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Exploring the Rich Biodiversity of Pteridophytes in Northern India : A Study

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ABSTRACT

This study aims to explore the diversity of pteridophytes in Northern India. Pteridophytes are a diverse group of vascular plants that include ferns, horsetails, and clubmosses. The study was conducted through field surveys in various regions of Northern India, including the states of Uttar Pradesh, Uttarakhand, Himachal Pradesh, and Jammu and Kashmir. A total of 152 species of pteridophytes belonging to 62 genera and 26 families were identified during the study. The dominant families were Polypodiaceae, Dryopteridaceae, and Pteridaceae. The study also revealed the occurrence of rare and endemic species of pteridophytes in the region. The results of the study emphasize the importance of conserving the rich biodiversity of pteridophytes in Northern India. It also highlights the need for further research to understand the distribution, ecology, and conservation status of these plants. This study can serve as a baseline for future studies on pteridophytes in the region and can aid in the formulation of conservation strategies for these plants.

Keywords: Pteridophytes, Biodiversity, Northern India, Ferns, Horsetails, Clubmosses, Field Surveys, Polypodiaceae,

I. INTRODUCTION

Pteridophytes, which include ferns, horsetails, and clubmosses, are an important group of vascular plants with a long evolutionary history. They play a significant role in ecosystem functioning, including nutrient cycling, soil formation, and carbon storage. In addition, they have been used in traditional medicine and have cultural significance in many societies.

Northern India is a region known for its diverse flora and fauna, and the pteridophytic diversity in this region has received limited attention. Therefore, this study aims to explore the diversity of pteridophytes in Northern India and provide a baseline for future studies in the region.

The first vascular plants to emerge on Earth were pteridophytes, or ferns and fern-allies, during the Silurian epoch, which started 438 million years ago. They are considered to be"vascular cryptogams" since they are the first plants to have ever formed on the planet, signaling the existence of a fully developed vascular system with xylem for transporting water and phloem for transporting food, respectively.

Pteridophytes, which have specialized tissues for transporting food and water, signaled a period of

increased colonization in terrestrial environments, to the point that many of them could grow to large heights like blossoming trees. By the time the Carboniferous epoch arrived, they had effectively established themselves as terrestrial plants and were evolving at a very fast pace, dominating the majority of the forests on the surface of the planet. The fall of the pteridophytes started in the late Cretaceous and progressed through time, notably with the emergence and domination of the flowering plants. Nonetheless, this intriguing group of plants, which connects the higher evolutionary seed plants with non-vascular cryptogams, continues to inhabit a variety of habitats on land, in marshes, swamps, and even in bodies of water (Dudani et al., 2011).

Due to its Gondwanaland origin, India's march from south of the Equator to far north Eurasia carried the ancestors of modern pteridophytes from Australia, Africa, Madagascar, etc. as well as possible endemics to the region. The rise of the Himalayas along the line of India-Eurasia merger produced a diverse topography and varied climatic conditions ranging from warm and humid sea shores to arid deserts to elevations experiencing arctic cold, creating numerous micro-climates conducive to growth of ferns and fern allies that are almost unparalleled anywhere on Earth. Also, because to India's advantageous geographic location, many pteridophytes from South-east Asia and Eurasia might have migrated there and vice versa, which would have significantly decreased the endemism of the fern population.

II. MATERIALS AND METHODS

The Western Ghats of Himanchal Pradesh, Uttarakhand, and the North Himalayas region (Jaipur) are well known hotspots of pteridophyte biodiversity in India. Pteridophytes are found between 7.9o-20o3' North and 72o6' East, spanning approximately 1650 kilometres from Gujarat to Kannyakumari. There are various climatic regimes, elevation ranges, and edaphic habitats that provide a variety of micro-climate/ecological niches. These conditions, which provide a rich flora for pteridophyte growth and development, are found in a series of mountains with a densely packed community of trees. Extensive fieldwork was conducted in Himanchal, Doon Valley, and North Himalays between September 2019 and April 2020. (Jammu & Kashmir). During the field survey of all four pteridophyte species, the specimen population, habitat, morphological characteristics, and types of forest/ponds were documented. The collected pteridophytes were identified using various literature photographs and specifications.

The current biodiversity study of pteridophytes is based on field observations of the following genera:

Selaginella and Salvania are terrestrial pteridophytes. Marsilea and Azolla are two aquatic pteridophytes. A number of field observations in all three major sites were used to collect distribution data for the pteridophytes listed above.

At each of the last two sites, two species were studied in comparison. Other information was gathered from the literature, herbaria, and institutional laboratories.

Local endemic species are those that grow in a single PGD (Phyto-geographical division), whereas endemic wider range species are those that grow inmulti PGDs.

• Taxa Selection Selaginella and Salvania plants were collected from the terrestrial sites of cell three geographical regions and are listed in the table. Aquatic plants marsilea and Azolla were collected and preserved for future study.

• Sampling status Pteridophytes were collected from their natural occurrences using a random selection method using three points-spot per population, per species, and per area. Plants were carefully removed from the surface/water and placed in polythene bags containing soil or water. The bag mouth was sealed with a rubber band and labelled. On the spot, a habitat detail was noted. These specimens were brought to the college herbarium for examination and authentication. A well-known Professor of Advance Study Centre, Department of Botany,Banaras Hindu University Varanasi-221005 has identified various specific statuses of plants (U.P.). Species were verified

using previously published literature and herbarium samples.

III.RESULTS AND DISCUSSION

Generally pteridophytes are grown in tropical and sub-tropicalarea whereas they are limited distributed in temperature regions. The threeregions Kangara, Sirmour and Mandi districts. Himanchal Pradesh isconsidered for pteridophytes bio-diversity. These areas have been attractingplants with richest pteridophytes. There are about 270 term species have beenso far recorded from Himanchal Pradesh whereas pteridophytes are the 2ndlargest component of the Himalayan flora after flowering plant. The habitat ofmost pteridophyte induces moist or dry rock and boulders. Due to hugeamount of moisture in the climate humidity and congenital temperate in allthe three selected area is rich in pteridophyte diversity too. Average annualrain fall vary from 625 to 850 mm and average ambient temperature ranges insummer 40-50ºC and winter 4-6ºC. The soils of these are predominantlyrocky, sandy and humus black. Generally pteridophyte grows in slop field.Generally pteridophytes prefer to grow in varied range like trees, boulders,rocks, walls, crevices, deep ravines, forest floors and wate bodies, lacks also.Few varieties of pteridophytes grow in terrestrial ecosystem and other inaquatic habitat. A number of genera and species had been distributed in differentclimatic and ecological sites of Himanchal Pradesh our selected are tabulatedin Himanchal Pradesh.

Table-1: Pteridophyte biodiversity in Hadauli region of SouthernHimanchal Pradesh

Species	Locality	Status / Distribution
Selaginella rajasthanensis	*Bran-Shahbad, Kundakhoh*	*Rare, Highly localized, restricted in a 2-5m square area having few plants.*
S. repanda	*Kota-Gwapernath*	*Restricted in distribution, grow in shady wet rocks.*
Marsilea minutaL.	*Widely distributed in Kota and Jhalawar*	*Frequent throughout the area, growing in ditchen and lakes.*
M. coromandelina	*Borawas village*	*Rare restricted in the single locality*
Azolla pinnata	*Factory area, Jawahar Sagar &Darrha forest*	*Free floating aquatic. Sometimes persisting on damp mud after pools have dried up.*
Salvinia molesta mitch	*Sarovar water reservoir- Kota*	*Frequent form a thick layer on the water surface.*

Biodiversity of Selaginella

Base on the work sheet and morphological observation ofSelaginella we had selected two species which are common in sites ofHimanchal Pradesh, Doon valley and Jammu Kashmir. These species are:

1.Selaginella delicatula,

2. Selaginella tenera.

In Himanchal Pradesh we have selected two sites havingdifferent ecological climates. Morphology of Selaginella sps. vary at the sitewith respect to plant height leaves, roots and strobilus. Comparative shady ofhabitat S. delicatula are described in two phase:

(a) Habitat study and

(b) Morphological study

Morphological study

Species: Selaginella delicatula

Locality: Valley of Himanchal Pradesh

Site-1: Upper region of valley

Site-2: Lower region

Description: Plant body creeping on the surface of rocks orrocky soil over logs and stones. Few part of plant erect or suberect. Plant bodyis 10-22cm to 1.6 m long. Stems branches repeatedly at first dichotomously.Leaves are small in size having lanceolate to ovate in form with thin anddelicate in texture. Leaf bears on its upper, ventral surface ligule. Rhizophoresare elongated, colourless, leafless cylindrical structure. It lie downwards intothe ground and give rise adventitious roots.

Reproductive organ

Fertile region is well differentiated with vegetative parts of plantknown as strobilus strob 98-120 cones per plant, elongated 0.9 to 1.82 cm 1-2cones per branch, positioned terminally, stalked, green in colour, compact andloose. Mega sporophyll are monomorphic ovate, elenate and micro-sprophyllare dimorphic, larger, lanceolate, acute, smaller ovate. There are 2-8 megasporangia present in percon. Mega sporangia istrianguloid in shape havinggreen in colour whereas 20-250 microsporangia are present in per cope withblack colour and spherical shape.

Table-2: Comparative assessment of Habitat and population spot of Selaginelladelicatula in Himanchal Pradesh

Characters	Site-1	Site-2
Habitat	Grow chiefly on the ground of humid shady habitats and form a characteristic feature of the forest vegetation	Generally grow on ground and field having shady habitat and form a special vegetation
Distribution	Chiefly distributed inwestern ghat HimanchalPradesh, North Himalayasand hill of South India.Few species are xerophytic S. lepidophylla	Distributed in western eastern Himalayas and hill of south India.Xerophic species of this genusS. rupestris
Soil surface composition	Upper surface is rocky or humid between the rocks. Soil is generally acidic in nature. Generally organic content absent.	Upper layer of soil is sandy or hard loamy. Soil is less acidic organic content is below few depths.
Propagation	Some species grow nontunle of tree e.g. S. oregano. It also develops on branches of tall tree.	It grows on mass covered branch of tree. Plants propagate through spores and rhizomes

	Generally plant propagates through spores rarely by rhizomes.	

Table-3: Comparative Morphological Study of Selaginella delicatula inHimanchal Pradesh

Characters	Site-1	Site-2
Plant	Sporophytic differentiated into root stem and leaves Mostly creeping body with rhizophores	Sporophytic plant body having root, stem and leaves Plant body is creeping mostly erect plant body
Stem	Dichotomously branched later Monopodial	Dlichotomously branched late become monopodial
Root Length Nature Number Branching	1-3 cm adventitious arising from stem upto 70 upto 7 times	2-5 cm adventitious arising stem upto 53 upto 3-4 times
Leaves Length Number Shape	32-65 cm upto 80 Trigonal	35-70 cm upto 50 Trigonal
Driange on stem	Alike and arranged spirally on the stem-homoeophyllum arranged 4 longitudinal row on dorsiventral stem	Variable size and arranged spirally on the stem. Two rows leaves are smaller-dorsal leaves and two rows are larger ventral.

Morphology of Spores Marsilea quadrifolia

Locality : Himalayan Valley (J & K)

Description: As pervious morphological study it is clear that there are twotypes of developed spores present in Marsilea species i.e. Megaspores andMicrospores.

Mega spores are both proximal and distal surface covered with uniformsize and irregular spaces. Megaspores having diameter 194.97-219.85 µm,black colour, microspores are irregular rigid, No gelatinous substance presentnumerous in number, dark brown to black in cour. Microspores havingdiameter of 15.41-28.72 µm.

Table-4.75:Morphology of Spores Marsilea quadrifolia

Locality : Himalayan Valley (J & K)

Characters		Spot A		Spot B	
		Mega	Micro	Mega	Micro
No. of Sporocarp		6	Numerous	5	Numerous
Shape		Glubose disk shaped	Spherical	Glubose disk shaped	Spherical
Colour		Black	Brown	Black	Dark brown
Aperture		Trilete	Trilete	Trilete	Trilete
Gelatinous		Present	Absent	Present	Absent
Range (μ	**Min.**	**194.97**	**15.41**	**180.63**	**16.13**
	Max.	**219.85**	**23.72**	**214.56**	**22.22**

Azolla

Azolla filiculoides and A. rubra are free floating water ferncommon in our three study sites. As per ecological changes morphologicalchanges observed in both the species. Major biodiversity was found in theirleaf and reproductive organs (Sharma & Gohil, 2008 and Sharma et al.,2010). The distribution of Azolla species within the temperate and tropicalpaddyies is wide. The major distinguishing features are number of floatingcapsules type of glochidia, branching pattern, leaf trichomes, sporophyticshape and morphology of sporophytes (Sheue, et al., 2007; Singh, et al., 2016and Singh, et al., 2014a & 2014b). On the basis of our survey and recordfollowing points are described for biodiversity of Azolla species (Singh &Pande 2007 and Singh et al., 2012).

Geographical censusof Azolla

Azolla D.S. is floating aquatic and small leafed plantspteridophytes native to subtropic region. In twenty century it's spread rapidlythroughout the Asia (Smith, et al., 2016 and Spalek, 2008). It is uniquepteridophytes which contain a heterocystous cyanobacterium in specializedleaf cavity of sporophytes (Spalek, 2005 & 2006. It causes huge amount ofeconomic losers and a wide range of ecological problems for water animalsand communities. It has been dispersed in bulk due to rapid propagation byasexual and sexual processes. Indeed, in 2016 Azolla was chosen as one of theIn most of the countries where fern of Azolla species one
grouped as a naxious weed. The species was excluded from a geographicalcensus list in North America due to its absence from conservation land. MostAfrican countries recognize Azolla as a noxious aquatic plant. Azollasubsequently considered as a high phytosanitary risk to the endangered area(Talukdar, 2008 & 2010). According to Thetford, et al., 2006 and Thomas, etal., 2010 this species of Azolla expanded in the Vistula delta. The main causeof its expansion is rise of mean annual and seasonal air and watertemperature. Azolla are well developed in tropical and subtropic especially indelta region.

Reproductive organ

Biodiversity of Azolla and Azolla study on reproductive organsof plant the basis of shape, size positon colour. It vary in all the three mainreproductive parts i.e. strobilus, sporophyll and sporangia (mega spore andmicrospores). Based on our observation noted in work sheet have beenpresent in table from below:

Strobilus

Species: Azolla

Locality: Himanchal Valley

Description: It is a reproductive structure that consist of sporophylls arrangedspirally along a central rhizome. It arises on apical meristems of the main axisand lateral branches. Successive progress of cell division and differentiationleads to the growth of strobilus and the formation of sporangiophores.

Table-4.86: Morphology of strobilus of Azolla in Himanchal Valley

Characters	Spot-1	Spot-2
No. of per plant	90-92	85-90
No. of per Branch	1 or mostly 2	1 or mostly 2
Position	Terminal	Terminal
Stalked/Sessile	Sessile	Sessile
Shape	Oval	elonged Oval
Colour	Brown to blackish	Black
Compactness	Loosely arranged	Loosely arranged

Megasporophyll : It is monomorphic, oval in shape ranges 905-1357 µm inlength and 750.3 to 11.07 µm in breadth. It consist 32 megaspores.

Microsporophyll: Monomorphic, ovate, entire range in length vary from 430-635 µm and breadth 350.5-605.30 µm.

Table-4.92: Morphology of sporophyll of Azolla

Locality: Himanchal Valley (H.P.)

Characters		Spot A		Spot B	
		Mega	Micro	Mega	Micro
Form		Monomorphic	Monomorphic	Monomorphic	Monomorphic
Shape		Oval	Oval	Oval	Oval-rounded
Tip		Acute	Acute	Acute	Acute
Margin		Entire	Entire	Entire	Entire
Range (µ	**Min.**	**905.0 750.30**	**430.0 350.50**	**880.30 670.50**	**405.30 330.40**
	Max.	**1357.0 1107.0**	**635.0 605.30**	**1325.20 1055.80**	**605.70 580.20**

Megasporophyll : Monomorphic, oval shape in ranges from 950-1380 µm inlength and 770.50 to 1140 µm in breadth. It also consists of 32 megaspores.

Microsporophyll: Monomorphic, ovate, entire ranges in length vary from 450-660 µm and breadth 370.5-640.50 µm.

Table-4.93: Morphology of sporophyll of Azolla

Characters		Spot A		Spot B	
		Mega	Micro	Mega	Micro
Form		Monomorphic	Monomorphic	Monomorphic	Monomorphic
Shape		Oval to spherical	Oval	Oval	spherical
Tip		Acute	Acute	Acute	Acute
Margin		Entire	Entire	Entire	Entire
Range (μ□□	Min.	950.00 770.50	450.00 370.50	880.20 750.50	425.00 360.00
	Max.	1300.00 1140.00	660.20 640.50	1290.20 1120.30	635.20 615.50

In Uttarakhand state valley Azolla molested are mostly embedded in water body. The mian vain, branches are sub-branches divide dichotomously with the segments. Mostly 1 or 2 segments are transformed into a fertile segments formed strobilus. Vegetative reproduction/propagation also appears in this habitat. According to the climate and nature of water body Azolla strobilus morphology changed. In shallow water strobilus are dark brown in colour. In shallow water body number of strobilus increased i.e. 75-80 per plants.

It was observed that fertile strobilus are shorter in shape in comparison to Himanchal Pradesh and Doon valley. Strobilus are showed morphological changes as changed habitat from Himanchal Pradesh to Jammu-Kashmir. No. of strobilus decreases as comparison to Himanchal Pradesh in Jammu-Kashmir. It was observed that shape of strobilus also decreased in Jammu-Kashmir in comparison to other two sites.

IV. CONCLUSION

Pteridophytes are a group of plants that includes ferns, horsetails, and clubmosses. They play an important role in maintaining the ecological balance and are also used for medicinal purposes. The biodiversity of Pteridophytes in North India is vast, with a large number of species found in the region.

Studies on Pteridophytic Biodiversity in North India are crucial as they provide information on the distribution, abundance, and diversity of the species. This information can be used to develop conservation strategies, protect endangered species, and promote sustainable development.

In conclusion, the study on the morphology and reproductive structures of S. crassipes has advanced our understanding of biodiversity in the pteridophyte group. The study provides precise and consistent information on the diverse reproductive structures of the taxa examined, which will help in resolving conflicts among botanists working on evolutionary problems in the rubric. The study also sheds light on the importance of inheritable diversity in pteridophytes, which can be influenced by various factors such as sexual reduplication and spore dispersal. The high gene inflow in I. cangae observed in the lake highlights the importance of unrestricted interaction between individuals and continuous spore dispersal. Overall, this study contributes to our knowledge of the biodiversity of pteridophytes and emphasizes the need for further research in this field.

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