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

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**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.

**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and studies of herbarium specimens, combined with whole chloroplast genome molecular phylogenetic analysis (data unpublished), we conducted a taxonomic revision of *Phlegmariurus* from China and neighboring regions, and discovered two new species from Yunnan and Guangxi,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47 species of Phlegmariurus including the two putative new species were generated and phylogenetically analyzed (data unpublished).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 (≡ Lycopodium sieboldii Miq.), P. fargesii (Herter) Ching (≡ Lycopodium fargesii Herter), P. cancellatus (Spring) Ching (≡ 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 (≡ Lycopodium henryi Baker), P. fordii (Baker) Ching (≡ Lycopodium fordii Baker), and P. cunninghamioides (Hayata) Ching (≡ 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>
<thead>
<tr>
<th>Character</th>
<th>P. yunfengii</th>
<th>P. sieboldii</th>
<th>P. fargesii</th>
<th>P. cancellatus</th>
<th>P. yunnanensis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of mature main stem</td>
<td>ca. 0.8 mm</td>
<td>1 to 3 mm</td>
<td>ca. 2 mm</td>
<td>ca. 4 mm</td>
<td>2 to 5 mm</td>
</tr>
<tr>
<td>Lateral branches</td>
<td>unequal in length</td>
<td>unequal in length</td>
<td>equal in length</td>
<td>unequal in length</td>
<td>unequal in length</td>
</tr>
<tr>
<td>Middle leaves shape</td>
<td>ovate</td>
<td>elliptic</td>
<td>linear-lanceolate</td>
<td>lanceolate</td>
<td>ovate-lanceolate</td>
</tr>
<tr>
<td>Middle leaves length to width ratio</td>
<td>ca. 2 : 1</td>
<td>ca. 2 : 1</td>
<td>ca. 7 : 1</td>
<td>ca. 5 : 1</td>
<td>ca. 6 : 1</td>
</tr>
<tr>
<td>Sporophyll</td>
<td>ovate, apex acute</td>
<td>ovate, apex obtuse or acute</td>
<td>ovate or ovate-lanceolate, apex acute</td>
<td>ovate, apex acuminate</td>
<td>ovate, apex acuminate to acute, or cuspidate</td>
</tr>
<tr>
<td>Sporophyll length to width ratio</td>
<td>ca. 1 : 1</td>
<td>less than 2 : 1</td>
<td>1 : 1 to 2 : 1</td>
<td>ca. 2 : 1</td>
<td>ca. 1 : 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Character</th>
<th>P. shingianus</th>
<th>P. henryi</th>
<th>P. fordii</th>
<th>P. cunninghamioides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle leaves</td>
<td>elliptic-lanceolate, apex acuminate</td>
<td>elliptic, apex acute</td>
<td>elliptic-lanceolate, apex acuminate</td>
<td>linear, apex acuminate</td>
</tr>
<tr>
<td>Middle leaves length width ratio</td>
<td>ca. 4 : 1</td>
<td>ca. 3 : 1</td>
<td>ca. 6 : 1</td>
<td>ca. 8 : 1</td>
</tr>
<tr>
<td>Middle leaves divergence angle</td>
<td>40°–50°</td>
<td>40°–50°</td>
<td>less than 25°</td>
<td>25°–30°</td>
</tr>
<tr>
<td>Sporophyll</td>
<td>elliptic-lanceolate</td>
<td>elliptic-lanceolate</td>
<td>lanceolate or elliptic-lanceolate</td>
<td>linear</td>
</tr>
<tr>
<td>Sporophyll length to width ratio</td>
<td>2 : 1 to 3 : 1</td>
<td>2 : 1 to 3 : 1</td>
<td>ca. 6 : 1</td>
<td>ca. 10 : 1</td>
</tr>
</tbody>
</table>
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, more slender than sterile part. Sporophylls similar to sterile leaves, sparsely arranged, elliptic-lanceolate, ca. 8–10 × 1.6–2.4 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 Mr. Yun-Feng Huang, a taxonomist working on medicinal plants in Guangxi, who kindly provided his collections of Phlegmariurus for our study.

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

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°), leaves elliptic-lanceolate, length to width ratio 4 : 1, sessile, apex acuminate; sporophylls similar to sterile leaves, sparsely arranged, elliptic-lanceolate, ca. 1.2–1.5 cm × 2.5–3 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. 8–10 × 1.6–2.4 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

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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


