PTERIDOPHYTIC WEALTH OF SIKKIM HIMALAYA

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ABSTRACT

One of the 17 mega biodiversity country, India possess only 2% land mass of world and harbors more than 7% of the global vascular plant species. Certain territories of India fall under different biodiversity hot spots of the world. Sikkim Himalaya with only 0.2% land surface of India is a small part of the 'Himalaya Biodiversity hot spot' and one of the richest biodiversity area of the country. The unique position, mountainous terrain and climatic variation within a small distance are the main factors for rich and diverse vegetation of the state. The lower vascular plants, Pteridophytes are also one of the richest plant groups in Sikkim Himalaya. On the basis of recent collection tours by author, scrutiny of various published work and after studying Herbaria of Botanical Survey of India (CAL & BSHC), it is clear that the Pteridophytes are represented here by about 500 taxa (480 species and 20 subspecies) which belongs to 25 families (according to the classification of Kramer and Green 1990) and 93 genera (108 genera following Holtum's splinter genera of Thelypteridaceae). Among these, 3 families, 5 genera and 28 species are fern allies and remaining are true ferns. Selaginellaceae is the largest fern ally family represented by about 18 species of Selaginella, followed by Lycopodiaceae (3 genera, 12 species) and Equisetaceae (1genus, 2 species). Among true ferns Dryopteridaceae is the largest family with 23 genera,155 species and 7 subspecies, followed by Pteridaceae (11 genera, 72 species and 7 subspecies), Polypodiaceae (17 genera 67 species and 1 subspecies), Thelypteridaceae (single genus *Thelypteris* or 16 splinter genera/sections, 36 species and 2 subspecies), Aspleniaceae (1 genus, 24 species and 2 subspecies), Dennstaedtiaceae (7 genera and 17 species), Hymenophyllaceae (2 genera and 14 species), Davalliaceae (5 genera and 11 species) and Vittariaceae (2 genera and 11 species). The remaining families are with less than 10 species. *Dryopteris* Adanson is the largest genus with 31 species and 4 subspecies (31+4) followed by *Polystichum* Roth.(29), *Athyrium* Roth.(28), Pteris L. (25+4), *Asplenium* L (24+2), *Diplazium* Sw.(17), *Aleuritopteris* Fee (15), *Lepisorus* (J.Sm.) C. Chr. (11) and *Adiantum* L. (10+2). The remaining genera are with less than 10 species. In tropical and temperate forests at certain places, pteridophytes constitute the dominant vegetation and they grow in diverse habitats. At certain places species of sub- arboreal tree fern *Cyathea* and gigantic fern *Angiopteris;* large thickets of *Gleichenia gigantea* Wall. ex Hook. & Bauer, *Dicranopteris* spp., *Osmunda claytoniana* L. subsp. *vestia* (Wall. ex Milde) A. Love and D. Love, *Dryopteris barbigera* (T. Moore ex Hook.) Kuntze, *Polystichum prescottianum* (Wall. ex Mett.) T. Moore, *Athyrium wallichianum* Ching; *Thelypteris elwesii* (Baker) Ching, *Matteuccia intermedia* C.Chr.; densely covered forest floors by Thelypterioid, Athyrioid and Dryopterioid ferns and thickly claded trees by epiphytic ferns shows the richness and majesty of this fascinating group of plant in the state. Beside that some species are also rare in distribution and few of them are threatened due to change in land use pattern or developmental activities. These rare and threatened species are also highlighted with the conservation strategies. Setting up of a fern garden or a fern sanctuary for the conservation of the rich and diverse fern flora of the state is strongly recommended with suitable justification.

KEYWORDS: Sikkim Himalaya, Pteridophytes, Diversity, Ecological groups, Conservation.

A shoe string fern, named after Sikkim - *Vittaria sikkimensis*

Micropolypodium sikkimensis - a fern new to science, collected for the first time from Sikkim and named after it

INTRODUCTION

Sikkim, a small state of India is situated between 88° 00'58" - 88° 55'25"E and 27° 4'00" - 28°7'48" N and spread over 7096 square km. Strategically the state has three international boundaries. The vast stretch of Tibetan plateau separates it from Tibet (Xizang) province of China in North, Chumbi valley in east separates it from Himalayan Republic of Bhutan and the high altitudinal mountainous water parting of Khangchendzonga range separates it from another Himalayan country Nepal in the west. The Great Rangit, Teesta and Reshi rivers makes national boundary in south with Darjeeling district of West Bengal state. The state is situated in "Himalaya Biodiversity Hot Spot" and with rich biodiversity as well as also awarded as the greenest states of India. The region is also renowned as the cradle of "The Mother Nature Rich Biological Diversity Resources". It is endowed by varied climate, complex topography, extreme altitudinal ranges (between 300-8598m) within a small distance and having unique position within the Himalaya. In general the climate is cold and humid, however, the river valleys are tropical with warm and humid climate on the one hand and on the other hand the far northern regions are similar to Tibetan cold desert. The annual average rainfall is over 250 cm. All these factors supports for the development of various types of forests, habitat diversity, ecological niches, rich and diverse flora and fauna of the state. One can see different types of vegetation within a small distance in this state. Botanically Sikkim and Darjeeling Himalaya are well explored by various botanists of the world since earlier times. The

Ferns growing in forest floors (Mesophyte)

state covers only 0.2% land mass of India but having 30% species (about 4500) of Indian flowering plants, among them about 527 (43%) species are Orchids, 58 are Primulas, 38 are Rhododendrons, 23 are Bamboos, 17 are conifers, 11 are Oaks (Anonymous 2003) and 55 species (ca. 59% Indian species) of *Pedicularis* L. (Garg and Hussain 2010). Many species of angiosperms and few pteridophytes are also used in traditional medicinal systems. The flora of the state is Sino Himalayan type with an admixture of Malaysian, Tibetan, Central Himalayan and some Indo-Gangetic elements. Hilly and mountainous terrain, heavy rains, dense tree canopy, large number of perennial water sources and varied altitudinal zonation results in a rich and diverse Pteridophytic flora of the state.

HISTORY OF PTERIDOLOGICAL STUDY IN SIKKIM

Along with higher plants, ferns and fern-allies of Sikkim were also collected by various pioneering plant collectors (J. D. Hooker, T. Thomson, W.W. Smith, C. B. Clarke, G. H. Cave, W. S. Atkinson, Capt. H. J. Walton, Major F. E. Younghusband, G. A. Gammie, J. Scott, J.S. Gamble, G. King, T. Anderson, H. C. Levinge, Kari, R. Pantling, H. J. Elwes, S.Kurz, Dr. D. Prain, R.E.Cooper, J.L.Lister, Watt, J.H.Lace, Dr. Treutler, N. L. Bor, Ribu and Rhomoo etc.). Besides these renowned field botanists, Bhutia, Lepcha and other local collectors (as King's collector) also collected plants for them. Based on these collections many new species were described and Sikkim pteridophytes were mentioned in various monumental works of renowned taxonomists like William Jackson Hooker (1846,1958,1860,1862,1864); William Jackson Hooker and John Gilbert Baker (1864); Thomas Moore (1857); John Smith (1875); Col. Richard Henry Beddome (1865, 1969, 1870, 1883,1892); Charles Baron Clarke (1880); Charles William Webly Hope (1899,1900, 1901, 1902,1903,1904); John Scott (1874); George Alexander Gammie 1893, John Gilbert Baker 1892, Carl Frederick Albert Christensen (1905, 1913, 1916,1931,1934); Ren-Chang Ching (1930, 1934, 1935,1937, 1958), Pran Nath Mehra (1932), Edwin Bingham Copeland (1947) etc. But the first detailed and descriptive taxonomic reports on the ferns of Sikkim were published by Chinese Pteridologist R. C. Ching (1931a,b,1933,1938 a,b,c).

A herbaium steet of rare *Dryopteris sikkimensis*, collected by Thomas Thompson from Mon Lepcha (Sikkim), 11-12000 ft., A duplicate of type in CAL!

It was late Prof. P. N. Mehra (1907-1994), the first Indian taxonomist who collected the Pteridophytes from Darjeeling and Sikkim Himalaya extensively between 1936-1939, but due to political turmoil (second world war, freedom movement of India, partition of India) his huge Pteridophyte collections and field data from this important phytogeographic region were left at Lahore (Pakistan) during the partition of India. With his new assignment at Punjab University, Chandigarh, Prof. Mehra again started the Pteridological study on this area in 1953, with the help of his research students and contributed the valuable works on the Pteridology of this area (Mehra 1961 a,b; Mehra & Bir 1960, 1964; Mehra and Verma 1957; Mehra and Loyal 1965; Verma 1964). For couple of decades, there was a little stagnation in Pteridophyte research in Sikkim, but, during several Japanese expeditions to Nepal and Eastern Himalaya,

Pteridophytes of this area were also collected along the other groups of plants and mentioned in their reports (Nishida 1966, Ito 1966 and Iwatsuki 1988). After the setting up of a research center of Botanical Survey of India at Gangtok, Sikkim in 1979, though much attention was paid on angiosperms by BSI botanists but few ferns were also collected along with angiosperms and were published in few small reports (Biswas and Basu 1982, Ghosh 1984, Krishna and Das 1984, Singh and Roy 1988). However, during last two decades, Pteridophytes of Sikkim were thoroughly collected by S. R. Ghosh (Ghosh et al.2004) and B.S. Kholia of (Khloia and Ansari 2009, Kholia 2008, 2010 a, b.) of Botanical Survey of India and their valuable collection is deposited in CAL and BSHC. In the meantime Mr. C.R. Fraser Jenkins has also collected few pteridophytes from some localities of Sikkim and deposited them in Forest Herbarium, Deorali, Gangtok, Sikkim.

A herbarium sheet of *Selliguea tricuspis* collected by Cave on 1st August, 1912 from Gangtok; Collected in India from only Sikkim (Namchi, Reshi, Geyzing, Gangtok) and Darjeeling (Goke), but this rare fern has never been collected during last hundred years

MATERIAL AND METHODS

A detailed study on the live plants and herbarium specimens of Sikkim Pteridophytes at BSHC, CAL and Lloyd Botanic Garden, Darjeeling was carried out according to the recent nomenclature, identifications and based on the various published works (Hooker 1846 - 1864; Hooker & Baker 1864; Moore1857; Smith1875; Beddmoe1865 - 1870, 1883 - 1892; Clarke 1880; Hope 1899 - 1903; Scott 1874; Gammie 1893; Copeland 1947; Ching 1931a,b,1933,1938 a,b,c; Mehra 1932; Mehra & Bir 1964; Dixit 1984, 1987, 1992; Khullar 1994, 2000; Fraser Jenkins 1997, 2008; Chandra 2002; Ghosh et. al 2004 etc.). On the scrutiny of these taxonomic information and records an exhaustive checklist of Sikkim Pteridophytes was prepared and verified according to recent nomenclature, erroneous and misidentified species were deleted and then the list was sent to renowned Pteridologist and field botanist Mr. C. R. Fraser Jenkins who kindly corrected the list with his valuable suggestions and inputs. The list is again updated accordingly in his Nepal fern presentation at International Symposium of Pteridology, Palampur, H. P. India in Nov. 2010. The verified list includes about 500 taxa (480 species and 20 subspecies) of Ferns and Fern allies from Sikkim which are grouped in to 25 families (Fig.1) according to the classification of Kramer and Green (1990) and 93 genera (Kramer and Green 1990, Fraser Jenkins 2008, 2009 with some minute alteration). In present communication the richness and diversity of Sikkim Pteridophytes is highlighted with the help of suitable diagrams and Tables (1&2) mentioning the details of families, genera, number of species (including subsp.) and their percentage representation in Indian Pteridophytic flora. The distribution, ecology, rarity, status and threats are also highlighted along with the conservation strategies of this rich and diverse biological heritage of the country.

OBSERVATIONS AND DISCUSSION

The Global diversity of Pteridophytes is yet not very clear, however, the estimated number of species of world pteridophytes is between 9000- 15000 (Smith et al. 2008, Mabberley 1997, Roos 1996, Haufler 1996). On the other hand, according to Kramer and Green (1990), Hassler and Swale (2001) and Moran (2008) there are approximately 13,600 species of pteridophytes, which have been named globally. Similarly, the exact number of Indian species of Pteridophytes is also yet not clear due to certain factors like misidentifications, erroneous and dubious species, new species syndrome, irregular and sudden change of views about many species etc., which can be resolved only after the revision of Indian Pteridophytic flora by thorough explorations and in-depth analysis of herbarium materials at Indian as well as foreign (European, Japanese and Chinese) Herbaria. On scrutiny of various enumerations, checklists and recent publications, it came to notice that the number of Indian Pteridophyte species is between 950- 1000 (Fraser- Jenkins 2008 a, b; Chandra and Fraser Jenkins 2008; Chandra et al 2008), 1050- 1100 (Fraser- Jenkins 2009) or about 1200 (Dixit 1984). But the author feels that after through search in virgin forests of Arunachal Pradesh and N.E. India which are also believed to be the part of center of origin and diversification of Sino Himalayan and/or Asian Pteridophytes or its nearness to the Yunnan province of China where maximum concentration of Asian ferns abound (Ching 1978, 1979, 1988, Ching and Wu 1980; Kung1984; Bir 1988) the number of Indian Pteridophytes will definitely increase above 1200. Moreover, it is true that about 10% of world Pteridophytes occur in the Indian landmass and furthermore more than 40% of Indian Pteridophytes flourish in Sikkim state of India having only 0.2% area of the country. Thus it is true that 4% of the world Pteridophytes occur in a very small landmass of world i.e. in Sikkim (Fig.1).

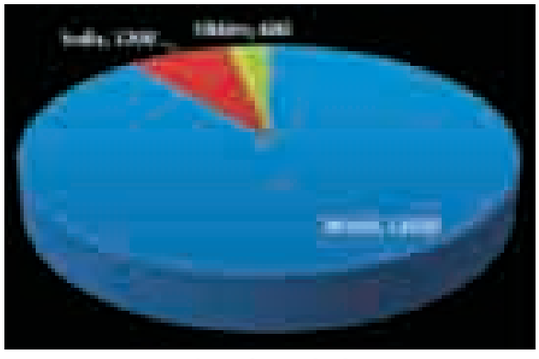


Fig. 1. Number of Pteridophyte species

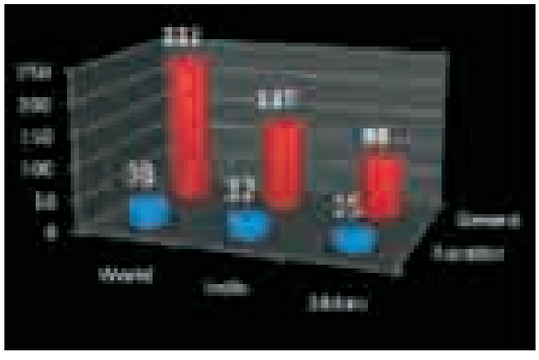


Fig.2. Number of Pteridophyte families and Genera

Out of 38 families of pteridophytes recognized by Kramer and Green (1990), the new world and far eastern families Cheiropleuriaceae (monotypic), Hymenophyllopsidaceae (1 genus 8 species), Lophosoriaceae (monotypic), Loxsomataceae (2 genera 5species), Matoniaceae (2 genera 4 species) and Metaxyaceae (monotypic) are not present in India. Among 32 families occurring in India, seven families viz. Psilotaceae, Isoetaceae, Dipteridaceae, Dicksoniaceae, Marsileaceae, Azollaceae and Salviniaceae are not represented in Sikkim, some of them are tropical and others are far eastern families with one or two genera (Fig.2). Hence 78.12% Indian families are represented in Sikkim. The monogeneric families present in Sikkim are Aspleniaceae, Cyatheaceae, Equisetaceae, Monachosoraceae, Nephrolepidaceae, Plagiogyriaceae and Selaginellaceae. Besides above monogeneric families, Marattiaceae,

Oleandraceae, Osmundaceae and Schizaeaceae are also represented in this area by only one genus. The remaining families are represented by more than one genera, most of them are temperate families, however, cosmopolitan and tropical families are not less in number. Representation of these tropical and warm families in this area is also important and interesting and few places of the state can be treated as transitional zone for temperate and tropical ferns.

Representation of different families and genera of Indian Pteridophytes in Sikkim

Table 1. Fern allies (Lycophyes)

Families	Genera	No. of Species in India	No of Species in Sikkim (+=Subsp.)	% of India species in Sikkim
Lycopodiaceae	*Huperzia* Bernh.	17	7	41.17%
	Lycopodium L.	8	3	37.50%
	Lycopodiella Holub.	1	1	100.00%
Selaginellaceae	*Selaginella* P. Beauv.	42	18	42.85%
Equisetaceae	*Equisetum* L.	4	2	50.00%

Table 2. Ferns

Families	Genera	No. of Species in India	No of Species in Sikkim (+=Subsp.)	Percentage of Indian species in Sikkim
Aspleniaceae	*Asplenium* L	81	24+2	29.62%
Blechnaceae	*Blechnum* L.	5	1	20.00%
	Stenochlaena J.Sm.	1	1	100.00%
	Woodwardia Sm.	1	1	100.00%
Cyatheaceae	*Cyathea* Sm.	16	6	37.50%
Davalliaceae	*Araiostegia* Copel.	9	6	66.66%
	Davallia Sm.	10	1	10%
	Davallodes Copel.	2	2	100%
	Gymnogrammitis Griffith	1	1	100%
	Leucostegia C.Presl.	1	1	100%
Dennstaedtiaceae	*Dennstaedtia* Bernh.	3	2	66.66%
	Histiopteris (J.Agardh) J.Sm.	1	1	100.00%
	Hypolepis Bernh.	2	1	100.00%
	Microlepia C.Presl.	22	8	36.36%
	Lindsaea Drynander ex Sm.	28	2	7.14%
	Pteridium L.	2	2	100.00%
	Sphenomeris Maxon	2	1	50.00%
Dryopteridaceae	*Acrophorus* C. Presl	1	1	100.00%
	Acystopteris Nakai	1	1	100.00%
	Arachniodes Blume	10	7	70.00%
	Athyrium Roth.	50	28	56.00%
	Cornopteris Nakai	5	5	100.00%
	Ctenitis (C.Chr.) C.Chr.	2	1	50.00%
	Cyrtomium. C.Presl.	6	4	66.66%
	Cystopteris Bernh.	5	2+1	40.00%
	Deparia Hook.et Grev.	10	6+1	60.00%

	Diplaziopsis C.Chr.	1	1	100.00%
	Diplazium Sw.	40	17	42.50%
	Dryopsis Holttum & Edwards	6	3	50.00%
	Dryopteris Adans.	61	31+4	50.81%
	Gymnocarpium Newman	3	2	50.00%
	Hypodematium Kunze	1	1+1	100.00%
	Matteuccia Tod.	2	1	50.00%
	Nothoperanema (Tagawa) Ching	2	1	50.00%
	Peranema D.Don	2	2	100%
	Pleocnemia C. Presl	2	1	50.00%
	Polystichum Roth.	50	29	58.00%
	Pteridrys (C. Chr.) Ching	3	1	33.33%
	Tectaria Cav.	26	6	23.07%
	Woodsia R.Br.	8	4	50.00%
Gleicheniaceae	*Dicranopteris* Bernh.	5	3	60.00%
	Gleichenia Sm.	2	1	50.00%
Grammitidaceae	*Micropolypodium* Hayata *(=Xiphopteris* Kaulf.)	1	1	100%
	Tomophyllum (E.Fourn.)Parris (=*Ctenopteris* Blume ex Kunze)	4	1	25%
Hymenophyllaceae	*Hymenophyllum* Sm.	13	6	46.15%
	Trichomanes L.	36	8	22.22%
Lomariopsidaceae	*Bolbitis* Schott.	17	6	35.29
	Elaphoglossum Schott ex J.Sm.	9	2	22.22%
Schizaeaceae	*Lygodium* (L.) Sw.	7	3	42.48%
Marattiaceae	*Angiopteris* Hoffm.	3	2	66.66%
Monachosoraceae	*Monachosorum* Kunze	1	1	100.00%
Nephrolepidaceae	*Nephrolepis* Schott.	6	2	33.33%
Oleandraceae	*Oleandra* Cav.	4	2	50.00%
Ophioglossaceae	*Botrychium* Sw.	6	5	83.33%
	Ophioglossum L.	11	4	36.36%
Osmundaceae	*Osmunda* L	6	2	33.33%
Plagiogyriaceae	*Plagiogyria* (Kunze) Mett.	4	2	50.00%
Polypodiaceae	*Arthromeris* (T. Moore) J.Sm.	10	5	50.00%
	Belvisia Mirbel	3	1	33.33%
	Colysis C. Presl.	2	2	100.00%
	Drynaria (Borry) J.Sm.	7	4	57.14%
	Goniophlebium C.Presl.	3	1	33.33%
	Lemmaphyllum C. Presl	3	2	66.66%
	Lepisorus (J.Sm.)C.Chr.	17	11	64.70%
	Leptochilus Kaulf.	10	3 +1	33.33%
	Loxogramme (Blume) C.Presl	5	5	100.00%
	Microsorum Link.	6	3	50.00%
	Neocheiropteris Christ	2	1	50.00%
	Phymatosorus Pici Serm.	1	1	100.00%
	Pichisermollodes Fraser-Jenk.	10	8	80.00%

	Polypodiodes Ching	8	6	75.00%
	Pyrrosia Mirbel	21	9	42.85%
	Selliguea Bory	8	4	50.00%
	Tricholepidium Ching	3	1	33.00%
Pteridaceae	*Adiantum* L.	15	10 +2	66.66.%
	Aleuritopteris	20	15	75.00%
	Ceratopteris Brogn.	2	1	50.00%
	Cerosora (Baker) Domin.	1	1	100.00%
	Cheilanthes Sw.	11	3	27.27%
	Coniogramme Fee	7	6	85.71%
	Cryptogramma R.Br.	2	2	100%
	Notholaena R.Br.	5	2	40.00%
	Onychium Kaulf.	8	6+1	75.00%
	Pityrogramma Link.	2	1	50.00%
	Pteris L	53	25+4	47.16%
Thelypteridaceae	*Thelypteris*(*Ampelopteris* Kunze)	1	1	100.00%
	Thelypteris(*Christella* A. Leveille)	22	8	36.00%
	Thelypteris (*Coryphopteis* Holttum)	1	1	100.00%
	Thelypteris(*Cyclogramma* Tag.)	2	2	100.00%
	Thelypteris(*Glaphyropteridopsis* Ching)	1	1	100.00%
	Thelypteris (*Macrothelypteris* Ching)	2	2	100.00%
	Thelypteris (*Oreopteris* Holub)	1	1	100.00%
	Thelypteris (*Parathelypteris* (H. Ito) Ching)	2	1	50.00%
	Thelypteris(*Phegopteris* C.Presl)	2	1	50.00%
	Thelypteris(*Pneumatopteris* Nakai)	1	1	100.00%
	Thelypteris(*Pronephrium* C. Presl)	11	3	27.00%
	Thelypteris(*Pseudocyclosorus* Airy Shaw)	7	5	71.42%
	Thelypteris(*Pseudophegopteris* Ching)	6	5+2	83.00%
	Thelypteris(*Stegnogramma* Blume)	4	2	50.00%
	Thelypteris(*Thelypteris* Schmidel)	7	1	14.28%
	Thelypteris(*Trigonospora* Holttum)	3	1	33.33%
Vittariaceae	*Antrophyum* Kaulf.	6	4	66.66%
	Vittaria Sm.	11	7	63.63%

From the Tables it is clear that out of total 108 genera (including splinter genera of Thelypteridaceae) reported from Sikkim, 28 genera contains all the species of respective genera occurring in India hence their representation in Sikkim is 100%. 22 genera are represented by 50% Indian species, however, 24 genera representation is in between 50% - 100% Indian species in Sikkim. Remaining genera are represented by less than 50% Indian species in Sikkim. Thus 74 (68.5%)

genera of Sikkim are represented by more than 50% Indian species and this clearly indicates the rich Pteridophytic wealth of the state. Though the remaining genera are represented by less than 50 % Indian species, but the total number of species within these genera is higher and they form the major and dominant fern vegetation of the state; these genera are *Selaginella* (18 species), *Asplenium* L. (24 species 2 subspecies), *Diplazium* (17), *Pteris* (25 species 4 subspecies) etc.

ECOLOGICAL DIVERSITY AND FERN VEGETATION IN SIKKIM FORESTS

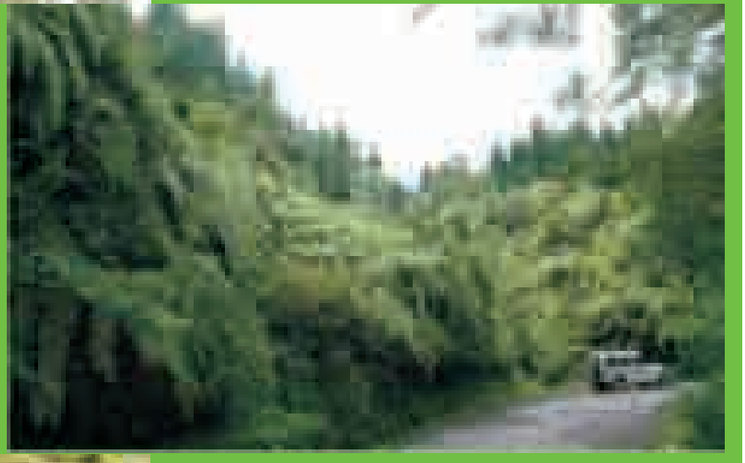
Like in other hilly areas, the habitat of Pteridophytes can be divided here as ferns and fern-allies growing on ground (Mesophyte), on rocks and walls (Lithophyte), on tree trunks (Epiphyte) and the hydrophytes (growing in water). These habitats are with several micro habitats like ferns growing in shady, exposed, humid and dry places, ferns growing along rivers and rivulets, ferns growing in open forests, ferns growing in dense forests, grasslands, rocks, forest margins etc. In general members of Dennstaedtiaceae, Dryopteridaceae, Marattiaceae Monachosoraceae, Thelypteridaceae, Ophioglossaceae, Osmundaceae and Plagiogyriaceae are the chief constituents of ground ferns (mesophytes) which grow in diverse mesophytic habitats. Besides mesophytes, epiphytism is also very rich in Himalayan forests due to the high rainfall and humidity. Members of Polypodiaceae, Davalliaceae, Oleandraceae and Vittariaceae are the chief constituents of the epiphytic fern flora of the state. Almost all the epiphytic ferns and fen-allies can also grow as lithophyte in humid Himalayan forests. Similarly, pteridophytes preferring the lithophyte habitats viz. members of Lycopodiaceae, Selaginellaceae, Grammitidaceae, Oleandraceae, Aspleniaceae and Hymenophyllaceae also grow as epiphyte everywhere in Himalayan forests. But here in Sikkim, beside all the lithophytes, several terrestrial ferns like *Aleuritopteris formosana* (Hayata) Tagawa, *Aleuritopteris albomarginata* (C. B. Clarke) Ching, *Dryopsis apiciflora* (Wallich ex Mett.) Holttum & Edwards, *Nephrolepis cordifolia* (L.) C. Presl, *Botrychium lanuginosum* Wallich ex Hook. et Grev. etc. are also noted occasionally growing as foot epiphytes at certain places due to very dense tree canopy, heavy rains, high humidity, competition for light etc.**.** This is probably by the dispersal of light spores by wind on tree trunks, dense mossy strata provide sufficient humidity for the germination of spores, regular rains maintains sufficient water for fertilization and thick mossy substratum as well as high humus contents on bark of tree supports establishment of

Ferns growing on walls or rocks (Lithophyte)

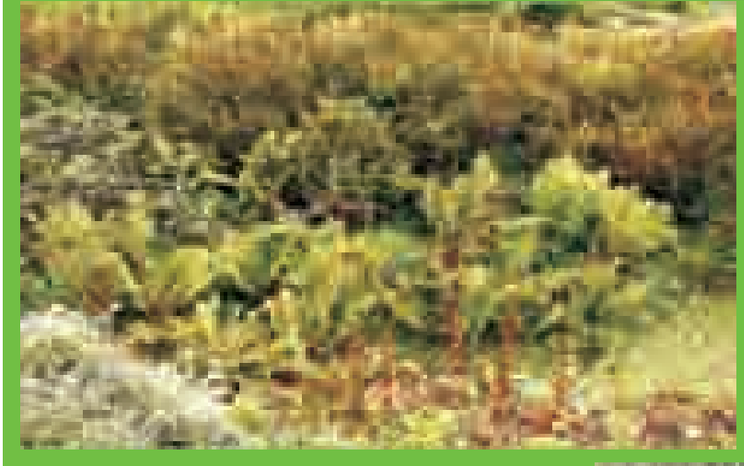
rhizome on them. Similarly, several epiphytic ferns and orchids are also noted growing on slopes of forest floors where there is no water logging. Though these epiphytes establish themselves on tree trunks but due to heavy biomass accumulation, rains, decomposition of branches etc., these established colonies and branches fall from trees and remain alive for few years and gradually die in due course of time. Species of *Lepisorus* (J.Sm.) Ching, *Huperzia* Bernh., *Drynaria* (Bory) J. Sm., *Arthromeris* (T. Moore) J. Sm., *Goniophlebium* C. Presl, *Phymatosorus* Pic. Serm., *Asplenium phyllitidis* D. Don, *Pseudodrynaria coronans* (Wall. ex Mett.) Ching, etc. are seen in such altered habitats within dense forests. Different genera of Pteridaceae either grow as mesophyte *(Pteris, Coniogramme,*) or lithophyte (*Adiantum, Aleuritopteris, Cerosora, Cheilanthes, Cryptogramma, Notholaena*) both mesophyte and lithophyte (*Onychium, Pityrogramma*) but never as epiphyte. The Lomariopsid ferns of state grow in diverse habitats as *Bolbitis major* (Beddome) Hannipman, *Bolbitis costata* (C. Presl) Ching, *Bolbitis heteroclita* (C. Presl) Ching prefers mesophyte habitats; *Bolbitis asplenifolia* (Borry) K. Iwats., *Elaphoglossum stelligerum* (Wall. ex Baker) T. Moore grow in both lithophyte and epiphyte habitats, however, *Elaphoglossum marginatum* (Wall. ex Baker) T. Moore prefers tree trunks. Different types of habitats like valleys, open Sal forests, mixed subtropical forests, dense forests, degraded forests, open forests, fallow land, scrubs, grassland, rocky substrata, ravine land, deep gullies, *Cryptomeria* plantation, road sides, landslide zones, humid dense mixed forests, dense inner Himalayan conifer or mixed forests, subalpine scrub area, alpine meadows and trans Himalayan dry valleys etc. have different types of composition of fern vegetation which is controlled by various factors like altitude, rainfall, humidity, aspect of slope, nearness or distance from foot hills, exposed or shady localities etc.

The climate of Sikkim is classified in to Tropical (below 610m), Subtropical (610-1520m), Temperate (1520-2740m), Sub-alpine (2740-3960m) and Alpine (above 3960m) (Anonymous b. 2004-05); however, the forests are classified (Singh and Chauhan 2000) as Tropical (up to 800m), Subtropical (800-1500m), Temperate (1500 - 3500m) and Alpine (3500 - 5000m). Generally, Pteridophytes are habitat specific plants and distributed according to their specific niches within their range of distribution. The growth and development of sporophyte, perennating of rhizome, germination of spores, development of gametophyte, fertilization, development of zygote and development of new sporophyte etc. are controlled by some specific climatic factors which vary from species to species. Because of hilly terrain, high rainfall, marked altitudinal variation within small distance, aspect and gradient of mountain etc. results in remarkable climatic and habitat heterogeneity in Sikkim. These factors are responsible for complex vegetation in these mountains and also influences the richness, diversity and distribution of ferns and lycophytes at local scale. Thus, there is no clear cut demarcation between different types of climatic and vegetational zones in this small area particularly with reference to pteridophytes. At certain places, many ferns and lycophytes from different climatic and vegetation zones grow together (perhaps it may be true for other groups of plants). In Sikkim, the temperature is higher than the western Himalaya, hence the tropical ferns like *Angiopteris* spp., *Cyathea* spp., *Thelypteris* (*Christella*) *arida* (D. Don) C. V. Morton, *Thelypteris* (*Christella*) *papilio* (C. Hope) K. Iwats., *Pteris biaurta* L., *Thelypteris* (*Pronephrium*) *nudata* (Roxb. C. V. Morton, *Lycopodiella cernua* (L.) Pic. Serm. etc. can be noted growing above 2000 m altitudes. Similarly few high altitude ferns and Lycopods also descend up to 1600 m in shady gullies and cold places due to sudden fall of temperature by irregular local rains. For example, at a few places, both *Lycopodium japonicum* Thunb. and *Lycopodiella cernua* (L.) Pic.Serm. grow together, however, sometimes the former descend up to 1500m and the later ascends up to 2200m. This range overlapping is a remarkable feature which supports evolution and diversification of ferns in the state. Continuous rains provide sufficient humidity for the germination of spore, longevity of gametophyte, more chances for fertilization, enhancement in sexual reproduction, possibilities for hybridization which may augments the development of varous cytotypes, polyploids or natural hybrids. Besides providing sufficient atmospheric humidity the frequent rains also lower the temperature, resulting in the growth of few seasonal ferns and polypods as perennial. On the other hand, many temperate pteridophytes like *Thelypteris* (*Pseudopegopteris*) *aurita* (Hook.) Ching, *Pteris aspericaulis* Wall. ex J. Agardh., *Lepisorus loriformis* (Wall. ex Mett.) Ching , *Lepisorus scolopendrium* (Ching) Mehra and Bir, *Drynaria propinqua* (Wall. ex Mett.) J.Sm., *Athyrium distans* (D. Don) T. Moore, *Aleuritopteris albomarginata* (Clarke) Ching, *Arachniodes speciosa* (D. Don) Ching etc. are seen growing in shady places and gullies of warmer valleys up to 500 m altitude in this state during warmer and drier months. Thus the growth of Pteridophyte is here controlled by local microclimate and the altitudinal range of species may vary to some extent for some habitat specific plants. Due to all these factors the ferns are not distributed uniformly in Himalayan mountains. As a general rule throughout the Himalaya

Epiphytic ferns densely covering tree trunks



Gleichenia gigantea forming gregarious patches in open spaces and forest margins



Dryopteris barbigera forming dense patches in subalpine scrub forests in openings

A fern named after village Lachen- *Polystichum lachenense* (this fern was first collected from Lachen valley by Sir J. D. Hooker along with Thomas Thomson during Hooker's expedition to Sikkim (1849-1851) and described as a new species by his father, famous Pteridologist Sir William Jackson Hooker

the outer part or foot hills near lowland or plains are warmer and dry with little fern diversity but the diversity and richness of pteridophytes increases towards middle Himalaya and lower parts of inner Himalaya up to a certain altitude (moist temperate forests) however, cold and harsh conditions of subalpine and alpine Himalaya act as a limiting factor, where fern vegetation gradually decreases with the increase of altitude and decrease in temperature. Thus the rule of latitudinal fern diversity gradient (Moran 2008) fails in the Himalayan Mountains. Similarly in India, this latitudinal fern diversity gradient (Moran 2008) is also altered by several factors, here the northern part (Himalaya) is richest in fern diversity, the Indo-Gangetic plains bordering to it in south are poorest in fern diversity and gradually when we passes from north to south (central India to peninsular India) the fern diversity increases.

Pteridophytic vegetation in valleys and lower altitudes of Sikkim

Valleys of Rangit (from Melli to Legship) and Teesta (From Melli to Mangan) and their tributaries and lower hills up to 1200 m are with dominant tropical and subtropical elements. These areas are generally hot and dry and without any sign of herbaceous flora or ferns in open places. Generally these low altitude valleys are dominated by Sal forests but in higher altitudes and along the water streams mixed tropical and subtropical forests are common. These mixed forests, gullies and tributaries of Teesta and Rangit are much humid and provide conducive conditions for tropical moist ferns where abundant growth of ferns can be noted throughout the year. In rainy season, many seasonal ferns also grow abundantly on forest floors, on rocks, slopes as well as on tree trunks. The fern vegetation growing in this zone is the combination of Malaysian and Sino Himalayan elements. The common ground ferns growing in these area are *Adiantum caudatum* L., *Adiantum incisum* Forssk., *Blechnum orientale* L., *Bolbitis heteroclita* (C.Presl) Ching, *Deparia boryana* (Willd.)Kato, *Diplazium dilatatum* Blume, *Diplazium esculentum* (Retz.) Sw., *Diplazium polypodioides* Blume, *Diplazium spectabile* (Wall. ex Mett.) Ching, *Dryopteris cochleata* (D. Don) C. Chr., *Dryopteris sparsa* (D. Don) Kuntze, *Lycopodiella cernua* (L.) Pic.Serm., *Microlepia rhomboidea* (Wall. ex Kunze) Prantl, *Microlepia speluncae* (L.) T. Moore, *Nephrolepis cordifolia* (L.) C. Presl, *Onychium siliculosum* (Desv.) C. Chr., *Pityrogramma calomelanos*(L.) Link, *Pteris biaurita* subsp. *fornicata* Fraser- Jenk., *Pteris biaurita* subsp. *walkeriana* Fraser- Jenk. & Dominik Rajkumar, *Pteris vittata* L., *Selaginella repanda* (Desv. ex Poir.) Spring, *Selaginella tenuifolia* Spring, *Tectaria coadunata* (Wall. ex Hook. et. Grev.) C. Chr., *Tectaria fuscipes* (Wall. ex Bedd.) C. Chr. , *Tectaria polymorpha* (Wall. ex Hook.) Copel., *Thelypteris* (*Pseudocyclosorus*) *tylodes* (Kunze) Ching, *Thelypteris flaccida* Blume Ching (syn.: *T. decipiens*), *Thelypteris* (*Ampelopteris*) *prolifera* (Retz.) C.F. Reed, *Thelypteris* (*Christella*) *crinipes* (Hook.) K. Iwats., *Thelypteris* (*Christella*) *arida* (D. Don) C. V. Morton, *Thelypteris* (*Christella*) *dentata* (Forssk.) E. P. St. John, *Thelypteris* (*Christella*) *procera* (D. Don) Fraser- Jenk., *Thelypteris* (*Macrothelypteris*) *ornata* (Wall. ex Bedd.) Ching, *Thelypteris* (*Macrothelypteris*) *torresiana* (Gaudich.) Alston, *Thelypteris* (*Pronephrium*) *lakhimpurensis* (Rosenst.) K. Iwats., *Thelypteris* (*Pronephrium*) *nudata* (Roxb.) C. V. Morton etc.

The common lithophyte ferns of this zone are *Adiantum philippense* L., *Aleuritopteris anceps* (Blanf.) Panigrahi, *Aleuritopteris bicolo*r (Roxb.) Fraser-Jenk., *Asplenium finlaysonianum* Wall. exx Hook., *Bolbitis heteroclita* (C. Presl) Ching, *Colysis elliptica* (Thunb.) Ching, *Colysis pothifolia* (D.Don) C.Presl, *Leptochilus decurrens* subsp. *hemionitideus* (C. Presl) Fraser-Jenk., *Leptochilus insignis* (Blume) Fras.-Jenk., *Leptochilus pteropus* subsp. *pteropus* (Blume) Fraser-Jenk., *Microsorum zippelii* (Blume) Ching, *Phymatopteris cuspidata* (D. Don) J. Sm., *Pteris ensiformis* Burm.f., *Pteris subindivisa* C. B. Clarke etc. *Lygodium flexuosum* (L.) Sw. is common climbing fern of rainy season in these forests which climbs on small bushes, however, *Lygodium salicifolium* C. Presl is rare creeping fern of this zone. *Asplenium phyllitidis* D. Don, *Drynaria quercifolia* (L.) J. Sm., *Huperzia phlegmaria* (L.) Rothm., *Huperzia squarrosa* (G.Forst.) Trevis., *Microsorum membranaceum* (D. Don) Ching, *Microsorium punctatum* (L.) Copel., *Pyrrosia costata* (C. Presl) Tagawa & K. Iwats., *Pyrrosia lanceolata* (L.) Farwell., *Pyrrosia porosa* (C. Presl) Hovenkamp, are the common epiphytes of this region which also grow as lithophyte at several places. The inner valleys at this altitudinal range are slightly damp, shady and cool with common subtropical ferns and scattered Tree ferns (*Cyathea* spp.) and Giant fern (*Angiopteris* spp.). Most of the temperate ferns also descend in these forests at shady and cool places. At several places, *Pseudodrynaria coronans* (Wall. ex Mett.) Ching forms very elegant colonies on tree trunks. Rainy season lithophyte *Cheilanthes tenuifolia* (Burmf.) Sw. is though common in this zone but it is restricted only up to Rangit valley which is slightly warmer than the Teesta valley. Similarly *Pteris pellucida* C. Presl is also restricted to Rangit valley.

South American adventive fern *Pityrogramma calomelanos* (L.) Link is spreading in the remote localities of this area (Fraser Jenkins 2010).

Pteridophytic vegetation in moist montane forests of Sikkim

Different types of Himalayan moist temperate and dense forests occur between 1000 m to 3200 m altitude in Sikkim. These are mostly mixed forests, oak rhododendron forests and conifer forests. These forests are the treasurer house of ferns and fern-allies. These forests have different types of Pteridophytes depending upon their specific habitats and altitudinal range. Beside altitudinal range the distance from foot hills or from main boundary thrust (MBT) is also responsible for the structure and composition of ferns and lycopods in these forests. Due to this factor the fern vegetation of Darjeeling hills differs from the fern vegetation of Sikkim in the same longitudes, same altitudes and even in the same type of forests.

The Pteridophyte vegetation of lower parts of middle hills are combination of pteridophytes of upper ranges of sub-tropical forests and lower ranges of inner Himalayan moist temperate conifer forests. Some common sub-tropical pteridophytes growing in lower ranges of these forests are *Adiantum incisum* Forssk., *Adiantum philippense* L., *Aleuritopteris bicolor* (Roxb.) Fraser-Jenk., *Deparia boryana* (Willd.)Kato, *Diplazium dilatatum* Blume, *Diplazium esculentum* (Retz.) Sw., *Dryopteris sparsa* (D. Don) Kuntze, *Huperzia squarrosa* (G. Forst.) Trevis., *Lycopodiella cernua* (L.) Pic.Serm., *Microsorum membranaceum* (D. Don) Ching, *Microsorium punctatum* (L.) Copel., *Microlepia strigosa* Thunb. C. Presl, *Nephrolepis cordifolia* (L.) C. Presl, *Phymatopteris cuspidata* (D. Don) J.Sm., *Polystichum discretum* (D.Don) J. Sm., *Pityrogramma calomelanos*(L.) Link, *Pteris biaurita* L., *Pyrrosia costata* (C. Presl) Tagawa & K. Iwats, *Pseudodrynaria coronans* (Wall. ex Mett.) Ching, *Tectaria coadunata* (Wall. ex Hook. et. Grev.) C. Chr., *Thelypteris* (*Christella*) *dentata* (Forssk.) E. P. St. John, *Thelypteris* (*Christella*) *procera* etc.

Besides these lower range ferns some common ground ferns of these forests up to 2200m (middle hills) are *Acrophorus paleolulatus* Pic. Serm., *Adiantum tibeticum* Ching & Y. X. Lin, *Adiantum venustum* D. Don, *Angiopteris indica* Desv., *Arachniodes cornucervi* (D. Don) Fraser-Jenk., *Arachniodes henryi* (H. Christ) Ching, *Athyrium distans* (D. Don) T. Moore, *Athyrium drepanopterum* (Kunze) A. Br. ex Milde, *Athyrium pectinatum* (Wall. ex Mett.) T, Moore, *Athyrium schimperi* Muog. ex Fee, *Botrychium lanuginosum* Wall. *ex* Hook. & Grev., *Coniogramme intermedia* Hieron, *Coniogramme procera* Wall. ex Fee., *Coniogramme pubescens* Harion., *Coniogramme serrulata* (Blume)Fee, *Cyathea spinulosa* Wall. ex Hook., *Cyathea chinensis* Copel., *Cyrtomium caryotideum* (Wall. ex Hook. & Grev.) C. Presl, *Cyrtomium hookerianum* (C. Presl.) C. Chr., *Dennstaedtia appendiculata* (Wall. ex Hook.) J. Sm., *Dennstaedtia scabra* (Wall. ex Hook.) T. Moore, *Deparia japonica* (Thunb.) Kato, *Deparia petersenii* subsp. *petersenii* (Kunze.) Kato, *Diplazium dilatatum* Blume, *Diplazium doederleinii* (Luerss.) Makino, *Diplazium forrestii* (Ching ex Z. R. Wang) Fraser- Jenk., *Diplaziopsis javanica* (Blume) C.Chr., *Diplazium kawakamii* Hayata, *Diplazium laxifrons* Rosenst., *Diplazium maximum* (D. Don) C. Chr., *Diplazium stoliczkae* Bedd., *Dryopteris gamblei* (C.Hope) C. Chr., *Dryopteris juxtaposita* H. Christ, *Dryopteris pulvinulifera* (Bedd.) Kuntze, *Equisetum diffusum* D.Don, *Histiopteris incisa* (Thunb.) J. Sm., *Hypolepis polypodioides* (Blume) Hook., *Monachosorum henryi* H. Christ, *Plagiogyria pycnophylla* (Kunze) Mett., *Pteridium revolutum* (Blume) Nakai, *Pteris aspericaulis* Wallich ex Agardh, *Pteris longipes* D.Don, *Pteris normalis* D.Don, *Pteris scabririgens* Fraser-Jenk., S.C.Verma & T.G.Walker, *Pteris spinescens* C. Presl, *Pteris wallichiana* J.Agardh. etc. *Tectaria ingens* Atk. ex C.B. Clarke) Holttum etc. Huge thickets of *Gleichenia gigantean* Wall. ex Hook. & Baur, *Dicranopteris* spp. *Peranema cyatheoides* D. Don, and *Pteridium revolutum* (Blume) Nakai are very common in open places in this zone.

The common lithophytes growing in this area are *Adiantum capillus-veneris* L., *Adiantum venustum* D.Don., *Aleuritopteris albomarginata* (C.B. Clarke) Ching, *Aleuritopteris formosana* (Hay.) Tagawa, *Aleuritopteris rufa* (D. Don) Ching, *Araiostegia pulchra* (D.Don) Copel., *Araiostegia squamata* (Decne.) Fraser-Jenk., *Arthromeris wallichiana* (Spreng.) Ching, *Asplenium amoenum* C. Presl ex Mett., *Asplenium cheilosorum* Kze ex Mett., *Asplenium gueinzianum* Mett. ex Kuhn., *Asplenium laciniatum* subsp. *laciniatum* D. Don, *Asplenium laciniatum* subsp. *tenuicaule* (Hayata) Fraser-Jenk., *Asplenium normale* D. Don, *Asplenium phyllitidis* D. Don, *Asplenium yoshinagae* Makino *var. indicum* (Sledge) Fraser- Jenk., *Athyrium woodsioides* H. Christ, *Athyrium drepanopterum* (Kunze) A. Br. ex Milde, *Davallodes membranulosum* (Wall. ex Hook.) Copel., *Davallia multidentata* Wall. ex Hook. & Baker, *Leucostegia*

truncata *Drynaria propinqua* (Wall. ex Mett.) J. Sm., *Dryopteris chrysocoma* (H. Christ) C.Chr., *Goniophlebium argutum* J. Sm. ex Hook., *Hymenophyllum* spp., *Lemaphyllum rostratum* (Bedd.) Tagawa, *Lepisorus scolopendrium* (Buch.-Ham. ex D. Don) Mehra & Bir, *Leucostegia truncata* (D. Don) Fraser- Jenk., *Lindsaea odorata* Roxb., *Odontosoria chinensis* (L.) J. Sm., *Loxogramme involuta* (D.Don) C. Presl, *Loxogramme porcata* M. G. Price, *Microsorium membranaceum* (D. Don) Ching, *Goniophlebium lachnopus*(Wall. ex Hook.) Beddome, *Polypodium microrhizoma* C.B.Clarke ex Baker, *Polystichum obliquum* (D.Don.) T. Moore, *Pteris subquinata* Wall. ex Agardh., *Pyrrosia flocculosa* (D. Don) Ching, *Pyrrosia lingua* (Thunb.) Farwell., *Pyrrosia porosa* (C. Presl) Hovenkamp, *Selliguea griffithiana* (Hook.) Fraser-Jenk., *Selliguea oxyloba* (Wall. ex Kunze) Fraser-Jenk., *Tricholepidium normale* (D. Don) Ching etc. Most of these lithophytes also grow as epiphytes along with the species of Polypodiaceae, Davalliaceae, Hymenophyllaceae, Grammitidaceae and few species of Asplenium (Spleenworts) .

Above 2200m altitudes the inner or upper hill forests are cooler and damp due to high rains. These upper hill forests extend up to subalpine forest or scrub. These mixed moist forests, oak-rhododendron forests and conifer forests are the major forests of Sikkim and are distributed in all the districts. These forests cover many areas of Khangchendzonga Biosphere Reserve (KBR), Barsey Rhododendron sanctuary, Dzongri, Yoksum, Bakhim, Hilley, Dentam, Uttarey, Chitray and western part of West Sikkim bordering Nepal; Maenam, Lingi, Sada, Karzi, higher elevations of Tendong forests of South district; Fambong-lho, Shotak, Bhusuk, Assam-lingzey, Chuzachen, Nathang, Pangolakha etc. of East district. In North district these forests start from lower elevations due to nearness to inner Himalaya and are abundant, besides the dense forests falling under KBR, forests at Lachung, Lachen, above Chungthang, Phensong RF, Dzongu area etc. comes under this category. The fern vegetation of this zone is mostly dominated by Sino- Himalayan elements. Many ferns growing on upper limits of mid hill forests extend in the lower elevations of these forests. Some of the pteridophytes abundantly growing in such forest floors and along rivulets in these humid forests are *Acrophorus paleolulatus* Pic. Serm., *Arachniodes superba* (Hook.) Fraser-Jenk., *Athyrium atkinsonii* Bedd., *Athyrium attenuatum* (C.B. Clarke) Tagawa, *Athyrium clarkei* Bedd., *Athyrium davidii* (Franch.) Christ, *Athyrium fimbriatum* Wall. ex Moore, *Athyrium flabellulatum* (C.B. Clarke) Tard.- Blot, *Athyrium foliolosum* Wall. ex Moore ex R. Sim., *Athyrium himalaicum* Ching ex Mehra & Bir, *Athyrium micropterum* Freser-Jenk., *Athyrium nephrodioides* (Bak.) Christ, *Athyrium pectinatum* (Wall. ex Mett.) T, Moore, *Athyrium puncticaule* (Blume) T. Moore, *Athyrium rubricaule* (Edgew. ex C.B. Clarke) Bir, *Athyrium rupicola* (Edgew.ex C.W. Hope) C.Chr., *Athyrium schimperi* Muog. ex Fee, *Athyrium setiferum* C.Chr., *Athyrium spinulosum* (Maxim) Milde, *Athyrium strigillosum* (T. Moore et Lowe)T. Moore ex Salmo., *Coniogramme affinis* C. Presl. ex Hieron., *Coniogramme intermedia* Hieron., *Coniogramme procera* Wall. ex Fee., *Coniogramme serrulata* (Blume) Fee, *Cyrtomium anomophyllum* (Zenker) Fraser-Jenk., *Cyrtomium fortunei* J. Sm., *Cyrtomium hookerianum* (C. Presl.) C. Chr., *Dryopsis apiciflora* (Wall. ex Mett.) Holttum &P. J. Edwards, *Dryopsis clarkei* (Baker) Holttum & P. J. Edwards, *Dryopsis ferruginea* (Baker) Holttum & P. J. Edwards, *Dryopsis nidus* (Baker) Holttum &P. J. Edwards, *Deparia allantodioides* (Bedd.) Kato, *Deparia subsimilis* (Christ) Fraser- Jenk., *Diplazium stoliczkae* Bedd., *Dryopteris chrysocoma* (H. Christ) C.Chr., *Dryopteris gamblei* (C. Hope) C.Chr., *Dryopteris hirtipes* (Blume) Kuntze, *Dryopteris juxtaposita* Christ, *Dryopteris redactopinnata* Basu & Panigrahi, *Dryopteris splendens* (Hook.) Kuntze, *Dryopteris wallichiana* subsp. *wallichiana* (Spreng.) N. Hyl., *Dryopteris xanthomelas* (H. Christ) C.Chr., *Dryopteris zayuensis* Ching & S. K. Wu, *Lycopodium japonicum* Thunb., *Monachosorum henryi* H. Christ, *Nothoperanema hendersonii* (Bedd.) Ching, *Nothoperanema squamiseta* (Hook.) Ching, *Osmunda claytoniana* subsp. *vestita* (Wall. ex Milde)A. Love & D. Love, *Osmunda japonica* Thunb., *Onychium cryptogrammoides* Christ, *Onychium japonicum* (Thunb.) Kunze., *Plagiogyria pycnophylla* (Kunze) Mett., *Polystichum longipaleatum* H. Christ, *Polystichum mucronifolium* (Blume) C. Presl, *Polystichum piceopaleaceum* Tagawa, *Polystichum punctiferum* C. Chr., *Polystichum scariosum* (Roxb. in Griff.) C.V. Morton, *Polystichum yunnanense* Christ, *Pteris aspericaulis* Wall. ex Agardh, *Pteris cretica* subsp. *cretica* L., *Pteris dactylina* Hook. *Pteris terminalis* Wall. ex J. Agardh., *Pteris longipinnula* Wall. ex. Agardh, *Pteris puberula* Ching, *Pteris spinescens* C. Presl, *Pteris wallichiana* J.Agardh, *Thelypteris levingei* (C.B. Clarke) Ching, *Thelypteris pyrrhorhachis* (Kunze.) Nayar & Kaur, *Thelypteris rectangularis* (Zoll.) K. Iwats., *Thelypteris auriculata* (J. Sm.) K. Iwats., *Woodwardia unigemmata* (Makino) Nakai etc.

The ferns growing as lithophytes along exposed as well as humid places in these forests are *Acystopteris tenuisecta* (Blume) Tagawa, *Aleuritopteris albomarginata* (C.B. Clarke) Ching, *Aleuritopteris chrysophylla* (Hook) Ching,

Aleuritopteris leptolepis Fraser.- Jenk., *Aleuritopteris formosana* (Hay.) Tagawa, *Aleuritopteris grisea* (Blanf.) Panigr., *Aleuritopteris stenochlamys* Ching, *Araiostegia beddomei* (C. Hope) Ching, *Araiostegiella hookeri* (Moore ex Beddome) Fraser-Jenk., *Asplenium ensiforme* Wall. ex Hook. & Grev., *Asplenium gueinzianum* Mett. ex Kuhn., *Asplenium laciniatum* subsp. *laciniatum* D. Don, *Asplenium paucivenosum* (Ching) Copel., *Asplenium tenuifolium* D. Don., *Athyrium anisopterum* Christ., *Athyrium micropterum* Fraser-Jenk., *Gymnocarpium fedtschenkoanum* Pojark., *Gymnocarpium oyamense* (Baker) Ching, *Gymnogrammitis dareiformis* (Hook.) Ching ex Tardieu & C. Chr., *Hymenophyllum exsertum* Wallich ex Hook., *Hymenophyllum levingei* C.B. Clarke, *Hymenophyllum simonsianum* Hook., *Hymenophyllum tenellum* D. Don, *Micropolypodium sikkimensis* (Hieron.) X. C. Zhang, *Tomophyllum donianum* (Spreng.) Fraser-Jenk. & Parris, *Oleandra wallichii* (Hook.) C. Presl, *Polystichum mehrae* Fraser- Jenk. et Khullar, *Polystichum manmeiense* (Christ) Nakaike, *Polystichum nepalense* (Spreng.) C. Chr., *Thelypteris (Stegnogramma) mollissima* (Fisch. ex Kze.) N. Thapa, *Vittaria flexuosa* Fee, *Vittaria taeniophylla* Copel., *Woodsia elongata* Hook., etc.

Epiphytism is also very rich in these forests due to dense and humid conditions, though most of the epiphytes here are seasonal plants and they wither in cold climate. Few lithophytes as species of *Asplenium, Oleandra, Vittaria, Hymenophyllum, Tomophyllum*, *Micropolypodium* along with *Araiostegia beddomei*, *Araiostegiella hookeri* and most of the members of polypodiaceae growing in this region are epiphytes. Some epiphytes are *Arthromeris himalayensis* (Hook.) Ching, *Arthromeris lehmannii* (Mett.) Ching, *Arthromeris mairei* (Brause) Ching, *Arthromeris tatsienensis* (Franch. & Bureau ex H. Christ) Ching, *Drynaria mollis* Bedd., *Goniophlebium argutum* (Wall. ex Hook.) J. Sm., *Lepisorus contortus* (H. Christ in Baroni & H. Christ) Ching, *Lepisorus loriformis* (Wall. ex Mett.) Ching, *Lepisorus mehrae* Fraser-Jenk., *Lepisorus morrisonensis* (Hayata) H. Ito, *Lepisorus nudus* (Hook.) Ching, *Lepisorus pseudonudus* Ching, *Lepisorus scolopendrium* (Buch.-Ham. ex D. Don) Mehra & Bir, *Pichisermollodes ebenipes* (Hook.) Fraser-Jenk., *Pichisermollodes erythrocarpa* (Mett. *ex* Kuhn) Fraser-Jenk., *Pichisermollodes malacodon* (Hook.) Fraser-Jenk., *Pichisermollodes nigrovenia* (Christ) Fraser-Jenk., *Pichisermollodes quasidivaricata* (Hayata) Fraser-Jenk., *Pichisermollodes stewartii* (Bedd.) Fraser-Jenk., *Pichisermollodes subebenipes* (Ching) Fraser-Jenk., *Selliguea griffithiana* (Hook.) Fraser-Jenk., *Polypodiodes amoena* (Wall. ex Mett.) Ching, *Polypodiodies hendersonii* **(**Bedd.) Fraser-Jenk., *Polypodiodies lachnopus* (Wall. ex Hook.) Ching., *Polypodiodies michrorhizoma* (C. B. Clarke) Ching, *Polypodiodies subamoena* (C.B.Clarke) Ching, *Polypodiodies yunnanense* (Franch.) Fraser-Jenk. etc.

Pteridophytic vegetation in subalpine and alpine Sikkim

The Alpine scrub and alpine meadows are abundant in Sikkim above the moist montane forests. These areas have harsh, cold, dry and windy conditions, hence are not rich in fern diversity. This area remains under snow in winter (November to April). The ferns growing in these areas are well adapted to harsh climatic conditions, their rhizomes remain dormant in winter and starts emerging soon after the rise in temperature and humidity and melting of snow. The mansoon rains provide humidity for the growth of these ferns. All pteridophytes growing here are short lived and fulfill their life cycle in short duration (April- September). Some ferns of upper limits of moist montane forests also ascend sometimes in warmer and exposed localities and in between boulders in many subalpine scrubby regions. *Osmunda claytoniana* L. subsp. *vestita* (Wall. ex Milde) A. Love & D. Love, *Dryopteris barbigera* (Moore ex Hook) O. Kuntze,, *Dryopteris komorovii* Koss., *Athyrium wallichianum* Ching etc., *Polystichum prescottianum var. prescotianum* (Wall. ex Mett.) Moore forms gregarious patches in exposed areas. The other Pteridophytes scattered here and there according to their habitat are *Athyrium attenuatum* (C.B. Clarke) Tagawa, *Athyrium davidii* (Franch.) Christ, *Athyrium dubium* Ching, *Athyrium himalaicum* Ching ex Mehra & Bir, *Athyrium rubricaule* (Edgew. ex C.B. Clarke) Bir, *Athyrium spinulosum* (Maxim) Milde, *Botrychium lunaria* (L.) Sw., *Cheilanthes nitidula* subsp. *nitidula* Wall. ex Hook., (earlier name *Pellaea nitidula*), *Cryptogramma brunoniana* Wall. ex Hook. & Grev., *Cryptogramma stellari* (Gmel.) Prantl, *Cystopteris fragilis* subsp. *fragilis* (L.) Bernh., C. Schrader, *Cystopteris fragilis* var. *dickieana* (R. Sim.) N. Hyland., *Cystopteris moupinensis* Franch., *Dryopteris alpestris* Tagawa ,*Dryopteris barbigera* (T. Moore ex Hook.) Kuntze, *Dryopteris serrato-dentata* (Bedd.) Hayata, *Dryopteris xanthomelas* (H. Christ) C.Chr., *Dryopteris zayuensis* Ching & S. K. Wu, *Lepisorus clathratus* (C.B.Clarke) Ching, *Lepisorus morrisonensis* (Hayata) H. Ito, *Notholaena delavayi* (Baker) C. Chr., *Notholaena himalaica* Fraser Jenkins, *Notholaena marantae* (L.) Desv., *Polystichum atkinsonii* Bedd., *Polystichum bakerianum* (Atk. ex C.B. Clarke) Diels in Engl.& Prantal, *Polystichum shensiense* H. Christ, *Polystichum*

thomsonii (Hook.f.) Bedd., *Polystichum woodsioides* H. Christ, *Polystichum sinense* (Christ) Christ, *Polystichum prescottinum* (Wall. ex Mett.) T. Moore, *Woodsia elongata* Hook. etc.

The trans Himalayan dry valleys and naked or exposed mountain tops and their slopes are with peculiar cold hardy elements of Tibetan or Siberian type, many of which are strictly restricted to these habitats. Some such Pteridophytes are *Botrychium simplex* E. Hitchc. (recently collected by author, Kholia *in press a,b*), *Cryptogramma brunoniana* Wall. ex Hook. & Grev., *Cryptogramma stellari* (Gmel.) Prantl, *Cystopteris fragilis* var. *dickieana* (R. Sim.) N. Hyland., *Dryopteris alpestris* Tagawa , *Dryopteris komorovii* Koss., *Athyrium rubricaule* (Edgew. ex C.B. Clarke) Bir, *Huperzia selago* (L.) Bernh. *ex* Schrank. & M. Martens subsp. *arctica* (Grossh. ex Tolm.) A. Love & D. Love, *Lycopodium annotinum* L. subsp. *alpestre* (Hartm.) A. Love & D. Love, *Lycopodium veitchii* Christ, *Polystichum lachenense* (Hook.) Bedd., *Woodsia andersonii* (Bedd.) H. Christ, *Woodsia cycloloba* Hand.- Mzt., *Woodsia lanosa* Hook. etc.

PTERIDOPHYTES WITH RARE OR RESTRICTED DISTRIBUTION

Beside above common Pteridophytes, several species of Pteridophytes are very rare in distribution within the state though few of them may be common in other part of Himalaya, E. India or S.E. Asia. Among fern-allies *H. phlegmaria* (L.) Rothm., is restricted only along the humid river bank of Teesta between Mangley to Dickhu area (500-700 m) where it is locally common and grows as lithophyte on rocks or epiphyte on tree trunks . The other rare Lycopods *Huperzia fordii* (Bak.) R. D. Dixit, *Huperzia selago* (L.) Bernh. *ex* Schrank. & M. Martens subsp. *arctica* (Grossh. ex Tolm.) A. Love & D. Love, *Lycopodium veitchii* Christ and *Lycopodium annotinum* L. subsp. *alpestre* (Hartm.) Å.Löve & D.Löve were reported from Zemu and Eumtso La (Zemu) by William Wright Smith, of Edinburgh Botanic Garden and the well known author and Superintendant at Lloyd Botanic Garden, George Cave (Smith and Cave). *Lycopodium annotinum* L. subsp. *alpestre* (Hartm.) Å.Löve & D.Löve is recently also collected by the author from North Sikkim (Kholia *in press*) after more than 100 years and it is believed that these fern allies are not as rare as they are believed, but they grow far away from human habitations and are not easy to explore. *Ceratopteris thalictroides* (L.) Brongn. (though yet to be verified for *C. succulenta* (Roxb.) Fraser-Jenk.) only representative of aquatic fern of the state has been collected from the Melli (CAL SRG. 56776; 4-10-1982) in Teesta river valley. *Aleuritoptersi tamburei* (Hook.) Ching, (Kholia and Ansari 2009), *Asplenium daghestanicum* Christ subsp. *aitchisonii* (Fraser-Jenk. & Reichst.) Fraser-Jenk. (Fraser Jenkins 2010), *Dryopteris sikkimensis* (Beddome) Kunze, *Dryopteris vidyae* **(**Fraser-Jenk.) Fraser-Jenk. *Gymnocarpium fedtschenkoanum* Pojark. *Gymnocarpium oyamense* (Baker) Ching, *Pteris medogensis* Ching & S.K.Wu, *Pichisermollodes tibetana* (Ching & S.K.Wu) Fraser-Jenk. are some other ferns with restricted distribution.

Lycopodium veitchii - a rare fern-ally of India, collected by Smith and Cave form Zemu valley on 13-07-1909. Only couple of sheets of this species are housed in CAL and Lloyad Bot. Garden Darjeeling, since then it has not been collected

Other ferns with rare or sparse distribution in the state are *Adiantum edgeworthii* Hook., *Aleuritopteris chrysophylla* (Hook) Ching, *Aleuritopteris dubia* (C. W. Hope.) Ching, *Aleuritopteris grisea* (Blanf.) Panigr., *Aleuritopteris stenochlamys* Ching, *Aleuritopteris subdimorpha* (C.B.Clarke & Baker) Fraser-Jenk. *Antrophyum coriaceum* (D. Don) Wall. ex T. Moore, *Antrophyum obovatum* Baker, *Antrophyum parvulum* Blume, *Arachniodes aristata* (G. Forst.) Tindale, *Arachniodes superba* (Hook.) Fraser-Jenk., *Asplenium capillipes* Makino, *Asplenium delavayi* (Franchet) Copel., *Asplenium excisum* C. Presl., *Asplenium nitidum* Sw., *Asplenium yoshinage* Makino var. *yoshinage* Makino, *Asplenium crinicaule* Hance , *Asplenium pellucidum* Lam., *Asplenium sikkimbirii* (Bir) Fraser-Jenk, *Athyrium anisopterum* Christ., *Athyrium clarkei* Bedd., *Athyrium cuspidatum* (Mett.) Kato, *Athyrium devolii* Ching, *Athyrium dubium* Ching, *Bolbitis asplenifolia* (Bory) K. Iwats., *Bolbitis costata* (C.Presl) Ching, *Bolbitis major* (Bedd.) Hennipman, *Bolbitis virens* (Hook. et Grev.) Schott, *Botrychium daucifolium* Wall. ex Hook.et Grev. *Botrychium ternatum*(Tunb.) Sw., *Botrychium lunaria* (L.) Sw., *Botrychium simplex* E. Hitchc (recently discovered by author), *Cheilanthes trichophylla* Baker, *Cerosora microphylla* (Hook.) R.M. Tryon, *Cornopteris banajaoensis* (Copel.) K.Iwats. & M.G. Price, *Cornopteris decurrenti-alata* (Hook.) Nakai, *Cornopteris opaca* (D. Don) Tagawa, *Cornopteris quadripinnatifida* M.Kato, *Cyathea khasyana* (T. Moore ex Kuhn) Domin, *Cyathea gigantean* (Wall. ex Hook.) Holttum, *Cyrtomium macrophyllum* (Makino) Tagawa, *Cystopteris moupinensis* Franch., *Diplazium bellum* (C. B. Clarke) Bir, *Diplazium latifolium* (D. Don.) T.Moore, *Diplazium longifolium* (D. Don) T. Moore, *Diplazium medogense* (Ching & S. K. Wu) Fraser- Jenk., *Drynaria mollis* Bedd., *Dryopteris alpestris* Tagawa, *Dryopteris atrata* (Kunze) Ching *Dryopteris gamblei* (C. Hope) C.Chr., *Dryopteris costalisora* Tagawa, *Dryopteris pulvinulifera* (Bedd.) Kuntze, *Dryopteris scotii* Ching ex C.Chr., *Dryopteris woodsiisora* Hayata, *Dryopteris yorii* Seriz., *Hymenophyllum khasianum* Baker, *Hymenophyllum levingei* C.B. Clarke, *Hymenophyllum simonsianum* Hook., *Hymenophyllum tenellum* D. Don, *Lemmaphyllum carnosum* (J. Sm. ex Hook.) C. Presl, *Lepisorus sublinearis* (Baker ex Takeda) Ching, *Leptochilus pothifolius* (D.Don) Fraser - Jenk., *Leptochilus pedunculatus* (Hook. & Grev.) Fraser-Jenk., *Loxogramme cuspidata* (Zenker) M. G. Price, *Loxogramme chinensis* Ching, *Loxogramme grammitoides* (Baker) C. Chr., *Lygodium salicifolium*

Lycopodium annotinum subsp. *alpestre* , another rare Lycopod of India, collected by Smith and Cave from Eumtso La during Zemu expedition; recently recollected from North Sikkim by present author after 100 years

C.Presl, *Microlepia hancei* Prantl, *Microlepia platyphylla* (D. Don) J. Sm., *Neocheiropteris ovata* (Fee) Fraser- Jenk., *Nephrolepis undulata* (Afz. ex Sw.) J. Sm, *Nothoperanema squamiseta* (Hook.) Ching, *Onychium ipii* Ching, *Ophioglossum petiolatum* Hook., *Ophioglossum reticulatum* L., *Pichisermollodes tibetana* (Ching & Wu) Fraser-Jenk., *Plagiogyria euphlebia* (Kunze) Mett., *Polypodiodies yunnanense* (Frrench) Fraser-Jenk., *Polystichum mannii* C. Hope *Polystichum acutidens* H. Christ, *Polystichum stenophyllum* H. Christ., *Pteris arisanensis* Tagawa, *Pteris khasiana* (C. B. Clarke) Hieron., *Pteris pellucida* C. Presl, *Pteris semipinnata* L., *Pyrrosia boothii* (Hook.) Ching, *Pyrrosia drakeana* (Franch.) Ching (Recently collected by author), *Stenochlaena palustris* (Burm.f) Bedd., *Tectaria dubia* (C.B. Clarke & Baker) Ching , *Tectaria simonsii* (Bedd.) Ching, *Thelypteris phegopteris* (L.) Sloss. ex Rydb., *Thelypteris* (*Trigonospora*) *tenera* (Roxb.) C. V. Morton, *Trichomanes campanulatum* Wall. ex Roxb in Griff., *Vittaria elongata* Sw., *Vittaria doniana* Mett., *Vittaria linearifolia* Ching , *Vittaria sikkimensis* Kuhn., *Vittaria zosterifolia* Willd., *Woodsia andersonii* (Bedd.) Christ, *Woodsia cycloloba* Hand.-Mazz.*etc.*

Thelypteris elwesii (Baker) Ching, once thought to be very rare (Dixit and Ghosh 1985) and included in Red Data Book by Ghosh (1988) is not so rare or not under any threat. It is widely distributed as weed in Lachung and Lachen valley of north Sikkim. Similarly, *Matteuccia intermedia* C.Chr. also thought to be rare in Sikkim is abundantly growing in open places between Chaten to Zemu in Lachen valley and also at Lachung area.

SOME DOUBTFUL PTERIDOPHYTES IN SIKKIM

Some of the Pteridophytes earlier reported from Sikkim Himalaya in British literature (Beddome 1883, Clarke 1880) have not been collected by recent collectors, either they are not present in present day Sikkim or perhaps few of them are rare and their exact locality is not known. It is also assumed that many such species were from Darjeeling district and foot hills because during British time, Sikkim comprised of both present day Gorkha Hill Council and Sikkim state.

One such example is *Dipteris wallichii* (R. Br.) T. Moore, mentioned in literature from Sikkim is actually from Kalimpong, this species grows in warmer places and extends up to east Nepal (Fraser Jenkins per. discussion and 2010) but is not found in the cooler climate of Sikkim. More confusion on its occurrence in Sikkim was due to herbarium sheets housed in BM (by J.D. Hooker) and CAL from Sikkim. In Central National Herbarium Howrah, CAL 21736 (including a duplicate) is identified by K. Biswas and mentioned the locality Sikkim, Gangtok, with the remark that "collected by General Secretary Sikkim Raj, 1933". Present author feels that either there was a mistake while Dr. Biswas was pasting the label on previously collected unlabelled sheet or it was under cultivation in Gangtok at that time. The nearest collection at CAL of this species is from British Bhutan (Kalimpong) by J. L. Lister 1889 and Bhutan (J. C. White f.n.19, Chung Khat, 5000 ft, date 27-05-1905; R. Lister (?) f. n. 90, 3000 ft, Bank of Dari Chu, 18-01-1912). Similarly *Stenochlaena palustris* (Burm.f) Bedd., is frequently growing in Darjeeling district at Melli but not crossed the river Teesta into Sikkim state. Earlier it was believed to grow in Rungpo area of Sikkim (as per local people) but Rungpo is now developed as a town, and perhaps this species may be eliminated.

Other examples reported from Sikkim are *Aleuritopteris argentea* (S. G. Gamel.) Fee and *Selaginella pulvinata* (Hook. et Grev.) Maxim. The former was collected by Riboo and Rhomoo 4-10-23 no.7634 and the later was collected by Capt. H. J.Walton and Major F. E. Younghusband from Khamba La in 1904 and both were actually from Tibet frontier but erroneously though to be from Sikkim (Fraser-Jenkins, per comm.). Similarly status of *Pteridrys cnemidaria* (Christ) C.Chr. & Ching in Sikkim is also doubtful though it may be present in the foot hills of Darjeeling. Some other species reported from Sikkim like *Plagiogyria euphlebia* (Kunzze) Mett., *Botrychium virginianum* (L.) Sw., *Goniophlebium mengtzeense* (Christ) Rold- Lind., *Christiopteris tricuspus* (Hook.) Christ. *Diplazium squamigerum* (Mett.) Matsum., *Cyathea contaminans* (Wall. ex Hook.) Copel., *Pyrrosia boothii* (Hook.) Ching etc. were not found in recent years. Some of them like *Christiopteris tricuspus* (Hook.) Christ., may recently be eliminated due to habitat destruction. *Cheilanthes trichophylla* Baker also needs further collection from Sikkim, initially this fern was reported by Prof. S. C. Verma from Gangtok to Nathula road but the specimen was lost (see Fraser Jenkins 2008). This fern was also described from Sikkim by Ghosh et al. (2004) but their drawing is from Augustine Hanry's Chinese collection at CAL. Moreover, recently (2010 at Palampur) Prof. Verma informed the precise locality of that plant to present author and efforts will be made to explore the same.

Endemism

On the basis of Dixit (1984) about 16% Indian Pteridophytes are endemic (Bir 1988), but later the list grew up to 530 species (Chandra and Kaur. 1984,Chandra, 1981, 1982, 1998, 2000 , 2001), perhaps this large number was due to lack of field knowledge, erroneous new species as well as unfamiliarity of authors with the Pteridophytic flora of adjoining countries. The northern and eastern part of India is well connected with the other landmasses and realms thus the possibilities of endemism in northern India are less (though some neoendemics or new geographical varieties may be there) than southern and peninsular India, which is also proved by the recent studies and now it was found that the endemism in Indian Pteridophytic flora is not as much (only 47 species less than 10%) as earlier expected (Fraser –Jenkins 2008 b). Furthermore, the fern spores are very light and are dispersed for longer distance by wind to establish themselves in conducive climate. Therefore endemism in Pteridophytes is much less as compared to other groups of plants.

The species like *Asplenium crinicaule* var. *sikkimense* Bir , *Cyathea sikkimensis* C.B. Clarke et Bak., *Athyrium subtriangulare* var. *sikkimense* Bir, *Cystopteris sikkimensis* Ching, *Luanthyrium sikkimensis* Ching , *Diplazium sikkimense* (C.B. Clarke) C.Chr., *Dryopteris sikkimensis* (Bedd.) O. Ktze, *Xiphopteris sikkimensis* (Hieron.) Copel., *Lycopodium sikkimense* Herter, *Elaphoglossum sikkimensis* Biswas et Ghosh, *Palhinhaea cernua* var. *sikkimensis* (Mull.) Kunze, *Hypolepis sikkimensis* Biswas, *Vittaria sikkimensis* Kuhn. *Microlepia sikkimensis* Biswas etc. which were earlier thought endemic to Sikkim are now also reported from other S. E. Asian countries, including Yunnan and Xizang provinces of China and moreover, many of them were erroneous species and now merged in to other species (Fraser Jenkins 1997, 2008).

THREATS AND CONSERVATION OF PTERIDOPHYTES

The general threats of biodiversity like habitat destruction for developmental activities are also responsible for loss of fern diversity. Other threats throughout the Himalaya are cardamom plantation, development of Tea gardens and plantation of tree ferns for aesthetic value are also discussed in detail earlier (Kholia 2010 a, 2010 b, 2010c Kholia and Joshi 2010).

This relic and intermediate group of plants were the dominant vegetation in earth history, they are the main source of present day's coal and petroleum, they are also the ancestors of modern plants. Furthermore, at present this group also plays a key role in the structure and function of every ecosystem. In certain tropical and temperate rain forests the dominant under story and richness of these plants in ground vegetation cannot be neglected. In terms of greenery, biomass production, nitrogen fixation (*Azolla* spp.) carbon assimilation, oxygen release by this group of plants in many ecosystems (including several aquatic ecosystems) are not less than other group of plants, thus their role cannot be neglected. Hence directly and indirectly these plants are also useful to mankind. But least attention is paid on their conservation as compared with higher plants and during the documentation of biodiversity or setting up of priorities for conservation strategies this group of plant is either neglected or not given the importance as the higher group of plants (Kholia 2010, 2010 b, Kholia *et al* 2010). Several sanctuaries like Rhododendron sanctuary, Orchid Sanctuary, Bamboo sanctuary, *Citrus* Sanctuary etc. were established in different part of India as well as in other countries for conserving these special groups, but there is no report about fern park or sanctuary established in any part of the world. It is perhaps because of the belief that Pteridophytes are directly less important to mankind as compared with higher plants as food, fodder, traditional medicine etc. But in modern world the aesthetic value of ferns and fern allies is not less than Orchids, Palms or other ornamental plants. Similarly in the changing environmental scenario these habitat specific plants can be used as the tool for the study of global warming, habitat change etc.

As discussed earlier the climate, topography, altitudinal zonation and position of Sikkim within Himalaya is best suited for the growth of Pteridophytes. The region has affinities with far Eastern as well as western Himalayan elements and almost all the Sino Himalayan, Nepal and Bhutan region ferns also grow here. On the other hand the fern flora of foot hills of the state is similar with the fern flora of Assam, Bengal plains and Central India. Keeping this in view the state is one of the best suited regions for the establishment of National Fern Garden, where almost all the plants can be grown at

Croziers of Diplaziums, locally called as *Ningro* are used as vegetable and sold in markets

A herbal practitioner selling *Equisetum* (Salli - Bisalli) used in traditional medicinal system

different altitudes or field stations within a small distance or within a same ridge or mountain slope. This garden will serve as the gene pool of Pteridophytic diversity of the Nation and center of excellence on Pteridophytes for multidimensional research including fern horticulture, formulation of policies of conservation and sustainable use of this neglected plant group.

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REFERENCES

Anonymous a. 2003. *Our natural resources and our responsibilities*. Information and public relations department, Government of Sikkim Gangtok.

Anonymous b. 2004-5. *Sikkim a statistical profile 2004-2005*.Directorate of Economics, statistics, monitoring and evaluation. Government of Sikkim.

Baker, J. G. 1892. *Summary of the New Ferns which have been discovered or described since 1874*.Clarendon press. Oxford.

Beddome, R. H. 1865-1870. *The Ferns of British India*. 1-120 (1865), 121-150 (1866); 2: 151-210 (1866), 211-255(1867); 256-300 (1868), 301-330(1869), 331-345 (1870). Ghant Brothers Madras. Reprinted in combined Volume.

Beddome, R. H. 1883- 1892. *Handbook to the Ferns of British India: Ceylon and the Malay Peninsula; with Supplement.* Thacker, Spink, and Co., Calcutta, India. 1892. xvi/500/110/(4) pp., 300 ill.

Beddome, R. H. 1883. *Handbook to the Ferns of British India: Ceylon and the Malay Peninsula*; With Supplement. Thacker, Spink, and Co., Calcutta, India. 1892. xvi/500/110/(4) pp., 300 ill.

Beddome, R. H. 1969. *The Ferns of Southern India*. Madras, India. Reprint (1873) Lubrecht & Cramer, India.

Bir, S. S. 1988. Evolutionary trends in the Pteridophytic flora of India. Presidential Address, section of Botany, *75th Indian Science Congress Session, Pune*. pp1-56.

Biswas, M. C. and Basu, S. K. 1982. A new variety of *Polystichum* (D. Don) Moore from Sikkim. *J. Econ. Taxon. Bot.* 3: 961-962.

Chandra, S. 1981. Additions to the Indian fern flora (1960-1980) - 1, *Kalikasan, Philipp. J. Biol.* 10: 177-189.

Chandra, S. 1982. Checklist of ferns endemic to India, *Nova Hedwigia* 36: 241-247.

Chandra, S. 1998. Endemic Pteridophytes of India: A Review, *J. Econ. Tax. Bot.* 22: 157-172.

Chandra, S. 2000. *The ferns of India (Enumeration, Synonyms & Distribution).* International Book Distributors, Dehra Dun, India. 459pp.

Chandra, S. 2001. Additions to the Indian Fern Flora - 2, *J. Econ. Tax. Bot.* 25: 125-144.

Chandra, S and Fraser-Jenkins, C. R. 2008. Threatened Pteridophytes of India. In: S.C. Verma, S.P. Khullar & H.K. Cheema (Eds.): *Perspectives in Pteridophytes*, pp 207-233. Bishen Singh Mahendra Pal Singh, Dehradun, India.

Chandra, S., Fraser-Jenkins, C. R., Alka Kumari and Archana Srivastava 2008. A Summary of the Status of Threatened Pteridophytes of India. *Taiwania*, 53(2): 170-209.

Chandra, S. and Kaur, S. 1984. Additions to the ferns endemic to India, *Indian Fern J.* 1: 83-87.

Ching, R. C. 1930- 1958. *Icones Filicum Sinicarum.* 1: 1-50 (1930) 2: 51-101 91934) 3: 101-150 (1935) 4: 151-200 (1937)5: 201-250 (1958).

Ching, R. C. 1931a. A revision of the genus *Tectaria* from China and Sikkim Himalaya. *Sunyatsenia* 2: 9-36.

Ching, R. C. 1931b. The studies of Chinese ferns VI. The genus *Vittaria* in China and Sikkim, E. Himalaya. *Sinensia* 1: 175-192.

Ching, R. C. 1933. *Lithostegia* a new genus of polypodiaceous ferns from Sikkim- *Yunnan*. *Sin. Contr*. 4: 1-9.

Ching, R. C. 1936-1938. A revision of the Chinese and Sikkim –Himalayan *Dryopteris* with reference to some species from neighboring regions. *Bull. Fan. Mem. Inst. Biol. Bot*. 6: 237-352 (1936), 8: 157-268, 275-337, 363-507 (1938).

Ching, R. C. 1978. The Chinese fern families and genera: Systemic arrangement and historical origin. *Acta Phytotax. Sin.* 16(3): 1-19, 16(4): 16-37.

Ching, R. C. 1979. The Himalaya as a center of concentration for the south eastern Polypodiaceous ferns. *Acta. Bot. Yunnan*. 1: 23-31.

Ching, R. C. and Wu, S. K. 1980. The floristic characteristics of the Xizang (Tibet), Pteridophytic flora in relation to the upheaval of the Himalaya. *Acta Bot. Yunnan*. 2(4): 383-389.

Christensen, C. 1905. *Index Filicum*. Hafniae.

Christensen, C. 1913. *Index Filicum Supplementum* 1: 1906-1912 Hafniae.

Christensen, C. 1916. *Index Filicum Supplementum* 2: 1913-1916 Hafniae.

Christensen, C. 1931. Asiatic Pteridophyta collected by Josheph F. Rock.1920-1924. *Contr. U. S. Nat. Herb.* 26(6) : 265-337. Smithsonian Institution U.S. Nat. Museum. U. S. Govt. Printing Office, Washington.

Christensen, C. 1934. *Index Filicum Supplementum tertium pro annis* 1917-1933 Hafniae.

Clarke, C. B. 1880. A Review of the Ferns of Northern India. *Trans. Linn. Society Series 2: Botany,* Vol. 1. London. (Reprinted in Delhi 1973).

Copeland, E. B. 1947. *Genera Filicum* . Cronica Botanica Co. Waltham Mass. USA

Dixit, R. D. 1984. *A Census of Indian Pteridophytes*. Botanical Survey of India Calcutta .

Dixit, R. D. 1988. *Lycopodiaceae of India*. Bishen Singh Mahendra Pal Singh Dehradun.

Dixit, R. D. 1992. *Selaginellaceae of India*. Bishen Singh Mahendra Pal Singh Dehradun.

Dixit, R. D. and Ghosh, S. R. 1985. *Oreopteris elwesii* (Bak.) Holttum- A poorly known endemic fern, rediscovered. *Bull. Bot. Surv. India* 26: 228-230.

Fraser- Jenkins, C.R. 1997. *New Species Syndrome in Indian Pteridology and Ferns of Nepal.* International Book Distributors, Dehradun.

Fraser- Jenkins, C. R. 2008. *Taxonomic revision of three hundred Indina subcontinent Pteridophytes.* Bishen Singh Mahendra Pal Singh Dehradun.

Fraser- Jenkins, C.R. 2008 b. Endemics and Pseudo-Endemics in Relation to the Distribution Patterns of Indian Pteridophytes. *Taiwania*, 53(3): 264-292.

Fraser-Jenkins, C. R. 2009. A brief comparison of modern Pteridophyte classifications (Families and genera in India). *Indian Fern J.* 26: 107-127.

Fraser- Jenkins, C. R. 2010. Nepal's unknown Pteridophytes, the central Himalayan gap, and the lost work of David Don (invited lecture). In International Symposium on Ferns and Fern-allies: diversity, bioprospection and conservation, Palampur H. P. India pp 3. abstract (typed matter also distributed).

Gammie, G. A.1893. Notes on Sikkim Tree ferns. *J. Linn. Soc. Bot.* 29: 482-485.

Garg, A. and Husain, T. 2010. Sikkim Himalayas – The Megadiversity Centre of *Pedicularis* L. in India. *Taiwania*, 55(2): 186-191.

Ghosh, S. R. 1984. New report of some ferns from Sikkim. *J. Econ. Taxon. Bot*. 5(1): 245-246.

Ghosh, S. R. 1988. *Oreopteris elwesii* (Bak.) Holtt. In Nayar, M. P. and Sastry, A.R. K. (Eds.) *Red Data Book of Indian plants*. Vol. 2. pp.267.

Ghosh, S. R., Ghosh, A., Bishwas, A. and Ghosh, R. K. 2004.*The Pteridophytic flora of Eastern India* 1. *Flora of India* series 4. Botanical Survey of India, Kokata.

Hassler, M. and Swale, B. 2001. Checklist of world ferns. Published by authors online : http:/homepages.caverock.net.nz/ ? bj/fern/list.htm.

Haufler, C. Species concept and speciation in Pteridophytes. In: J. M. Camus, M. Gibby and R. J. Johns (eds) *Pteridology in perspective*, pp.291-305. Royal Botanic Gardens, Kew.

Hooker, W. J. 1846-1864 *Species Filicum,* Volumes I-V. {1: 1-245 t.1-70 (1846); 2: 1-250, t.71-149 (1958); 3: 1-291 t. 141-210 (1860); 4: 1-292, t. 211-280 (1862); 5: 1-314,t. 281-303(1864) }Lubrecht & Cramer. London (Reprinted in 1974).

Hooker, W. J. and Baker, J. G. 1864. *Synopsis Filicum, or A Synopsis of All Known Ferns, including the Osmundaceae, Schizeaceae, Marattiaceae, and Ophioglossaceae*. Robert Hardwicke, London.

Hope, C.W. 1899-1904. The Ferns of North -West India. *J. Bombay Nat. His. Soc.* 12: 315- 325, 527-538, 621-633 (1899); 13: 25-36, 236-251 (1900); 13: 443-461, 657-671 (1901), 14: 118-127, 252-266, 458-480 (1902), 14: 720-749, 15: 78-111 (1903); 15: 415-419 (1904). Reprinted in book form in Delhi with altered pagination.

Ito, H. 1966. Pteridophyta. In Hara, H. (ed.) *The flora of eastern Himalaya*. Results of the botanical expeditions to eastern Himalaya organized by the University of Tokyo, 1960 and 1963. 453-500. Tokyo.

Iwatsuki, K. 1988. An enumeration of the Pteridophytes of Nepal. In: E. Ohaba & Malla (ed.) The Himalayan Plants 1. pp. 231-339. Tokyo

Iwatsuki, K. 1988. An enumerations of the ferns of Nepal, in Ohaba, H and Malla, S. B. (Eds.) *The Himalayan plants* 1: 231-339.

Kholia, B. S. 2008. Pteridophytic diversity of Sikkim Himalaya. *International Symposium on Perspectives in Pteridophytes (Abstract)* pp. 101-102. National Botanical Research Institute, Lucknow.

Kholia, B. S. 2010 a. *Ferns and fern-allies of Sikkim, A pictorial handbook Part-I.* Sikkim state Biodiversity Board and Botanical Survey of India.

Kholia, B. S. 2010 b. Sikkim silver brake Fern at risk. *Curr. Sci.* 99(8): 999.

Kholia, B.S. 2010 c. Sikkim Himalayan Pteridophytes- traditional uses, economic potentials, threats and conservation. *In International Symposium on Ferns and Fern-allies: diversity, bioprospection and conservation, Palampur H. P. India* abstract. pp. 71.

Kholia, B. S. (*in press*) *Ferns and fern-allies of Sikkim, A pictorial handbook Part-II.* Sikkim state Biodiversity Board and Botanical Survey of India.

Kholia, B. S. (*in press*) *Botrychium simplex* E. Hitchock-A new moonwort for Indian Himalaya.

Kholia, B. S. and Ansari, A. A. 2009. On the occurrence of *Aleuritopteris tamburii* (Hook.) Ching in India. *Nat. Acad. Sci. Lett.* 32(7&8): 227-230.

Kholia, B. S. and Joshi, R. 2010. International Year of Biodiversity – Reviewing Practices for Conservation in Eastern Himalaya and Northeast India. *NeBIO* 1(2): 55-61.

Kholia B.S.,Joshi,R,.Usha Lachungpa and P. Das 2010.International Year of Biodiversity- Revisiting Curricula for conservation. *Curr. Sci*.99(1):1637.

Khullar, S. P. 1994. *An illustrated fern flora of west Himalaya Vol I*. International Book Distributors Dehra Dun.

Khullar, S.P. 2000. *An illustrated fern flora of West Himalaya Vol. II*. International Book Distributors Dehradun.

Krishna B. and Das, B. K. 1984. Addition to the Pteridophytic flora of Sikkim Himalaya. *Bull. Bot. Surv. India*. 26(3-4): 220-221.

Kung, H. S. 1984. The Phytogeographical features of Pteridophytes of Sichuan, China with some remarks on the "Polysticho-Dryopteris Flora". *Acta Bot. Yunnan*. 6(1): 27-38.

Mabberley, D.J. 1997. *The Plant Book- a portable dictionary of vascular plants*. Cambridge University Press.

Mehra P. N. and Verma S. C. 1957. Cytology of Indian species of *Onychium*. *Nature*. 180: 715-716.

Mehra, P. N. 1932.*Ceropteris calomelanos* L. in Sikkim Himalaya. *J. Indian Bot. Soc*. 4: 340-341.

Mehra, P. N. 1961 a. Chromosome number of Himalayan ferns. *Res. Bull. Panjab. Univ. (n.s.)* 12: 139- 164.

Mehra, P. N. 1961 b. Cytological evolution of ferns with particular reference to Himalayan ferns. *Proc. Indian Sci. Cong. Presedential Address (part III)* 48: 130-153.

Mehra, P. N. and Bir, S.S. 1960. Cytological observations on the Himalayan species of Athyrium and comments on the evolutionary status of the genus. *Amer. Fern J*. 50: 276-295.

Mehra, P. N. and Bir, S.S. 1964. Pteridophytic flora of Darjeeling and Sikkim Himalayas. *Res. Bull. Pnajab. Univ. (n.s.)* 15: 69- 182.

Mehra, P. N. and Loyal, D. S. 1965. Cytological investigations in the Himalayan *Dryopteris* Adanson. *Caryologia* 18:461- 498.

Moore, T. 1857. *Index Filicum: A synopsis, with characters, of the genera, and an enumeration of the species of ferns, with synonymes, references, &c. &c*. William Pamplin, 45, Frith St. Soho square. London.

Moran, R. C. 2008. Diversity, biogeography and floristics. In: *Biology and evolution of ferns and lycopods.* (Eds.)Tom A. Ranker and Christopher H. Haufler. Cambridge University Press. pp. 367-394.

Nishida, M. 1966. Ophiglossaceae. In Hara, H. (ed.) *The flora of eastern Himalaya*. Results of the botanical expeditions to eastern Himalaya organized by the University of Tokyo, 1960 and 1963. 453-500. Tokyo. Roos, M. 1996. Mapping the World's Pteridophytic diversity- Systematics and flora. In: J. M. Camus, M. Gibby and R. J. Johns (eds) *Pteridology in perspective*, pp.29-42. Royal Botanic Gardens, Kew.

Scott, J. 1874.Notes on the tree ferns of the Sikkim, with description of three new species, and a few supplemental remarks on their relations to the palms and cycads. *Trans. Linn. Soc. London* 30(1):1-44.

Singh V. P. and Roy, S. K. 1988. Cytology of forty-four species from Sikkim Himalaya. *Indian Fern J*. 5: 162-169.

Singh, P. and Chauhan, A. S. 2000. Sikkim: *in Floristic diversity and conservation strategies in India*. Botanical Survey of India. Howrah. pp. 1419-1446.

Smith, A. R., Pryer, K. M., Schuettpelz, P. K., Schneiler, H. and Wolf, P. J. 2008. Fern classification. In: *Biology and evolution of ferns and lycopods.* (Eds.)Tom A. Ranker and Christopher H. Haufler. Cambridge University Press. pp. 417-467.

Smith, J. 1875. *Historia Filicum- An exposition of the nature, number and organography of ferns and review of the principles upon which genera are founded, and the systems of classification of the principal authors, with a new general arrangement ; characters of the genera ; remarks on their relationship to one another ; their species ; reference to authors ; geographical distribution; etc., etc.,* Macmillan & Co. London.

Verma, S. C. 1964. *Cytotaxonomic investigations on some E. Himalayan Pteroids*. Ph. D. Thesis Punjab University Chandigarh.