Indian Journal of Plant Sciences ISSN: 2319–3824(Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jps.htm
2014 Vol.3 (1) January-March, pp. 28-39/Dudani et al.
Research Article

PTERIDOPHYTE DIVERSITY IN WET EVERGREEN FORESTS OF SAKLESHPUR IN CENTRAL WESTERN GHATS

Sumesh N. Dudani[1, 2], M. K. Mahesh[2], M. D. Subash Chandran[1] and *T. V. Ramachandra[1]
[1]Energy and Wetlands Research Group, Centre for Ecological Sciences,
Indian Institute of Science, Bangalore – 560 012
[2]Department of Botany, Yuvaraja's College (Autonomous),
University of Mysore, Mysore - 57005

ABSTRACT
The present study deals with the diversity of pteridophytes in the wet evergreen forests of Sakleshpurtaluk of Hassan district in central Western Ghats. A significant portion of the study area comprises of the Gundia river catchment region which is considered to be the 'hottest hotspot of biodiversity' as it shelters numerous endemic and threatened species of flora and fauna. Survey of various macro and micro habitats was carried out in this region, also a haven for pteridophytes. A total of 45 species of pteridophytes from 19 families were recorded in the study. The presence of South Indian endemics like *Cyathea nilgirensis*, *Bolbitissub crenatoides*, *B. semicordata* and *Osmunda huegeliana* signifies the importance of this region as a crucial centre of pteridophytes. Similar regions in the Western Ghats, rich in network of perennial streams have been targeted widely for irrigation and power projects. With regard to an impending danger in the form a proposed hydro-electric project in the Gundia River, threatening the rich biodiversity, an overall ecological evaluation was carried out in the entire river basin. Special attention was paid to inventorisation of the pteridophytes, seldom ever attempted in such cases. The overall efforts succeeded in thwarting off the imminent project, thereby underscoring the necessity of making such studies as a prerequisite for any development programmes in biodiversity hotspots.

Keywords: *Pteridophytes, Sakleshpur, Western Ghats, Biodiversity hotspots*

INTRODUCTION
Pteridophytes (ferns and fern-allies) are the most primitive vascular plants that appeared on the Earth, in the mid-Paleozoic era during the Silurian period which began 438 million years ago. They are the earliest of the plants ever evolved on the earth heralding the presence of a well developed vascular system -xylem for water and phloem for food transport respectively and hence, are referred as 'vascular cryptogams'. The arrival of pteridophytes, with specialized water and food conducting tissues, heralded an era of greater colonization in terrestrial ecosystems, to an extent that many of them could attain great heights like the flowering trees. After successfully establishing themselves as land plants, a very rapid rate of evolution was stimulated and witnessed among them with which they dominated most of the forests on earth's surface by the approach of carboniferous period. With the passage of time, especially with the evolution and dominance of the flowering plants, beginning in the late Cretaceous, the decline of the pteridophytes began. Nevertheless, this interesting group of plants, bridging the non-vascular cryptogams with the seed plants, higher in the evolutionary hierarchy, continues to occupy numerous niches on the land and in marshes and swamps and even in water bodies (Dudani *et al.*, 2011).

India has a rich and varied pteridophytic flora due to its Gondwanaland origin, its drift from south of the Equator towards Eurasia far north, carrying the progenitors of today's pteridophytes from Australia, Africa, Madagascar etc. as well as probable endemics of its own. The rise of the Himalayas along the India-Eurasia merger line created diversified topography and varied climatic conditions ranging from warm and humid sea shores to arid deserts to elevations experiencing arctic cold, creating numerous

micro-climates congenial for growth of ferns and fern allies, almost unparalleled anywhere on the Earth. Moreover India's strategic geographical position would have facilitated migration of species, including several pteridophytes from Eurasia and South-east Asia and *vice-versa*, a notable factor that would have reduced endemism among the fern community. Today, among the vascular plants, pteridophytes form a major part next only to the angiosperms in India. Of the 12, 000 or so pteridophyte species enumerated in the world, around 1000 species from 70 families and 192 genera occur in India. The major centers for pteridophytes diversity are Eastern and Western Himalayas, Western Ghats, Eastern Ghats, Central India and Andaman and Nicobar Islands.

The Western Ghats constitute one of the 34 global biodiversity hotspots along with Sri Lanka, on account of exceptional levels of plant endemism and by serious levels of habitat loss (Conservation International, 2005). The rugged range of hills stretching for over 1600 km along the west coast from south of Gujarat to the end of the peninsula (lat. 8° and 21° N and long. 73° and 78° E), covering a geographical area of about 160,000 $km^{2,}$ is interrupted only by a 30 km break in Kerala, the Palghat Gap (Radhakrishna, 2001). The Western Ghats have an average height of 900 m, with several cliffs rising over 1000 m. The Nilgiri Plateau to the north and Anamalais to the south of the Palghat Gap exceed 2000 m in many places. Towards the eastern side the Ghats merge with the Deccan Plateau which gradually slopes towards the Bay of Bengal. The Western Ghats of Karnataka state encompasses mainly the districts of Uttara Kannada, Shimoga, Chikmagalur, Hassan, Kodagu, Udupi and Dakshina Kannada, constituting the Central Western Ghats, a region endowed with a wide range of vegetation types and extremely rich biodiversity (Ramachandra *et al.*, 2012).

The presence of perennial streams and rivers, evergreen forests, grasslands and high altitude sholas and many other habitats of this mountain chain harbor almost 320 species of ferns and fern-allies. The pteridophytes tend to increase in number in the north-south direction of Western Ghats, obviously due to the more number of rainy months and higher altitudes with cooler climates. Maharashtra has 64 species of Pteridophytes, most of them confined to northern Western Ghats, (Manickam *et al.*, 2003), Karnataka has about 174 species of pteridophytes, mostly growing in central Western Ghats (Rajagopal and Bhat, 1998) and Kerala and Tamil Nadu together, especially in a block south of Palghat gap alone account for 239 species (Manickam and Irudayaraj, 1992).

There have been some notable studies on the pteridophytes of central Western Ghats in Karnataka with the earliest record of 75 ferns species from North Canara district (Matchperson, 1890). After a gap of more than three decades, Blatter and Almeida (1922) included 90 species of ferns from North Canara district in their work 'Ferns of Bombay'. Subsequent studies on pteridophytes of Karnataka included collection of four species of *Selaginella*from the state by Alston (1945); listing of 25 species of pteridophytes by Kammathy *et al.*, (1967); preparation of an artificial key for the 70 species of pteridophytes recorded from Mysore city and its neighbouring areas; inclusion of 10 species of fern family Thelypteridaceae in 'Flora of Hassan District' by Holttum (1976) and inclusion of 12 species of fern by Yoganarasimhan *et al.*, (1981) in 'Flora of Chikmagalur District. After a significant time gap, there has been a surge in various research aspects of pteridophytes of central Western Ghats. Some of the recent studies on ferns and fern-allies include the record of 23 species of pteridophytes in Madhuguni state forest of central Western Ghats by Deepa *et al.*, (2011); enumeration of 22 species of pteridophytes from Agumbe forest of central Western Ghats (Nataraja et al, 2011); survey and record of 21 species of pteridophytes in the Yana sacred forests of central Western Ghats by Dudani *et al.*, (2013) and record of 38 taxa of pteridophytes from Kemmangundi forest of Karnataka by Deepa *et al.*, (2013). As it is evident from the available literatures, there is still a serious derth of information pertaining to the pteridophyte diversity of many important biodiversity rich areas of Karnataka. Hence, this study was taken up with the aim of exploring the pteridophytic diversity as a part of an ecological study carried out by our multi-disciplinary team during 2010-11 in the Sakleshpurtaluk of Hassan district.

MATERIALS AND METHODS

Hassan is one of the districts from the central Western Ghats of Karnataka State, located between Lat.12°31' and 13°33' N and Long. 75°33' and 76°38' E. Our study region was mainly confined to the basin of the Gundia River and its adjoining areas (Figure 1) falling in Sakleshpurtaluk. Gundia, originating at an elevation of about 1400 m in the mountains is an important tributary of the west flowing river Kumaradhara. The Gundia catchment comes under the influence of South-west monsoon in the months of June to September. The average annual rainfall received by Sakleshpur is around 2316 mm. The study was carried out as a part of the integrated ecological study of the heavily wooded Sakleshpur region during 2010-2011. Various macro and micro habitats mainly associated with the *Dipterocarpus indicus – Kingiodendron pinnatum- Humboldia brunonis* type climax evergreen-semievergreen forests of low elevation (0-850 m elevation) and *Mesuaferrea – Palaquium ellipticum* type of medium elevation (650-1400 m) forests and their various degradation stages accounted for majority of the ferns observed in the region. The geographical co-ordinates of the locations surveyed were noted down using pre-calibrated GPS (global positioning system).The taxa were identified using appropriate floras, journals, monographs and revisions (Manickam and Irudayaraj 1992; Fraser-Jenkins 2008a; Rajagopal and GopalkrishnaBhat 1998). Special emphasis was given to the occurrence of endemic and threatened pteridophytes (as evaluated by Fraser-Jenkins 2008b and Chandra *et al.*, 2008).

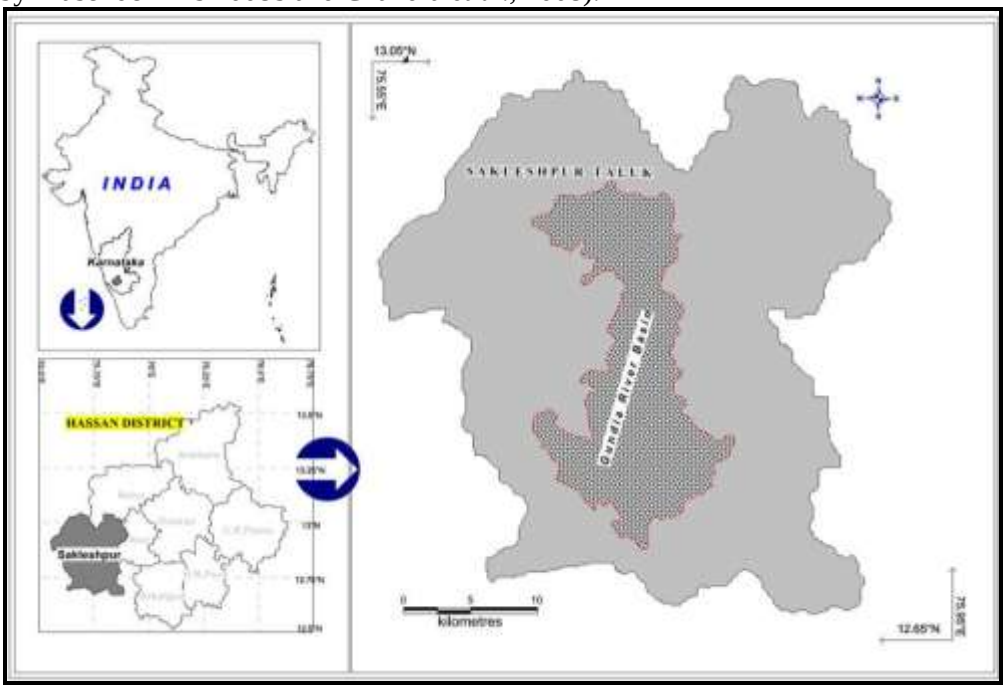

Figure 1: Map showing the location of Sakleshpur and Gundia region

RESULTS AND DISCUSSION

Gundia river basin (Figure 2) is situated along the narrow belt of evergreen and semi-evergreen climax and potentially related forests belonging to two categories (Pascal et.al, 1982). The first category is *Dipterocarpus indicus – Kingiodendron pinnatum– Humboldia brunonis* type of low elevation (0-850 m elevation). The second category is *Mesuaferrea – Palaquium ellipticum* type of medium elevation (650-1400 m). This river basin constitutes one of the prime centers of biodiversity in the central Western Ghats (Ramachandra *et al.*, 2010). Of the flowering plants collected from here 36% were Western Ghat endemics. Considering the ecological significance and rich biodiversity, and the threats looming large on

the region, due to many unplanned developmental activities, there is an urgent need for *declaring the region as an* Eco-sensitive one as per sub-section (1) with clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) and clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 in concurrence with the provisions of the Indian Forests Act, 1927 (16 of 1927) and Forest (Conservation) Act, 1980 (69 of 1980) the Wildlife (Protection) Act, 1972 (53 of 1972) and also Biological diversity act 2002 (Ramachandra *et al.,* 2010).

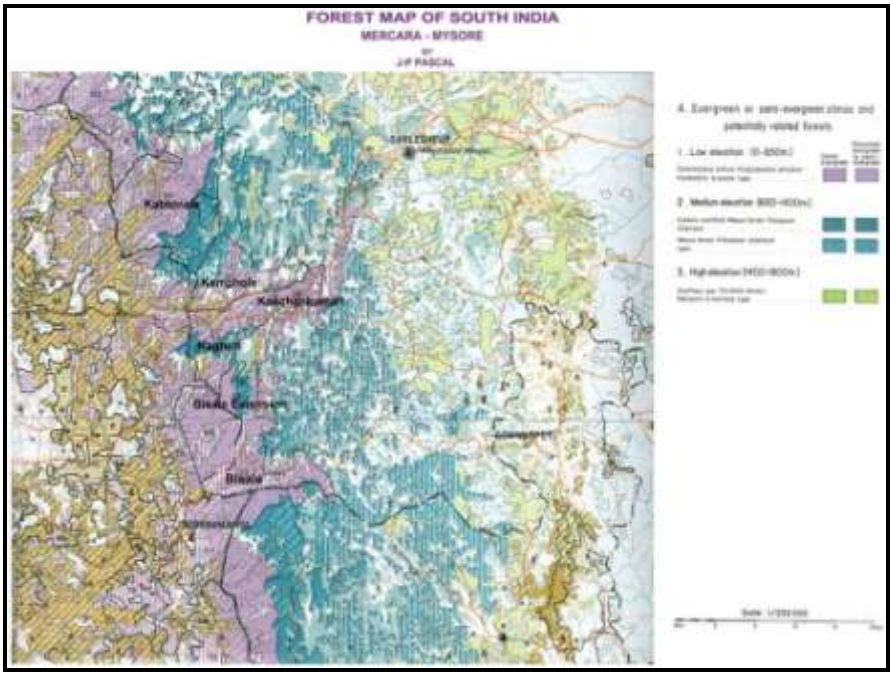

Figure 2: Evergreen and semi-evergreen climax and potentially related forests of Gundia basin (source – Pascal *et al.*, 1982)

The vegetation of the region (including the degradation stages of the major forest types mentioned and the humanized landscapes) can be broadly divided into the following different types:

1. Tropical wet evergreen to semi-evergreen rainforests
2. The riparian vegetation
3. Tropical wet deciduous forests
4. Scrub jungles
5. Grasslands and savannas
6. Scattered trees along plantations and abandoned fields

The tropical wet evergreen and semi-evergreen forests encompass a wide array of floristic diversity which includes angiosperms, pteridophytes, bryophytes, fungi, etc. The presence of many perennial streams, waterfalls and other moist habitats support rich growth of pteridophytes. Apart from the mention of 10 fern species of Thelypteridaceae family by Holttum (1976) from the Hassan district, there has been no other significant study enumerating or highlighting the pteridophytic wealth of this region. A comprehensive collection of ferns and fern allies have been archived at JCB herbarium of Centre for Ecological Sciences, Indian Institute of Science, Bangalore, many of which have been collected from this region too. Apart from our first hand field collection of pteridophyte specimens, we also referred the JCB herbarium collections and other available literatures to enumerate the pteridophytic wealth of this region.

In the current study, a total of 45 species of ferns and fern-allies belonging to 26 different genera and 19 different families (Table 1) were recorded.

Table 1: Pteridophytes recorded from the Sakleshpur taluk in central Western Ghats

S. No.	Botanical Name	Family	Distribution and Ecology
1.	*Adiantum philippense* L. subsp. *Philippense* Syn. *Adiantum lunulatum* Burm. F.	Adiantaceae	Commonly seen along partially or fully exposed roadsides.
2.	*Angiopteris helferiana* C. Presl.	Marattiaceae	Common along the shaded stream banks.
3.	*Asplenium obscurum* Bl.	Aspleniaceae	Terrestrial or lithophytes along fully shaded stream banks.
4.	*Athyrium hohenackerianum* (Kuntze) T. Moore	Woodsiaceae	Growing as terrestrials or lithophytes on rock crevices along fully or partially shaded roadsides.
5.	*Athyrium solenopteris* (Kuntze) T. Moore	Woodsiaceae	Commonly found along fully shaded stream banks and also on forest floor and in fully exposed marshy places.
6.	*Blechnum orientale* L.	Blechnaceae	Growing on fully exposed dry places and clearing along roadsides and road cuttings.
7.	*Bolbitis appendiculata* (Willd.) K. Iwatz	Lomariopsidaceae	Growing as lithophytes in large colonies along fully or partially shaded streams or stream banks.
8.	*Bolbitis semicordata* (Bak.) Ching	Lomariopsidaceae	Usually found as lithophytes growing along shaded stream banks. Endemic to south India.
9.	*Bolbitis subcrenatoides* Fras.-Jenk.	Lomariopsidaceae	Occurs in partially shaded or open road side cuttings in semi-evergreen and evergreen forests. Endemic to South India
10.	*Cyathea gigantea* (Wall. *ex* Hook.) Holttum	Cyatheaceae	Found abundantly growing as terrestrial plants along the shaded stream banks.
11.	*Cyathea nilgirensis* Holttum	Cyatheaceae	Endemic to South India and distributed along shaded stream banks.
12.	*Cheilanthes tenuifolia* (Burm. f.) Sw.	Pteridaceae	Gregarious in fully exposed canals or paddy fields, ponds or other such marshy places.
13.	*Dicranopteris linearis* (Burm. F.) Underwood	Gleicheniaceae	Found extensively growing along the road cuttings in shaded or open areas.
14.	*Diplazium esculentum* (Retz.) Sw.	Woodsiaceae	Terrestrial ferns growing as large colonies in open marshy places along

			streams and canals.
15.	*Diplazium polypodioides* Bl.	Woodsiaceae	Usually found along partially or fully shaded stream banks.
16.	*Drynaria quercifolia* (L.) J. Sm.	Polypodiaceae	Epiphytes on the bark of trees in partly or fully shaded places.
17.	*Dryopterisjuxtaposita* Christ	Dryopteridaceae	
18.	*Dryopteris cochleata* (Buch. Ham. ex D. Don) C. Chr.	Dryopteridaceae	Terrestrial plants frequently growing along fully exposed roadsides, dry places or clearings.
19.	*Huperzia squarrosa* (Forst.) Trev. Syn. *Lycopodium squarrosum*Forst.	Lycopodiaceae	
20.	*Lepisorusnudus* (Hook.) Ching	Polypodiaceae	Common epiphytes on shola trees and sometimes as lithophytes along stream banks or on forest floor.
21.	*Leucostegia truncata* (D. Don) Fras.-Jenk. syn.: *Leucostegia immersa*C. Presl.	Davalliaceae	Terrestrial or lithophytes on fully or partially exposed dry places along roadsides, clearings or forest edges.
22.	*Lycopodiella cernua* (L.) Pic. Ser.	Lycopodiaceae	Common along fully exposed road sides, on road cuttings and on muddy walls.
23.	*Lygodium flexuosum* (Linn) Sw.	Schizaeaceae	Terrestrials, climber along fully or partially exposed roadsides.
24.	*Microlepias peluncae* (L.) Moore	Dennstaedtiaceae	Terrestrials on forest floor or along shaded stream banks, rarely found along shaded road sides.
25.	*Microsorum punctatum* (L.) Copel.	Polypodiaceae	Epiphytes along fully or partially shaded stream banks.
26.	*Ophioglossum costatum* R. Br.	Ophioglossaceae	Terrestrials in mixed deciduous forests.
27.	*Ophioglossum gramineum* Willd.	Ophioglossaceae	Terrestrials on fully exposed sandy soil along a river mingled with *O. nudicaule.*
28.	*Ophioglossum nudicaule*L.	Ophioglossaceae	Gregarious on a swampy, grassy spot in a shrub-savanna.
29.	*Osmunda huegeliana* Presl.	Osmundaceae	Terrestrials growing as large colonies or bushes in fully exposed in fully exposed marshy places near streams or lakes.
30.	*Pityrogramma calomelanos* (L.) Link.	Pteridaceae	Usually terrestrial, rarely lithophytes along roadsides in fully exposed dry places.
31.	*Pteridium revolutum* (Blume) Nakai Syn. *P. aquilinum* (L.)	Dennstaedtiaceae	Gregariously growing on fully exposed grassy slopes on the forest edge,

	Kuhn.		roadsides and clearings.
32.	*Pterisbiaurita* L.	Pteridaceae	Usually seen along roadsides on fully exposed places.
33.	*Pteris confuse* T. G. Walker	Pteridaceae	Usually found growing along stream banks in forest interior, rarely seen on partially or fully exposed roadsides.
34.	*Pteris quadriaurita* Retz.	Pteridaceae	Most common species of *Pteris*distributed in various kinds of habitats.
35.	*Selaginella delicatula* (Desv) Alston	Selaginellaceae	Common on stone walls or rock crevices along road sides.
36.	*Selaginella proniflora* (Lam.) Baker	Selaginellaceae	
37.	*Selaginellarepanda* (Desv) Spring	Selaginellaceae	Growing as terrestrials on shady, moist soil cover.
38.	*Selaginella tenera* (Hook. &Grev.) Spring	Selaginellaceae	Usually growing as terrestrials on the forest floor in shade and rarely seen along shaded roadsides.
39.	*Tectaria coadunata* (J. Sm.) C. Chr.	Dryopteridaceae	Frequent along fully or partially shaded roadsides, along waysides inside the forest or on forest floor.
40.	*Tectaria polymorpha* (Wallich. Ex Hook.) Copel.	Dryopteridaceae	On mountain slopes in dense forests.
41.	*Thelypteris*(*Ampelopteris*) *prolifera* (Retz.) Copel	Thelypteridaceae	
42.	*Thelypteris* (*Christella*) *dentate* (Forssk) E. P. St. John	Thelypteridaceae	Found throughout the Western Ghats, along roadsides, clearings and along stream banks in partially or fully exposed places.
43.	*Thelypteris* (*Christella*) *parasitica* (L.) Tardieu	Thelypteridaceae	Very common in partially shaded places in the evergreen forests.
44.	*Thelypteris* (*Cyclosorus*) *interruptus*(Willd.)	Thelypteridaceae	Usually occurring frequently as large colonies in open marshy places, lakes, walls and borders of paddy fields.
45.	*Thelypteris* (*Macrothelypteris*) *torresiana* (Gaudich.) Ching	Thelypteridaceae	Usually grows along partially or fully shaded stream banks.

Some of the notable pteridophyte species of the study region are shown in Figure 3.

The dominant families were Pteridaceae and Thelypteridaceae with 5 species each followed by Dryopteridaceae, Woodsiaceae and Selaginellaceae (4 species each). The most common and widely distributed species in the study area are *Dicranopteris linearis*, *Blechnum orientale*, *Adiantum philippense* L. subsp. *philippense*, *Pityrogramma calomelanos*, *Tectaria coadunata*, *Thelypteris* (*Christella*) *parasitica*and *Thelypteris* (*Christella*) *dentata.* The presence of South Indian endemic species *Bolbitissemicordata*, *Bolbitissubcrenatoides*, *Osmundahuegeliana* and *Cyatheanilgirensis* (Fraser-Jenkins, 2008b) in the study region adds to the exemplary biodiversity of the region. Of these, *B.*

*semicordata*is a rare species in South India itself whereas *C. nilgirensis*is Near-threatened implying a high conservation status to them (Chandra *et al,* 2008).

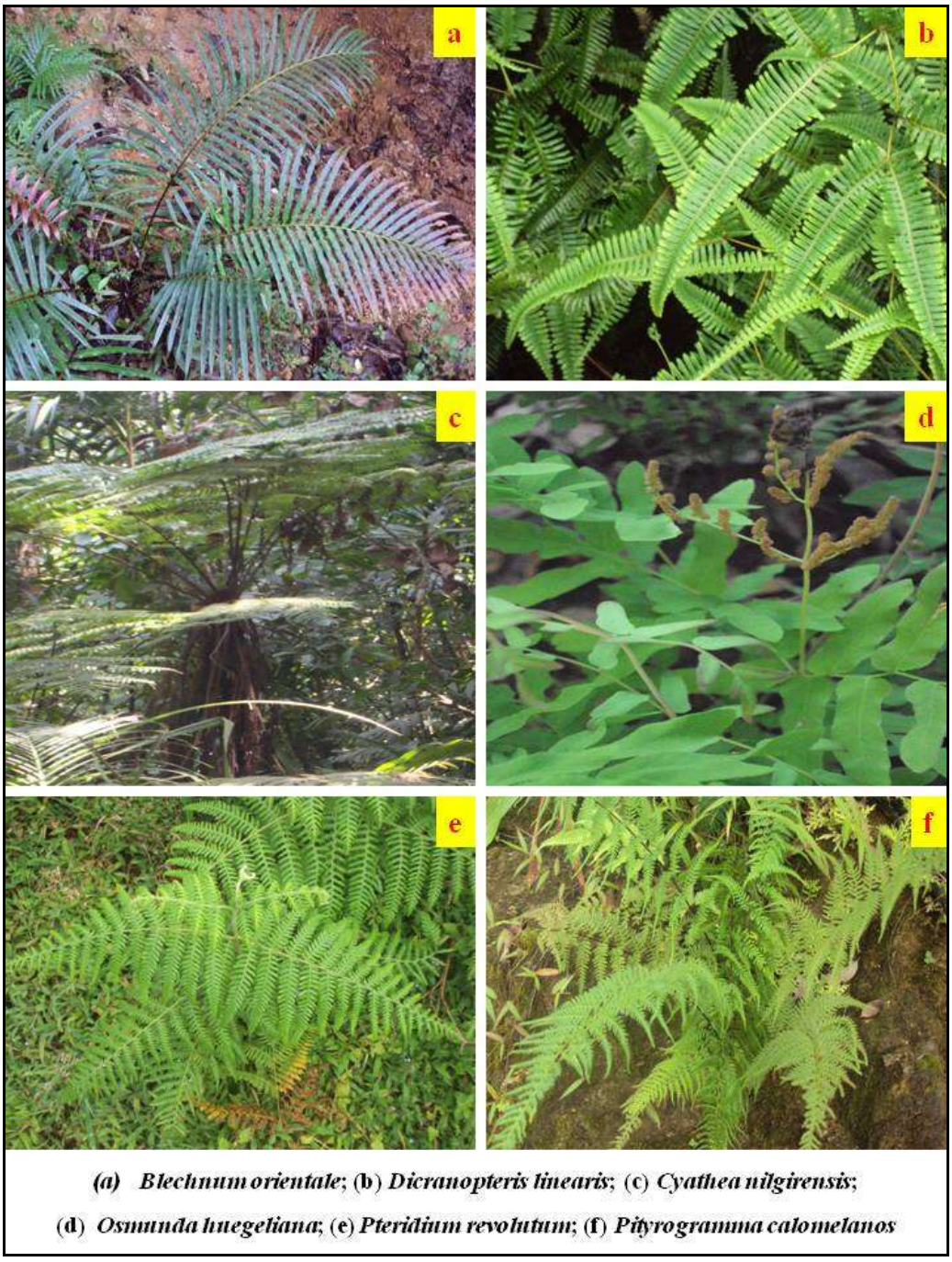

Figure 3: Notable pteridophytes in the study area

Each species of fern has its own preferences of micro habitat depending on the temperature, humidity, soil type, moisture, pH, light intensity, etc., and in many cases are very specific indicators of the conditions they need (Shaikh and Dongare, 2009). It is well observed and noted that most species of ferns succeed under high humidity and shade conditions (Page 1979), unless they are species that prefer more xeric conditions and are more heliophilous. *Cyathea*sps. And *Angiopteris* sp. are among those perennial ferns which prefer swampy/moist habitats with low light intensities for their growth. Similarly, another endemic fern *Osmundahuegeliana* prefers the moist and humid banks of free flowing perennial streams and rivers (Dudani *et al.,* 2012). Another endemic fern species *Bolbitissubcrenatoides* is commonly found growing as terrestrial inside the fully covered forest floors and sometimes along road cuttings or edges in the forest. *Pteridium revolutum*syn. *Pteridium aquilinum*is an adventive alien species (Jenkins, 2008a) of the region, an escape from gardens into the wild surroundings of Western Ghats, which has a preference for growing gregariously on fully exposed grassy slopes. *Lygodium flexosum* is the only scandent or climbing fern recorded in the current study prefers to grow among the bushes along the partially or fully exposed roadsides. The commonly growing terrestrial species such as *Blechnum orientale* and *Dicranopterislinearis* were observed to be growing abundantly and forming thickets in many places. The common lithophytic fern species in the study region were *Pityrogramma calomelanos, Leucostegia truncata* and *Adiantum philippense* while the common epiphytic fern species observed were *Drynaria quercifolia* and *Lepisorus nudus.*

Most of the pteridophytes recorded in this study have various medicinal and other miscellaneous applications. Among all, *Pteridium revolutum* is perhaps the most widely used terrestrial fern species for various purposes. The tender fronds of this fern are used as vegetables and also in soup preparations while the rhizomes are boiled or roasted and eaten. The rhizome of this fern is astringent, anthelmintic and is useful in diarrhea and inflammation of the gastric and intestinal mucous membranes. The rhizome is boiled in oil and is made into an ointment for wounds. The dried fronds of the fern are also employed as packaging material and have also been tried as a source for paper pulp (Manickam and Irudayaraj, 1992). Another widely occurring fern in the study region – *Tectariaco adunata*, has antibacterial properties and is used in the cases of asthma, bronchitis, honey bee stings and the cooked tender portion of this fern is employed for curing stomach trouble (Dixit and Vohra, 1984; Manandhar, 1996; Das, 1997). The climbing fern *Lygodium flexosum* is used as an expectorant and in the treatment of rheumatism, sprains, scabies, ulcers, eczema and coughs (Singh et al, 1989; Manandhar, 1996). Other important medicinal applications of the pteridophytes include: use of the rhizome of *Drynari aquercifolia* as antibacterial, anti-inflammatory, tonic, in the treatment of typhoid fever, dyspepsia, cough, diarrhea, ulcers and other inflammations (Dixit and Vohra, 1984; Warrier *et al,* 1996); use of the fronds of *Osmunda huegeliana* as tonic, styptic and also for the treatment of rickets, rheumatism and for intestinal gripping (Nair, 1959; Dixit and Vohra, 1984); use of the fronds of *Pityrogramma calomelanos* for the treatment of asthma, cold and chest congestion (Dixit and Vohra, 1984); use of the rhizome of *Leucostegia truncata* as antibacterial and in the treatment of constipation (Benjamin and Manickam, 2007). Besides these exemplary medicinal properties, the pteridophytes have long been greatly valued as ornamentals. They are used to enhance the beauty of the landscape and find their place in gardens, nurseries and during functions for beautification purposes.

However, as the humid places and water bodies are prioritized by the humans for settlements, farming, power generation, setting up of industries etc. the most sensitive pteridophytes depending upon such habitats tend to vanish from the region. The Gundia river basin in Sakleshpurhas already lost vast area of primary forests, evident from barren hill tops, stretches of secondary forests, scrub jungles, monoculture tree plantations and drying streams. It is unfortunate that this region has been experiencing heavy anthropogenic pressures since last two decades, especially from cultivation of coffee and cardamom and arecanut dominated spice gardens. Coupled with these factors, the incessant collection of ferns from the

forests by visitors and locals for ornamental purposes, medicinal purposes and during excursions have also increased the pressure for survival on these plants. Such threats apart, nevertheless, the same region, one of the last bastions of pteridophytic wealth in the central Western Ghats, is being considered for the implementation of 200 MW hydel project in the Gundia River. However this proposal is kept in abeyance due to the agitation by local people and considering the ecological sensitiveness of the region. There is a dire need to identify and conserve such threatened ecosystems which consist of the germplasm of most humid tropical pteridophytes of Western Ghats. Also, the sore lack of knowledge on pteridophytes among the public in general is a major issue to be addressed through awareness programmes for holistic habitat conservation.

ACKNOWLEDGEMENT
We are grateful to the NRDMS division, Department of Science and Technology, Government of India and Indian Institute of Science for the financial and infrastructure support. We thank the forest officials of Hassan Forest Division, Karnataka Forest Department for permitting us to undertake the study and field assistance. We also thank C. R. Fraser-Jenkins, Royal Botanical Garden, Edinburgh; Dr. P. K. Rajagopal and Prof. K. Gopalkrishna Bhat, Department of Botany, Poornaprajna College, Udupi and Prof. P. V. Madhusudhanan, Department of Botany, Calicut University for their expert comments and inputs. Thanks are also due to G. R. Rao, Prakash Mesta, Vishnu Mukri and Srikant Naik for their inputs and help in the field.

REFERENCES

Alston AHG (1945). An enumeration of Indian species of *Selaginella. Proceedings of the National Institute of Sciences of India* **11** 211-235.

Benjamin A and Manickam VS (2007). Medicinal pteridophytes from the Western Ghats. *Indian Journal of Traditional Knowledge* **6**(4) 611-618.

Blatter E and Almeida JF (1922). *The ferns of Bombay (*DB Taporevala Sons & Co., Bombay).

Chandra S, Fraser-Jenkins CR, Kumari A and Srivastava A (2008). A summary of the status of threatened pteridophytes of India. *Taiwania* **53**(2) 170 – 209.

Conservation International (2005). Hotspots revisited: Earth's biologically richest and most endangered terrestrial eco regions. CI, US, 392 pp.

Das K (1997). Less known uses of plants among the *Aids* of Arunachal Pradesh. *Ethnobotany* **9** 90-93.

Dixit RD and Vohra JN (1984). *A dictionary of the pteridophytes of India (*Botanical Survey of India, Howrah).

Deepa J, Parashurama TR, Krishnappa M and Nataraja S (2011). Enumeration of pteridophytes in Madhuguni forest, central Western Ghats, Karnataka, South India. *Indian Fern Journal* **28** 112-119.

Deepa J, Parashurama TR, Krishnappa M and Nataraja S (2013). Pteridophytic flora of Kemmangundi forest, Karnataka, South India. *Annals of Plant Sciences* **02(11)** 484-488.

Dudani SN, Chandran MDS, Mahesh MK and Ramachandra TV (2011). *Diversity of Pteridophytes of Western Ghats*. Sahyadri E-News Issue-33. Accessed on 15th March 2011. Available: http://wgbis.ces.iisc.ernet.in/biodiversity/sahyadri_enews/newsletter/issue33/index.htm

Dudani SN, Mahesh MK, SubashChandran MD and Ramachandra TV (2012). Conservation strategies for the hygrophilous pteridophytes of central Western Ghats. *Proceedings of LAKE 2012: National Conference on conservation and Management of Wetland Ecosystems organized by Mahatma Gandhi University, Kottayam, Kerala.*

Dudani SN, Mahesh MK, Subash Chandran MD and Ramachandra TV (2013). Fern diversity in the sacred forests of Yana, Uttara Kannada, Central Western Ghats. *Indian Fern Journal* **30** 61-68.

Fraser-Jenkins CR (2008a). Taxonomic revision of three hundred Indian sub-continental pteridophytes with a revised census list – a new picture of fern-taxonomy and nomenclature in the Indian subcontinent. (Bishen Singh Mahendra Pal Singh Publishers, Dehradun).

Fraser-Jenkins CR (2008b). Endemics and pseudo-endemics in relation to the distribution patterns of Indian pteridophytes. *Taiwania* **53**(3) 264 – 292.

Holttum RE (1976). Thelypteridaceae. In: *Flora of Hassan district of Karnataka, India edited by* Saldanah CJ and Nicolson DH (Amerind Publishing Co Pvt Ltd, New Delhi).

Kammathy RV, Rao AS and Rao RS (1967). A contribution towards Flora of Biligirirangan Hills, Mysore state. *Bulletin of the Botanical Survey of India* **9**(1-4) 206-234.

Manandhar PN (1996). Ethnobotanical observations on ferns and fern allies of Nepal. *Journal of Economic and Taxonomic Botany Add ser* **12** 414 – 422.

Manickam VS and Irudayaraj V (1992). *Pteridophyte flora of the Western Ghats – South India* (BI Publications Pvt Ltd, New Delhi).

Manickam VS, Seeni S, Sutherland L and Wilson J (2003). Supporting and multiplying concern for sustainable development among teachers and children: Experiences of the Kodaikanal Botanic Garden Project 14. Available: http://www.bgci.org/barcelona04/abstracts/pdf_abstracts/Manickam.pdf

Matchperson TRM (1986). List of ferns gathered in North Kanara. *Journal of Bombay Natural History Society* **5** 375-377.

Nair BK (1959). Medicinal ferns of India. *Bulletien of National Botanical Garden,* Lucknow **29** 1-36.

Nataraja S, Deepa J, Ramesh Babu HN and Krishnappa M (2011). Pteridophytic survey in Agumbe forest of central Western Ghats, Karnataka. *International Journal of Plant Sciences* **6**(2) 345-347.

Page CN (1979). Experimental aspects of fern ecology. In: *The Experimental biology of ferns*, edited by AF Dyer (Academic Press, London/New York) 552-581.

Pascal JP, Sunder SS and Meher-Homji MV (1982). Forest Map of South-India Mercara – Mysore. *Karnataka and Kerela Forest Departments and The French Institute, Pondicherry.*

Radhakrishna BP (2001). The Western Ghats of Indian Peninsula. *Memoir of Geological Society of India* **47** 133-144.

Rajagopal PK and GopalkrishnaBhat K (1998). Pteridophytic flora of Karnataka state, India. *Indian Fern Journal* **15** 1 – 28.

Ramachandra TV, Chandran MDS, Bhat HR, Dudani S, Rao GR, Boominathan M, Mukri V and Bharath S (2010). Biodiversity, Ecology and Socio-economic aspects of Gundia river basin in the context of proposed mega hydroelectric power project. *CES Technical Report-122, Centre for Ecological Sciences, Indian Institute of Science, Bangalore.*

Ramachandra TV, SubashChandran MD, Joshi NV and Dudani S (2012). Exploring biodiversity and ecology of central Western Ghats. *ENVIS Technical Report – 39, Centre for Ecological Sciences, Indian Institute of Science, Bangalore.*

Shaikh SD and Dongare M (2009). The influence of microclimatic conditions on the diversity and richness of some ferns from the North-Western Ghats of Maharashtra. *Indian Fern Journal* **26** *128 – 131.*

Singh KK, Saha S and Maheshwari JK (1989). Ethnobotanical use of some ferns amongst the tribals of Uttar Pradesh. *Indian Fern Journal* **6** 63 – 67.

Warrier PK, Nambiar VPK and Raman Kutty C (1996*).* *Indian Medicinal Plants* **5** (Orient Longman Ltd.).

Yoganarasimhan SN, Subramanyam K and Razi BA (1981). *Flora of Chikmagalur district, Karnataka, India* (International Book Distributors, Dehradun).

Energy and Wetlands Research Group [No Date]. Energy Research Group (Research in the area of Energy and Environment). Available: http://wgbis.ces.iisc.ernet.in/energy (Accessed on 15th January and 26th March, 2012; 10thMay and 7th September, 2013).

Energy and Wetlands Research Group [No Date]. Sahyadri – Western Ghats Biodiversity Information System. Available: http://ces.iisc.ernet.in/biodiversity (Accessed on 23rd August, 2012).
MINISTRY OF LAW AND JUSTICE (Legislative Department) (2003). The Wildlife (Protection) **Amendment Act, 2002.** Available: http://envfor.nic.in/legis/wildlife/wild_act_02.pdf (Accessed on 3rd April, 2012)
The Indian Forest Act (1927). Available: http://envfor.nic.in/legis/forest/forest4.html (Accessed on 12th April, 2012)
The Environment Protection Act (1986). Available: http://envfor.nic.in/legis/env/env1.html (Accessed on 21st May, 2012).