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Research Article

Floristic, morpho-anatomical and ethnobotanical study of pteridophyte flora of Dalkajhar Forest, West Bengal, India

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Abstract

Dalkajhar forest is very important diverse forest landscape in Terai region of Darjeeling district of West bengal. Our study shows diverse pteridophyte flora comprising of 16 species, 12 genera and 9 families in this forest.This study area is largely dominated by family Pteridaceae and Polypodiaceae and few plants were very rare and restricted to some pockets of this forest. The high Simpson's diversity index (1 - D = 0.911) coupled with a low Berger–Parker dominance index (0.153) indicates low species dominance and a well-balanced community structure. Different morpho-anatomical characteristics were studied for proper identification and documentation of different plant species. The variations in sporoderm sculpture were also studied through scanning electron microscopy (SEM). This study also highlights the various uses of pteridophytes as vegetable, fodder, ornamental plant and also in treatment of various human ailments. Therefore, this study may also help in further exploration of pteridophytic flora and their conservation in Dalkajhar forest.

Article info

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Introduction

Pteridophytes are a group of plants placed between non-vascular and spermatophytes, encompassing over 48 families, 587 genera, and 12000 species worldwide (Khoja et al. 2022). The earliest vascular plants were pteridophytes which has dominated the world's vegetation during Devonian and Carboniferous period of Paleozoic era (Kalita and Bezbaruah 2025). Pteridophytes are widely utilized as vegetables, ethnomedicine, and for ornamental horticulture (Dey and Bhandari 2022). Edible pteridophytes contain a variety of metabolites, including steroids, terpenoids, phenolic acids, and flavonoids, as well as proteins, vitamins, crude fiber, and minerals (Murthy et al. 2023). They also serve as bioindicators of environmental conditions, soil quality, and climate changes (IhsanulIman et al. 2025).

Floristic assessment of pteridophytes helps in listing the diversity, occurrence, and ecological role of this plant group (Jesubalan et al. 2025). It also offers an important data for biodiversity conservation and sustainable management of forest ecosystems. Furthermore, morpho-anatomical studies in pteridophytes helps in recognizing adaptive characters related to specific ecological conditions, improving our understanding of the survival strategies and diversification of pteridophytes across different habitats (Mitra and Moktan 2025).

Dalkajhar forest of Bagdogra forest range under Kurseong forest division is located 20.6 km away from Naxalbari subdision in Darjeeling District. It is situated between latitude 26.7333˚ North and longitude 88.2704˚ East. The Dalkajhar forest area is about 33.1 square kilometres. In this forest temperature ranges from 35˚C during summer and 10˚C during the winter seasons and the average annual rainfall is about 900 mm. This forest represents a vast habitat diversity and floristic richness in differrent plant groups. The present study investigates the different morphological and

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anatomical characters of vegetative as well as reproductive parts of the pteridophytes found in Dalkajhar forest.The phytosociological stuies were also performed regarding the pteridophytic flora of this forest. The detailed socio-economical uses of these plants were enlisted after communicating with the local populations.

Materials and Methods

Study area

The present investigation is based on floristic study, diversity and distribution of pteridophytes in Dalkajhar forest, West Bengal (Fig. 1C).

Survey

The extensive survey of Dalkajhar forest was carried out from the month of December, 2022 to October, 2023. The quadrat sizes of 10ft x 10ft were taken to study pteridophytic species in different seasons. The plant materials from the Dalkajhar forest area were identified and documented in Pteridology and Palaeobotany Laboratory, University of North Bengal, West Bengal, India. The spore morphology was determined with the help of Scanning electron microscope. The phytosociological studies were conducted statistically with standard formulae.

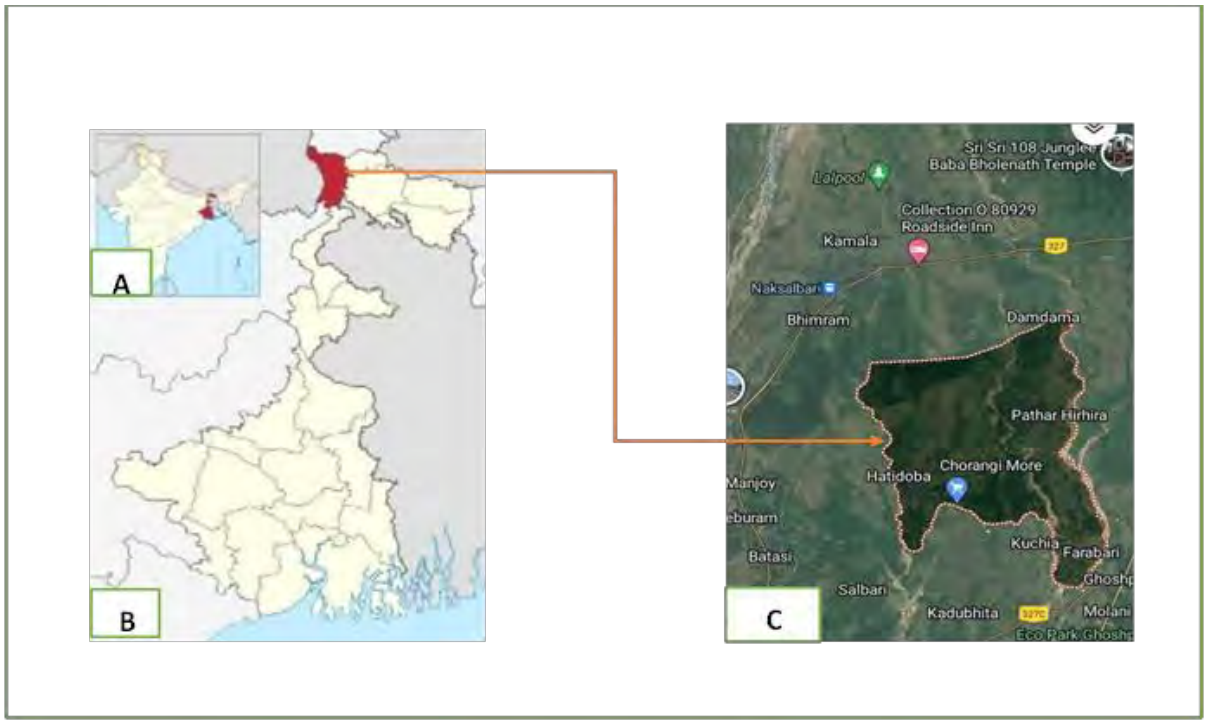

Figure 1. (A) Map of India, (B) Map of West Bengal, (C) Map showing surveyed area Dalkajhar Forest in Darjeeling District.

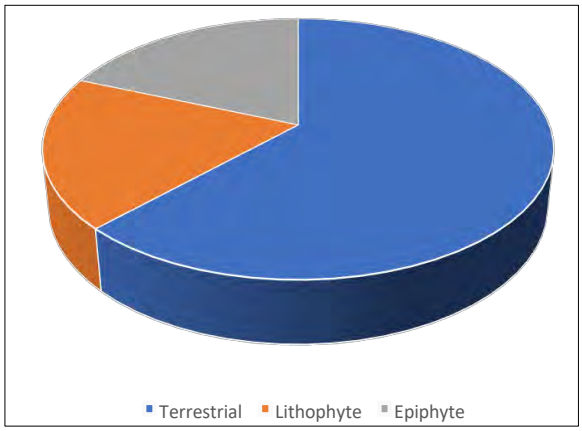

Figure 2. Habitat status of Pteridophytes.

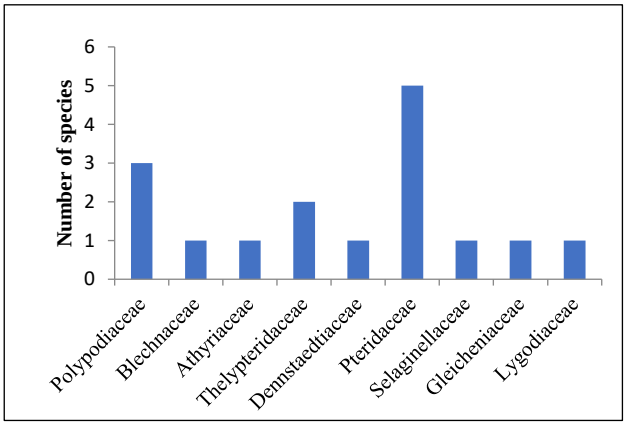

Figure 3. Number of documented species in the study area

Results

The pteridophytic flora comprising of 16 species, 12 genera and 9 families were recorded in Dalkajhar forest, Darjeeling District, West Bengal in our study. The family Pteridaceae and Polypodiaceae has maximum number of species with respect to other seven families. Maximum number of species were terrestrial with respect to lithophytes and epiphytes (Fig. 2). The data related to phytosociological studies is represented in Table 1. Few peridophytes like *Diplazium esculentum*, *Thelypteris dentata*, *Drynaria quercifolia* and *Microsorum punctatum* has maxium importance value index (IVI) with respect to others. *Pteris cretica* and *Selaginella repanda* has minium IVI value. The quantitative values of different community indices of pteridophytic flora of Dalkajhar forest, West Bengal is given in Table 2.

Table 1. Relative frequency (R.F), Relative density (R.D), Relative abundance (R.A) and Importance value index (IVI) of Pteridophytic flora of Dalkajhar forest, Darjeeling District, West Bengal

Sl. No.	Plants	RF	RD	RA	IVI
1	*Diplazium esculentum*	11.06	15.26	9.83	36.15
2	*Thelypteris triphylla*	7.21	2.56	2.52	12.29
3	*Blechnum orientale*	6.73	4.76	5.04	16.54
4	*Thelypteris dentata*	8.65	15.12	12.45	36.23
5	*Microlepia speluncae*	4.33	4.01	6.59	14.93
6	*Gleichenia truncate*	5.29	5.18	6.98	17.44
7	*Pteris biaurita*	6.73	7.67	8.11	22.51
8	*Pteris cretica*	5.29	1.86	2.51	9.66
9	*Pteris semipinnata*	7.21	4.35	4.30	15.86
10	*Lygodium flexuosum*	4.33	3.52	5.80	13.65
11	*Pteris vittata*	5.29	4.90	6.61	16.80
12	*Adiantum capillus -veneris*	6.25	5.66	6.45	18.37
13	*Selaginella repanda*	4.33	0.90	1.48	6.70
14	*Drynaria quercifolia*	5.29	9.12	12.28	26.68
15	*Microsorium punctatum*	4.81	8.49	12.59	25.89
16	*Pyrrosia lanceolata*	7.21	6.63	6.55	20.39

Table 2. Quantitative Analysis of Community Diversity Indices of Pteridophyte Flora from Dalkajhar forest, West Bengal, India

Community indices	Value
Shannon and Wiener Index (Species Diversity)	2.584
Simpson's Diversity index (1-D), where D is Dominance	0.911
Margalef index (Species richness)	2.06
Menhinick's index	0.42
Equitability Index	0.93
Berger-Parker Dominance Index	0.153

The Shannon-Wiener index (H′ = 2.584) reflects a heterogeneous pteridophyte assemblage, suggesting favourable microhabitat conditions such as adequate moisture, shade, and substrate heterogeneity, which are known to support fern diversity in tropical forests. The high Simpson's diversity index (1 - D = 0.911) coupled with a low Berger-Parker dominance index (0.153) indicates low species dominance and a well-balanced community structure. The high equitability value (J = 0.93) further confirms an almost uniform distribution of individuals among species. The important morpho-anatomical characteristics and ethnobotanical uses of the 16 species is given in the Table 3.

Table 3. Morpho-anatomical characteristics along with their ethnobotanical uses

Botanical Name	Habitat	Morphological characters	Rhizome scale	Epidermal characters	Reproductive structures	Uses
Diplazium esculentum	Terrestrial	Rhizome short, ascending or short-creeping, Fronds 60-180cm long, bipinnate, deltoid or broadly lanceolate.	Scales linear-lanceolate.	Stomata polocytic.	Sporangium is immersed, short stalk and globose in shape. Spores monolete bilateral, shape ellipsoidal, size (p×E)-60×35 µm in diameter Fig 6(C).	Used in treating headache, body pain and fever.
Thelypteris triphylla		Rhizomelong, 0.5cm thick, creeping, slender covered with scales, root hairs blackish-brown in colour.	Clathrate scales present at the base of the petiole, dark-brown in colour	Stomata copolocytic.	Sporangium is immersed, sessile and globose, Spores size (p×E)52×25 µm, monolete, reniform, regulate, exinespinulose	Mature fronds are used to decorate home
Blechnum orientale		Rhizome forming a short, erect trunk with densely scaly apex, scales subulate, brown or reddish-brown, shiny, 15-20 mm long, margin entire or toothed. Fronds 200 cm long, fertile, and sterile fronds similar	Scales brown, linear-lanceolate, concolors with ciliate margins	Stomata polocytic.	Sporangium is immersed, round and sessile, Spores monolete bilateral, shape ellipsoidal, size (p×E)-65×30 µm yellowish-brown.	Warm decoction made from the pinnae is commonly used on cuts and wounds to help prevent infection.
Thelypteris dentata		Rhizome short, ascending or short-creeping, apex scaly, margin more or less entire.	Scales brown 1cm. long, lanceolate	Stomata polocytic.	Sporangium is globose, sessile and round. Spores monolete bilateral, shape ellipsoidal, dark-brown, size (p×E)- 48×25 µm Fig 6(B)	Used as antibacterial agent
Microlepia speluncae		Rhizome long-creeping, thick, dia. 0.4-0.7 cm, hairy; Hairs brown, short, stiff, uniseriate. Stipes 25-40 cm long, dark-green to brownish, thick, dia. 0.2-0.3 cm, dorsally grooved, hairy or glabrous.	-	Stomata diacytic.	Sporangium is immersed, stalked round in shape. Spores brown, trilete, tetrahedral, Size (p×E)- 60×35 µm, non-perinate, exine granulate.	Used to treat eye diseases.

Gleichenia truncataa		Rhizome creeping, hairy; Hairs dark-brown, acicular, straight. Primary rachis commonly forked 3 or more times, both the branches at each forking more or less equal.	-	Stomata polocytic.	Sporangia globose, short stalk, immersed. Spores trilete, shape tetrahedral, size (p×E)- 58×35 µm.	Used as anti-malarial agent and treat fever
Pteris biaurita	Terrestrial, Sciophyte	Rhizome short. Erect, apex scaly;Paleae up to 6×0.5 mm., basifixed, subulate-lanceolate, entire, acuminate, dark brown, bicolorous.	Scales brown, margins irregularly fimbriate with a few long projection.	Stomata polocytic.	Sporangium is immersed, comparatively large with short stalk. Spores trilete, tetrahedral, dark brown, (p×E)-60×35 µm.	A decoction made from the rhizome and fronds is used to treat long-term ailments.
Pteris cretica		Rhizomes short-creeping, paleaceous at apex; roots many, medium sized, firm; paleae up to 5×0.5 mm, basifixed, oblong-lanceolate, entire, long acuminate, brown, concolorous, isotoechae.	Scales brown, margins irregular.	Stomata polocytic.	sporangium large, globose, stalk long; spores size (p×E)-74×48 µm, trilete, brown, opaque, dorsal surface irregularly warted.	Used to treat wonds
Pteris semipinnata		Rhizomes erect, short creeping, paleaceous, hard; roots many, hairy; paleae up to 6×0.5 mm, basifixed, subulate-lanceolate, undulate or repand, acuminate, bicolorous.	-	Stomata polocytic	Sporangium globose, sessile, comparatively large; Spores size (p×E)-60×38 µm, trilete, tetrahedral brown, perispore thick, not folded, surfaces minutely granulate Fig 6 (F)	Mature fronds in paste form promotes in wound healing and relieve pain
Lygodium flexuosum		Rhizome short creeping. Climbing rachis wiry, suberect, flattened on one side with ridged edges, glabrous or sparsely pubescent. Each branch is palmately lobed. Sterile fronds pinnate, fertile fronds bipinnate at the base.	Hairs are present in rachis.	Stomata polocytic.	Sporangium globose, sessile, arranged along the margin of pinnules, protected by indusia. Spores trilete tetrahedral about (p×E)- 80×64µm in diameter.	Rhizome is used against gonorrhea, jaundice, piles
Pteris vittata	Terrestrial, Lithophyte	Rhizome creeping, thick, scaly; Stipe length variable, 5-50 cm long, generally much shorter than the lamina, thick, scaly and fibrillose; scales abundant at base.	Scales light-brown, narrow, linear-lanceolate, margin entire, apex acuminate.	Stomata polocytic.	Sporangium immersed, sessile and comparatively large. Spores trilete tetrahedral and globose in shape, light-brown, size (p×E)-65×34 µm.	Whole plant is used to treat cut and wounds.
Adiantum capillus - veneris		Creeping rhizome, slender. Stipe long, thick, scaly at the base, glabrous above, dark, glossy; Lamina ovate, variable in size, 10-30 cm long, up to 20 cm broad, bi or tripinnate. The apical part of lamina is simple pinnate.	Linear-lanceolate scales.	Stomata diacytic.	Sporangium globose, sessile, immersed, Spores trilete, tetrahedral, size (p×E)-(58×30) µm Fig 6(A)	Fresh juice of fresh plants is used to cure cough and diabetes

Selaginella repanda	Sciophyte, Lithophyte	Plant branched and about 30 to 50 cm long. Branches many, alternate, tripinnate. Main stem erects, somewhat fleshy, decumbent and bearing rhizophores near the base of stem. Rhizophores many, slender, thick and long like stilt roots.	-	Stomata anomocytic.	Strobili borne on ultimate branches, cones four sided, 1 to 2 cm long, Strobili terminal, dimorphic. Spores are two different types, Megaspores circular, size (p×E)- 160×135 µm in diameter. Microspores size (p×E)- 58×32 µm in diameter.	Young plants are consumed as vegetable
Drynaria quercifolia	Epiphyte	Rhizome appearing woolly or brown soft, long tapering scaly. Scales long with ciliate margins. Nest fronds ovate, 7-30 cm long and 2-20 cm broad, lobed. Lobes with round apices Foliage fronds 30-100 cm or more long.	-	Stomata polocytic.	Sporangium large, round with short stalk. Spore monolete, globose, size (p×E)- 65×39 µm Fig 6(D).	Pinnae paste is used to set fractured bones, while rhizome and frond paste is applied for blood clotting, tuberculosis, and throat infections.
Microsoriump unctatum		Rhizome creeping, densely scaly. Scales dull brown, clathrate, margin more or less toothed, apex acuminate. Stipes thick and short.	Scales brown, linear-lanceolate, concolors with ciliate margins.	Stomata Diacytic.	Sporangium is immersed, short stalk, comparatively large and round. Spore monolete, ellipsoidal size (p×E)- 58×35 µm.	Fronds are used as feed for chickens and cattle, improve rice field fertility, and have antibacterial and insecticidal properties
Pyrrosia lanceolata		Rhizomes wide-creeping 1.5 mm across paleaceous, roots profuse; paleae up to 6×0.5 mm, peltate, lanceolate, long toothed to hairy, toothed towards base and hairy upwards, acuminate.	-	Stomata anomocytic.	Sporangium globose present with stalk. Spores size (p×E)- 64-68×48-52 µm, monolete, greenish yellow to light brown, reniform, tuberculated, tubercles large Fig 6 (E).	Leaf decoction is consumed to cure cold and sore throats.

Figure 4. Collected species during the field study (A) *Adiantum capillus-veneris*, (B) *Blechnum orientale*, (C) *Thelypteris dentata*, (D) *Diplazium esculentum*, (E) *Drynaria quercifolia*, (F) *Gleichenia truncate*, (G) *Lygodium flexuosum*, (H) *Microlepia speluncae*, (I) *Pteris biaurita*.

Figure 5. Collected species during the field study (J) *Pteris cretica*, (K) *Pteris semi-pinnata*, (L) *Pteris vittata*, (M) *Pyrrosia lanceolata*, (N) *Selaginella repanda*, (O) *Thelypteris triphylla*, (P) *Microsorum punctatum* (Q) Dalkajhar forest-(Study Area).

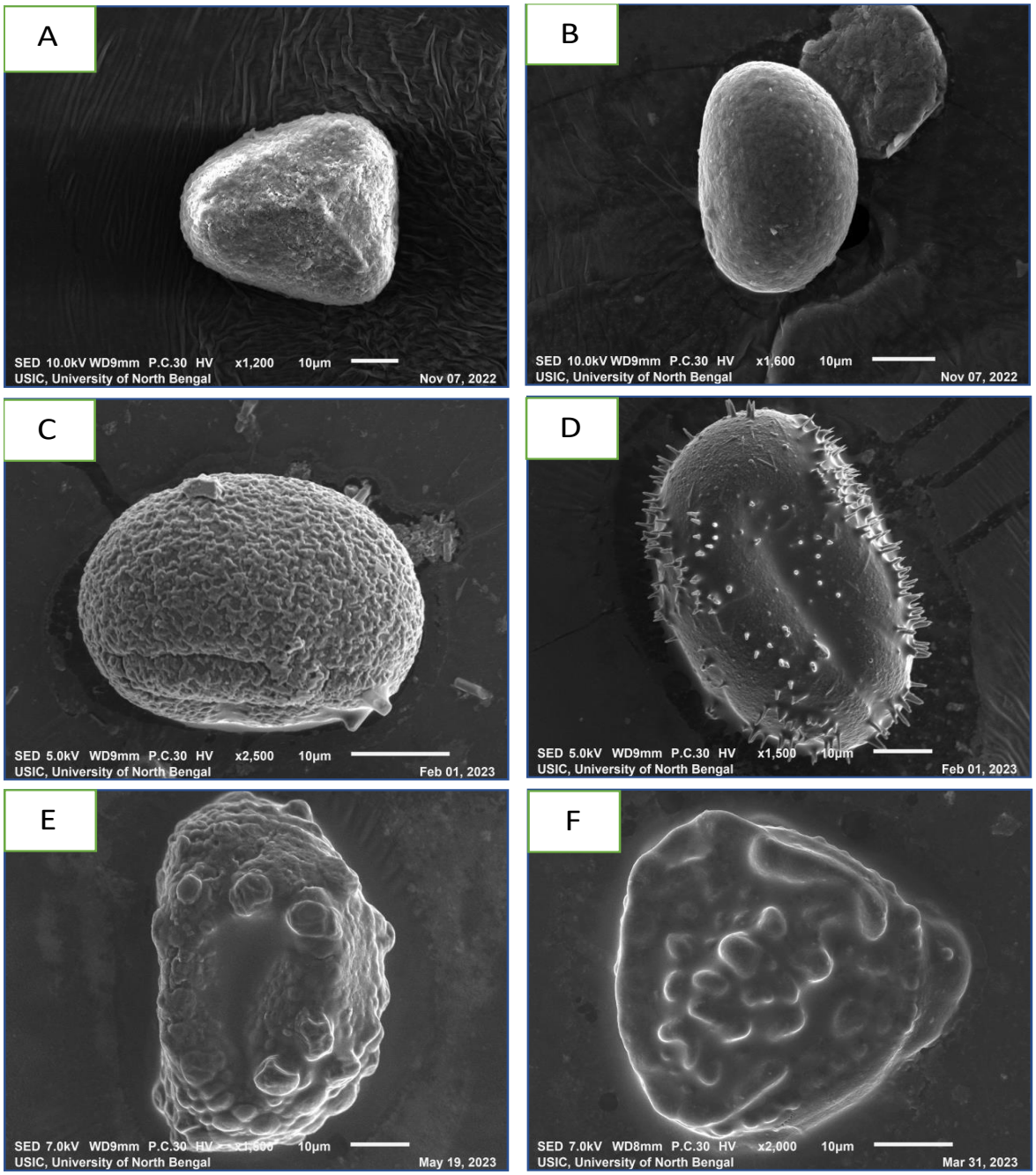

Fig 6. Scanning Electron Microscopic Photograph of spore (A) *Adiantum capillus-veneris*, (B) *Thelypteris dentata*, (C) *Diplazium esculentum*, (D) *Drynaria quercifolia*, (E) *Pyrrosia lanceolata*, (F) *Pteris semipinnata*.

Discussion

Floristic study of pteridophytes is important because it helps us understand the diversity, distribution, and ecological role of these ancient vascular plants **(Nayak et al. 2020)**. Pteridophytes, such as ferns and their allies, are sensitive to variations in moisture, shade, and habitat quality, so their presence often indicates the ecosystem well-being **(Krishnan and K. 2021)**. Studying their flora also contributes to conservation methods, as many species are rare or restricted to specific environments. In addition, floristic data provide a baseline for future ecological and climate-related studies, helping scientists track environmental changes over time **(Bargali et al. 2025).** Phytosociological studies of the Dalkajhar forest in the Terai region of Darjeeling, West Bengal, are important for understanding the structure, composition, and ecological relationships of its plant communities. The quantitative analysis of community diversity indices indicates that the pteridophyte flora of Dalkajhar Forest, West Bengal, India exhibits moderate to high species diversity and strong structural stability. This forest represents a unique transitional ecosystem influenced by rainfall, fertile alluvial soils, and human pressure, making it ecologically sensitive. Our study helps identify the

diversity of pteridophytes in this forest, which is essential for sustainable forest management. The combined diversity, richness, and evenness metrics demonstrate that the pteridophyte community of Dalkajhar forest is ecologically balanced and structurally resilient**.** Our finding draws attention to the conservation importance of the survey area and emphasize to the need for regular monitoring to protect pteridophyte diversity under increasing anthropogenic and climatic pressures. It also provides valuable data regarding structural variation and ethno-medicinal uses of vascular cryptogams and conservation planning in this biologically rich Terai landscape.

The richness of pteridophytes in a forest can reflect the stability of the ecosystem and the overall health and quality of the forest environment (**Rahmad and Akomolafe 2019).** A total 16 pteridophytes were recorded in this study area. Maximum species of pteridophytes were from Pteridaceae and Polypodiaceae family. We found several species of pteridophytes like *Diplazium esculentum, Thelypteris dentata, Pteris biaurita, Microsorium punctatum, Pyrrosia lanceolata, Thelypteris triphylla, Gleichenia truncate, Lygodium flexuosum* etc. In our study we found maximum species were terrestrial then lithophytes and epiphytes.

Morphological and anatomical studies are essential in pteridophytes because they provide reliable characters for identification, classification, and comparison of species. External features such as frond shape, venation, and sporangial arrangement, along with internal structures like vascular tissue, epidermal features, and spore anatomy, help distinguish closely related taxa **(Yang et al. 2023)**. Together, morphology and anatomy form a strong foundation for understanding species diversity, variation, and ecological specialization within pteridophytes. Our study contributes to the better understanding of morphological, anatomical and palynological diversity of pteridophytes of Dalkajhar forest for very first time.

Ethnobotanical studies of pteridophytes helps in documenting traditional knowledge related to their medicinal, nutritional, and cultural uses, much of which is rapidly disappearing **(Sureshkumar et al. 2018)**. Such studies provide a scientific basis for identifying bioactive compounds with potential pharmaceutical value, while also highlighting species of conservation importance. Understanding indigenous uses of pteridophytes supports sustainability, biodiversity conservation, and cultural preservation while linking traditional knowledge with modern science **(Mandal and Fraser-Jenkins 2024)**. The different tribal populations of our study area used these 16 species of pteridophytes for treating different human ailments and decorating purposes.

Conclusion

The present study highlights the very first study in the diversity and distribution of pteridophytes in Dalkajhar forest. This study reveals the pteridophytic flora of Dalkajhar forest which will be helpful in understanding the status of vascular cryptogams in this important Terai region of Darjeeling district. The ethnomedicinal uses of these 16 species shall be helpful in more detailed study in medicinal importance of this plant group. Some of the pteridophytes like *Selaginella repanda* and *Pteris cretica* were found to be restricted in some pockets of this forest. This research study will be useful for indigenous communities and ethno-botanists for further investigation of medicinal and economical uses of pteridophytes present in this area.

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