Asian Journal of Environment & Ecology

15(4): 28-36, 2021; Article no.AJEE.70977
ISSN: 2456-690X

Diversity of Pteridophyte Flora in Rajamala, Eravikulam National Park, Kerala, India

M. S. Arjun[1*], Raju Antony[2], A. Azhar Ali[3], C. Abhirami[1] and M. M. Sreejith[4]

[1]Department of Natural Resource Management, College of Forestry, Kerala Agricultural University, Thrissur, Kerala, Pin: 680656, India.
[2]Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Karimancode P.O. Palode, Thiruvananthapuram, Kerala-695 562, India.
[3]Department of Forest Products and Utilization, College of Forestry, Kerala Agricultural University, Thrissur, Kerala, Pin: 680656, India.
[4]Department of Silviculture and Agroforestry, College of Forestry, Kerala Agricultural University, Thrissur, Kerala, Pin: 680656, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author MSA designed the study, conducted the fieldwork, prepared the herbaria of collected specimens and wrote the first draft of the manuscript. Author RA identified the species and edited the first draft of the manuscript. Author AAA assisted in fieldwork and the preparation of herbaria. Author CA managed the literature searches and the analyses of the study. Author MMS assisted in literature searches and field exploration. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2021/v15i430235
Editor(s):
(1) Dr. Ravi Kant Chaturvedi, Chinese Academy of Sciences, P. R. China
Reviewers:
(1) Hadil Allam, University of Tlemcen, Algeria.
(2) Ovat Innocent Ovat, Cross River University, Nigeria.
Complete Peer review History: https://www.sdiarticle4.com/review-history/70977

Short Research Article

Received 30 April 2021
Accepted 10 July 2021
Published 10 July 2021

ABSTRACT

Aims: To enumerate the fern diversity in the disturbed landscapes of Rajamala part of Eravikulam National Park, Western Ghats
Study Design: Purposive sampling method was adopted in the study area and habitats suitable for ferns were surveyed.
Place and Duration of Study: The study area is Rajamala, a tourist impacted site inside Eravikulam National Park in Kerala, India. Intensive field explorations were carried out in this area during February 2018- April 2019, to document the ferns and fern-allies.

**Corresponding author: E-mail: arjunms001@gmail.com ;*

Methodology: A preliminary study was conducted in February 2018 to identify the probable habitats of ferns for further detailed study. Purposive sampling was done in the study area considering the most suitable habitats in both shola ecosystems and grassland ecosystems of the area. Materials for herbaria were processed using standard methods. The collected plants were identified with the help of standard field guides and flora. The potential medicinally important ferns were also listed out.
Results: 54 species of pteridophytes including fern and fern allies belonging to sixteen different families were found from the Rajamala region of Eravikulam National Park. Aspleniaceae was the most common family with 11 species followed by Polypodiaceae. The majority of the Pteridophytes found in the region are showing terrestrial habit. Eleven species found in the study site are medicinally important.
Conclusion: Despite the high tourism pressure in the study area, pteridophyte species richness is higher in the Rajamala region of Western Ghats. The suitable habitat with ideal substrate conditions and year-long moisture availability in the substrates could be the reason for a higher number of pteridophyte species in this area.

Keywords: Ferns; fern allies; grassland; shola forests; southern western ghats.

1. INTRODUCTION

India is one of the top ten plant-diverse countries in the world. The world flora consists of about 12000 species of pteridophytes [1], and among them, more than 1200 species of pteridophytes including both fern and fern- allies have been reported from India [2,3]. Pteridophytes are considered to be important because of their evolutionary significance. They are a notable ancient group of species with a significant number of relict and endemic ones [4]. Pteridophytes are considered as an intermediate between the higher vascular plants (gymnosperms and angiosperms) and lower non-vascular plants because of their specialized vascular system. Their life cycle is also remarked by the independent alternation of the generation of sporophyte and gametophyte. Pteridophytes are generally categorized into Ferns and Fern Allies, which are not scientifically very distinct [5]. Ferns are considered an advanced group that originated later during the Carboniferous period (325 million years back) and marked by a well-developed plant body (sporophyte–spore-bearing generation) with rhizome, roots, large leaves but no flowers and fruits. The fern allies had originated and established in the Silurian (395 million years back) and were characterized by having small (microphyllous) leaves each with a single vein on the stele. The spores arranged are also different in both ferns and fern allies, sporangia are superficial (on the lower surface of the leaf) or marginal in ferns, whereas in fern allies they are generally produced in terminal strobili (sorus) at branch tips [6].

The potential use of Pteridophytes especially the edible and medicinal properties are explored by many workers in India. They reported much information about the various ethnobotanical utility and medicinal properties of the pteridophytes [7,8,9,10,11,12]. Sixty Pteridophytes used by the tribals of the Western Ghats which have medicinal importance are reported during an ethnobotanical study [8]. Other than the economic uses, many Pteridophytes were cultivated indoors of the houses or outdoors due to their attractive beautiful fronds. The medicinally important properties of the Pteridophytes were reported by many workers [12]. Several species of ornamentally potential ferns were also reported in India [13,14,15,16,17,18] with twenty ornamental pteridophytes from Nilgiris [19].

Pteridophytes are a wide-range group that fills every possible ecological niche but the diversity is maximum in the high temperature and rainfall conditions of tropics. The ongoing shrinkage of the tropical biome is a matter of concern as many pteridophyte species are yet to be discovered from the diverse and dense forests of this area [20]. According to the threat assessment of pteridophytes of India, roughly 43 percent of the total pteridophytes seen in India are threatened [21]. The Western Ghats is a region of a richly diverse collection of wild flora and fauna and the Kerala part of it is further rich in plant diversity due to its climatic condition with about 3000 mm rainfall throughout the year. Recently 283 species of fern and fern allies were described from Kerala [6]. Kerala provides an ideal condition for the growth and development of fern and fern allies. There are also many endemic ferns including the tree fern, *Cyathea nilgirensis* that have distribution in this part of Western Ghats [22].

Various researchers have explored the fern flora in the Western Ghats also [23,24,25,26]. The smallest fern of the earth, *Ophioglossum malviae* was a recent discovery from the northern parts of Western Ghats [27]. Most of the ferns are under threat due to habitat destruction and climate change. Most of them have narrow ecological amplitude and require specific microclimatic conditions for their better growth and development. The Eravikulam National park is an area of diverse plant collection of Angiosperms, Gymnosperms, and Pteridophytes that was managed as game reserves by the colonial planters. Its unique floral and faunal composition that is supported by the highly specialized shola-grassland ecosystem culminated in the declaration of this area as the first national park of Kerala in 1978 [28]. Rajamala is a tourist spot in the Eravikulam National Park located at an altitude of 2197 m. Average annual visitors of Rajamal exceeds 4,00,000 who visit the park for enjoying the shola-grasslands, for seeing the Niligiri Thar in their natural habitat and also to have the great view of Neelakurunji which blooms once in 12 years. Pteridophyte diversity of Eravikulam National Park has not been specifically attempted by any fern researchers. This emphasizes studying the pteridophyte diversity of this region with special mention to medicinally important ones.

2. MATERIALS AND METHODS

2.1 Study Area

Eravikulam National Park is located in the High Ranges (Kannan Devan Hills) of the Southern Western Ghats in the Devikulam Taluk of Idukki District, Kerala State between 10º 05′ – 10º 20′ N Latitude and 77º 0′ – 77º 10′ E Longitude. (Fig.1). Raja mala is situated in the South-West part of the National Park. The annual precipitation in the region is approximately 6899 mm and the average annual temperature ranges from 13-22^0 C. The humidity varies with season and during monsoon, it reaches 83-100 %. The maximum altitude of the region is 2197m [28].

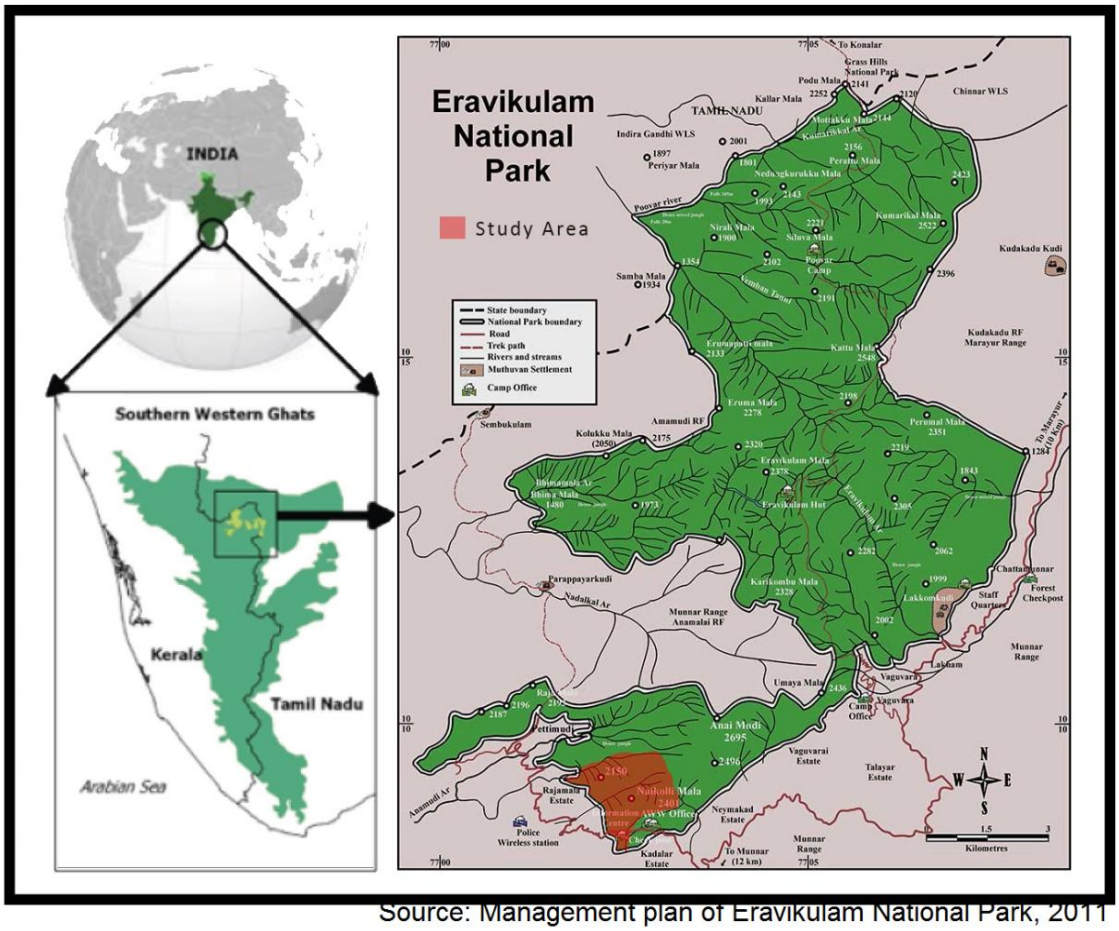

Fig. 1. Map of the study area

2.2 Methodology

Intensive field explorations were carried out in Rajamala, Eravikulam National Park, Kerala during February 2018- April 2019, to document the ferns and fern-allies of the study area. All of the specimens were examined for diagnostic characteristics, and appropriate field notes were taken on fresh plant material. Materials for herbaria were processed using standard methods and deposited in the Herbaria of College of Forestry, Kerala Agricultural University. The collected plants were identified with the help of *The Ferns of Southern India*, *Pteridophyte Flora of the Western Ghats – South India* [24], and the *Hand Book on ferns and fern allies of Kerala* [6]. The potential medicinally important ferns were also listed out.

3. RESULTS AND DISCUSSION

3.1 Species Richness

54 species of pteridophytes belonging to 16 different families including fern and fern allies were found from the Rajamala region of Eravikulam National Park (Table 1). It includes terrestrial, epiphytic, and lithophytic species of pteridophytes. Among the 54 species of pteridophytes, 51 are ferns and 3 species are fern-allies.

Table 1. Family wise list of Pteridophytes identified from the study area along with their Life form details

S.No	Family name	Name of Species	Habitat
1	Aspleniaceae	*Asplenium aethiopicum*	L
		Asplenium formosum	E
		Asplenium crinicaule	E
		Asplenium decrescens	E
		Asplenium normale	E
		Asplenium obscurum	E
		Asplenium tenuifolium	L
		Asplenium unilaterale	L
		Asplenium zenkerianum	L
		Asplenium phyllitidis	E
		Asplenium yoshinagae var. indicum	E
2	Athyriaceae	*Athyrium solenopteris*	T
3	Blechnaceae	*Blechnum orientale*	T
4	Cyatheaceae	*Cyathea spinulosa*	T
		Cyathea crinata	T
5	Davalliaceae	*Araiostegia pulchra*	L
6	Dennstaedtiaceae	*Microlepia speluncae*	T
		Peridium revolutum	T
7	Dryopteridaceae	*Arachniodes tripinnata*	T
		Elaphoglossum nilgiricum	E
		Dryopteris cochleata	T
		Dryopteris hirtipes	T
		Dryopteris austro-indica	T
		Dryopteris sparsa	T
		Polystichum harpophyllum	T
8	Gleicheniaceae	*Dicranopteris linearis*	T
9	Hymenophyllaceae	*Crepidomanes plicatum*	E
10	Lindsaeaceae	*Lindsaea odorata*	E
		Odontosoria chinensis	T
11	Lomariopsidaceae	*Nephrolepis auriculata*	E
12	Lycopodiaceae	*Huperzia hamiltonii*	E
		Huperzia squarrosa	E
		Lycopodiella cernua	T
		Huperzia serrata	T

13	Osmundaceae	*Osmunda huegeliana*	T
14	Polypodiaceae	*Lepisorus amaurolepidus*	E
		Lepisorus nudus	E
		Leptochilus decurrens	T
		Phymatosorus beddomei	E
		Loxogramme chinensis	E
		Microsorum pteropus	E
		Pyrrosia heterophylla	E
		Pyrrosia lanceolata	E
15	Pteridaceae	*Adiantum raddianum*	T
		Cheilanthes anceps	T
		Pityrogramma austroamericana	T
		Pteris argyraea	T
2	Selaginellaceae	*Selaginella involvens*	L
		Selaginella brachystachya	T
		Selaginella tenera	T
		Selaginella nayarii	T
		Selaginella intermedia	T
16	Thelypteridaceae	*Trignospora caudipinna*	T
		Pseudocyclosorus ochthodes	T

**T- Terrestrial, E- Epiphytes; L- Lithophytes*

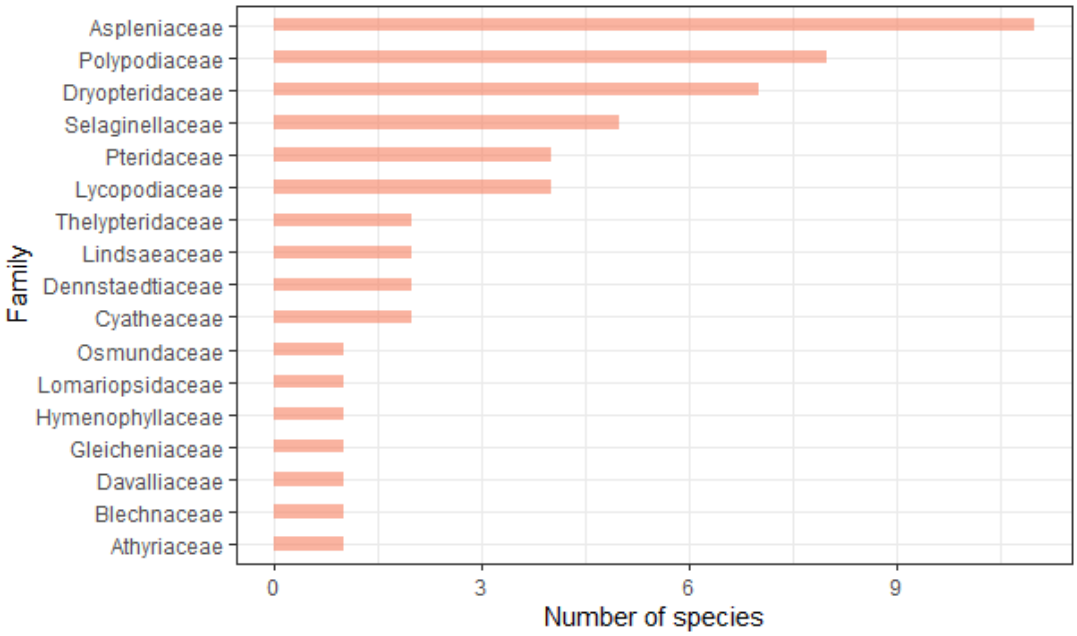

Fig. 2. Distribution of pteridophyte species in different families

The maximum number of species in the study area belongs to the Aspleniaceae family where 11 species were observed during this study. Polypodiaceae comes next with 8 species. Seven different families of pteridophytes viz. Osmundaceae, Lomariopsidaceae, Hymenophyllaceae, Gleicheniaceae, Davalliaceae, Blechnaceae, and Athyriaceae in the study area is represented by a single species only (Fig. 2)

Each fern species has its micro habitat requirements, which vary based on various factors such as temperature, humidity, soil type, soil pH, light intensity, and other factors, and are often quite specific in their requirements with narrow ecological amplitude [4]. In the present study, the majority of the species were found in terrestrial or plant substrates that retain maximum moisture content throughout the year. Comparing to other pteridophyte exploratory

studies done in the Western Ghats, the species richness in the current study area is higher. It indicates that the year-long moist tracts of the area and the shola-grassland mosaic ecosystem are excellent in supporting diverse Pteridophytes. Few studies in eastern ghats have found higher species richness of pteridophytes probably in a larger landscape [29,30]. An exploratory study in the central Western Ghats only recorded 23 species from moist tropical forests of the area [31]. The diversity of pteridophytes in the wet evergreen forests of central-western Ghats was also less compared to the present study [32]. Similar to their observation maximum pteridophytes were found in high-shade areas inside shola forests. Other pteridophyte diversity studies across the Western Ghats in small landscapes didn't show richness comparable to the present study [33,34]. Low light intensities and high moisture content of the substratum could be the most favorable conditions for pteridophyte growth according to the observations made in the present study. It is also evident that shola-grassland mosaics are supporting higher diversity of pteridophytes in comparison with similar studies that happened in wet evergreen forests of Western Ghats. The ecosystem and the position of the study area in the southern portion of Western Ghats could be the reasons for higher species richness.

3.2 Species Richness among Different Life Forms

Among the identified species, 20 species are terrestrial, 19 species are epiphytes and 6 species are lithophytes (Fig. 3). The distribution of pteridophytes in the study area varies widely. Mostly they were found in the forest floors of the shola ecosystem and many of them were growing as epiphytes in the short-statured shola trees. Lithophytes were less compared to other groups maybe because rocks go partially dry after the monsoon season of the year.

The higher number of terrestrial forms of pteridophytes could be attributed to the higher elevation of the study area. A study in the central Western Ghats found an increase of terrestrial pteridophytes at elevations over 1500 meters [30]. A study concentrating on the species richness of pteridophytes along an altitudinal gradient in Costa Rica also found a steady increase in terrestrial forms at higher altitudes [35].

3.3 Medicinally Important Pteridophytes and Their Uses

Eleven species identified from the study showed medicinal values which were identified following the earlier publications on the ethnobotany of pteridophytes of Western Ghats [10,36] (Table 2).

Even though pteridophytes are a medicinally important taxonomic group, compared to other vascular plants of India, their importance is largely ignored. Among the identified pteridophytes from the study area, 20 percent is having medicinal values starting from remedy for sore throat to the treatment of Leprosy (Table 2). Among the indigenous people, the knowledge of the medicinal uses of pteridophytes is popular while scientific studies on the same are very scarce. In the present study, the majority of pteridophytes are used as whole plants while a detailed review on ethnomedical properties of pteridophytes found that the fronds are the most frequently used part in curing diseases [37]. The tribal minorities of the study area are actively using these medicinally important pteridophytes based on their traditional knowledge on the same.

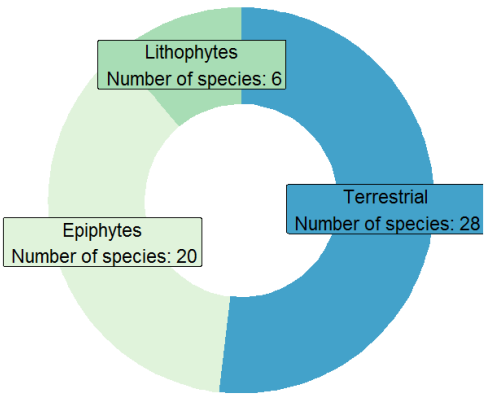

Fig. 3. Life form composition of Pteridophyte species in the study area

Table 2. Medicinally important pteridophyte species found in the study area and their uses

S. No	Name of species	Plant parts used	Uses
1.	*Lycopodiella cernua*	Whole plant	Cough, beri-beri, and skin eruption.
2.	*Selaginella involvens*	Whole plant	Reduce high fever, antidote, cough and bleeding piles.
3.	*Blechnum orientale*	Rhizome	Anthelmintic, typhoid.
4.	*Trignospora caudipinna*	Rhizome	Fever.
5.	*Cyathea spinulosa*	Soft pith and roots	Local drinks.
6.	*Dicranopteris linearis*	Whole plant	Throat pain, asthma, and antibacterial.
7.	*Nephrolepis auriculata*	Frond	Cough.
8.	*Asplenium unilaterale*	Whole plant	Digesting problems.
9.	*Pyrrosia lanceolata*	Frond	Sore throat.
10.	*Leptochilus decurrens*	Whole plant	Cough and chest pain.
	Microlepia speluncae	Whole plant	Eye disease
11.	*Dryopteris cochleata*	Rhizome	Leprosy, antifungal, swellings, ulcer, and pains

4. CONCLUSION

Pteridophytes are the group of plants which are mostly neglected by the taxonomist and researchers in India. Despite the ecotourism pressure, the Raja mala landscape of Eravikulam national park is supporting a rich diversity of pteridophytes. The specialized ecosystem, the shola-grassland mosaics in the area is ideal for pteridophyte growth because of the low light intensities and high humidity of the area. The present study reported higher species richness than the evergreen forests of central Western Ghats because of its peculiar ecosystem and the position of the study area in floristically rich Southern Western Ghats. The majority of the pteridophytes in the study area showed terrestrial life forms which are ideal in high altitude conditions. Eleven species among the identified pteridophytes from the study area are medicinally important. The utility of many pteridophytes is still unknown. Pteridophytes have great potential for medicinal, edible and ornamental uses. They have a great role in the ethnobotanical utility of the tribal peoples. The increasing tourist pressure in the Rajamala is imparting disturbances to this group of plants and conserving them is necessary for the ecological balance. Both *ex-situ* and *in-situ* conservation methods could be used in the conservation of existing Pteridophytic flora of the region even though they do not form an important component of the vegetation of this ecosystem.

ACKNOWLEDGEMENTS

We express our deep sense of gratitude and thanks to Dr. S. Gopakumar, Head of the Department, Department of Natural Resource Management, Kerala Agricultural University who provided us the logistical support for the study. We thank the Dean, College of Forestry, Kerala Agricultural University for the financial and technical support. Thanks to all the forest guards and friends who helped us with the fieldwork. We also thank the anonymous reviewers and the Subject Editor for their critical comments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chapman AD. Numbers of Living Species in Australia and the world. Report of the Australian Biological Resources Study, Canberra, Australia; 2009.
2. Chandra S. The ferns of India (Enumeration, Synonyms & Distribution). International Book Distributors. Dehra Dun, India; 2000.
3. Dixit RD. A census of the Indian Pteridophytes. Flora of India ser. 4, Botanical Survey of India, Howrah, Calcutta, India; 1984.
4. Patil S, Lavate R, Rawat V, Dongare M. Diversity and distribution of pteridophytes from Satara District, Maharashtra (India). Plant Sci. Today. 2016;3:149–156.
5. Kramer KU, Green PS, editors. Pteridophytes and Gymnosperms, 1st ed. The Families and Genera of Vascular Plants 1. Springer-Verlag Berlin Heidelberg; 1990.

6. Madhusoodanan PV. Hand Book on ferns and fern allies of Kerala. Malabar Botanical Garden and Institute for Plant Sciences (MBGIPS); 2015.
7. Dixit RD, Vohra JN. A dictionary of the Pteridophytes of India. Botanical Survey of India, Howrah, Calcutta, India; 1984.
8. Benjamin A, Manickam VS. Medicinal Pteridophytes from the Western Ghats, Indian J. Tradit. Knowl. 2007;6(4):611-618.
9. Kaushik P, Dhiman K. Common medicinal Pteridophytes. Indian Fern J. 1995; 12:139-145.
10. Nayar BK. Medicinal ferns of India. Bull. Nat. Bot. Garden. 1957;29:1-36.
11. Singh HB, Viswanathan V. Useful Pteridophytes of India – A gift of nature to Human beings, J. Econ. Taxon. Bot. 1996: 12: 24-36.
12. Vasudeva SM. Economic importance of Pteridophytes. Indian Fern J. 1999; 16:130-152
13. Singh S, Dixit RD, Sahu TR. Ethnomedicinal uses of pteridophytes of Amarkantak, Madhya Pradesh. Indian J. Tradit. Knowl. 2005: 4 (4): 392-395.
14. Mannan MM, Maridass M, Victor BA. Review on the potential uses of ferns. Ethnobot. leafl. 2008;1:33.
15. Upreti K, Jalal JS, Tewari LM, Joshi GC, Pangtey YPS, Tewari G. Ethnomedicinal uses of Pteridophytes of Kumaun Himalaya, Uttarakhand, India. J Am Sci. 2009;5(4):167-170.
16. Perumal G. Ethnomedicinal use of pteridophyte from Kolli Hills, Namakkal District, Tamil Nadu, India. Ethnobot. leafl. 2010;(2):5.
17. Karthik V, Raju K, Ayyanar M, Gowrishankar K, Sekar T. Ethnomedicinal uses of pteridophytes in kolli hills, Eastern Ghats of Tamil Nadu, India. J Nat Prod Plant Resource. 2011;1(2): 50-55.
18. Sathiyaraj G, Muthukumar T, Ravindran KC. Ethnomedicinal importance of fern and fern allies traditionally used by tribal people of Palani Hills (Kodaikanal), Western Ghats, South India. J. Med. Herbs Ethnomed. 2015;4-9.
19. Sonia Abraham, Ramachandran VS, Sofia C. Potential ornamental Ferns from Nilgiris, Tamil Nadu. Adv. Appl. Sci. Res. 2012;3(4):2388-2391.
20. Jermy AC. Conservation of Pteridophytes. In: Kramer KU, Green PS, editors. Pteridophytes and Gymnosperms, 1st ed. The Families and Genera of Vascular Plants 1. Springer-Verlag Berlin Heidelberg; 1990.
21. Chandra S, Fraser-Jenkins C, Kumari A, Srivastava A. A Summary of the Status of Threatened Pteridophytes of India. Taiwania. 2008;53:170–209. Available:https://doi.org/10.6165/tai.2008.53(2).170
22. Dudani SN, Mahesh MK, Chandran MDS, Ramachandra, TV. Cyathea nilgirensis Holttum (Cyatheaceae: Pteridophyta): a threatened tree fern from central Western Ghats, India. J. Threat. Taxa. 2014;6: 5413–5416.
23. Beddome RH. The Ferns of Southern India. Gantz Bros., Madras; 1864.
24. Manickam VS, Irudayaraj V. Pteridophyte Flora of the Western Ghats – South India. B. I. Publications, New Delhi, India; 1992.
25. Nampy S, Madhusoodhanan PV. The Fern Flora of South India: Taxonomic Revision of Polypodoid Ferns, Daya Publishing House, Delhi; 1998.
26. Antony R. The Studies on the Pteridophyte Flora of Agastyamala, Western Ghats. Ph. D thesis, Kannur University; 2013.
27. Patel M, Reddy MN. Discovery of the World's Smallest Terrestrial Pteridophyte. Sci. Rep. 2018;8:5911. Available:https://doi.org/10.1038/s41598-018-24135-2.
28. Government of Kerala. Management plan of Eravikulam National Park - 2012-13 to 2021-22; 2011.
29. Mandal KK, Kar T, Pattanaik C, Reddy CS. A census of pteridophytes in Eastern Ghats, India. Trop Plant Res. 2020;7:117–125.
30. Sureshkumar J, Ayyanar M, Silambarasan, R. Pteridophyte species richness along elevation gradients in Kolli Hills of the Eastern Ghats, India. J. Asia-Pac. Biodivers. 2020;13:92–106.
31. Deepa J, Parashurama TR, Krishanappa M, Nataraja S. Enumeration of pteridophytes in Madhuguni forest, Central Western Ghats, Karnataka, South India. Indian Fern J. 2011;28:112–119.
32. Dudani SN, Mahesh MK, Subash CMD, Ramachandra TV. Pteridophyte diversity in wet evergreen forests of Sakleshpur in Central Western Ghat. Ind J PltSci. 2014; 3:28–29.
33. Deepa J, Parashurama TR, Krishnappa M, Nataraja S. Distribution of pteridophytes in kigga forest, Central western Ghats,

Karnataka, South India. Indian Fern J. 2013;30:18–24.
34. Sukumaran S, Jeeva S, Raj ADS. Diversity of pteridophytes in miniature sacred forests of Kanyakumari district, southern Western Ghats. Indian J. For. 2009; 32:285–290.
35. Watkins Jr JE, Cardelús C, Colwell RK, Moran RC. Species richness and distribution of ferns along an elevational gradient in Costa Rica. Am. J. Bot. 2006; 93: 73–83.
36. Karthik V, Raju K, Ayyanar M, Gowrishankar K, Sekar T. Ethnomedicinal uses of pteridophytes in kolli hills, Eastern Ghats of Tamil Nadu, India. J Nat Prod Plant Resour. 2011;1:50–55.
37. Sureshkumar J, Silambarasan R, Bharati KA, Krupa J, Amalraj S, Ayyanar M. A review on ethnomedicinally important pteridophytes of India. J. Ethnopharmacol. 2018;219: 269–287.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/70977