

Taxonomic revision of the *Pternopetalum delavayi* complex (Apiaceae)

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A revision of three endemic Chinese species of *Pternopetalum* (*P. cardiocarpum*, *P. delavayi* and *P. sinense*), based on herbarium material and field observations, is presented. Examination of critical diagnostic characters showed that there is a single morphologically well-delimited species here treated as *P. delavayi*. *Pternopetalum cardiocarpum* and *P. sinense* are its taxonomic synonyms.

Key words: Apiaceae, morphology, nomenclature, *Pternopetalum*, taxonomy.

Introduction

Pternopetalum cardiocarpum (Franchet) Hand.-Mazz., *P. delavayi* (Franchet) Hand.-Mazz. and *P. sinense* (Franchet) Hand.-Mazz. represent a complex group of perennial herbaceous plants with variable morphological characters. They are distributed in northwestern Yunnan, south-eastern Tibet and western Sichuan, China. The three species were all established by (Franchet 1894) based on the collections from northwest Yunnan made by J. M. Delavay (Fig. 1). Franchet (1894) placed them in the genus *Carum*. Latter taxonomic studies (Dunn 1903, Wolff 1927) confirmed that they should be separated from *Carum*, and the currently accepted generic placement was made by Handel-Mazzetti (1933). Although the three species were generally included in Chinese national and local floras, such as *Index Florae Yunnanensis* (Wu 1984), *Flora Reipublicae Popularis Sinicae* (Pu

1985), *Vascular plants of Hengduan Mountain* (Pu 1993), *Yunnan Flora* (Pu 1997) and *Flora of China* (Pu & Phillippe 2005), their taxonomy has not been critically examined.

Pu (1993) and Pu and Phillippe (2005) considered that *P. sinense* and *P. cardiocarpum* maybe conspecific with *P. molle* (Franchet) Hand.-Mazz. (the name has been widely misapplied in China) and the East Himalayan *P. radiatum* (W.W. Smith) P.K. Mukherjee & Constance., respectively. However, *P. molle* (*sensu* Franchet 1894) and *P. radiatum* are typically delicate annual herbs with a single and fusiform root. They are usually not more than 30 cm high and have a lower conic stylopodium. *Pternopetalum cardiocarpum* and *P. sinense* are stout perennial herbs, over 30 cm high, with well-developed caudexes, and a conic stylopodium. In fact, the three taxa are extremely similar in their appearance (Figs. 1 and 2), as was clearly indicated by Franchet (1894); his phrase “*fructus C. sinense*” suggests that *P. car-*

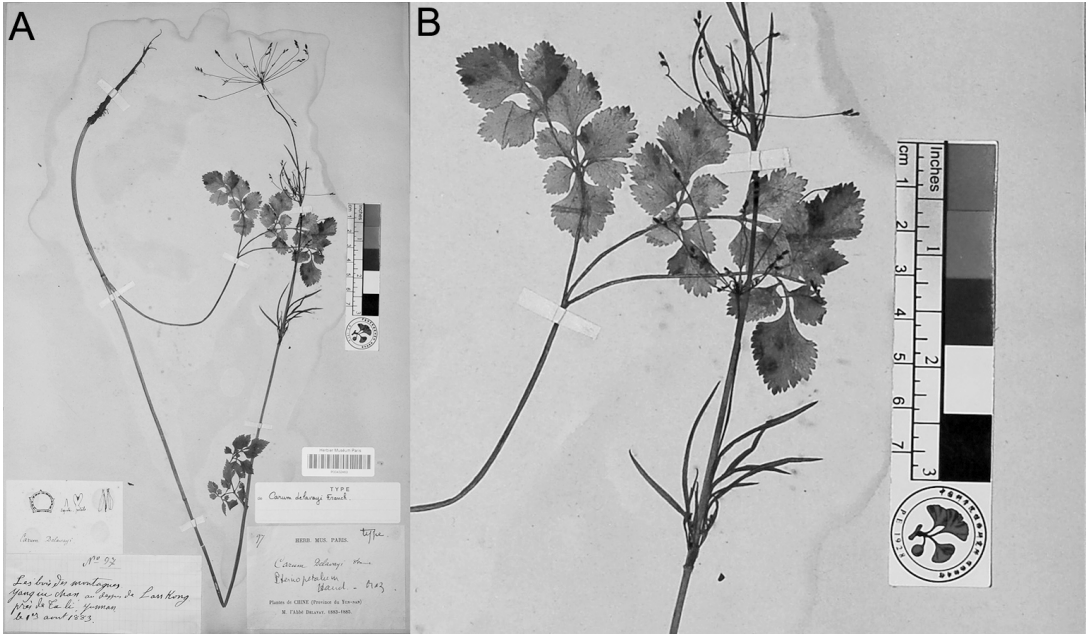


Fig. 1. — **A:** Holotype of *Pternopetalum delavayi* (Delavay 97, P!). — **B:** Flowers and young fruits on a single immature umbel appeared (Delavay 97).

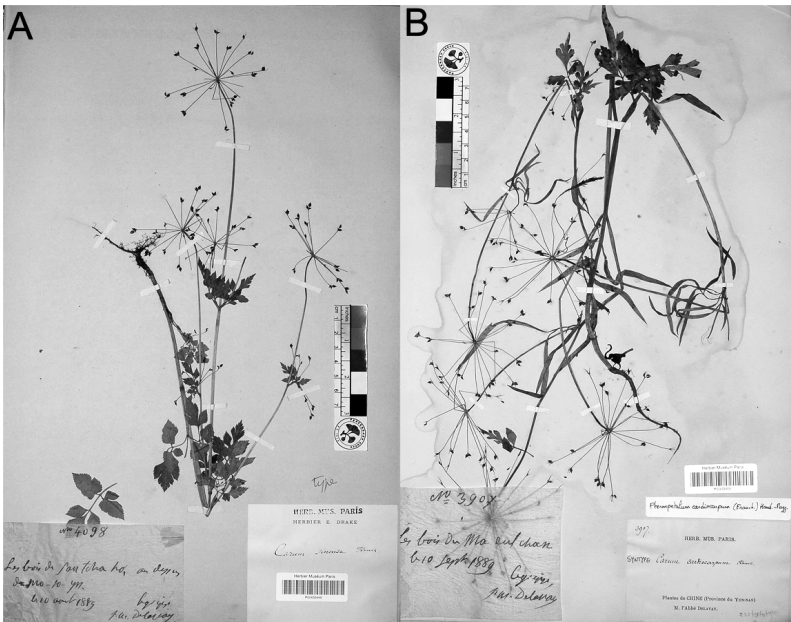


Fig. 2. — **A:** Holotype of *Pternopetalum sinense* (Delavay 4098, P!). — **B:** Holotype of *P. cardiocarpum* (Delavay 3907, P!).

diocarpum has similar fruits with *P. sinense*. In the first line of the description of *P. delavayi*, the phrase “*C. cardiocarpum* quam maxime affine” denotes that *P. delavayi* was closely similar to *P. cardiocarpum*. Morphological distinction of the three taxa has been difficult. In all examined her-

barium specimens of them, only seven specimens (two gatherings, including four type specimens) belong to *P. sinense*. The name *P. cardiocarpum* and *P. delavayi* alternatively appeared on the different duplicate specimens of one collection, in fact identified by the same author.

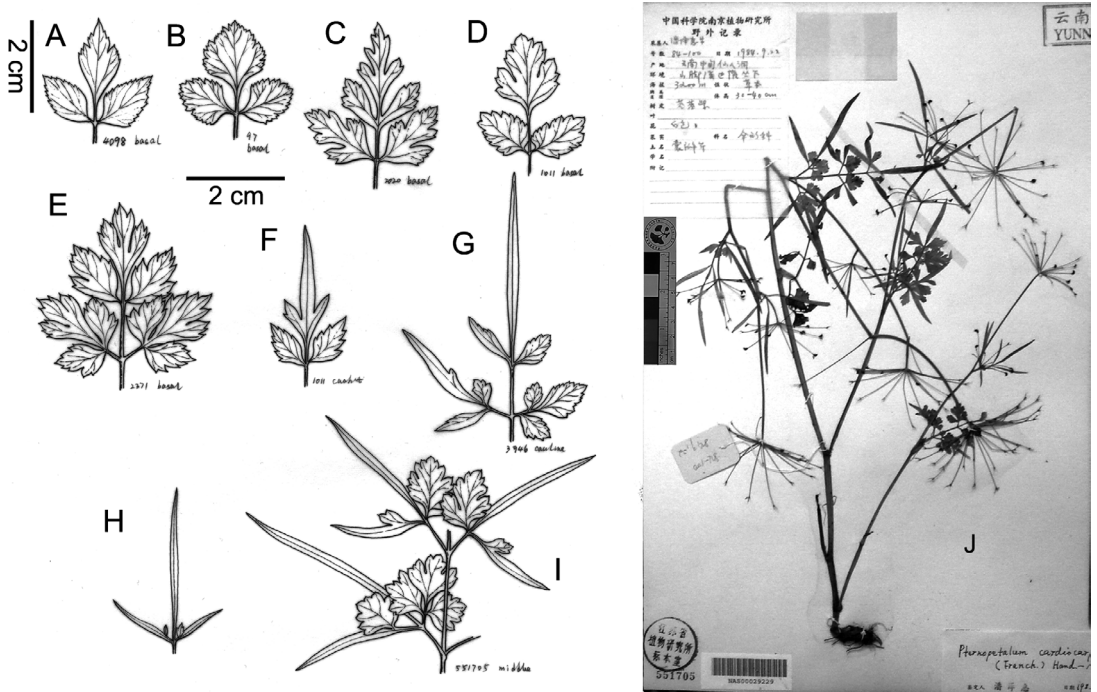


Fig. 3. Variable ultimate leaf segments of specimens assigned to *Pternopetalum cardiocarpum*, *P. delavayi* and *P. sinense*. — **A–E:** Rhomboidal and flabelliform segments (basal leaves). — **F–I:** Elongate-linear segments (cauline leaves). — **J:** Plant with different ultimate leaf segment shape and a single compound leaf (*Pan Z. H. et al. 84-100, NAS!*).

The increased number of herbarium specimens collected during field trips rendered it possible to critically examine the morphology. We evaluate the diagnostic characters applied for the three species, and propose a new taxonomic concept.

Material and methods

Morphological characters were evaluated from herbarium specimens conserved at the herbaria BM, CDBI, E, HGAS, IBSC, K, KUN, NAS, P, PE, SM, SZ, and SWFC. All relevant type specimens and original descriptions were carefully examined. Photographs of the type specimens from NY and L were also consulted. Field investigation was carried out by the author in Guizhou, Sichuan and Yunnan during several visits in 2003–2005. The fruit characters were examined and photographed with a NIKON Digital Camera DXM1200F and a scanning electron microscope (SEM). The fruits of *P. sinense*

were manually transected to examine the vittae number. BRAHMS 5.58 (<http://herbaria.plants.ox.ac.uk/bol/home/>) was used for management of specimen datasets (the recent version 5.64 is available from the above link).

Results

Diagnostic characters examined

Leaves

Pternopetalum sinense was originally delimited by its homomorphic basal and cauline leaves, which were shown to be heteromorphic for *P. cardiocarpum* and *P. delavayi* by Pu (1997) and Pu and Phillippe (2005). According to those treatments, the main difference of homomorphic and heteromorphic leaves lies in the shape of the ultimate leaf segments (Table 1), which was shown to be ovate in *P. sinense* (Fig. 3A). The basal leaves of *P. cardiocarpum* and *P. delavayi* have

rhomboidal or flabelliform ultimate segments (Fig. 3B–E), and their cauline leaves have elongate-linear ultimate segments (Fig. 3F–I). This diagnostic character was originally observed by Franchet (1894), who stated “*folia omnia homomorpha pallide virentia*” (*P. sinense*); “*folia heteromorpha*” (*P. cardiocarpum*); and “*folia flaccida heteromorpha*” (*P. delavayi*). Working with inadequate herbarium specimens, Franchet did not realize that variable leaf segments are very common in this group, rather than being a distinct interspecific difference. For instance, the isotype of *P. sinense* (Delavay 4098, PE!), also has elongate-linear ultimate leaf segments (Fig. 3H). As for *P. cardiocarpum* and *P. delavayi*, it is easy to find plants with intermediate and variable forms of the ultimate segments (Fig. 4B–I). Most significantly, a single compound leaf can have heteromorphic and homomorphic ultimate segments (Fig. 3F–I). The continuous variation of ultimate leaf segment shape is clearly demonstrated in the specimens *Pan Z. H. 84-100* (Fig. 3J). Its well-developed basal leaves usually have rhomboidal or flabelliform ultimate segments (Fig. 3C–E). On the middle part of the plant, rhomboidal, flabelliform and elongate-linear segments occur in a single compound leaf (Fig.

3G–I). In the upper part of the plant, nearly all leaves have elongate-linear segments (Fig. 3H).

Bracts and bracteoles

The bracts and bracteoles of *P. sinense* were described as 2–3 on each umbel and umbellule, respectively (Pu & Phillippe 2005), as was also observed by Franchet (1894). However, I observed that bracts are absent in the type specimen of *P. sinense*, and the bracteoles vary from being absent to numbering two on each umbellule. Therefore, the number of bracts and bracteoles does not distinctly differ among the three taxa. In fact, absence of bracts is a common character of *Pternopetalum* (Shan & Pu 1978, Pu 1985, 2001, Pu & Phillippe 2005).

Petal color

The petal color has been reported to be slightly different among the three species (Table 1), and has been used to key out *P. delavayi* and *P. sinense* (Pu 1985, 1997, 2001, Pu & Phillippe 2005). Franchet (1894) described *P. cardiocar-*

Table 1. The distinguishing morphological characters of *Pternopetalum cardiocarpum*, *P. delavayi* and *P. sinense*, extracted from Pu (1997) and Pu and Phillippe (2005).

Characters	<i>P. sinense</i>	<i>P. cardiocarpum</i>	<i>P. delavayi</i>
Basal and cauline leaves	homomorphic	heteromorphic	heteromorphic
Basal leaves	2–3-ternate	1–2-ternate	2-ternate
Cauline leaves	2–3-ternate	1–2-ternate	1–2-ternate
Ultimate leaf segments (basal)	ovate, 1–2 × 1–1.5 cm	rhomboidal or, flabelliform 1 × 1 cm	rhomboidal or flabelliform, 1–5 × 2–3 cm
Ultimate leaf segments (cauline)	ovate, 1–2 × 1–1.5 cm	elongate-linear, 1–2.5 × 0.2 cm	elongate-linear, 4–10 × 0.3–0.8 cm
Bracts	2–3	absent	absent
Bracteoles	2–3	1–3, ca. 0.5 mm	2–4, 0.5–1.2 mm
Petal color	white	purple-white	white, sometimes tinge pink
Stylopodium	low-conic	low-conic	conic
Styles	short ca. 0.4 mm	ca. 0.5 mm, as long as stylopodium	elongate, stylopodium and style ca. 0.9 mm
Calyx teeth	lanceolate, ca. 0.4 mm	subulate, ca. 0.4 mm	subulate, ca. 0.3 mm
Fruits	ovate, ca. 3 × 2 mm	ovoid, 2–3 × 1.5–2 mm	oblong-ovoid, 2–4 × 1.2–2 mm
Ribs	finely scabrid	filiform	filiform
Vittae	absent	1–3 in each furrow, 4 on commissure	1–3 in each furrow, 4 on commissure

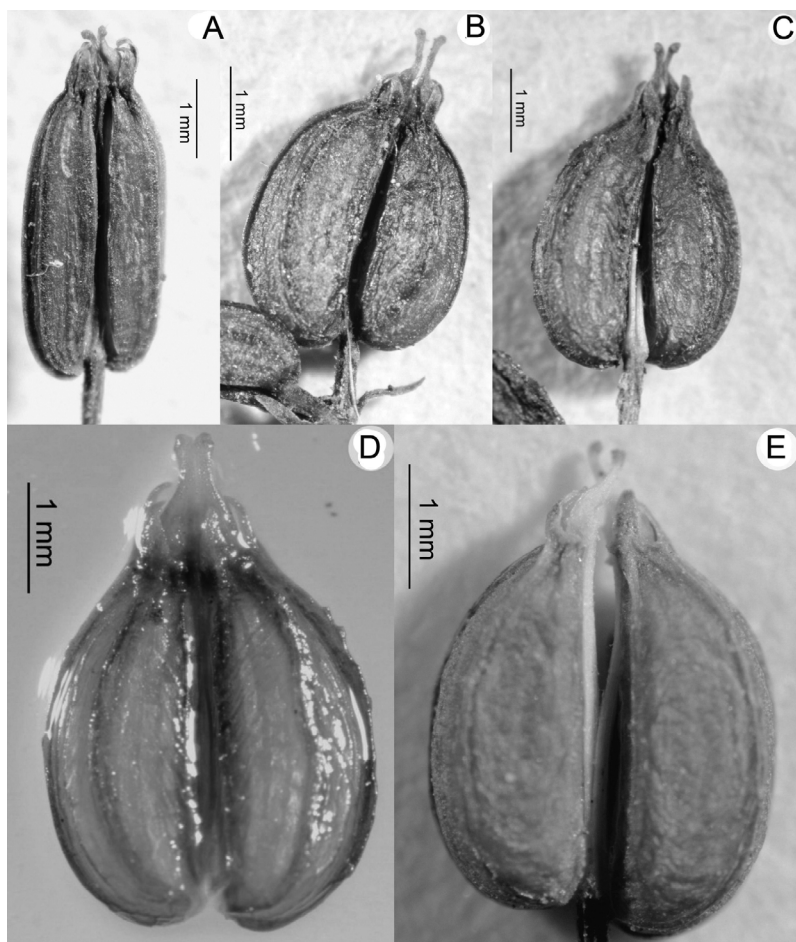


Fig. 4. Fruit shape and rib morphology in *Pternopetalum cardiocarpum*, *P. delavayi* and *P. sinense*. — **A:** Immature oblong-ovate fruit of *P. delavayi* (compare with E). — **B–E:** Mature ovate fruits of the three “species”. — **D:** Small denticulate rib in *P. sinense*.

pum as “*flores atropurpurei* (Delavay)”, and *P. delavayi* as “*flores albi*”. Since all type specimens of *P. cardiocarpum* were collected during fruiting time, Franchet used “(Delavay)” to indicate that this character was taken from Delavay’s field observations written on the specimen sheet. In all examined herbarium material of *P. cardiocarpum*, the petals nearly always are white. My field investigation revealed that there are plants of *Pternopetalum* having purplish petals sparsely intermixed with individuals with entirely white petals. This variation is especially distinct in high-altitude populations in southwestern China. Due to the harsh environment in those areas, particularly the intensive UV light, purplish coloration appears to be an environmentally induced variation. Moreover, this variation in colour was not only seen in petals but also in the stems, petioles, leaf blades, pedicels and bracteoles. There-

fore, this character cannot be used to distinguish the taxa.

Fruit shape

Following the description by Franchet (1894), *P. delavayi* was described as having oblong-ovoid fruits (Fig. 4A), different from the ovate fruits of *P. cardiocarpum* and *P. sinense* (Fig. 4B–C) (Pu 1985, 1997, 2001, Pu & Phillippe 2005). My close examination revealed that the type specimens of *P. delavayi* bear some mature flowers and young fruits in a single umbel (Fig. 1B). Therefore, the oblong-ovoid fruits represent an immature state. The same was observed for the isotype of *P. sinense*. Actually, the mature fruits of the three taxa were all ovate and ca. 2×3 mm in size (Fig. 4B–E).

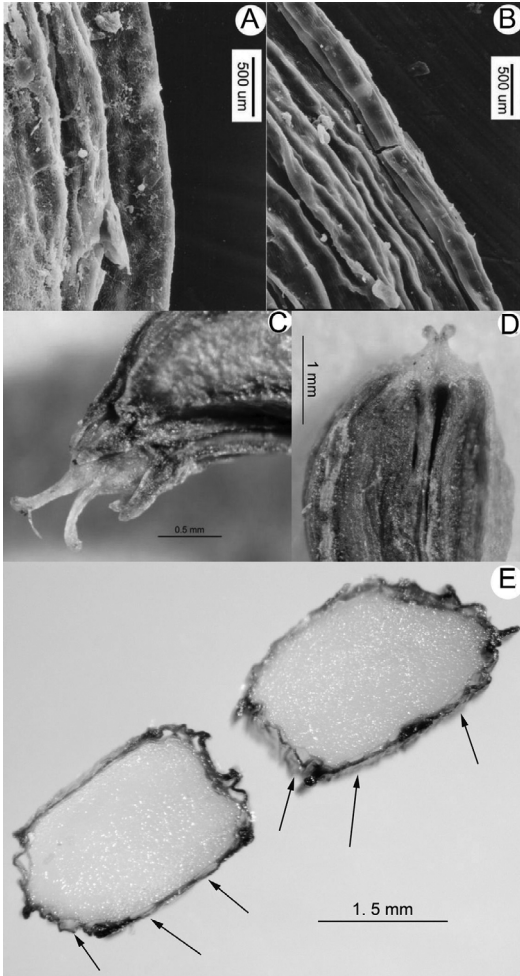


Fig. 5. — **A** and **B**: Smooth rib surface of *Pternopetalum sinense*, *P. cardiocarpum* and *P. delavayi* (SEM). — **C**: Conic stylopodium and elongate styles of the three “species”. — **D**: Low conic stylopodium and shorter styles in *P. tanakae*. — **E**: Transverse section of fruits of *P. sinense*, arrow = place of vittae.

Ribs

The present descriptions of rib surface are somewhat confusing. For *P. cardiocarpum* and *P. delavayi* it was described as filiform, relative to finely scabrid for *P. sinense*, by Pu and Phillippe (2005). However, I observed that the ribs of the three species are filiform, and their surface is smooth or slightly scabrid (Figs. 4 and 5A–B). Occasionally, slightly denticulate ribs were found in several fruits (Fig. 4D).

Stylopodium, styles and calyx teeth

The shape and size of the stylopodium, style and calyx teeth have been shown to be a useful character combination for delimitation of major groups within *Pternopetalum*. Previous observations (Pu 1997, Pu & Phillippe 2005) averred that *P. delavayi* has a conic stylopodium and elongate styles, different from *P. cardiocarpum* and *P. sinense* (Table 1). However, all of the three species have a conic stylopodium and elongate styles (Figs. 4 and 5C). Low conic stylopodia and shorter styles are only found in delicate members (usually not more than 30 cm high), such as *P. tanakae* (Fig. 5D).

Vittae

The vittae of *P. sinense* were recorded as being absent in each furrow and on the commissure (Pu & Phillippe 2005). Transverse sections of the fruit, however, show that the vittae are 1–3 in each furrow and 3 on the commissure (Fig. 5E). It is the same in *P. cardiocarpum* and *P. delavayi* (Table 1).

Taxonomic treatment

Pternopetalum delavayi (Franchet) Hand.-Mazz.

Symbolae Sinicae VII: 718. 1933. — TYPE: China. “Yunnan, in silvis montanis ad Yang in chan supra Lankong; fr. 1 Aug. 1883” [Now Yunnan Province, Erh-Yuan Xian], *Delavay, J. M.* 97 (lectotype P!; isolectotype K!) (Fig. 1A).

Pternopetalum sinense (Franchet) Hand.-Mazz., Symbolae Sinicae VII: 718. 1933, *syn. nov.* — TYPE: China. “Yunnan, in silvis ad Sau-tcha-ho supra Mo-so-yn; fruct. 10 Aug. 1889” [Now Yunnan Province, Erh-Yuan Xian], *Delavay, J. M.* 4098 (holotype P!; isotypes PE!, NAS (photocopy)!) (Fig. 2A).

Pternopetalum cardiocarpum (Franchet) Hand.-Mazz., Symbolae Sinicae VII: 718. 1933, *syn. nov.* — TYPE: China. “Yunnan, in silvis ad Ma-eul-chan; fruct. 10 Sept. 1889” [Now Yunnan Province, Erh-Yuan Xian], *Delavay, J. M.* 3907 (lectotype P!; isolectotypes K!, photographs seen NY, L) (Fig. 2B).

Perennial herb, mostly with a single cylindrical root, caudexes not well-developed at base, covered with very slim leaf-sheath remains;

leaves nearly uniformly occurring on whole plants (different from plants only having basal leaves, or leaves on base and upper parts), mainly 1–2-ternate, more or less heterophyllous, ultimate leaf segments rhomboidal, flabelliform (ca. 2×4 cm) or elongate-linear ($4\text{--}7 \times 0.5$ cm), blades strigose along veins and margins; peduncles of umbel terminal and lateral, umbellule 2–3(–4)-flowered, usually with one aborted mericarp; stylopodium conic attached with elongate styles (stylopodium plus styles distinctly longer than calyx teeth); mature fruits ovate, ca. 2.5×3 mm, ribs prominent and filiform, surface smooth, slightly scabrid or occasionally denticulate.

Relative to *P. cardiocarpum* and *P. sinense*, the name *P. delavayi* has been generally used in Chinese literature and on herbarium sheets, as well as included in several well-known online biological databases, such as NCBI (<http://www.ncbi.nlm.nih.gov/>) and GBIF (<http://www.europe.gbif.net/portal/index.jsp>). Therefore I have selected that name for this species, although nomenclaturally it has the same priority as *P. cardiocarpum* and *P. sinense* at the specific rank.

DISTRIBUTION AND HABITAT: West Sichuan, southeast Tibet (Xizang) and northwest Yunnan; 2300–4500 m, forest, meadow and alpine scrub.

REPRESENTATIVE SPECIMENS EXAMINED: **China.** — Sichuan. 17.VII.1975 *s. coll.* 9424 (CDBI, PE); Batang, 23.VII.1983 Lang, K. Y., Li, L. Q. & Fei, Y. 2305 (KUN); Butuo, 1.VII.1979 *Collection Team of Butuo County, Chongqing Municipal Academy of China (1978) 0507* (SM); Danba, *National Geographical Society Russian–Chinese Joint Umbelliferae Expedition (1998) 229* (PE); Daocheng: 27.VI.1971 Liu, Z. G. 0114 (CDBI, NAS); Derong, 4.VIII.1981 *Tibet Group 3249* (CDBI, KUN); Huili, 20.VII.1976 *Biological Department of Southwest Normal University (1976) 12342* (CDBI); Jinyang, 18.VIII.1978 *Collection Team of Jinyang County, Chongqing Municipal Academy of China (1978) 0631* (SM); Jiulong, 2.VII.1979 Wang, Q. Q. 20341 (CDBI); Kangding, 8.VI.1980 Chen, Z. Y. & Xiong, Z. X. 112614 (SZ); Litang, 8.VIII.1973 *Sichuan Vegetation Expedition 3807* (CDBI); Ma-erh-k'ang, 29.VII. 1975 *s. coll.* 9498 (CDBI, KUN, NAS); Maoxian, 26.VII.1952 He, Z. & Zhou, Z. L. 13499 (NAS, PE, SZ); Meigu, 23.VIII.1959 *s. coll.* 1964 (SM); Muli, 16.VIII.1978 Zhao, Q. S. 8549 (CDBI, SZ); Nanping, 27.VII.1984 Chen, W. L. 8609 (PE); Xiangcheng, 30.VI.1973 *Vegetation Expedition of Sichuan (1973) 2858* (CDBI, NAS, PE); Yanyuan, 20.VII.1983 *Tibet Group 12133* (KUN); Yuexi, 14.VII.1979 *s. coll.* 0732 (SM). — Tibet (Xizang). Bomi, 10.IX.1980 Ni, Z. C. 1574 (PE); Chagla, 17.VI.1952 Tsoong, P. C. 6650 (PE); Ch'a-yu, 7.VIII.1973 *Tibet Group 73992* (KUN, PE); Lin-chih, 22.VI.1972 *Expedition of Chi-*

nese medical plants on Tibet 3522 (PE); Yigong, 11.VII.1965 Ying, J. S. & Hong, D. Y. 0508 (PE). — Yunnan. *s. d.* Delavay 2345 (K); 10.VIII.1889 *Delavay 4097* (P); Yu, T. T. 15309B (PE); Binchuan, 9.IX.1984 *Pan Z. H. 8432* (KUN, NAS); Dali, 28. V.1986 He, B. G. 11 (NAS); Dayao, 26.V.1989 Chen, Y. & Bai, B. 069 (KUN); Deqin, 6.VII.1937 Yu, T. T. 8777 (KUN, NAS, PE); Erh-yuan, 4.IX.1889 *Delavay 3946* (P); 8.VI.1993 *Kunming, Edinburgh, Gothenburg Expedition (1993) 1011* (E); VIII.1935 Wang, C. W. 69090 (NAS, PE); Fugong, 1.VIII.1979 Lin, Q. 791948 (KUN); Gongshan, 31.VIII.1940 Feng, K. M. 7192 (PE); Heqing, 8.VIII.1929 Ching, R. C. 23584 (PE); Lijiang, 28.IX.1984 *Pan Z. H. 84197* (KUN, NAS); Weixi, Wang, C. W. 68723 (KUN, NAS, PE); Zhongdian, 7.VII.1937 Yu, T. T. 12004 (NAS, PE).

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