

# *Polystichum kungianum*, sp. nov. (sect. *Mastigopteris*, Dryopteridaceae) from Chongqing, China

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

<sup>1</sup>Department of Biology, Chongqing Normal University, Shapingba, Chongqing 400047, P.R. China

<sup>2</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

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**ABSTRACT.** A new fern species, *Polystichum kungianum* (sect. *Mastigopteris*, Dryopteridaceae), is described from Chongqing, China. The new species, occurring on limestone walls near a small karst cave, is the fourth species known so far in the section *Mastigopteris*. It is morphologically most similar to *P. erosum*, but its pinnae are deltate-lanceolate, and those below the middle of lamina are profoundly pinnatifid. It has an inconspicuous terminal bulbil at the apex of the rachis which never elongates, and its basal pair of pinnae is never reflexed. These differences are obviously distinct from *P. erosum* and make it clear that it could not merely be a variant population within that species, but must be a distinct species. Morphological and geographical features of the accepted species in sect. *Mastigopteris* are discussed, and a key to all four species is given.

**Keywords:** China; Chongqing; Dryopteridaceae; Karst flora; *Polystichum kungianum*; *Polystichum* sect. *Mastigopteris*; Taxonomy.

## INTRODUCTION

Worldwide tropical and subtropical karst landscapes are usually richer in vegetation type, plant species diversity, and endemism than other landscapes under similar climatic conditions (Furley and Newey, 1979). Karst landscapes are normally characterized by karst caves, which provide unique habitats for calcicole ferns. Not all available habitats of certain species are occupied by the same species, which suggests that some critical stage in their life cycle limited their colonization (Wild and Gagnon, 2005). Poor water holding capacity and frequent drought stress are the common hydrological features of limestone areas, while ferns are highly water-dependent in their sexual generation. This might result in a local scarcity of calcicole ferns, leading to their isolation and speciation.

The genus *Polystichum* Roth (Dryopteridaceae) is the species-richest fern genus in China, with 168 species documented in *Flora reipublicae Popularis Sinicae*, the Chinese version of Flora of China (Kung et al., 2001). Its species diversity is still not fully understood, especially in the underexplored mountainous hinterland in Southwest China with its extensive karst landscapes, where countless limestone caves of great variety offer particularly suitable habitats for the development of a fern flora rich in *Polystichum* (Wang, 1998). Further field investigations

often lead to the discovery of new taxa. In Guizhou Province alone, one of the most karst-dominant regions in Southwest China, more than ten species have recently been described or found new to science (Wang and Wang, 2001; Wang and Wang, 2003; Luo, 2009; Zhang and He, 2009a, b; 2010; Zhang et al., 2010). These new species are mostly endemic to karst areas, occurring in habitats of limestone crevices or cave mouths with twilight conditions. It may be noted that most of these species have very small population sizes.

During field work on polystichoid ferns in Chongqing, Southwest China, in 2008, a species of *Polystichum*, which looks, at first glance, like a species of *Woodsia* and occurs on limestone walls, was found to be distinctive. It shares some similarities with species in sect. *Mastigopteris* Tagawa (1940) in its habit, scale types, and most importantly the terminal bulbil at the apex of rachis. However it is significantly morphologically different from any known species in the genus *Polystichum*. Therefore it is described below as *P. kungianum* H. He & L. B. Zhang and grouped in sect. *Mastigopteris*.

## MATERIAL AND METHODS

The morphological data are based on the voucher specimens: CHINA. Chongqing: Wuxi, H. He & Y. Q. Yang 791 (CTC, MO), see below. Morphological measurement of roots, petiole, rachis, scales and indusia was conducted with a micrometer under a microscope.

\*Corresponding author: E-mail: Libing.Zhang@mobot.org; Tel: +1-314-577-9454; Fax: +1-314-577-9596.

## TAXONOMIC TREATMENT AND RESULTS

The new species is described as follows:

**Polystichum kungianum** H. He & L. B. Zhang, sp. nov.

—TYPE: CHINA. Chongqing: Wuxi County, Wenfeng Town, Hongchiba, 31°32.47' N, 108°03.80' E, on moist limestone walls at the edge of a small karst cave, alt. 1,750 m, 17 July 2008, H. He & Y. Q. Yang 791 (HOLOTYPE: CTC; ISOTYPES: CDBI, CTC, HAST, MO). 憲需耳蕨 Figures 1, 2

Species affinis *P. eroso* Ching & Shing, sed pinnis aliquot parium inferiorum profunde pinnatifidis, lobis paris proximi fere liberis, rachi infra gemmam minimam instructa apicis haud prolongata, pinnis deltoideo-lanceolatis, omnibus patentibus et vix deflexis a quo differt.

Plant perennial, evergreen, 12–16 cm tall. *Rhizome* 0.5–2.0 cm long, 2–3 mm in diam., up to 1.5 cm in diam. with base of remnant old petioles, erect or slightly prostrate; scales linear-lanceolate, c. 3.0 × 0.8 mm, dull brown, margin subentire; roots up to 10 cm long, 3–4 mm in diam. *Fronde* caespitose; petiole 1.5–4.5 cm long, 1–2 mm in diam. at middle, adaxially canaliculate, stramineous; scales on basal petiole narrowly deltoid-lanceolate, 3–4 × 0.3–1.2 mm, thin chartaceous, brown, apex filiform, margin at base with outgrowth, outgrowth hair-like, tortuose and soft, margin upward sparsely fimbriate or nearly entire; scales on distal petiole similar but narrower, mostly linear-lanceolate, up to 3 × 0.5 mm, thin chartaceous, brown, apex filiform. *Lamina* lanceolate, 5.5–12.5 × 1.5–2.5 cm, acuminate towards the apex, slightly narrower at the base; rachis 0.5–1.2 mm in diam. about its middle, apex with a small proliferous bulbil, with no flagelliform prolongation; 1-pinnate-pinnatifid. *Pinnae* 18–22 pairs, 0.5–1.5 × 0.3–0.6 (–0.8) cm, shortly petiolate, alternate, lower pairs deltate-lanceolate, attached almost at right angles to the rachis, upper pairs shorter and rhombic-lanceolate, spreading to slightly ascending, acroscopic base auriculate, basiscopic base cuneate, apex acute and terminating in a mucronate spine, several pairs of pinnae below the middle of the lamina deeply pinnatifid with their proximal pair of lobes nearly free, pairs above the middle serrate at their margin with a mucronate tip at tooth apex and basal acroscopic auricle deltate; lobes obliquely oblong to obovate, mucronate at apex, margin entire; texture chartaceous, adaxial surface slightly yellowish green and with occasional articulate hairs especially along midrib, abaxial surface only slightly paler and moderately clothed with scattered microscales; microscales linear-subulate, up to 2.5 mm long, brown, usually with a few curly hair-like outgrowth at the margin of their broader base; venation pinnate, obvious abaxially, lateral veins free, 1–2 times forked. Sori terminal on distal branchlets of forked veinlets, 0.5–2.5 mm apart (when young), (1)–3–5 (–6) in one row on each side of midrib, submarginal; indusia peltate, irregularly lacerate at the margin, membranaceous, white when young, glossy brown later, adjacent ones often overlapping by 0.5–1.5 mm and extending over the pinna

margins when mature. Spores not seen.

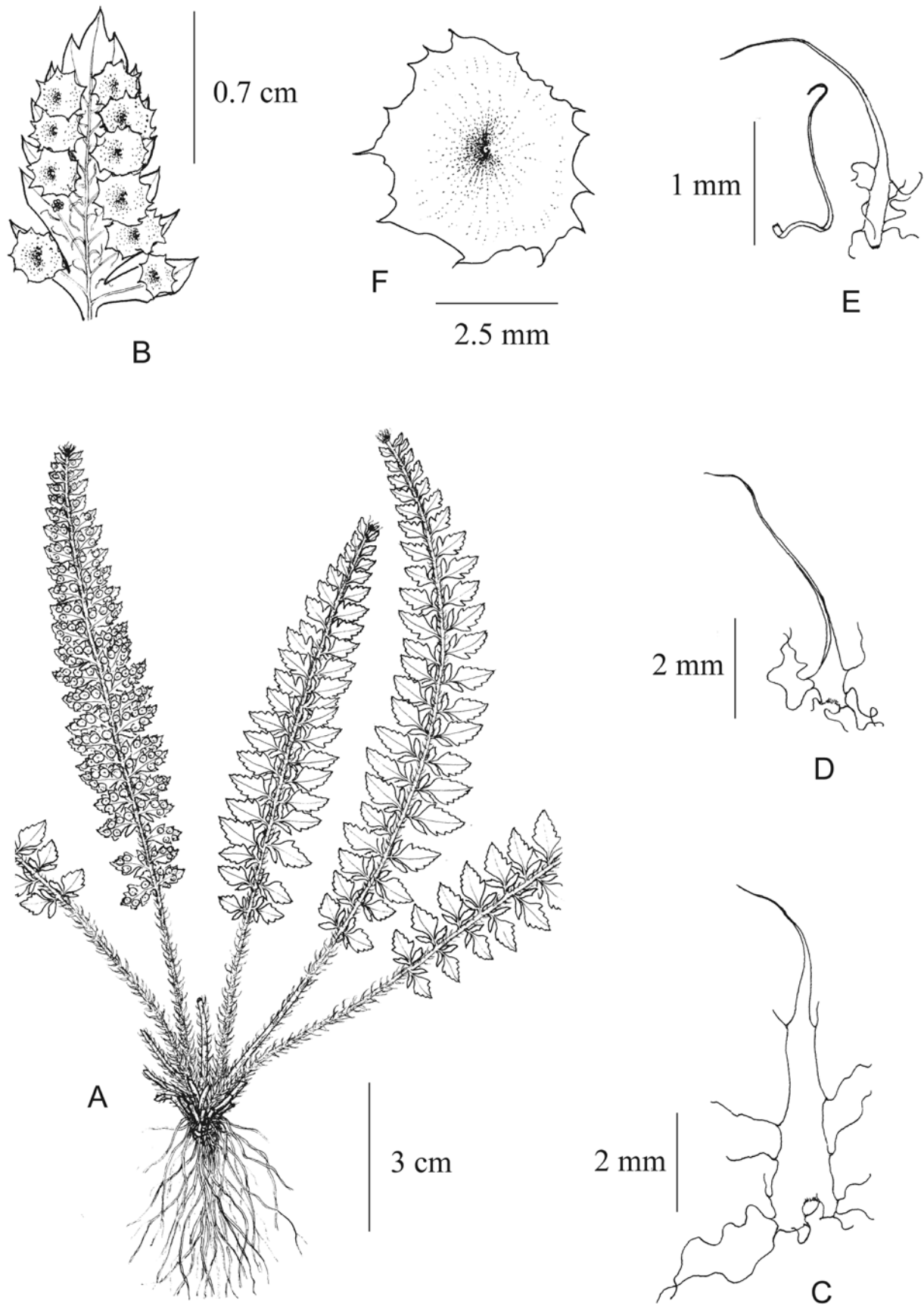
*Morphological Distinctiveness.* *Polystichum kungianum* has a similar stature and lacerate indusia to *P. erosum*, but the pinnae below middle of the lamina of the former are profoundly pinnatifid with the proximal pair of lobes almost free from the other parts. Basal and adjacent pairs of pinnae of *P. kungianum* are attached almost at right angles to rachis, whereas they are usually more or less reflexed in *P. erosum*. Most importantly, *P. kungianum* has deltate-lanceolate pinnae and a rather small terminal bulbil borne directly on the foliose apex of the rachis which never elongates, while *P. erosum* has a much bigger terminal bulbil on the rachis which usually elongates between the terminal bulbil and the uppermost foliose part.

*Geographical Distribution.* This species is only known from the type locality in Hongchiba National Forest Park, Wuxi County, Chongqing, China. This area is located in a series of parallel ridge-valley regions in the southern part of Dabashan Mountain bordering Shaanxi Province. It is assumed that the new species might also occur in neighboring counties of Wuxi in Chongqing and/or Shaanxi in similar habitats.

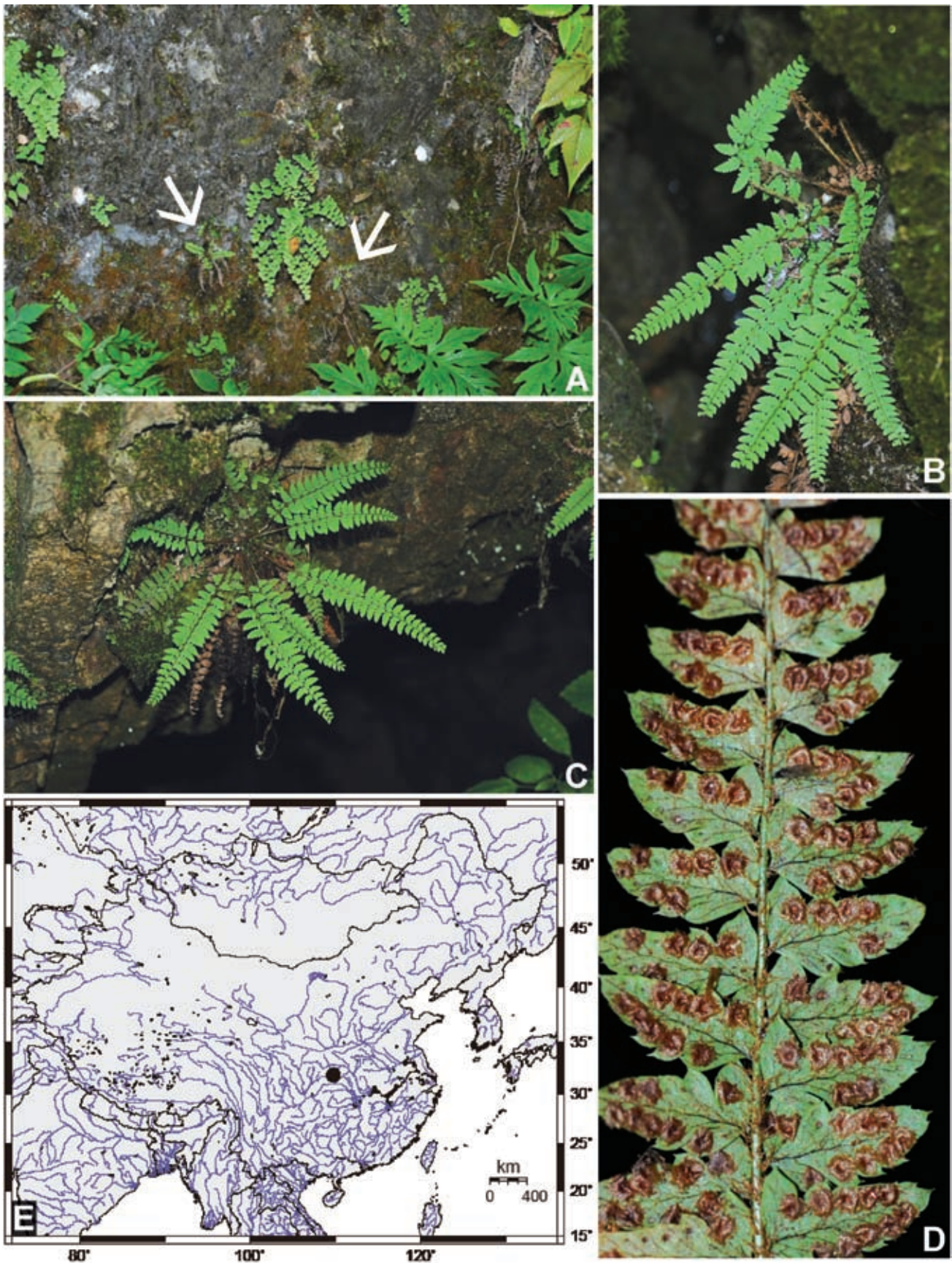
*Ecology.* The new species occurs on shady moist limestone walls at the edge of a small northeast-facing downward sloping karst cave, which is located at the foot of a gradual mountain slope at the southern margin of a narrow area of flat land, extending from the northwest to the southeast at 1,750 m. alt.

It is accompanied by *Adiantum wattii* Baker mixed together in a mat of mosses and liverworts. On the ground and around the cave mouth, there are *Ligularia hodgsonii* Hook. f., *Matteuccia orientalis* (Hook.) Trevis., *Neillia sinensis* Oliv., *Rubus mesogaeus* Focke ex Diels, *Sinacalia tangutica* (Maxim.) B. Nord., *Sorbaria arborea* Schneider, *Spiraea japonica* L. f., and unidentified species of *Corydalis*, *Cotoneaster*, *Elatostema*, *Heracleum*, *Impatiens*, *Salix*, etc. The mountain slope is covered with interspersed patches of secondary deciduous shrubs and broadleaf forests, characterized by *Betula albosinensis* Burkill, *Corylus heterophylla* Fisch. ex Bess. var. *sutchuensis* Franch., *Populus lasiocarpa* Oliv., *Salix fargesii* Burkill, and *Toxicodendron vernicifluum* (Stokes) F. A. Barkley among others. Grasses and forbs dominate the flat land with swamps in between supporting species of *Eleocharis*, *Fimbristylis*, *Juncus*, etc. It has been reported that the flat land was the result of a geological upheaval and filling-up of an inland lake (Chen et al., 1994).

*Conservation Assessments.* Less than 50 individuals of the new fern are scattered on the limestone walls over an area of less than 3 m<sup>2</sup> and c. 1.5 m below to 1 m above the horizontal surface of the flat land. The new species should clearly be classified as CE —Critically Endangered— following the IUCN (The International Union for Conservation of Nature and Natural Resources) guidelines (IUCN, 2008). Hongchiba National Forest Park, where the new species was discovered, has been established since 2002.



**Figure 1.** *Polystichum kungianum*. A, Habit; B, Pinna; C, Scale from base of stipe; D, Rachis scale; E, Microscales; F, Indusium. (based on an isotype H. He & Y. Q. Yang 791, MO).



**Figure 2.** *Polystichum kungianum*. A, Habitat with two individuals (arrows inset) accompanied by *Adiantum wattii*; B-C, Plants showing habit; D, Portion of lamina of a mature leaf; E, Geographical distribution (●) in northeastern Chongqing, China.

*Etymology.* We name this species *Polystichum kungianum* in honor of the late Professor Hsian-Shiu Kung (Xian-Xu Kong) of the Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, for his long and dedicated study of the fern diversity of Chongqing and Sichuan, China. He was the volume editor of *Flora Reipublicae Popularis Sinicae* vol. 5(2) (Kung et al., 2001) and one of the major contributors of the treatment of *Polystichum* in this flora as well as the author of *Flora Sichuanica* vol. 6 (Pteridophytes) which documents the lycophytes and about half of the fern species in Chongqing and Sichuan (Kung, 1988). The second author of this paper earned his M.Sc. under him and started his career as a pteridologist in his laboratory.

## DISCUSSION

The section *Mastigopteris* Tagawa in *Polystichum* contains a small group of species characterized by their 1-pinnate lamina, prolonged rachis with a proliferous bulbil at its apex, narrow scales with hairy outgrowths on their lower margins, sori terminal on distal branchlets of the forked lateral veins, arranged in straight rows and often only in the acroscopic half of the pinna, and indusia large and persistent (Tagawa, 1940; Daigobo, 1972; Wu and Ching, 1991; Kung et al., 2001). A terminal bulbil at the apex of the rachis is a unique feature of Sect. *Mastigopteris*, and other species in the same genus either have no bulbil at all or have a bulbil on other parts of the rachis, usually subapically. As for the reproductive ability of the terminal bulbil, rooting and sprouting leaves were only occasionally found both in the field and in herbaria and most often in *P. craspedosorum* (Maxim.) Diels, another member of sect. *Mastigopteris*. The length of prolonged rachis in between the terminal bulbil and the foliose part varies considerably, from almost no elongation to more than 10 cm (flagelliform). The scales on the stipe (petiole) and rachis and microscales on the abaxial surface of the pinnae especially along the veins in this section are very uniform with some minor modifications in shape and size. However, scale-density varies greatly among different populations and individuals, and field observation found that senescence leads to detachment and loss of the partly deciduous scales. Considering the characters of sect. *Mastigopteris* described above, the new fern, *P. kungianum*, undoubtedly falls into this section morphologically.

Of the four species, including *P. kungianum*, placed in sect. *Mastigopteris*, *P. craspedosorum* is the most variable in size and form, within which several infraspecific taxa have been proposed based on certain morphological characters (Maximowicz, 1870; Baroni and Christ, 1897; Makino, 1912). It should be mentioned that *P. craspedosorum* var. *giraldii* Baroni & Christ was reported to have no elongated rachis below the terminal bulbil and *P. craspedosorum* var. *dissectum* Makino to have pinnatifid pinnae resembling *P. kungianum*. Under

certain circumstances individuals of *P. craspedosorum* may have some leaves without elongated flagelliform rachides or rarely even without a terminal bulbil (as in some specimens collected in a karst cave in Guizhou, *L. B. Zhang, H. He, & C. B. Jiang 729*, CDBI, CTC, MO), but an elongated flagelliform rachis terminating in a rooting bud was also found in leaves of the same individual plant. Both *P. craspedosorum* and *P. shandongense* J. X. Li & Y. Wei usually have entire indusia (Li et al., 1984; Kung et al., 2001). Some plants found on limestone walls in southern Chongqing with crenulate margined indusia, coarsely serrated pinnae, and relatively larger size (but smaller than in *P. shandongense*) correspond with *P. leucochlamys* Christ (1911), which is treated as a synonym of *P. craspedosorum* (Tagawa, 1940; Nakaïke, 1975). Plants of both *P. erosum* and *P. kungianum* have lacerated or erose margined indusia, and they both have a seldom rooting terminal bulbil with a relatively shorter elongated rachis or without elongation at all.

Geographically, sect. *Mastigopteris* as a whole is distributed in eastern Asia, including China, the Korean Peninsula, Japan, and southeastern Siberia of Russia. The most widely distributed species is *P. craspedosorum*, occurring in all the areas mentioned for the section. Concerning its wide distribution, we still think it is reasonable to identify plants corresponding to *P. leucochlamys* as belonging to *P. craspedosorum*, but further investigation might justify its separation. *Polystichum shandongense* is endemic to three counties in Shandong and one county in Liaoning provinces (Li et al., 1984; Kung et al., 2001). Though *P. erosum* was formerly reported as endemic to Sichuan (common in Mt. Emei) and the southern slopes of Qinling (Ching, 1964; Anonymous, 1974), later explorations found it scattered in the provinces of Yunnan, Guizhou, Sichuan, southern Gansu, southern Shaanxi, western Hubei and western Hunan (Wu, 1992; Wang and Wang, 2001; Kung et al., 2001; Lu, 2005; Guo et al., 2008). So far, *P. kungianum* has only been discovered in northeastern Chongqing. With few exceptions, plants of sect. *Mastigopteris* grow on rocks or crevices, and they are most often found in karst areas on limestone walls in Southwest China (see Wu, 1992; Lu, 2005; Guo et al., 2008).

The four members of sect. *Mastigopteris* can be distinguished from one another by the following key:

### Key to *Polystichum craspedosorum* and its allies in sect. *Mastigopteris*

1. Indusia entire or rarely minutely crenate at the margin; rachis often with an obvious flagelliform prolongation below the proliferous terminal bulbil.
2. Pinnae oblong or deltate-lanceolate, shorter than 2 cm; scales on stipe base lanceolate ..... *P. craspedosorum*
2. Pinnae lanceolate, 2-2.5 cm long; scales on stipe base narrowly ovate ..... *P. shandongense*

1. *Indusia* erose or lacerate at the margin; rachis shortly or not elongated below the mostly smaller terminal bulbil.
3. Lamina 1-pinnate; pinnae oblong or oblong-lanceolate, obviously serrate at the margin; basal pairs of pinnae often reflexed; rachis more or less with a non-foliose elongation below the terminal bulbil .....  
.....*P. erosum*
3. Lamina 1-pinnate-pinnatifid; pinnae deltate-lanceolate, pairs above the middle serrate at their margin, lower pairs of pinnae profoundly pinnatifid with proximal pair of lobes nearly free; pinnae spreading or slightly ascending; rachis never elongated below rather small terminal bulbil.....  
.....*P. kungianum*

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## 中國重慶石灰巖地區耳蕨屬邊果耳蕨組一新種：憲需耳蕨

何海<sup>1</sup> 張麗兵<sup>2</sup>

<sup>1</sup> 重慶師範大學生物繫 (CTC)

<sup>2</sup> 中國科學院成都生物研究所 (CDBI); 密蘇裏植物園 (MO)

本文描述了在中國重慶發現的耳蕨屬邊果耳蕨組 (*Polystichum* sect. *Mastigopteris*) 一新種：憲需耳蕨 (*P. kungianum*)，並提供線繪圖與彩色照片以資辨識。該新種生於一個小型岩溶洞穴邊緣石灰岩壁上，是耳蕨屬邊果耳蕨組中迄今發現的第 4 個種。憲需耳蕨與蝕蓋耳蕨 (*P. erosum*) 最接近，但其葉片中部以下多對羽片深羽裂，葉軸頂端較小而不明顯的芽胞之下無伸長的葉軸，羽片三角狀披針形，下部羽片平展而從不向下反折斜展等特徵可以區別。文中還討論了邊果耳蕨組已知種類的形態變化、地理分佈和生境等特徵並編制了這 4 個種的檢索表。

**關鍵詞：**中國；重慶；鱗毛蕨科；喀斯特植物；憲需耳蕨；邊果耳蕨組；分類。

