
Polystichum normale (Dryopteridaceae), a New Species in Section *Crucifilix* from Guizhou, China

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ABSTRACT. A new fern species, *Polystichum normale* Ching ex P. S. Wang & Li Bing Zhang (Dryopteridaceae), is described from Guizhou and illustrated for section *Crucifilix* Tagawa. Distributed in southern Chongqing, northeastern and southeastern Guizhou, and northwestern Hunan, China, the new species is morphologically similar to *P. tripterum* (Kunze) C. Presl and *P. hancockii* (Hance) Diels. *Polystichum normale* has toothed and oblong or almost rectangular pinnae with an acute apex. In contrast, *P. tripterum* has coarsely serrate and falcate-lanceolate pinnae with an acuminate apex. While *P. normale* has sori close to the pinna margins, indusia 0.6–0.8 mm in diameter, and a perispore with an irregularly perforate sculpture, *P. hancockii* has sori closer to the costa, indusia 0.3–0.4 mm in diameter, and a perispore with reticulate sculpture. It is considered Vulnerable (VU), based on IUCN Red List criteria.

Key words: China, Dryopteridaceae, Guizhou, IUCN Red List, *Polystichum*.

While in San Francisco in April 2009, the first author (L.-B.Z.) examined the collections of *Polystichum* Roth (Dryopteridaceae) and allies at the CAS herbarium. A specimen from the collection *Sino-Amer. Exp. 388* of *Polystichum*, collected on 27 August 1986 from northeastern Guizhou, China, had reflexed pinnae and almost upright, obtuse teeth on pinna margins. Its reflexed pinnae resemble those of *P. deflexum* Ching & W. M. Chu, but the tooth shape of the pinnae was very different. The reflexed pinnae and teeth, as well as the sori spread across the entire pinnae, distinguished the specimen from *P. submarginale* (Baker) Ching ex P. S. Wang. After returning to St. Louis, L.-B.Z. sent images of this specimen to the second author (P.-S.W.), who in fact had collected many specimens of this undescribed taxon since October 1985, initially from Mt. Leigong in Guizhou, and had long recognized this as a distinct

species. Subsequent herbarium examinations in CDBI, HGAS, KUN, PE, PYU, and Herbarium Pei-Shan Wang, as well as molecular (Zhang, unpublished) and palynological work, confirm that this species is new to science. We now validly publish the previously ined. name *P. normale* used by Ching based on material collected by P.-S.W.

Polystichum normale Ching ex P. S. Wang & Li Bing Zhang, sp. nov. TYPE: China, Guizhou: Jiangkou Co., Fanjing Shan, Zhuantang, Huangba Cun, 27°46'19.96"N, 108°44'0.18"E, 600 m, sandstone substrate, acidic soil, 20 Sep. 2007, L.-B. Zhang, H. He, B. Xu & Y. Wang 635 (holotype, CDBI; isotypes, CTC, MO). Figures 1, 2.

Species (sectionis *Crucifilicis* Tagawa) *Polystichum tripteronti* (Kunze) C. Presl et *P. hancockii* (Hance) Diels affinis, sed a *P. tripteronte* pinnis dentatis oblongis vel fere rectangularibus apice acutis, a *P. hancockii* soris prope margines pinnarum dispositis, indusiis 0.6–0.8 mm diam. atque perisporarum sculptura irregulariter perforata differt.

Plants perennial, evergreen, (11–)16–33 cm tall; rhizome short, 0.5–2 cm, ascending or erect; scales narrowly ovate, chartaceous, light brown to brown, 3–4 mm; roots dark brown to brown when dry, to 7 cm, 0.2–0.3 mm diam., sparsely covered with hairlike scales. Leaves caespitose; 4 to 7 per rhizome; petiole (4–)6–17 cm, (0.4–)0.7–2.6 mm, median diam., adaxially canaliculate, green, stramineous when dry; basal petiole scales (Fig. 1C) narrowly ovate to lanceolate, 5–7 × 1.2–1.5 mm, thinly chartaceous and brown at mid-portion, membranous and light brown marginally, the margin almost entire, apex acuminate or caudate, matte; distal petiole scales similar but narrower and shorter toward rachis apex, lanceolate or less often narrowly ovate, membranous, light brown, margin ciliate, apex caudate, matte; leaf

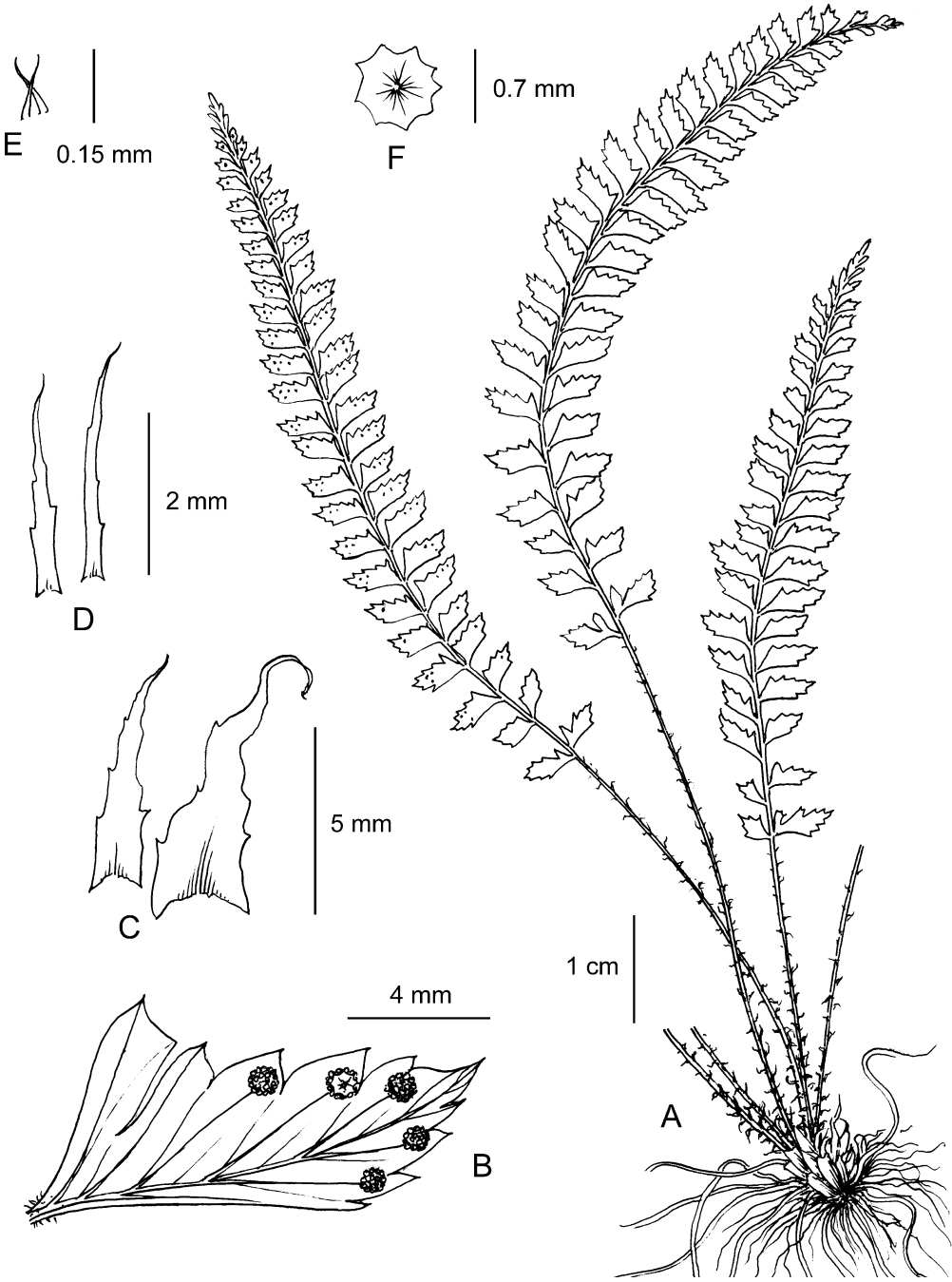


Figure 1. *Polystichum normale* Ching ex P. S. Wang & Li Bing Zhang. —A. Habit. —B. Pinna with sori. —C. Scales from base of petiole. —D. Rachis scales. —E. Narrow-type microscales from abaxial surface of pinna. —F. Indusium. Drawings taken from the paratype *P.-S. Wang F0606* (CDBI).

lamina lanceolate, slightly contracted toward base, 1-pinnate, (6–)9–27 × 1.9–3.3 cm wide at mid-portion, apex acuminate; rachis 0.7–1.3 mm in median diam., without proliferous buds, adaxially sulcate; rachis

scales 1.5–3 × 0.3–0.7 mm, variable in size, membranous, light brown, margin ciliate, apex caudate, matte (Fig. 1D); pinnae in 14 to 28 pairs, not overlapping, pointing upward, basalmost pairs

simple, pinnatifid or 1-pinnate, 8–35 × 3.5–12 mm, the basal 2 pairs 0.7–1.4 cm apart, alternate, green, oblong to nearly rectangular, middle pinnae 9–17 × 3.5–7.2 mm, shortly petiolulate, with petiolules ca. 1.2 mm, chartaceous, acroscopic bases auriculate, basiscopic bases truncate and often forming a (90°–) 100°–110° angle with rachis, apex acute, round but mucronate, acroscopic margins of pinnae repand and serrate, abaxially scaly, adaxially glabrous; microscales on abaxial surface subulate without dilated base (narrow-type microscales; cf. Fig. 1E), 0.1–0.23 mm, 0.05–0.1 mm wide at base; pinnae with the venation pinnate; midrib abaxially slightly raised, adaxially flat and invisible; lateral veins free, in 4 to 7 pairs from midrib per pinna, each lateral vein further dichotomous, indistinct on both surfaces. Sori terminal on veins of pinnae, (1 to) 4 to 8 per fertile pinna (Fig. 1B), located between midrib and pinna margin, 0.7–2.2 mm distant from pinna margin; all pinnae on fertile lamina fertile; indusia peltate, 0.6–0.8 mm diam., membranous, brown, margin erose (Fig. 1F).

Spore morphology. The bilateral spores in *Polystichum normale* are circular in polar view and elliptic in equatorial view. The spore size is ca. 50.5 × 41.3 μm (polar axis × equatorial axis). The ratio of the length of the polar axis to that of the equatorial axis (P/E ratio) is ca. 1.22:1. The perispore sculpture is irregularly perforate, with a few ridges and numerous spinules (Fig. 2G) and is diagnostic for the new species. This contrasts with the reticulate sculpturing observed in *P. hancockii* (Chen, 2007, unpublished).

Distribution and ecology. As currently known, *Polystichum normale* is restricted to southern Chongqing, northeastern and southeastern Guizhou, as well as northwestern Hunan provinces in China. *Polystichum normale* grows in thick, acidic soils derived from sandstone. Populations were observed under forest cover or in shaded areas in valleys. Elevations of collected populations ranged from 600 to 1850 m.

IUCN Red List category. There seem to be no serious concerns about the conservation status of *Polystichum normale*. The taxon has been found in many populations in a relatively wide range across three provinces in China. The core distribution areas, Mt. Fanjing (the type locality) and Mt. Leigong, are now well-protected national parks in Guizhou Province. The most recent collection dates back to 2007 from Mt. Fanjing (the type), although the population size was small, estimated at no more than 100 individuals

scattered in a river valley. However, the geographical range of *P. normale* appears to be severely fragmented. The current status of the population collected in 1992 from Sandu County, Guizhou Province, of the population collected in 1979 from Chongqing Municipality, and finally of the population not re-collected since 1958 in Sangzhi County, Hunan, is currently unknown and its reduction in population size may be suspected. These populations should be under increasing threat of extinction as a result of known deforestation and human disturbance (Zhang & Wang, pers. obs.). Therefore, the status of *P. normale* is best classified as Vulnerable or VU, according to IUCN (2008) criteria.

Etymology. The epithet of the new species is taken from the Latin “normale,” which refers to the completely green or nonvariegated coloration of the fronds.

Discussion. Our unpublished phylogenetic analysis based on chloroplast *trnL-F* sequences resolved *Polystichum normale* as sister to *P. tripterum*, with 97% jackknife support. In another independent phylogenetic analysis based on the chloroplast *rbcl* gene sequences, *P. tripterum* was resolved as sister to *P. hancockii* with 100% bootstrap support (Liu et al., 2007). These two independent studies suggest that *P. hancockii*, *P. normale*, and *P. tripterum* form a supported monophyletic clade. This clade corresponds to *Polystichum* sect. *Crucifilix* and is characterized by 1-pinnate lamina with a pair of 1-pinnate or pinnatifid (or simple) basal pinnae.

Morphologically, *Polystichum normale* is distinguished from *P. tripterum* by having toothed and oblong or almost rectangular pinnae with an acute apex and by having basal pinnae that are simple (Figs. 1, 2C, D), pinnatifid (Fig. 2B), or 1-pinnate (Fig. 2A). The basalmost pinnae are almost as long as (Fig. 1) to twice as long as the median pinnae (Fig. 2A). In contrast, *P. tripterum* has coarsely serrate and falcate-lanceolate pinnae with an acuminate apex and basal pinnae ca. six times as long as the median pinnae. *Polystichum tripterum* is widely distributed in China, Japan, the Korean Peninsula, and the Russian Far East.

Morphological differences between *Polystichum normale* and *P. hancockii* lie in that *P. normale* has the sori positioned closer to pinna margins and the indusia are larger, 0.6–0.8 mm in diameter, whereas *P. hancockii* has the sori slightly closer to the midrib, with the indusia only 0.3–0.4 mm. In addition, the basal pinnae of *P. normale* can be simple or pinnatifid or 1-pinnate, while those of *P. hancockii* are consistently 1-pinnate (at least some laminae on

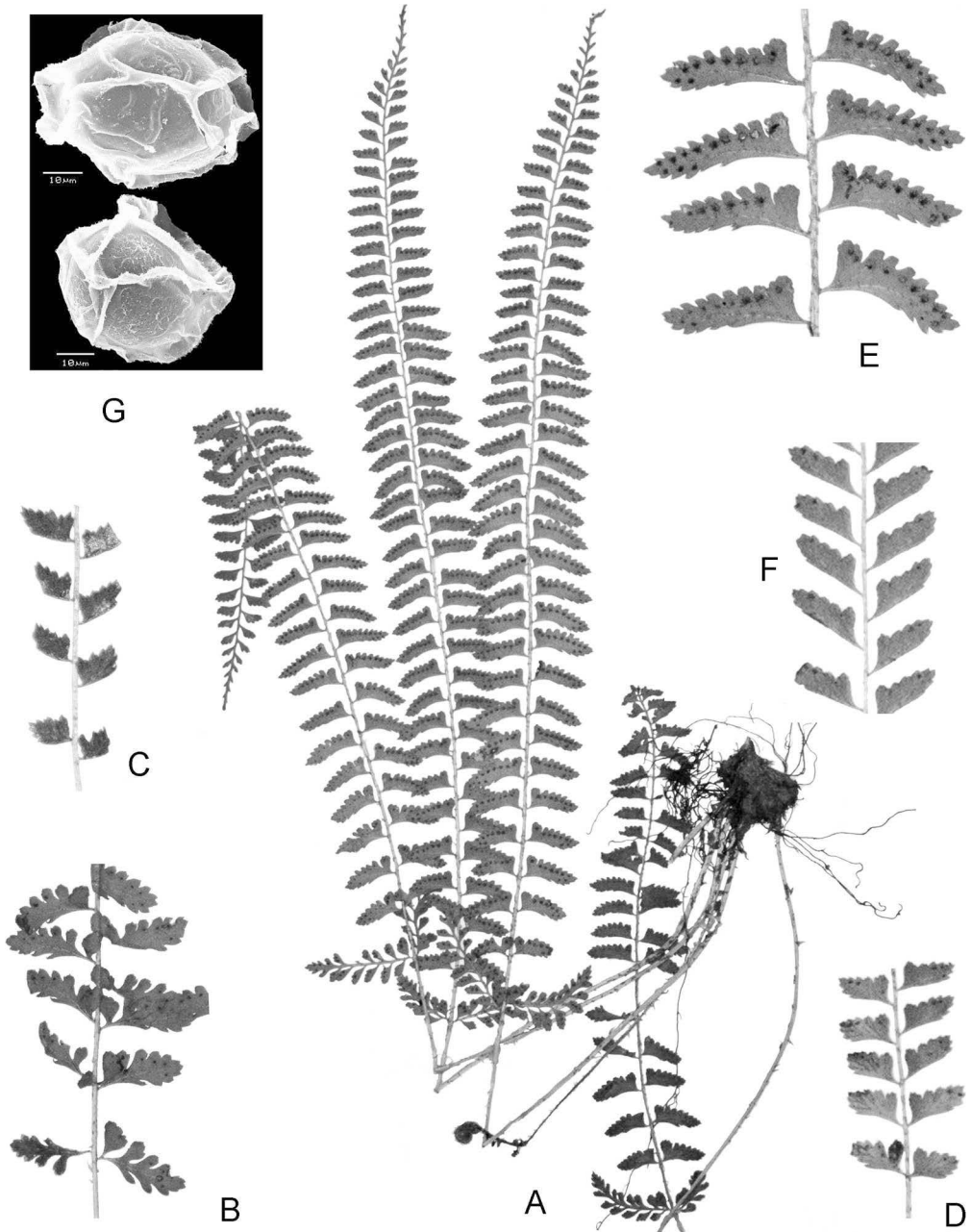


Figure 2. *Polystichum normale* Ching ex P. S. Wang & Li Bing Zhang. —A. Habit. Photo taken of the paratype *Sino-Amer. Exp. 388* (CAS). —B–D. Basal portions of leaf laminae showing the morphological variability in the basalmost pinnae. B taken from *P.-S. Wang F0606* (PYU); C taken from *L. Liu 1991* (KUN); D taken from *Sino-Amer. Exp. 388* (PYU). —E, F. Portions of leaf laminae showing pinna forms. E taken from *Sino-Amer. Exp. 388* (CAS); F taken from *Sino-Amer. Exp. 388* (PYU). —G. SEM micrographs of equatorial (upper) and polar (lower) views of spores showing the irregular perforate sculpturing of the perispore. Taken from the isotype *Zhang et al. 635* (MO). Scale bars = 10 μ m.

any given plant of *P. hancockii* have 1-pinnate basal pinnae). *Polystichum hancockii* is distributed in southern, eastern, and central China, Japan, and the Korean Peninsula (Kung et al., 2001).

These three species of *Polystichum* sect. *Crucifilix* are known to grow in acidic soils. In fact, across the broader taxonomic concept of *Polystichum* sect. *Haplopolystichum* Tagawa (1940) s.l., within which

P. hancockii, *P. normale*, and *P. tripterum* affine, ca. nine species (Zhang & He, 2009a) are known to edaphically prefer acidic soils. Acidophiles in section *Haplopolystichum* s.l. include *P. balansae* Christ, *P. falcatilobum* Ching ex W. M. Chu & Z. R. He, *P. formosanum* Rosenst., *P. hookerianum* (C. Presl) C. Chr., *P. uniseriale* (Ching ex K. H. Shing) Li Bing Zhang, and *P. yaanense* Liang Zhang & Li Bing Zhang, in addition to the three species discussed herein for section *Crucifilix*. Additionally, *P. acutidens* Christ and *P. deltodon* (Baker) Diels are sometimes noted as tolerant of acidic soils. This contrasts with the 12 species occurring in basic soils and restricted to limestone areas as described in recent years (Wang & Wang, 1994, 1997, 2001; Zhang & He, 2009a, 2009b, 2010, 2012; He & Zhang, 2010, 2011; Zhang et al., 2010).

Polystichum normale is one of the morphologically most variable species in section *Haplopolystichum* s.l., sensu Zhang and He (2009a). Its pinna shape, marginal teeth, as well as the morphology of the basal pinnae, are quite variable (Fig. 2), but this variation seems continuous among those specimens seen. It could be hypothesized that this variability may correlate with the relatively broad distribution of *P. normale* across three provinces in south-central China as well as with the diverse habitats observed.

KEY TO SPECIES OF *POLYSTICHUM* SECT. *CRUCIFILIX*

- 1a. Pinnae coarsely serrate on margins, falcate-lanceolate in shape, apex acuminate *P. tripterum*
 1b. Pinnae toothed on margins, oblong or almost rectangular, apex acute 2
 2a. Basal pinnae commonly 1-pinnate (at least some laminae on a given plant have 1-pinnate basal pinnae); sori slightly closer to midrib; indusia 0.3–0.4 mm diam.; perisores with reticulate sculpture *P. hancockii*
 2b. Basal pinnae rarely 1-pinnate; sori closer to pinna margins; indusia 0.6–0.8 mm diam.; perisores with irregularly perforate sculpture *P. normale*

Paratypes. CHINA. **Chongqing:** Qianjiang Co., Xinjian, Xiongjiagou, 750 m, 9 July 1979, S.-x. Tan & C.-L. Li 735 (PYU). **Guizhou:** Jiangkou Co., Fanjing Shan, Tongkuangchang to Yu'ao, 800 m, 17 Oct. 1985, P.-S. Wang F0638 (CDBI, HGAS, PYU, Herbarium Pei-Shan Wang); Heiwan River, 700 m, 16 Oct. 1985, P.-S. Wang F0606 (CDBI, PYU, Herbarium Pei-Shan Wang); 27 Aug. 1986, *Sino-Amer. Exp.* 388 (A, CAS, PYU); Daheiwang, 720 m, 16 Oct. 1985, P.-S. Wang F0614 (HGAS); Leishan Co., Taoliang, 1030 m, 25 Apr. 1984, P.-S. Wang & B. Liu 76941 (CDBI, Herbarium Pei-Shan Wang); Leigong Shan, 1850 m, 13 Mar. 1984, B. Liu 300 (CDBI, Herbarium Pei-Shan Wang); Wudong, Xiangshuiyan, above Wei-Cheng Rd., 1130 m, 22 May 1965, Z.-P. Jian, C.-Z. Dang, N.-G. Ye et al. 50150 (PE); Fangxiang, Pingxiang to Getou, 1060

m, 28 June 1965, Z.-P. Jian, C.-Z. Dang, N.-G. Ye et al. 51037 (PE); Sandu Co., Lalan, 2 Apr. 1992, F. Wang 407 (CDBI, Herbarium Pei-Shan Wang). **Hunan:** Sangzhi Co., Shadiping, Baheshe, 1152 m, on slope, 16 June 1958, L. Liu 1991 (KUN, MO, PYU).

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Literature Cited

- Chen, N. J. 2007. Scanning Electron Microscopic Studies on the Spore Morphology of Dryopterioideae from Taiwan. [Unpublished] M. Sc. Thesis, National Sun Yat-sen University, Kaohsiung, Taiwan.
 He, H. & L.-B. Zhang. 2010. *Polystichum kungianum*, sp. nov. (sect. *Mastigopteris*, Dryopteridaceae) from Chongqing, China. *Bot. Stud. (Taipei)* 51(3): 395–401.
 He, H. & L.-B. Zhang. 2011. *Polystichum cavernicola*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae) from a karst cave in Guizhou, China, and its phylogenetic affinities. *Bot. Stud. (Taipei)* 52(1): 121–127.
 IUCN. 2008. IUCN Red List Categories and Criteria, Version 7. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.
 Kung, H.-S., W.-M. Chu, Z.-R. He & L.-B. Zhang. 2001. *Polystichum*. Pp. 1–246 in C.-Y. Wu (editor), *Flora Reipublicae Popularis Sinicae*, Vol. 5(2), edited by H.-S. Kung. Science Press, Beijing.
 Liu, H.-M., X.-C. Zhang, Z.-D. Chen & Y.-L. Qiu. 2007. Inclusion of the Eastern Asia endemic genus *Sorolepidium* in *Polystichum* (Dryopteridaceae): Evidence from the chloroplast *rbcL* gene and morphological characteristics. *Chin. Sci. Bull.* 52: 631–638.
 Tagawa, M. 1940. *Polystichum* of Japan, Korea, and Formosa, I. *Acta Phytotax. Geobot.* 9: 119–138.
 Wang, P.-S. 1989. Pteridophytes from the Leigong Mountain Nature Reserve, Guizhou Province. Pp. 302–341 in Z.-X. Zhou & M. S. Yao (editors), *Scientific Survey of the Leigong Mountain Nature Reserve*. The People's Publishing House of Guizhou, Guiyang.
 Wang, P.-S. 1992. *Polystichum* Roth. Pp. 125–131 in Pteridophytes of the Fanjing Mountain Nature Reserve. Guizhou Science & Technology Press, Guiyang.
 Wang, P.-S. & X.-Y. Wang. 2001. *Polystichum* Roth. Pp. 517–552 in Pteridophyte Flora of Guizhou. Guizhou Science & Technology Press, Guiyang.
 Wang, X.-Y. & P.-S. Wang. 1994. Studies on pteridophytes in Guizhou (II). *Acta Bot. Yunnan.* 12(2): 53–57.

- Wang, X.-Y. & P.-S. Wang. 1997. New materials for *Polystichum* from Guizhou. *Acta Bot. Yunnan.* 19(1): 41–42.
- Zhang, L.-B. & H. He. 2009a. *Polystichum peishanü* (sect. *Haplopolystichum*, Dryopteridaceae): A new fern species from a limestone area in Guizhou, China. *Bot. Stud. (Taipei)* 50(1): 101–106.
- Zhang, L.-B. & H. He. 2009b. *Polystichum minutissimum*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae): The smallest *Polystichum* found in a karst cave in China. *Bot. Stud. (Taipei)* 50(3): 353–358.
- Zhang, L.-B. & H. He. 2010. *Polystichum speluncicola*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae) based on morphological, palynological, and molecular evidence with reference to the non-monophyly of *Cyrtogonellum*. *Syst. Bot.* 35: 13–19.
- Zhang, L.-B. & H. He. 2012. *Polystichum perpusillum*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae) from a karst cave in China and its isolated phylogenetic relationships. *Ann. Bot. Fenn.* 49: 67–74.
- Zhang, L.-B., H. He & Q. Luo. 2010. *Polystichum puteicola*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae) from a karst sinkhole in Guizhou, China, based on molecular, palynological, and morphological evidence. *Bot. Stud. (Taipei)* 51(1): 127–136.