

УДК 582.381.2:581.96(510)

Two new species of *Phlegmariurus* (Lycopodiaceae) from China

R.-H. Jiang^{1,2}, X.-C. Zhang^{2,3*}

¹ Guangxi Forestry Research Institute, Guangxi, Nanning, 530028, China. ORCID iD: <https://orcid.org/0000-0003-4908-3487>

² State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany,
Chinese Academy of Sciences, Beijing 100093, China

³ E-mail: zhangxc@ibcas.ac.cn; ORCID iD: <https://orcid.org/0000-0003-3425-1011>

*Corresponding author

Keywords: morphology, new species, *Phlegmariurus*, taxonomy.

Summary. Based on morphological study, two new species of the lycophyte genus *Phlegmariurus* Holub, *P. yunfengii* R.-H. Jiang et X.-C. Zhang and *P. shingianus* R.-H. Jiang et X.-C. Zhang from China are described and illustrated. Detailed description, ecology, distribution, conservation status as well as a comparison with morphologically similar species are provided.

Два новых вида *Phlegmariurus* (Lycopodiaceae) из Китая

Ж.-Х. Цзян^{1,2}, С.-Ч. Чжан²

¹ Научно-исследовательский институт лесного хозяйства Гуанси, г. Наньнин, 530028, Китай

² Лаборатория систематики и эволюционной ботаники, Институт ботаники Китайской
Академии наук (КАН), г. Пекин, 100093, Китай

Ключевые слова: морфология, новый вид, таксономия, *Phlegmariurus*.

Аннотация. На основе морфологического исследования описаны из Китая два новых вида плауновидных из рода *Phlegmariurus* Holub: *P. yunfengii* R.-H. Jiang et X.-C. Zhang и *P. shingianus* R.-H. Jiang et X.-C. Zhang. Представлены морфологические описания, иллюстрации, охарактеризованы экология, распространение, охранный статус видов, а также дано морфологическое сравнение с близкими видами.

Introduction

Phlegmariurus is the largest genus of Lycopodiaceae (Herter, 1909; Holub, 1964), with about 250 species distributed in the tropics and subtropics of the world (PPG I, 2016). *Phlegmariurus* plants in the Old World are mainly epiphytic (Zhang, Iwatsuki, 2013). The taxonomy of *Phlegmariurus* is still problematic due to intra-specific morphological variation or little morphological difference between closely related species. Combining genetic markers

and morphological evidence is the best approach for species delimitation, much needed in *Phlegmariurus*. With climatic changes and habitat loss, the population of many species of this genus is rapidly decreasing. Based on extensive field investigation and studies of herbarium specimens, combined with whole chloroplast genome molecular phylogenetic analysis (data unpublished), we conducted a taxonomic revision of *Phlegmariurus* from China and neighboring regions, and discovered two new species from Yunnan and Guangxi, respectively.

Material and methods

Morphological studies: Morphological studies of herbarium specimens were conducted in GXMG, GXMI, IBK, and PE, online images of specimens from A, BM, E, CSH, HITBC, HUST, IBSC, K, KUN, MO, NY, P, PYU, SZG, TAI, and US were checked. The type specimens of the new species were deposited in PE and GXMI respectively.

Molecular evidence: Chloroplast genomes of 47 species of *Phlegmariurus* including the two putative new species were generated and phylogenetically analyzed (data unpublished).

Results

Morphological comparison: The specimens of *Phlegmariurus yunfengii* (F. Y. Huang 11) from Yunnan were compared with *P. sieboldii* (Miq.) Ching (\equiv *Lycopodium sieboldii* Miq.), *P. fargesii* (Herter) Ching (\equiv *Lycopodium fargesii* Herter),

P. cancellatus (Spring) Ching (\equiv *Lycopodium cancellatum* Spring), and *P. yunnanensis* Ching, it differs from them in stem diameter and leaf shape (Table 1). The specimens of *Phlegmariurus shingianus* (S. C. Ng 3325) from Guangxi were compared with *P. henryi* (Baker) Ching (\equiv *Lycopodium henryi* Baker), *P. fordii* (Baker) Ching (\equiv *Lycopodium fordii* Baker), and *P. cunninghamioides* (Hayata) Ching (\equiv *Lycopodium cunninghamioides* Hayata); it differs from these species in the angle of leaf divergence and leaf shape (Table 1, 2).

Molecular phylogenetic analyses: Phylogenetic analysis based on chloroplast genomes strongly supported *P. yunfengii* as an independent lineage sister to the *P. fargesii* – *P. yunnanensis* clade. *Phlegmariurus shingianus* was also recovered as a monophyletic group with the sister relationship to *P. cunninghamioides*, and then together sister to *P. henryi* (data unpublished).

Table 1

Comparison of morphological characters of *Phlegmariurus yunfengii* with similar species

Character	<i>P. yunfengii</i>	<i>P. sieboldii</i>	<i>P. fargesii</i>	<i>P. cancellatus</i>	<i>P. yunnanensis</i>
Diameter of mature main stem	ca. 0.8 mm	1 to 3 mm	ca. 2 mm	ca. 4 mm	2 to 5 mm
Lateral branches	unequal in length	unequal in length	equal in length	unequal in length	unequal in length
Middle leaves shape	ovate	elliptic	linear-lanceolate	lanceolate	ovate-lanceolate
Middle leaves length to width ratio	ca. 2 : 1	ca. 2 : 1	ca. 7 : 1	ca. 5 : 1	ca. 6 : 1
Sporophyll	ovate, apex acute	ovate, apex obtuse or acute	ovate or ovate-lanceolate, apex acute	ovate, apex acuminate	ovate, apex acuminate to acute, or cuspidate
Sporophyll length to width ratio	ca. 1 : 1	less than 2 : 1	1 : 1 to 2 : 1	ca. 2 : 1	ca. 1 : 1

Table 2

Comparison of morphological characters of *Phlegmariurus shingianus* with similar species

Character	<i>P. shingianus</i>	<i>P. henryi</i>	<i>P. fordii</i>	<i>P. cunninghamioides</i>
Middle leaves	elliptic-lanceolate, apex acuminate	elliptic, apex acute	elliptic-lanceolate, apex acuminate	linear, apex acuminate
Middle leaves length width ratio	ca. 4 : 1	ca. 3 : 1	ca. 6 : 1	ca. 8 : 1
Middle leaves divergence angle	40°–50°	40°–50°	less than 25°	25°–30°
Sporophyll	elliptic-lanceolate	elliptic-lanceolate	lanceolate or elliptic-lanceolate	linear
Sporophyll length to width ratio	2 : 1 to 3 : 1	2 : 1 to 3 : 1	ca. 6 : 1	ca. 10 : 1

Taxonomic treatment

Phlegmariurus yunfengii R.-H. Jiang et X.-C. Zhang, **sp. nov.** (Fig. 1).

Diagnosis: The new species is similar to *P. sieboldii*, *P. yunnanensis* and *P. fargesii*, but differs in the basal leaves linear-lanceolate, ca. 4×0.8 mm, length to width ratio ca. $5 : 1$; middle leaves ovate, apex acuminate, ca. 1.7×0.9 mm, length to width ratio ca. $2 : 1$; upper leaves ovate, ca. 0.8×0.8 mm, apex acute, length to width ratio ca. $1 : 1$; sporophylls ovate, ca. 0.8×0.8 mm, apex acute.

Holotype: “China. Yunnan, Funing County, in limestone mountains, epiphytic on tree trunks, alt. 1400 m. 19 IX 2017. F. Y. Huang 11” (GXMI!).

Plants epiphytic, 30–55 cm long. Stems caespitose, ca. 0.8 mm in diam., mature branches pendulous, one to several times forked. Leaves spirally arranged, conspicuously dimorphic, margin entire, lustrous, leathery; basal sterile leaf from linear-lanceolate, ca. 4×0.8 mm, length to width ratio $5 : 1$; middle sterile leaves ca. 2 mm long, ovate-triangular, apex acuminate, ca. 2×1 mm wide, length to width ratio $2 : 1$; upper broadly ovate to deltate, apex acute; midrib indistinct, raised abaxially, base cuneate and decurrent, sessile. Strobili terminal on branches, 0.4–0.7 mm in diam. Sporophylls ovate-subdeltate, ca. 0.8×0.8 mm, length to width ratio $1 : 1$, midrib indistinct, base cuneate, margin entire, apex acute. Sporangia exposed, only covered at their base by sporophylls, yellowish, reniform, opening at the apex with a vertical slit.

Etymology: The species is dedicated to Mr. Yun-Feng Huang, a taxonomist working on medicinal plants in Guangxi, who kindly provided his collections of *Phlegmariurus* for our study.

Distribution and habitat: *Phlegmariurus yunfengii* is endemic to southeast Yunnan. It is epiphytic on tree trunks at elevations from 1600 to 1800 m.

Conservation status: Only two small populations of *Phlegmariurus yunfengii* were found in Funing County, Southeast Yunnan. The number of mature individuals were less than 50. Therefore, it should be classified as a critically endangered species (CR) according to the IUCN criteria (IUCN 2019).

Additional specimen examined: “China. Yunnan, Funing County, epiphytic on tree trunks, 2015, ZH-XJ1” (GXMI!).

Phlegmariurus shingianus R.-H. Jiang et X.-C. Zhang, **sp. nov.** (Fig. 2).

Diagnosis: The new species is similar to *P. fordii* and *P. henryi*, but differs in leaves attached at acute angles to the stem or slightly angled upward ($> 30^\circ$), leaves elliptic-lanceolate, length to width ratio $4 : 1$, sessile, apex acuminate; sporophylls elliptic-lanceolate, length to width ratio ca. $4 : 1$, apex acuminate.

Holotype: “China. Guangxi, Shangsi County, epiphytic, alt. 800–1000 m. 10 XII 2001. S. C. Ng 3325” (PE-1434066!; iso – IBK, KFBG).

Plants epiphytic, 30–45 cm long. Stems caespitose, erect or pendulous, one to three times forked, main stems ca. 2.5 mm in diam. Sterile leaves spirally arranged, dimorphic, attached at acute angles with stem or slightly angled upward ($> 30^\circ$), lustrous, leathery, middle leaves elliptic-lanceolate, ca. $1.2\text{--}1.5$ cm \times $2.5\text{--}3$ mm, length to width ratio $4 : 1$, midrib distinct, base cuneate, decurrent, sessile, margin entire, apex acuminate. Strobili terminal on branches, more slender than sterile part. Sporophylls similar to sterile leaves, sparsely arranged, elliptic-lanceolate, ca. $8\text{--}10 \times 1.6\text{--}2.4$ mm, length to width ratio $4 : 1$, midrib distinct, base cuneate, margin entire, apex acuminate. Sporangia yellowish, reniform, opening at the apex with a vertical slit.

Etymology: The species is dedicated to Prof. K. H. Shing, a famous pteridology student of the late Professor Ren-Chang Ching. Prof. Shing worked as an assistant of Prof. Ching for a long time from 1950s to 1980s and monographed on *Cyrtomium* and *Pyrrosia* and edited two volumes of the national flora of China (*Flora Reipublicae Popularis Sinicae*). Prof. Shing has made great contribution to the taxonomy of Chinese ferns through cooperation with pteridologists at home and abroad.

Conservation status: *Phlegmariurus shingianus* was found from the valley forest in Shiwandashan, Guangxi; the exact population size is unknown.

Distribution and habitat: *Phlegmariurus shingianus* is endemic to South Guangxi. It is an epiphytic on tree trunks in deep forest, alt. 800–1000 m.

Acknowledgements

The authors are grateful to Xin-Cheng Qu for the nice line drawing. This study was supported by grants from the National Science Foundation of China (NSFC-32160048, 31370260 & 31470317) and Survey and Collection of Germplasm Resources of Woody & Herbaceous Plants in Guangxi, China (GXFS-2021-34).

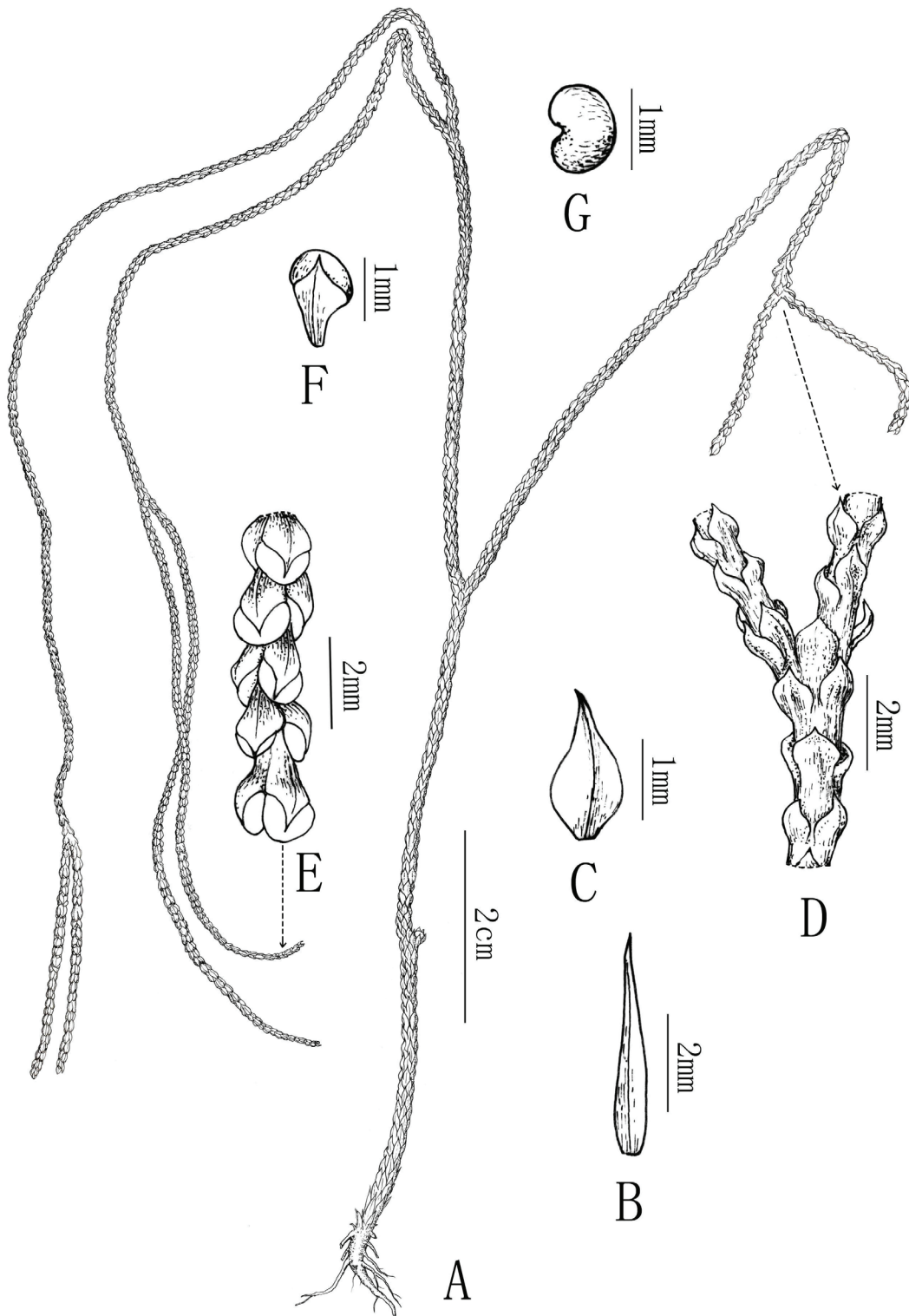


Fig. 1. *Phlegmariurus yunfengii* R.-H. Jiang et X.-C. Zhang: A – habit; B – basal leaf; C – middle leaf; D – abaxial view of strobilus; E – adaxial view of strobilus; F – sporophyll; G – sporangium (drawn from F. Y. Huang 11, GXMI).



Fig. 2. Holotype of *Phlegmariurus shingianus* R.-H. Jiang et X.-C. Zhang (S. C. Ng 3325, PE).

REFERENCES

- Herter G.** 1909. Beiträge zur Kenntniss der Gattung *Lycopodium*. Studien über die Untergattung *Urostachys*. *Bot. Jahrb. Syst.*, Beibl. 98(43): 1–56.
- Holub J.** 1964. *Lycopodiella*, nový rod řádu Lycopodiales. *Preslia* 36(1): 16–22.
- PPG I (The Pteridophyte Phylogeny Group).** 2016. A community-derived classification for extant lycophytes and ferns. *J. Syst. Evol.* 54(6): 563–603. DOI: 10.1111/jse.12229
- Zhang L. B., Iwatsuki K.** 2013. Lycopodiaceae. In: Wu Z. G., Raven P. H., Hong D. Y. (eds.). *Flora of China*. Vol. 2–3. Beijing: Science Press; St. Louis: Missouri Botanical Garden Press. Pp. 13–34.