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A new fern of Thelypteridaceae from Jiangxi, China

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ABSTRACT: *Coryphopteris jiulianshanensis* (Thelypteridaceae) is described and illustrated here. This new species resembles *Coryphopteris angulariloba* in rhizomes, laminae, and pinnae shape; however, it can be distinguished from the latter by the following characteristics: unicellular setae (vs. multicellular acicular hairs) along the abaxial side of the costae, veins, and rachis; 4–7 pairs of lateral veins (vs. 2–4 pairs); and sori that are closer to the main veins than to the margins (vs. being located at the middle of the main veins and margins). The conservation status of *C. jiulianshanensis* is temporarily assessed as "Near Threatened" according to the IUCN Red List Categories and Criteria.

KEY WORDS: *Coryphopteris jiulianshanensis*, Flora of Jiangxi, IUCN Red List, Jiulianshan National Nature Reserve.

INTRODUCTION

The Thelypteridaceae is among the largest fern families, with 1034 recognized species, comprising about 10% of all fern species diversity (PPG I, 2016). The family is cosmopolitan, with the greatest diversity near the equator, and species range as far north as Greenland and Alaska, and as far south as southern New Zealand (Fawcett and Smith, 2021). Because most of the diagnostic features needed to identify species are microscopic or require complete fertile fronds with rhizomes, making this an especially challenging group for both field and herbarium botanists (Fawcett and Smith, 2021). The identification of taxa within the family is notoriously difficult, taxonomist had proposed diffrent generic classification system based on phylogenomic and morphological study, for example, He and Zhang (2012) proposed recognition of eight genera, indicated that *Parathelypteris* species were not monophyletic and intermixed with *Coryphopteris* and *Amauropelta*. Almeida *et al*. (2016), proposed the recognition of 16 genera in the family. Recently, Fawcett and Smith (2021), with increased sampling based on morphological, biogeographical, and phylogenomic data, proposed a new generic classification system for Thelypteridaceae. This new classification system included many taxonomic revisions, such as treating species of *Parathelypteris* within *Coryphopteris* or in three of the four subgenera of *Amauropelta.* We adopt their new generic classification system in this study.

Coryphopteris is widely distributed on mainland Asia from northeastern India to southern Russia (Fawcett and Smith, 2021). It was sister to the clade of *Amauropelta* and *Metathelypteris* phylogenetically (Almeida *et al*., 2016). Morphologically, it is most similar to *Amauropelta* s.l., but it may be distinguished by its usually erect, trunk-like rhizomes, proximal pinnae largest or only slightly reduced, and by the presence of ffliform scales or multicellular hairs along abaxial costae, it most diverse in the mountainous areas of Malesia, Melanesia, and Polynesia, usually above 1000 m, this genus includes 68 species and reaches its greatest diversity in the mountains of Papua New Guinea (Fawcett and Smith, 2021). After excluding synonyms, there were 21 species of *Parathelypteris* ditributed in China in total (Lin *et al*., 2013; POWO, 2025); among them, 13 species were transfer to *Coryphopteris* (Fawcett and Smith, 2021), 6 of which were endemic to China (Lin *et al*., 2013), viz. *C. chinensis* (Ching) S.E. Fawc. & A.R.Sm., *C. chingii* (K.H.Shing & J.F.Cheng) S.E.Fawc. & A.R.Sm., *C. caudata* (Ching ex K.H.Shing) S.E. Fawc. & A.R.Sm., *C. trichochlamys* (Ching ex K.H.Shing) S.E.Fawc. & A.R.Sm., *C. pauciloba* (Ching ex K.H.Shing) S.E.Fawc. & A.R.Sm. and *C. nigrescens* (Ching ex K.H.Shing) S.E.Fawc. & A.R.Sm, most of them are distributed in a narrow regions, for example, *C. trichochlamys* are only distributed in their type locality, Dangshan, Huaiji County, Guangdong Province (Shing, 1999; Lin *et al*, 2013); 5 species of *Parathelypteris* were placed in *Amauropelta* subg. *Parathelypteris*, 1 species was placed in *Amauropelta* subg. *Venus* (Lin *et al*, 2013; Fawcett and Smith, 2021). *Parathelypteris borealis* (Hara) K.H.Shing, which widely distributed in China and Japan was treated as a heterotypic synonyms of *C. nipponica* (Franch. & Sav.) S.E.Fawc. & A.R.Sm (Fawcett and Smith, 2021; POWO, 2025). The taxonomic position of *P. changbaishanensis* Ching ex K.H.Shing and *P. qinlingensis* Ching ex K.H.Shing, which were previously placed in *Parathelypteris* Sec. *Parathelypteris* Ser. *Nipponicae* (Shing, 1999), were not resolved, because research on their type materials still not enough (Fawcett and Smith, 2021).

In June 2021, during the investigation of ferns in Jiulianshan National Nature Reserve, Jiangxi Province, we found an unknow species of Thelypteridaceae, it resembles *Coryphopteris angulariloba* (Ching) L.J.He & X.C.Zhang in many morphological characteristics (Zhang, 2012; Lin *et al*., 2013), For example, the rhizomes are decumbent or ascending, the stipe bases have long spreading acicular hairs, the laminae are oblong, and the pinnae are lanceolate or linear-lanceolate without spherical glands. However, after comparing its specimen with *C. angulariloba* under an optical microscope, we found that the pinnae and rachis indumentum of this species differed from that of *C. angulariloba*. To confirm its systematic position, we extracted its DNA for sequencing plastid regions and analysis. We further reviewed the relevant literature (Lin *et al*., 2013; Peng *et al*., 2013; Fernandes and Alino, 2016; Ebihara *et al*., 2020; Fawcett *et al*., 2020), and concluded that it is a new species of *Coryphopteris*.

MATERIALS AND METHODS

***Morphological study*:** The authors collected and made specimens, carefully observed and measured both living mature individuals and dried specimens of the unknown species, recorded the size, shape, colour, and other characteristics of each part of the plant. The indumentum on different parts of the plants was examined under an Olympus-ML31 dissecting microscope (Tokyo, Japan) and an Olympus-CX33 optical microscope (Tokyo, Japan). Additionally, a systematic review of online digital images of Thelypteridaceae was conducted using resources available on CVH (https://www.cvh.ac.cn/) and GBIF (https://www.gbif.org/). To determine whether this species is capable of sexual reproduction, we counted the number of spores from ten unopened sporangia of different individuals under an optical microscope.

Sampling and DNA sequencing: We randomly selected three plants of the presumed new species to collect leaves for DNA extraction. Fresh leaf material was preserved in silica gel for rapid drying. Total genomic DNA was extracted from dried leaves using modified cetyl trimethylammonium bromide (CTAB) protocol (Doyle and Doyle, 1987). Phylogenetic relationships among the presumed new species and other members of Thelypteridaceae were inferred based on sequences of seven plastid markers (*atpA, rbcL, rps4, trnL-trnF* intergenic spacer*, matK, psbA* and *psbA-trnH* intergenic spacer). Primers and PCR protocols followed He *et al.* (2012) and Kuo *et al.* (2020). For comparison, we also sequenced three samples of *Coryphopteris angulariloba* (JSL4016, JSL7212, JSL7886A), one sample of *C. nigrescens* (Zuo5946) and one sample of *C. chingii* (XGL03). All othe DNA sequences of species from Thelypteridaceae, along with two additional species of other family as outgoup, were downloaded from NCBI (https://www.ncbi.nlm.nih.gov/). Voucher information, locality, and GenBank accession numbers were provided in Table S1.

We assembled and aligned the newly obtained sequences along with those from GenBank using MAFFT v.7.017 (Katoh *et al*., 2002), subsequently using PhyloSuite v.1.2.3 (Zhang *et al*., 2020) gblocked and concatenated the aligned sequences. Phylogenetic analyses were conducted using both the maximum likelihood (ML) and Bayesian inference (BI) approaches. The ML analyses was performed with IQ-TREE 1.6.12 (Nguyen *et al*., 2015), applying the GTR+R6 model and 5000 ultrafast bootstrap replicates. Bayesian Inference analyses were conducted with MrBayes 3.2.6 (Ronquist *et al*., 2012) using two runs of four Markov Chain Monte Carlo (MCMC) chains, ten million generations, with one tree sampled every 1000 generations and the first 25% of trees were discarded as burn-in.

RESULTS

The 42 aligned plastid gene sequences are 5322 bp in length, with a total of 353 parsimony-informative sites. Consensus trees from the BI analyses exhibited identical topologies to those from the ML tree. The phylogeny reconstructed from the combined dataset using both methods is presented in Fig. 1. The major clades of the phylogeny reconstructed in this study were also congruent with those of previous studies (He *et al*., 2012; Almeida *et al*., 2016; Fawcett *et al*., 2021). The clade of *Coryphopteris*, *Amauropelta*, *Metathelypteris*, and *Thelypteris* were monophyletic with high support values respectively. The new species nested within *Coryphopteris*, being closely related to *Coryphopteris nigrescens* and *C. hirsutipes* with high support values, it was sister to the subclade I which comprises *C. nigrescens* and *C. hirsutipes*. *C. angulariloba* and *C. chingii* formed a subclade II that is significantly distant from the new species (Fig.1).

TAXONOMIC TREATMENT

Coryphopteris jiulianshanensis G.L.Xu & Z.G.Zhou, ***sp. nov***, **Figs. 2 & 3**

Type: CHINA. Jiangxi Province, Longnan City, Jiulianshan National Natrue Reserve, 24°56'13.99"N, 114°47'49.36"E, altitude ca. 739 m, under the evergreen broad-leaved forests, 27 April, 2023, Guo-Liang Xu, *JLSXGL20230427* (Holotype: SYS!, isotype: KUN!).

***Diagnosis*:** It is most similar to *Coryphopteris angulariloba* morphologically, However, it can be distinguished from the latter by abaxially along costae, veins, rachis with unicellular setae (*vs.* multicellular acicular hairs); lateral veins 4–7 pairs (*vs.* 2–4 pairs); sori closer to main veins than to margins (*vs.* middle of main

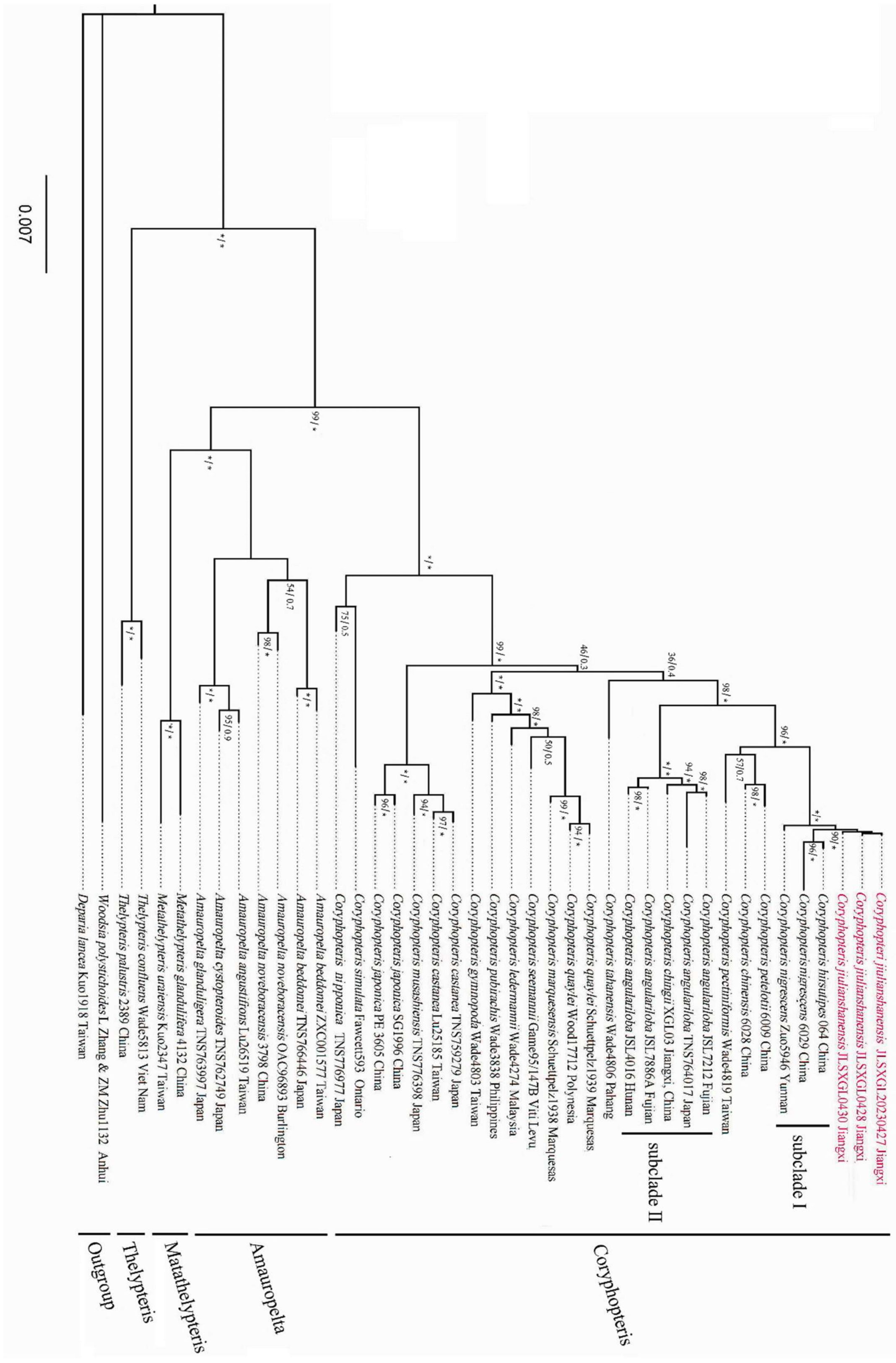

Fig1. The phylogenetic position of Coryphopteris jiulianshanensis based on seven plastid markers (*atp*A, *rbc*L, *rps*4, *trn*L-trnF, *mat*K, *psb*A and *psb*A-*trn*H). The numbers associated with branches are maximum likelihood bootstrap support (MLBS) values followed by Bayesian inference posterior probabilities (BIPP). "*" indicates MLBS = 100% or BIPP = 1. Black vertical bars indicate those genera classified by Fawcett *et al*. (2021), subclade. Inside black vertical bars indicate subclade Ⅰ and subclade Ⅱ.

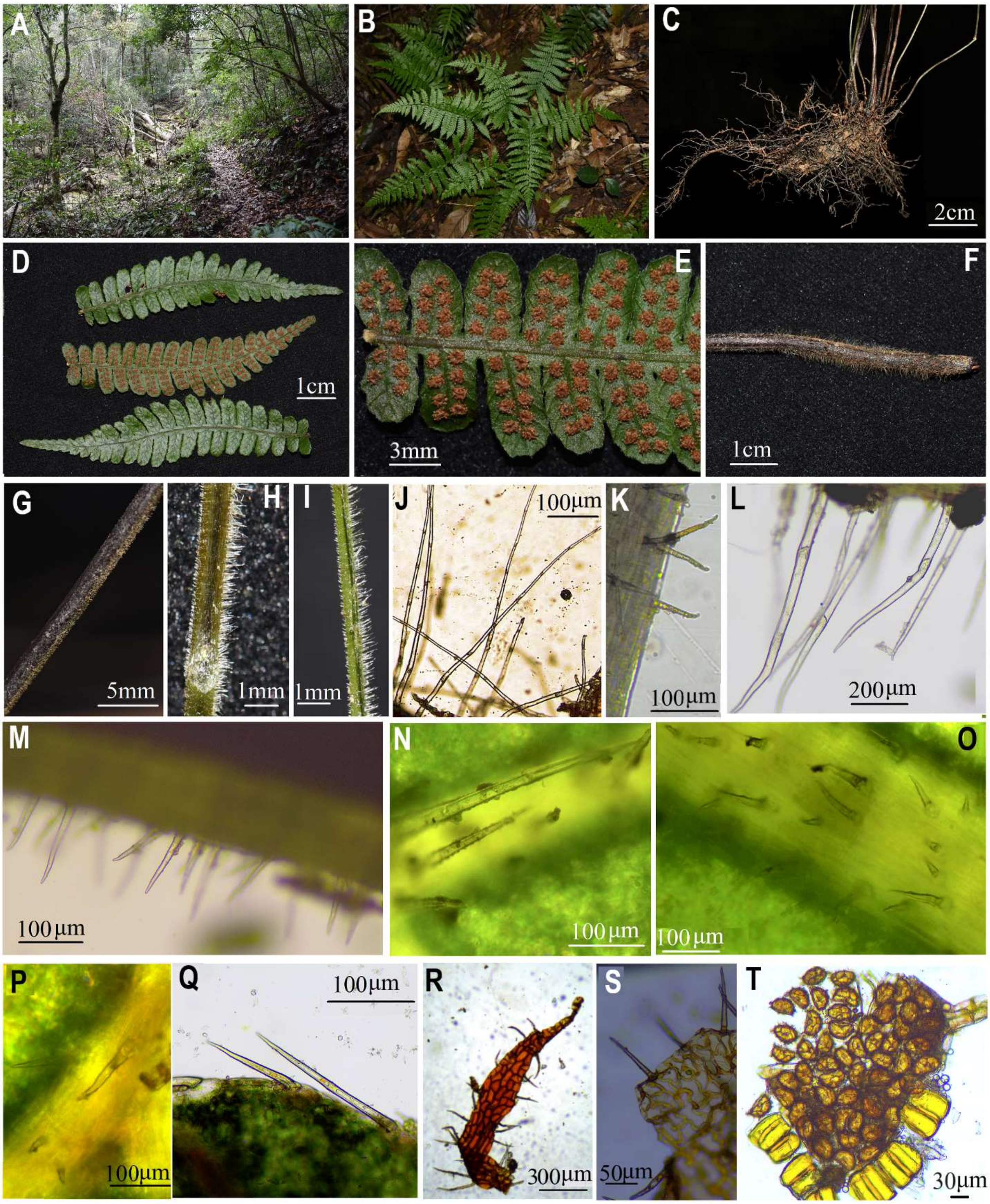

Fig. 2. ***Coryphopteris jiulianshanensis*** sp. nov. **A.** Habitat; **B.** plants; **C.** rhizome; **D.** both surfaces of pinnae; **E.** segments; **F.** stipe base; **G.** distal stipe; **H.** indumentum abaxially along rachis (on left) and adaxially along rachis (on right); **I.** indumentum abaxially along costae (on left) and adaxially along costae (on right); **J.** multicellular acicular hairs of stipe base; **K.** unicellular setae along distal stipe; **L.** multicellular acicular hairs adaxially along rachis; **M.** unicellular setae abaxially along rachis; **N.** multicellular acicular hairs adaxially along costae; **O.** unicellular setae abaxially along costae; **P.** unicellular setae along veins; **Q.** multicellular acicular hairs along segment margins; **R.** magnification of scales; **S.** unicellular setae of sporangia; **T.** spores dispersed from a sporangium.

Table 1. Comparison of morphological characteristics between ***Coryphopteris jiulianshanensis***, ***C. angulariloba***, ***C. nigrescens*** and ***C. hirsutipes***.

Characters	***Coryphopteris jiulianshanensis***	***C. angulariloba***	***C. nigrescens***	***C. hirsutipes***
Rhizome	decumbent or ascending	decumbent or ascending	erect	erect
Indumentum	abaxially along costae, veins, and rachis with unicellular setae	abaxially along costae, veins, and rachis with multicellular acicular hairs	abaxially along costae, veins, and rachis with unicellular hairs intermixed with multicellular hairs	abaxially along costae, veins, and rachis with multicellular acicular hairs
Pinnae	12–15 pairs, greenish when dry, abaxially without spherical glands	ca. 20 pairs, greenish when dry, abaxially without spherical glands	15–18 pairs, dark green or blackish brown when dry, abaxially without spherical glands	20–25 pairs, dark green when dry, abaxially with spherical glands
Segments	rectangular; apices rounded and with blunt angles, margin shallowly undulate	rectangular or subsquare, apices rounded-truncate or rounded and with blunt angles, entire	narrowly ligulate, apices rounded-obtuse and without angles, margin slightly undulate or entire	rectangular, apices rounded and without angles, entire
Lateral veins	4–7 pairs per segment	2–4 pairs per segment	5–6 pairs per segment	5–8 pairs per segment
Sori	closer to main veins	at middle of lateral veins	slightly high places at middle of lateral veins	at middle of lateral veins

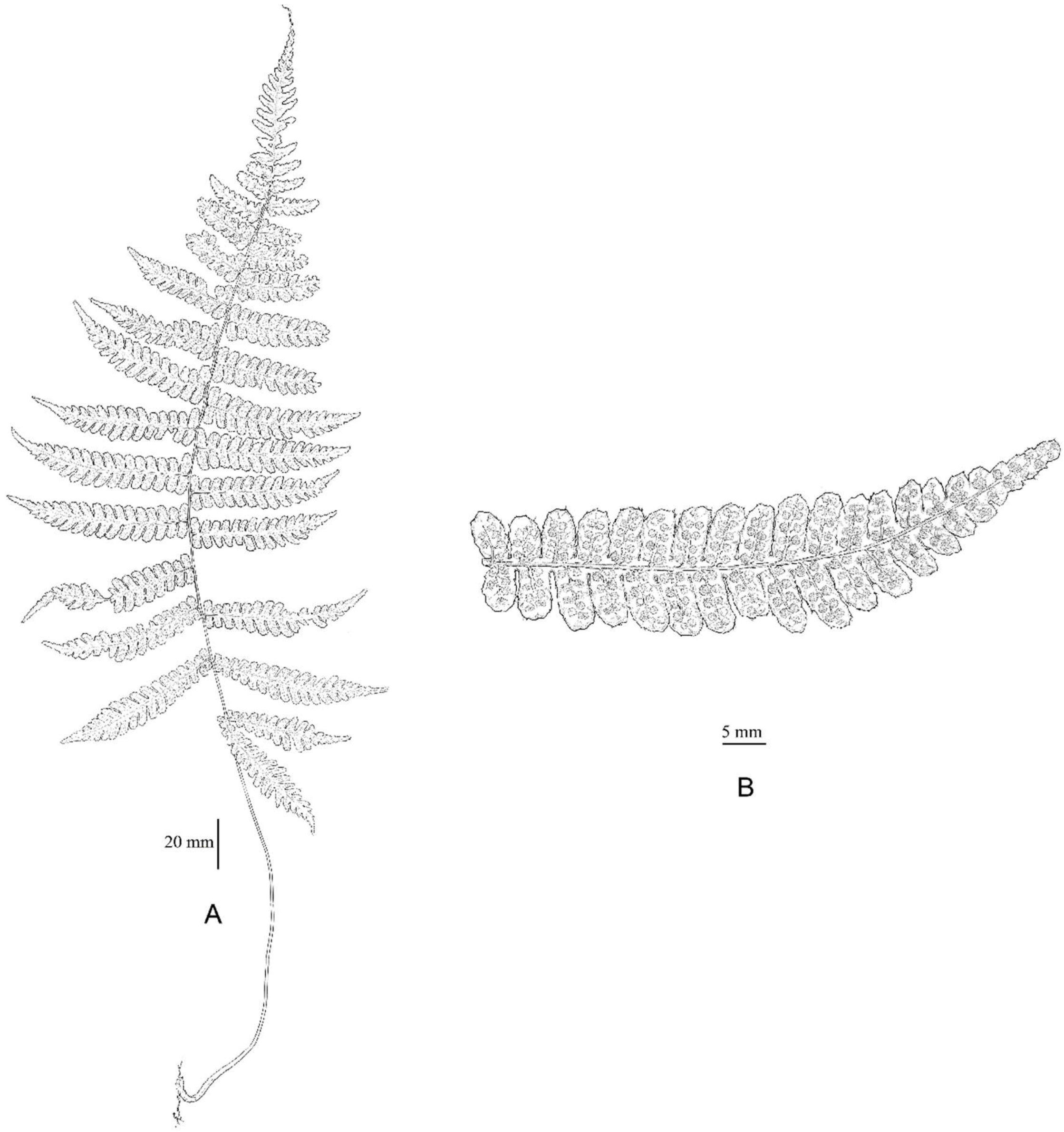

Fig. 3. ***Coryphopteris jiulianshanensis*** sp. nov. **A.** adaxial face of laminae; **B.** abaxial face of pinnae.

veins and margins), detailed comparisons in Table 1 (Shing, 1999; Lin *et al*., 2013).

Description: Plants 30–80 cm tall, rhizomes short, decumbent or ascending, nearly black, fronds clustered. Stipes 20–40 cm, 1–3 mm in diameter, bases chestnut and sparsely scaly, scales russety, lanceolate, along its marge with 1–2 cells 150–250 μm long acicular hairs. Stipe bases densely with 8–12 cells 1–3 mm long spreading grayish white acicular hairs, distally stramineous or castaneous-red, densely with unicellular 30–200 μm long setae. Laminae oblong, 20–40 × 10–16 cm, pinnate-pinnatifid, apices acuminate and pinnatifid, pinnae ca. 15 pairs, lanceolate or linear-lanceolate, 2–8 × 0.8–1.5 cm, apices acuminate, bases truncate, subsymmetrical, proximal pair slightly tapering at bases, alternate, pinnatifid and reaching broad wing on both sides of costae, slightly short stiped, 1–3 cm apart, proximal pair slightly shortened, reflexed. Rachis stramineous, adaxially with shallow groove, densely with 1–3 cells 200–900 μm long acicular hairs, abaxially densely with 30–200 μm long unicellular setae. Segments 7–14 pairs, 4–8 × 3–4 mm, rectangular, margin shallowly undulate, apices rounded and with 2–4 blunt angles, margins with 1–2 cells 100–300 μm long acicular hairs. Veins evident, lateral veins simple, reach margins, 4–7 pairs per segment. Laminae herbaceous, abaxially with 30–200 μm long unicellular setae along costae, main veins and lateral veins; greenish when dry; adaxially along costal grooves densely with 1–3 cells 50–500 μm long acicular hairs, along veins sparsely with 30–200 μm long unicellular setae; both surfaces glabrous between main veins and lateral veins; abaxially without spherical glands, but with orange capitate glands along costae and veins. Sori orbicular, nearer to main veins than to edge, 1–7 pairs per segment; indusia medium-sized, orbicular-reniform, brown, thickly membranous, densely with unicellular short setae, persistent. Spores with lophate perispore, longer diameter 42–52 μm excluding perispore.

Distribution and habitat: We found three populations grow in wet and shady places, under evergreen broad-leaved forests, Jiulianshan national nature reserver, Longnan city, Jiangxi Province, China. Companion species were shade-loving plants such as *Cibotium barometz* (L.) J.Sm., *Plagiogyria adnata* (Blume) Bedd., and *Arachniodes amoena* (Ching) Ching.

Etymology: The new species was found in Jiulianshan National Nature Reserve, Jiangxi Province, so the specific epithet is derived from the type locality, Jiulianshan National Nature Reserve, namely "*jiulianshanensis*".

Vernacular name: 九连山栗金星蕨 (Chinese name); Jiǔ Lían Shān Lì Jīng xīng Júe (Chinese pronunciation).

Provisional conservation status: *Coryphopteris jiulianshanensis* is currently known from three populations, comprising approximately 500 mature individuals, at the type locality in Jiulianshan National Nature Reserve, Longnan City, Jiangxi Province, China. These populations are stable at present, as the habitat is protected by the management of Jiulianshan National Nature Reserve. The EOO and AOO of the new species are approximately 1.5 km² and 50 m², respectively. Given the limited number of individuals of these three populations, the species should be temporarily assessed as Near Threatened (NT), according to the IUCN Red List Categories and Criteria (IUCN, 2024).

Additional specimens examined (paratype): CHINA. Jiangxi Province: Ganzhou City, Longnan City, Jiulianshan national nature reserve, 24°56'13.99"N, 114°47'49.36"E, altitude ca. 769 m, 24 April 2023, *JLSXGL20230424* (LBG).

Note: *Coryphopteris nigrescens* and *C. hirsutipes* both are the species most closely related to *C. jiulianshanensis* phylogenetically, so we selected *C. nigrescens*, *C. hirsutipes*, *C. angulariloba* and *C. jiulianshanensis* four species for a detailed morphological comparisons in Table 2 (Shing, 1999; Lin *et al*., 2013).

The phylogenetic analysis includes 22 taxa of *Coryphopteris* in this study, 9 of which are distributed in China. We were unable to sample *Coryphopteris caudata* (Ching ex K.H.Shing) S.E.Fawc. & A.R.Sm., *C. trichochlamys* (Ching ex K.H.Shing) S.E. Fawc. & A.R.Sm., *C. indochinensis* (Christ) S.E.Fawc. & A.R.Sm and *C. pauciloba* (Ching ex K.H.Shing) S.E.Fawc. & A.R.Sm., because their population sizes and distribution range are relatively small, however, our sample covered most of *Parathelypteris* Sec. *Melanostipes* species in China (Shing, 1999; Lin *et al*., 2013), in addition, we compared type specimens of these four species with *C. jiulianshanensis* carefully, found that their morphology could be distinctly distinguished from *C. jiulianshanensis.* For example, *C. caudata* and *C. trichochlamys* both with reddish purple spherical glands abaxially, both segments are much smaller than *C. jiulianshanensis*, both rhizomes are erect; *C. indochinensis* segments linear-lanceolate, not sinuslike angular at apices, laminae abaxially with dense multicellular barblike long hairs.

In the leptosporangiate ferns, there are two reproductive types: the sexual reproductive type generally with 64 spores in a sporangium, and the apomictic type generally with 32 spores (Lovis, 1978; Wang *et al*., 2011). The spores of the new species, *Coryphopteris jiulianshanensis*, were well-developed, and we observed that each sporangium contains 64 spores (Fig. 3), indicated that this new species is sexually reproducing. Indumentum is the most reliable and consistent characteristic for distinguishing related species within the Thelypteridaceae (Fawcett and Smith, 2021). The distinctive indumentum of *C. jiulianshanensis* sets it apart from other species of *Coryphopteris.* Based on a detailed comparison with the other six species of *Coryphopteris* which is distributed in Jiangxi Pronvince, an identification key to these species is provided. (Lin *et al*., 2013; Peng *et al*., 2021; POWO, 2025).

1. Pinnae with reddish purple spherical large glands abaxially ……… 2
- Pinnae without reddish purple spherical large glands abaxially ……. 5

2. Several pairs of pinnae on proximal part of lamina clearly shortened …………………………………………… *C. nipponica*
- Proximal pinnae not shortened or slightly shortened ……..……… 3
3. Bases of stipe with multicellular acicular hairs …………… *C. chingii*
- Bases of stipe glabrous …………………………………………….. 4
4. Laminae lanceolate; middle pinnae 0.8–1.2 cm wide, glabrous abaxially …………………..………………………….. *C. chinensis*
- Laminae ovate-oblong; middle pinnae 1.3–1.6 cm wide, pubescent abaxially ………………………………………………….. *C. japonica*
5. Rhizomes erect, bases of sipe mixed with grayish white setae and few spreading multicellular hairs, indusia slightly pubescent …………… ………………………………………………………... *C. pauciloba*
- Rhizomes decumbent or ascending, bases of sipe only with spreading multicellularhairs, indusia densely pubescent …………………….. 6
6. Sori dorsifixed at middle of lateral veins, abaxially along costae and veins with multicellular short acicular hairs ……….. *C. angulariloba*
- Sori closer to mainveins than to edge, abaxially along costae and veins with unicellular short setae …………………….. *C. jiulianshanensis*

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Supplementary materials are available from Journal Website