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ORIGINAL ARTICLE

Ecological assessment and Phytosociological enumeration of Pteridophyte composition in Gorumara National Park and adjoining area, West Bengal, India

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ABSTRACT
Pteridophytes, also known as ferns and fern allies, are a group of vascular plants that thrive in forest ecosystems. This group of vascular plants often receives limited recognition for their diverse characteristics. Present data on pteridophytes in forest area of Gorumara National Park is a step in fulfill the lacuna regarding the taxonomical distribution and ecological status of pteridophytes. The study offered an opportunity to discuss the compilation of a composting plant and the analysis of field data, focusing on the maximum number of species. Present communication records the thorough documentation and distribution of Pteridophytes from Gorumara National Park and adjoining area. A total of 73 species under 43 genera and 23 families were reported. Pteridaceae, Polypodiaceae, Thelypteridaceae and Dryopteridaceae are the families largely represented in the study area. The current study uncovered intriguing phytosociological discoveries regarding the pteridophyte flora of the forest. This exploratory survey may potentially serve as a useful tool for additional in-depth study on pteridophytes and conservation aspects.
Keywords: *Pteridophytes, Gorumara National Park, Phytosociology, IVI, Species Diversity, Species Evenness*

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INTRODUCTION

Pteridophytes, also known as vascular cryptogams, are a group of non-flowering plants that reproduce via spores. They are considered to be one of the oldest groups of land plants and play a crucial role in the ecosystem. Members of the group have immense economical and ecological significance. Although 250 million years ago pteridophytes constituted the majority of flora of the planet, thereafter they were mostly left behind by seed-bearing plants [1]. Pteridophytes comprising Polypodiopsida and Lycopodiopsida (including Selaginella), are the second most extensive assemblage of vascular plants, encompassing over 11,916 documented species [2]. Pteridophytes exhibit a unique life cycle, that combines wind-dispersed spores and mostly with free-living gametophytes [3]. While their typical distribution is in damp, shady environments like the understory of rainforests, certain species also inhabit rocky terrains and grow as epiphytes in the canopies of forests [4-7]. As pteridophytes are so sensitive to changes in environmental factors like humidity and sunshine intensity, they may serve as signs of climatic change and other environmental disturbances [8]. They are important contributors to biodiversity in numerous forested regions and have a vital impact on the functioning of these ecosystems. Ferns and their allies provide valuable habitat for numerous other organisms, such as insects, birds, and small mammals. Their fronds, stems, and rhizomes offer shelter, nesting sites, and food sources for these animals, supporting the intricate food web within the forest. Conservation of biological diversity has become a major concern, for a large part of the society and many government agencies at all levels[9]. However, very little attention was received by pteridophytes in most of the parts of the globe.

Forests offer a substantial quantity of renewable resources that are being utilised by all animals, including humans [10]. Most of the forests of the globe have a wide variety of plant and animal populations that engage in intricate interactions. To gain a deeper comprehension of forest ecosystems, it is crucial to examine the phytosociological characteristics and diversity patterns of each community within these ecological settings [11]. Though pteridophytes are very significant part of the forest vegetation but in most cases they were neglected. In a forest most of the focus has been gained by timber producing trees and the sources of well recognized Non Timber Forest Products [12]. Since few years some workers have investigated the ecological status of pteridophytes in some forested areas [13-15]. The habitat of numerous pteridophytic species in several forests and biodiversity regions was destroyed by anthropogenic activities. Furthermore, Infrastructure building, road expansion, and tourism have been observed to negatively impact these populations. Since few decades many researchers have set their goal to this direction and conducted many phytosociological and ecological surveys in several forests and adjoining biodiversity regions [16-18] but in most cases pteridophytes were neglected. Pteridophytes play crucial roles in the ecosystem, such as providing habitat for other organisms, contributing to soil formation, and acting as indicators of environmental quality. Documenting Pteridophytes is crucial for safeguarding the variety of this relatively unfamiliar plant group [19-25].

MATERIAL AND METHODS

Study Sites:

The Gorumara National Park is a renowned tropical deciduous forest known for its diverse wildlife, including the iconic one-horned great Indian Rhino, as well as other species such as elephants, Indian bison, Royal Bengal tigers, and leopards [16]. It is situated in the foothills of the Eastern Himalayas (Fig 1A, 1B, 1C) and is also known for its rich plant biodiversity [10, 16, 26-29]. The national spread in between the localities of Lataguri, Chalsa and Nagrakata by the side of National Highway 31 that runs between Siliguri and Guwahati [30]. Unique ecosystem of the forested region, with its varied habitats ranging from evergreen forests to grasslands and wetlands, provides a suitable environment for the growth and survival of various pteridophyte species.

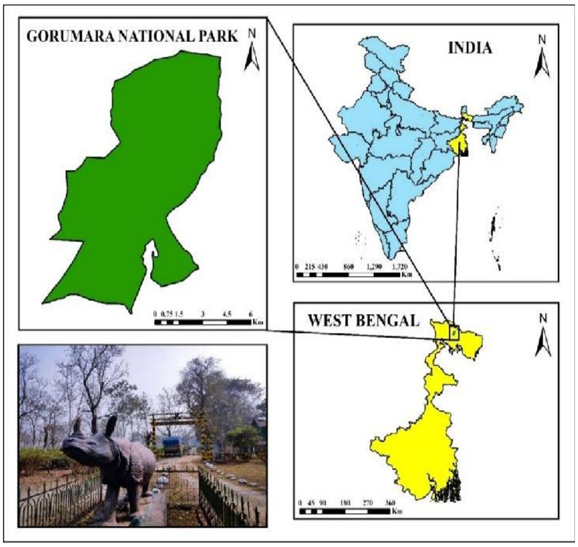


Fig 1A: Location of Gorumara National Park

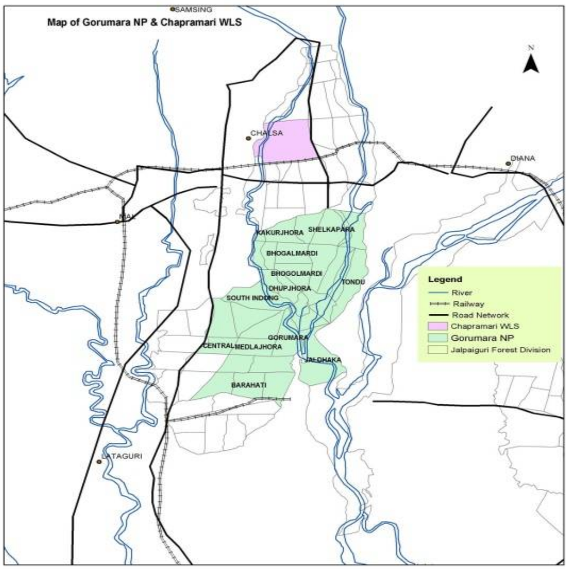


Fig 1B: Area map of Gorumara National Park

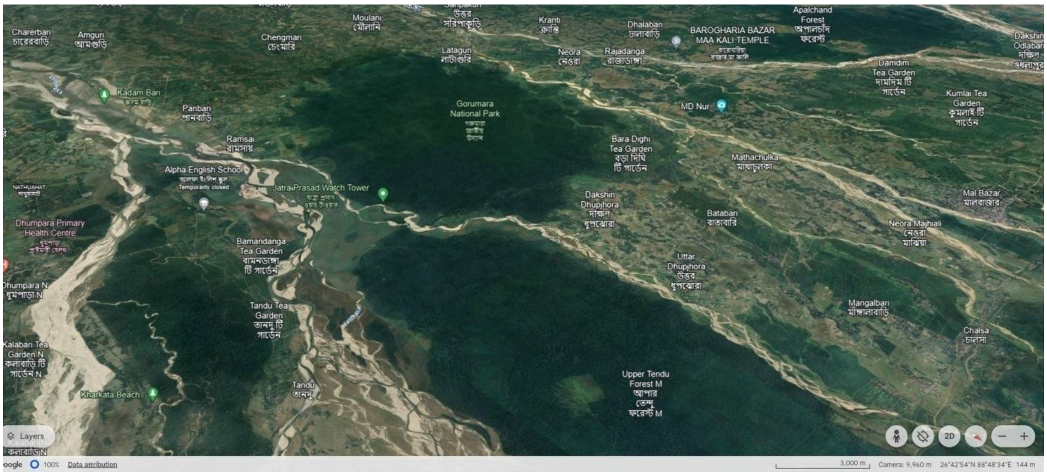


Fig 1C: GPS location of Gorumara National Park

Methodology:

The study area underwent comprehensive investigation from 2017 to 2023, covering three distinct seasons: summer (March-May), rainy (June-October), and winter (November-February).Phytosociological data were acquired by using a 10m×10m plot to measure pteridophytic species [31]. The plot area has been identified as a favourable location for studying the variety of Pteridophytes in both natural and man-made forests [32]. A minimum distance of 50 meters was maintained between plots at each research location. The study employed a non-random selection approach to determine plot locations, ensuring that each plot included at least one unique pteridophyte. The GPS Garmin eTrex 10 device was employed to obtain the geographic coordinates of each study site. Several researchers utilized cubic quadrant techniques to examine the biodiversity of pteridophytes in both man-made and natural forests [33]. The specimens were collected and subjected to air drying, pressing, and pasting onto herbarium sheets using the standard herbarium preparation process described by [34]. In all the plots, the pteridophyte species present were recorded and classified as terrestrial, epiphytes, lithophytes, climbers and aquatic& semi aquatic. Data on diverse pteridophytic characteristics in several plots were gathered and statistically examined [35-36]. As the majority of individual fern species typically emerge from a common, inseparable subterranean rhizome, each fern stipe (i.e. the entire frond emanating from the rhizome) is considered an individual fern. This is due to the fact that clusters are formed thereby.

Herbarium specimens of collected species have also been deposited in the Botanical Survey of India (BSI), Arunachal Pradesh Regional Centre (ARUN!) and Herbarium of Dept. of Life Science, Govt. Model School, Mal (GMSMH), Jalpaiguri. Field photographs and collected specimens were identified by experts of BSI, ARUN!, Itanagar, Arunachal Pradesh through comparing with digital images of vouchers and type-specimens deposited in herbaria & consultation of several relevant literature [37-45]. In addition, conservation status of such pteridophytes was determined based on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List Categories and Criteria [44, 46].

Data Analysis:

The following analyses were conducted by following formulas

$$\text{Density} = \frac{\text{Total no. of individual species}}{\text{Total no. of plot studied}}$$

$$\text{Relative Density} = \frac{\text{Total no. of individuals of a species in all the plots}}{\text{Total no. individuals of all species in all the plots}} \times 100$$

$$\text{Frequency} = \frac{\text{No. of transect in which species studies}}{\text{Total no. of plots studied}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Aundance} = \frac{\text{Total no. of individual species}}{\text{Total no. of plots studied}}$$

$$\text{Relative Abundance} = \frac{\text{Total no. of individual species in all the plots}}{\text{Total no. of plots in which species has occurred}} \times 100$$

Importance value index (IVI) is calculated by the formula
IVI = Relative Frequency + Relative density+ Relative Abundance

Species diversity (H'):
Based on the data of the occurrence of the species in these transects by Shannon-Weiner Index: [47] was calculated which is represented below:

$$H' = -\Sigma [(ni/N). \ln (ni/N)]$$

Where, ni = Number of individuals of the "i" th species; N = Total number of individuals

Simpson's diversity index(D):
Simpson's diversity index was calculated as follows:

$$D = \sum \frac{ni\,(ni-1)}{N\,(N-1)}$$

Where,ni = Number of individuals of the "i" th species; N = Total number of individuals

Species dominance (Cd):
Species dominance was calculated [48] as follows:

$$Cd = \Sigma (ni/N)^{2,}$$

where, ni and N are the same as those for Shannon Weiner information function

Equitability of evenness (e)
Equitability of evenness[49] refers to the degree of relative dominance of each species in that area. It was calculated as: Evenness (e) = H'/log S
where, H'= Shannon index, S = number of species

Species richness (D)
Species richness was determined by Margalef index [50] as:
D=(S-1)/ln N.
where, S = number of species; N= total number of individuals

Menhinick's index (D_{mm}):
Menhinick's index [51] is expressed as D_{mm}= S/N, where N is the number of individuals in the sample and S is the species number

(f) **Equitability Index**
The Shannon's equitability Index [52] is expressed as
(EH) = H/H_{max} = H/ln S
Where, H is the Shannon index and S is the species number.

Berger-Parker Dominance Index
The Berger-Parker Dominance Index [53]is a simple measure of the numerical importance of the most abundant species and is expressed a d = N_{max}/N.
N max is the number of individuals in the most abundant species and N is the total number of individuals in the sample. The increase in the value of reciprocal of Berger-Parker Dominance Index reflects the increase in diversity and a reduction in dominance.

RESULT

A total of 73 species of ferns and fern-allies belonging to 43 genera, and 23 families at different habitat were recorded during the investigation. The records and phytosociological analysis of the taxa is presented in Table 1 and Table 2 respectively. The family Pteridaceae, Polypodiaceae, Thelypteridaceae and Dryopteridaceae has maximum number of species. Some pteridophyteslike *Diplazium esculentum* (Retz.) Sw., *Drynaria quercifolia* (L.) J. Sm., *Microsorum punctatum* (L.) Copeland, *Thelypteris dentata* (Forssk.) Brown. & Jermy, *Microlepia speluncae* (Linn.) Moore, *Pteris biaurita* L. sub sp. *Walkeriana* Fraser-Jenk. & Dom. Rajkumar, *Pyrrosia lanceolata* (L.) Farwell, *Lygodium flexuosum* (L.) Sw., *Blechnum orientale* L., *Vittaria elongata* Swartz were found very familiar with the forest and Important Value Index (IVI) for these specieswere much higher than others. Highest IVI was recorded for *Microsorum punctatum* (L.) Copeland and minimum IVI were recorded for *Huperzia squarrosa* (Froster) Trevisan, *Lycopodium japonicum* Thunberg., *Coniogrammes ferrulata* (Blume) Fee., *Pteris kathmanduensis* Fraser-Jenk. & T.G.

Walker, *Stenochlaena palustris* (Burm.) Bedd. Shannon diversity and Simpson diversity indices of the recorded pteridophytes exhibit substantial variations (Table 2).

DISCUSSION

The forest vegetation is naturally occurring complex and diversified which is characterized by untamed growth of a wide range of plant and animal species that interact with each other and their environment [10]. However, the global community is increasingly acknowledging the harsh reality that numerous forests are facing the imminent threat of vegetative extinction [10]. Among the plant species found in forest communities, ferns and their allies, collectively known as pteridophytes, play a vital role in shaping and maintaining the ecosystem's health and functionality. The phytosociological assessment of any plant group is a crucial feature in the field of forestry, and it is also important in other scientific disciplines such as conservation, management, and bioprospecting of phytoresources [54]. Our present study reported the presence of these diverse groups in the Gorumara National Park, which highlights the importance of the forest in conserving and protecting these ancient plant species. The forest lies in the moist tropical zone where the average temperature remains much lower and it remains adequately. A total 73 pteridophytes were found in this study sites. India possesses a diverse and abundant pteridophytic flora as a result of its Gondwanaland heritage and its migration from the southern hemisphere towards Eurasia in the far north. This migration brought with it the ancestors of the present-day pteridophytes from Australia, Africa, Madagascar, and other regions, as well as potentially unique species that are native to India [55]. The Eastern Himalayan region is very diverse, which alone is home to around 700 species of ferns and fern allies [56]. As the present study sites- Gorumara National Park is situated at Eastern Himalayan foothill, it also contributes a large number of fern within a limited area.The abundance of pteridophytesin a forest can serve as an indicator of the forest's stability and overall quality[13]. In our studies several species were found abundant, viz., *Azolla pinnata* R. Br., *Pyrrosia stenophylla* (Bedd.) Ching., *Adiantum capillus-veneris* L., *Adiantum philippense* L., *Odontosoria chinensis* subsp. *chinensis* (L.) Smith, *Leptochilus decurrens* Blume subsp. *Hemionitideus* Fraser-Jenk., *Pyrrosia mannii* (Giesenh) Ching. *Microsorum punctatum* (L.) Copeland etc.

Pteridophyteshave unique microhabitat preferences based on temperature, humidity, soil type, wetness, pH, light intensity, and other factors. These preferences are often highly specific to the circumstances required [57]. They thrive in lush tropical and temperate forest, rocky cliffs, shaded tree limbs, wetlands and bodies of water. In case of this study 38 species were terrestrial, 14 were epiphytic, 13 were lithophytic, 8 were aquatic and only one climber was recorded. Epiphytic pteridophytes, a diverse group of plants, are found worldwide and consist of roughly 2,600 species, which accounts for about 29% of all pteridophyte species [8]. In this study sites 19.18% of all pteridophytes are epiphytic.They perch on trees like *Shorea robusta* Gaertn.,*Trewia nudiflora* L., *Bombax ceiba* L., *Alstonia scholaris* (L.) R. Br., *Schima wallichii* Choisy., *Wrightia tinctoria* (Roxb.) R. Br., *Amoora spectabilis* Miq., *Acrocarpus fraxinifolius* Arn., *Tectona grandis* L.f., *Lagerstroemia parviflora* Roxb. The tall, well stratified trees in the forests offer an ideal home for epiphytic pteridophytes to flourish, where as some others; prefer open tree trunks and branches[58]. The spatial arrangement of pteridophyte species and the organisation of their communities are primarily influenced by factors such as climate, soil, and evolutionary history [59].

Ecological value of pteridophytes in forested area is often overlooked, possibly due to the fact that most scientific research considered that they are typically a minor component of natural vegetation. Over the past few years, there has been a growing interest in studying pteridophytes and some workers set their focus on this under estimated community of the forest [7,8,14,15]. However, there is still a lack of knowledge about the phytosociological aspects of fern communities. The present study also uncovered intriguing phytosociological discoveries regarding the pteridophyte flora of the forest patches of Gorumara National Park. In our study we have found that instead of one species, a few species had a high level of abundance. Considering the complex nature of biodiversity in natural systems, various indexes have been proposed to evaluate it. To assess the diversity of fern in University Sains Malaysia, a tropical university campus, authors have used Shannonindex, Simpson index and Margalef index along with other phytosociological data [31]. Akomolafe *et al.* [60] also used Shannon index, Simpson index, Evenness index, Fisher's alpha, and Margalef index to study the pattern of ferns community assemblages in some Malaysian and Nigerian tropical forests.The indices determined in our study showed that the forest is rich in pteridophyte vegetation and diversity (Table 3).The significance of the Shannon-Wiener Index lies in its ability to provide a quantitative measure of biodiversity, which is essential for various ecological studies and conservation efforts. It allows researchers to compare the diversity of different communities, monitor changes in diversity over time, assess the impact of environmental factors or disturbances on biodiversity, and evaluate the effectiveness of conservation strategies. Barbour *et al.*, [61] state that a community is considered more varied if its Shannon index exceeds 2.000.In our studies, we have found Shannon index value as 3.9693for fern vegetation of Gorumara National Park. It may be concluded that the sampled sites had a higher diversity of pteridophytes, as indicated by their Shannon index values exceeding 2.000.Higher species diversity in ecosystems leads to greater stability and production due to the dynamic character of the driving species[62,63]. Simpson Index is frequently employed as a metric for quantifying species diversity. It provides an approximation of the number of species that are similarly abundant and would lead to the same level of dominance [64]. A greater Simpson index in any given forest signifies that it is mostly controlled by a few fern species that are more prevalent throughout the entire forest. Higher Margalef Index also indicates least disturbance in forested habitat [31].This index enables the comparison of biodiversity between various communities or over time by measuring the relative species richness in relation to the sample size [64]. Our current study found that the Margalef Index of the study sites much higher (8.5414).The Margalef index is extensively utilized in ecological research and biodiversity evaluations because to its ability to offer a straightforward and useful measure of species richness, while also taking into consideration the dataset's size [64]. The lower species evenness index seen in a forest can be explained to the scarcity of individual ferns and the absence of any species occurring in more than 2 or 3 plots [31]. In present study site species evenness index was recorded much higher (2.1302).

Monitoring of global scale as well as local scale threats on pteridophyte and similar lower plants is also very important for ecological study. Unfortunately, various pteridophyte species are at risk of extinction (Table 1) as a result of habitat destruction and degradation. The majority of natural ecosystems pteridophytes have been found to be disrupted to varying degrees, primarily as a result of numerous human activities and inadequate forest management towards lower plant group. Damage of trees due to natural calamities or pathogenic infection can also damage epiphytic ferns. Collection of edible and medicinal ferns by forest fringe people on regular basis can lead rapid destruction of their vegetation [20]. Like many other plant species, pteridophytes in the Gorumara National Park face threats from habitat loss, fragmentation, and climate change. As the adjoining areas are highly populated, edible ferns are collected not only for domestic consumption but also for selling in local markets. Conservation efforts, including sustainable management practices and awareness campaigns, are crucial to ensure the long-term survival of these unique and fascinating plants [65]. Propagation of specific pteridophytes is also impacted by the habitat. Pteridophytes are either restricted to habitats where these conditions are frequently present or necessitate special adaptations to regulate the timing of spermatozoid release to coincide with opportune seasons. In our study we have found five types of habitat for pteridophyte community of the forest (Fig 2). Growth habit and life patterns of each individual is also distinct from others and thus influence the ecosystem distinctly.

TABLE 1: Pteridophytes of Gorumara National Park

S.N.	Pteridophyte Species	Habitat	IUCN Red list status	Species Occurrence in studied habitat	Life Forms	Growth Habit
LYCOPODIACEAE						
1.	*Huperzia squarrosa* (Froster) Trevisan	Epiphytic	EN	R	Epi	Solitary
2.	*Lycopodium japonicum* Thunberg.	Terrestrial	NE	R	Mic	Colony
3.	*Lycopodiella cernua* (L.) Pich. Sermolli	Terrestrial	LC	O	Mic	Colony
SELAGINELLACEAE						
4.	*Selaginella ciliaris* (Retz.) Spring	Lithophytic	NE	A	Mic	Patch
5.	*Selaginella monospora*Spring.	Lithophytic	NE	F	Mic	Patch
6.	*Selaginella repanda*(Desv. ex Poir.) Spring.	Lithophytic	NE	O	Mic	Patch
7.	*Selaginella chrysocaulos* (Hooker &Greville) Spring.	Lithophytic	NE	O	Mic	Patch
EQUISETACEAE						
8.	*Equisetum ramosissimum*Desf.	Semi-aquatic	NE	F	Mic	Patch
OPHIOGLOSSACEAE						
9.	*Helminthostachys zeylanica* (L.) Hook.	Terrestrial	LC	R	Mic	Solitary
10.	*Ophioglossum reticulatum*Linn.	Terrestrial	LC	F	Mic	Solitary
MARATTIACEAE						

11.	*Angiopteris crassipes* Wall. Ex C. Presl.	Terrestrial	LC	O	Meg	Solitary
LYGODIACEAE						
12.	*Lygodium flexuosum* (L.) Sw.	Terrestrial	LC	A	Lia	Patch
MARSILEACEAE						
13.	*Marsilea minuta* L.	Aquatic	LC	F	Mic	Colony
GLEICHENIACEAE						
14.	*Dicranopteris linearis* (Burm. f.) Underw.	Terrestrial	LC	A	Meg	Colony
POLYPODIACEAE						
15.	*Microsorum cuspidatum*(D. Don) Tagawa	Epiphytic	VU	O	Epi	Solitary
16.	*Microsorum punctatum* (L.) Copeland	Epiphytic	NE	D	Epi	Patch
17.	*Drynaria quercifolia* (L.) J. Sm.	Epiphytic	NE	D	Epi	Colony
18.	*Drynaria propinqua* (Wall. ex Mett.) J. Sm. ex Bedd.	Epiphytic	LC	R	Epi	Colony
19.	*Pyrrosia costata* (C.Presl ex Bedd.)Tagawa &K.Iwats	Epiphytic	NE	A	Epi	Colony
20.	*Pyrrosia mannii* (Giesenh) Ching.	Epiphytic	NE	O	Epi	Colony
21.	*Pyrrosia lanceolata* (L.) Farwell	Lithophytic	NE	A	Epi	Colony
22.	*Pyrrosia stenophylla* (Bedd.) Ching.	Epiphytic	NT	O	Epi	Patch
23.	*Lepisorus contortus (Christ.) Ching.*	Epiphytic	NE	R	Epi	Patch
24.	*Leptochilus decurrens* Blume sub sp. *hemionitideus* Fraser-Jenk.	Semi aquatic	LC	O	Mic	Patch
25.	*Leptochilus pteropus* (Blume) Fraser-Jenk.	Semi aquatic	VU	R	Mic	Patch
26.	*Loxogramme involuta* (D.Don) C.Presl.	Epiphytic	NE	O	Epi	Patch
CYATHEACEAE						
27.	*Cyathea gigantea* (Wall. ex. Hook.) Holttum.	Terrestrial	VU	O	Meg	Solitary
DENNSTAEDTIACEAE						
28.	*Hypolepis polypodioides*(Blume) Hooker	Terrestrial	NE	R	Mes	Solitary
29.	*Microlepia speluncae* (Linn.) Moore	Terrestrial	LC	A	Mic	Solitary
30.	*Microlepia rhomboidea* (Wall. ex Kunz.) Prantl	Terrestrial	NE	O	Mes	Solitary
LINDSAEACEAE						
31.	*Lindsaea ensifolia* Sw.	Terrestrial	VU	R	Mic	Patch
32.	*Odontosoria chinensis* sub sp. *chinensis* (L.) Smith	Terrestrial	LC	F	Mic	Colony
PTERIDACEAE						
33.	*Adiantum philippense* L.	Lithophytic	LC	F	Mic	Colony
34.	*Adiantum capillus-veneris*L.	Lithophytic	LC	F	Mic	Colony
35.	*Adiantumin cisum* Forssk. subsp. *incisum* Fraser-Jenk.	Lithophytic	NE	O	Mic	Patch
36.	*Adiantum caudatum* Klotz.	Lithophytic	NE	O	Mic	Patch
37.	*Aleuritopteris bicolour* (Roxb.) Fraser-Jenk.	Lithophytic	NE	O	Mic	Patch
38.	*Ceratopteris thalictroides* (L.) Brongn.	Aquatic	LC	O	Mic	Colony
39.	*Coniogramme serrulata* (Blume) Fee.	Terrestrial	NT	R	Mes	Solitary
40.	*Onychium siliculosum* (Desv.) Christ.	Terrestrial	LC	O	Mes	Patch
41.	*Pityrogramma calomelanos* (L.) Link.	Terrestrial	NE	F	Mic	Patch
42.	*Pteris vittata* L. sub sp. *vittata*	Lithophytic	NE	O	Mic	Patch

43.	*Pteris alata* L.	Terrestrial	NE	A	Mic	Patch
44.	*Pteris biaurita* L.sub sp. *fornicata* Fraser-Jenk.	Terrestrial	NE	F	Mes	Patch
45.	*Pteris biaurita* L. sub sp. *walkeriana* Fraser-Jenk. & Dom. Rajkumar	Terrestrial	NE	A	Mes	Patch
46.	*Pteris aspericaulis* Wall. ex J. Agardh.	Terrestrial	NE	R	Mes	Colony
47.	*Pteris ensiformis* Burm. f.	Terrestrial	NE	R	Mic	Patch
48.	*Pteris kathmanduensis* Fraser-Jenk. & T.G.Walker	Terrestrial	EN	R	Mic	Patch
49.	*Pteris multifida* Poir.	Lithophytic	LC	R	Mic	Patch
VITTARIACEAE						
50.	*Antrophyum reticulatum* (G. Forst.) Kaulf.	Epiphytic	VU	O	Epi	Patch
51.	*Vittaria elongata* Swartz	Epiphytic	LC	A	Epi	Colony
ASPLENIACEAE						
52.	*Asplenium crinicaule* Hance	Epiphytic	NT	O	Epi	Patch
53.	*Asplenium finlaysonianum* Wall. ex Hook et Grev.	Lithophytic	ED	R	Mic	Patch
THELYPTERIDACEAE						
54.	*Thelypteris nudata* (Roxb.) Morton	Terrestrial	NE	A	Mes	Patch
55.	*Thelypteris triphylla* (Sw.) Iwatsuki	Terrestrial	EN	F	Mic	Colony
56.	*Thelypteris dentata* (Forssk.) Brown. & Jermy	Terrestrial	NE	D	Mic	Colony
57.	*Thelypteris arida*(Don) Morton	Terrestrial	LC	A	Meg	Patch
58.	*Thelypteris torresiana* (Gaudich) Alston	Terrestrial	NE	O	Mic	Patch
59.	*Thelypteri sprocera* (D. Don) Fraser-Jenk.	Terrestrial	NE	F	Mes	Patch
60.	*Thelypteris prolifera*(Retz.) C F. Reed	Terrestrial	NE	O	Mes	Solitary
WOODSIACEAE						
61.	*Diplazium esculentum*(Retz.) Sw.	Terrestrial	LC	D	Mic	solitary
DRYOPTERIDACEAE						
62.	*Dryopteris cochleata* (D. Don) C. Chr.	Terrestrial	NE	O	Mes	Solitary
63.	*Polystichum lentum* (D. Don) T. Moore	Terrestrial	NE	F	Mic	Patch
64.	*Polystichum manmeiense* (Christ) Nakaike	Terrestrial	NE	R	Mic	Patch
65.	*Tectaria coadunata* (J. Sm.) C. Chr.	Terrestrial	LC	F	Mes	Patch
66.	*Tectaria polymorpha*(Wall. ex Hook.) Copeland	Terrestrial	EN	O	Mic	Patch
OLEANDRACEAE						
67.	*Nephrolepis cordifolia* (L.) C. Presl.	Terrestrial	NT	O	Mic	Colony
DAVALLIACEAE						
68.	*Davallia trichomanoides* Blume	Epiphytic	NE	F	Epi	Patch
BLECHNACEAE						
69.	*Blechnum orientale* L.	Terrestrial	NE	A	Mes	Patch
70.	*Stenochlaena palustris*(Burm.) Bedd.	Climbing, Creeping	NE	R	Mes	Solitary
AZOLLACEAE						
71.	*Azolla pinnata* R.Br.	Aquatic	LC	F	Mic	Colony
SALVINIACEAE						
72.	*Salvinia cucullata* Bory	Aquatic	LC	R	Mic	Colony
73.	*Salvinia natans* (L.) All.	Aquatic	LC	O	Mic	Colony

IUCN status- NE- Not Evaluated, LC- Least Concern, VU- Vulnerable, ED- Endangered, EN- Endemic, NT- Near Threatened.

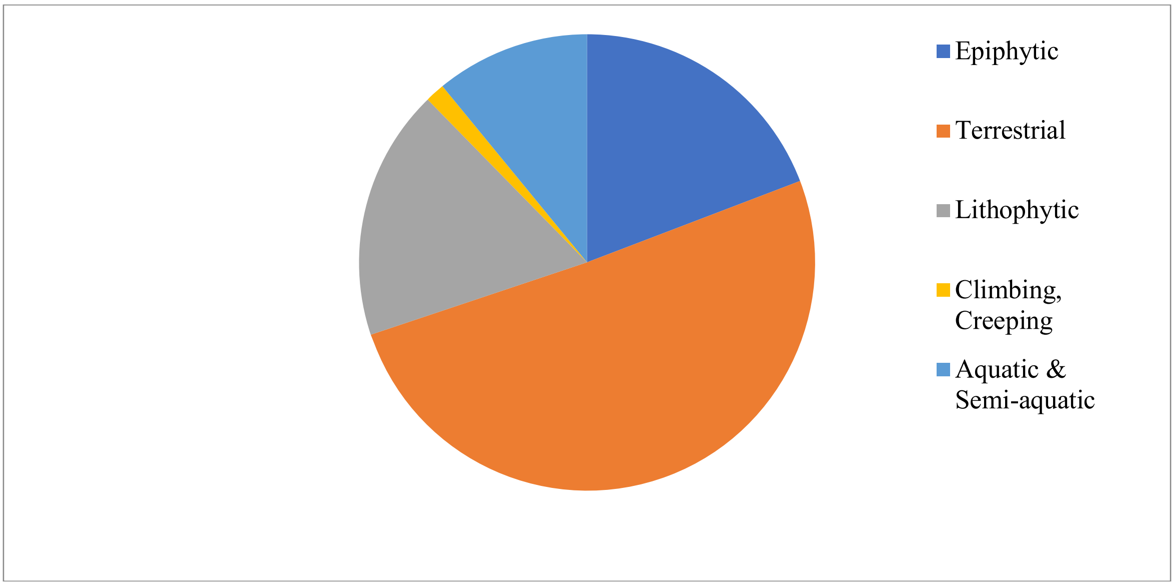


Fig 2: Habitat based grouping of recorded Pteridophyte

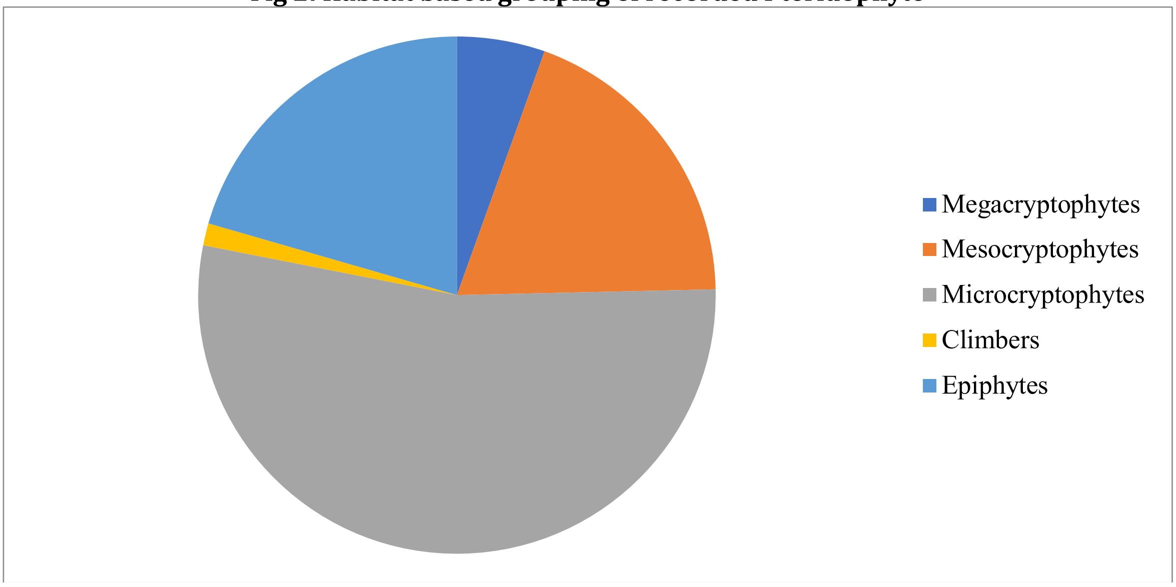


Fig 3: Categorization of recorded Pteridophytes based on life forms

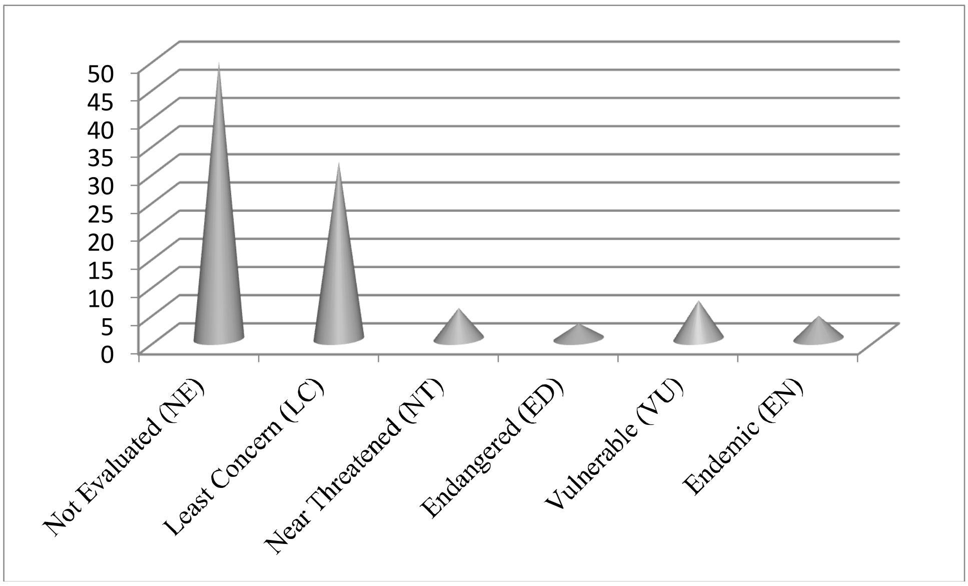


Fig 4: Categorization of recorded Pteridophytes based on life forms

Table 2: Phytosociological enumeration of recorded Pteridophytes.

Sl. No.	Pteridophyte Species	Relative Abundance	Relative Density	Relative Frequency	IVI
1.	*Huperzia squarrosa* (Froster) Trevisan	0.35	0.11	0.47	0.93
2.	*Lycopodium japonicum* Thunberg.	0.35	0.11	0.47	0.93
3.	*Lycopodiella cernua*(L.) Pich. Sermolli	1.39	0.87	0.93	3.19
4.	*Selaginella ciliaris* (Retz.) Spring	1.32	2.07	2.34	5.73
5.	*Selaginella monospora* Spring.	1.51	1.42	1.40	4.33
6.	*Selaginella repanda* (Desv. ex Poir.) Spring.	1.57	0.98	0.93	3.48
7.	*Selaginella chrysocaulos* (Hooker &Greville) Spring.	1.39	0.87	0.93	3.19
8.	*Equisetum ramosissimum* Desf.	1.04	0.98	1.40	3.42
9.	*Helminthostachys zeylanica* (L.) Hook.	0.70	0.22	0.47	1.39
10.	*Ophioglossum reticulatum* Linn.	1.74	1.64	1.40	4.78
11.	*Angiopteris crassipes* Wall. Ex C. Presl.	1.04	0.66	0.93	2.63
12.	*Lygodium flexuosum* (L.) Sw.	1.60	2.51	2.34	6.45
13.	*Marsilea minuta* L.	1.91	2.40	1.87	6.18
14.	*Dicranopteris linearis* (Burm. f.) Underw.	1.51	2.84	2.80	7.15
15.	*Microsorum cuspidatum* (D. Don) Tagawa	1.22	0.76	0.93	2.91
16.	*Microsorum punctatum*(L.) Copeland	2.53	5.57	3.27	11.37
17.	*Drynaria quercifolia* (L.) J. Sm.	1.44	3.60	3.74	8.78
18.	*Drynaria propinqua* (Wall. ex Mett.) J. Sm. ex Bedd.	1.39	0.44	0.47	2.30
19.	*Pyrrosia costata* (C.Presl ex Bedd.) Tagawa &K.Iwats	0.81	1.53	2.80	5.14
20.	*Pyrrosia mannii* (Giesenh) Ching.	2.44	1.53	0.93	4.90
21.	*Pyrrosia lanceolata* (L.) Farwell	1.91	3.60	2.80	8.31
22.	*Pyrrosia stenophylla* (Bedd.) Ching.	2.61	1.64	0.93	5.18
23.	*Lepisorus contortus* (Christ.) Ching.	1.39	0.44	0.47	2.30
24.	*Leptochilus decurrens* Blume subsp. *hemionitideus* Fraser-Jenk.	2.44	1.53	0.93	4.90
25.	*Leptochilus pteropus* (Blume) Fraser-Jenk.	1.74	0.55	0.47	2.76
26.	*Loxogramme involuta* (D.Don) C.Presl.	1.91	1.20	0.93	4.04
27.	*Cyathea gigantea* (Wall. ex. Hook.) Holttum.	0.70	0.44	0.93	2.07
28.	*Hypolepis polypodioides* (Blume) Hooker	0.70	0.22	0.47	1.39

29.	*Microlepia speluncae* (Linn.) Moore	1.04	1.64	2.34	5.02
30.	*Microlepia rhomboidea* (Wall. ex Kunz.) Prantl	0.35	0.22	0.93	1.50
31.	*Lindsaea ensifolia* Sw.	1.39	0.44	0.47	2.30
32.	*Odontosoria chinensis* subsp. *chinensis* (L.) Smith	2.44	3.06	1.87	7.37
33.	*Adiantum philippense* L.	2.35	2.95	1.87	7.17
34.	*Adiantum capillus-veneris* L.	2.55	2.40	1.40	6.35
35.	*Adiantum incisum*Forssk. subsp.*incisum* Fraser-Jenk.	2.09	1.31	0.93	4.33
36.	*Adiantum caudatum* Klotz.	1.74	1.09	0.93	3.76
37.	*Aleuritopteris bicolour* (Roxb.) Fraser-Jenk.	1.22	0.76	0.93	2.91
38.	*Ceratopteris thalictroides* (L.) Brongn.	1.57	0.98	0.93	3.48
39.	*Coniogrammes ferrulata* (Blume) Fee.	0.35	0.11	0.47	0.93
40.	*Onychium siliculosum* (Desv.) Christ.	1.39	0.87	0.93	3.19
41.	*Pityrogramma calomelanos* (L.) Link.	0.87	1.09	1.87	3.83
42.	*Pteris vittata* L. sub sp. *vittata*	1.74	1.09	0.93	3.76
43.	*Pteris alata* L.	1.46	2.29	2.34	6.09
44.	*Pteris biaurita*L.sub sp. *fornicata* Fraser-Jenk.	0.93	0.87	1.40	3.20
45.	*Pteris biaurita* L. subsp.*walkeriana* Fraser-Jenk. & Dom. Rajkumar	1.28	2.40	2.80	6.48
46.	*Pteris aspericaulis* Wall. ex J. Agardh.	0.70	0.22	0.47	1.39
47.	*Pteris ensiformis*Burm. f.	1.04	0.33	0.47	1.84
48.	*Pteris kathmanduensis* Fraser-Jenk. &T.G.Walker	0.35	0.11	0.47	0.93
49.	*Pteris multifida* Poir.	1.74	0.55	0.47	2.76
50.	*Antrophyum reticulatum* (G. Forst.) Kaulf.	1.39	0.87	0.93	3.19
51.	*Vittaria elongata* Swartz	1.80	3.38	2.80	7.98
52.	*Asplenium crinicaule*Hance	1.39	0.87	0.93	3.19
53.	*Asplenium finlaysonianum* Wall. ex Hook et Grev.	0.70	0.22	0.47	1.39
54.	*Thelypteris nudata* (Roxb.) Morton	1.32	2.07	2.34	5.73
55.	*Thelypteris triphylla*(Sw.) Iwatsuki	2.09	2.62	1.87	6.58
56.	*Thelypteris dentata* (Forssk.) Brown. &Jermy	1.74	3.82	3.27	8.83
57.	*Thelypteris arida*(Don) Morton	1.18	1.86	2.34	5.38
58.	*Thelypteris torresiana* (Gaudich) Alston	1.22	0.76	0.93	2.91
59.	*Thelypteris procera* (D. Don) Fraser-Jenk.	0.93	0.87	1.40	3.20
60.	*Thelypteris prolifera* (Retz.) C. F. Reed	1.04	0.66	0.93	2.63
61.	*Diplazium esculentum*(Retz.) Sw.	1.59	4.48	4.21	10.28
62.	*Dryopteris cochleata* (D. Don) C. Chr.	1.39	0.87	0.93	3.19
63.	*Polystichum lentum* (D. Don) T. Moore	1.39	1.31	1.40	4.10
64.	*Polystichum manmeiense* (Christ) Nakaike	0.35	0.11	0.47	0.93
65.	*Tectaria coadunata*(J. Sm.) C. Chr.	0.87	1.09	1.87	3.83
66.	*Tectaria polymorpha* (Wall. ex Hook.) Copeland	1.04	0.66	0.93	2.63
67.	*Nephrolepis cordifolia* (L.) C. Presl.	1.22	0.76	0.93	2.91
68.	*Davallia trichomanoides* Blume	1.86	1.75	1.40	5.01
69.	*Blechnum orientale* L.	1.11	1.75	2.34	5.20
70.	*Stenochlaena palustris* (Burm.) Bedd.	0.35	0.11	0.47	0.93
71.	*Azolla pinnata* R. Br.	2.67	2.51	1.40	6.58
72.	*Salvinia cucullata* Bory	0.70	0.22	0.47	1.39
73.	*Salvinia natans* (L.) All.	1.39	0.87	0.93	3.19

Table 3: Different community indices of Pteridophyte Vegetation of Gorumara National Park, India.

Community Index	Value
Shannon and Wiener Index (Species Diversity)	3.9693
Simpson's diversity index	0.0229
Equitability of evenness (Species Evenness)	2.1302
Margalef index (Species richness)	8.5414
Menhinick's index	0.0159
Equitability Index	0.9251
Berger-Parker Dominance Index	0.0556

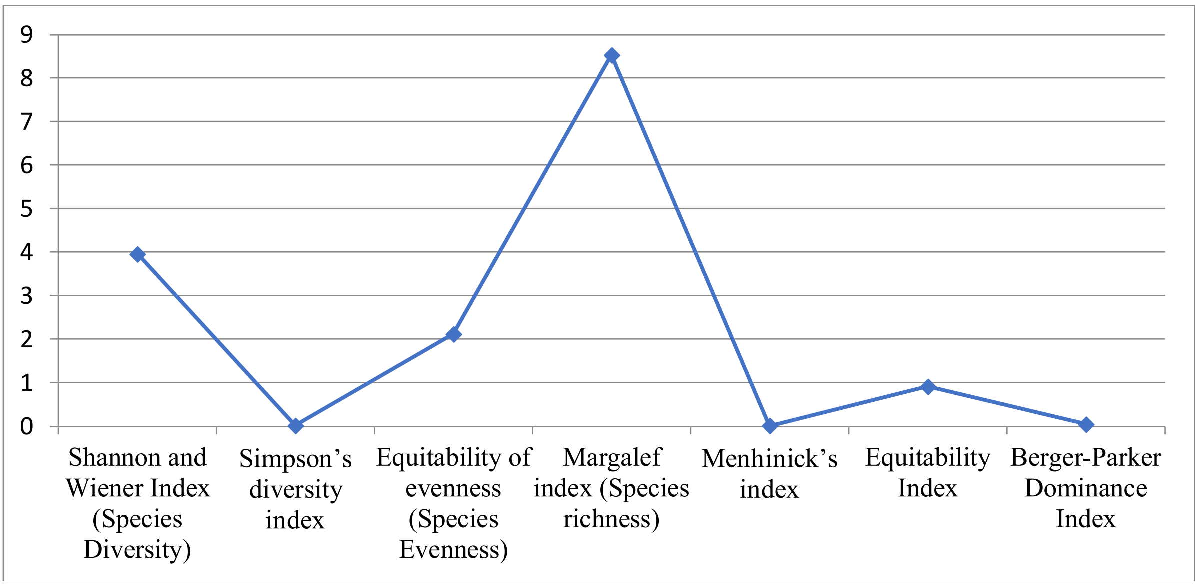


Fig 4: Graphical representation of different community indices of Pteridophyte vegetation

CONCLUSION

Although the survey was conducted for just a few years, the initial assessment offered insights into the varied characteristics of the Gorumara National Park in relation to fern species.This study will establish the foundation for conservation initiatives targeting overlooked plant groups, including pteridophytes, which encompass all ferns and their related species. Pteridophytes also help to create microclimates by modifying the local environment with their leaves and stems. This can include creating a more humid or shaded environment, which can be beneficial for other plants and animals. Regrettably, this region has been subjected to significant anthropogenic pressures for the past two decade. Hence, more research encompassing a broader timeframe and geographical regions is necessary to better elucidate the abundance and diversity of the forest in the coming years.

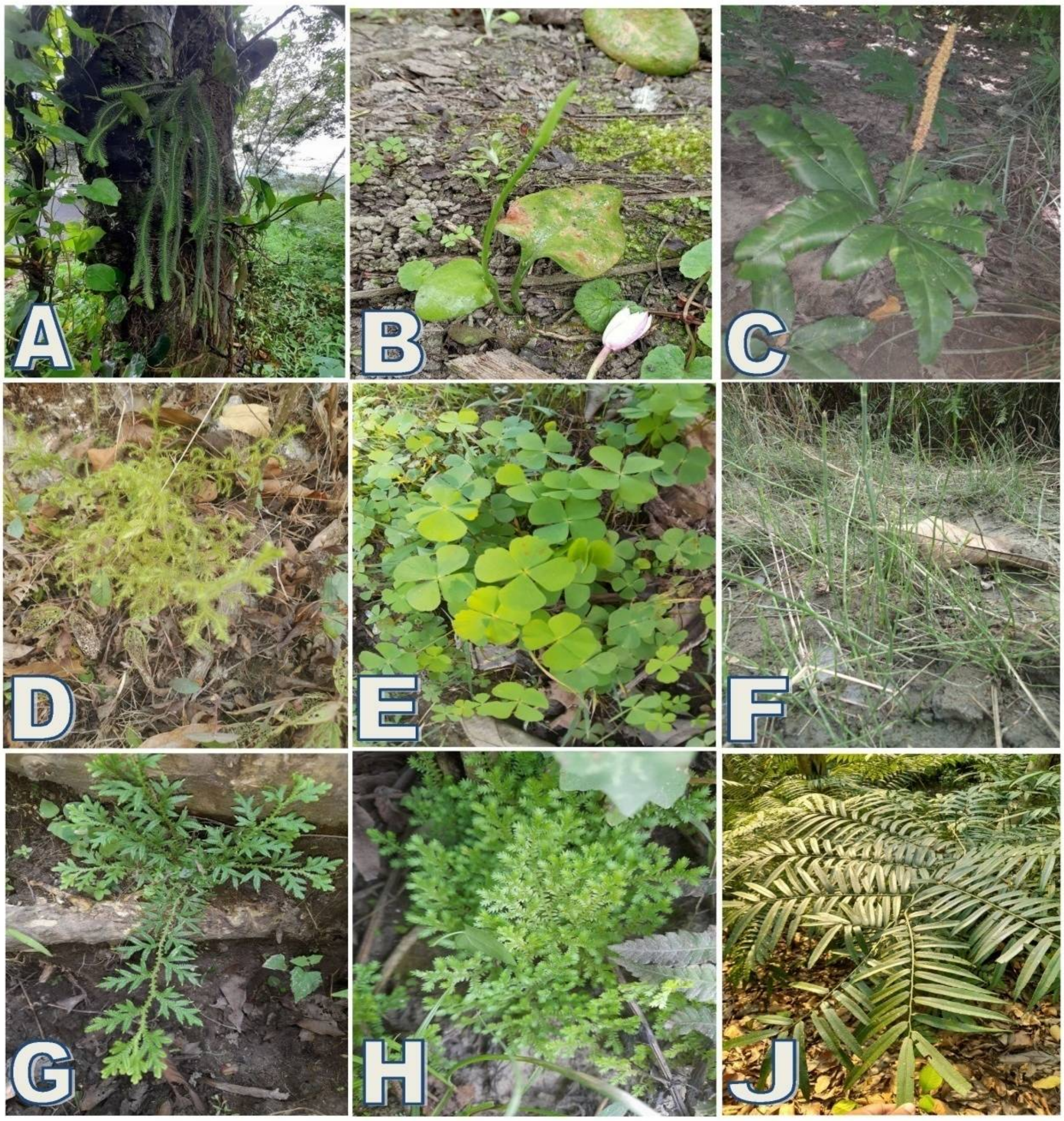


PLATE - 1: A. *Huperzia squarrosa* (Froster) Trevisan; B. *Ophioglossum reticulatum* L.; C. *Helminthostachys zeylanica* (L.) Hook; D. *Lycopodiella cernua* (L.) Pich. Sermolli ; E. *Marsilea minuta* L. ; F. *Equisetum ramosissimum* Desf.; G. *Selaginella monospora* Spring. ; H. *Selaginella ciliaris* (Retz.) Spring ; J. *Angiopteris crassipes* Wall. Ex C. Presl.

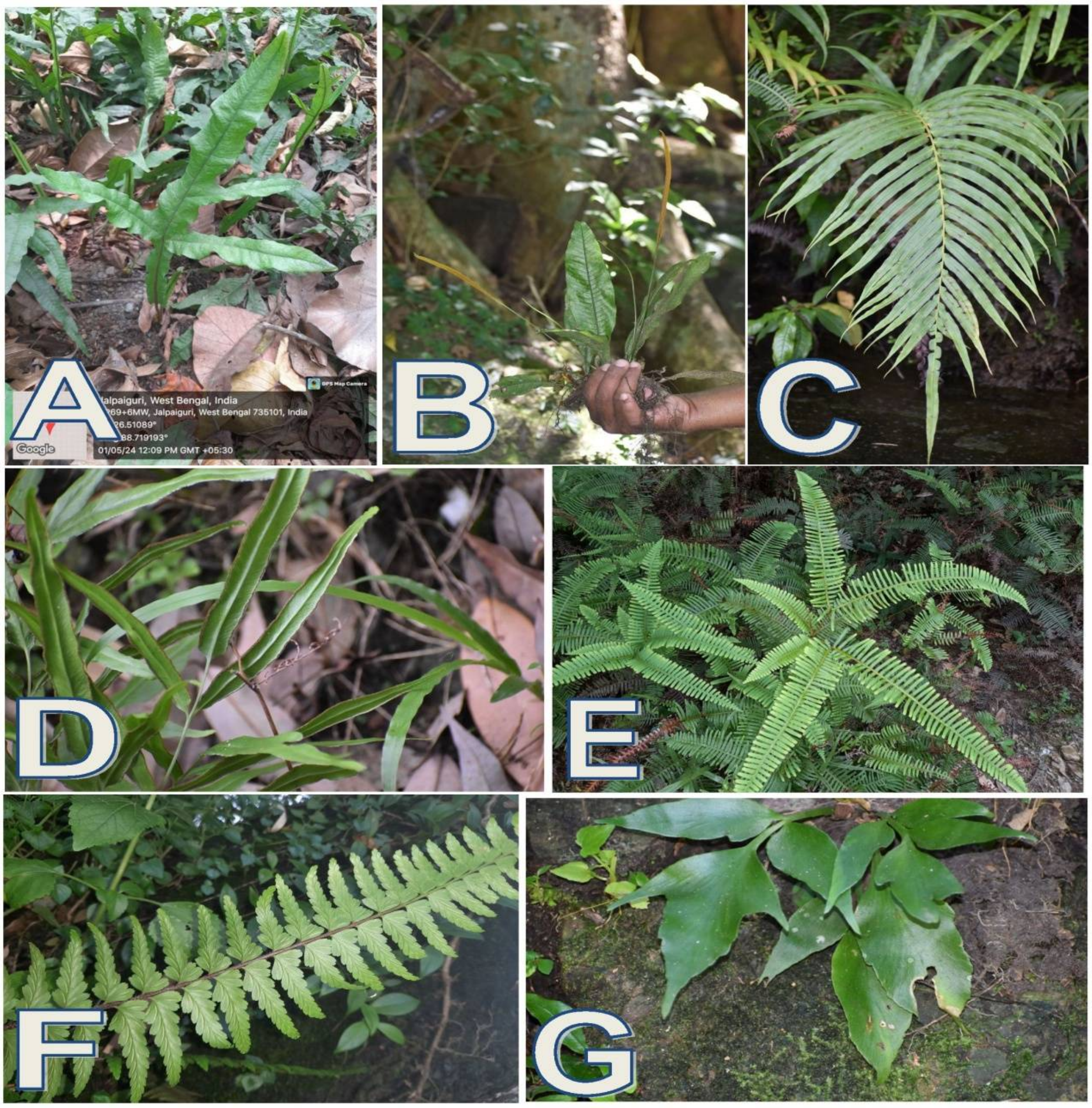
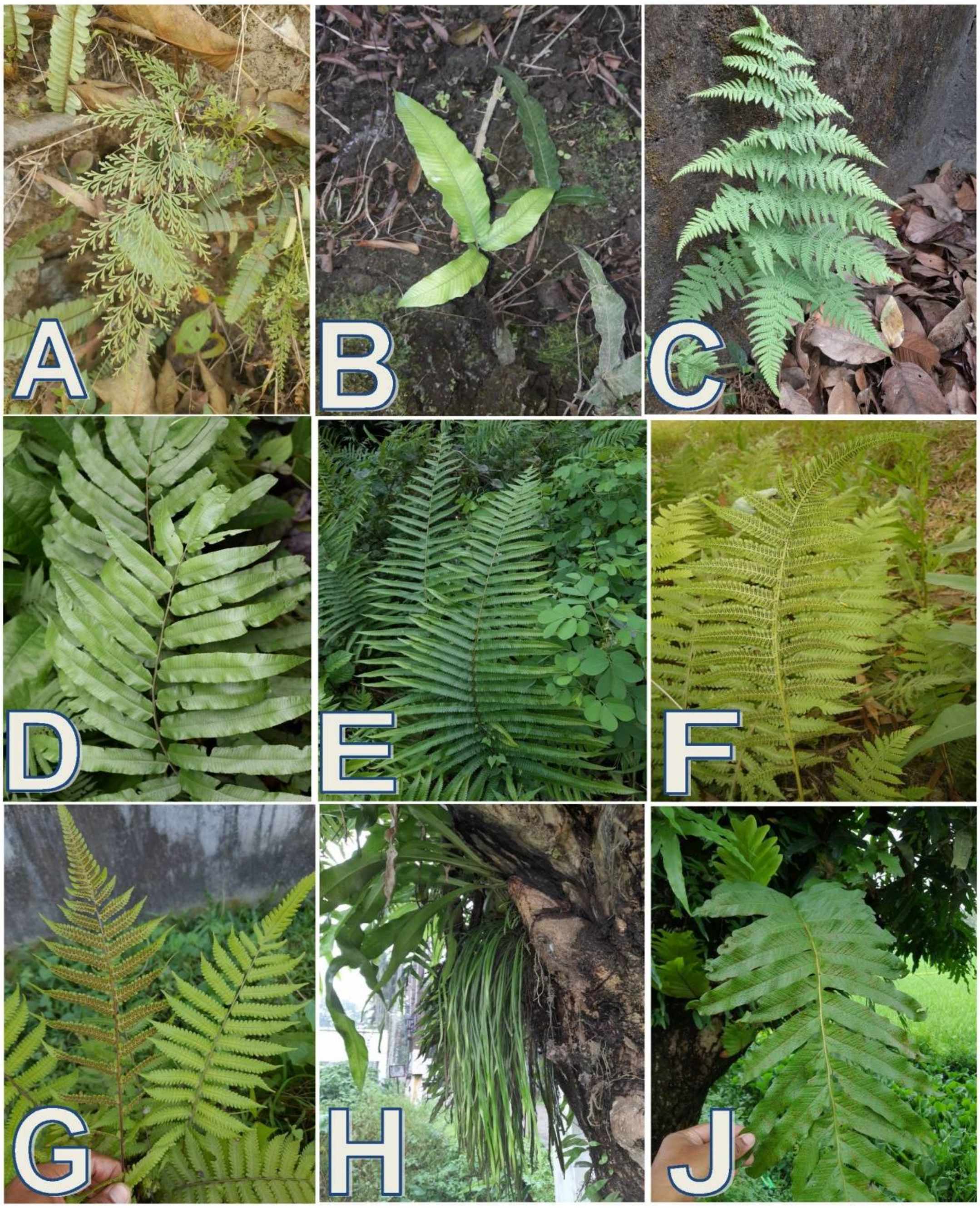
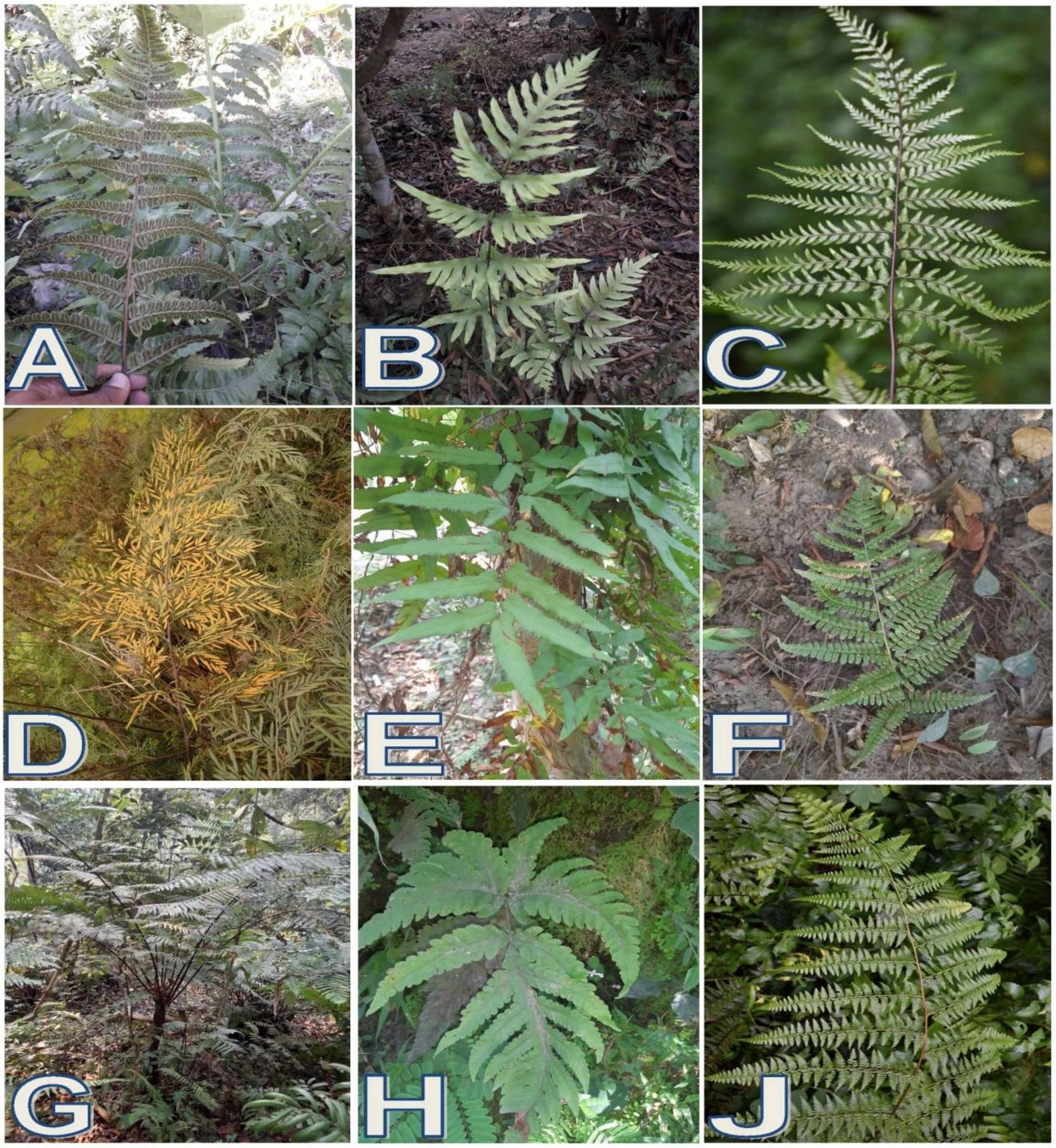


PLATE- 2: A. *Leptochilus pteropus* (Blume) Fraser-Jenk.; B. *Leptochilus decurrens* Blume subsp. *hemionitideus* Fraser-Jenk. ; C. *Blechnum orientale* L. ; D. *Lindsaea ensifolia* Sw. ; E. *Dicranopteris linearis* (Burm. f.) Underw. ; F. *Asplenium crinicaule* Hance ; G. *Asplenium finlaysonianum* Wall. ex Hook et Grev.



PLATE– 3: A. *Odontosoria chinensis* subsp. *chinensis* (L.) Smith ; B. *Thelypteris triphylla* (Sw.) Iwatsuki ; C. *Thelypteris torresiana* (Gaudich) Alston ; D. *Thelypteris nudata* (Roxb.) Morton ; E. *Thelypteris arida* (Don) Morton ; F. *Thelypteris procera* (D. Don) Fraser-Jenk. ; G. *Thelypteris dentata* (Forssk.) Brown. & Jermy ; H. *Vittaria elongata* Swartz ; J. *Drynaria quercifolia* (L.) J. Sm.



PLATE– 4: A. *Diplazium esculentum* (Retz.) Sw. ; B. *Pteris alata* L.; C. *Pityrogramma calomelanos* (L.) Link.; D. *Onychium siliculosum* (Desv.) Christ.; E. *Lygodium flexuosum* (L.) Sw. ; F. *Dryopteris cochleata* (D. Don) C. Chr.; G. *Cyathea gigantea* (Wall. ex. Hook.) Holttum. ; H. *Tectaria coadunata* (J. Sm.) C. Chr. ; J. *Microlepia speluncae* (Linn.) Moore

PLATE - 5: A - G. Different sites of the GNP; H - M: Authors during field survey.

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