

# PTERIDOPHYTES OF WESTERN GHATS

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## ABSTRACT

The Western Ghats is one of the 34 Global Biodiversity Hotspots and harbors a rich diversity of flora and fauna with many endemic and RET species. Along with the angiospermic plants, the Western Ghats is also a rich repository of pteridophytic plant wealth. The pteridophytes form a conspicuous element of the earth's vegetation and are important from evolutionary point of view as they show the evolution of vascular system and reflect the emergence of seed habitat in the plants. About 250 million years ago they formed the dominant part of earth's vegetation, but in present day flora have been largely replaced by the seed bearing plants. About 12,000 species of pteridophytes occur in the world flora of which around 1000 species are distributed in different biogeographical regions of India with the main centers being the Himalayas, the Western Ghats and the Eastern Ghats. The Western Ghats harbor about 320 species of ferns and fern allies with more species diversity in the southern part. The major families of pteridophytes found in the Western Ghats are Aspleniaceae, Polypodiaceae, Thelypteridaceae, Selaginellaceae, Pteridaceae, etc. Whereas on the generic level, maximum diversity is observed in the genus *Asplenium*, *Selaginella*, *Pteris*, *Athyrium*, *Diplazium*, etc. The Western Ghats also harbors endemic species like *Polystichum manickamii*, *Cyathea nilgiriensis*, *Bolbitis semicordata*, *Selaginella radicata*, etc. The habitat of the pteridophytes consists of microclimatic conditions with special preference for moist and shady places and a minor disturbance in their microclimate conditions can lead to loss of large number of species. They occur in abundance in tropical, sub-tropical, temperate and moist-deciduous forests of India and their life-cycle is based on the existence of the forests. However, large scale deforestation and increasing anthropogenic factors have caused the elimination of the habitats which is posing a serious threat to the pteridophytes of Western Ghats and many endangered pteridophytes like *Psilotum nudum*, *Tectaria zeylanica*, *Lindsaea malabarica*, *Cheilanthes rufa*, etc. may soon face the brunt of extinction. In the recent years, though the pteridological studies have picked up in various parts of the country, many questions regarding the pteridophytic wealth of the Western Ghats remain unanswered and hence, more studies are required for developing *in situ* and *ex situ* conservation strategies for this wonderful and important group of plants.

**Keywords:** Pteridophytes, Western Ghats, Conservation

## INTRODUCTION

The Western Ghats of the Indian peninsula constitute one of the 34 global biodiversity hotspots along with Sri Lanka, on account of exceptional levels of plant endemism and higher levels of habitat loss (Conservation International 2005). The rugged range of hills stretching for about 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), is interrupted only by a 30 km break in Kerala, the Palghat Gap (Radhakrishna 2001). The flora of Western Ghats comprises about 12,000 species ranging from unicellular cyanobacteria to angiosperms. In this spectrum the flowering plants constitutes about 27% of Indian flora with 4000 species of which about 1500 species are endemic. Apart from harboring a rich diversity of the angiospermic flora, the Western Ghats are also a rich repository of cryptogams such as pteridophytes, bryophytes, lichens, fungi and algae. The Western Ghats along with the Himalayas, Eastern Ghats and parts of Central India forms a major centre for the distribution of the ferns and fern-allies.

The pteridophytes are non-flowering, vascular and spore-bearing plants including ferns and fern-allies. They form a conspicuous element of the earth's vegetation and are important from evolutionary point of view as they show the evolution of vascular system and reflect the emergence of seed habitat in the plants. About 250 million years ago they formed the dominant part of earth's vegetation, but in present day flora, they have been largely replaced by the seed bearing plants. They grow luxuriantly in moist tropical and temperate forests and their occurrence in different eco-geographically threatened regions from sea level to the highest mountains are of much interest (Dixit, 2000). The pteridophytes form a connecting link between the lower group of plants and the higher group of seed bearing plants and hence are placed between bryophyte and higher vascular plants i.e., gymnosperms and angiosperms.

### Diversity of Pteridophytes

The world flora consists of approximately 12,000 species of pteridophytes of which around 1000 species distributed in 70 families and 192 genera are likely to occur in India (Dixit, 2000). Most of the pteridophytes diversity is observed in the Himalayas, Eastern and Western Ghats. Manickam *et al* have worked on the pteridophytes of Western Ghats in detail. Some of the earlier prominent publications are Ecological studies on the Fern Flora of Palni hills (Manickam, 1984), Fern Flora of Palni Hills, South India (Manickam, 1986), Cytology of the ferns of Western Ghats, South India (Manickam and Irudayaraj 1988) and Pteridophyte flora of Western Ghats, South India (Manickam and Irudayaraj, 1992). Pteridophyte flora of Western Ghats South India includes illustrations for 256 ferns and fern allies collected from the Western Ghats region lying south of Palghat Gap.

The central Western Ghats passing through Karnataka state is also a rich repository of floral diversity and the pteridophytes of this region have been documented by few researchers in their studies. Blatter and Almeida (1992) included 90 species of ferns from

Uttara Kannada district, then a part of Bombay Presidency, in their “Ferns of Bombay”. Holttum (1976) included 10 members of Thelypteridaceae in the “Flora of Hassan District” while Yoganarsimhan *et al.* (1981) recorded 12 species of ferns in their “Flora of Chikmagalur District”. The only in-depth and comprehensive work on the pteridophytes of Karnataka is in Pteridophytic Flora of Karnataka state, India (Rajagopal and Bhat, 1998) with the data on Pteridophyte diversity of Karnataka state from 1988-1995. After a long gap of about one and half decade, Ramachandra *et al.* (2010) documented 54 pteridophyte species from the Gundia river basin in Hassan district.

Based on the analysis of the diversity of species at family level it is found that maximum number of diversity occurs in Aspleniaceae family comprising of 27 species followed by Polypodiaceae (25 spp.), Athyriaceae (24 spp.), Thelypteridaceae (23 spp.), Selaginellaceae (20 spp.), Pteridaceae (17 spp.), Aspidaceae (13 spp.), etc. whereas at the generic level, maximum diversity is observed in the genera *Selaginella* (20 spp.), *Pteris* (17 spp.), *Diplazium* (7 spp.), etc. (Dixit, 2000).

Though the pteridophytes occur in abundance in the tropical, sub-tropical and moist deciduous forests of India, large scale destruction of forests has drastically affected the diversity of pteridophyte species. The life-cycle of the ferns and fern-allies is dependent upon the existence of forests, but due to habitat destruction many species have been reduced and the rare ferns are being extinct or are on the verge of extinction (Dixit, 2000). Manickam (1986) gave an account of the rare and endangered ferns of Western Ghats and later Madhusoodanan (1991) gave an account of the rare and endangered ferns and fern-allies of Western Ghats of Kerala. Benniamin *et al.* (2008) developed a key for identification of rare and endangered ferns and fern allies in the Western Ghats. Based on the field observations, data from herbarium collections and literature reference, Jenkins and other Indian pteridologists assessed the rare and threatened pteridophytes of India (Chandra *et al.*, 2008). Many rare and endangered ferns and fern-allies like *Psilotum nudum*, *Tectaria zeylanica*, *Lindsaea malabarica*, *Cheilanthes rufa*, *Cyathea nilgiriensis*, etc. have been recorded from the Western Ghats by different researchers and they need urgent attention for conservation.

## Economic Importance of Pteridophytes

Humans have been dependent upon the plants as an important source of medicine since the time immemorial. Even today, many tribal communities and rural population is dependent heavily upon the natural resources obtained from the surrounding forest regions for treatment of various ailments and diseases. The Indian traditional medicine is based on different systems such as Ayurveda, Siddha and Unani used by various tribal communities (Gadgil, 1996). Though, lot of studies focusing on the medicinal properties of plants, especially angiosperms, have been taken place, unfortunately limited amount of studies have been done to explore the medicinal potentialities of the pteridophytes. The medicinal qualities of ferns, real or imaginary, are mentioned as early as 300 B.C. by the Greek

philosopher Theophrastus (Corne, 1924a) and by his Indian contemporaries Sushrut and Charak. The medicinal uses of some ferns and pteridophytes of India have also been described (Caius, 1935; Nair, 1959). The medicinal uses of 61 different ferns and fern-allies have been well documented earlier (Benjamin and Manickam, 2007).

Another important pteridophyte which is commonly occurring in many parts of Western Ghats and India and which plays many important and different roles in the ecosystem is *Azolla* (Family – Azollaceae). *Azolla* has a symbiotic association with nitrogen-fixing, blue-green algae namely – *Anabaena azollae* Strasburger and due to this property, the agronomic potential of *Azolla* as biofertilizer for rice has been recognized in many countries including India, Philippines, USA, Sri Lanka and Thailand (Ahluwalia *et al.*, 2002). The remarkable activity of *Azolla* to take up heavy metals from polluted water can be used for treatment of wastewater (Sanyahumbi *et al.*, 1998; Vermaat and Hanif, 1998). Its use as traditional medicine for treating cough and sore throat is also known (Wagner, 1997; Usher, 1974).

The ferns have also shown to be having an important role in bioremediation of wastewater. Ma *et al.* (2001) found the Chinese Bracken fern namely *Pteris vittata* L. to be a hyper-accumulator of the toxic Arsenic metal. Besides producing large biomass, they also found this fern to be efficient in Arsenic accumulation with the concentrations as high as 2.3% in the aerial portions of the fern. Nichols *et al.*, 2000; Olguín *et al.*, 2007; Suné *et al.*, 2007 have shown that several species of *Salvinia* such as *S. herzogii*, *S. minima*, *S. natans*, *S. rotundifolia* possess the potential of removing various contaminants including heavy metals from the wastewater.

The ornamental use of ferns has been practiced since long time. Due to ornamental nature of the fronds of *Dryopteris*, *Adiantum*, *Nephrolepis*, the potted plants of these species find place in the terrace of houses, hotels, gardens, etc. (Dixit, 2000). They are propagated either by spores or vegetative means and sold commercially by many nurseries for ornamental values. The fronds of ferns are also used in bouquets and for decorating stages, halls, etc. during various functions.

## Threats and Conservation of Pteridophytes

The pteridophytes are moisture and shade loving plants and dependent upon the microclimatic conditions of the region for their successful survival in that region. Any kind of disturbance in these microclimatic conditions can hinder the growth and evolutionary processes occurring naturally in these plants thereby, leading to decline in their populations. Thus, factors like climate change, increasing urbanization, industrialization, encroachment of forest lands, unplanned developmental activities, over exploitation of natural resources, pose a major threat to the survival of these groups of plants. Due to unplanned felling of trees in the forests the members of epiphytic pteridophytes belonging to the families Polypodiaceae, Davalliaceae, Aspleniaceae, Vittariaceae, have been reduced day-by-day (Dixit, 2000). Large scale collection of ferns from the forests by the visitors and local people for ornamental purpose, medicinal purpose and during excursions also increases the pressure on these plants.

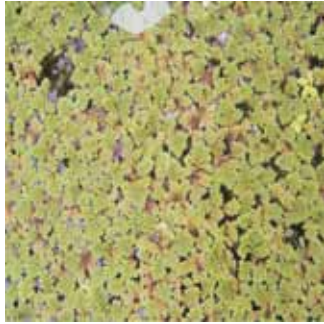


Fig. Some Ferns and Fern-allies of Western Ghats

Biodiversity conservation is the need of time and hence, it has become imperative to develop *in situ* and *ex situ* conservation methods for conservation of the diminishing biodiversity. The *in situ* conservation is very beneficial as it allows the evolution of the species to continue within the area of natural occurrence. Hence, the steps for conserving the ferns *in situ* should be focused upon. The *ex situ* conservation includes development of botanical gardens or conservatories, germplasm banks, DNA banks, seed banks and involve the use of techniques such as tissue culture, cryopreservation; incorporation of disease, pest and stress tolerance traits through genetic transformation and ecological restoration of rare plant species and their populations (Kapai *et al.*, 2010). The conservation of flowering plants has been achieved to good extent by developing conservatories and botanical gardens which also help in creating awareness among the local people. However, developing a fern conservatory or fern garden is not preferred much and hence, such steps should be considered and implemented for conserving the rare and endangered species. The tissue culture is a very useful technique for the mass multiplication of the plant species in a short time and hence, researches focusing on developing a protocol for *in vitro* regeneration of ferns and fern-allies should be encouraged. Parts of areas rich in abundant pteridophyte diversity can be declared as pteridophyte biosphere reserves or small gene sanctuaries can be established to save the epiphytic pteridophytes.

## Conclusions

This paper gives a broad outlook about the pteridophytes, focusing on global biodiversity hotspot - the Western Ghats. The pteridophytes form a vital component of the ecosystem and most of them being forest dwellers can be taken as good indicators of the extent of problems like deforestation and habitat destruction. Many pteridophytes appear in the list of threatened species in one category or the other and yet, effective solutions have not been investigated to combat this world-wide problem. It is inevitable that effective measures need to be increased for developing pteridophyte sample-reserves which are strictly protected against the problems of grazing, disturbance and deforestation which are otherwise affecting the existing reserves. The conservation focus should not be restricted upto the commercially important species and specific strategies for conservation of pteridophytes should be taken into account with much consideration. Botanical explorations should increase in the under-explored botanically rich areas for documenting the diversity and ecological characteristics of pteridophytes and taxonomic reinvestigations should take place in order to avoid the confusions with new species and existing species.

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## REFERENCES

- Abraham, A., Ninan, C.A. and Mathew, P.M. (1962). Studies on the cytology and phylogeny of pteridophytes VII. Observations in one hundred species of South Indian Ferns. *Journal of Indian Botanical Society*, 41: 339 – 421.
- Ahluwalia, A.S., Pabby, A. and Dua, S. (2002) *Azolla*: A green gold mine with diversified applications. *Indian Fern Journal*, 19: 1 – 9.
- Benjamin, A. and Manickam, V.S. (2007). Medicinal pteridophytes from the Western Ghats. *Indian Journal of Traditional Knowledge*, 6(4): 611 – 618.
- Benniamin, A., Irudayaraj, V. and Manickam, V.S. (2008). How to identify rare and endangered ferns and fern allies. *Ethnobotanical Leaflets*, 12: 108 – 117.
- Bir, S.S. and Vasudeva, S.M. (1971). Pteridophytic flora of Kodaikanal, South India. *J. Bombay Nat. Hist. Soc.*, 68: 169 – 195.
- Bir, S.S. (1987). Pteridophytic flora of India: rare and endangered elements and their conservation. *Indian Fern Journal*, 4: 95 – 101.
- Bir, S.S. (1988). Evolutionary trends in the Pteridophytic flora of India. Presidential address, Section of Botany, Indian Science Congress Platinum Jubilee Session 1977, *Proceedings of Indian Science Congress*, 75: 1-56. [Abridged versions repeated in *Curr. Sci.* 57: 321-323 (1988); *Everyman's Science*, 23: 29-35 (1988) and In: Bir S.S. and M.I.S. Sago (eds), *Perspectives in Plant Sci. India*: 1-22 (1989), *Today and Tomorrows Printers and Publishers, New Delhi*.
- Blatter, E. and Almeida, J.F.D (1992). The Ferns of Bombay. *D.B. Taporevala Sons & Co., Bombay*.
- Caius J.F. (1935), The medicinal and poisonous ferns of India. *J. Bombay Nat. His. Soc.*, 341 – 361.
- Chandra, S., Fraser-Jenkins, C.R., Kumari Alka and Srivastava, A. (2008). A summary of status of threatened pteridophytes of India. *Taiwania*, 53(2): 170-209.
- Conservation International (2005). Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. *CI, US*, 392 pp.
- Dixit, R.D. (1983). Rare and interesting Pteridophytes of India – 1. In: An assessment of threatened plants of India, (S.K. Jain, ed.), Botanical Survey of India, Howrah (Calcutta), India. pp. 328-334.
- Dixit, R.D. (2000). Conspectus of Pteridophytic diversity in India. *Indian Fern Journal*, 17: 77 – 91.
- Fraser-Jenkins, C.R. (2008). Endemics and pseudo-endemics in relation to the distribution pattern of Indian pteridophytes. *Taiwania*, 53(3): 264-292.
- Joseph, H.L., Manickam, V.S. and Gopalkrishnan, S. (1991), Phytochemistry of three species of *Polystichum* from the Western Ghats. *Abstr. Natl. Symp. Current Trends in Pteridology*, 41 – 42.
- Joseph, H.L., Manickam, V.S. and Gopalkrishnan, S. (1993). Phytochemistry of members of *Polystichum* Roth from the Western Ghats. *Indian Fern Journal*, 10: 152 – 156.

- Kapai, V.Y., Kapoor, P. and Rao, I.U. (2010). *In vitro* propagation of Rare and Threatened plants of India – A review. *International Journal of Biological Technology*, 1(2): 1-14.
- Kirtkar, K.R. and Basu, B.O. (1935). Indian Medicinal Plants Vol. 4. *Bishen Singh and Mahendra Pal Singh, Dehradun*.
- Kuriachan, P.I. (1979). Interspecific origin of *Salvinia molesta* Mistchel Evidence from *karyotype*. *Indian J. Bot.*, 2: 51 – 54.
- Ma, L.Q., Komar, K.M., Tu, C., Zhang, W.H., Cai, Y. and Kennelley, E.D. (2001). A fern that hyperaccumulates arsenic - a hardy, versatile, fast-growing plant helps to remove arsenic from contaminated soils. *Nature*, 409, 579-579.
- Madhusoodanan, P.V. (1991). Rare and endangered ferns and fern-allies of Western Ghats of Kerala. In: Karunakaran C.K. (ed.), Proceedings of Symposium on Rare, endangered and endemic plants of the Western Ghats, Thiruvananthapuram, India, pp. 103-107.
- Madhusoodanan, P.V., Sijimol, P.S. and Rajesh, K.P. (2001). Pteridology in South India – A Retrospection. *Indian Fern Journal*, 18: 18-34.
- Mandal, B., Vlek, P.L.G. and Mandal, L.N. (1999). Beneficial effect of blue green algae and *Azolla* excluding supplying nitrogen on wetland rice fields: a review. *Biol Fertil Soils*, 28: 329 – 342.
- Manickam, V.S. (1984). Ecological studies on the fern flora of the Palni hills (South India). *Today and Tomorrow's Printers and Publishers, New Delhi*.
- Manickam, V.S. (1986). Fern flora of the Palni Hills (South India). *Today and Tomorrow's Printers and Publishers, New Delhi*.
- Manickam, V.S. (1986). Rare and Endangered ferns of the Western Ghats of South India. *Fern Gaz.* 15: 1-10.
- Manickam, V.S. and Irudayaraj, V. (1988). Cytology of the ferns of Western Ghats (South India). *Today and Tomorrow's Printers and Publishers, New Delhi*.
- Manickam, V.S. and Irudayaraj, V. (1992). *Pteridophyte Flora of the Western Ghats – South India*. B. I. Publications, New Delhi.
- Manickam, V.S. and Rajakumar, D.S. (1999). Polymorphic ferns of the Western Ghats – South India. *Bishen Singh Mahendra Pal Singh, Dehradun*.
- Nair, B.K. (1959). Medicinal ferns of India. *Bull. Nat. Bot. Gard., Lucknow*, 29: 1 – 36.
- Nichols, P.B., Couch, J.D. and Al-Hamdani, S.H. (2000). Selected physiological responses of *Salvinia minima* to different chromium concentrations. *Aquatic Botany*, 68: 313-319.
- Olguín, E.J., Sánchez-Galván, G. and Pérez-Pérez, P. (2007). Assessment of the phytoremediation potential of *Salvinia minima* Baker compared to *Spirodela polyrrhiza* in high-strength Organic Wastewater. *Water, Air and Soil Pollution*, 181, 135–147.
- Radhakrishna, B.P. (2001., The Western Ghats of the Indian peninsula. *Memoir Geological Society of India*, 47: 133 – 144.
- Raja, P.D., Manickam V.S., De Britto J.A., Gopalkrishnan S., Ushioda T., Saton M, Tanimura A., Fuchino H. and Tenaka N. (1995). Chemical and chemotaxonomical studies on *Dicranopteris* species. *Chem. Pharma Bull.*, 43: 1800-1803.

- Rajagopal, P.K. and Bhat K.G. (1998). Pteridophyte flora of Karnataka state, India. *Indian Fern Journal*, 15: 1 – 28.
- Ramachandra T.V., Chandran, M.D.S., Bhat, H.R., Dudani, S., Rao, G.R., 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.
- Rout, S.D., Panda, T. and Mishra, N. (2009). Ethnomedicinal studies on some pteridophytes of Simlipal Biosphere Reserve, Orissa, India. *International Journal of Medicine and Medicinal Sciences*, 1(5): 192 – 197.
- Sahoo, S.K. and Datta, B.K. (1999). Weed control by *Azolla* in rice (*Oryza sativa*) fields of south 24-Parganas West Bengal. *Indian J. Agri. Sci.*, 69: 283 – 284.
- Saldanah, C.J. and Nicolson, D.H. (1976). *Flora of Hassan district, Karnataka, India*. Amerind Publishing Co. Pvt. Ltd., New Delhi.
- Sanyahumbi, D., Duncan, J.R., Zhao, M. and Van Hille, R. (1998). Removal of lead from solution by non viable biomass of water fern *Azolla filiculoides*. *Biotech Lett.m*, 20: 745 – 747.
- Sharma, M.P., Singh, R. and Singh, R. (1999). Effect of *Azolla* on Wheat (*Triticum aestivum*) yield and soil properties. *Indian J. Agri. Sci.*, 69: 55 – 57.
- Suné, N., Sa´nchez, G., Caffaratti, S. and Maine, M.A. (2007). Cadmium and chromium removal kinetics from solution by two aquatic macrophytes. *Environmental Pollution*, 145: 467-473.
- Vermaat, J.E. and Hanif, M.K. (1998). Performance of common duckweed species (Lemnaceae) and the water fern *Azolla filiculoides* on different types of wastewater. *Water Res (Oxford)*, 32: 2569 – 2576.
- Usher, G. (1974). A dictionary of plants used by Man. *Hafner Press, New York*.
- Wagner, G.M. (1997). *Azolla*: A review on its biology and utilization. *Bot Rev.*, 63: 1 – 26.
- Yoganarasimhan, S.N., Subramanyam, K. and Razi, B.A. (1981). *Flora of Chikmagalur district*. International Book distributors, Dehradun.