

# *Polystichum minutissimum* sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae): The smallest *Polystichum* found in a karst cave in China

Li-Bing ZHANG<sup>1,\*</sup> and Hai HE<sup>2</sup>

<sup>1</sup>Chengdu Institute of Biology, Chinese Academy of Sciences, P.O. Box 416, Chengdu, Sichuan 610041, P.R. China and Missouri Botanical Garden, P.O. Box 299, St. Louis, Missouri 63166-0299, USA

<sup>2</sup>Department of Biology, Chongqing Normal University, Shapingba, Chongqing 400047, P.R. China

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**ABSTRACT.** *Polystichum minutissimum* (sect. *Haplopolystichum*, Dryopteridaceae) from a karst cave in southern Guizhou, China, is described as new. *Polystichum minutissimum* is the smallest species in the genus. It is morphologically most similar to *P. liboense*, a species also described from a limestone area in southern Guizhou, but differs from *P. liboense* in lacking hydathodes near the margin of the pinnae. Additionally, *P. minutissimum* has much smaller lamina (1.3-3.8 × 0.7-1.1 cm) and pinnae (middle ones 2.9-5.8 × 2.8-4.5 mm). In fact, it has the smallest lamina and pinnae in the genus. *Polystichum minutissimum* grows in cool, moist, and twilight conditions in a cave, where it can be extremely sensitive to environmental changes, thereby raising concern for its conservation.

**Keywords:** Cave flora; China; Dryopteridaceae; Guizhou; *Polystichum minutissimum*; Smallest polystichoid fern; sect. *Haplopolystichum*.

## INTRODUCTION

Karst landscapes often support unusual plant and animal species, both above and below ground (Mohr and Poulson, 1966; Zhou et al., 1996; Culver et al., 1995, 2000; Shui and Chen, 2006; Zhang and He, 2009). As the “Karst Province” of China, Guizhou is one of the three provinces in China featuring extensive karst areas, with about 74% of its land area covered by karst landscapes (Zhang et al., 2006). Although many groups of plants are relatively well known in Guizhou (e.g. Onagraceae; Boufford, 1990), the rich and diverse fern flora of Guizhou Province had not been adequately explored until recently (Wang and Wang, 2001). This is especially true for the fern flora in karst landscapes in Guizhou, characterized by karst caves (Mo et al., 2005).

As the most prominent feature of karst landscapes, karst caves offer unique habitats for certain species of ferns that are adapted to the cool, moist, and twilight conditions of cave mouths. In the fern genus *Polystichum* (Dryopteridaceae) alone, about eight species are found to be endemic to one or a few karst caves in Guizhou and neighboring regions (Zhou et al., 1996; Kung et al., 2001; Wang and Wang, 2001; Zhang & He, unpubl. data). Exploration of 27 caves during our 2007 field work in Guizhou has resulted in the discovery of a new species of

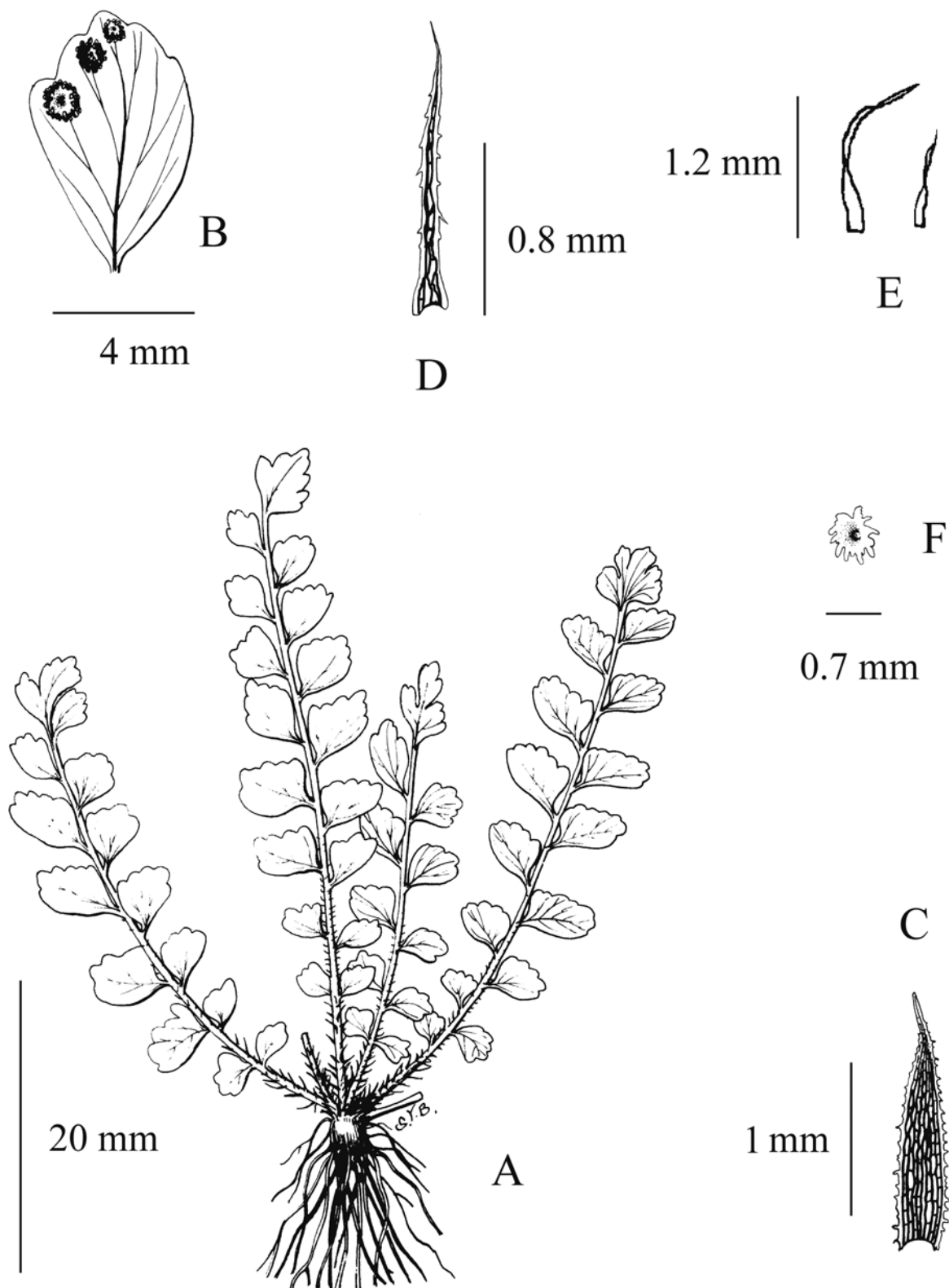
*Polystichum*, the smallest species currently known.

Recent chloroplast DNA sequences have identified a strongly supported so-called BCPC (Lu et al., 2007) or CCPC clade (Li et al., 2008) containing species of *Polystichum* sect. *Haplopolystichum* s.l. (Zhang and He, 2009), *Cyrtomidictyum* Ching, *Cyrtogonellum* Ching, and *Cyrtomium* C. Presl subser. *Balansana* Ching & Shing (Little and Barrington, 2003; Driscoll and Barrington, 2007; Lu et al., 2007; Li et al., 2008). It has also been suggested that the currently defined genus *Cyrtomidictyum* be expanded to accommodate all taxa in this clade (Little and Barrington, 2003). While the relationships within this clade are to be well resolved with good sampling and thorough nomenclatural changes are to be proposed, we here still assign our new species to *Polystichum*.

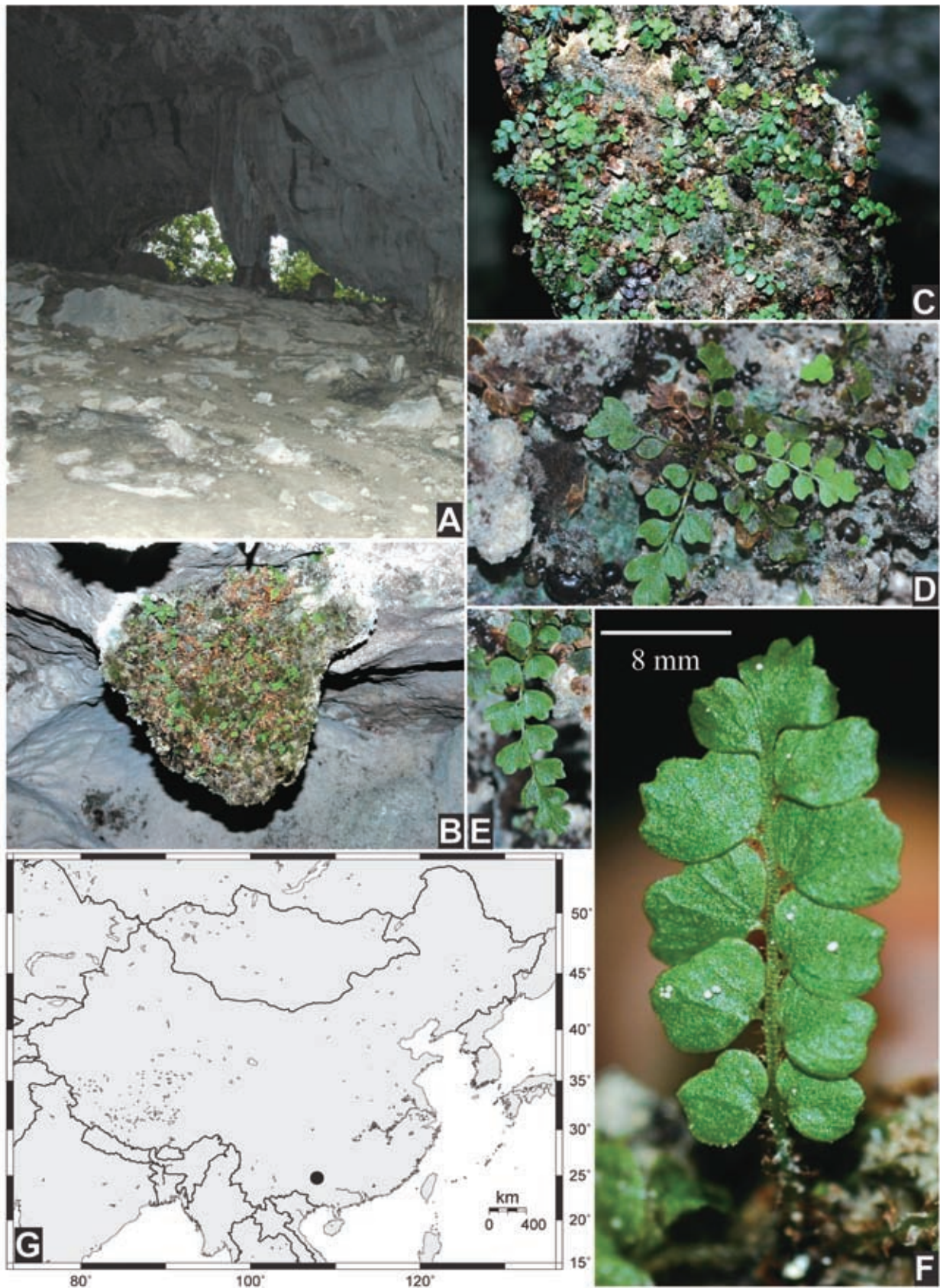
## NEW SPECIES

***Polystichum minutissimum*** L. B. Zhang & H. He, sp. nov.—TYPE: CHINA. Guizhou Province, Libo County, Dongtang Town, Yaosuo Village, Wuyanqiao, Shenxiandong (Cave of the gods), 25°17.29' N, 108°04.06' E, on limestone wall and stalactites, inside a karst cave, c. 10 m from the cave mouth, 0.5-1.5 m above the ground, alt. 750 m, 17 Sep 2007, L. B. Zhang, H. He, B. Xu & Y. Wang 502 (holotype: MO, here designated; isotypes: CDBI, CTC, HAST, MO).  
微小耳蕨 Figures 1, 2

\*Corresponding author: E-mail: Libing.Zhang@mobot.org; Fax: +1-314-577-9596.



**Figure 1.** *Polystichum minutissimum* L. B. Zhang & H. He. A, Frond; B, Pinna; C, Scale from base of petiole; D, Scale of rachis; E, Microscyles; F, Indusium (From the holotype, L. B. Zhang, H. He, B. Xu & Y. Wang 502, MO).



**Figure 2.** *Polystichum minutissimum* L. B. Zhang & H. He. A, Inside view of Shenxiandong (Cave of the gods) in southern Guizhou, China, about 10 m from the entrance of which *P. minutissimum* was discovered; B, Stalactite inside cave on which c. 50 individuals of *P. minutissimum* grow; C, Portion of stalactite with c. 25 individuals of *P. minutissimum*; D, Habit; E, Lamina; F, Frond; G, Distribution in southern Guizhou Province, China (●).

*Species affinis P. liboensi* P. S. Wang & X. Y. Wang, *sed lamina minore* (in *P. liboensi* 6.5-10 × 1.2-1.6 cm), *pinnis minoribus* (in *P. liboensi* c. 9 × 4 mm) *et hydathodis destitutis* (in *P. liboensi* *pinnis prope marginem hydathodis clavatis instructis*) *differt*.

Plants perennial, evergreen, 1.6-4.1 cm tall. *Rhizome* 0.3-0.5 cm long, erect; roots 1-1.5 cm long, c. 0.23 mm\* in diam., sparsely covered with scales; scales lanceolate, brown, ca. 1.4 mm long. *Fronde* cespitose, 6-9 per rhizome; petiole 3.4-8 mm long, 0.23-0.45 mm in diam. at middle, adaxially canaliculate, green; basal petiole scales lanceolate, 1-1.5 × 0.35-0.55 mm, chartaceous, brown, margin slightly ciliate, apex acuminate to caudate, matte; distal petiole scales similar but narrower and shorter toward apex of rachis, varying in size, narrowly lanceolate to subulate, chartaceous, brown, margin shortly and sparsely ciliate, apex caudate, matte. *Lamina* shortly lanceolate, 1-pinnate, 1.3-3.8 cm long, contracted toward base, 0.7-1.1 cm wide at middle, apex obtuse; rachis 0.23-0.45 mm in diam. at middle, without proliferous buds, adaxially sulcate; scales of rachis subulate to linear, 0.7-1.2 mm long, differing in size, chartaceous, brown, margin ciliate, apex caudate, matte. *Pinnae* 5-8 pairs, 2 basal pairs 2.3-4.8 mm apart, alternate, attached at c. 70-degree angles to rachis, middle pinnae 2.9-5.8 × 2.8-4.5 mm, shortly petiolate, nearly rectangular, thinly chartaceous, acroscopic base auriculate, base cuneate, apex obtuse, margin bluntly toothed, abaxially scaly, adaxially glabrous; microscales on abaxial surface linear, 1.1-2.9 mm long; venation pinnate; midrib slightly raised abaxially, flat adaxially; lateral veins free, 2 or 3 pairs from midrib per pinna, abaxially slightly raised and nearly indistinct, adaxially indistinct. *Sori* terminal on veins of upper pinnae, 1-3(or 4) per fertile pinna, close to and c. 0.7 mm distant from margin of pinna; *indusia* peltate, c. 0.7 mm in diam., membranaceous, yellowish brown, margin erose.

*Morphological Distinctiveness.* *Polystichum minutissimum* is similar in stature to *P. liboense*, which is also found in limestone areas of Libo County, Guizhou, but *P. liboense* is larger with lamina 6.5-10 × 1.2-1.6 cm and the middle pinnae c. 9 × 4 mm (Wang and Wang, 2003). Most importantly, *P. liboense* has hydathodes near the margin of the pinnae, while *P. minutissimum* does not. Interestingly, both species have nearly rectangular pinnae with no spinules on the margin.

*Geographical Distribution.* *Polystichum minutissimum* is known only from the type locality in Maolan National Nature Reserve, Libo County, southern Guizhou, China (Figure 2G). Since the Reserve borders Guangxi, it is tempting to assume that *P. minutissimum* may also occur in Guangxi.

*Ecology.* *Polystichum minutissimum* grows on dripping

limestone walls and stalactites, c. 10 m from the entrance inside a karst cave, 0.5-1.5 m above the ground, alt. 750 m. The new species is believed to have adapted to the cool, moist, and twilight conditions. Presumably it has strict light, moisture, temperature, and substrate requirements and thus can be extremely sensitive to environmental changes.

There was no other vascular plants co-occurring with *P. minutissimum* on the walls or stalactites in the cave, although a species of *Selaginella* was dominant on the ground with twilight conditions and several other species, including a climber *Ficus* and species of *Urticaceae*, *Gesneriaceae*, were also found.

*Conservation Assessments.* Only one population with c. 150 individuals was found. *Polystichum minutissimum* should clearly be classified as CE – Critically Endangered following the IUCN (The International Union for Conservation of Nature and Natural Resources) guidelines (IUCN, 2008). A popular tourist route in Maolan Nature Reserve leads through the cave where *P. minutissimum* was discovered. This raises serious concern for its conservation.

*Etymology.* From the Latin *minutum*, small, and the Latin superlative suffix *-issimum*, most, referring to the species being the smallest in the genus.

*Additional specimen examined.* **CHINA.** Guizhou Province: Libo County, Dongtang Town, Yaosuo Village, Wuyanqiao, Shenxiandong (Cave of the gods), 25°17.29' N, 108°04.06' E, on limestone wall and stalactites, inside a karst cave c. 10 m from the cave mouth, 0.5-1.5 m above the ground, alt. 750 m, 27 Oct 2008, L. B. Zhang, H. He & C. B. Jiang s.n. (HGAS).

## DISCUSSION

Other species of *Polystichum* have been found to be confined to one or a few caves, e.g. *P. articulatifoliosum* H. G. Zhou & H. Li in one cave in Napo County, Guangxi (Zhou et al., 1996), *P. houchangense* Ching ex P. S. Wang endemic to a few caves in adjacent Anshun, Qinglong, and Ziyun counties, Guizhou (Wang and Wang, 2001), *P. pseudolanceolatum* Ching ex P. S. Wang in about four karst caves in Anshun County, Guizhou (Wang and Wang, 2001; our own observations). Similar restricted occurrences have also been reported for angiosperms, e.g. for *Begonia* (Li et al., 2005; Liu et al., 2007; Peng et al., 2005, 2006, 2008; Ku et al., 2008, etc.).

In *Polystichum* sect. *Haplopolystichum* s.s. (Daigobo, 1972), in addition to the recently described *P. neoliui* D. S. Jiang (Jiang et al., 2000), which is very similar to *P. liui* Ching and needs further study, ten species have the apex of the pinnae obtuse, round or truncate (instead of acuminate or acute). These ten species are *P. articulatifoliosum*, *P. dielsii* Christ, *P. guangxiense* W. M. Chu & H. G. Zhou, *P. jinshoshanense* Ching & Z. Y. Liu, *P. kwangtungense* Ching, *P. lanceolatum* (Baker) Diels, *P. liboense* P. S. Wang & X. Y. Wang, *P. liui* Ching, *P. oblongum* Ching ex W. M.

\*The measurement of roots, petiole, rachis, scales and indusia was conducted with micrometer under the microscope.

Chu & Z. R. He, and *P. minutissimum*, the new species described here. Except *P. dielsii* which also occurs in northern Vietnam, the remaining nine species are endemic to China (Kung et al., 2001; Wang and Wang, 2003). It is not known if this group is monophyletic, since it is unwise to infer affinities using morphological data only.

Within this group, *P. minutissimum* stands out by having the smallest lamina ( $1.3-3.8 \times 0.7-1.1$  cm) and pinnae (the middle ones  $0.29-0.58 \times 0.28-0.45$  cm). These 10 species can be distinguished from one another by the following key (cf. Kung et al., 2001).

### Key to *Polystichum minutissimum* and allies

1. Pinnae covered with scales and long multicellular hairs ..... *P. articulatifoliosum*
1. Pinnae covered with scales and sometimes also short articulate hairs.
  2. Pinnae with hydathodes near margin ..... *P. liboense*
  2. Pinnae without hydathodes.
    3. Apex of pinnae not mucronate.
      4. Lamina  $12-27 \times 2.7-3.6$  cm, middle pinnae  $1.7-2 \times 0.6-0.8$  cm, margin entire or repand ..... *P. guangxiense*
      4. Lamina  $1.3-3.8 \times 0.7-1.1$  cm, middle pinnae  $0.29-0.58 \times 0.28-0.45$  cm, margin repand ..... *P. minutissimum*
    3. Apex of pinnae mucronate.
      5. Margin of pinnae shallowly repand or toothed, apex round or round-acute.
        6. Lamina less than 12 cm long, thinly papery, margin of scales long-fimbriate ..... *P. oblongum*
        6. Lamina often more than 20 cm long, papery or nearly coriaceous; margin of scales sparsely toothed, ciliate or entire.
          7. Scales of petiole ovate-lanceolate, dark brown, margin ciliate; cells of scale dimorphic, central cells narrow and straight, surrounding cells irregularly curved ..... *P. kwangtungense*
          7. Scales of petiole lanceolate, dark brown to chestnut-brown, margin entire or sparsely toothed; cells of scale monomorphic, narrow and straight ..... *P. dielsii*
5. Margin of pinnae aristate-spinose, apex acute.
  8. Pinnae thinly papery, margin serrate but not aristate-spinose, abaxially with sparse microscales and short articulate hairs ..... *P. jinshoshanense*
  8. Pinnae nearly coriaceous, margin toothed and aristate-spinose.
    9. Adaxial surface of pinnae matte, green, abaxially with sparse microscales and short articulate hairs; scales of rachis lanceolate or broadly lanceolate, apex acuminate ..... *P. liui*
    9. Adaxial surface of pinnae lustrous, dark green, abaxially with sparse short articulate hairs; scales of rachis ovate, apex caudate ..... *P. lanceolatum*

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## 微小耳蕨（新種，半開羽耳蕨組）：最小的耳蕨屬種類 發現於中國貴州一喀斯特岩洞

張麗兵<sup>1</sup> 何海<sup>2</sup>

<sup>1</sup> 中國科學院 成都生物研究所 (CDBI) 密蘇里植物園 (MO)

<sup>2</sup> 重慶師範大學 生物系 (CTC)

本文描述了在中國貴州一喀斯特岩洞中發現的耳蕨屬半開羽耳蕨組 (*Polystichum* sect. *Haplopolystichum*) 一新種：微小耳蕨 (*P. minutissimum*)，並提供線繪圖與彩色照片以資辨識。該新種是耳蕨屬中迄今發現的植株最小的種。微小耳蕨與另一發現於貴州南部石灰岩地區的荔波耳蕨 (*P. liboense*) 最接近。兩者形態上最重要的區別是，微小耳蕨的羽片邊緣不具泌水器，而荔波耳蕨的羽片邊緣脈端具有明顯的泌水器。此外，微小耳蕨的葉片 (1.3-3.8 × 0.7-1.1 cm) 及羽片 (中部羽片 2.9-5.8 × 2.8-4.5 mm) 遠小於荔波耳蕨的葉片及羽片。微小耳蕨是適應於岩洞洞口的潮濕而陰冷的特殊生境的種類，因而可能對環境變化特別敏感，其生境應予以保護。

**關鍵詞**：洞穴植物；中國；鱗毛蕨科；貴州；微小耳蕨；最小的耳蕨；半開羽耳蕨組。