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The status of genus *Goniophlebium* (Polypodiaceae) in India

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Abstract- This paper confirms the occurrence of approximately 14 species of the genus *Goniophlebium* in India, including *G. amoenum, G. argutum, G. decurrentiadnatum, G. fieldingianum, G. hendersonii, G. lachnopus, G. manmeiense, G. mengtzeense, G. mieheorum, G. niponicum, G. simonsianum, G. subamoenum, G. subauriculatum,* and *G. yunnanense*. Each species is comprehensively documented with updated nomenclature, etymology, type localities, detailed taxonomic descriptions, ecological information, examined specimens, distribution data, and key diagnostic morphological characters. Additionally, a diagnostic key to the species of *Goniophlebium* occurring in India is provided to facilitate identification and further research.

Keywords: Polyodiaceae, *Goniophlebium*, morphology, Epiphyte, Lithophyte

INTRODUCTION

Goniophlebium and *Polypodiodes* are two morphologically distinct yet molecularly related fern genera within the family Polypodiaceae, subfamily Microsoroideae. As per the Pteridophyte Phylogeny Group,[1] *Goniophlebium* comprising about 25-26 species is a basal lineage sister to the rest of Microsoroideae, supported by 2019 molecular phylogenetic analyses. *Goniophlebium* species are characterized by long-creeping rhizomes, imparipinnate fronds with articulate, stalked pinnae, and finely anastomosing venation forming 2-3 rows of areoles near the costa. Sori is borne in costal areoles and often accompanied by early-stage paraphyses. They occur predominantly as epiphytes or lithophytes in tropical Asian montane to subalpine forests (1000-3800 m), favoring humid, shaded habitats. Subtle morphological traits, such as rhizome thickness, frond size, pinnae shape, and surface indumentum hold taxonomic significance. The genus includes both widespread species (e.g., *G. amoenum*, *G. argutum*) and narrow endemics (e.g., *G. niponicum, G. decurrentiadnatum*), some of which are ecologically specialized and conservation-priority taxa due to habitat sensitivity.

In contrast, *Polypodiodes* (ca. 17 species, mostly in Himalayan region)) has creeping rhizomes and deeply pinnatisect fronds with sessile, confluent segments on a winged rachis. Venation forms both narrow and broad areoles; sori occur in costular areoles with transient paraphyses. These ferns inhabit wet tropical to temperate forests, growing epiphytically or lithophytically. A key diagnostic difference lies in pinnae attachment *Goniophlebium* has separated, stalked pinnae; *Polypodiodes* features sessile, joined pinnae. Historically treated under a broad *Polypodium sensu lato* (e.g., Ching,

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1978), both genera were later segregated particularly by Fraser-Jenkins (2012)[2] based on morphological and biogeographic evidence. While some molecular analyses have proposed merging them, integrative taxonomic approaches strongly support their distinction. Recent Chinese efforts to synonymize them lack robust phylogenetic backing. Ongoing fieldwork since 2018 in Northeast India has documented 16 *Microlepia* species and clarified Goniophlebioid diversity, with herbarium specimens deposited in ARUN, ASSAM, CAL, BSA, and SFRI. A diagnostic key to 14 Indian *Goniophlebium* species underscores the complexity and need for further taxonomic resolution.

In summary, *Goniophlebium* ferns range from sea level to 4000 m, inhabiting shaded, mossy sites as medium to large epiphytes or lithophytes. They feature clathrate scales on long-creeping rhizomes, monomorphic pinnate fronds with articulate pinnae, 1-4 rows of areoles, glandular hairs, and exindusiate sori with hairy or scaly paraphyses. Chromosome numbers are typically n = 36 or 37. Their combination of wide ecological amplitude and narrowly endemic taxa highlights both diversity and conservation importance.

Fraser *et al.* (2021)[3] reclassified several species previously assigned to the genus *Goniophlebium* including *Goniophlebium argutum* (Wall. ex Hook.) Bedd., *Goniophlebium mengtzeense* (Christ) Rödl-Linder, and *Goniophlebium subauriculatum* (Blume) C.Presl. under the genus *Polypodiodes*. These were treated as various taxa within *Polypodiodes*, such as *Polypodiodes amoena* (Wall. ex Mett.) Ching (including subsp. *amoena* and subsp. *yunnanensis* (Franch.) Fraser-Jenk.), *P. hendersonii* (Bedd.) Fraser-Jenk., *P. lachnopus* (Wall. ex Hook.) Ching, *P. manmeiensis* (Christ) Fraser-Jenk., *P. mieheorum* Fraser-Jenk., *P. niponica* (Mett.) Ching, *P. simonsiana* Fraser-Jenk. & Shalimov, and *P. subamoena* (C.B.Clarke) Ching. In contrast, the Pteridophyte Phylogeny Group[1] continues to treat all these species under the genus *Goniophlebium*.

TAXONOMIC ACCOUNT

Goniophlebium (Blume) C. Presl

Rhizome long-creeping, glossy, and covered with dark brown, small, deciduous scales that are clathrate with an ovate base and acuminate apex. Fronds are isomorphic. Stipes are distinct and arise from the rhizome. Lamina is pinnate or at least pinnate on the lower half, with the upper half pinnatifid; pinnae are sessile and articulated to the rachis. Lower pinnae are free and short-petiolate, middle pinnae have an adnate base, while distal pinnae are confluent. Veins anastomose to form a single row of areolae on each side of the costa, with marginal veins free; each areola contains a free included veinlet. Sori is superficial and not immersed; paraphyses are triangular, peltate, clathrate, and long-stalked. Spores are light brown or yellowish, bilateral, monolete, and perinate.

About 20 species: mainly in tropical Asia; 14 species in India.

KEY TO THE SPECIES

1a. Lamina pinnate, at least lower part of rachis terete 2
1b. Lamina pinnatisect to pinnatifid……...5
2a. Plant more than 1 m long; lateral pinnae 30–40 pairs…….....13. ***G. subauriculatum***
2b. Plant less than 1 m long; pinnae up to 30 pairs.....3
3a. Rhizome 5–8 mm thick with linear-lanceolate scales; lamina deltoid to obovate-lanceolate.....2. ***G. argutum***
3b. Rhizome less than 5 mm thick; lamina ovate or lanceolate-oblong …… 4
4a. Lamina ovate; lateral pinnae up to 5 pairs; pinnae decurrent-adnate to rachi.....…….3. ***G. decurrentiadnatum***
4b. Lamina lanceolate-oblong, lateral pinnae 15–25 pairs; pinnae not as above……8. ***G. mengtzeense***
5a. Rhizome strongly glaucous, nearly glabrous...10. ***G. niponicum***
5b. Rhizome not glaucous, densely scaly…..... 6
6a. Rhizome scales hair pointed. …..…….7
6b. Rhizome scales never hair pointed…….…….8
7a. usually most of the veins free…….....….5. ***G. hendersonii***
7b. Veins anastomosing forming areola with included veinlets…….....6. ***G. lachnopus***
8a. Sori sunken .....…….……..…….. 9
8b. Sori superficial …..……..…….…….12
9a. Lamina up to 20 cm long, ...…..…..……..9. ***G. mieheorum***
9b. Lamina more than 20 cm, ……..…….. 10
10a. Pinnae more than 30 pairs, 5–15 cm long, more than 1 cm wide, prominently upward deflexed or horizontal, apex long acuminate..…… 11
10b. Pinnae up to 30 pairs, less than 5 cm long, up to 1 cm wide, prominently backward-deflexed, apex acutely pointed .....11. ***G. simonsianum***

11. Lamina glabrous but rachis scaly.…….....1. ***G. amoenum***

11b. Lamina hairy and scaly on rachis……..….. 14. ***G. yunnanense***

12a. Basal pinnae hardly abbreviated, apex of frond pinnatifid…….....…. 13

12b. Basal pinnae abbreviated, apex of frond serrulate…….....12. ***G. subamoenum***

13a. Rachis abaxially straw-colored; lamina with basal lobes deflexed ..... 7. ***G. manmeiense***

13b. Rachis abaxially castaneous; lamina with basal lobes not or very slightly deflexed .....4. ***G. fieldingianum***

1. *Goniophlebium amoenum* (Wall. ex Mett.) J.Sm. ex Bedd., Ferns Brit. India 5, t. 5. 1866; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 244. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 94. 2023. *Polypodium amoenum* Wall. ex Mett., Abhandl. Senckenb. Naturf. Ges. 2(1): 80. 1857. *Goniophlebium amoenum* J.Sm. in Hooker & Bauer, Gen. Fil.: t. 51. 1840, *nom. nud. Polypodiodes amoena var. pinnatifida* (Dhir) P.C Pande in Pande, Pande & Bhandari, Indian Fern J. 11(1 & 2): 32. 1995 (1994), *comb. inval.*

Fronds 40–80 × 10–30 cm, *c.* 2 cm apart; Rhizomes long creeping, subterranean, scaly, thick, 5–8 mm thick, densely scaly; Scales pale-brown, base broad, narrow, mid-brown, fimbriate, margin erosed, apex acuminate, peltate, ovate-lanceolate, entire, acuminate, brown, concolorous; Stipe up to 10–30 cm long, adnate on frondiferous buds phyllopodia of rhizome, non-articulate, stramineous, glabrous, lustrous, grooved, scaly upwards; Rachis similar, winged, scaly; Lamina 30–60 cm long, lamina-lobes 05–15 × 1–2 cm; Pinnae 20–40 pairs, basal 1–2 pairs deflexed, rest pairs horizontal, slanting upwards gradually, small, acute, base cordate, upper subfalcate, subulate-lanceolate, subentire, acuminate, margins serrate or deeply lobed, apex acute; Veins and Veinlets prominent, reticulate, forming one series of areoles with single included veinlets ending in hydathodes, marginal veins free; Sori brown, round, exindusiate, median, one row of either side of costa at the end of included veinlets, sunk, covered by short staked, pelatate, clathrate umbrella-shaped brown paraphyses; Spores monolete, yellow, hyaline, oval to bean-shaped.

Fertile phase.: June–November.

Distribution. India: Mid to high-altitude epiphytic fern species, fairly common as pendent epiphyte on branches of the trees or a lithophyte throughout between 1800–3000 m.; usually growing on moss-claded branches. Arunachal Pradesh, Assam State, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Uttarakhand, West Bengal.

Bhutan, China, Laos, Myanmar, Nepal, Taiwan, Thailand, Tibet, Vietnam.

Note: Lamina varying from subglabrous to bearing scattered small glandular hairs on both sides.

2. *Goniophlebium argutum* (Wall. ex Hook.) Bedd., Ferns Brit. India 6, t. 6. 1866; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 107. 2021. *G. argutum* J.Sm. in Hook. & Bauer, Gen. Fil.: t. 51. 1840, *nom. nud. Polypodium argutum* Wall. ex Hook., Sp. Fil. 5: 32. 1864. *Schellolepis arguta* (Wall. ex Hook.) J.Sm., Hist. Fil. 93. 1875.

Plant up to *c.* 40–50 cm cm long with pendent, simple pinnate, lanceolate habit; Rhizome long-creeping, thick, stout, densely scaly; Scales 1–2 mm long, linear-lanceolate, black-brown, clathrate, margin hooked; Stipes 3–12 cm long, glabrous, purplish, shining, with short multicellular hairs, slender, erect, articulate to rhizome; Lamina deltoid to obovate-lanceolate; Pinnae 10–20 pairs, sessile, with shortly toothed margins, 10–50 × 8–21 cm, pinnate, glabrous, with a terminal pinna, similar to the lateral ones, cuneate or short-lobe at the base; lateral pinnae opposite to subopposite, numerous, sessile or adnate; Lowest pair of pinnae reduced to the above, largest pinnae oblanceolate, sessile or adnate to rachis, up to 12–15 × 2–3 cm, truncate or broad at base, acuminate apex, margin serrate, firm, membranous texture, greenish-yellow; Venation prominent, costa clear, lateral veins anastomose to regular areoles; Areoles uniseriate, pentagonal, oblong on both sides of costa, free included veinlets present; Sori globose, exindusiate, uniseriate on both sides of the costa, small, covered by peltate paraphyses, one in each coastal areole on either side of the pinna-costa, terminal on the included veinlets inside the areoles, light-brown; Spores bilateral, perisporiate, exine smooth, greenish-yellow, hyaline.

Fertile phase.: July – October.

Distribution. India: This is a common high altitude, variable epiphyte species usually hanging from moss covered lower branches of trees grows or on moist, moss-covered tree trunks as well as rocks in forests in between 2000–3000 m. altitude. Arunachal Pradesh, Himachal

Pradesh, Nagaland, Sikkim, Uttarakhand, West Bengal, Bhutan, China, Myanmar, Nepal, Thailand, Tibet.

Note: Fern with pendent, simply pinnate fronds (to 40 cm), sessile toothed pinnae, creeping scaly rhizome, glabrous stipe, anastomosing veins with costal areoles, and solitary sori in each costal areole beside the pinna-costa.

3. *Goniophlebium decurrentiadnatum* (Rosenst.) Panigrahi, Pl. Sci. Res. (India), 20th Ann. Conf. Orissa: 54. 1996. *Polypodium decurrentiadnatum* Rosenst., Fedde Repert. Spec. Nov. Regni Veg. 12:248. 1913. *Goniophlebium decurrentiadnatum* (Rosenst.) Panigrahi, Pl. Sci. Res., Orissa 20 (1 & C 2): 44. 1998, *isonym*. *Phymatopteris decurrentiadnata* (Rosenst.) S.R.Ghosh in S.R.Ghosh, B.Ghosh, Anjali Biswas & R.K.Ghosh, Pterid. Fl. E. India 1: 544. 2004. *Arthromeris decurrentiadnata* (Rosenst.) Fraser-Jenk. & Kandel, Fraser-Jenk. *et al.*, Annot. Checkl. Ind. Pterid. 3: 86. 2021.

Rhizome long creeping, branched, about 3–4 mm thick, scaly, Scales ferruginous, lanceolate, apex acuminate, margin denticulate, non-clathrate; Stipe remote, erect, 12–30 cm long, stipe and rachis brown, glabrous; Lamina ovate, pinnate, *ca* 25 × 15 cm, pinnae opposite, equal, upto 5 jugate, each pair of pinnae separated by a distant of 3–4 cm, pinnae suberect-patent, subequal, middle pinnae about 8 × 2 cm, each pinnae at base, broadly adnate, upper ones narrow, contracted, all decurrent-adnate to rachis, elongate-oblong, margin cartilaginous, thick, crenato-repand, notch present between each pair of lateral veins, main lateral veins nearly reach upto margin, distinct, cross veins forming areola containing free included veinlets; Sori large, in one row, towards midrib.

Fertile phase.: August–January.

Distribution. India: Endemic fern species grows as an epiphyte from 1200–1800 m altitude. Manipur.

4. *Goniophlebium fieldingianum* (Kunze ex Mett.) T.Moore, Index Fil. 389. 1862. *Polypodium fieldingianum* Kunze ex Mett. in Abh. Senckenberg. Naturf. Ges. 2: 75. 1856. *Polypodium microrhizoma* C.B.Clarke ex Baker, in Hooker & Baker, Syn. Fil., ed. 2, 511. 1874; *Goniophlebium microrhizoma* (C.B.Clarke ex Baker) C.B.Clarke ex Bedd., Suppl. Ferns S. Brit. India 21, t. 384. 1876; *Polypodium microrhizoma* var. *xerophyticum* Mehra, Punjab Univ. Bot. Publ. 7, Ferns Mussoorie: 22. 1939, as "*xerophytica*", *nom. inval. Polypodiodes microrhizoma* (C.B.Clarke ex Baker) Ching, Act. Phytotax. Sin. 16(4): 27. 1978. *Polypodiodes fieldingiana* (Kunze ex Mett.) Fraser–Jenk., Kandel & Pariyar, Ferns Fern–Allies Nepal 1: 42. 2015; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 246. 2021; ; S.K. Singh *et al*., Pterido. Meghalaya: 95. 2023.

Plant 30–45 cm long; Rhizome wide creeping, 2 mm diam., scales sparse, dark-brown, ovate, acuminate; Frond distant, erect; Stipe 10–14 cm long, naked, shining, castaneous on lower side and on rachis also; Lamina lanceolate 22–30 cm × 7–10 cm broad, deeply pinnatifid to rachis with pinnae 20–30 pairs, patent, lanceolate, acute, distantly inciso-serrate, texture membranaceous, green, naked on both surface, basal pinnae free from next above, connected by a narrow wing along rachis; Veins distinct on both sides, areolae uniseriate, close; Sori small, oblong, medial.

Fertile phase.: July–November.

Distribution.: Growing at the elevation in between 2500–3800 m altitude. Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Nagaland, Sikkim, Uttarakhand.

Asia: Bhutan, China, Myanmar, Nepal, Taiwan, Thailand, Tibet.

Note: Fronds to 50 cm, lanceolate with caudate-acuminate apex; rhizome short-creeping, hairy, with small brown-grey clathrate toothed scales; stipe and rachis glabrous, castaneous beneath; lamina very thin, deciduous; pinnae 15–25 pairs, shallowly incised; sori pale yellow, exindusiate, one per areole with key features as caudate apex, hairy rhizome with clathrate scales, thin deciduous lamina, castaneous rachis underside, exindusiate pale yellow sori.

5. *Goniophlebium hendersonii* Bedd., Suppl. Ferns S. Brit. India 21, t. 383. 1876. *Polypodium hendersonii* Atk. ex Baker in Hooker & Baker, Syn. Fil., ed. 2, 511. 1874, *nom. illeg.*, non E.J. Lowe 1858. *Polypodiodes hendersonii* (Bedd.) Fraser–Jenk., New Sp. Syndrome Indian Pteridol. 202. 1997; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 248. 2021.

Plant long, narrow, up to *c.* 30 cm long; Rhizome short creeping, densely scaly; Scales pale grey, glossy, large, with a reticulum of darker-walled cells, denticulate margins; Pinnae short, up to *c.* 2–3 cm, 20–25 pairs, acutely toothed along the margins, lowest pair of pinnae deflexed, pinna-apex acute; Sori exindusiate, round, yellow, one in each coastal areole.

Fertile phase.: August–December.

Distribution. India: This is scattered to fairly common high altitude Himalayan species, growing on moss-clad

tree branches or sometimes lithophytic on mossy rocks. Arunachal Pradesh, Sikkim, West Bengal.

Bhutan, China, Nepal, Tibet.

Note: This species can be identified by slender, parallel-sided fronds, up to 30 cm; short-creeping rhizome densely covered with large pale grey, glossy scales with reticulate darker cells and denticulate margins; pinnae short (to 3 cm), 20–25 pairs, sharply toothed, lowest pair deflexed; sori round, yellow, exindusiate, one per coastal areole.

6. Go*niophlebium lachnopus* (Wall. ex Hook.) Bedd., Ferns Brit. India t. 163. 1866. *Polypodium lachnopus* Wall. ex Hook., Icon. PI. 10: t. 952. 1854. *Schellolepis lachnopus* (Wall. ex Hook.) J.Sm., Hist. Fil. 93. 1875. *Polypodium lachnopus* var. *xerophyticum* Mehra, Panjab Univ. Bot. Publ. 7, Ferns Mussoorie: 22. 1939. *Polypodiodes lachnopus* (Wall. ex Hook.) Ching, Act. Phytotax. Sin. 16(4): 27. 1978; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 248. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 95. 2023.

Plant up to *c.* 50 cm long, thin, herbaceous linear-lanceolate, epiphytes. Rhizome wide-creeping, densely covered with linear, blackish-brown, scaly; Scales fibrillose, long acuminate tip, base subulate, margin fimbriate; Stipes 05–15 cm long, slender, erect, pale-brown, articulate to rhizome, sparsely scaly; Scales similar to rhizome scales; Lamina 15 – 30 × 4 – 8 cm, simple pinnatifid; Pinnae numerous, deeply cut down, near to the rachis, alternate, decurrent at base, upto 35 pairs, oblong, hairy, herbaceous, color light green, lowest pair reduced to above, terminal with a single lanceolate, acuminate lobe; largest pinnae up to 5 × 1 cm, linear-lanceolate, broad at base, gradually tapering into obtuse or acute apex, margin serrulate or crenate; texture thin, membranous, dorsal surface of rachis covered with white tomentum, ventral surface covered with hair-like, small scales; Veins indistinct, reticulate, forming one to two row of areoles with single free included veinlet, marginal veins free, visible, minute; Sori small, circular, exindusiate, in two rows, one on either side of costule in each segment, covered by peltate, clathrae, paraphyses; spores oval, yellow-brown, bilateral, monolete, hyaline, perisporiate.

Fertile phase.: July October.

Distribution. India: This is a common upper-mid altitude species, growing on mossy tree-trunks or on mossy rocks, often on humus covered rocks up to 1000 to 2000m altitude. Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Sikkim, Uttarakhand, West Bengal.

Bhutan, China, Myanmar, Nepal, Thailand, Tibet.

Key features: Thin, linear-lanceolate fronds up to 50 cm; long-creeping rhizome with brown ciliated scales tipped with hair-like black apices; straw-colored stipe and rachis, sparsely scaly; 30–40 regular pinnae pairs; reticulate veins; round, exindusiate sori, one per areole.

7. *Goniophlebium manmeiense* (Christ) Rodl–Linder, Blumea 34(2): 394. 1990. *Polypodium manmeiense* Christ, Bull. Herb. Boissier 6(11): 870. 1898. *Polypodium simulans* Baker, Bull. Misc. Inf. Kew 1906: 13. 1906. *Polypodiodes manmeiensis* (Christ) Fraser–Jenk., New Sp. Syndrome Indian Pteridol. 201. 1997; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 249. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 95. 2023.

Plant 7–12 cm long; Rhizome long creeping, 2–4 mm in diam., densely scaly; Scales dark brown, lanceolate, acuminate at apex, broad at base, ciliate at margin; Fronds remote; Stipe straw-colored, brown at base, 6–12 cm, densely scaly at base, glabrous upward; Lamina narrowly lanceolate, 20–30 × 5–8 cm, deeply pinnatifid, herbaceous, green, glabrous; Pinnae usually decurrent to next lobes, acuminate apex, lateral lobes 20–30 pairs, narrowly lanceolate, spreading except base with one pair deflexed, shortened, margins incised-undulate, acute to obtuse at apex; rachis and costa straw-colored; Veins free, veinlets forked, ending in elliptic hydathodes; Sori orbicular, in a single row on each side of costa, medial, superficial.

Fertile phase: July–November.

Distribution. India: This is very rare mid altitude epiphytic species, growing mossy tree-branches up to 1000–2500 m. Arunachal Pradesh, Meghalaya, Nagaland.

Cambodia, China, Laos, Myanmar, Nepal, Thailand.

Note: Delicate-fronded species has very narrow rhizomes, segments and a narrow, attenuated frond apex, and sori are deeply immersed.

8. *Goniophlebium mengtzeense* (Christ) G.Roedl–Linder, Philipp. J. Sci. 116(2): 154. 1987; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 108. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 87. 2023. *Polypodium mengtzeense* Christ, Bull. Herb. Boissier 6(11): 869. 1898. *Polypodium argutum* forma *khasianum* C.B. Clarke, J. Linn. Soc, Bot., 24: 417–418. 1888.

Plant 20–35 cm long; Rhizome creeping, epigaeous, 2–4 mm thick, scaly; Scales dense deltoid-subulate dark brown, clathrate; Stipes slender, shining, pale stramineous,

9–12 cm long; Frond lanceolate-oblong, simply pinnate, 25–35 cm long, membranaceous, green, glabrous on both surface, rachis naked; Pinnae free, sessile, 6–8 cm × 8–14 mm, subopposite, lanceolate, acuminate, patent, margin obscurely inciso-crenate, base obliquely truncate, caudate, dialatato-auricled on both sides, auricles rounded, lower auricle, imbricating the rachis, upper pinnae more or less adnate, decurrent, terminal pinnae large; Veins slender but distinct, costa raised on both surface, areola large, uniseriate, along both side of costa, usually with one included soriferous veinlets; Sori small, globose, superficial.

Fertile phase.: August–January.

Distribution. India: This is rare fern species growing as epiphyte from 1000–3000 m altitude. Manipur, Meghalaya, Mizoram, Nagaland, Tripura.

China, Japan, Laos, Myanmar, Philippines, Taiwan, Thailand, Vietnam.

9. *Goniophlebium mieheorum* (Fraser–Jenk.) R.Kr.Singh & V.K.Rawat, J. Biodivers. Conservation 8(3): 81. 2024. *Polypodiodes mieheorum* Fraser-Jenk. in Fraser–Jenkins, Gandhi, & Kholia, Annot. Checklist Indian Pterid. 2: 447(–448). 2018; Fraser–Jenkins *et al*., Annot. Checkl. Ind. Pterid. 3: 250. 2021.

This species is closely related to *P. amoenum* but differs in several key morphological features. It possesses a narrower rhizome and a smaller lamina (15–20 cm long). The pinnae are short, densely lobed, and basally conjoined, with broad, rounded apices. The lamina is glabrous, with prominently dark brown to black veins and veinlets. Unlike *P. amoenum*, the leaf tips are not deeply lobed. Overall, this is a small, glabrous fern with closely spaced lamina lobes (pseudopinnae), rounded apices, and distinct black venation.

Fertile phase.: September–January.

Distribution. India: Epiphytic or lithophytic, on mossy trunks or boulders in moist temperate to subalpine forests, 3000–3600 m. Arunachal Pradesh.

Asia: Myanmar.

10. *Goniophlebium niponicum* (Mett.) Bedd. ex Rödl–Linder, Blumea 34: 407. 1990. *Polypodium niponicum* Mett., Ann. Mus. Bot. Lugd.–Bat. 2(8): 222. 1866. *Polypodium niponicum* var. *wattii* Bedd., J. Bot. Brit. For. 26(7): 235. 1888. *Goniophlebium niponicum* var. *wattii* (Bedd.) Bedd., Suppl. [Handb.] Ferns Brit. Ind. 90. 1892. *Polypodiodes niponica* (Mett.) Ching, Act. Phytotax. Sin. 16(4): 27. 1978 (as '*nipponica'*); Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 250. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 95. 2023. *Goniophlebium niponicum* (Mett.) Panigrahi, Pl. Sci. Res., Orissa, 20(1&2): 44. 1998 (as '*nipponicum'*), *isonym Goniophlebium wattii* (Bedd.) Panigrahi & Sarn.Singh, Ferns Fern–Allies Arunachal Pradesh 2: 463. 2005, *isonym*

Plant 25–40 cm long; Rhizomes wide-creeping, stout, black, covered with whitish bloom, branched, scaly; Scales deciduous; Fronds *c.* 25–30 × 5–7 cm, distantly originated; Stipes *c.* 10 cm long, articulated, glabrous, stramineous; Rachis hairy on both surfaces; Lamina *c.* 15–20 cm long, oblong-lanceolate, pinnatifid, caudate acuminate; Lamina-lobes up to 3 × 1 cm, wide at base, subulate-oblong, entire, densely hairy, acute, costae hairy on both surfaces; Veins anastomosing, forming one row of costal areoles, free veinlets ending into hydathode before margin, each areole with one included free veinlet, drying grey-green, herbaceous, densely hairy on both surfaces; Sori circular, terminal on the free included areolar-vein, paraphyses umbrella-shaped, brown; Spores reniform, bilateral, hyaline to bluish-green, perispore folded.

Fertile phase.: August–January.

Distribution. India: Rare pendent epiphytic fern growing in the forest. Arunachal Pradesh, Manipur, Meghalaya, Mizoram.

China, Japan, Myanmar, Taiwan, Tibet, Vietnam.

11. *Goniophlebium simonsianum* (Fraser-Jenk. & Shalimov) R.Kr.Singh & V.K.Rawat, J. Biodivers. Conservation 8(3): 81. 2024. *Polypodiodes simonsiana* Fraser-Jenk. & Shalimov, Turczaninowia 18(3) 113–116. 2015; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 251. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 95. 2023.

Plant epiphyte, 20–45 cm long; Rhizome long creeping, up to 5 mm thick, drying black, without whitish blume. fleshy, covered with whitish scales; Scales lanceolate, dark brown, margin serrate, apex acuminate; Stipe 5–15 cm, dark straw-colored, pubescent; Lamina pinnatipartite, oblong, yellowish green, herbaceous, glabrous, without pubescence on both surfaces, nor on the rachis pubescent, whitish shortly hairy on both surfaces or densely so abaxially 20–45 × 7–10 cm, rachis wings ca. 3–5 mm on each side, truncate to cordate at base, caudate at apex, segments 15–20 pairs, 4–5 × 1–1.5 cm, entire margin, apex obtuse; lowest pair of pinnae deflexed, lowest half of the lamina also ± deflexed or lowest ones subspreading– slightly deflexed; Veins anastomosing to form single row of areoles on each side of the rachis, each

side of the pinna-costa; Sori orbicular, close to costa, in single row on each side of costa, terminal on included veinlets.

Fertile phase.: July–December.

Distribution. India: Rare hanging epiphyte or lithophytes of high altitude in the subtropical forest up to 1500 m altitude. Arunachal Pradesh, Manipur, Meghalaya, Nagaland. Myanmar.

12. *Goniophlebium subamoenum* (C.B. Clarke) Bedd., Handb. Ferns Brit. India 317. 1883. *Polypodium subamoenum* C.B. Clarke, Trans. Linn. Soc. London, 2 Bot., 1: 550, t. 82, f. 2. 1880. *Polypodiodes subamoena* (C.B. Clarke) Ching, Act. Phytotax. Sin. 16(4): 27. 1978; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 252. 2021.

Plant small, narrow triangular up to *c.* 20 cm long; Rhizome creeping, 4–5 mm thick, densely scaly; Scales 2–4 mm long, toothed, brownish, lanceolate– subulate, margins dentate, apices acuminate; Stipe 4–8 cm long, thin, stramineous, scaly at base, glabrous above, scales as on the rhizome; Lamina lanceolate, 7–20 × 3–6 cm, membraneous, deeply pinnatifid, hirsute on upper surface; Pinnae 10–15 pairs, 3 × 0.5 cm, linear-lanceolate, adnate to rachis, margins serrate, apices acute, lower pair distant and deflexed, rachis scaly on the lower surface; Veins reticulate, distinct, uniseriate areoles along costa, each areole with one free included veinlet, marginal veins free; Sori exindusiate, circular in one row on either side of midrib, one in each areole, covered by peltate, clathrate paraphyses; Spores monolete, reniform, brownish, broadly perisporiate, granulated.

Fertile phase.: August–January.

Distribution. India: This is a rare to uncommon, upper-mid to high altitude lithophytic species, mainly on mossy rocks at the forest edges or epiphytic. Sikkim, West Bengal

Asia: China, Nepal, Tibet.

Key features: Small, narrowly triangular fronds up to 20 cm; long-creeping thin rhizome with small black toothed scales; 10–15 pairs of pinnae with small teeth; lowest pinnae slightly deflexed; obtuse, toothed pinna apex; sori in a single row along each side of the costa.

13. *Goniophlebium subauriculatum* (Blume) C.Presl, Tent. Pterid. 186. 1836; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 109. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 87. 2023. *Polypodium subauriculatum* Blume, Enum. Pl. Javae 2: 133. 1828. *Schellolepis subauriculata* (Blume) J.Sm., Ferns Brit. For. 82. 1866. *Goniophlebium molle* Bedd., Ferns Brit. Ind. 206, t. 206. 1866. *Schellolepis tomentella* (C.Chr.) Pic.Serm., Webbia 28: 470. 1973. *Goniophlebium integrum* Copel., Philipp. J. Sci. 81. 1952.

Plant *ca* 1m long; Rhizome subprunate, creeping, densely scaly; Scales narrow acuminate, hair pointed; Stipes more than 25–30 cm long, scaly, scales rufus brown; Frond firm, subcoriaceous, glabrous, about 1 m. tall, pinnate; Pinnae horizontally patent, numerous, remote, 20–25 cm long, upto 1 cm broad, shortly stalked, jointed to rachis, base truncate or caudate, auricled base, linear-lanceolate, firm, gradually acuminate, margin serrated; Veins forming two series of costular areola including free veinlets, marginal veins free; Sori in single series forming slightly elevated pustule on upper surface.

Fertile phase.: July–December.

Distribution. India. Mid altitude epiphyte or sometimes epilithic between 1000–1500 m altitude. Eastern India: Meghalaya, Mizoram.

China, Indonesia, Cambodia, Laos, Malaysia, Philippines, Thailand, Vietnam, Australia, New Guinea.

14. *Goniophlebium yunnanense* (Franch.) Bedd., Suppl. [Handb.] Ferns Brit. India 88–89.1892. *Polypodium yunnanense* Franch., Bull. Soc. Bot. France 32: 29. 1885. *Polypodiodes yunnanensis* (Franch.) Fraser–Jenk., in Fraser–Jenkins & Benniamin, Panjab Univ. Res. J., Sci. 59(1–4): 4. 2010 ("2009"). *Polypodiodes amoena* var. *pilosa* (C. B. Clarke & Baker) S.R. Ghosh, in S.R.Ghosh, B.Ghosh, Anjali Biswas & R.K.Ghosh, Pterid. Fl. E. Himalaya 1: 590–591. 2004, *comb, inval.*, *Polypodiodes chinensis* (Christ) S. G. Lu, Act. Bot. Yunnan. 21: 24. 1999. *Goniophlebium krameri* Panigrahi & Sarn. Singh, Ferns Fern–Allies Arunachal Pradesh 2:461–463, t. 163. 2005. *Polypodiodes amoena* subsp. *yunnanensis* (Franch.) Fraser-Jenk. in Fraser-Jenk. & Kandel, Ferns Fern–Allies Nepal 2: 402. 2019; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 3: 245. 2021; S.K. Singh *et al*., Pterido. Meghalaya: 94. 2023.

Plant 25–50 cm long; Rhizome long creeping, 2–3 mm in diam., densely scaly; Scales ovate-lanceolate, black, toothed margin, apex acuminate; Fronds remote, herbaceous, subglabrous on both surfaces, scaly abaxially; Stipe straw-colored, 10–20 cm, glabrous; Lamina ovate-lanceolate to broadly lanceolate, pinnatipartite or pinnatisect at lower portion, 15–25 × 8–10 cm, base cordate, apex caudate, lobes linear-lanceolate, 15–25 pairs, 3–5 × 0.5–0.7 cm, margin serrate, apex acuminate; basal pairs slightly shorter and deflexed; Veins reticulate, costa

visible, straw-colored, veinlets invisible; Sori round to orbicular, small, close to costa, terminal on included veinlets.

Fertile phase.: July-October.

Distribution. India: This is a rare high altitude epiphytic on rocks or on tree trunks growing on mossy tree trunks or mossy rocks between 1000–3000 m. Arunachal Pradesh, Himachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim, Uttarakhand, West Bengal. Bhutan, China, Nepal, Tibet.

Note: This subspecies is similar to subsp. *amoena* but the lamina is prominent and rather densely hairy on both surfaces and margins.

Table 1- Detailed comparative table for the *Goniophlebium* species

Species	Size (cm)	Rhizome/ scales	Stipe (cm) & Features	Lamina & Pinnae	Veins & Areoles	Sori	Spores & Notes
G. amoenum	40–80 × 10–30	Long creeping, thick (5–8 mm), densely scaly, pale-brown, fimbriate scales	10–30, non-articulate, stramineous, grooved, scaly upwards	30–60 cm; lobes 5–15 × 1–2 cm; 20–40 pairs; basal 1–2 deflexed; margins serrate or deeply lobed	Reticulate, 1 series areoles, free included veinlets ending in hydathodes; marginal veins free	Brown, round, exindusiate; median row on each side of costa; covered by peltate brown paraphyses	Monolete, yellow, oval to bean-shaped
G. argutum	Up to 40–50	Long creeping, thick, stout, densely scaly; black-brown, clathrate scales	3–12, glabrous, purplish, articulate to rhizome, short hairs	Deltoid to obovate-lanceolate; 10–20 pairs; sessile pinnae; toothed margins; largest 12–15 × 2–3 cm	Prominent venation; uniseriate pentagonal areoles with free included veinlets	Globose, exindusiate; uniseriate on both sides of costa; covered by peltate paraphyses	Bilateral, perisporiate, greenish-yellow, smooth exine
G. decurrentiadnatum	~25 × 15	Long creeping, branched, 3–4 mm thick; ferruginous lanceolate scales, denticulate margin	12–30, erect, brown, glabrous	Ovate, pinnate; 5 jugate pinnae pairs; suberect-patent; margins crenato-repand	Cross veins form areoles with free included veinlets	Large sori, one row toward midrib	—
G. fieldingianum	30–45	Wide creeping, 2 mm diam., sparse dark-brown ovate acuminate scales	10–14, naked, shining; castaneous lower side	Lanceolate, 22–30 × 7–10; deeply pinnatifid; 20–30 pairs; distantly inciso-serrate	Uniseriate close areolae; distinct veins	Small, oblong, medial sori	—
G. hendersonii	Up to 30	Short creeping, densely scaly; pale grey large scales with denticulate margins	—	Pinnae short (2–3 cm); 20–25 pairs; acutely toothed margins; lowest pair deflexed	—	Exindusiate, round, yellow; one per coastal areole	—
G. lachnopus	Up to 50	Wide creeping, densely scaly with linear blackish-brown fibrillose scales	5–15, slender, pale-brown, articulate; sparsely scaly	15–30 × 4–8; simple pinnatifid; up to 35 pairs; oblong hairy pinnae; serrulate margins	Reticulate; 1–2 rows of areoles with single free veinlet; marginal veins free	Small, circular, exindusiate; two rows per segment; covered by peltate paraphyses	Oval, yellow-brown; bilateral; monolete
G. manmeiense	7–12	Long creeping, 2–4 mm diam., densely scaly; dark brown lanceolate scales, ciliate margin	Straw-colored, brown base, 6–12 cm, densely scaly at base, glabrous upward	Narrowly lanceolate 20–30 × 5–8 cm, deeply pinnatifid, herbaceous, green, glabrous; 20–30 pairs lateral lobes, acuminate apex	Veins free, forked veinlets ending in elliptic hydathodes	Orbicular, single row on each side of costa, medial, superficial	—
G. mengtzeense	20–35	Creeping, epigaeous, 2–4 mm thick, dense dark brown clathrate deltoid-subulate scales	Slender, shining, pale stramineous, 9–12 cm	Lanceolate-oblong, simply pinnate, 25–35 cm, membranaceous, green, glabrous; pinnae 6–8 cm × 8–14 mm, sessile, subopposite	Slender veins, distinct; costa raised both surfaces; large uniseriate areola along costa with included soriferous veinlets	Small, globose, superficial	—
G. mieheorum	15–20 (lamina)	Narrower rhizome (details not specified)	—	Small lamina, glabrous; pinnae short, densely lobed, basally conjoined, broad rounded apices; dark brown to black veins	—	—	Small, glabrous; distinct black venation
G. niponicum	25–40	Wide-creeping, stout, black with whitish bloom, branched, scaly; scales deciduous	~10 cm, articulated, glabrous, stramineous	Oblong-lanceolate, pinnatifid, 15–20 cm; lobes 3 × 1 cm, wide at base, subulate-oblong, entire, densely hairy; rachis hairy	Anastomosing veins; one row of costal areoles with free veinlets ending in hydathodes; each areole with one included veinlet	Circular sori terminal on free included areolar vein; umbrella-shaped brown paraphyses	Reniform, bilateral, hyaline to bluish-green, folded perispore
G. simonsianum	20–45	Long creeping, up to 5 mm thick, drying black, no whitish bloom; fleshy, whitish scales	5–15 cm, dark straw-colored, pubescent	Pinnatipartite, oblong, yellowish-green, herbaceous, glabrous; 20–45 × 7–10 cm; rachis wings 3–5 mm; segments 15–20 pairs	Anastomosing veins forming single row of areoles on each rachis side and pinna-costa sides	Orbicular, single row on each side of costa, terminal on included veinlets	—
G. subamoenum	Up to 20	Creeping, 4–5 mm thick, densely scaly; brownish lanceolate-subulate scales, dentate margins	4–8 cm, thin, stramineous, scaly at base, glabrous above	Lanceolate, 7–20 × 3–6 cm, membranaceous, deeply pinnatifid, hirsute upper surface; 10–15 pairs, linear-lanceolate, adnate	Reticulate veins, uniseriate areoles along costa; each areole with one free included veinlet; marginal veins free	Exindusiate, circular, one row each side of midrib; covered by peltate clathrate paraphyses	Monolete, reniform, brownish, broadly perisporiate, granulated
G. subauriculatum	~100 (ca. 1 m)	Subprunate, creeping, densely scaly; narrow acuminate scales, hair pointed	>25–30 cm, scaly, rufous-brown scales	Firm, subcoriaceous, glabrous; pinnate; pinnae 20–25 cm long, ~1 cm broad, shortly stalked, jointed to rachis; auricled base	Two series of costular areola including free veinlets; marginal veins free	Sori single series forming slightly elevated pustule on upper surface	—
G. yunnanense	25–50	Long creeping, 2–3 mm diam., densely scaly; black ovate-lanceolate scales, toothed margins	Straw-colored, 10–20 cm, glabrous	Ovate-lanceolate to broadly lanceolate, pinnatipartite or pinnatisect at base; 15–25 × 8–10 cm; 15–25 pairs lobes linear-lanceolate	Reticulate veins; costa visible, straw-colored; veinlets invisible	Round to orbicular, small, close to costa, terminal on included veinlets	—

Table 2- Altitude Range Summary: The taxa span mid-altitude to high Himalayan zones

Altitude Category	Taxa
Mid-altitude	*G. amoena*, *G. lachnopus*, *G. manmeiensis*
Upper-mid altitude	*G. amoena*, *G. lachnopus*, *G. subamoena*, *G. fieldingiana*
Higher altitude	*G. amoena*, *G. fieldingiana*, *G. hendersonii*, *G. subamoena*, *G. yunnanensis*, *G. argutum*
High Himalayan	*G. hendersonii*

Table 3- Substrate Preference

Substrate	Taxa
Epiphytic	*G. amoena*, *G. argutum*, *G. manmeiensis*, *G. lachnopus*, *G. hendersonii*, *G. fieldingiana*, *G. yunnanensis*,
Lithophytic	*G. fieldingiana*, *G. hendersonii*, *G. subamoena*, *G. lachnopus*
Primarily lithophytic	*G. subamoena*

- Most taxa prefer mossy substrates, especially moss-laden tree trunks, branches, or rocks.
- *Polypodiodes manmeiensis* is a very rare epiphyte restricted to mid-altitudes.
- *Polypodiodes subamoena* is mainly lithophytic, unusual among these taxa.

Table 4- Abundance Pattern

Abundance Category	Taxa
Very common	*G. amoena*, *G. lachnopus*
Common	*G. fieldingiana*, *G. argutum*
Scattered to uncommon	*G. subamoena*, *G. hendersonii*
Rare or very rare	*G. manmeiensis*, *G. yunnanensis*

Notable Observations:

Epiphytism is dominant, with several species also tolerating lithophytic niches. Moss cover appears essential across all taxa, indicating microhabitat specificity. Altitudinal overlap occurs significantly in the upper-mid to higher altitude range, especially among *G. amoena*, *G. fieldingiana*, *G. hendersonii*, and *G. argutum*. Rare species (*G. manmeiensis*, *G. yunnanensis*) may be more habitat-restricted and sensitive to disturbance.

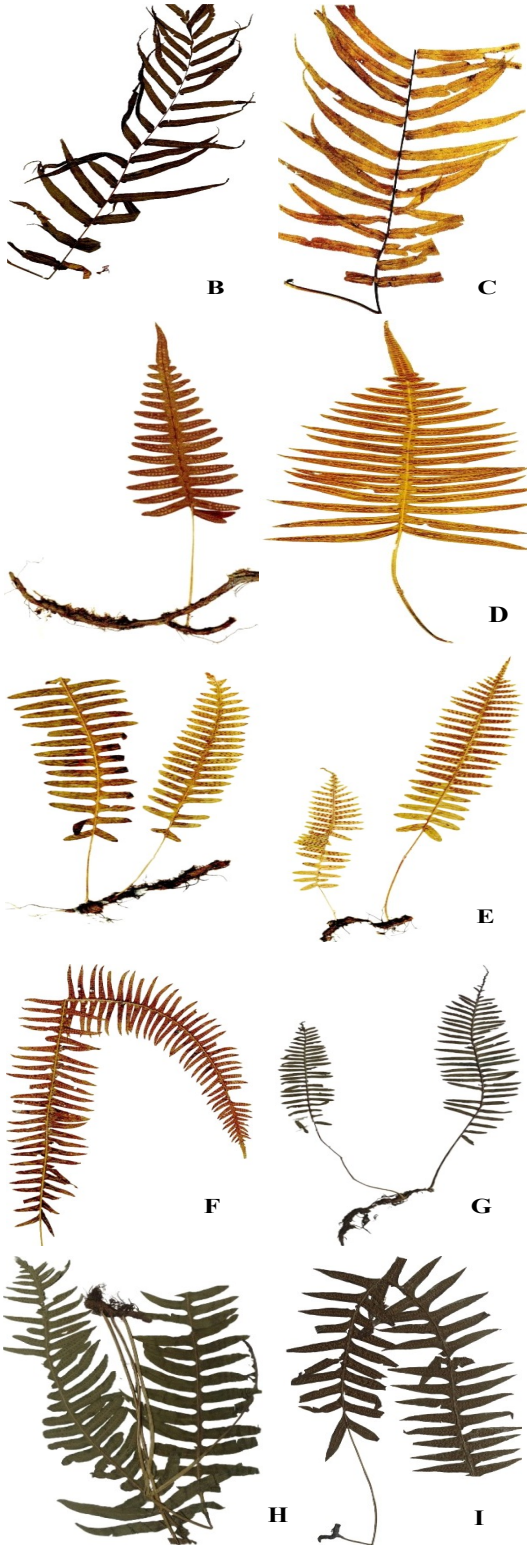

Fig: -A- *Goniophlebium argutum*, B- *Goniophlebium mengteense,* C- *Goniophlebium subauriculatum,* D- *Goniophlebium amonea*, E, F- *Goniophlebium lachnopus,* G-*Goniophlebium manmienes,* H- *Goniophlebium niponicum,* I- *Goniophlebium simonsiana*

CONCLUSION

This study highlights the diversity, distribution, and ecological significance of *Goniophlebium* species in India. Though underexplored, the genus shows notable endemism and ecological specialization, particularly in the Eastern Himalayas, Northeast India, and the Western Ghats. Fourteen species are recorded, including *G. amoenum*, *G. argutum*, *G. decurrentiadnatum*, *G. fieldingianum*, *G. hendersonii*, *G. lachnopus*, *G. manmeiense*, *G. mengtzeense*, *G. mieheorum*, *G. niponicum*, *G. simonsianum*, *G. subamoenum*, *G. subauriculatum*, and *G. yunnanense*. These ferns typically inhabit moist, shaded montane to subalpine forests between 1000–3500 m, growing epiphytically or lithophytically on moss-laden trunks and boulders. Taxonomic debate persists: while Fraser-Jenkins transferred some species to *Polypodiodes* based on morphology, the Pteridophyte Phylogeny Group retains them under a broadly defined *Goniophlebium*. High-altitude specialists like *G. manmeiense* and *G. mieheorum* are of particular conservation concern due to their narrow distributions. Ecologically, *Goniophlebium* species contribute to forest ecosystem stability and serve as sensitive bioindicators of habitat quality. However, habitat loss, climate change, and other anthropogenic pressures threaten their survival, especially those confined to restricted ecological niches. Conservation efforts must prioritize habitat protection, inclusion in biodiversity strategies, and increased public and scientific engagement. Long-term monitoring, ex situ conservation, and integrative taxonomic and molecular research are essential to ensure the persistence of these ecologically important yet overlooked ferns.

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