INTERNATIONAL JOURNAL OF APPLIED AND EXPERIMENTAL BIOLOGY
(ISSN PRINT: 2790-6523; ISSN ONLINE: 2790-6531)
2024, Vol. 3, NO. 2, 239-252
doi: 10.56612/ijaaeb.v1i1.63
https://eminentscientists.com/

Taxonomic investigation of monilophytes from North Waziristan Tribal District KP, Pakistan

Tariq Aziz[1*], Alia Gul[1], Jan Alam[1]

[1]Department of Botany, Hazara University, Mansehra, Pakistan

Abstract

Floristic surveys and assessment of relationships between species richness and elevational gradients help in developing more efficient conserving strategies for biodiversity under climate change. North Waziristan Tribal District (NWD) has been identified as the second largest district in FATA. The study area encompasses diverse altitudes, ranging from 600 m to over 3000 m. Due to its distinct geological history, low temperature, and rich biodiversity, the North Waziristan Tribal District gives an excellent opportunity to assess taxonomic distribution of ferns. Field visits were conducted during 2021, thoroughly documenting fern species along with essential field-related characteristics such as habits, habitats, GPS coordinates, etc. Floristic studies of ferns (monilophytes) from NWD showed that it has an exceptionally diverse monilophyte flora. A total of 114 fern specimens were collected during these field visits. After a comprehensive examination, 17 species distributed across 13 genera and 7 families were identified. The predominant family was Pteridaceae, comprising six species, followed by Aspleniaceae and Thelypteridaceae with three species each. Additionally, Dryopteridaceae accounted for two species, while the remaining three had only one species each. *Asplenium* was the leading genus, documented with three species, followed by *Pteris*, *Cheilanthes*, and *Adiantum*, each with two species. Finally, a dichotomous key was made based on morphological, anatomical, and palynological characters for identification and characterization purposes. In terms of altitude, the highest number of taxa was observed at elevations above 2200 m, while the lowest species count was reported between 600 -1000 m. Species richness of ferns reached to a maximum at moderate elevations, which could have been due to combination of moderately low temperature and high humidity. Ethnobotanical documentation revealed eight species, six genera, and four families within the study area.

ARTICLE TYPE
Research Paper (RP)

SECTION
Plant Biology (PB)

HANDLING EDITOR
Athar, H.R. (CE, BP)

ARTICLE HISTORY
Received: 10 Mar, 2023
Accepted: 02 Feb, 2024
Published: 04 Jul, 2024

KEYWORDS
Aspleniaceae;
Ferns;
Floristic survey;
Monilophytes;
Pteridaceae;
Sporangium

Introduction

Vascular plants, reproducing by spores rather than seeds are known as pteridophytes. Pteridophytes had been classified into lycophytes (fern allies) and monilophytes (ferns) (Smith, 2006). Approximately, 12000 species of pteridophytes are documented from various regions of the world (Chapman, 2009), and Hassler and Swale (2001) prepared a list of 12838 taxa of pteridophytes. Joseph et al. (2015) documented 10000 taxa and 305 genera from the world, while 1000 taxa and 191 genera of pteridophytes from India.

Totally, 133 taxa, 41 genera and 9 families of pteridophytes were reported from West Pakistan and Kashmir (Stewart, 1972), representing approximately four percent diversity of vascular plants

***CONTACT** Tariq Aziz, tariqbot2018@gmail.com, Department of Botany, Hazara University Mansehra, Pakistan

TO CITE THIS ARTICLE: Aziz, T., Gul, A., Alam J. (2024). Taxonomic investigation of monilophytes from North Waziristan Tribal District KP, Pakistan. *International Journal of Applied and Experimental Biology* 3(2): 239-252.

(Mehltreter, 2010). A checklist of 82 taxa, 30 genera and 18 families of ferns were documented from Pakistan (Nakaike and Malik, 1993). Gul et al. (2017) published a checklist of 19 families, 62 genera and 202 taxa of ferns from Pakistan. The dominant family was Dryopteridaceae, followed by Pteridaceae. Thirty six taxa of monilophytes were reported from Punjab, Pakistan. Dryopteridaceae was the leading family with seven taxa (Sundas et al., 2012). Sixteen species of pteridophytes were taxonomically and ethnobotanically documented from Utror Valley Swat (Attaullah et al., 2019).

Most of ferns are used for various purposes (medicinal, ornamental, food, etc.), making them important components of the flora, ecosystems, and biodiversity in various areas (Uddin et al., 2008; Sarker and Hossain, 2009). Fifty one species and 28 families of ferns were documented for medicinal purposes from Arunachal Pradesh, India (Benniamin, 2011). Ferns have been familiar as food in Asian countries for centuries. Fifty edible ferns were reported from India and Athyriaceae was the leading family followed by Dryopteridaceae (Giri and Uniyal, 2022). Economically, monilophytes are noted as the important group of pteridophytes due to their medicinal value, but unfortunately, most of the plants are threatened in Pakistan due to loss of habitat (Khan, 2017).

Ferns are an important group of land plants to study due to several reasons including their potential role in ecosystem, distinct ability to transport water and nutrients over long distances within plant body, and their use as medicine, etc. In Pakistan, angiosperms and gymnosperms are well studied and documented in Flora of Pakistan. However, ferns have received considerably poor attention particularly for taxonomic studies in Pakistan. Floristic surveys are an important part of primary taxonomy to document biodiversity and devise conservation strategies. Thus, we present here the results of surveys conducted for exploring ferns in North Wazirstan Tribal District with a unique landscape and topography.

Materials and Methods

Study area

North Waziristan Agency (NWA) used to be the former name of North Waziristan Tribal District (NWTD), which is located to the West and South West of KP, Pakistan. It covers an area of around 4706 km^2 and is divided into three sub-divisions (Mirali, Miranshah and Razmak) and nine tehsils. The capital of the study area is Miranshah. NWTD is generally mountainous, situated at latitudes 32°-35´ and 33°-20' N and 70°-40´ E. Coniferous and scrub forests cover an area of approximately 50,960 ha in NWTD. Champion et al. (1996) documented that Razmak and Shawal valley totally fall under the dry temperate forest. Mughal et al. (2008) noted 0.5 m to 1.5 m of snow and 75 mm of rainfall in the mountains of Razmak and Shawal. The maximum rainfall occurs between June and September, while snowfall is generally reported between January and April. According to Ali and Qaiser (1986), Shawal valley is entirely located in the Sino -Japanese Region (**Figure 1**).

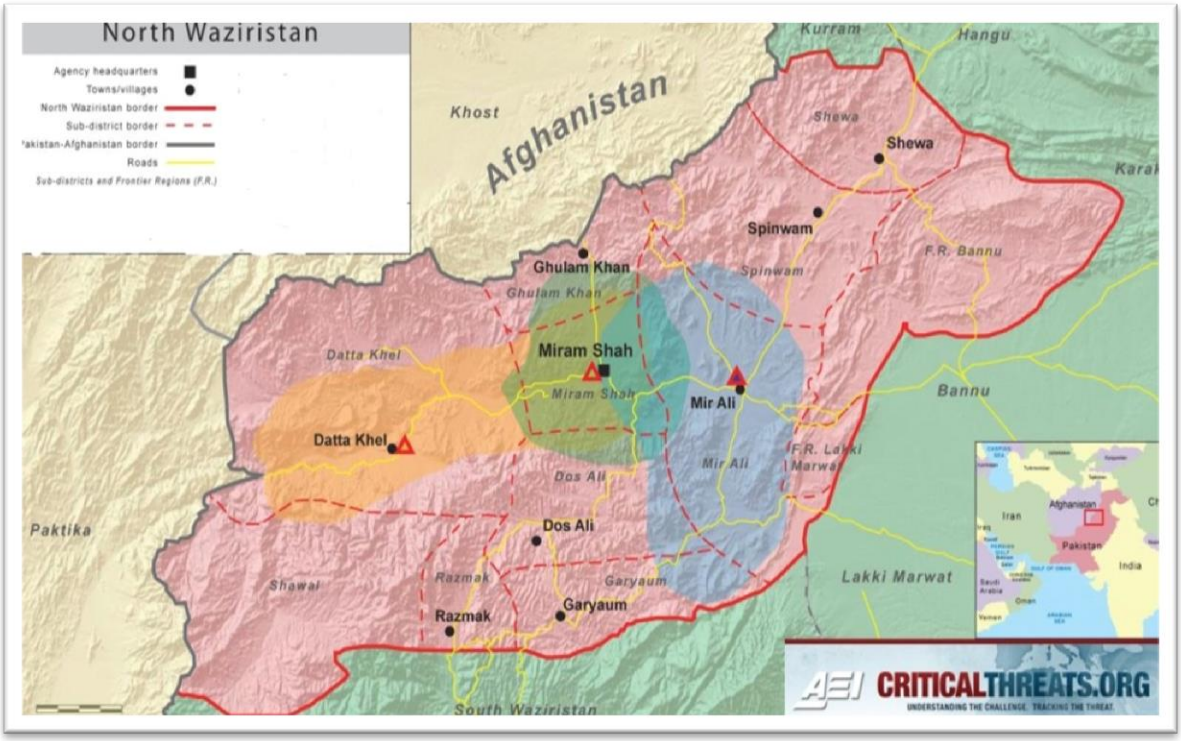

Figure 1. Map of the study area (North Waziristan Tribal District KP, Pakistan)

Field trips to various areas of NWTD were arranged for ferns collection. Epiphytes were collected from fallen trees or tree branches, or up to 2 m on tree trunks. Permits for collection were obtained from the Forest Department, KP, Pakistan. All details related to the field visits were noted in the field notebook and assigned a number to each collected fern specimen. Habitat pictures were captured using a Canon camera with a 55-250 mm lens. The collected specimens were pressed properly in the newspapers (Hyland, 1972). After pressing, the specimens were treated with plant preservation solution (10 g phenolic crystals, 10 g copper sulphate, and 2 g mercuric chloride dissolved in 2.5 L ethanol). After treatment of the preservation solution, each specimen was mounted on strandard herbarium sheets (length x width; 17.5 cm x 11.5 cm). Labels were pasted in the right corner of each herbarium sheet which contained all related information, including botanical name, habit, habitat, sporangium and spore shape. The larger species such as *Pteris vittata* were mounted in the forms of V, W and M (Iremonger, 1995).

For the proper identification of each specimen, morphological, antomical and palynological characters were examined. Various morphological characters, such as size and shape of lamina, pinnae and pinnules, scales and rhizome were studied using a stereo-microscope with a lens (55 -275 mm) and a microscopic scale. During the anatomical study, the rachis of each specimen was cut transversely. It was then stained with safranin to focus on the stele of the rachis. During palynological study, the size and shape of spores and sporangia was examined. The arrangement of spores in each sporangium was also noted. Photographs of each character were taken using an Optika camera fixed on a stereo-microscope or light microscope (Bhutta and Sadiq, 1987). All pictures of each species were arranged in a photo-plate using the Adobe Photoshop. Subsequently, the captured photos were matched with the web pages of various international herbaria (K, BM and P) (Haque et al., 2016).

For proper identification and characterization, various research articles, book chapters and flora were also consulted (Lowe, 1872; Beddome, 1866; 1873; 1883; Moore, 1859; 1860; Hooker and Baker, 1874; Hoshizaki and Moran, 2001; Tryon and Tryon, 1982; Rodin, 1960; Stewart, 1972; Nakaike and Malik, 1993; Fraser-Jenkins, 2008). After correct identification, the families, genera in each family and taxa in each genus were arranged alphabetically. The identified specimens were deposited in the Herbarium of Botany Department, Hazara University, Mansehra (HUP) KP, Pakistan, for reference and further studies.

Results and Discussion

During the taxonomic investigation of monilophytes of District North Waziristan Tribal District (ex - FATA), KP, Pakistan, a total of 114 specimens were collected during various field visits at different stages from January to December of 2021, the description of which is presented in **Table 1**. During the field visits, information related to habitat, habit, GPS value etc. was collected. Ethnobotanical information was also collected using a proper questionnaire. The collected specimens were deposited in the Herbarium of Department of Botany, Hazara University, Mansehra, KPK, Pakistan for reference and future studies. After proper identification of each specimen using various characters of morphology, anatomy and palynology, 17 fern species, 13 genera and six families were correctly identified. Pteridaceae was the largest family, having six species, followed by Aspleniaceae with three species. While *Asplenium* was reported as the largest genus having three taxa.

Family: Aspleniaceae

Asplenium adiantum-nigrum L., published in Sp. Pl. : 1081 (1753)

Plants 14-25 cm tall; rhizome usually erect, scales at apex and entire scaly. Fronds generally papery; stipe long 6-18 cm; hair-like scales; lamina tri-pinnate with acute-acuminate apex and hairy; pinnae alternate, 6-12 pairs, lower pair largest; pinnules usually oblong or elliptic oblong, with 3-8 pairs, sessile or small stalk; glabrous costa and rachis; veins forked or simple, anadromously branched; sori linear, 1-4 pairs on each pinna, with white or brown indusial. Spores' color brown (**Figure 2**).

Asplenium dalhousiae Hook., Icon. Pl. 2: t.105 (1837)

Plant 11-22 cm tall. Rhizome unbranched, short, erect, with dark (brown) scales. Frond length 13-24 cm, glabrous, papery, with small 1-2 cm stipe; blade 9-18 cm length, lanceolate, pinnatipartite, narrow at base, apex obtuse while base tapered; pinnae 9-15 pairs, elliptic to lanceolate, base gradually tapered, margin entire. Rachis not grooved, glabrous; scales lanceolate and of brown color; veins free but forked at margin. Sori 3-6 at every segment, indusiate; indusia color brown, linear, membranous. Spore color brown (**Figure 3**).

Table 1. Species description

FAM	Species	Altitude	Distribution	Medicinal value	Way of use
ASP	*Asplenium adiantum - nigrum* L.	1600 - 1930 m	Razmak and adjoining area	Diarrhea	Fronds used orally
	Asplenium dalhousiae Hook.	1061 - 2230 m	Razmak and Datta Khel	Hepatitis and gonorrhea	Used orally after boiling the rhizome
	Asplenium tripteropus Nakai	2462 m	Shawal	Nil	Nil
CYS	*Cystopteris fragilis* L.	2253 - 2290 m	Razmak and adjoining area	Stomach and injuries	Decoction of fronds for washing of injured parts
DRY	*Cyrtomium muticum* (Christ) Ching	1054 - 1056 m	Datta Khel	Nil	Nil
	Polystichum neolobatum Nakai	2250 - 2686 m	Razmak	Infertility	Rhizome in powder form
EQU	*Equisetum ramosissimum* Desf.	674 - 1115 m	Mirali, Miranshah, Spinwam and Shawa	Skin infection, bone fracture, female infertility	Plant extract derived after grinding
MRA	*Marsilea quadrifolia* L.	695 -714 m	Spinwam and Shawa	Nil	Nil
PTE	*Adiantum capillus-veneris L.*	660 - 2240 m	Found all over the study area	Diabetes, cough, scorpion bite	Fresh juice of frond used orally
	Adiantum incisum Forssk.	1250 - 1280 m	Razmak and Adjoining area	Skin diseases and falling of hairs	Fresh juice used orally
	Cheilanthes rufa D.Don	2208 m	Shawal	Nil	Nil
	Pteris vittata L.	1003 - 2030 m	Datta Khel and Razmak	Nil	Nil
	Pteris cretica L.	975 - 1019 m	Razmak and Adjoining area	Healing of wounds	Extract is pasted on wounds
	Pellaea nitidula (Wall. ex Hook.) Bak.	1050 - 2270 m	Datta Khel and Razmak	Nil	Nil
THE	*Pseudophegopteris levingei* (C.B.Clarke) Ching	1090 m	Razmak	Nil	Nil
	Christella dentata (Forssk.) Brownsey & Jermy	1125 - 1133 m	Razmak	Nil	Nil
	Phegopteris connectilis (Michx.) Watt	2530 m	Shawal	Nil	Nil

FAM (Families): ASP = Aspleniaceae; CYS = Cystopteridaceae; Dry = Dryopteridaceae; EQU = Equisetaceae; MRA = Marsileaceae; PTE = Pteridaceae; THE = Thelypteridaceae

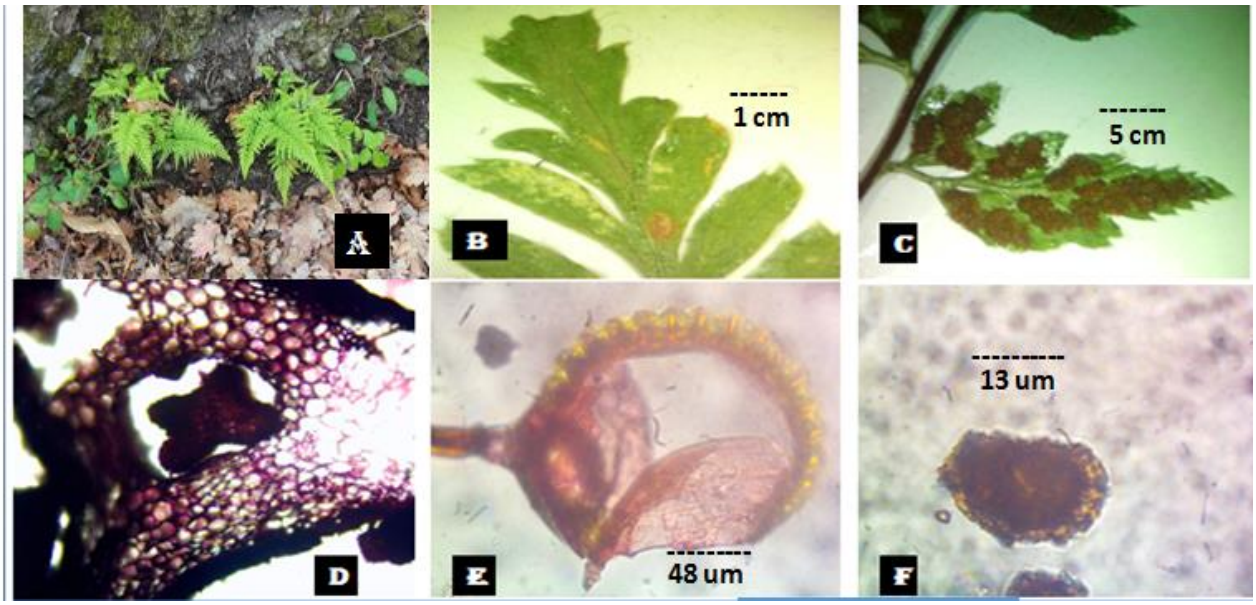

Figure 2. *Asplenium adiantum-nigrum:* A. Habitat, B. Adaxial surface of frond, C. Sori arrangement, D. Rachis anatomy, E. Sporangium, F. Spore

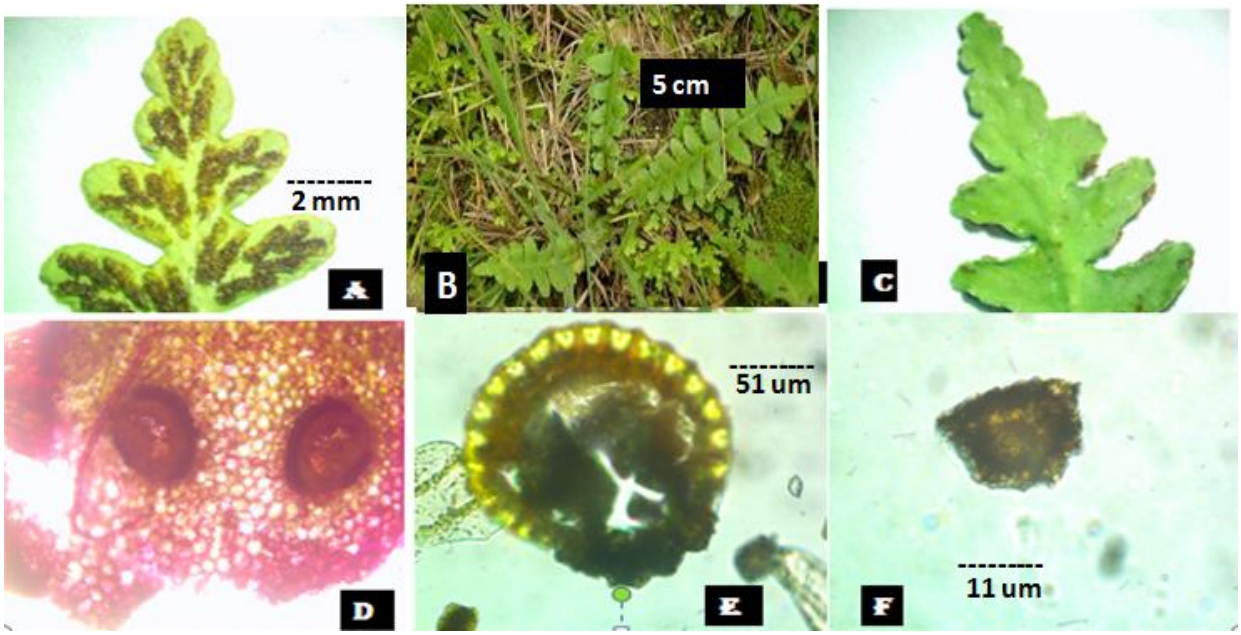

Figure 3. ***Asplenium dalhousiae:*** **A. Arrangement of sori, B. Habitat, C. Adaxial surface of frond, D. Rachis anatomy, E. Sporangium, F. Spore**

Asplenium tripteropus Nakai, Bot. Mag. (Tokyo) 44: 9 (1930)

Plants 15-28 cm tall. Rhizome short, erect, having scales at apex; Fronds have brown to black stipe, with terete base, rachis persistent; lamina linear; pinnae sessile, sub-opposite to alternate, many pairs (21-35), asymmetrical at base, crenate at margin, obtuse apex; Veins forked, single, pinnate; rachis sub-glabrous, shiny, stout; Sori linear, 3-6 on each pinna, indusiate; indusia membranous, entire, semi-elliptic, opening toward costa.

Family: Cystopteridaceae

Cystopteris fragilis L. Neues J. Bot. 1(2): 27 (1806)

Plant medium size. Rhizome creeping and short, hair absent, lanceolate scales at apex. Fronds monomorphic, stipe at base, length 5-13 cm; lamina bipinnate-bipinnatifid, lanceolate-elliptic; pinnae 10-13 pairs, glabrous, ovate-lanceolate, toothed at apex; pinnules 3-6 pairs, sessile; veins free. Sori 2-4 pairs at each pinnule, orbicular, indusiate; indusia thin membranous and brownish. Spore echinate, monolete, and of dark brown color (**Figure 4**).

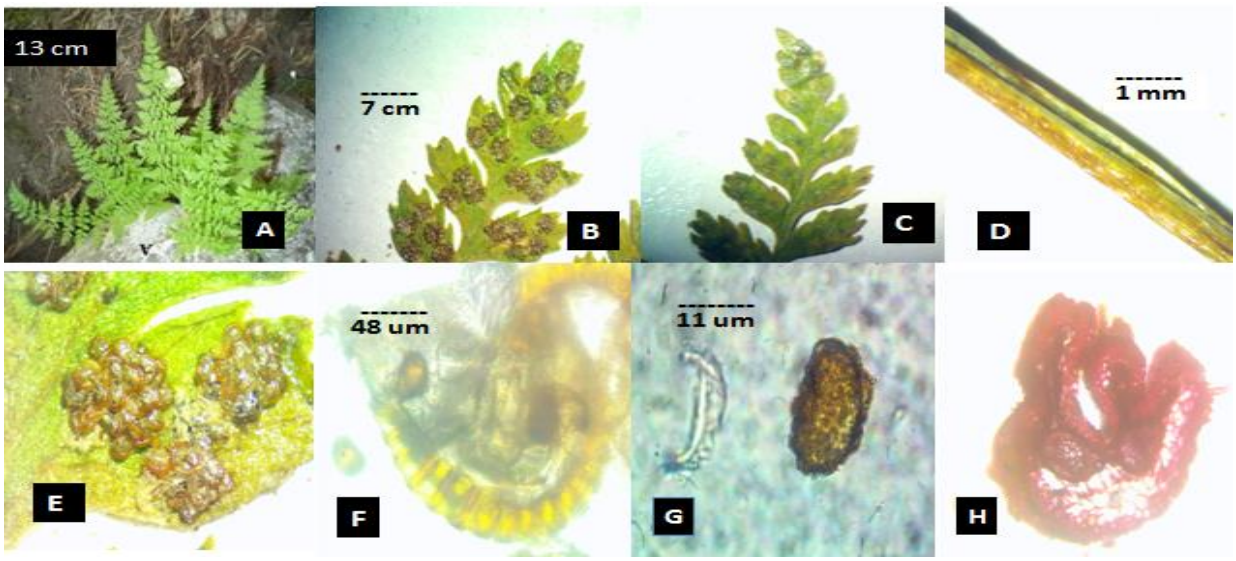

Figure 4. ***Cystopteris fragilis:*** **A. Habitat, B & C. Abaxial & adaxial surface of fronds, D. Rachis, E. Sori, F. Sporangia, G. Spore, H. Rachis anatomy**

Family: Dryopteridaceae

Cyrtomium muticum (Christ) Ching in C. Christensen Index Filic., Suppl. 3: 66. (1933)

Plant 48 cm tall. Rhizome erect, having lanceolate scales with 3-4 mm stramineous stipe. Lamina imparipinnate, oblong-lanceolate, apex obtuse; linear scales at rachis. Lateral pinnae 6-9 pairs, ascendant, little stalked, ovate usually, margin undulate, apex caudate; Terminal pinnae ovate mostly, forked, abaxially covered with small scales, while glabrous adaxially; Sori present abaxially; indusia present and are entire (**Figure 5**).

Polystichum neolobatum Nakai, Bot. Mag. (Tokyo) 39: 118. (1925)

Plant size medium, evergreen. Rhizome erect, scaly; scales color brown, lanceolate. Frond length 57 cm, brown color ovate scales at base, and stramineous stipe. Lamina length 28-55 cm, round-cuneate, apex acuminate; rachis scaly, proliferous bulbils absent; pinnae pairs 22-27, average length 2-8 cm, alternate, ascendant rarely, stalk short; pinnules pairs 5-12, alternate, approximate, margin entire, ovate-lanceolate; Sori indusiate, rows present on both sides of midrib (**Figure 6**).

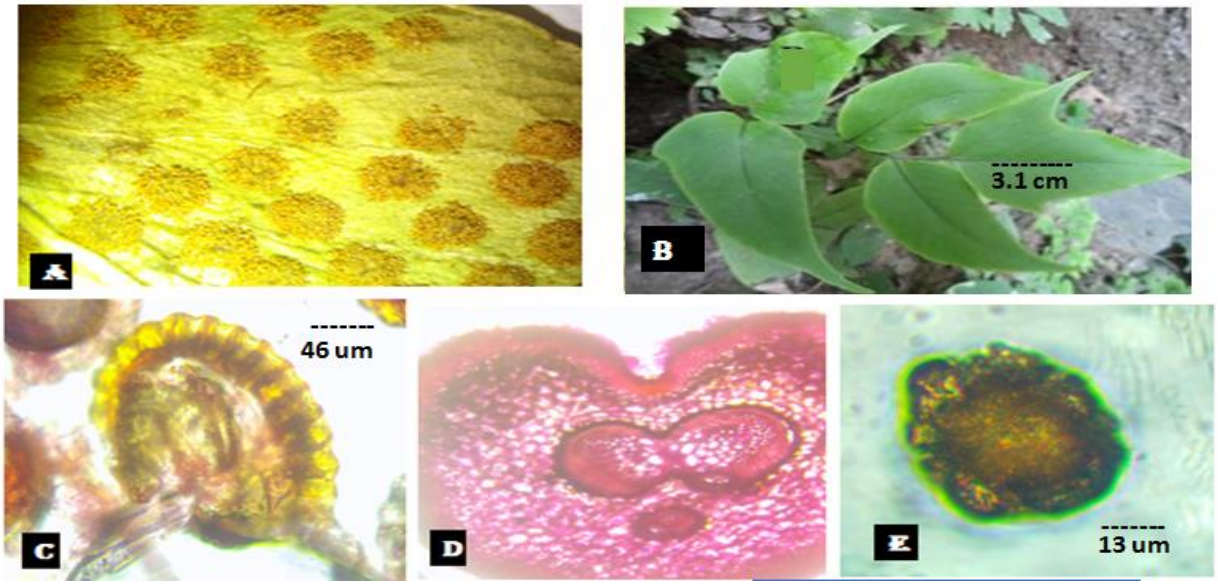

Figure 5. ***Cyrtomium muticum:*** **A. Arrangement of Sori, B. Habitat, C. Sporangium, D. Rachis anatomy, E. Spore**

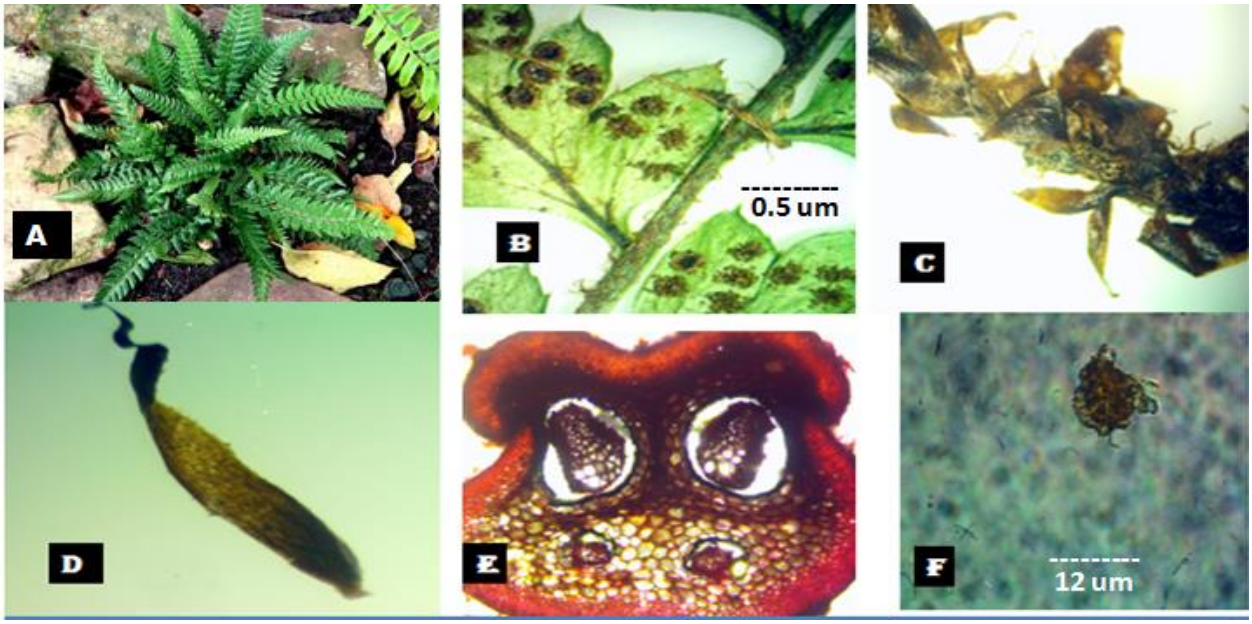

Figure 6. ***Polystichum neolobatum:*** **A. Habitat, B. Arrangement of sori, C. Scales arrangement, D. Scales morphology, E. Rachis anatomy, F. Spore**

Family: Equisetaceae

Equisetum ramosissimum Desf., Fl. Atlant. 2: 398 (1799)

Plant size average. Rhizome color black, vertical, 3 to 6 mm whorl root at nodes; Main stem perennial, 35 to 65 cm length, 2 to 5 cm diameter, monomorphic, branched, grooved, 8 to 13 branches at node, internodes 2 to 8 cm long. Leaves scaly, oblong, fused through nodal sheath, length 8 to 12 mm, width 7 mm. Strobilus ellipsoid, length 0.7 to 2.6 cm, width 0.3 to 0.6 cm, apex acute and sessile (**Figure 7**).

Family: Marsiliaceae

Marsilea quadrifolia L., Sp. Pl. 2: 1099. (1753)

Rhizomes 22 -28 cm long, creeping, internode length 3.5—4.6 cm, petiolate, petiole about 12 cm long, glabrous, roots usually arise from nodes. Pinnae length 1.4 cm, about 1.2 cm broad, usually entire but rarely crenate, color green, four in number, fan shaped, arising from stipe. Sporocarp oval -elliptic shaped occurring on stalk, branched, ascending, length 4.5 mm, thickness 2.4 mm (**Figure 8**).

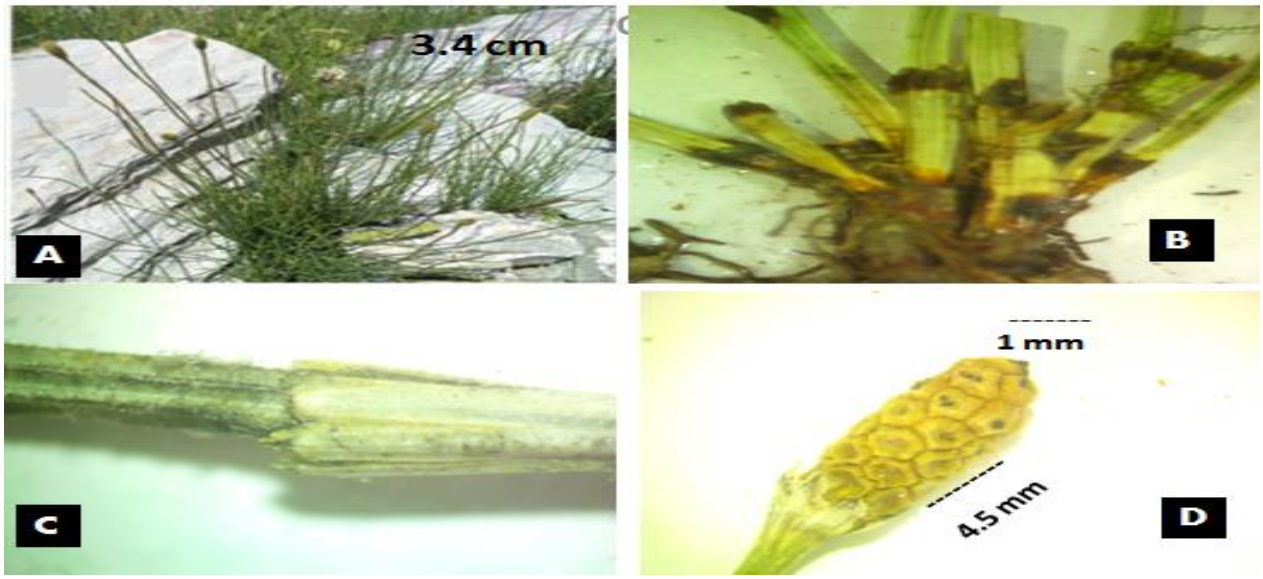

Figure 7. ***Equisetum ramosissimum:*** **A. Habitat, B. Rhizome, C. Node and Internode, D. Strobili**

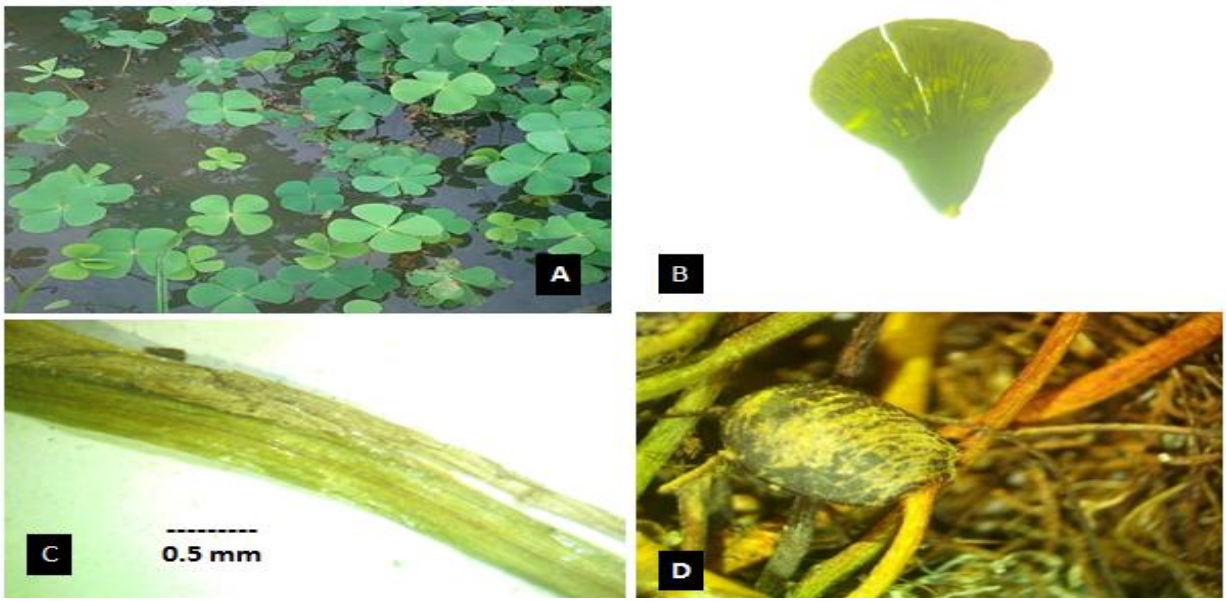

Figure 8. ***Marselia quadrifolia:*** **A. Habitat, B. Pinna, C. Rachis, D. Sporocarp**

Family: Pteridaceae

Adiantum capillus-veneris L., Sp. Pl. 2: 1096. (1753)

Plant size small-medium, usually terrestrial. Rhizome thin, branched, short, creeping, scaly; scales small, brown, margin entire; stipes black, length 4-18 cm, glabrous with scaly base. Frond length 23-53 cm, pendant, cluster loosely; lamina herbaceous, length about 32.5 cm, above center uni-pinnate, below center bi-pinnate, color brown-green, triangular, acute apex and cuneate base; pinnae alternate occurring 5-11 at each side of blade; pinnules obovate, stalked, lobed apical margin occurring 5 at each pinna; Veins dichotomously forked. Sori 2-11 at each pinna, tip cover with lobes, indusiate; indusia entire, persistent, membranous; spore trilete, with 44 µm diameter (**Figure 9**).

Adiantum incisum Forssk., Sp. Pl. 2: 1096. (1753)

Rhizome erect or creeping, short about 9 mm, lanceolate scales, margin pale with brown color. Fronds tufted, remote, monomorphic, membranous -herbaceous; stipe black-dark brown, rarely shiny, with several reddish long hairs, having brown and linear scales. Blade pinnate-bipinnate, linear to lanceolate, with cuneate base; pinnae alternate, about 20 pairs, few larger basal pinnae, sessile or rarely small petiole, apex and base are of reduced size as compared to center; veins usually prominent, dichotomously forked, closely reaching to margins. Sori 2-5 on each pinnule, green, circular -oblong, indusiate; indusia false, orbicular or reniform (**Figure 10**).

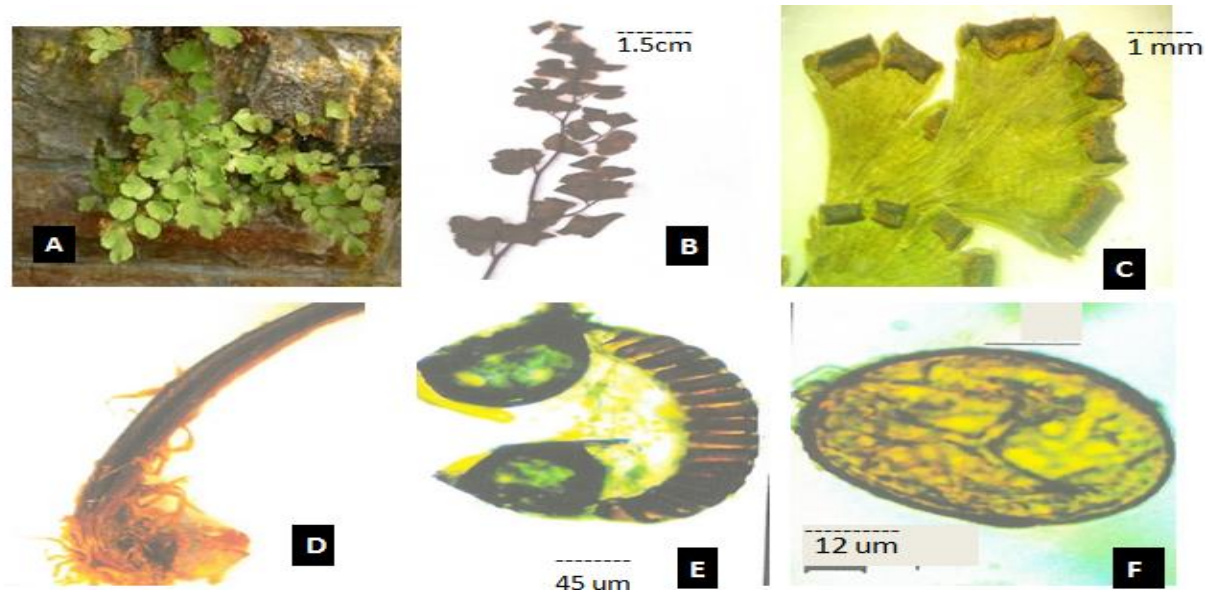

Figure 9. ***Adiantum capillus-veneris:*** **A. Habitat, B. Frond, C. False indisum, D. Rachis, E. Sporangium, F. Spore**

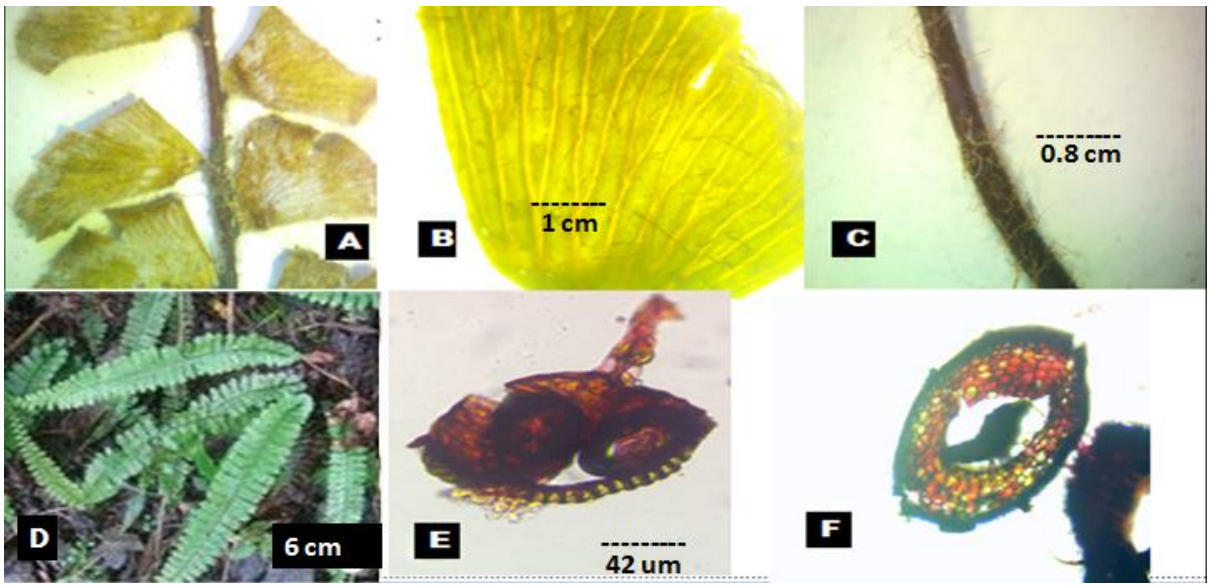

Figure 10. ***Adiantum incisum:*** **A. Arrangement of pinnae, B. Pinna, C. Rachis, D. Habitat, E. Sporangium, F. Rachis anatomy**

Cheilanthes rufa D. Don, Prodr. Fl. Nepal. 16. (1825)

Rhizome short, erect and tiny; scales bi-colorous, blackish, margins brown, narrowly lanceolate. Fronds grouped, black or brown black stipe, mostly smaller than blade, usually scaly and hairy; scales lanceolate-hairlike, orange brownish color. Blade oblong, pinnate to pinnatifid, papery or herbaceous when dried, abaxially hairs and scales; scales linear to lanceolate, adaxially multi-cellular hairs, costae, rachis and stipe have similar scales; pinnae 3-10 pairs, sessile, sub-opposite, opposite, oblong triangular or oblong lanceolate basal pinnae, pinnatifid; adjacent acroscopic pinnules shorter than basal ones. Sori with few-many sporangia. Indusia false, having fimbriate margin (**Figure 11**).

Pteris vittata L., Sp. Pl. 2: 1074. (1753)

Plant size more than 45 cm. Stem color yellowish, erect, small, creeping, scaly; scales usually brown or yellow color. Fronds occur in groups; rachis color straw and scaly; stipe straw or brownish color, rigid, diameter above 25 mm long, scaly; Lamina whitish green, oblanceolate to oblong at outline, single pinnate, glabrous, leathery; lower pinnae sessile, base and apex of pinnae short as compared to that of the middle pinnae; mid vein straw color, forked or simple; scales at rachis. Sori narrow (**Figure 12**).

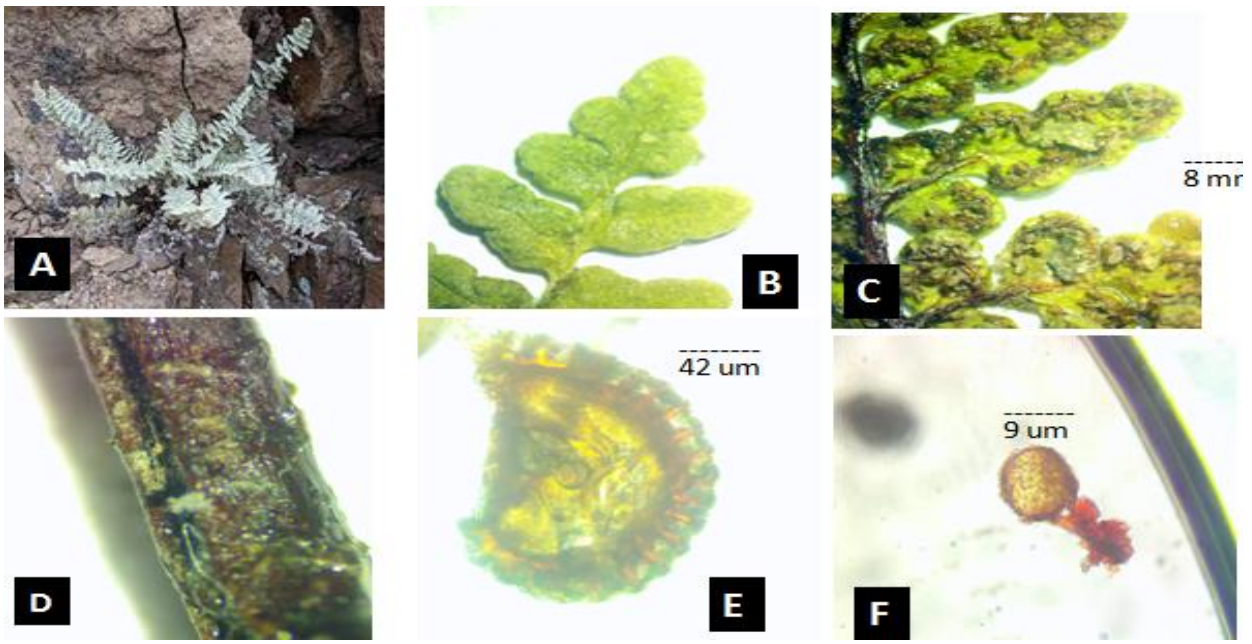

Figure 11. ***Cheilanthes rufa:*** **A. Habitat, B. Adaxial surface of frond, C. Abaxial surface of frond, D. Rachis, E. Sporangia, F. Spore**

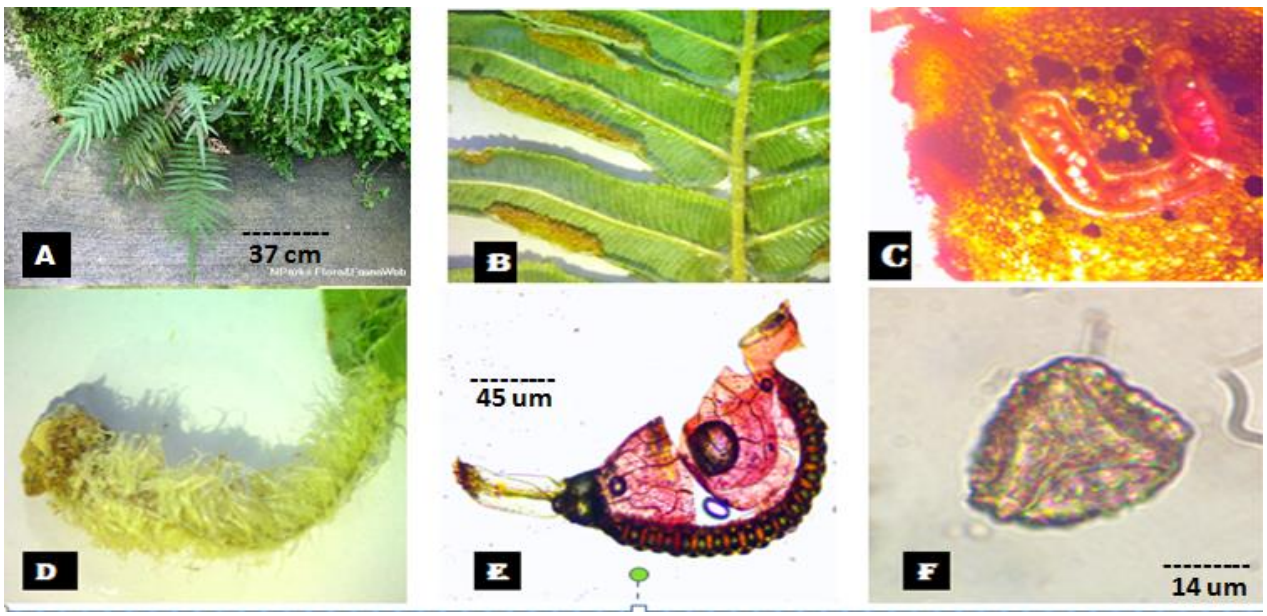

Figure 12. ***Pteris vittata:*** **A. Habitat, B. Abaxial surface of pinnae, C. Rachis anatomy, D. Hairs on the rachis base, E. Sporangium, F. Spore**

Pteris cretica L. Mant. Pl. 1: 130. (1767)

Plants 16-23 cm size. Rhizome slender, ascending or creeping, with brown scales at apex. Fronds clustered, dimorphic-subdimorphic; stipe glabrous, straw, distally brownish, proximally dark color, 13-40 cm, scales at base. Blade ovate, uni-pinnate or rarely digitate, no wings on rachis, rachis has terminal decurrent pinna; rachis adaxially not grooved, without hairs, pinnae 1-3 pairs, separate from each other, rarely opposite, decumbent, stalk short or sessile, lanceolate or narrowly lanceolate upper pinnae, rarely basiscopic lobe, serrate or cartilaginous margins, cuneate at base, while acuminate apex. Fertile fronds long, spiny to serrate, decumbent, small stalk, linear upper pinnae, rarely having pinnules latterly, opposite or alternate upperly, glabrous, narrow as compared to sterile ones; acroscopic acute, decurrently basiscopic. Veins forked or simple at base, free; sori narrow (**Figure 13**).

Pellaea nitidula (Wall. ex Hook.) Bak. Sp. Fil. 2: 112. (1852)

Rhizome short, ascending-erect, rarely creeping branches; scales broad or narrow, bicolorous, dark brown color with light brown margins, subulate to lanceolate. Leaves spaced or clustered, numerous. Stipe bicolorous, dark brown or nearly black, linear to subulate-lanceolate close to base, scales with single cell, short, red brown, sometimes adaxial. Blade oblong to oblong deltoid, both surfaces glabrous, bipinnate-pinnatifid, green brown when dried; caudate or blunt apex; rachis hairy and dark brown. Pinnae sessile or sometimes sub-sessile, 3-5 pairs; base pair long, deltoid, 1.9 cm diameter; pinnules spaced, 3-6 basal pairs, oblong, adnate-costae; enlarged basiscopic pinnules, basiscopic larger than acroscopic pinnules, pinnatifid, having 4-7 pairs of lanceolate-deltoid segments, more pinnules linear or lanceolate while some lobed to entire, obtuse apex. Sori confluent, not interrupted at sinuses or segment tips. False indusia continuous, membranous, brown, margins irregularly erose to dentate, usually ciliate (**Figure 14**).

Family: Thelypteridaceae

Pseudophegopteris levingei (C.B.Clarke) Ching, Acta Phytotax. Sin. 8(4): 314 (1963)

Plant about 40 cm in length. Rhizome long, creeping, hairs and scales at rhizome; Scale colour brownish, broad, lanceolate. Frond length 24 cm, remote, stipe stramineous, proximal end having scales; lamina colour dark green after drying, herbaceous, hairs on abaxial surface, pinnate, lanceolate, slightly taper base, acuminate apex; pinnules with broad base, obtuse apex, opposite. Veins forked, 4 to 6 each pinnules. Sori oblong (**Figure 15**).

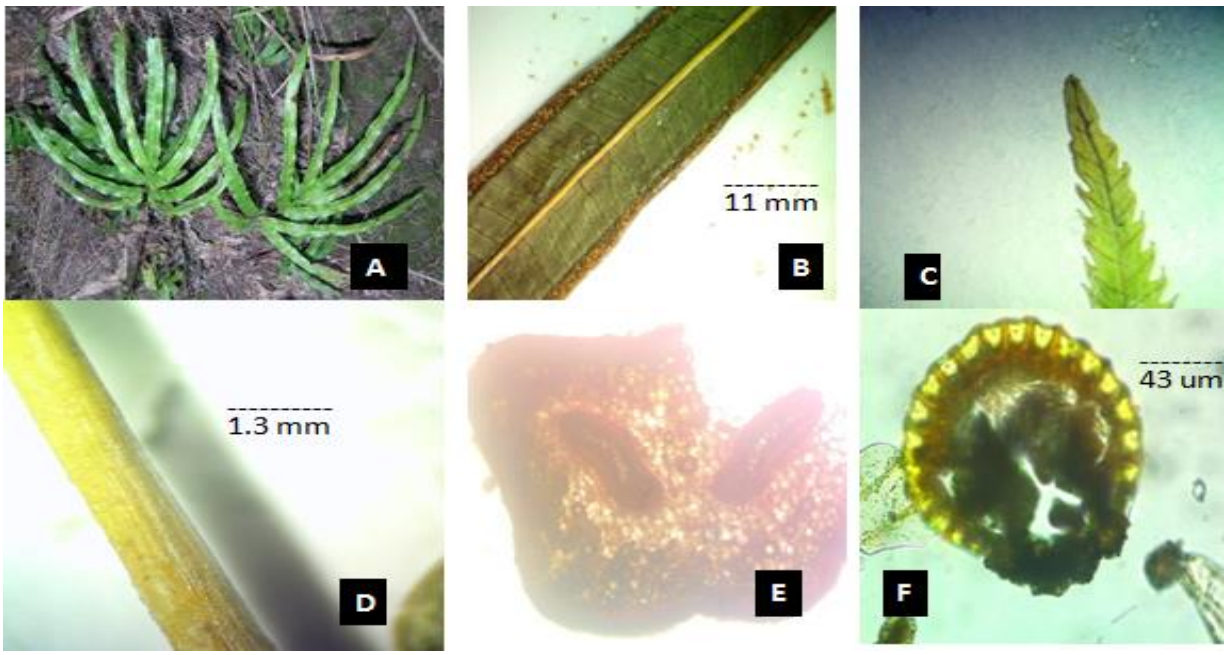

Figure 13. *Pteris cretica*: A. Habitat, B. Abaxial surface of pinnae, C. Tips of fronds, D. Rachis, E. Rachis anatomy, F. Sporangia

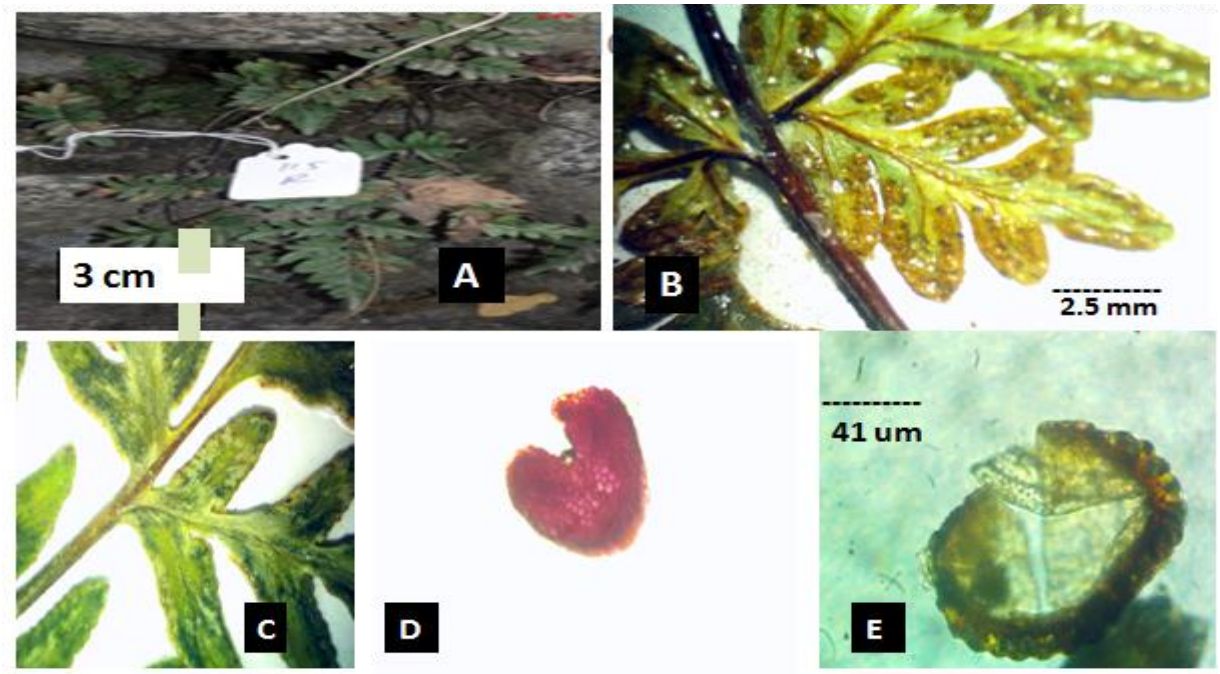

Figure 14. ***Pellaea nitidula:*** **A. Habitat, B. Sori arrangement, C. Adaxial surface of pinna, D. Rachis anatomy, E. Sporangium**

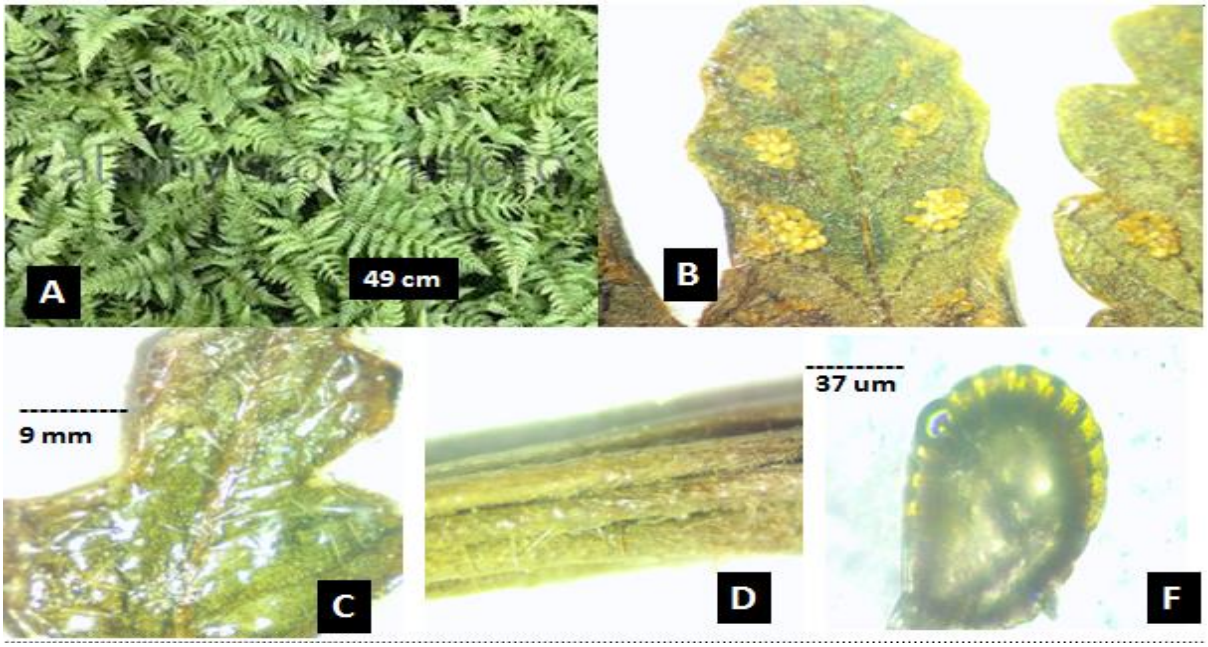

Figure 15. ***Pseudophegopteris levingei:*** **A. Habitat, B. Sori arrangement, C. Adaxial surface of pinna, D. Rachis, F. Spore**

*Christella dentata (*Forssk.) Brownsey & Jermy, Brit. Fern Gaz. 10: 338 (1973)

Plants 45 cm in length. Rhizome creeping to sub-erect, short, scales linear to lanceolate. Fronds stramineous and dark brown at base. Lamina length 10 -21 cm, 8-19 pairs of pinnae laterally, herbaceous to papery, hairs short adaxially, 11-19 cm, base narrow, apex acuminate, mostly oblong, base acroscopic. Veins proximally anastomosing, 5-8 pairs at each segment. Sori orbicular, medial. Sporangia glandular. Spore colour brown, irregularly cristate (**Figure 16**).

Phegopteris connectilis (Michx.) Watt, Canad. Naturalist Geol. n.s., 3(2): 159 (1867)

Plants 23 -38 cm tall. Stem 1-3 mm long, ovate to lanceolate, creeping, colour brown, scales at apex. Fronds monomorphic, di-pinnatifid, petiole colour straw, lanceolate scales, usually glabrous margins, black brown base of stipe. Blade mostly long, dentate narrowly, stramineous distally, smooth or sparse scales, base taper rarely, pinnae sessile, segments oblong, margin usually entire; lower pinnae gradually short, wing triangular. Veins pinnate, usually simple. Sori mostly orbicular, borne near margin; sporangia hairy.

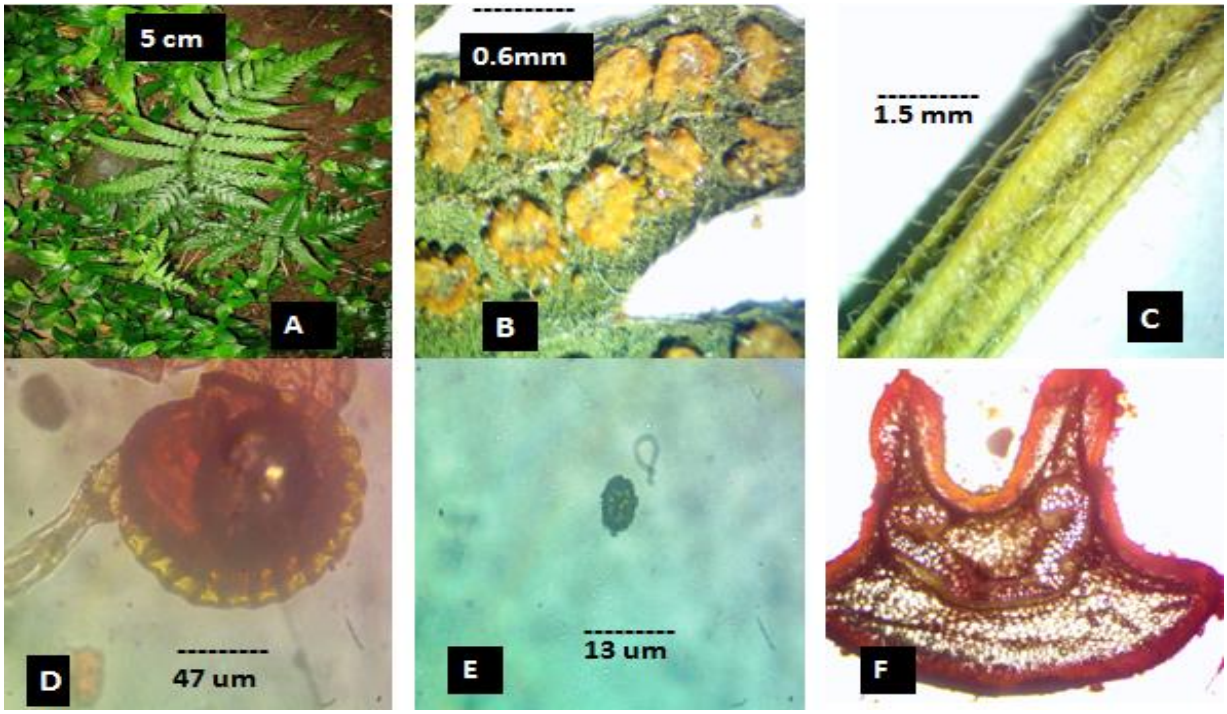

Figure 16. ***Christella dentate:*** **A. Habitat, B. Abaxial surface of pinnae, C. Rachis, D. Sporangium, E. Spore, H. Rachis anatomy**

Author(s), Editor(s) and Publisher's declarations

Acknowledgement
The current study was funded by the IFS project [1-3-F-6135-1] and Higher Education commission ,National Research Programme for Universities Pakistan [No: Ref No. 20-14667/NRPU/R&D/HEC/2021 2021].

Conflict of interest
The authors declare no conflict of interest.

Source of funding
None declared.

Contribution of authors
Conceptualization and designing of the study: TA, AG, JA. Conduction of research and collection of data: TA, AG. Written first draft of the manuscript: TA, AG. Helped to prepare figures and tables: TA, AG, JA. Final draft reviewed and read by all authors.

Ethical approval
This study does not involve human/animal subjects, and thus no ethical approval is needed.

Handling of bio -hazardous materials
The authors certify that all experimental materials were handled with care during collection and experimental procedures. After completion of the experiment, all materials were properly discarded to minimize/eliminate any types of bio-contamination(s).

Availability of primary data and materials
As per editorial policy, experimental materials, primary data, or software codes are not submitted to the publisher. These are available with the corresponding author and/or with other author(s) as declared by the corresponding author of this manuscript.

Authors' consent
All contributors have critically read this manuscript and agreed for publishing in IJAaEB.

Disclaimer/editors'/publisher's declaration

All claims/results/prototypes included in this manuscript are exclusively those of the authors and do not inevitably express those of their affiliated organizations/enterprises, or those of the publisher/journal management, and the editors/reviewers. Any product mentioned in this manuscript, or claim rendered by its manufacturer, is not certified by the publisher/Journal management. The journal management disown responsibility for any injury to organisms including humans, animals and plants or property resulting from any ideas/opinions, protocols/methods, guidelines or products included in the publication. The IJAaEB publisher/Management stays impartial/neutral pertaining to institutional affiliations and jurisdictional claims in maps included in the manuscript.

Declaration of generative AI and AI -assisted technologies in the writing process

It is declared that we the authors did not use any AI tools or AI-assisted services in the preparation, analysis, or creation of this manuscript submitted for publication in the International Journal of Applied and Experimental Biology (IJAaEB).

References

Abercrombie III, C.L., Davidson, D., Hope, C.A., Scott, D.E. (1980). Status of Morelet's crocodile *Crocodylus moreleti* in Belize. *Biological Conservation* 17(2):103-113.

Ali, S.I., Qaiser, M. (1986). A phytogeographical analysis of the phanerogams of Pakistan and Kashmir. *Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences* 89:89-101.

Attaullah, A., Khan, Z.U.D., Midrarullah, A. (2019). Taxonomic studies of pteridophytes of Utror valley, district Swat, Khyber Pakhtunkhwa, Pakistan. *Pakistan Journal of Botany* 52(6):2059-2065.

Beddome, R.H. (1870). "The Ferns of British India: Being Figures and Descriptions of Ferns from All Parts of British India (exclusive of Those Figured in The Ferns of Southern India and Ceylon)*",* 1st edn. Gantz Brothers, Adelphi Press, India.

Beddome, R.H. (1873). "The Ferns of South India: Being Descriptions and Plates of the Ferns of the Madras Presidency," 2nd edn. Higginbotham and Company, India.

Beddome, R.H. (1883). "Handbook to the Ferns of British India, Ceylon and the Malay Peninsula: with Supplement," Thacker, Spink and Company, India.

Benniamin, A. (2011). "Medicinal Ferns of North Eastern India with Special Reference to Arunachal Pradesh," NISCAIR-CSIR, India.

Bhutta, A.A., Sadiq, A. (1987). A modified technique to study the xylem of plants or plant organs. *Bulletin of. The Palaeobotany and. Palynology Club of Pakistan* 1:43-45.

Champion, S.H., Seth, S.K., Khattak, G.M. (1965). "Forest Types of Pakistan". Pakistan Forest Institute, Peshawar, Pakistan.

Chapman, A.D. (2009). "Numbers of Living Species in Australia and the World," 2nd edn. Report for the Australian Biological Resources Study, Canberra, Australia.

Fraser-Jenkins, C.R. (2008). "Three Hundred Indian Subcontinental Pteridophytes with a Revised Census List". Bishen Singh Mahendra Pal Singh. Dehra Dun.

Giri, P., Uniyal, P.L. (2022). Edible ferns in India and their medicinal uses: A review. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences* 92(1):17-25.

Gul, A., Alam, J., Majid, A., Ahmad, H., Qaiser, M. (2017). Diversity and distribution patterns in the Pteridophyte flora of Pakistan and Azad Kashmir. *Pakistan Journal of Botany* 49:83-88.

Haque, A.K., Khan, S.A., Uddin, S.N., Rahim, M.A. (2016). Taxonomic checklist of the pteridophytes of Rajkandi Reserve Forest, Moulvibazar, Bangladesh. *Jahangirnagar University Journal of Biological Sciences* 5(2):27-40.

Hassler, M., Swale, B. (2001). "World Fern Statistics by Country". http://homepages.caverock.net.nz/~bj/fern/ferndist.htm

Hooker, W.J., Baker, J.G. (1874). "Synopsis Filicum; or A Synopsis of All Known Ferns Including Osmundaceae, Schizaeaceae, Marattiaceae and Ophioglossaceae," 2nd edn. Wyman and Sons Printers, London.

Hoshizaki, B.J., Moran, R.C. (2001). "Fern's Grower Manual," Revised and expanded edition. Timber Press, Portland, USA.

Hyland, B.P. (1972). A technique for collecting botanical specimens in rain forest. *Flora Malesiana Bulletin* 26(1):2038-2040.

Iremonger, S., Liesner, R., Sayre, R. (1995). Plant records from natural forest communities in the Bladen Nature Reserve, Maya Mountains, Belize. *Caribbean Journal of Science* 31(1-2):30-48.

Joseph, J.M., Thomas, B., Rajendran, A., Prabhu Kumar, K.M. (2015). Medicinal chasmophytes of Urumbikkara Hills, Idukki district, Kerala, India. *Asian Journal of Pharmaceutical Science & Technology* 5(1):11-17.

Khan, Z.U.D. (2017). Taxonomic and ethnobotanic study of pteridophytes of Miandam valley, District Swat, Khyber Pakhtunkhwa, Pakistan. *International Journal of Biosciences* 10(3):72-79.

Lowe, F.J. (1872). "Ferns: British and Exotic. Vol. I. Gymnogramma, Nothochlaena, Niphobolus, Polypodium". George Bell & Sons, London.

Mehltreter, K. (2010). *Fern conservation*. *In* "Fern Ecology" (K. Mehltreter, L.R. Walker, J.M. Sharpe, eds.). pp. 323-359. Cambridge University Press, Cambridge.

Moore, T. (1859). "British Ferns Being Figures and Description of the Species and Varieties of Ferns Found in the United Kingdom," Vol. I., Bradbury and Evans, London.

Moore, T. (1860). "British Ferns Being Figures and Description of the Species and Varieties of Ferns Found in the United Kingdom," Vol. II. Bradbury and Evans, London.

Mughal, M.S., Wazir R.R., Muhammad Muslim, C.H. (2008). Synecological study of coniferous forest of Shawal in North Waziristan Agency. *The Pakistan Journal of Forestry* 58(2):94-100.

Nakaike, T., Malik, S. (1993). A list of pteridophytes collected from Pakistan in 1991. *Cryptogamic Flora of Pakistan* 2:317-359.

Nasir, E., Ali, S.I. (1971-1991). "Flora of West Pakistan No. 1- 190". Pakistan Agriculture Research Council, Islamabad, Pakistan.

Rodin, R.J. (1960). Ferns of the Sierra (Yosemite: Yosemite Natural History Association, 1960). *Published as Yosemite Nature Notes*.39(4):45-124. https://www.jstor.org/stable/1546482

Sarker, S.K., Hossain, A.E. (2009). Pteridophytes of greater Mymensingh district of Bangladesh used as vegetables and medicines. *Bangladesh Journal of Plant Taxonomy* 16(1):47-56.

Smith, A.R., Pryer, K.M., Schuettpelz, E., Korall, P., Schneider, H. et al. (2006). A classification for extant ferns. *Taxon* 3:705-731.

Stewart, R.R. (1972). An annotated catalogue of the vascular plants of West Pakistan and Kashmir. *Flora of West Pakistan* 12(17):1-24.

Sundas, I., Zaheer, U.D.K., Noreen, R. (2012). A contribution to the taxonomic study of fern flora of Punjab, Pakistan. *Pakistan Journal of Botany* 44(Suppl. 1):315-322.

Tryon, R.M., Tryon, A.F. (1982). "Ferns and Allied Plants with Special Reference to Tropical America". Spring-Verlag New York.

Uddin, S.B., Rahman, M.A., Uddin, M.G., Pasha, M.K. (2008). Ethno-botanical uses of Pteridophytes from Chittagong Hill Tracts of Bangladesh. *Nepal Journal of Plant Science* 2(1):89-93.