

Oreocharis scutifolia (Gesneriaceae) , a unique new species from the Dry and Hot Valley of Jinsha River Basin, Yunnan, China

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Abstract

A unique new species, *Oreocharis scutifolia* Z. Xie, Miao Zhang & H. H. Kong, endemic to the Dry and Hot Valley of Jinsha River Basin, Yunnan, China, is described and illustrated here. It is similar to *O. cordatula* (Craib) Pellegr. and *O. aurantiaca* Baill. in some morphological characters, but differs in its unique peltate, ovate to oblong leaf blades with emarginated apex, places and types of indumentum, length of peduncles and corolla, also have significant differences in these species. Molecular phylogenetic analysis based on transcriptome data strongly supported *O. scutifolia* as a new species, while it forms a sister group with *O. henryana* Oliv., *O. cordatula* (Craib) Pellegr., *O. minor* Pellegr. and *O. aurantiaca* Baill. (ML = 100). Due to its tiny population, narrow distribution range, and the serious threat from human activities, invasive plants and damaged habitat, the new species is assessed as “critically endangered” following the IUCN categories and criteria.

Introduction

Oreocharis Benth. (Gesneriaceae) is a species-rich genus which distributed in the Old World (Kong et al., 2022; Möller et al. 2011). As of August 2021, there are 147 *Oreocharis* species (including a suspect species) in China (Wen et al., 2021), and in recent two years, the number of species in this genus is still increasing at a rate of more than 3–6 per year (Gong et al., 2022; Huang et al., 2023; Hu et al., 2022; Hu et al., 2023; Khuong et al., 2022; Li et al., 2023; Li et al., 2022; Ling et al., 2022; Liu et al., 2021; Lv et al., 2021; Yang et al., 2022; Yang et al., 2021; Zhou et al., 2023).

Almost all of the *Oreocharis* species currently known are growing on shady and wet rocks, or stony soils (Kong et al., 2022). When the environment becomes dry, these plants can’t grow well, and can’t flower normally during the flowering period, or even dry up and die. In July 2023, we unexpectedly discovered an unknown and unique species of *Oreocharis* (Gesneriaceae) during a field investigation in the Dry and Hot Valley of Jinsha River Basin, Dayao County, Yunnan Province, China. These plants only grow on dry soil slopes or rocks, and they continue to thrive even in extremely dry and hot environments, blooming in the process. The habitat is dominantly occupied by *Quercus franchetii* Skan (Fagaceae), and accompanied by species such as *Petrocosmea* sp. (Gesneriaceae), *Deyeuxia mazzettii* Veldkamp (Poaceae), *Arisaema erubescens* (Wall.) Schott (Araceae), and *Thalictrum* sp. (Ranunculaceae), and so on.

This species exhibits distinctive characteristics, including rosette plants, basal leaves, axillary cymose inflorescence, slenderly cylindric corolla and 2-lipped limbs, 4 stamens and 1 staminode, and annular disk. These traits align with the morphological description of *Oreocharis* (Wang et al., 1990; 1998; Möller et al., 2011). It also shares some similar morphological characters while we compared it with *O. cordatula* and *O.*

aurantiaca, it can be distinguished by its unique leaves, peduncles and corolla. These characteristics set it apart from the aforementioned two species. Detailed literature reviews (Cai et al., 2017; 2019; 2020a; 2020b; 2020c; 2020d; Chen et al., 2013; 2016; 2018; 2020; Chen et al., 2017; Guo et al., 2018; Han et al., 2017; Li et al., 2015; 2017; Möller et al., 2018; Pan et al., 2019; Truong et al., 2017; Wei et al., 2016; Wu et al., 1987; 1991; Yang et al., 2015; Yang et al., 2019; Yang et al., 2015; 2017; 2018; Yi et al., 2019) and morphological comparisons with herbarium specimens confirm that this is indeed a unique and previously undiscovered species. Phylogenetic analysis primarily utilizing transcriptomes, has further confirmed its position within the genus *Oreocharis*.

Material and methods

Morphological description and comparison

Morphological data for the new species were collected from field collections, primarily based on observations of living plants in their natural habitat. We also measured the similar species, *Oreocharis cordatula* and *O. aurantiaca* in the field and the specimens at herbarium (PE, IBSC & KUN). Morphological measurements were taken using a vernier caliper from Yantai Greenery Tools Co., Ltd. (Yantai, China), to document specific characters that were deemed relevant for species differentiation. The terminology used for describing morphological characters followed the guidelines proposed by Harris & Harris (1994) and the Flora of China (Wang et al., 1990; 1998). Voucher specimens for our study, including the type materials, were carefully archived in the herbarium of the South China Botanical Garden, Chinese Academy of Sciences / South China National Botanical Garden (IBSC), Guangzhou, China. In our examination of *Oreocharis* s.l. specimens, we comprehensively reviewed collections from various herbaria, including IBSC, PE, CDBI, KUN, IBK, SM, NAS, GZTM, CSH, HGAS, WCSBG, K, E, P, MPU and UC. Our evaluation encompassed both physical specimens and digital images accessible via the National Plant Specimen Resource Center (www.cvh.ac.cn/index.php) and the JSTOR Global Plants web portal (<https://plants.jstor.org/>).

Molecular analyses

In this study, we sampled 118 samples representing 106 *Oreocharis* species (Supplement Table 1), which included the new species, *O. aurantiaca*, *O. cordatula*, and *O. henryana* Oliv., among with six species from other genera of Gesneriaceae [*Cyrtandra hawaiiensis* C.B. Clarke, *Petrocodon dealbatus* Hance, *Didymocarpus cortusifolius* (Hance) W.T. Wang, *Anna mollifolia* (W.T. Wang) W.T. Wang et K.Y. Pan, *Aeschynanthus moningeriae* (Merr.) Chun and *A. buxifolius* Hemsl.] as outgroups based on previous molecular phylogenetic analyses (Möller et al., 2011; Kong et al., 2022). We meticulously recorded essential information, including collection date, location, habitat, altitude, latitude and longitude, and the morphological characteristics of the observed species in the field. We collected one or more whole living plants ensuring their roots' lower portions were gently enclosed with damp paper towels, or, if available, with damp mosses (Kong et al., 2022). Subsequently, we transported these living plants to the greenhouse at South China Botanical Garden, Chinese Academy of Sciences for cultivation and recovery. Once recovered, we collected fresh, young leaves, removed impurities, rapidly frozen in liquid nitrogen, then stored them in a -80 refrigerator. The new species was collected from the type locality, and *O. cordatula* was collected from Jiulong County, Sichuan, China. Voucher specimens were obtained for each collection and were securely deposited in the herbarium of South China Botanical Garden, Chinese Academy of Sciences (IBSC). Other samples were sourced from our previous study.

We submitted frozen leaves the new species and *Oreocharis cordatula* to Novogene Technology Co., Ltd. for transcriptome sequencing. A custom Perl script (Feng et al. 2017) was employed to eliminate low-quality reads. We then referenced a previously published dataset, which included 574 orthologous genes and covered 104 *Oreocharis* species, and extracted the relevant orthologous genes by GeneMiner as a prior study (Kong et al., 2022). These additional genes were incorporated into the dataset for phylogenetic reconstruction.

Results

Morphology

A morphological comparison of the new species with known *Oreocharis* species reveals a remarkable resemblance to *O. cordatula* and *O. aurantiaca* (Fig 3 & Fig 5). The new species shares common characters such as leathery leaf blades and yellow flowers, which are similar to these two species. However, it can be distinguished by its distinctive peltate, ovate to oblong leaves, the petiole adnate to the leaves' margin approximately 0.5–1 cm from base, margin shallowly undulate to almost entire, adaxially smooth and hairless, peduncles 3–7 cm long, and corolla 1.1–1.3 cm long. A comprehensive comparison of the morphological characteristics of similar species is presented in Table 1.

Molecular analyses

A total of 112 taxa (including outgroups) were included in the molecular phylogenetic analysis (Fig. 1), comprising 118 populations of *Oreocharis* (Supplement Table 1). A dataset of 572 orthologous genes was obtained. Two genes were eliminated due to the absence in the two newly added species. The transcriptome data from this study are openly accessible via NCBI – with Bioproject accession number PRJNA1032259 and BioSample accession numbers from SAMN37989791 to SAMN37989792 (<https://www.ncbi.nlm.nih.gov/sra/PRJNA1032259>).

The phylogenetic analyses based on maximum likelihood algorithm (ML) of orthologous genes, strongly supported the clustering of the new species with *O. henryana* Oliv., *O. cordatula* (Craib) Pellegr., *O. minor* Pellegr. and *O. aurantiaca* Baill. (ML = 100), and together with *O. cinnamomea* Anthony, they form a maximum supported clade (ML = 100, Fig. 1). Based on the above compelling evidence, the species is conclusively identified as a unique new species, and is named *Oreocharis scutifolia* Z. Xie, Miao Zhang & H. H. Kong sp. nov.

Discussion

In recent years, a growing number of new *Oreocharis* species have been published with most of these new species being identified solely based on morphological features. Only a limited number of these new species have been described with a combination of both morphological and phylogenetic evidence (Puglisi et al., 2011; Guo et al., 2018; Hu et al., 2023; Ling et al., 2020; 2022; Lv et al., 2021; Yang et al., 2022), and the phylogenetic analyses have predominantly relied on ITS and chloroplast DNA fragment (trnL-F) sequences, which provided weak statistical support for most nodes (Chen et al., 2014). Extensive incomplete lineage sorting (ILS) and interspecific hybridization during the rapid radiation of *Oreocharis* have introduced significant complexity into the phylogenetic analyses (Kong et al., 2022). These complexities emphasize the need for a more comprehensive approach to reconstructing the phylogenetic relationships of *Oreocharis*, as relying solely on a few genetic loci are insufficient (Moller et al. 2011). Notably, only one new species in *Oreocharis*, *O. qianyuensis* Lei Cai, J. W. Yang & Q. Zhang, has been described using transcriptome data (Yang et al., 2022).

It is well-established that plant morphological characteristics are highly variable, especially among different species of the same genus, and even within different populations of the same species (Wang et al., 2015). Relying solely on morphological features for the description of new species can lead to errors, a phenomenon observed frequently within the Gesneriaceae family (Pan, 1986;1987; Chen et al., 2020). Following the extensive revision of *Oreocharis* by Moller et al. (2011), a notable taxonomic trend has emerged where numerous species from other genera are consistently being transferred into the *Oreocharis* genus. This practice has contributed to the increasing complexity of the taxonomic challenges associated with the genus (Chen et al., 2014; Fu et al., 2019; Moller et al., 2011; 2015; Yang et al., 2020). Therefore, even we suspected the species was a new discovery while we encountered it in the field, we refrained from jump to conclusions. Instead, we confirm it as a new species through a comprehensive approach, including transcriptome analysis, literature review, examination of herbarium specimens comparison of morphological characteristics with similar species, and by assessing the plants of *Oreocharis* within the original distribution area, Dayao County, Yunnan, China.

We thoroughly considered the ecological characteristics of the new species. Previous studies reported three endemic species of *Oreocharis* in Dayao County (Wang et al., 1990; 1998; Moller et al., 2011), including *O.*

vulpina (B. L. Burt & R. A. Davidson) Mich. Moller & A. Weber, *O. trichantha* (B. L. Burt & R. A. Davidson) Mich. Moller & A. Weber, and *O. rubra* (Hand. -Mazz.) Mich. Moller & A. Weber. However, our new species exhibits significant differences from three species. It exclusively thrives in dry and shady slopes on soils or, in some cases, on rocks, beneath *Quercus franchetii* Forests (Fig 3A, 3B), which is the climax plant community of the Dry and Hot Valley of Jinsha River Basin in Dayao County, at an altitude of 2100–2200m. The soil type in its habitat is Dayao Red Purple Soil (Hu et al., 2006). In contrast, *O. cordatula* and *O. aurantiaca* are only found in dark and damp forests, and grow on rocks. Although *O. trichantha* also inhabits relatively dry areas, it is specifically found on vertical stone walls, distinguishing it from the new species. Notably, *O. vulpina* and *O. rubra* have not been observed as living plants since their publication. Additionally, the distinct difference in corolla morphology between the new species and the aforementioned species suggest potential variations in their respective pollinators (Ling et al., 2022). The new species occupies a unique ecological niche and has evolved in a different direction, diverging from species like *O. henryana*, *O. aurantiaca*, *O. minor* and *O. cordatula*, leading to the formation of the new species we now recognize as *O. scutifolia*.

In addition, many herbarium specimens have yet to be digitized, especially in some remote small herbariums. Therefore, it is impractical to examine all the specimens individually, and omissions are inevitable. Moreover, when the new species are pressed into specimens, their flower features such as corolla shapes and colors, are often easily lost, and the presence of peltate leaves may not be obvious. The specimens of the newly described species, *O. cordatula*, *O. aurantiaca*, and even *O. henryana*, exhibit significant similarities, making it challenging to distinguish them even upon visual examination (Table 1). In the absence of physical specimens, differentiation becomes nearly impossible. Consequently, no exact specimens of this new species have been observed to date. Additionally, during our research, we encountered a population of *O. henryana* with peltate leaves in florescence on wet rocks in Miyi County, Sichuan, China (located on the roadside of Wantan Hydropower Station to Malong Township, 26°53'N, 101°26'E, at an elevation of 1270 m, September 13, 2017, collected by H. H. Kong, L. H. Yang, and B. F. Zhou with accession number SCMY04 at IBSC). The formation and evolution process of these two peltate-leaved species warrant further investigation.

The newly described species, *Oreocharis scutifolia*, is endemic to Dayao County, which is situated in the northwest of Chuxiong Yi Autonomous Prefecture, Yunnan Province, China (Fig. 4). All the rivers in this county are part of the Jinsha River Basin (Zhu, 2005). The region falls under a Plateau Monsoon Climate, exhibiting distinct features of a Low-latitude Mountain Monsoon Climate: ample sunlight, significant heat, limited and intermittent precipitation, well-defined dry and wet seasons, with extended dry periods (Wu, 2020). Dominant soil types in the area include red-purple soil, yellow-purple soil, purple soil, light-purple soil, purple-gray foam soil, and paddy soil (Hu et al., 2006). The natural vegetation primarily consists of Mid-subtropical Semi-humid Evergreen Broad-leaved Forests in Yunnan-Guizhou Plateau and *Pinus yunnanensis* Coniferous Forests (Zhu, 2005; Hu et al., 2006).

Due to the terrible challenging geographical and climatic conditions in the Dry and Hot Valley, the region has received limited attention in terms of plant diversity investigation. This is one of the reasons why previous specimens of this new species have not yet been discovered. Nevertheless, the unique habitat of the Dry and Hot Valley is home to several endemic species, such as *Senegalia propinqua* L. Bai, specialized in the Dry and Hot Valley of Yuanjiang, Yunnan, China (Bai et al., 2021), and *Colubrina zhaoguangii* J. Hu & Yi Yang, which is endemic to the Dry and Hot Valley of the upper Jinsha River, Sichuan, China (Hu et al., 2022). Our identification of this new species introduces a novel member to the biodiversity of the Dry and Hot Valley within Jinsha River Basin of Dayao County, emphasizing the existence of many yet-undiscovered species, even in seemingly accessible areas. Consequently, special habitats of this region should be a focal point in future biodiversity investigations.

Human activities in the Dry and Hot Valley area are frequent, posing a substantial threat to the fragile ecological environment (Zhao et al., 2023). Notably, the distribution of the new species is close proximity to villages where local inhabitants cultivate economic trees like walnuts and chestnuts, grow crops such as corn,

construct roads, and engage in tree felling, resulting in severe soil erosion. Additionally, a significant presence of *Ageratina adenophora* (Spreng.) R. M. King & H. Robinson has been observed in the side of the new species, competing for living space and exerting a lasting and substantial influence on the environment (Fig 3B). Therefore, the survival of this new species is in jeopardy, necessitating immediate protective measures.

Taxonomy treatment

Oreocharis scutifolia Z. Xie, Miao Zhang & H. H. Kong sp. nov (Fig 2).

Type.

China, Yunnan Province, Chuxiong Yi Autonomous Prefecture, Dayao County, Shiyang community, Dashiqiao village, 25deg50'N, 101deg4'E, alt. 2134m, on Dry and Hot Valley, rocks or soils on hillsides in the forests, flowering, 12 July 2023, Z. Xie & M. Zhang, XieZ 3677 (holotype, IBSC! isotype, IBSC!).

Diagnosis.

This species resembles to *Oreocharis aurantiaca* in morphology and systematic, especially in flower. However, it exhibits peltate, ovate to oblong leaf blade (*vs.* rhomboid narrowly ovate to narrowly elliptic leaf blade in *O. aurantiaca*, same as followings), petiole adnate to the lower half of leaf blade at a position 0.5—1 cm upwards from the base (*vs.* petiole adnate to the leaves' base directly), leaf blade margin shallowly undulate to nearly entire (*vs.* serrate), and adaxially smooth and glabrous (*vs.* densely appressed pubescent); peduncles 3—7 cm long (*vs.* 10—16 cm long), corolla 1.1—1.3 cm long (*vs.* 1.7—2.1 cm long).

Description.

Herb perennial and stemless, rhizomatous. Leaves basal; petiole densely brown manicate lanose, leaf blade leathery, adaxially green, smooth and glabrous, midrib veins hollowly, lateral veins not obviously; abaxially brown, densely brown manicate lanose, midrib and lateral veins distinct; base rounded, apex obtuse, margin shallowly undulate to nearly entire. The outer leaf: petiole 3.9—6.2 cm long, leaf blade oblong to ovate, 4.5—7.7 x 3.3—4.5 cm, lateral veins 6—7 on each side of midrib; the inner leaf: petiole 2.3—3.7 cm long, leaf blade oval to rounded, 2.8—3.4 x 1.8—3.5 cm, lateral veins 5—7 on each side of midrib. Inflorescence cymose, axillary, 4—6 per plant, 6—12 flowered per cyme. Peduncle 2—4 branched, 3—7 cm long, densely white glandular pubescent; bract usually not present or caducous. Pedicel 1.2—1.8 cm long, densely white glandular pubescent. Calyx 2.4—3.0 mm long, 5-sect nearly from base; segments equal, oblong, 1.9—2.7 x 1.1—1.3 mm, margin entire, apex obtuse, adaxially glabrous, abaxially sparsely white glandular pubescent. Corolla slenderly cylindric, yellow, 1.1—1.3 cm long, outside white glandular pubescent and inside glabrous; tube cylindric, gradually slightly narrowing from base of tube, 8—9 mm long, throat constricted, base of the tube 2.9—3.2 mm in diam., and middle of the tube 1.8—1.9 mm in diam.. limb 2-lipped, 3.6—3.9 x 4.4—5.2 mm in diam.; adaxial lip smaller, 1.4—1.6 x 1.5—1.8 mm, apex obtuse; abaxial lip larger, 3-lobed, lateral lobes larger than the central one, central lobe oblong, apex obtuse, 2.3—2.9 x 1.3—1.5 mm; lateral lobes ovate, apex rounded, 2.8—3.3 x 2.3—2.6 mm. Stamens 4, free; adaxial stamens 6.1—6.6 mm long, adnate to corolla tube 3.0—3.4 mm from the base; abaxial stamens 3.3—3.6 mm long, adnate to corolla tube 0.8—1.1 mm from the base; filaments glabrous; anthers basifixed, 0.9—1.1 mm long, elliptic, 2-loculed, dehiscing longitudinally; staminode 3.1—3.3 mm long, adnate to corolla tube 0.7—1.0 mm from the base. Disc ring-like, yellow, 1—2 mm high, margin 5-lobed shallowly. Pistil glabrous, 0.5—1.6 cm long; ovary elliptic, 0.4—1.2 cm, 1-loculed; style 0.2—0.4 cm; stigma 1, emarginate. Capsule straight, narrowly elliptic, glabrous, 2—3 cm x 0.3—0.5 cm. Seeds not seen.

Distribution, habitat and phenology.

The new species is endemic to the Dry and Hot Valley of Jinsha River Basin, and is currently known to occur exclusively in Dashiqiao village, Shiyang community, Dayao County, Chuxiong Yi Autonomous Prefecture, Yunnan, China. On rocks or soils under the semi-humid evergreen broad-leaved forests in Dry and Hot Valley. Flowering is July to August, and fruiting is August to September.

Conservation status.

To date, only one population of the new species has been observed in the field, located at the type locality on the hillside of the village, comprising ca. 500 mature individuals and ca. 10,000 m² (100 m x 100 m) area. This habit is under severe threat from various human activities, including road construction, building, deforestation and grazing. Furthermore, it has been continuously invaded by *Ageratina adenophora* for an extended period, and this invasive species covers a substantial area while expanding within the vicinity, which directly jeopardize the survival of the new species. According to the IUCN Red List Categories and Criteria, the new species is hereby assessed as “Critically Endangered [CR, (B1+B2a,b (iii))]” (IUCN, 2021).

Etymology.

The species is named after its peltate leaves.

Vernacular name.

In Chinese mandarin ‘Dun Ye Mǎ Líng Jǔ Tái’ (盾叶马铃苣苔).

Key to the similar species with *O. scutifolia*.

- 1, leaf blade peltate.2.
- 1, leaf blade is not peltate.3.
- 2, Flower purple red. *O. henryana* .
- 2, Flower yellow. *O. scutifolia* .
- 3, Pistil glabrous.4.
- 3, Pistil covered with light brown glandular pubescence. *O. cordatula* .
- 4, Flower yellow.....5.
- 4, Flower purple red..... *O. henryana* .
- 5, Plant small, adaxially blade leaf glabrous. *O. minor* .
- 5, Plant tall, adaxially blade leaf puberulent. *O. aurantiaca* .

Additional specimens of *O. scutifolia*.

There is no additional specimen of *O. scutifolia* available, and therefore, we are unable to list any specimen beyond XieZ 3677 due to the rarity of this new species. We conducted extensive examinations of specimens from PE, KUN and IBSC that collected from Dayao County, Chuxiong Yi Autonomous Prefecture, Yunnan Province, China. Regrettably, we did not come across any specimens of this plant in these herbaria. Moreover, we meticulously examined all specimens of *Oreocharis* and even the entire Gesneriaceae family within the herbarium, but found no records of this species. It is our estimate that very few botanist have conducted field investigations and specimen collections in this specific area over the past century. This new species appears to be exclusively distributed in this region, XieZ 3677 remains the sole collection of this new species, serving as the type specimen.

Data availability statement

The sequences of this study have been deposited in The National Center for Biotechnology Information (NCBI) database. The transcriptome data of *Oreocharis scutifolia* and *O. cordatula* in this study are openly available from NCBI: <https://www.ncbi.nlm.nih.gov/sra/PRJNA1032259>. GenBank accession numbers of transcriptome data in this study can be found in Supplement Table 1.

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Conflict of interest statement

There's no conflict of interest to declare.

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Figure Legends

Figure 1. A maximum likelihood (ML) phylogeny of *Oreocharis* based on the transcriptome data set of 572 orthologous genes. The new species is shown in red, with the branch on which it was placed marked in yellow.

Figure 2. *Oreocharis scutifolia*. (A) Plants with flowers and dehiscent capsules; (B) Adaxial leaf (left) and abaxial leaf (right); (C) Flower; (D) Opening corolla showing stamens and staminode; (E) Pistil with sepals; (F) Dehiscent capsule. Drawn by Yun-Xiao Liu from South China Botanical Garden.

Figure 3. *Oreocharis scutifolia* Z. Xie, Miao Zhang & H. H. Kong sp. nov. (A) Habitat, the *Quercus franchetii* Forests; (B) Population, invaded by *Ageratina adenophora*; (C) Habit; (D) The outer leaves: adaxially blade (left) and abaxially blade (right); (E) The inner leaves; (F) Cyme; (G) Left side view of the flowers; (H) Calyx; (I) Front view of flower; (J) Opening corolla, showing stamens and staminode; (K) Pistil and disk; (L) Dehiscent capsules.

Figure 4. Distribution map of *Oreocharis scutifolia*, *O. cordatula*, *O. aurantiaca*, *O. henryana*, and *O. minor*.

Figure 5. Comparison of *Oreocharis scutifolia* (A1–A7), *O. cordatula* (B1–B7) and *O. aurantiaca* (C1–C7). A1, B1 & C1, Habit. A2, B2 & C2, Leaves: adaxially blade (left) and abaxially blade (right). A3, B3 & C3, Leaf base: adaxially blade. A4, B4 & C4, Leaf base: abaxially blade. A5, B5 & C5, Cymes. A6, B6 & C6, Front view of flowers. A7, B7 & C7, Left side view of the flowers. C3, C4, C5 & C7 were taken by Xin-Xin Zhu; C6 was taken by Hang-Hui Kong; and other photos were taken by Zhi Xie & Miao Zhang.

Table 1. Morphological comparison among *O. scutifolia*, *O. cordatula*, *O. aurantiaca*, *O. minor* and *O. henryana*.

Supplement Table 1. List of sampled taxa and their GenBank accession numbers of transcriptome data. Species in bold were generated in this study, and the transcriptome data of other populations came from our previous study.

Figure 1. A maximum likelihood (ML) phylogeny of *Oreocharis* based on the transcriptome data set of 572 orthologous genes. The new species is shown in red, with the branch on which it was placed marked in yellow.

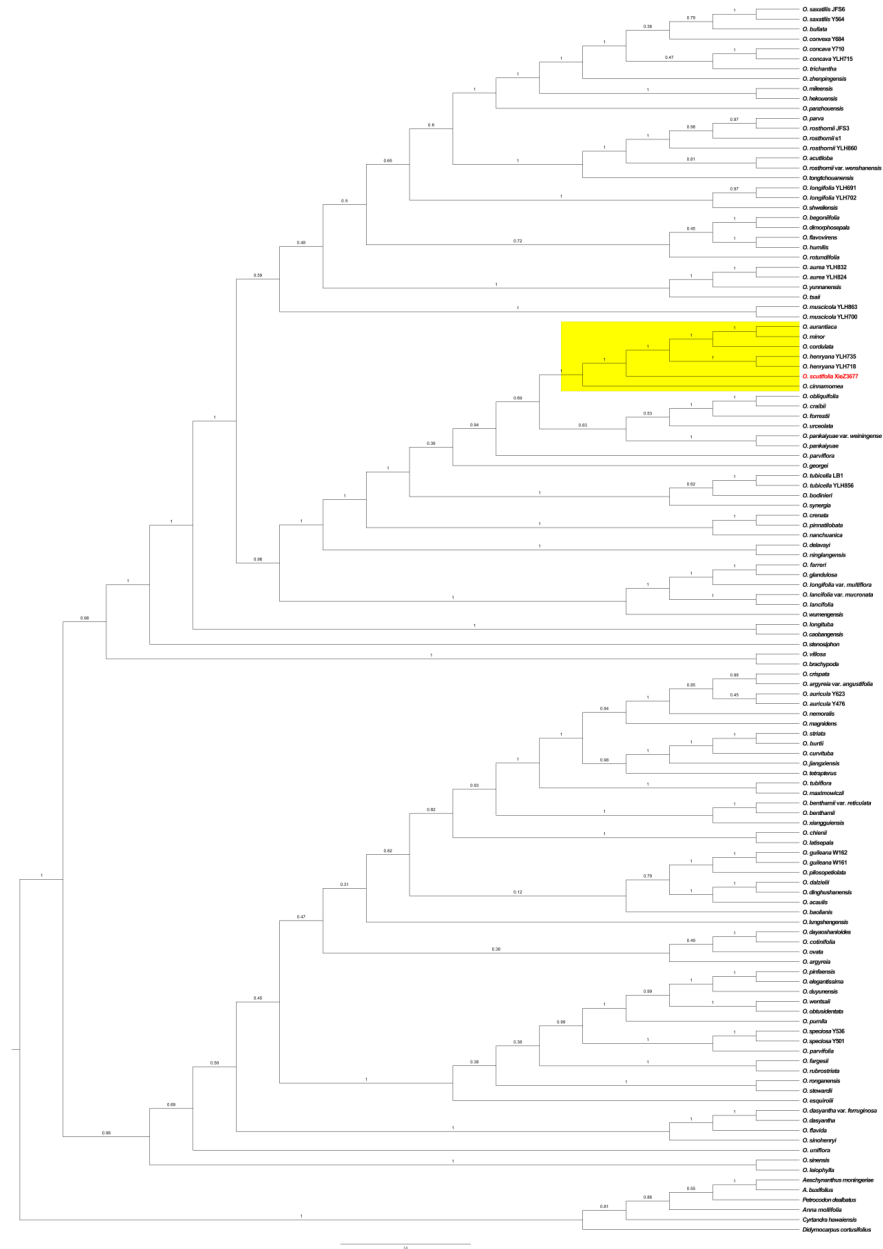


Figure 2. *Oreocharis scutifolia*.

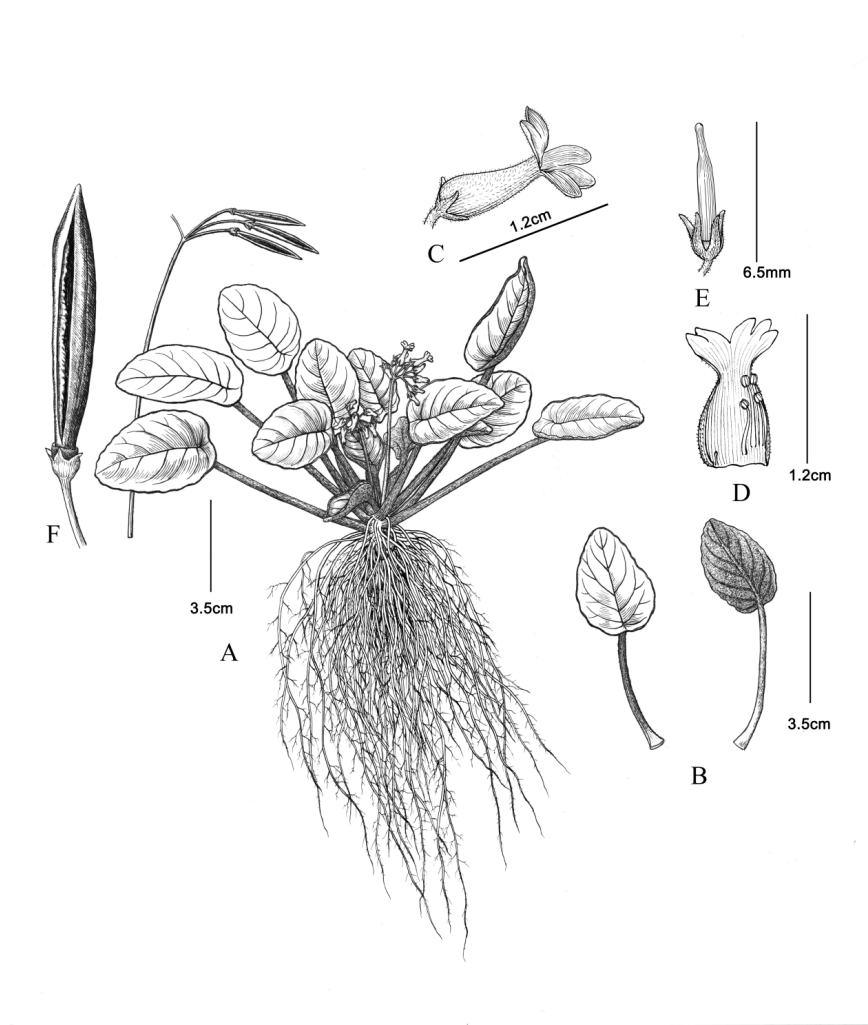


Figure 3. *Oreocharis scutifolia* Z. Xie, Miao Zhang & H. H. Kong sp. nov.

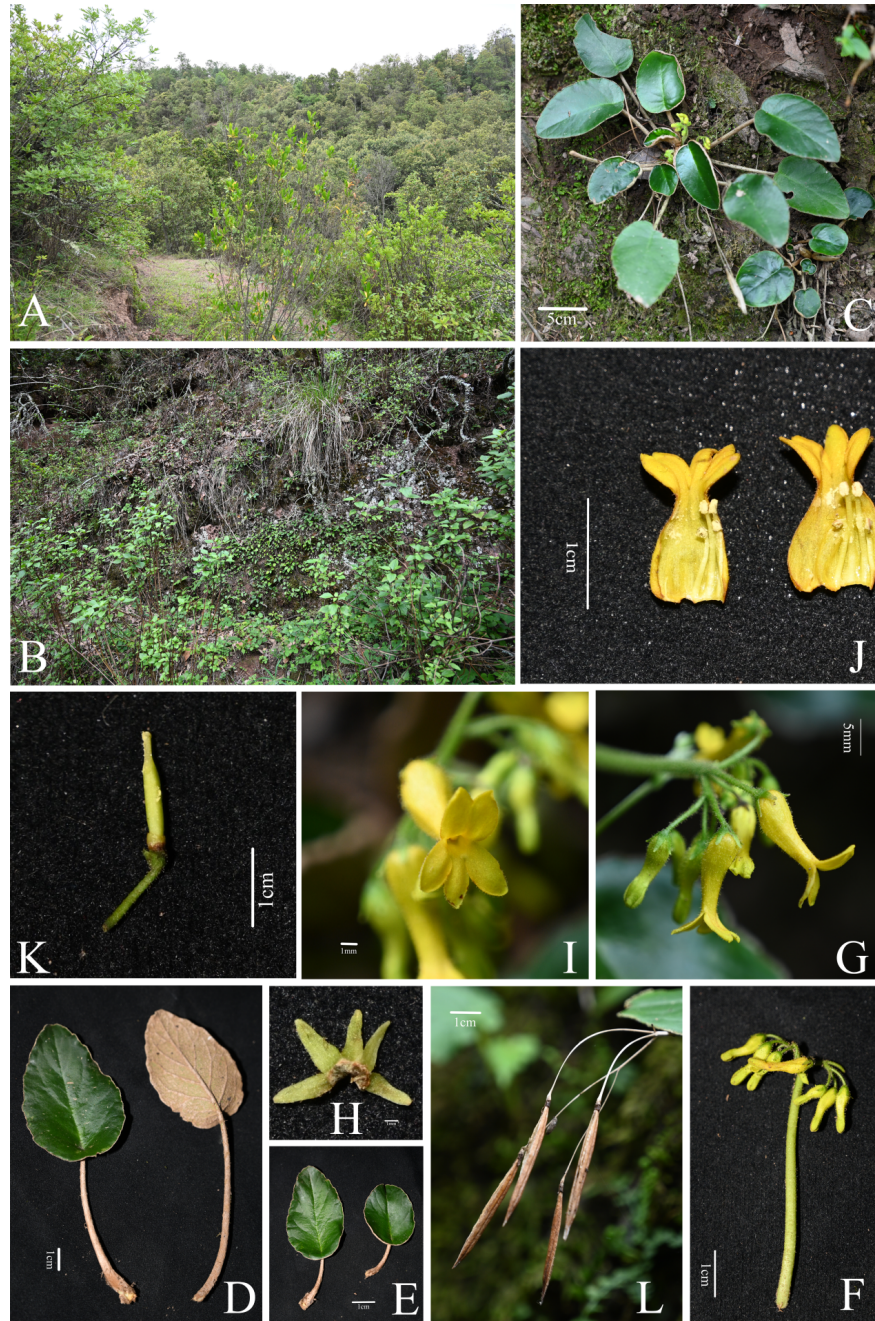


Figure 4. Distribution map of *Oreocharis scutifolia* , *O. cordatula* , *O. aurantiaca* , *O. henryana* , and *O. minor* .

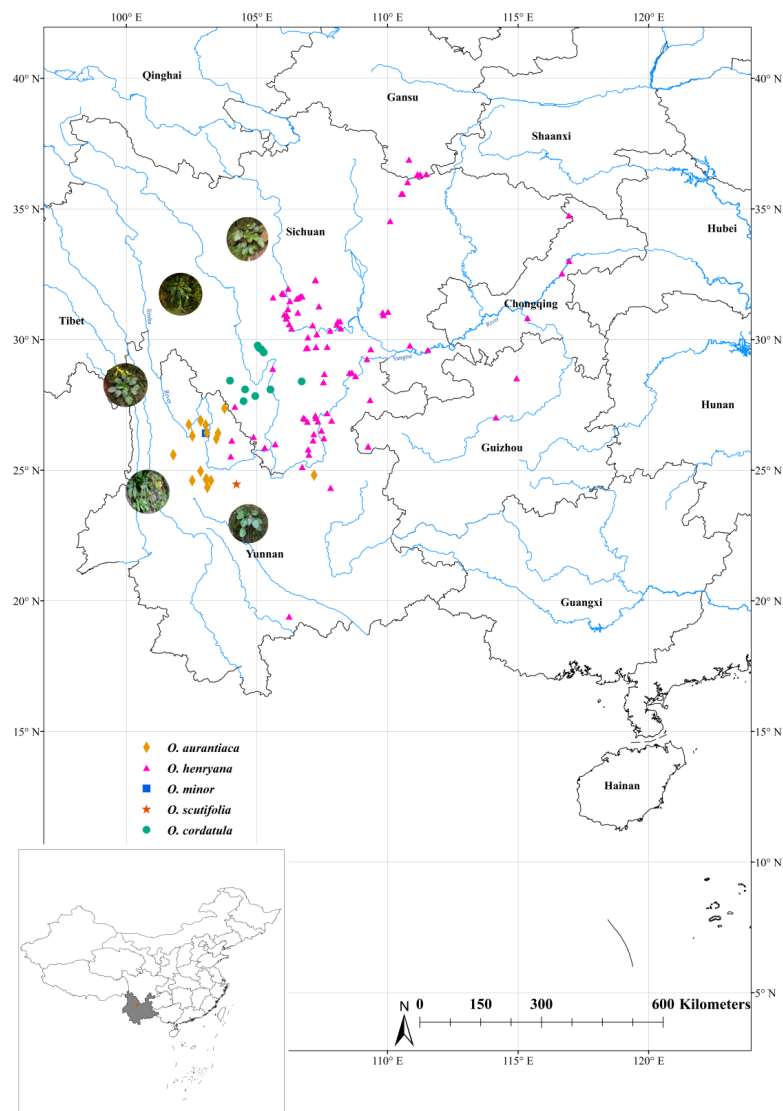


Figure 5. Comparison of *Oreocharis scutifolia* , *O. cordatula* and *O. aurantiaca* .

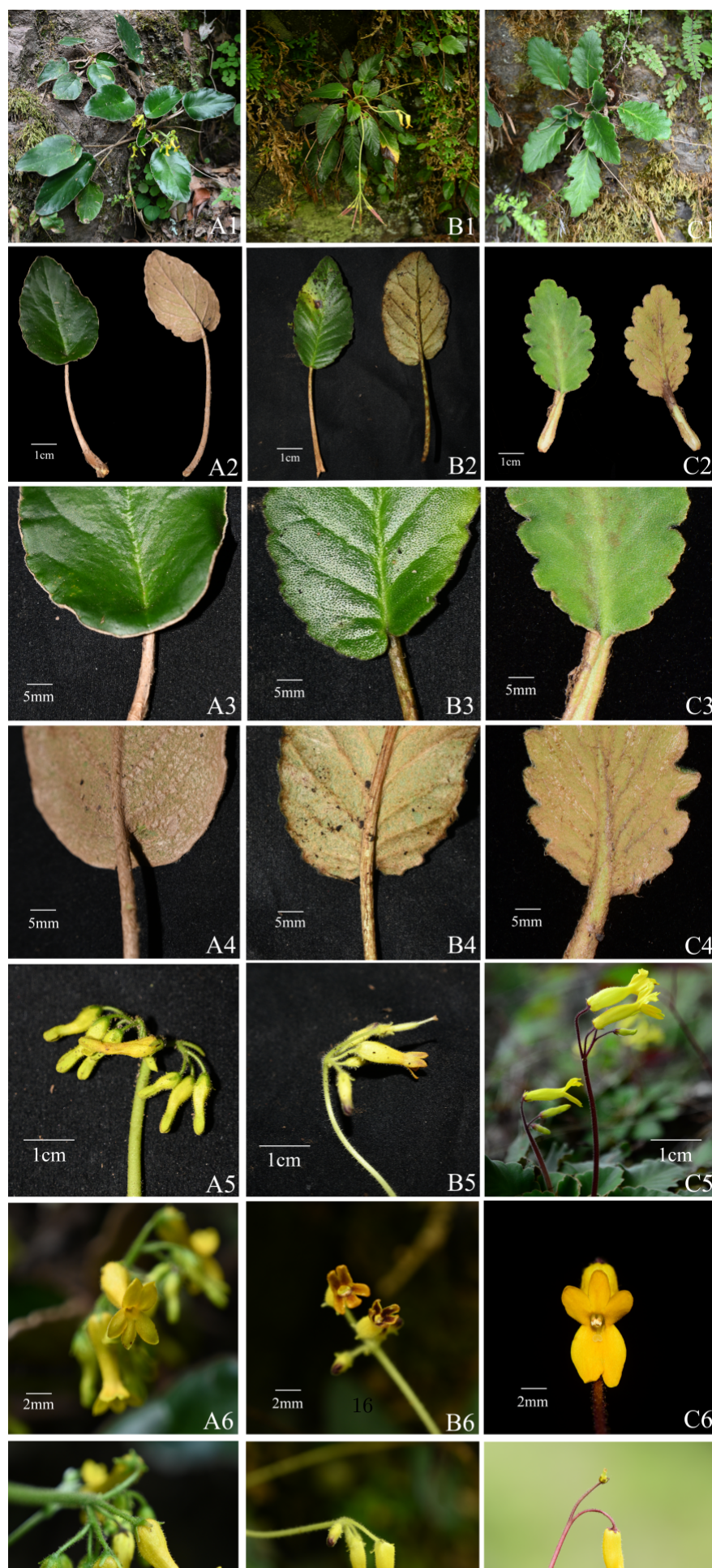


Table 1. Morphological comparison among *O. scutifolia* , *O. cordatula* , *O. aurantiaca* , *O. minor* and *O. henryana* .

Characters	<i>O. scutifolia</i>	<i>O. cordatula</i>
Habitat	On rocks or soils under the semi-humid evergreen broad-leaved forests.	On rocks or soils
Leaf blade		
Shape	Peltate, oblong to ovate, even rounded in the inner leaf.	Ovate-lanceolate
Adaxial surface	Smooth and hairless.	Densely appressed
Abaxial surface	Densely brown manicate lanose.	Densely pale lanose
Margin	Shallowly undulate to nearly entire.	Coarsely crenate
No. of Lateral veins	5—6 pairs.	5 or 6 pairs.
Peduncle indumentum	Densely covered with white glandular pubescence.	Translucent tomentum
Bract	Bract usually not present.	2, deciduous, tomentose
Corolla limp		
Color and size	Yellow, 1.1—1.3 cm.	Deep orange to red
Adaxial lip lobes size	1.4—1.6 × 1.5—1.8 mm.	3—4 × 3—5 mm
Abaxial lip lobes size	2.3—2.9 × 1.3—1.5 mm.	6—7 × ca. 2 mm
Stamens		
Places in corolla tube	Adnate to corolla tube 3.0—3.6 mm from base.	Adnate to corolla tube
Free filaments length	3—7 mm.	8—11 mm.
Staminode length	3.1—3.3 mm.	Ca. 0.5 mm.
Ovary	Glabrous.	Glandular pubescent

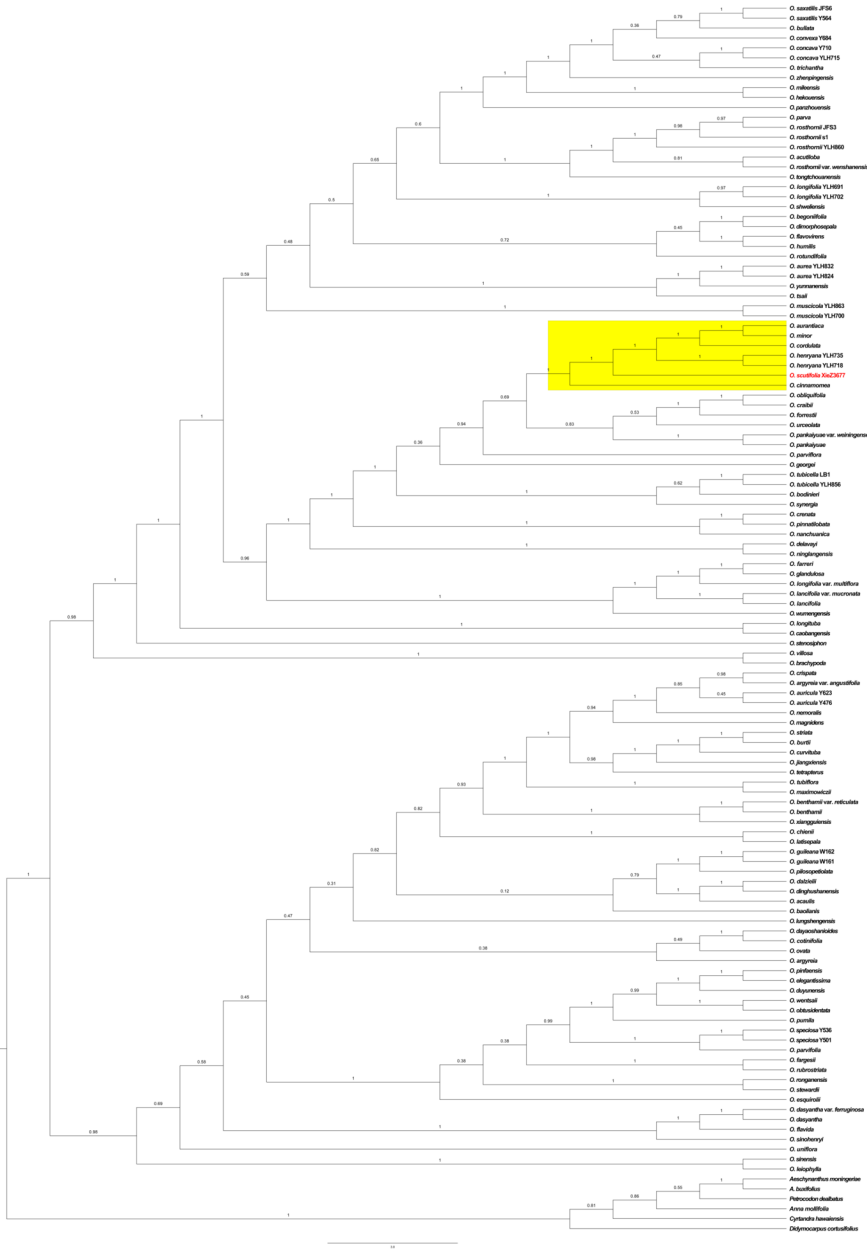
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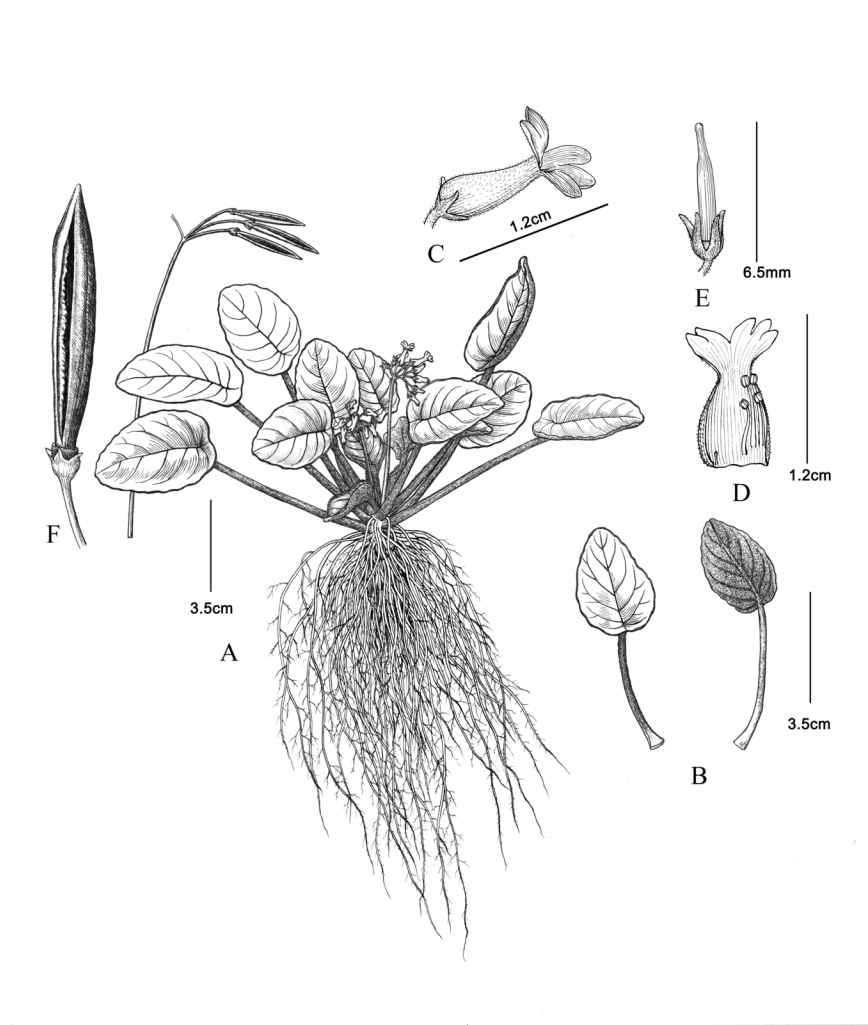
Species	Voucher number	Location	BioProject	BioSample accession
Ingroup				
<i>O. acaulis</i>	Y434	Longmen, Guangdong, China	PRJNA649046	SAMN156558
<i>O. acutiloba</i>	YLH820	Yuxi, Yunnan, China	PRJNA649046	SAMN156558
<i>O. argyreia</i>	Y626	Shanglin, Guangxi, China	PRJNA649046	SAMN156558
<i>O. argyreia</i> var. <i>angustifolia</i>	Y475	Jinggangshan, Jiangxi, China	PRJNA649046	SAMN156558
<i>O. aurantiaca</i>	YLH812	Ninglang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. aurea</i>	YLH824	Honghe, Yunnan, China	PRJNA649046	SAMN156558
<i>O. aurea</i>	YLH832	Yuanyang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. auricula</i>	Y476	Jinggangshan, Jiangxi, China	PRJNA649046	SAMN156558
<i>O. auricula</i>	Y623	Yangshan, Guangdong, China	PRJNA649046	SAMN156558
<i>O. baolianis</i>	W144	Changting, Fujian, China	PRJNA649046	SAMN156558
<i>O. begoniifolia</i>	Y671	Jingdong, Yunnan, China	PRJNA649046	SAMN156558
<i>O. benthamii</i>	Y1000	Boluo, Guangdong, China	PRJNA649046	SAMN156558
<i>O. benthamii</i> var. <i>reticulata</i>	Y496	Qingyuan, Guangdong, China	PRJNA649046	SAMN156558
<i>O. bodinieri</i>	KUN1	Qiaojia, Yunnan, China	PRJNA649046	SAMN156558
<i>O. brachypodus</i>	Y587	Tongren, Guizhou, China	PRJNA649046	SAMN156558
<i>O. bullata</i>	Y767	Huize, Yunnan, China	PRJNA649046	SAMN156558
<i>O. burtii</i>	Y446	Longnan, Jiangxi, China	PRJNA649046	SAMN156558
<i>O. caobangensis</i>	W45	Cao Bang, Vietnam	PRJNA649046	SAMN156558
<i>O. chienii</i>	HS1	Taishun, Zhejiang, China	PRJNA649046	SAMN156558
<i>O. cinnamomea</i>	YLH808	Ninglang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. concava</i>	Y710	Yanbian, Sichuan, China	PRJNA649046	SAMN156558

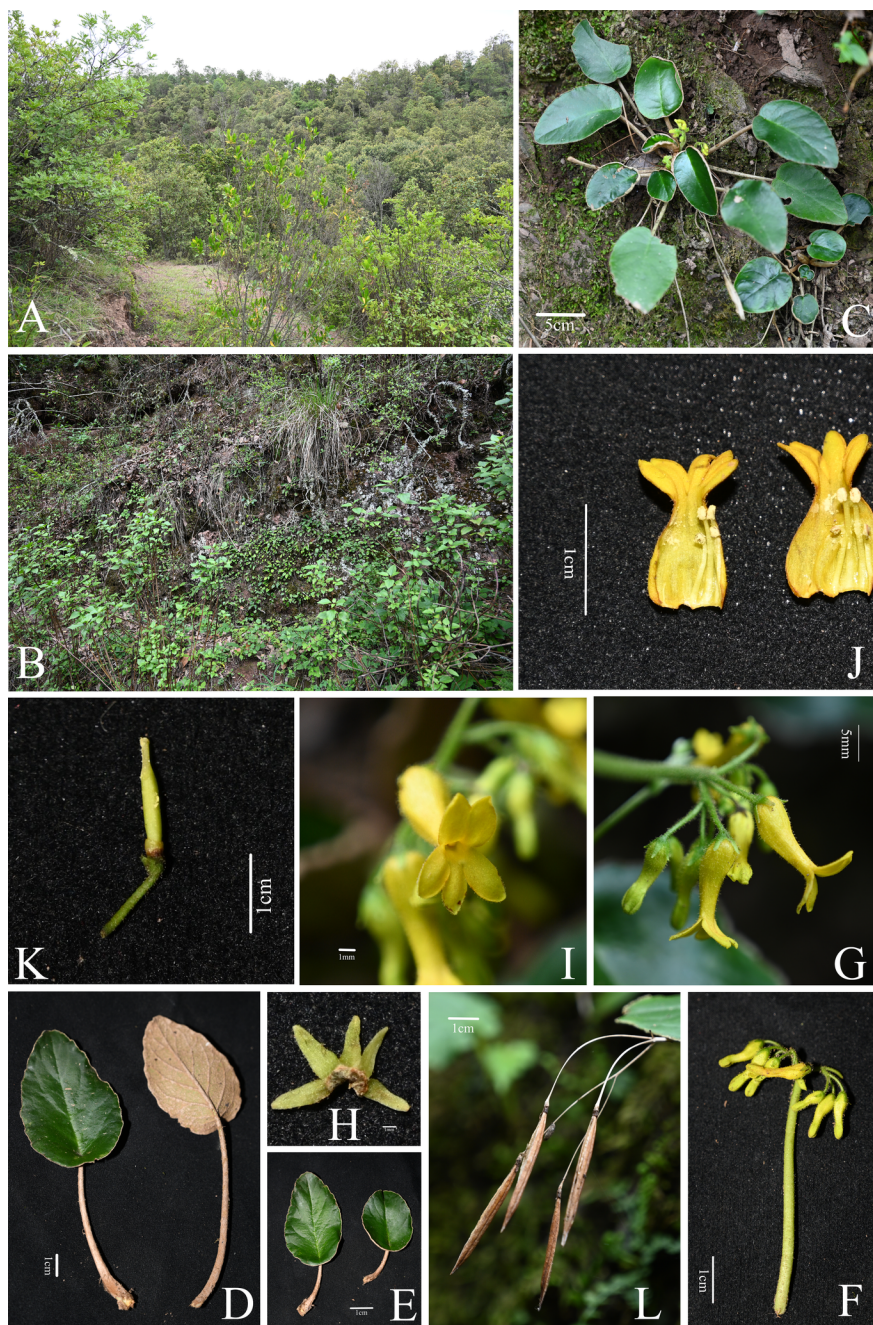
Species	Voucher number	Location	BioProject	BioSample ac
<i>O. concava</i>	YLH715	Yanyuan, Sichuan, China	PRJNA649046	SAMN156558
<i>O. convexa</i>	Y684	Dali, Yunnan, China	PRJNA649046	SAMN156558
<i>O. cordatula</i>	XieZ3724	Jiulong, Sichuan, China	PRJNA1032259	SAMN3798
<i>O. cotinifolia</i>	W6	Jinxiu, Guangxi, China	PRJNA649046	SAMN156558
<i>O. craibii</i>	YLH810	Ninglang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. crenata</i>	Y561	Wuxi, Chongqing, China	PRJNA649046	SAMN156558
<i>O. crispata</i>	W164	Quanzhou, Guangxi, China	PRJNA649046	SAMN156558
<i>O. curvituba</i>	Y921	Guanyang, Guangxi, China	PRJNA649046	SAMN156558
<i>O. dalzielii</i>	W152	Xinfeng, Guangdong, China	PRJNA649046	SAMN156558
<i>O. dasyantha</i>	Y794	Ledong, Hainan, China	PRJNA649046	SAMN156558
<i>O. dasyantha</i> var. <i>ferruginosa</i>	Y795	Chanzhou, Hainan, China	PRJNA649046	SAMN156558
<i>O. dayaoshanioides</i>	Y625	Wuzhou, Guangxi, China	PRJNA649046	SAMN156558
<i>O. delavayi</i>	Y699	Deqin, Yunnan, China	PRJNA649046	SAMN156558
<i>O. dimorphosepala</i>	YLH838	Yuanyang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. dinghushanensis</i>	Y866	Zhaoqing, Guangdong, China	PRJNA649046	SAMN156558
<i>O. duyunensis</i>	W56	Duyun, Guizhou, China	PRJNA649046	SAMN156558
<i>O. elegantissima</i>	YLH605	Dushan, Guizhou, China	PRJNA649046	SAMN156558
<i>O. esquirolii</i>	Y774	Anlong, Guizhou, China	PRJNA649046	SAMN156558
<i>O. fargesii</i>	Y568	Chengkou, Chongqing, China	PRJNA649046	SAMN156558
<i>O. farreri</i>	YLH734	Longnan, Gansu, China	PRJNA649046	SAMN156558
<i>O. flavida</i>	Y786	Baoting, Hainan, China	PRJNA649046	SAMN156558
<i>O. flavovirens</i>	W149	Longnan, Gansu, China	PRJNA649046	SAMN156559
<i>O. forrestii</i>	YLH817	Lijiang, Yunnan, China	PRJNA649046	SAMN156558
<i>O. georgei</i>	YLH805	Muli, Sichuan, China	PRJNA649046	SAMN156558
<i>O. glandulosa</i>	YLH740	Wenxian, Gansu, China	PRJNA649046	SAMN156558
<i>O. guileana</i>	W161	Shenzhen, Guangdong, China	PRJNA649046	SAMN156558
<i>O. guileana</i>	W162	Shenzhen, Guangdong, China	PRJNA649046	SAMN156558
<i>O. hekouensis</i>	YLH847	Mengzi, Yunnan, China	PRJNA649046	SAMN156558
<i>O. henryana</i>	YLH718	Yuexi, Sichuan, China	PRJNA649046	SAMN156558
<i>O. henryana</i>	YLH735	Wenxian, Gansu, China	PRJNA649046	SAMN156558
<i>O. humilis</i>	Y777	Wuxi, Chongqing, China	PRJNA649046	SAMN156558
<i>O. jiangxiensis</i>	Y447	Xunwu, Jiangxi, China	PRJNA649046	SAMN156558
<i>O. lancifolia</i>	YLH729	Lushan, Sichuan, China	PRJNA649046	SAMN156558
<i>O. lancifolia</i> var. <i>mucronata</i>	W160	Wenchuan, Sichuan, China	PRJNA649046	SAMN156558
<i>O. latisepala</i>	Y1008	Jingning, Zhejiang, China	PRJNA649046	SAMN156558
<i>O. leiophylla</i>	YLH450	Yongan, Fujian, China	PRJNA649046	SAMN156558
<i>O. longifolia</i>	YLH691	Baoshan, Yunnan, China	PRJNA649046	SAMN156558
<i>O. longifolia</i>	YLH702	Jingdong, Yunnan, China	PRJNA649046	SAMN156558
<i>O. longifolia</i> var. <i>multiflora</i>	Y736	Wenxian, Gansu, China	PRJNA649046	SAMN156558
<i>O. longituba</i>	W47	Farsipan, Vietnam	PRJNA649046	SAMN156559
<i>O. lungshengensis</i>	W32	Longsheng, Guangxi, China	PRJNA649046	SAMN156559
<i>O. magnidens</i>	W9	Jinxiu, Guangxi, China	PRJNA649046	SAMN156559
<i>O. maximowiczii</i>	Y964	Suichuan, Jiangxi, China	PRJNA649046	SAMN156559
<i>O. mileensis</i>	YLH851	Shilin, Yunnan, China	PRJNA649046	SAMN156559
<i>O. minor</i>	YLH818	Lijiang, Yunnan, China	PRJNA649046	SAMN156559
<i>O. muscicola</i>	YLH700	Deqin, Yunnan, China	PRJNA649046	SAMN156559
<i>O. muscicola</i>	YLH863	Chayu, Tibet, China	PRJNA649046	SAMN156559
<i>O. nanchuanica</i>	YLH796	Nanchuan, Chongqing, China	PRJNA649046	SAMN156559
<i>O. nemoralis</i>	Y913	Shuangpai, Hunan, China	PRJNA649046	SAMN156559
<i>O. ninglangensis</i>	YLH809	Ninglang, Yunnan, China	PRJNA649046	SAMN156559

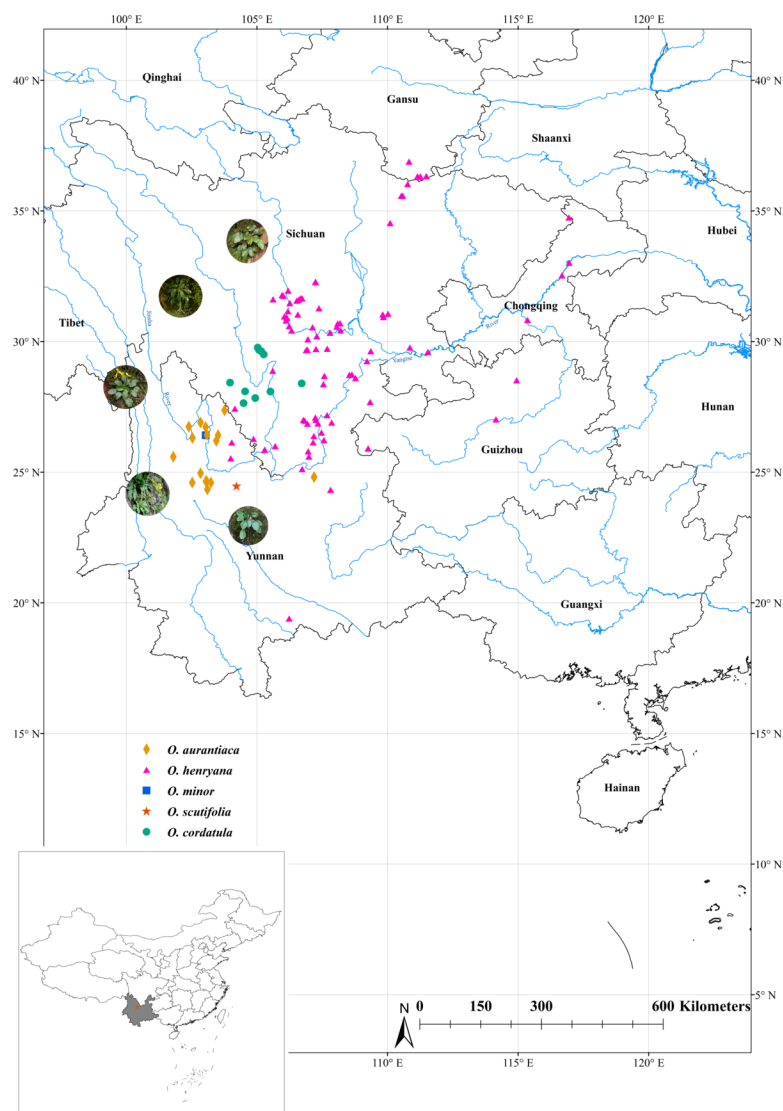
Species	Voucher number	Location	BioProject	BioSample ac
<i>O. obliquifolia</i>	YLH802	Miyi, Sichuan, China	PRJNA649046	SAMN156559
<i>O. obtusidentata</i>	Y615	Suining, Hunan, China	PRJNA649046	SAMN156559
<i>O. ovata</i>	LN3	Liannan, Guangdong, China	PRJNA649046	SAMN156559
<i>O. pankaiyuae</i>	Y743	Mabian, Sichuan, China	PRJNA649046	SAMN156559
<i>O. pankaiyuae</i> var. <i>weiningense</i>	YLH761	Weining, Guizhou, China	PRJNA649046	SAMN156559
<i>O. panzhouensis</i>	W142	Panzhou, Guizhou, China	PRJNA649046	SAMN156559
<i>O. parva</i>	Y529	Xuanen, Hubei, China	PRJNA649046	SAMN156559
<i>O. parviflora</i>	Y697	Lanping, Yunnan, China	PRJNA649046	SAMN156559
<i>O. parvifolia</i>	W143	Guiding, Guizhou, China	PRJNA649046	SAMN156559
<i>O. pilosopetiolata</i>	W158	Huidong, Guangdong, China	PRJNA649046	SAMN156559
<i>O. pinfaensis</i>	K23	Pingfa, Guizhou, China	PRJNA649046	SAMN156559
<i>O. pinnatilobata</i>	Y577	Qianjiang, Chongqing, China	PRJNA649046	SAMN156559
<i>O. pumila</i>	W166	Daxin, Guangxi, China	PRJNA649046	SAMN156559
<i>O. ronganensis</i>	W16	Rongan, Guangxi, China	PRJNA649046	SAMN156559
<i>O. rosthornii</i>	JFS3	Nanchuan, Chongqing, China	PRJNA649046	SAMN156559
<i>O. rosthornii</i>	s1	Emei, Sichuan, China	PRJNA649046	SAMN156559
<i>O. rosthornii</i>	YLH860	Panzhou, Guizhou, China	PRJNA649046	SAMN156559
<i>O. rosthornii</i> var. <i>wenshanensis</i>	YLH849	Wenshan, Yunnan, China	PRJNA649046	SAMN156559
<i>O. rotundifolia</i>	YLH846	Pingbian, Yunnan, China	PRJNA649046	SAMN156559
<i>O. rubrostriata</i>	W150	Rongshui, Guangxi, China	PRJNA649046	SAMN156559
<i>O. saxatilis</i>	JFS6	Nanchuan, Chongqing, China	PRJNA649046	SAMN156559
<i>O. saxatilis</i>	Y564	Chengkou, Chongqing, China	PRJNA649046	SAMN156559
<i>O. scutifolia</i>	XieZ3677	Dayao, Yunnan, China	PRJNA1032259	SAMN3798
<i>O. shweliensis</i>	Y685	Baoshan, Yunnan, China	PRJNA649046	SAMN156559
<i>O. sinensis</i>	W37	Longmen, Guangdong, China	PRJNA649046	SAMN156559
<i>O. sinohenryi</i>	W15	Fangchenggang, Guangxi, China	PRJNA649046	SAMN156559
<i>O. speciosa</i>	Y536	Jianshi, Hubei, China	PRJNA649046	SAMN156559
<i>O. speciosa</i>	Y501	Huaihua, Hunan, China	PRJNA649046	SAMN156559
<i>O. stenosphon</i>	Y579	Xianfeng, Hubei, China	PRJNA649046	SAMN156559
<i>O. stewardii</i>	W61	Sanjiang, Guangxi, China	PRJNA649046	SAMN156559
<i>O. striata</i>	Y1004	Youxi, Fujian, China	PRJNA649046	SAMN156559
<i>O. synergia</i>	YLH814	Yongsheng, Yunnan, China	PRJNA649046	SAMN156559
<i>O. tetrapteris</i>	W155	Hezhou, Guangxi, China	PRJNA649046	SAMN156559
<i>O. tongtchouanensis</i>	YLH766	Huize, Yunnan, China	PRJNA649046	SAMN156559
<i>O. trichantha</i>	YLH703	Dayao, Yunnan, China	PRJNA649046	SAMN156559
<i>O. tsaii</i>	Y645	Menglian, Yunnan, China	PRJNA649046	SAMN156559
<i>O. tubicella</i>	LB1	Leibo, Sichuan, China	PRJNA649046	SAMN156559
<i>O. tubicella</i>	YLH856	Ganluo, Sichuan, China	PRJNA649046	SAMN156559
<i>O. tubiflora</i>	W145	Nanping, Fujian, China	PRJNA649046	SAMN156559
<i>O. uniflora</i>	Y1001	Huidong, Guangdong, China	PRJNA649046	SAMN156559
<i>O. urceolata</i>	Y717	Yanyuan, Sichuan, China	PRJNA649046	SAMN156559
<i>O. villosa</i>	Y571	Shizhu, Chongqing, China	PRJNA649046	SAMN156559
<i>O. wentsaii</i>	Y596	Taijiang, Guizhou, China	PRJNA649046	SAMN156559
<i>O. wumengensis</i>	K9	Yanjin, Yunnan, China	PRJNA649046	SAMN156559
<i>O. xianguiensis</i>	Y616	Xinning, Hunan, China	PRJNA649046	SAMN156559
<i>O. yunnanensis</i>	Y641	Lancang, Yunnan, China	PRJNA649046	SAMN156559
<i>O. zhenpingensis</i>	YLH559	Zhenping, Shaanxi, China	PRJNA649046	SAMN156559
Outgroup				
<i>Cyrtandra hawaiiensis</i>	W109	Guiling, Guangxi, China	PRJNA649046	SAMN156559
<i>Petrocodon dealbatus</i>	W24	Lingchuan, Guangxi, China	PRJNA649046	SAMN156559

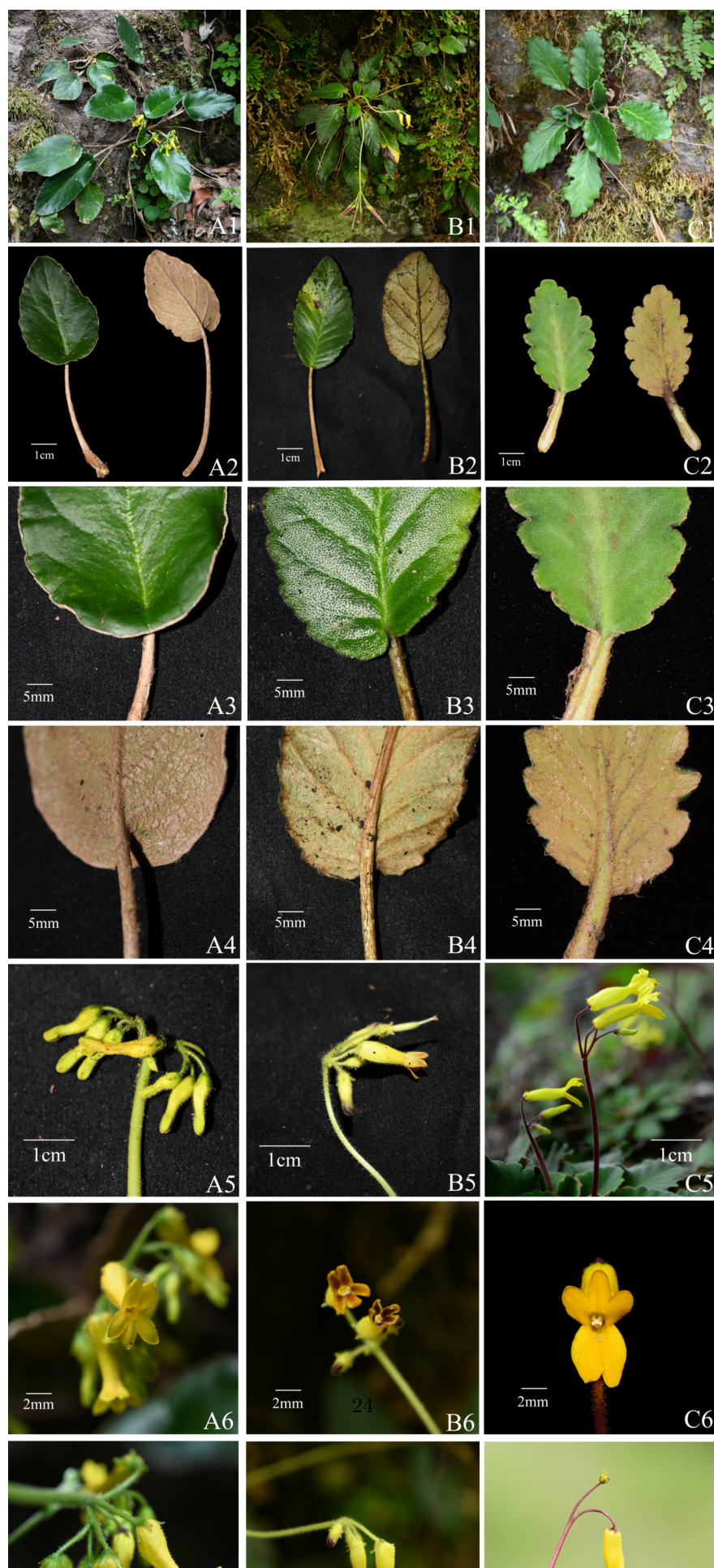
Species	Voucher number	Location	BioProject	BioSample ac
<i>Didymocarpus cortusifolius</i>	W82	Leqing, Zhejiang, China	PRJNA649046	SAMN156559
<i>Anna mollifolia</i>	W93	Napo, Guangxi, China	PRJNA649046	SAMN156559
<i>Aeschynanthus moningeriae</i>	Y792	Wuzhishan, Hainan, China	PRJNA649046	SAMN156559
<i>Aeschynanthus burifolius</i>	YLH825	Honghe, Yunnan, China	PRJNA649046	SAMN156559











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