

DIVERSITY AND DISTRIBUTION OF THE THELYPTERIDACEAE (POLYPODIOPSIDA) IN PAKISTAN

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ABSTRACT

The present taxonomic study of Thelypteridaceae (Polypodiopsida) in Pakistan is based on the study of fern specimens in 15 herbaria in Asia, Europe and USA. A total of six genera and eight species are recognized; a key, detailed description of species, distribution in Pakistan and worldwide, ecology, and a list of specimens examined from Pakistan are provided.

Key words: Thelypteridaceae, Polypodiopsida, Pakistan, Taxonomy, Key to species.

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INTRODUCTION

Thelypteridaceae Ching ex Pic.Serm. is a large family of pteridophytes which is represented by two sub-families, 37 genera and approximately 1200 species worldwide (PPG I 2016; Fawcett and Smith 2021). Some authors prefer to treat all the species under a broad concept of *Thelypteris* Schmidel (e.g. POWO; Fraser-Jenkins 2014; Fraser-Jenkins *et al.* 2016). Members of the Thelypteridaceae range from temperate to tropical regions, achieving greatest diversity in tropical humid forest environments, in both montane and lowland habitats. The foundation of the taxonomy in the family Thelypteridaceae is based on cytological and morphological studies (Ching 1940; Holttum 1982). Within the last two decades, a series of molecular phylogenetic studies have improved our understanding of the evolutionary relationships within the family, enabling taxonomic refinements (Smith and Cranfill 2002; He and Zhang 2012; Rothfels *et al.* 2012; Almeida *et al.* 2016; Patel *et al.* 2019a; Fawcett *et al.* 2021; Fawcett 2022). The taxonomic treatment here follows the circumscription of the family Thelypteridaceae, which recognizes separate genera (Fawcett and Smith 2021).

Previous studies have included species lists of the Thelypteridaceae of Pakistan, but did not provide detailed descriptions or keys. Stewart (1972) reported seven species from various localities of Pakistan; Fraser-Jenkins (1992; 2014) listed all eight known species from Pakistan from specimens collected or seen in herbaria,

providing regional distribution for seven of them; Nakaike and Malik (1992; 1993) reported six species from Azad Jammu and Kashmir, Abbottabad, Kohistan, Mansehra and Peshawar districts; Iltaf *et al.* (2012) documented three species from Punjab province, Pakistan; Fraser-Jenkins *et al.* (2016) listed all the Pakistan species with detailed synonymy and taxonomic comments, also giving their global range. Shah *et al.* (2019) investigated the spore morphology of five species from Malakand division, Pakistan; Attaullah *et al.* (2020) reported one species from Utror valley, district Swat, Pakistan. Irfan *et al.* (2022a) documented the floristic diversity and chorotype analysis of the seven species of Thelypteridaceae in Pakistan. Khullar *et al.* (2022) documented the detailed taxonomy, habitat, distribution, and specimens examined of sixteen species of Thelypteridaceae from Jammu and Kashmir. Recently Fraser-Jenkins *et al.* (2023) described and illustrated the detailed specimen-lists of seven species from districts Buner, Swat, and Shangla, in Khyber Pakhtunkhwa province, Pakistan. At the present time, a relatively small proportion of herbarium specimens of Thelypteridaceae from Pakistan have been digitized, which necessitates study of physical herbarium specimens.

The aim of the present study is to provide an account of the Thelypteridaceae in Pakistan, with updated taxonomy, including synonymy, a key to genera and species, detailed morphological descriptions and distributions both within Pakistan, and globally, for the eight known species.

MATERIALS AND METHODS

The present study is based on specimens deposited in the herbaria of Asia, Europe and USA, including BM, CAL, DD, HUP, ICP, ISL, K, KUH, MO, MUZU, NY, PFI, PMNH, RAW, TNS (acronyms according to Thiers 2023). All the images of type specimens were accessed through the JSTOR Global Plants project database (<https://plants.jstor.org>). Many fern specimens collected from Pakistan, including type specimens at BM, CAL, DD, ISL, K, KUH, PFI, PMNH, NY and RAW were carefully examined. Extensive lists of specimens examined provided by C.R. Fraser-Jenkins have corroborate our findings, and reflect the same patterns of diversity and distribution. Different parameters, including correct name, locality, altitude, habitat, distribution, collector's name, year, voucher specimen-number and herbarium acronym were documented. Descriptions of the species are based on morphological and taxonomic characters of specimens examined from Pakistan. Definition of terms follows the glossary by Lellinger (2002). Distribution data for Pakistan is based on specimens deposited at the above herbaria.

RESULTS

Taxonomic treatment

Class Polypodiopsida Cronquist, Takht. & W.Zimm.

Order Polypodiales Link

Suborder Aspleniineae H.Schneid. & C.J.Rothf.

Family Thelypteridaceae Ching ex Pic.Serm.

Key to species

1. Some blades indeterminate in growth, apex elongating, rachis producing adventitious bulbils and plantlets.....*Ampelopteris prolifera*
- 1.' All blades determinate, apex gradually reduced, or pinna-like, not producing plantlets.....2.
2. Blades simply pinnate, pinna margins sub-entire to serrate or shallowly lobed*Menisciopsis penangiana*
- 2.' Blades pinnate-pinnatifid to tripinnate.....3.
3. Sori subcostular.....*Glaphyropteridopsis erubescens*
- 3'. Sori medial to inframarginal.....4.
4. Veins free.....5.
5. Acroscopic bases of segments not auricled; stalked lands absent*Christella dentata*
- 5'. Acroscopic bases of at least lower 10 pairs of segments auricled; stalked glands present on both surfaces of costae..... *Christella multiauriculata*
- 4'. At least some lateral veins forking.....6.
6. Stipe typically longer than blade, laminae pinnate-pinnatifid.....*Phegopteris connectilis*
- 6'. Stipe much shorter than blade, laminae bipinnate or more divided.....7
7. Stipe stramineous, abaxial surface of rachis and costa

hairy *Pseudophegopteris levingei*
 7'. Stipe castaneous, abaxial surface of rachis and costa glabrous..... *Pseudophegopteris microstegia*
 subsp. *late-repens*

Ampelopteris prolifera (Retz.) Copel., Gen. Fil. 144. 1947; Stewart (1957, 1972); Nakaike and Malik (1993); Haq *et al.* (2022); Irfan *et al.* (2022a, b) Fig. 1 A–D.

Basionym: *Hemionitis prolifera* Retz., Obs. Bot. 6: 36, 38. 1791.

Synonyms: *Goniopteris prolifera* (Retz.) C.Presl, Tent. Pterid. 183. 1836.

Dryopteris prolifera (Retz.) C.Chr., Index Fil. 5: 286. 1905.

Thelypteris prolifera (Retz.) C.F.Reed, Phytologia 17(4): 306. 1968.

Type: INDIA. "India orientale", no date, *J.G. Koenig s.n.* (Lectotype: K-000951406!).

Description. A proliferous, clambering species, plants 80–120 cm tall, rhizome thick, creeping; fronds clustered, often trailing along the ground with sterile fronds often having proliferous bulbils on the rachis which develop into new plants while still attached to the main frond; stipe stramineous, 35–40 cm, stipe base bearing sparse dark brown lanceolate scales and hairs; lamina herbaceous, lanceolate, base slightly narrowed; pinnae short, spreading, entire, sub-opposite, sub-sessile, lanceolate, 5–12 × 1.4–1.8 cm, rounded at base, margins undulate, apex shortly pointed; pinnae having 3–4 pairs of veinlets anastomosing to join a common excurrent vein. Sori located at the middle of veinlets, mostly confluent at maturity, indusia absent. Sporangial capsules with stalked glands, spores monolete and elliptic (Figure 1 A–D).

Distribution and ecology. *Ampelopteris prolifera* (Retz.) Copel. is terrestrial near streams, in moist and shady places at elevations ranging from 250–1200 m and is found infrequent. It is distributed in Asia (Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Nepal, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam); Africa (South Africa, Madagascar and the Mascarenes); Australasia (Australia and New Caledonia).

Specimens examined:

PAKISTAN. Khyber Pakhtunkhwa: • Sarai salah, Mansehra, 25 Sep. 1956, *R. R. Stewart 27648* (RAW) • Bara Gali, Abbottabad, 27 May 1972, *S. Roy s.n.* (PUB) • Galiat, Abbottabad, 27 May 1973, *M. Yousaf s.n.* (PUB) • Mansehra, Hazara, 14 Aug. 1977, *M. Shah & Manzoor 75* (ISL) • Peshawar, 30 Aug. 1979, *N. Sher 86* (ICP) • Ayubia, Abbottabad, 6 Apr. 1984, *S. Akhtar s.n.* (LAH) •

Peshawar, 14 Aug. 1987, *B. Rehmat 11* (PUB) • Peshawar, University, Peshawar, 19 Apr. 1990, *I. M. Khan s.n.* (PUB) • Peshawar University, Peshawar, 19 Apr. 1990, *N. Akhtar 7* (PUB) • Peshawar, 18 Oct. 1991, *T. Nakaike & S. Malik 1534* (PMNH) • Peshawar, 11 Jul. 1992, *Shaukat s.n.* (PUB) • Swat, 20 Aug. 1993, *S. Ali s.n.* (PUB). **Punjab:** • Lahore botanical garden, Lahore, 1 Apr. 1957, *A. H. Khan s.n.* (PFI) • Choa, Sidan shah, Chakwal, 10 Oct. 1965, *E. Nasir & M. A. Siddiqui 3659* (RAW) • Kallar kahar, Jhelum, 18 Oct. 1975, *M. N. Chaudhri, M. A. Siddiqui, M. Ashraf & Nisar 36* (ISL) • Choa saidan shah, Jhelum, 24 Sep. 1976, *M. A. Siddiqui, M. Akram & L. Khan 67* (ISL) • Jinnah garden, Lahore, 14 Feb. 1984, *S. Vehra s.n.* (LAH) • Nundi pur, Sialkot, 1987, *L. Shehnaz s.n.* (LAH).

Christella dentata (Forssk.) Brownsey & Jermy, Brit. Fern Gaz. 10(6): 338. 1973; Nakaike and Malik (1992, 1993); Gul *et al.* (2016a, b); Shah *et al.* (2019); Haq *et al.* (2022); Irfan *et al.* (2022a, b) Fig. 2 A–D.

Basionym: *Polypodium dentatum* Forssk., Fl. Aegypt.-Arab. 185. 1775.

Synonyms: *Dryopteris dentata* (Forssk.) C.Chr., Kongel. Danske Vidensk. Selsk. Skr., 8, 6(1): 24. 1920.

Thelypteris dentata (Forssk.) E.St.John, Am. Fern. Journ. 26: 4. 1936.

Cyclosorus dentatus (Forssk.) Ching, Bull. Fan Mem. Inst. Biol., Bot., 8(4): 206–209. 1938.

Type: YEMEN. in montibus ad Bolghose, 1 Jan. 1763, *P. Forsskal 809* (holotype: C-10002814!).

Description. Plant 40–60 cm tall, rhizome short-creeping; fronds loosely clustered; stipes 10–30 cm, bases dark brown, stramineous distally; stipes with brown linear-lanceolate scales; laminae papery, monomorphic, long, lanceolate, triangular, dark green, bases tapering, pinnate-pinnatifid, apex acuminate, rachis diam. 1–2 mm, rachis and costa hairy, abaxially raised, rachis grooved adaxially with brownish color; pinnae sub-opposite, lanceolate, alternate, 2.1–2.5 cm apart, 10–17×1.7–1.9 cm, veins simple or seldom forked, reaching near margins. . Sori brownish, oblong, reniform, located amongst costa & margins; indusiate, indusia smaller, orbicular with a sinus, membranous, shriveling and deciduous, spores monolet and elliptic.

Distribution and ecology. *Christella dentata* (Forssk.) Brownsey & Jermy is terrestrial on banks of water courses, and in lowlands in villages at an elevation of 300–2000 m, found abundantly, and distributed in Asia (Afghanistan, Bangladesh, Bhutan, China, Indonesia, Iran, Iraq, Japan, Korea, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Thailand, and Yemen); Australia (Australia, New Zealand and New

Guinea); Africa (Comoros, Madagascar, Mascarenes and Socotra); South America and North America.

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: Poonch, 19 Apr. 1952, *R. R. Stewart & E. Nasir s.n.* (RAW) • Poonch, 7 Jul. 1952, *R. R. Stewart & E. Nasir 24135* (RAW) • Poonch, 20 Apr. 1952, *J. Muhammad s.n.* (DD) • Nikyal, Kotli, 21 Jul. 1953, *A. R. Khan s.n.* (MUZF) • Poonch, 12 Sep. 1953, *R. R. Stewart, E. Nasir & A. Rashid s.n.* (RAW) • Muzaffarabad on way to Neelam valley, 28 Sep. 1970, *M. Qaiser & S. A. Farooqi 3090* (KUH) • Kotli, 5 June 1977, *Shehzad, Nisar & Ayaz 1890* (ISL) • Poonch, 18 June 1977, *Shahzad & Nisar 157* (ISL) • Chikar, Jhelum valley, 1989, *A. A. Awan s.n.* (LAH) • Muzaffarabad, 1 Jul. 1989, *N. Bano s.n.* (MUZU) • Muzaffarabad, 1 Dec. 1989, *N. Hussain s.n.* (MUZU) • Jhelum valley, 1 Aug. 1990, *A. A. Awan s.n.* (MUZU) • Muzaffarabad, 12 Apr. 1990, *S. Younas s.n.* (MUZU) • Chikar, Jhelum valley, 14 Sep. 1991, *S. U. R. Kashmiri & R. Ayub s.n.* (MUZU) • Chikar, Jhelum valley, 1 Oct. 1991, *S. U. R. Kashmiri & Qadeer s.n.* (MUZU).

Khyber Pakhtunkhwa: • Gari Habibullah, Mansehra, 1 Jul. 1886, *E. W. Trotter s.n.* (DD) • Torghar, Col. Gatacre *s.n.* (DD) • Siran valley, Mansehra, 18 June 1896, *Inayat & J. F. Duthie 20439, 20440* (DD) • Siran valley, Mansehra, 3 Sep. 1899, *Inayat & J. F. Duthie 23238, 23245* (K) • Chitral, 1 Oct. 1909, *S. M. Toppin 830* (K) • Malakand, 1 Oct. 1910, *S. M. Toppin 2025* (CAL) • Saidu sharif, Swat, 11 Aug. 1952, *R. J. Rodin 5448* (K) • Sarai salih, Mansehra, 29 Sep. 1956, *R. R. Stewart 27647* (RAW) • Dadar, Mansehra, 13 Apr. 1959, *R. R. Stewart 28804* (RAW) • Shogran, Mansehra, 1 Aug. 1964, *A. H. Zafar s.n.* (LAH) • Pir baba, Buner, 19 May 1968, *S. A. Khan 792, 813* (PFI) • Balakot, Mansehra, 10 Aug. 1971, *S. U. Abedin & M. Qaiser 8673* (KUH) • Abbottabad, 6 Apr. 1973, *M. A. Siddiqui & Y. Nasir 7261* (RAW) • Sarai salih, Mansehra, 12 Apr. 1975, *M. N. Chaudheri, M. A. Siddiqui, I. Dar & Anjum 92* (ISL) • Saidu sharif, Swat, 16 Oct. 1975, *M. Shah, Javid & Manzoor 625* (ISL) • Mansehra, Hazara, 8 May 1976, *M. A. Siddiqui, M. Shah, Shahzad, Ashraf & Manzoor 920* (ISL) • Mansehra, Hazara, 28 Jul. 1976, *Shaukat & Nisar 636* (PMNH) • Mansehra, Hazara, 6 Oct. 1976, *Shaukat & Nisar 1769* (ISL) • Haripur, 26 June 1977, *M. Shah & Ayaz 971* (ISL) • Balakot, Mansehra, 3 Oct. 1977, *M. A. Khan & Afzal 1310* (ISL) • Peshawar, 3 Aug. 1979, *N. Sher 86* (ICP) • Mansehra, Hazara, 27 Aug. 1981, *M. Shah & M. Ashfaq s.n.* (PMNH) • Abbottabad, 31 Jul. 1982, *K. Saeed & M. J. Iqbal s.n.* (PMNH) • Karakar mountain, Buner, 18 Mar. 1984, *M. R. Awan, Z. U. Khattak & M. Ashfaq s.n.* (PMNH) • Mansehra, Hazara, 13 Apr. 1984, *Y. Nasir, R. Akhtar & Khan 10775* (RAW) • Batkhela, Malakand, 18 Oct. 1985, *Riwali 85* (PUB) •

Dadar, Mansehra, 11 Sep. 1986, *Y. Nasir, R. Akhtar & Hanif 12131, 12134, 12136* (PMNH) • Sardheri, Charsadda, 10 Aug. 1987, *R. Ullah s.n.* (PUB) • Mansehra, Hazara, 20 Apr. 1988, *K. Nazir & F. Ahmed 774* (PMNH) • Thakot, Batgram, Mansehra, 28 Aug. 1988, *S. Omer & M. Qaiser 2235* (KUH) • Marghuzar, Swat, 22 Sep. 1989, *M. R. Awan, Z. U. Khattak & M. Ashfaq s.n.* (PMNH) • Batal, Mansehra, 30 Sep. 1989, *S. I. Ali 3094* (KUH) • Deewana baba, Buner, 13 Mar. 1990, *M. R. Awan, Z. U. Khattak, M. Ashfaq & Liaqat s.n.* (PMNH) • Gokand, Buner, 15 Mar. 1990, *M. R. Awan, Z. U. Khattak & M. Ashfaq s.n.* (PMNH) • 1600 m, road-bank c. 1 km S. of Chattar Plain, at top of road-climb, c. 18 km S.E. of Batagram, on road to Mansehra, N.W. of Mansehra, 13 Sep. 1990, *C. R. Fraser-Jenkins 16435* (BM) • c. 2100 m, in remnant Pine forest, 1½ miles below and west of top of Shangla Pass, above and east of Khwaza khela, eastern rim of mid-Swat valley, 17 Sep. 1990, *C. R. Fraser-Jenkins 16997* (BM) • Abbottabad, Mansehra, & Swat, 12 Oct. 1991, *T. Nakaike & S. Malik 189, 560, 561, 566* (PMNH & TNS) • Dir lower, Laal Qilla, Kambat, 1028 m, 19 Sep. 2015, *M. Irfan & I. Ahmad 47* (HUP) • Dir lower, Laalqilla, 1250 m, 20 Sep. 2015, *M. Irfan & I. Ahmad 52* (HUP). **Punjab:** • Rawalpindi, 1 Sep. 1870, *J. E. T. Aitchison 1469* (K) • Lahore, 2 Jul. 1987, *L. Shehnaz s.n.* (LAH).

Christella multiauriculata Punetha, J. Indian Bot. Soc. **69:** 177 (1990), non *Thelypteris multiauriculata* (Copel.) C.F.Reed. Fig. 3 A & B.

Synonym: *Thelypteris punethae* Fraser-Jenk., Annotated Checklist Indian Pterid. **1:**461 (2016).

Holotype: from India, Uttarakhand, Pithoragarh, College compound, 1900 m., *N. Punetha 726*, 9.1985 (K).

Plant 35–55 cm tall, rhizome thick, rather erect, scaly; scales linear-lanceolate, margin smooth, hairs pointed, yellowish-brown; stipes up to 20 cm long, scaly at base, glabrous above, hairy; hairs unicellular, hyaline, straight; rachis hairy; laminae up to 75 cm long, lanceolate, bright-green; distinctive dense, sessile, pale glands on lower surface; most fronds taper downwards towards the stipe; pinnae: lowermost 5–6 pairs gradually slightly reduced, auricled, 1.0 × 0.5 cm, middle ones the largest, up to 1.5 × 2 cm, oblong-lanceolate, base broad, deeply lobed, 3/4 to the costa, both surfaces hairy, acroscopic lobes of basal 5–10 pairs larger in size; veins 9–10 pairs, 1.5- to 2.5 pairs of veinlets anastomosing to form a commissure leading to the base of the sinus, other veins reach the margin; pale veinlets well raised beneath and all the veins beneath and the margins rather densely covered with medium-length, stiff white hairs. Sori medial, indusiate, suborbicular, indusia margins irregular, hairy. Spores rather small, not abortive, dark-brown, thinly perisporiate. Chromosome number reported as tetraploid, (Punetha & Sen, 1989).

Distribution and ecology. *Christella multiauriculata* Punetha is terrestrial on banks of water courses at an elevation of 1000–2000 m, found rarely, and distributed in Asia (Bangladesh, India, Nepal, and Pakistan).

Specimens examined:

PAKISTAN. Yarkhand Expedition, 13 Nov. 1870, *Dr. [G.] Henderson 954* (K) determined by C.R. Fraser-Jenkins.

Initially considered a synonym of *Christella dentata* by Fraser-Jenkins (2008), he later recognized it as a distinct species (Fraser-Jenkins *et al.* 2016). This species is characterized by most fronds tapering downwards towards the stipe; lamina beneath with rather dense distinctive stalked white glands; veinlets pale, well raised beneath; veinlets varying from 1.5–2.5 pairs anastomosing below the sinus.

Glaphyopteridopsis erubescens (Wall. ex Hook.) Ching, Act. Phytotax. Sin. **8(4):** 320. 1963; Nakaike and Malik (1992, 1993); Shah *et al.* (2019); Haq *et al.* (2022); Irfan *et al.* (2022a) Fig. 4 A–D.

Basionym: *Polypodium erubescens* Wall. ex Hook., Sp. Fil. **4:** 236. 1863

Synonyms: *Thelypteris erubescens* (Wall. ex Hook.) Ching, Bull. Fan Mem. Inst. **6:** 293. 1936.

Phegopteris erubescens (Wall. ex Hook.) J.Sm., Hist. Fil. **233.** 1875.

Dryopteris erubescens (Wall. ex Hook.) C.Chr., Index Fil. **263.** 1905.

Lastrea erubescens (Wall. ex Hook.) Copel., Gen. Fil. **138.** 1947.

Type: INDIA. Uttarakhand: Kumoon, N. Wallich cat. no. 330, 1827, *R. Blinkworth s.n.* (lectotype: K-001109836! designated by Fraser-Jenkins *et al.* 2016); Syntypes: K-000951465!, K-000951466!, K-000951467!, GH-00021832! UC-267903!.

Description. Plants 1–2 m tall, rhizome robust, glabrous, fronds clustered; stipe 1–1.5 m, glabrous, stramineous; lamina 22–44 × 90–180 cm, papery, tapering at base, pinnate, acuminate at apex, pinnatifid; rachis rectangular in cross-section, stramineous; pinnae 38–50, sessile, middle pinna linear, truncate at base, pinnatifid near costa, acute at tip; pinna glabrous, pinnules 45–60 pairs, linear-lanceolate; veins evident, costa adaxially grooved, veinlets 10–24 sets per segment; sori orbicular, 7–10 sets per pinnule, closer at base of veinlets near sides of costules in one row on each side, glabrous, indusia absent; sporangia glabrous, rarely hairy, spores monoletic and elliptic.

Distribution and ecology. *Glaphyopteridopsis erubescens* (Wall. ex Hook.) Ching is terrestrial near streams, in moist and shady places at an elevation of

1200–2000 m found commonly, and distributed in Asia (Bhutan, China, India, Japan, Laos, Myanmar, Nepal, Pakistan, Philippines, and Vietnam).

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: • Jhelum valley, 1 Sep. 1889, *E. W. Trotter 361* (RAW) • Poonch, 18 Apr. 1952, *R. R. Stewart 23775* (RAW) • Bagh, Poonch, 15 Sep. 1952, *A. R. Khan s.n.* (KUH & MUZF) • Poonch, 26 Sep. 1952, *A. R. Khan s.n.* (RAW) • Poonch, 26 Apr. 1953, *R. R. Stewart 25565* (RAW) • Nakial, Mirpur, Poonch, 19 Jul. 1953, *A. R. Khan s.n.* (RAW) • Bagh, Poonch, 15 Sep. 1953, *J. Muhammad 1518* (ISL) • Harhyala, Muzaffarabad, 8 Aug. 1976, *J. Muhammad 3556, 3557, 3564* (ISL) • Jhelum valley, 13 Dec. 1989, *N. Bano s.n.* (MUZU) • Chotagra, Muzaffarabad, 8 Sep. 1991, *T. Nakaike & S. Malik 890, 891, 979, 981, 983* (PMNH & TNS) • Chikar, Jhelum valley, 14 Sep. 1991, *S. U. R. Kashmiri & R. Ayub s.n.* (MUZU). **Khyber Pakhtunkhwa:** • Torgar, 1 Nov. 1888, *Col. Gatacre s.n.* (DD) • Shinkiar, Mansehra, 26 June 1896, *Inayat & J. F. Duthie 20412, 20442* (DD & K) • Siran valley, Mansehra, 27 Aug. 1899, *Inayat & J. F. Duthie 23239* (K) • Dadar, Mansehra, 13 Apr. 1959, *R. R. Stewart s.n.* (RAW) • Changla Gali, Abbottabad, 19 Apr. 1962, *R. R. Stewart, E. Nasir & M. A. Siddiqui 284* (RAW) • Marghuzar, Swat, 14 Oct. 1975, *M. Shah, Manzoor & Javid 495* (RAW) • Dadar, Mansehra, 11 Sep. 1986, *Y. Nazir, R. Akhtar & Hanif 12148* (RAW) • Kaghan valley, Mansehra, *J. Shan & H. H. Naqvi s.n.* (PUB) • 1600 m, road-bank c. 1 km S. of Chattar Plain, at top of road-climb, c. 18 km S.E. of Batagram, on road to Mansehra, N.W. of Mansehra, 13 Sep. 1990, *C. R. Fraser-Jenkins 16436* (BM) • c. 2100 m, in remnant Pine forest, 1½ miles below and west of top of Shangla Pass, above and east of Khwaza khela, eastern rim of mid-Swat valley, 17 Oct. 1990, *C. R. Fraser-Jenkins 16998* (BM) • Jabori, Mansehra 28 Jul. 2013, *A. Gul & J. Alam 925* (HUP).

Menisciopsis penangiana (Hook.) S.E. Fawc. & A.R. Sm., *Sida, Bot. Misc.* 59: 53 (2021) Fig. 5 A–D.

Basionym: *Polypodium penangianum* Hook., *Sp. Fil.* 5: 13. 1864.

Synonyms: *Goniopteris penangiana* (Hook.) Bedd., *Ferns Brit. India* t. 232. 1867.

Dryopteris penangiana (Hook.) C.Chr., *Index Fil.* 283. 1905.

Abacopteris penangiana (Hook.) Ching, *Bull. Fan Mem. Inst. Biol., Bot.*, 8(4): 255–259. 1938.

Thelypteris penangiana (Hook.) C.F.Reed, *Phytologia* 17(4): 303. 1968.

Dryopteris rampans (Baker) C.Chr., *Index Fil.* 287. 1905.

Pronephrium penangianum (Hook.) Holttum, *Blumea* 20: 110. 1972.

Type: NEPAL. "mislocalized as Penang MALAYSIA", 1822, *N. Wallich 299* (lectotype: K-000951547!; isolectotypes: K-000951508!, K-000951509! designated by Holttum, 1972).

Description. Plants 1–1.5 m tall, rhizome creeping, dark brown, 1.2–1.8 cm in diameter, rarely with few brownish scales; frond remote; stipe brown, distally reddish brown, glabrous; lamina papery, glabrous, oblong, lanceolate, dark green, 35–70 × 26–42 cm, lateral pinnae 11–16 pairs, spreading, alternate, stalked, broadly linear, proximal middle pinnae 18–32 × 2–2.5 cm, sharply serrate, distal pinnae slightly shortened; terminal pinna with same size and shape as that of lateral pinnae, stalked; veinlets evident abaxially, spreading and parallel, 8–10 pairs, joined at their ends and forming triangular areoles between veinlets, distal 2–4 pairs of veinlets are free and reach at margins. Sori orbicular, located on middle of veinlets in two rows, 5–7 per row, without indusia, sporangia glabrous; spores monolete and reniform.

Distribution and ecology. *Menisciopsis penangiana* (Hook.) S.E.Fawc. & A.R.Sm. is terrestrial in mountains in moist temperate forests at an elevation of 1000–2000 m found infrequently, and is distributed in Asia (Bhutan, China, India, Myanmar, Nepal and Pakistan).

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: Poonch, 7 Jul. 1952, *R. R. Stewart & E. Nasir 24515* (K) • Bagh, 12 Sep. 1953, *A. R. Khan s.n.* (MUZF). **Khyber Pakhtunkhwa:** Galyat, Abbottabad, 27 May 1972, *J. Khan s.n.* (PUB) • Abbottabad, 28 May 1973, *M. Ali 8* (PUB) • Abbottabad, 20 May 1973, *T. M. Khattak 7* (PUB) • Galyat, Abbottabad, 25 June 1976, *A. Shah s.n.* (PUB) • Abbottabad, 10 Jul. 1978, *S. A. H. Zaidi s.n.* (PUB) • Peshawar University, Peshawar, 20 Aug. 1980, *M. N. Ali s.n.* (PUB). **Punjab:** Murree hills, Rawalpindi, 27 May 1972; *H. Khan s.n.* (PUB).

This species has been treated in *Pronephrium*, however, phylogenetic data have shown that it is distantly related to *Pronephrium s.s.* (Fawcett *et al.* 2021).

Phegopteris connectilis (Michx.) Watt, *Canad. Naturalist Geol.*, n.s., 3(2): 159. 1867; Nakaike and Malik (1992, 1993); Gul *et al.* (2016a, b); Shah *et al.* (2019); Murad *et al.* (2000); Irfan *et al.* (2022a, b) Fig. 6 A–D.

Basionym: *Polypodium connectile* Michx., *Fl. Bor.-Amer.* (Michaux) 2: 271 (–272) (1803).

Synonyms: *Polypodium phegopteris* L., *Sp. Pl.* 2: 1089. 1753.

Dryopteris phegopteris (L.) C.Chr., *Index Fil.* 284. 1905.

Thelypteris phegopteris (L.) Sloss. ex Rydb., *Fl. Rocky Mts.* 1043. 1917.

TYPE: CANADA. "Hab. in Canada" Michaux s.n. (P). Lectotype: Michaux Herbarium (P), designated by Morton [photograph 3362] (1967); Holttum (1969).

Description. Plants 24–40 cm tall, rhizome creeping, apex scaly; frond herbaceous, gray-green with sparse hairs on both surfaces, remote; stipe 14–28 cm, brown at base; laminae deltoid, acuminate, pinnatifid at apex; rachis diameter 1–1.5 mm, hairy, grooved adaxially, light brown; pinnae 12–15 pairs, 6.7–7.9 × 1.4–1.5 cm, usually opposite to sub opposite, lanceolate, largest at middle, apex acuminate, entire, rounded; veins pinnate, lateral veins may be simple or forked. Sori ovate, orbicular, oblong, born on the middle of veins, indusiate, indusia smaller, spores monolete and reniform.

Distribution and ecology. *Phegopteris connectilis* (Michx.) Watt is terrestrial near streams among bushes at an elevation of 1400–2000 m found infrequently, and distributed in Asia (Bhutan, China, Georgia, Japan, Nepal, Pakistan, Russia, and Turkey); Europe (widespread); and North America (Canada and USA).

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: Neelam valley, 1 Jul. 1990, *M. R. Khan s.n.* (MUZU). **Khyber Pakhtunkhwa:** Chitral, 17 June 1895, *S. A. Hariss 16831* (BM, CAL & DD) • about 3-4 miles from Batakundi, between Naran and Batakundi, Kaghan valley, Mansehra, 31 Jul. 1961, *A.H. Sheikh 17291* (BM) • c. 2300 m, among large rocks on south side of and near river, shortly above entrance to Jalband valley, W.S.W. of Kalam, upper Swat valley, 14 Oct. 1990; *C. R. Fraser-Jenkins 16910* (BM).

We follow Fraser-Jenkins *et al.* (2016), in recognizing *Phegopteris connectilis*, however, it is possible that the plants in Pakistan are more closely related to *Phegopteris tibetica* Ching than they are to the Canadian type of *Phegopteris connectilis*. *Phegopteris tibetica* is poorly characterized, and no material was available for study. Study of the *Phegopteris connectilis* complex has revealed cytological and taxonomic complexity in the group (Matsumoto 1982; Patel *et al.* 2019b), and further study of this widespread complex is needed.

Pseudophegopteris levingei (C.B.Clarke) Ching, Act. Phytotax. Sin. 8(4): 314. 1963; Nakaike and Malik (1992, 1993); Gul *et al.* (2016a, b); Shah *et al.* (2019); Haq *et al.* (2022); Irfan *et al.* (2022a, b) Fig 7 A & B.

Basionym: *Gymnogramma aurita* var. *levingei* C.B.Clarke, Trans. Linn. Soc. Lond., 2 Bot., 1: 568. 1880.

Synonyms: *Leptogramma aurita* var. *levingei* (C.B.Clarke) Bedd., Handb. Ferns Brit. India 377, 379. 1883.

Dryopteris levingei (C.B.Clarke) C.Chr., Index Fil. 275. 1905.

Thelypteris levingei (C.B.Clarke) Ching, Bull. Fan Mem. Inst. Biol., Bot., 6(5): 273-274. 1936.

Type: INDIA. Jammu & Kashmir: Jhelum Valley, 1 Aug. 1875, *H.C. Levinge 27106* (lectotype: K-000951391! designated by Holttum, 1969).

Description. Plants 48–60 cm tall, rhizome long creeping, horizontal to suberect, hairy and scaly; fronds remote, stipe stramineous, hairy; leaves monomorphic, dying back in winter, clustered, laminae herbaceous, green, drying dark green, abaxially hairy, pinnate-pinnatifid, lanceolate, oblong, base slightly tapering, acuminate at apex; rachis diameter 2 mm, hairy, brownish; pinnae 6.5 × 1.4 cm, opposite, sessile, proximal pinnae smallest, lanceolate to triangular; veins hairy visible on both surfaces, lateral veins may be simple or forked. Sori round, submarginal, suborbicular, 3–7 pairs per pinnule, borne on middle of ultimate veins, indusiate, indusia yellow-reddish and hairy, sporangia having 1–3 hairs below annulus, spores monolete and elliptic.

Distribution and ecology. *Pseudophegopteris levingei* (C.B.Clarke) Ching is terrestrial near streams, moist and shady places at an elevation of 900–1800 m found infrequently, and is distributed in Asia (Afghanistan, Bhutan, China, India, Nepal, and Pakistan).

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: Jhelum valley, 23 Sep. 1875, *H. C. Levinge s.n.* herb *C. B. Clarke 27105* (K) • Rawalakot, 23 June 1876, *C. B. Clarke 31107* (K) • Muzaffarabad, 4 Oct. 1977, *Shahzad & Ayaz 875, 954, 1154, 1350, 1573* (ISL) • Sharda, Neelum, 20 June 1978, *Shahzad & Ayaz 1565* (ISL) • Muzaffarabad, 1 May 1990, *T. Mehmood & K. Hussain s.n.* (MUZU) • Neelam valley, 1 Jul. 1990, *M. R. Khan s.n.* (MUZU) • Neelam valley, 21 Jul. 1990, *N. Bano s.n.* (MUZU) • Pir chinasi, Muzaffarabad, 6 Sep. 1991, *T. Nakaike & S. Malik 807, 856, 863, 1134, 1137, 1140, 1226, 1302* (PMNH & TNS). **Gilgit-Baltistan:** Hunza valley, 4 Aug. 1886, *G. M. Giles 562* (DD). **Khyber Pakhtunkhwa:** Kaghan valley, Mansehra, 22 Aug. 1896, *Inayat & J. F. Duthie 20384* (K) • Siran valley, Mansehra, 2 Sep. 1896, *Inayat & J. F. Duthie 20435* (DD) • Chitral, 1 Sep. 1899, *S. A. Hariss s.n.* (DD) • Malam Jabba, Swat, 11 June 1947, *R. R. Stewart 23204* (K) • Kabal, Swat, 19 Aug. 1952, *R. R. Stewart 24573* (RAW) • Bishigram, Swat, 9 Jul. 1953, *R. R. Stewart & A. Rehman 24920* (RAW) • Lowari top to Dir, Chitral, 6 Aug. 1954, *M. A. Siddiqui & A. Rehman 26878* (RAW) • Buner, 19 Aug. 1955, *Sarwar 10* (PFI) • Nathya Gali, Abbottabad, 30 Jul. 1958, *R. R. Stewart 28695* (RAW) • Kaghan valley, Mansehra, 7 Sep. 1959, *M. A. Ali 486, 501* (PFI) • About 3-4 miles from Batakundi, between Naran and Batakundi, Kaghan valley, Mansehra, 31 Jul. 1961, *A. H. Sheikh 17290* (BM)

• Sharhan, Kaghan valley, Mansehra, 26 Aug. 1962, *A. H. Sheikh 17310* (BM) • Sharan forest, Mansehra, 20 Aug. 1964, *A. H. Zafar s.n.* (LAH) • Gabral valley, Swat, 4 Sep. 1975, *M. Shah & Manzoor 428* (ISL) • c. 1900 m, stream c. 2 km below Kalam, upper Swat valley, 1 Oct. 1978, *C. R. Fraser-Jenkins 7942, 7943* (BM) • Sharan forest, Mansehra, 5 Sep. 1979, *M. Zubair & Z. H. Shah 27* (ISL) • c. 2300 m, grassy ledges by stream coming down from south side of valley to join the main river, above entrance to Jalband valley, W.S.W. of Kalam, upper Swat valley, 14 Oct. 1990, *C. R. Fraser-Jenkins 16924* (BM) • Five km above and S. of Pursad, S.E. of Shishi, N.E. of Drosh, S. of Chitral town, Chitral, 28 Nov. 1991, *C. R. Fraser-Jenkins 18730* (BM).

Pseudophegopteris microstegia (Hook.) Ching subsp. *late-repens* (E.W.Trotter) Irfan & S.E. Fawc., **comb. nov.** Fig. 8 A–D.

Basionym: *Polypodium laterepens* E.W.Trotter, in Hope, J. Bombay Nat. Hist. Soc. 12(4): 628–633, t. 14. 1899.

Synonyms: *Dryopteris laterepens* (E.W.Trotter) C.Chr., Index Fil. 274. 1905.

Pseudophegopteris pyrhorhachis subsp. *laterepens* (E.W.Trotter) Fraser-Jenk., New Sp. Syndrome Indian Pteridol. 215. 1997.

Thelypteris pyrhorhachis subsp. *laterepens* (E.W.Trotter) Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 199. 2008.

Thelypteris microstegia (Hook.) Fraser-Jenk. subsp. *laterepens* (E.W.Trotter) Fraser-Jenk., Indian Checklist 1: 457. 2016.

Type: PAKISTAN. Khyber Pakhtunkhwa, Hazara division, Thandiani, Abbottabad district, 8500 ft., 12 Sep. 1890, *E. W. Trotter 523* (lectotype: NY-00127724! designated by Holttum, 1969).

Description. Plants 75–110 cm tall, rhizome long creeping, scaly, scales brownish, broadly lanceolate; fronds remote; stipe castaneous, 30–40 cm, base having sparse brown lanceolate scales; laminae 50–75 × 18–28 cm, herbaceous, green, both sides with small hairs on veins, pinnate-pinnatifid; rachis stramineous, adaxially grooved; pinnae 18–28 pairs, sub-opposite, spreading, proximal pinnae linear, 11–16 × 2–3 cm, base truncate, apex acute, pinnules 20–26 pairs per pinna, 1–1.5 × 0.5 cm, dentate, sparsely ciliate, obtuse at apex; veins visible abaxially, lateral veins forked, 6–7 pairs per pinnule. Sori orbicular, born on middle of acroscopic veins of lateral vein pair, sporangia glabrous, spores monoletic and elliptic.

Distribution and ecology. *Pseudophegopteris microstegia* (Hook.) Ching subsp. *laterepens* (E.W.Trotter) Fraser-Jenk. is terrestrial in moist temperate montane forests at an elevation of 1100–2000 m found abundantly, and is distributed in Asia (Bhutan, China, India, Nepal and Pakistan).

Specimens examined:

PAKISTAN. Azad Jammu and Kashmir: Poonch, 3 Jul. 1952, *R. R. Stewart & E. Nasir 24060* (RAW) • Chikkar, Jehlum valley, 24 May 1962, *R. R. Stewart 442* (RAW) • Muzaffarabad, 12 Jul. 1966, *Shahzad & Maqsood 684* (ISL) • Leepa valley, 5 Sep. 1969, *J. Muhammad s.n.* (RAW) • Muzaffarabad, 11 Oct. 1975, *M. N. Chaudhri, M. A. Siddiqui, Manzoor & Javid 21* (ISL) • Muzaffarabad, 4 Oct. 1977, *Shahzad & Ayaz 1407* (ISL) • Muzaffarabad, 21 June 1978, *Shahzad & Ayaz 1680* (ISL) • Muzaffarabad, 12 Sep. 1991, *M. Khan 25* (MUZU) • Sudhan Gali, Bagh, 14 Sep. 1991, *S. U. R. Kashmiri & R. Ayub s.n.* (MUZU) • Chikkar, Jehlum valley, 1 Oct. 1991, *S. U. R. Kashmiri & M. Khan 25* (MUZU). **Khyber Pakhtunkhwa:** Donga Gali, Abbottabad, 7 Aug. 1889, *E. W. Trotter 302* (RAW) • Nathya Gali, Abbottabad, 5 Sep. 1890, *E. W. Trotter 486* (RAW) • Thandiani, Abbottabad, 12 Sep. 1890, *E. W. Trotter 523* (K) • Siran valley, Mansehra, 26 June 1896, *Inayat & J. F. Duthie 20434* (DD) • Siran valley, Mansehra, 9 Jul. 1896, *Inayat & J. F. Duthie 20442* (CAL) • Kaghan valley, Mansehra, 12 Aug. 1896, *Inayat & J. F. Duthie 20437* (DD) • Siran valley, Mansehra, 10 Aug. 1896, *Inayat & J. F. Duthie 20438* (DD) • Jabbori, Siran valley, Mansehra, 25 Aug. 1899, *Inayat & J. F. Duthie 23236, 23237* (K) • Miandam, Swat, 15 Aug. 1952, *R. R. Stewart 24441* (RAW) • Bishigram, Swat, 11 Jul. 1953, *R. R. Stewart & A. Rehman 25016* (RAW) • Bahrain, Swat, 17 Aug. 1954, *R. R. Stewart 24485* (RAW) • Changla Gali, Abbottabad, 1 Jul. 1954, *R. R. Stewart 13995* (RAW) • Thandiani, Abbottabad, 5 Aug. 1956, *R. R. Stewart 27660* (RAW) • Nathya Gali, Abbottabad, 21 Jul. 1959, *R. R. Stewart 28920* (RAW) • Naran, Mansehra, 1 Aug. 1960, *A. H. Sheikh s.n.* (LAH) • Khaira Gali, Abbottabad, 13 Aug. 1977, *Saboor & Ayaz 758* (ISL) • One mile N.W. of Changla Gali, on road to Abbottabad, Murree to Abbottabad, Hazara Division, 8 Sep. 1989, *C. R. Fraser-Jenkins 15549* (BM) • Abbottabad, Mansehra and Swat, 16 Sep. 1991, *T. Nakaike & S. Malik 853, 909, 913, 917, 937, 958, 1016, 1018, 1049, 1066, 1147, 1190, 1272, 1360* (PMNH & TNS). **Punjab:** Murree hills, Rawalpindi, 1 Oct. 1944, *R. R. Stewart 21403* (K).

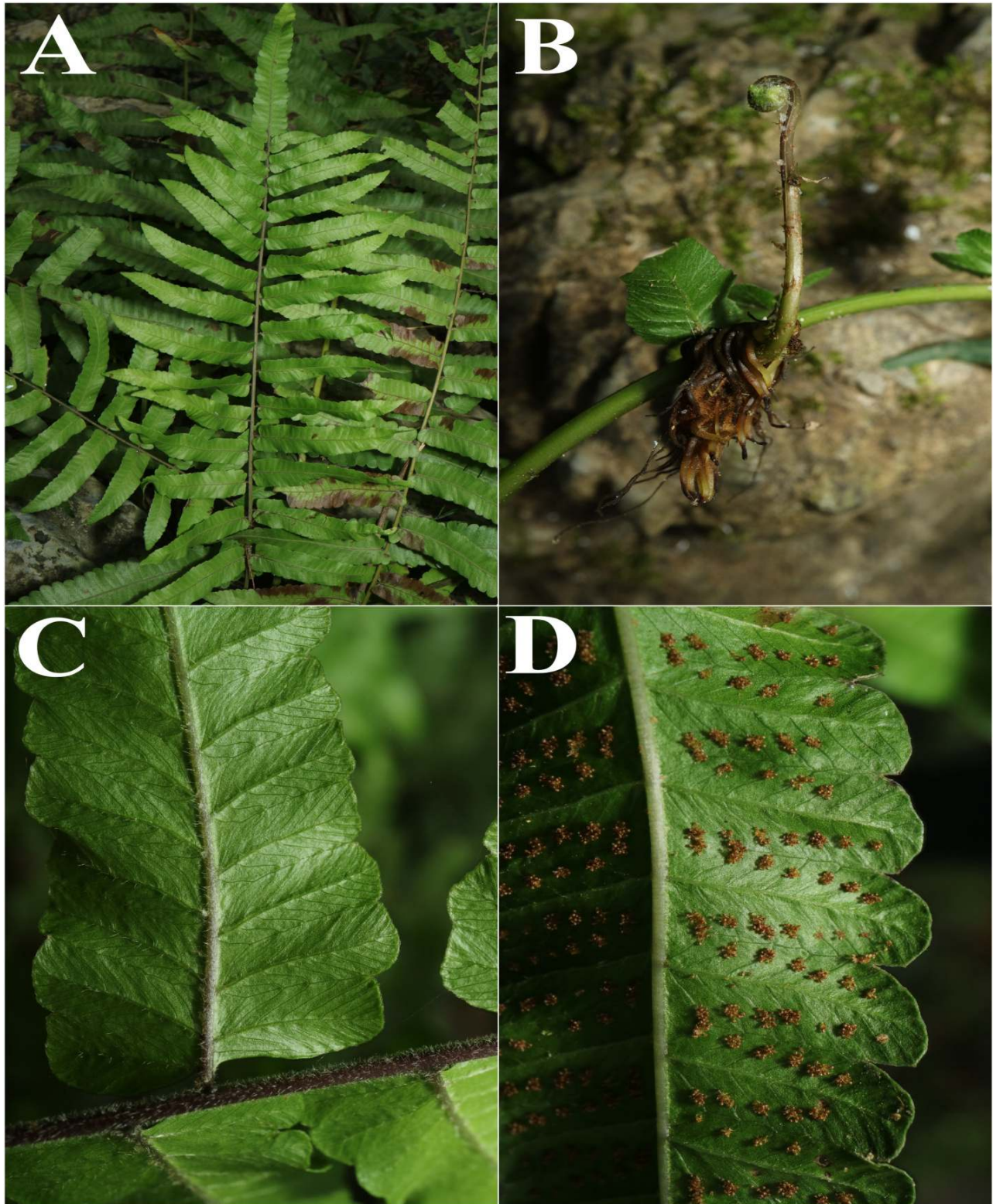


Fig. 1. *Ampelopteris prolifera* (Retz.) Copel. A. Habitat. B. circinate vernation of a new frond developing from proliferous bud. C. Abaxial surface of lateral pinnae showing costae, hairs and veins. D. Abaxial surface of lateral pinnae showing veins and sori.

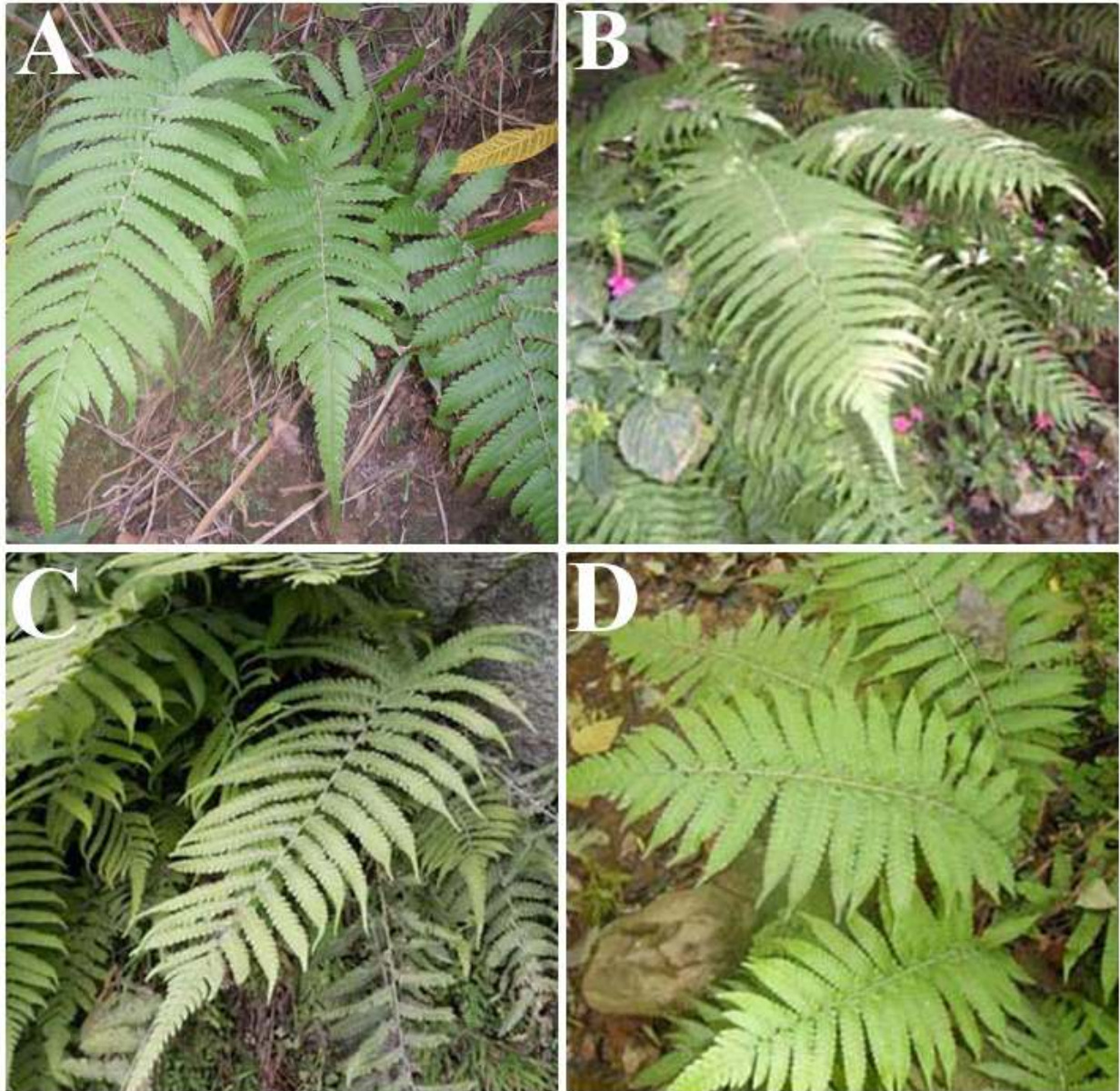


Fig. 2. *Christella dentata* (Forssk.) Brownsey & Jermy. A–D. Habitat

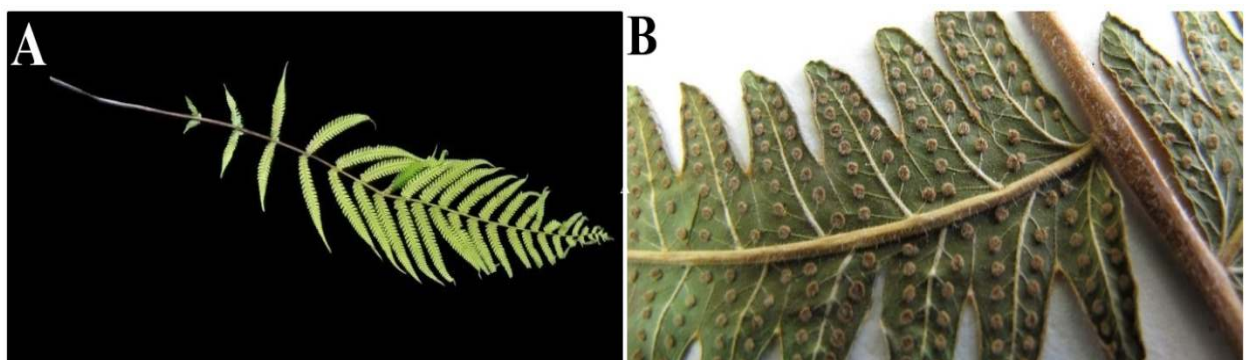


Fig. 3. *Christella multiauriculata* Punetha. A. Habitat, B. Abaxial surface of pinnae showing rachis, costae, veins and sori.

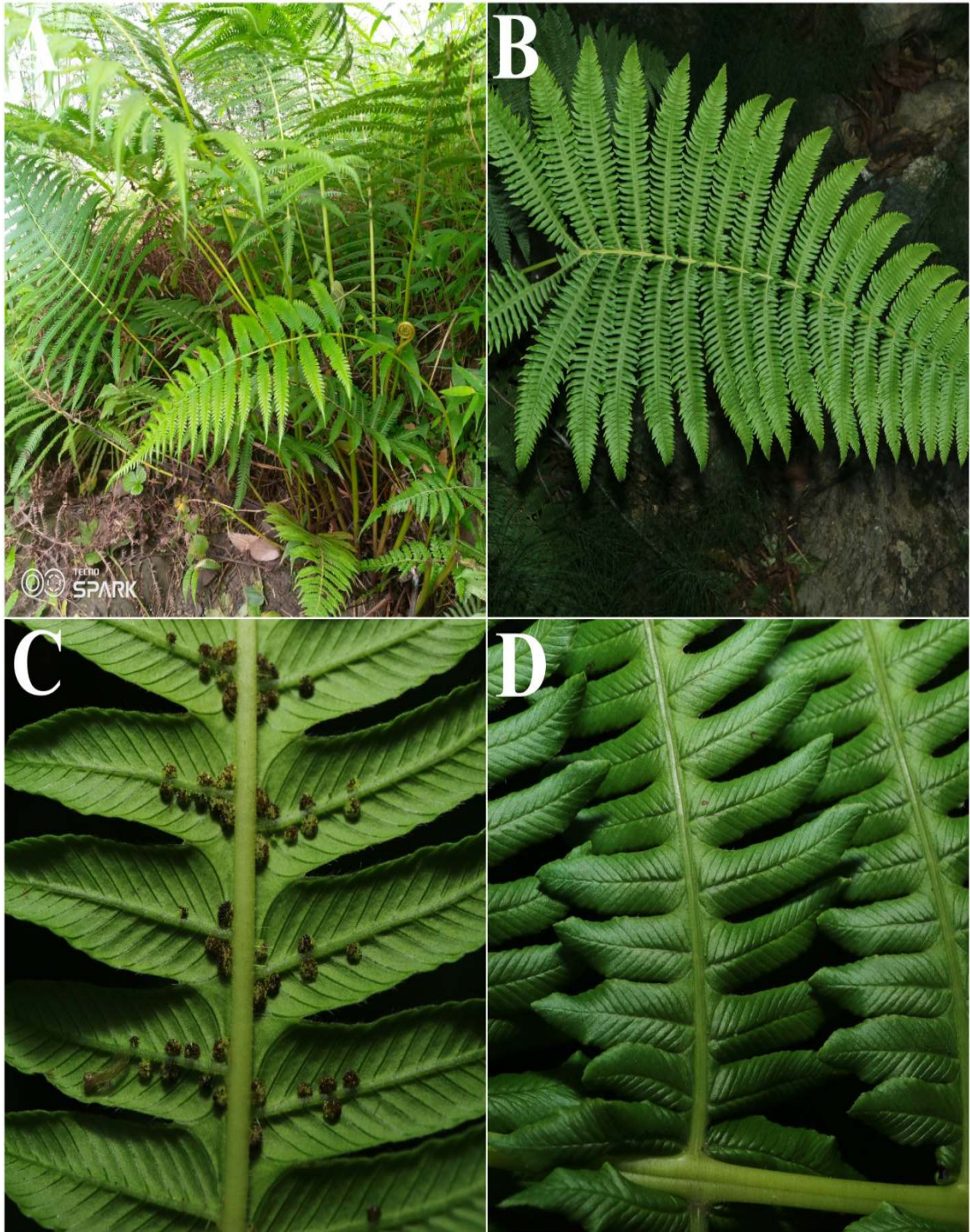


Fig. 4. *Glaphyopteridopsis erubescens* (Wall. ex Hook.) Ching A. Habitat. B. Adaxial surface of frond. C. Abaxial surface of pinnules showing costae, veins and sori. D. Adaxial surface of pinna showing rachis, costae and veins.

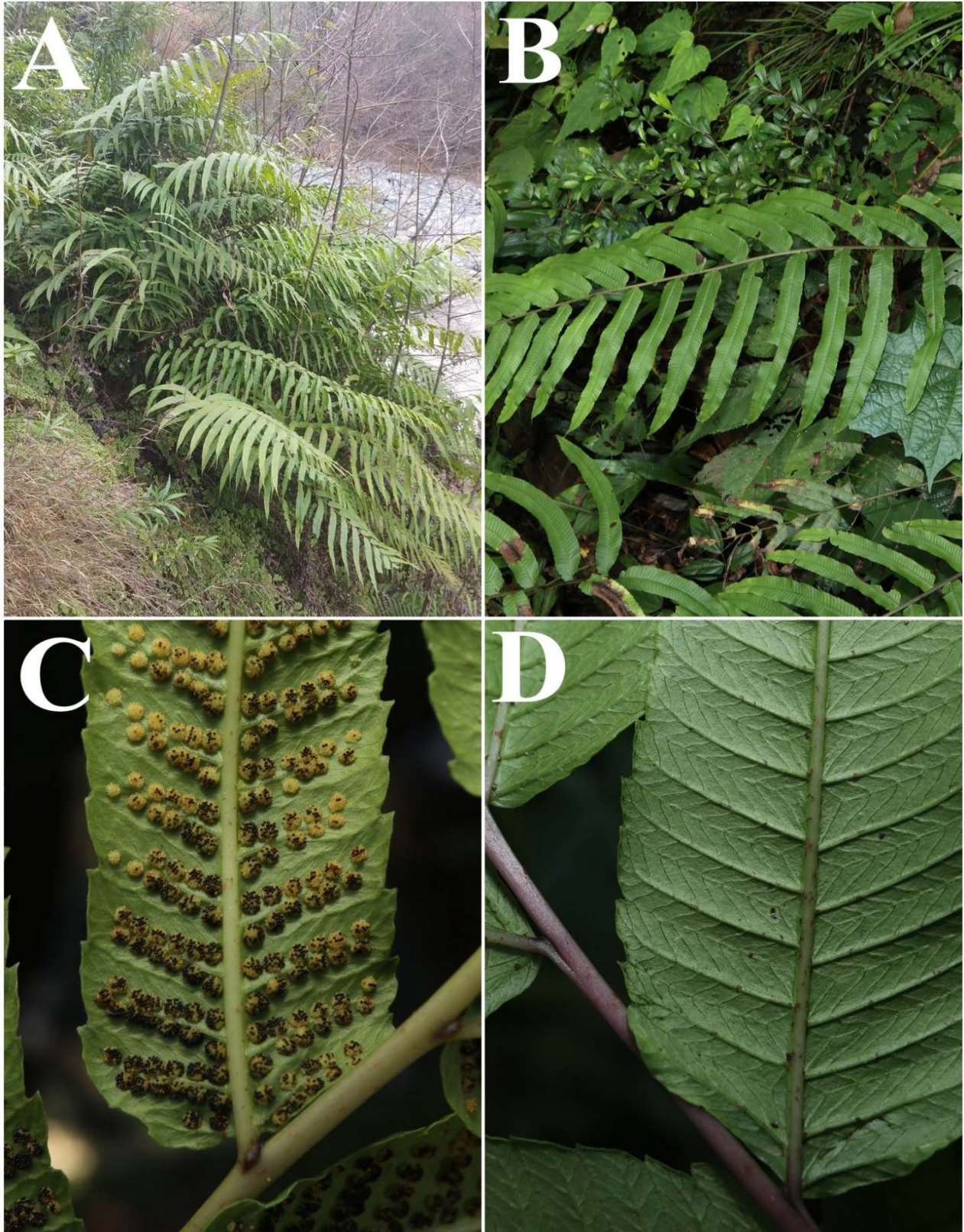


Fig. 5. *Menisciopsis penangiana* (Hooker) S.E. Fawc. & A.R. Sm. A. Habitat. B. Adaxial surface of frond. C. Abaxial surface of pinna showing rachis, costae, veins and sori. D. Abaxial surface of pinna showing rachis, costae and veins.

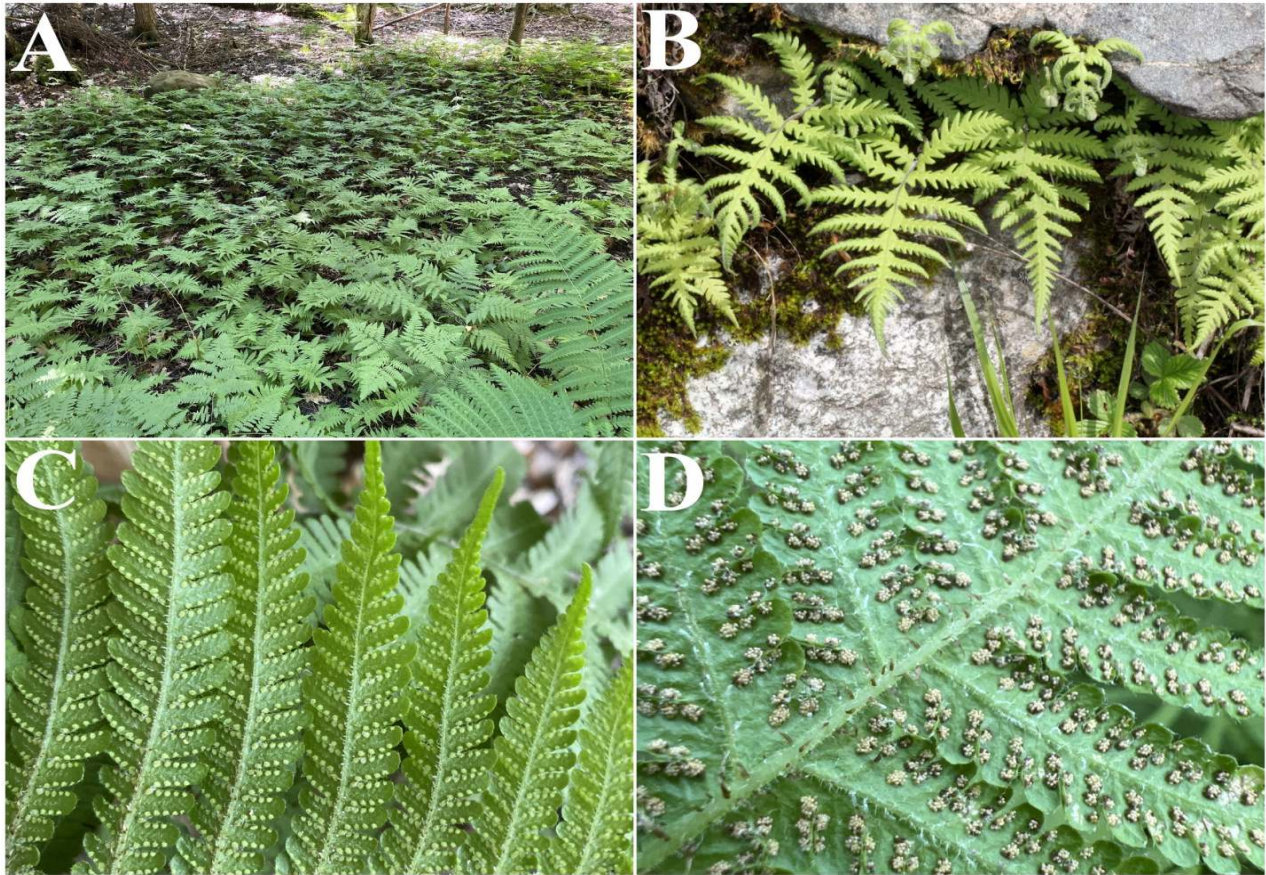


Fig. 6. *Phegopteris connectilis* (Michaux) Watt A & B. Habitat. C & D. abaxial surface of pinnae showing costae, veins and sori.



Fig. 7. *Pseudophegopteris levingei* (C.B. Clarke) Ching, A. Habitat. B. abaxial surface of pinnae showing costae, veins and sori.



Fig. 8. *Pseudophegopteris microstegia* subsp. *late-repens* (E.W.Trotter) Irfan & S.E. Fawc. A, B. Habitat. C, D. Abaxial surface of pinnae showing costae, veins and sori.

DISCUSSION

The Thelypteridaceae in the flora of Pakistan are predominantly of South East Asian and Sino Himalayan affinity, but also shares elements with Africa (e.g.,

Ampelopteris prolifera) and hosts a southern extension of a circumboreal taxon (*Phegopteris connectilis*). The diverse and varied climates of Pakistan host 168 taxa of lycophytes and ferns (Fraser-Jenkins 2014; Irfan *et al.* 2022a), many of these adapted to arid environments. The

Thelypteridaceae tends to be most diverse in humid, tropical montane areas, and its occurrence in Pakistan is limited to eight species, which correspond to those recognized in earlier studies (Stewart 1945, 1957, 1967, 1972, 1982; Fraser-Jenkins 1992, 2014). The species in Pakistan were previously collected by well known botanists mainly from the Himalayan range in Azad Jammu and Kashmir, Hazara and Malakand division, while some localities are still not explored. Fewer species occur in the Hindu-Kush and Karakorum ranges due to relatively low precipitation. Some interesting pteridophyte rich localities in Pakistan are Sharan Forest, Kagan valley, Saiful-Maluk Lake, Neelam valley, Kalam valley, Malam Jaba, Murree hills, Shahi and Binshahi, Hunza valley, Bara Gali, Nathiya Gali, Donga Gali, Meranjani, Gadoon valley and Shangla pass. Four species are shared with the Sino-Himalayan region, while two species have S.E. Asian affinities, and two species are cosmopolitan.

Most of these species are widespread, and their populations are globally stable, and not of conservation concern. Five species are collected infrequently, but *Glaphyopteridopsis erubescens* is common, and *Christella dentata* is abundant. In contrast, *Christella multiauriculata* is rare and localized, and may be of conservation concern. The lack of digitized specimens from Pakistan has made it a challenging group to study. For example, only three specimens of Thelypteridaceae from Pakistan were available in GBIF as of Oct. 24, 2022, necessitating visits to herbaria to examine specimens in person. Our hope is that providing a key, detailed description of species and fine-scale distribution records will facilitate exploration and discovery of biodiversity in Pakistan.

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