G: calyx; H: pistils with calyx lobes, shoeing the stigma; I: opened corolla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