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# A New Species of *Pedicularis* (Orobanchaceae) from the Hengduan Mountains, Southwestern China

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**ABSTRACT.** *Pedicularis obliquigaleata* W. B. Yu & H. Wang (Orobanchaceae) is described and illustrated from the Hengduan Mountains, in Yunnan Province, southwestern China. This new species was found in alpine meadows and along the edge of *Abies* Mill. forest. The new taxon is placed in *Pedicularis* ser. *Dissectae* H. L. Li and is similar to *P. souliei* Franch. from Sichuan Province. *Pedicularis obliquigaleata* differs by having densely gray pubescent stems; a pinnatipartite leaf with segments that are triangular-ovate to oblong-ovate with dentate margins; and flowers with two calyx lobes, a bent galea, semicircular beak, and a purple or rose-red corolla lower lip with a subtruncate middle lobe. Pollen and seed coat surface micromorphology of *P. obliquigaleata* were examined by scanning electron microscopy, and the chromosome number and karyotype were determined as  $2n = 16 = 2m + 12sm + 2st$ .

**Key words:** China, Hengduan Mountains, IUCN Red List, Orobanchaceae, *Pedicularis*.

The genus *Pedicularis* L. (Orobanchaceae) comprises more than 600 to 800 species distributed primarily in the Arctic and alpine regions of the Northern Hemisphere (Li, 1951; Yang et al., 1998; Mill, 2001; Wu et al., 2003; Wang et al., 2009). More than 368 species occur in China (Yang et al., 1998; Zhang et al., 2006). About two thirds of these species are confined to the region of the Hengduan Mountains in southwestern China (Yang et al., 1998; Ree, 2005; Yu et al., 2008), which represents one of the main centers of species diversity and endemism for this genus (Ree, 2005; Yu et al., 2008).

Floral diversification in *Pedicularis* is remarkable among flowering plants. Species from the Hengduan Mountains region span a rich diversity of floral types

in this genus (Yang et al., 2003; Yu & Wang, 2008; Wang et al., 2009). Floral characters in *Pedicularis* have a high degree of homoplasy, and morphologically similar corollas have apparently been derived independently multiple times (Ree, 2005).

Between the summers of 2006 and 2007, we conducted extensive field investigations on the genus *Pedicularis* in the Hengduan Mountains region. The type of the new species was collected from Daxue Mountain (in the Shangri-La area), which is located along the border between Shangri-La County in northwestern Yunnan and Xiangcheng County in southwestern Sichuan. After careful examination of related herbarium specimens, *P. obliquigaleata* is identified here as a new species.

Flowers of the new species were observed directly in the field and rehydrated before measurements were taken and illustrations were prepared. For morphological descriptions, all materials were studied using a microscope (Olympus TGHM, Olympus Corp., Tokyo, Japan). Pollen and seed coat surface micromorphology were examined using a KYKY-10000B scanning electron microscope (Science Instrument Company, Beijing, China). For cytological study, we followed the methodology of Cai et al. (2004).

***Pedicularis obliquigaleata* W. B. Yu & H. Wang, sp. nov.** TYPE: China. Yunnan: Shangri-La Co., Daxue Mtn., 28°33.518'N, 99°50.947'E, ca. 4294 m, 25 July 2007, *Wen-bin Yu 643* (holotype, KUN 0888324; isotypes, KUN, MO). Figures 1, 2.

Haec species *Pedicularidi souliei* Franch. maxime affinis, sed ab ea caule simplici cano-pubescente, foliis pinnatipartitis (nec pinnatisectis) segmentis ovato-deltaideis usque ovato-oblongis, dentatis (nec ovato-lanceolatis, pinnatifidis usque pinnatipartitis), dentibus calycis 2 (nec 5), galea

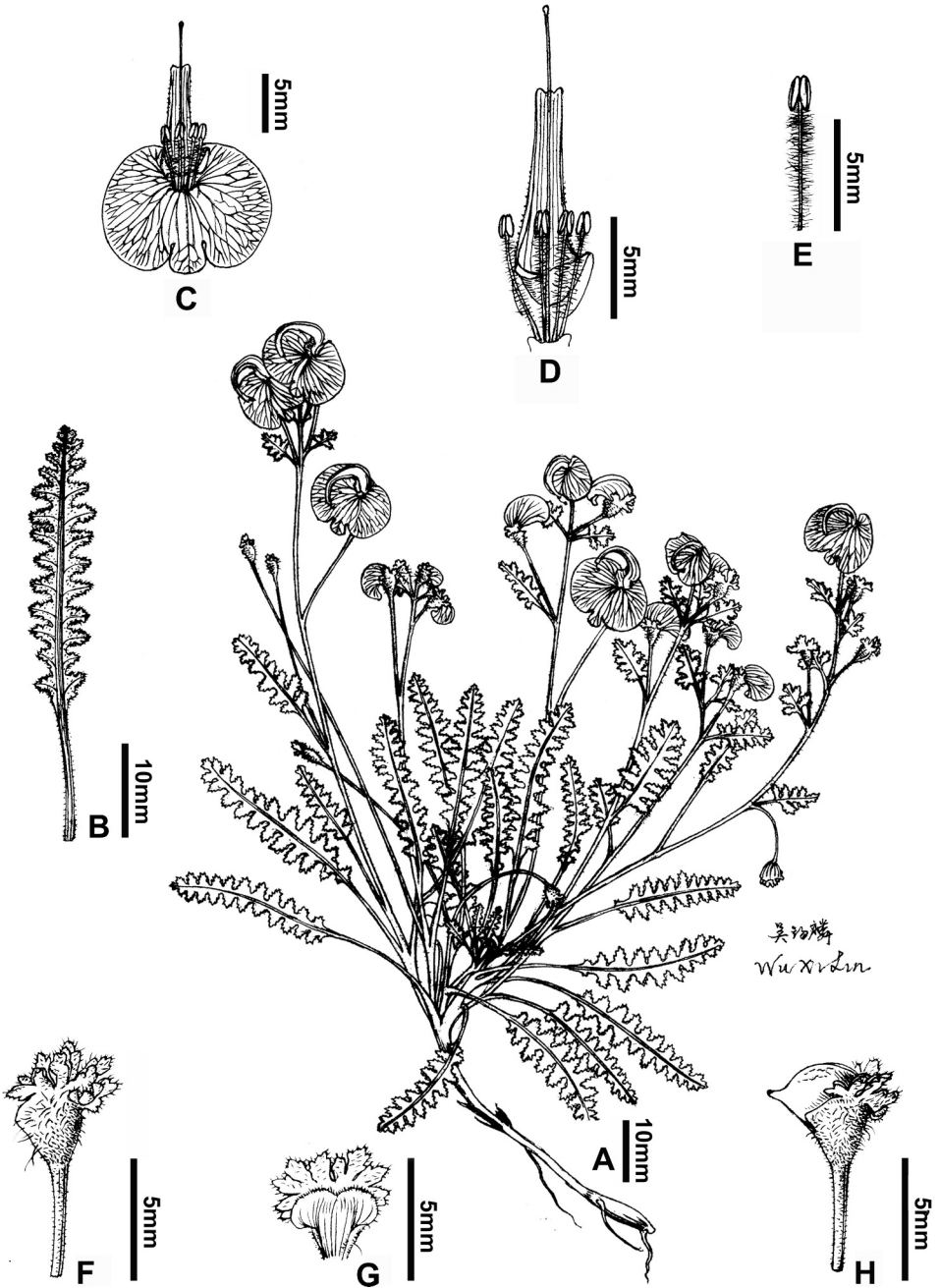


Figure 1. *Pedicularis obliquigaleata* W. B. Yu & H. Wang. —A. Habit. —B. Leaf. —C. Corolla lower lip. —D. Open beak showing stamens and style. —E. Anther and upper part of filament. —F. Calyx and pedicel, lateral view. —G. Open calyx. —H. Capsule. Drawn by Xi-Lin Wu from the holotype, *Wen-bin Yu 643* (KUN).

*helictis obliqua* (nec *torsiva*), *rostris semicirculari* (nec *sigmoidei*) atque *labii inferioris lobo mediano subtruncato* (nec *ovato*) differt.

Perennial herb, 9–15 cm tall, drying slightly black; taproots slender, long-conical, fusiform, ± fleshy;

stems caespitose, mostly 5 to 9, unbranched and erect or ± ascending, densely gray pubescent. Basal leaves few or withering early; leaves with the petiole 1.5–3 cm, narrowly winged, pubescent; blades lanceolate-oblong to ovate-oblong, 2.5–4.3 × 0.8–1.2 cm,



Figure 2. *Pedicularis obliquigaleata* W. B. Yu & H. Wang. —A. Habit. —B. Inflorescence. —C. Close-up of two flowers. —D. Pollination of *P. obliquigaleata* flower by a bumblebee. Photographed at the type locality on Daxue Mountain by Wen-Bin Yu. Scale bars: A = 5 cm; B–D = 1 cm.

abaxially and adaxially completely pubescent, abaxially  $\pm$  furfuraceous, pinnatipartite; leaf segments in 7 to 14 pairs, triangular-ovate to oblong-ovate,  $0.4\text{--}0.9 \times 0.2\text{--}0.5$  cm, margin dentate, sparsely long-pubes-

cent. Cauline leaves often pseudo-opposite, alternate apically, similar to basal ones, but smaller with a shorter petiole,  $1\text{--}2.5$  cm. Inflorescences racemose,  $3\text{--}12$  cm, centrifugal; bracts leaflike; flowers alternate

and axillary; basal pedicels 4–5.5 cm, apically only 0.5–1 cm, finely pubescent. Calyx tube 3.9–4.6 mm, the cleft nearly 1/2 anteriorly, densely pubescent; calyx lobes 2, leaflike, with 4 or 5 cleft divisions, incised-dentate; corolla purple or rose-red, white at throat; corolla tube erect, 4.9–7.1 mm; corolla galea bent obliquely to the left at a right angle apically (in front view); corolla beak 1–1.2 cm, semicircular; corolla lower lip 12.1–14.1 × 16.3–19.3 mm, ciliate, the middle lobe obviously smaller, subtruncate, 2.2–3.2 mm wide; anther filaments 4, pubescent. Capsule semiglobose, laterally mucronate, 0.5–0.8 × 0.6–1 cm; seeds 2.9–4.6 × 1.8–2.6 mm, nearly ellipsoid, but irregularly, ivory to white or beige; seed hilum indistinct, ventrally located.

*Pollen and seed morphology.* Pollen grains are radially symmetrical and isopolar (Fig. 3A), medium in size (polar length [P]:  $23.23 \pm 1.53 \mu\text{m}$  × equatorial diameter [E]:  $24.47 \pm 1.70 \mu\text{m}$ ), and spheroidal to prolate (P:E = 1–1.46) in shape. The pollen aperture is bisyncolpate, and the colpi are usually wide, with the colpus membrane covered with granular elements (Fig. 3A); the exine ornamentation is microscabrate (Fig. 3B). The seed coat surface is covered with irregular reticulate sculpturing, i.e., quadrilateral or pentagonal meshes (Fig. 3C). The transverse ridges of the reticulum are widened and nearly smooth, and the longitudinal ones are narrow or inconspicuous (Fig. 3D). The cells formed by the reticulum are filled with alveolate meshwork (Fig. 3E).

*Cytology.* The somatic chromosome number is  $2n = 16$ , as counted from metaphasic chromatids from meiotic cells of the root tip (Fig. 3F). The karyotype formula is  $2m + 12sm + 2st$ , representing two metacentric chromatids (the seventh pair in Fig. 3G), 12 submetacentric, and two subtelo-centric chromatids (the eighth pair in Fig. 3G).

*Distribution and ecology.* *Pedicularis obliquigaleata* is endemic to the Hengduan Mountains in northwestern Yunnan and southwestern Sichuan provinces (Fig. 4). In addition to the type locality of Daxue Mountain, individuals of the new taxon were also collected from Wengtula Mountain of Daocheng County in southwestern Sichuan. *Pedicularis obliquigaleata* occurs in alpine meadows or along the edge of *Abies* Mill. forest from 3900 to 4500 m in elevation. At least 11 species were recorded as sympatric with *P. obliquigaleata*, i.e., *P. brachycrania* H. L. Li, *P. confertiflora* Prain, *P. confertiflora* subsp. *parvifolia* (Hand.-Mazz.) P. C. Tsoong, *P. cyathophylla* Franch., *P. cymbalaria* Bonati, *P. densispica* Franch. ex Maxim., *P. elwesii* Hook. f., *P. lutescens* Franch. ex

Maxim., *P. rupicola* Franch. ex Maxim., *P. superba* Franch. ex Maxim., and *P. siphonantha* D. Don var. *stictochila* H. Wang & W. B. Yu.

*IUCN Red List category.* This new species has only been collected from the two sites mentioned above. However, it is common at these localities with populations of densely aggregated individuals (e.g., there are ca. 15 to 40 individuals per square meter at the type locality). According to IUCN Red List criteria (IUCN, 2001), *Pedicularis obliquigaleata* should be regarded as Least Concern (LC).

*Phenology and pollination.* The new species was found flowering from late June to August, and fruiting from mid July to October. Based on field observations, it appears to be exclusively pollinated by bumblebees (Fig. 2D).

*Etymology.* The specific epithet of the new species, *obliquigaleata*, refers to the oblique orientation of the corolla galea, which is bent to the left at a right angle as viewed apically from the front (Fig. 2C).

*Relationships.* According to the classification systems of Li (1949) and Tsoong (1963), *Pedicularis obliquigaleata* should be placed in series *Dissectae* H. L. Li. This series, separating from series *Oxycarpae* Prain, was established by Li (1949). Li (1949) proposed that series *Dissectae* differed from series *Oxycarpae* by having very long pedicels, axillary lower flowers that were scattered, and a short capsule. *Pedicularis obliquigaleata* is very similar to *P. souliei* Franch., also in series *Dissectae*, but it is distinguished from *P. souliei* (isotype, US, US image seen online) by having densely gray pubescent stems (vs. sparse indument in *P. souliei*), a pinnatipartite leaf with triangular-ovate to oblong-ovate leaf segments with dentate margins (vs. pinnatisect leaves with ovate-lanceolate to pinnatifid segments), two calyx lobes (vs. five), an obliquely bent galea (vs. twisted), a semicircular beak (vs. a sigmoid shape), and a corolla with a purple or rose-red lower lip and an apically subtruncate middle lobe (vs. pink or white, with an acute lobe apex) (see Table 1). In addition, *P. obliquigaleata* resembles *P. franchetiana* Maxim. and *P. mussotii* Franch. of series *Franchetianae* Prain by its basal flowers with longer pedicels, its pinnatipartite leaf, and its laterally mucronate and semiglobose fruit. Nevertheless, the racemose inflorescence, the shorter pedicels of the apical flowers, and the obliquely bent galea clearly distinguish *P. obliquigaleata* from these two species.

The key below serves to identify *Pedicularis obliquigaleata* and its related species. It includes all species belonging to series *Dissectae* and two species of series *Franchetianae* mentioned above.

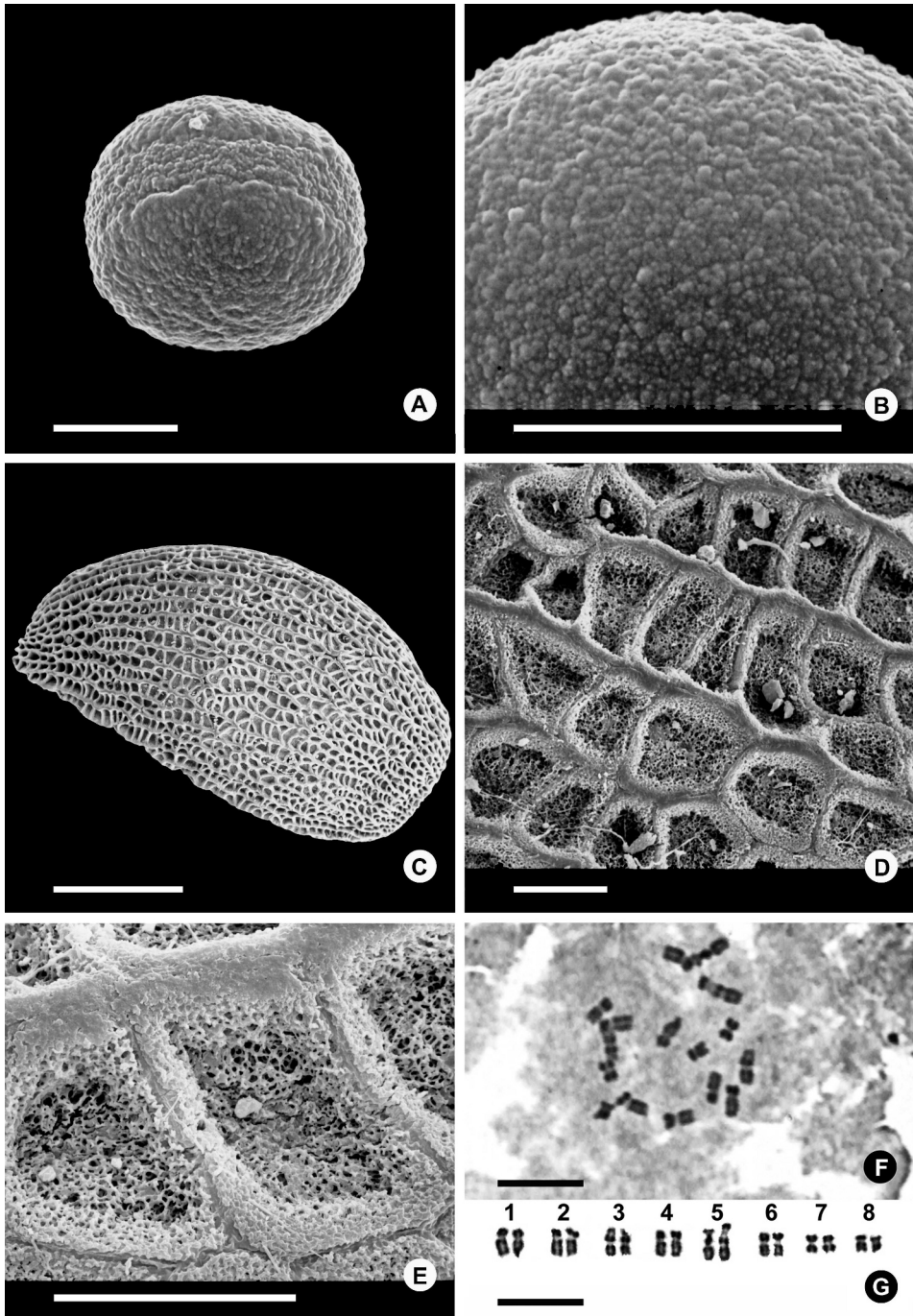


Figure 3. *Pedicularis obliquigaleata* W. B. Yu & H. Wang. A, B. SEM imaging of pollen morphology. —A. Pollen grain. —B. Detail of exine ornamentation. C–E. SEM imaging of seed morphology. —C. Entire seed, lateral view. —D, E. Seed coat surface. F, G. Karyological micrographs. —F. Metaphasic chromatids. —G. Karyogram. Scale bars: A, B, F, G = 10  $\mu$ m; C = 1 mm; D, E = 100  $\mu$ m.

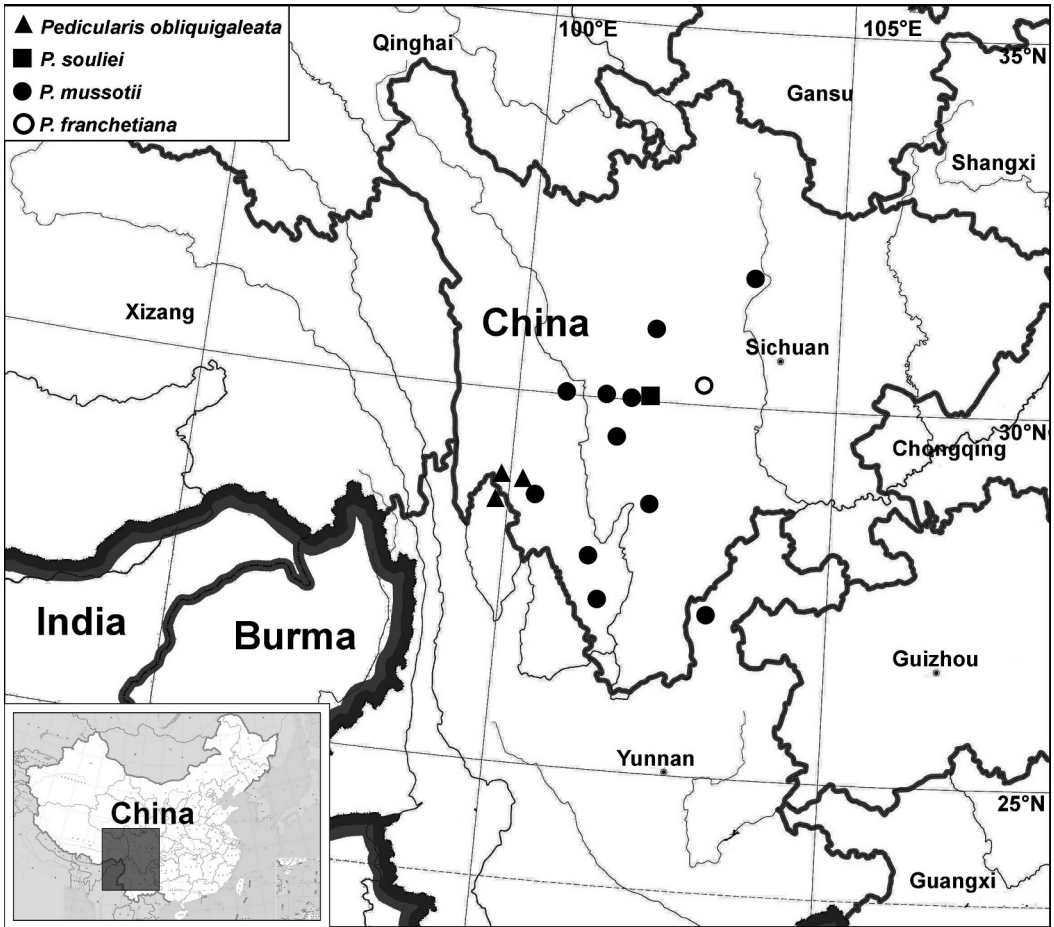


Figure 4. Distribution map of *Pedicularis obliquigaleata* and related taxa.

KEY TO SIMILAR SPECIES WITHIN *PEDICULARIS* SER. *DISSECTAE* AND *FRANCHETIANAE*

- 1a. Leaf pinnatipartite; inflorescence axillary; pedicel to 3–11.5 cm; galea erect; fruit semiglobose (series *Franchetianae*) . . . . . 2
- 1b. Leaf pinnatisect or pinnatisect; inflorescence racemose; pedicel < 5.5 cm; galea bent or twisted; fruit semiglobose or oblate-ovate (series *Dissectae*) . . . 3
- 2a. Stem branched; beak pendant and parallel to calyx, curved apically; middle lobes of lower lip equal to lateral ones; only 2 filaments pubescent . . . *P. franchetiana*

Table 1. Comparison of diagnostic characters between *Pedicularis obliquigaleata* and *P. souliei*.

Characters	<i>P. obliquigaleata</i>	<i>P. souliei</i>
Stems	unbranched, densely gray pubescent	unbranched, sparsely pubescent
Leaf	pinnatipartite	pinnatisect
Leaf segments	triangular-ovate to oblong-ovate, dentate	ovate-lanceolate, pinnatifid to pinnatipartite
Pedicel length, mm	5–55	5–40
Calyx tube length, mm	3.9–4.6	3–5
Calyx lobes	2; 4 or 5 cleft and incised-dentate	5, lateral one lanceolate and dentate
Corolla tube length, mm	4.9–7.1	6–7
Corolla galea (front view)	bent to left at a right angle apically	twisted
Corolla beak	semicircular	S-shaped
Corolla lower lip	purple or rose-red, ciliate, spreading, 12.1–14.1 × 16.3–19.3 mm	pink or white, ciliate, spreading, ca. 15 × 10–12 mm
Middle lobe of lower lip	smaller than lateral ones and apically subtruncate	smaller than lateral ones and apically ovate

- 2b. Stem unbranched; beak semicircular; middle lobes of lower lip smaller than lateral ones; 4 filaments pubescent . . . . . *P. mussotii*
- 3a. Stem branched only basally; fruit semiglobose . . . . 4
- 3b. Stem branched basally and above; fruit oblate-ovate . . . 5
- 4a. Stem densely gray pubescent; leaf pinnatifid; segments triangular-ovate to oblong-ovate with dentate margins; calyx lobes 2; corolla purple or rose-red; galea bent to left; beak semicircular . . . . . *P. obliquigaleata*
- 4b. Stem sparsely gray pubescent; leaf pinnatifid; segments ovate-lanceolate to pinnatifid; calyx lobes 5; corolla pink or white; galea twisted; beak S-shaped . . . . . *P. souliei*
- 5a. Calyx lobes 3, equal, palmatifid; corolla purple-red; galea with a 2-auriculate protuberance; pedicel to 1.4 cm . . . . . *P. honanensis* P. C. Tsong
- 5b. Calyx lobes 3, unequal, posterior lobe linear and subentire, lateral pair palmatifid; corolla yellow or whitish with purple-red galea; galea without a 2-auriculate protuberance; pedicel to 3 cm. . . . . 6
- 6a. Leaves sparsely hairy abaxially; segments 8 to 12 pairs, ca. 4–5 mm wide; calyx hairy externally . . . . . *P. petitmenginii* Bonati
- 6b. Leaves glabrous abaxially; segments 6 to 9 pairs, ca. 2–3 mm wide; calyx glabrous externally . . . . . *P. dissecta* (Bonati) Pennell & H. L. Li

*Paratypes.* CHINA. **Yunnan:** Shangri-La Co., Daxue Mtn., 4100–4200 m, 16 Aug. 2005, *Wen-bin Yu, Shu-dong Zhang & Ding Wu 042* (KUN). **Sichuan:** Xiangcheng Co., Daxue Mtn., 3900–4000 m, 3 Aug. 1981, *Qing-Zang Exp. 3700* (KUN, PE); Daocheng Co., Wengtula Mtn., 4000 m, 21 Aug. 1937, *T. T. Yü 12817* (KUN, PE).

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