PROCEEDINGS

western ghats

BIOGEOGRAPHY, BIODIVERSITY & CONSERVATION

UGC SPONSORED THREE DAY NATIONAL SEMINAR

14th, 15th and 16th of February 2013

DEPARTMENT OF BOTANY

NSS COLLEGE, MANJERI, MALAPPURAM, KERALA

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proceedings

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foreword

It is a fact that the declaration of *Western Ghats* as a '*World Heritage Site'* by the *United Nations* has stirred huge excitement among naturalists and conservationists. We know that this area, also known as the *Sahyadrs*, is a mountain range along the western side of India starting near the border of Gujarat and Maharashtra, south of the River Tapti, and runs approximately 1600 km through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanyakumari, at the southern tip of India. These hills cover 1,60,000 km^2 and form the catchment area for a complex of river systems that drain almost 40% of India. It is the Western Ghats, which shapes the climate and makes this region suitable for life.

Being one of the world's ten '*Hottest Biodiversity Hotspots',* it habours more than 300 globally threatened species and thousands of endemics, which demand special ecological niches for their survival. Although the total area is less than 6 percent of the land area of India, it accomodates more than 30 percent of all organisms found in India. The area is also rich in diverse natural, semi-natural and agro-ecosystems. In addition to rich biodiversity, the Western Ghats is home to diverse social, religious, and linguistic groups. It also supports the livelihood of over 200 million people, directly and indirectly through ecosystem services. The *Western Ghats Ecology Expert Panel* (WGEEP) constituted by the Ministry of Environment and Forests has made several salutary recommendations for the long-term conservation of this hotspot. The report is now the subject of intense debate. To realize the truth and to plan conservation measures, an in-depth knowledge about this beautiful, unique and species rich ecosystem which is already under threat, is essential.

It is in this juncture, that the Department of Botany, N.S.S College, Manjeri could organize a *UGC Sponsored Three Day National Seminar* on **'Western Ghats - Biogeography, Biodiversity & Conservation'**, in collaboration with *Malabar Botanical Garden, Kozhikode* on **14^{th}, 15^{th} & 16^{th} of February 2013.** The seminar aimed to generate a thorough knowledge on various aspects of this Biodiversity Hotspot, by bringing scientists and experts from various fields and to disseminate information to more people and join hands in the conservation measures.

In addition to the 11 Invited presentations by experts in the field, we have received about 50 Research papers in 5 broad areas such as Biogeography, Plant Diversity, Animal Diversity, Endemism & Conservation, out of which, 31 were selected for Oral and 11 for Poster presentations. More than 230 participants attended the seminar, which includes scientists, faculties, researchers and students. It gives me great pleasure to present the Proceedings of the papers delivered and discussed at the seminar. I earnestly hope that this will serve as agood source of reference in the areas concerned. I believe that the seminar enlightened all the particpants about the need to conserve the biological diversity and ecological balance of the Western Ghats, which is a concern of the global community too.

I take this occasion to sincerely thank our Principal, Dr. T.N. Vijayakumar, my colleagues, students and friends for their dedicated service and support in making the seminar a great success. It is my privilege to present this work to the scientific community and look forward to receive the valuable comments.

Dr. Kishore Kumar. K.
(Convenor of the Seminar)
Assistant Professor in Botany

25/03/2013

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It is an event of great pleasure and privilege when the Department of Botany is bringing out the Proceedings of the Three Day National Seminar on **'Western Ghats - Biogeography, Biodiversity and Conservation'** held during **14th to 16th February 2013** with financial assistance of the University Grants Commission. The venture would serve the very purpose of disseminating the knowledge acquired by the science community among the administrators as well as the general community at large. I deeply congratulate the Convenor and department staff in their sincere effort and pain taken up and wish them all success.

Dr. Vijayakumar T.N.

(Chairman, Organizing Committee)
Principal,
NSS College, Manjeri

27/03/2013

message

Declaration of Western Ghats as a World Heritage Site has been widely appreciated. The recently published *Western Ghats Ecology Expert Panel (WGEEP)* Committee Report also triggered huge excitement among the masses. It is in this context that the Department of Botany, NSS College, Manjeri has organized a Three-day National seminar on **Western Ghats - Biogeography, Biodiversity and Conservation** during 14-16th of February 2013, with the support of UGC. The event was a great success.

It gives me immense pleasure to note that the organizers could bring out the Proceedings of the seminar in a record time. I appreciate the efforts taken by Dr. Kishore kumar K., Assistant Professor, Department of Botany, NSS College, Manjeri and Convenor of the National seminar on Western Ghats for publishing the Proceedings promptly.

Dr. Balakrishnan P.

(Vice Chairman,
Organizing Committee)
HOD of Botany, NSS College, Manjeri

27/03/2013

message

The **Western Ghats**, one of the world's ten "Hottest biodiversity hotspots" harbours a large proportion of the country's plant and animal species; many of which are only found here and nowhere else in the world. The environmental sensitivity and ecological significance of the Western Ghats and the complex interstate nature of its geography, as well as possible impacts of climate change on this region are well known. But many species in Western Ghats are under high anthropogenic pressure compounded by habitat fragmentation, river diversion, dams, industries, deforestation, mining and pollution, all of which are threatening the rich biological heritage of our country.

We found that it was a timely and noble venture by the Department of Botany, NSS College, Manjeri to organize a UGC sponsored Three Day National Seminar on **'Western Ghats - Biogeography, Biodiversity and Conservation'** which was held during 14th to 16th February 2013. It was a great opportunity for the **Malabar Botanical Garden** to collaborate with this National Seminar, which proved to be a strong platform for serious discussions by distinguished personalities on the issues involved. It is also a matter of pleasure and pride to learn that the Department of Botany is bringing out the Proceedings of the Seminar, which will serve as a good source of reference for scientists, researchers, teachers, students and all those who are interested in this area. I wish the organisors all the best.

Dr. Prakash kumar R.
(Collaborator of the Seminar)
Managing Director,
Malabar Botanical Garden, Calicut

25/03/2013

about the organisers

N.S.S. College, Manjeri, established in 1965 and affiliated to the University of Calicut is one of the pioneer institutions of higher learning situated in the Manjeri Municipality of Malappuram District. It is located on a hill of scenic beauty that provides an ideal natural setting for the pursuit of higher education. The college owned and managed by the Nair Service Society considers education as a social service. Like the other 23 colleges owned and nursed by Nair Service Society, this college also owed its origin to its legendary founder the **Late Padmabhushan Mannathu Padmanabhan**. The generosity of **Sri. P.M. Thirumulpad** had helped him a great deal to start a college at Manjeri. At present the college offers eight Graduate courses and two Post Graduate courses. Recently the college was accredited by NAAC with 'B' grade (CGPA 2.75).

The **Department of Botany** was established in 1965. It offers B.Sc. Plant Science course, which was initiated in 1999. A *Career Oriented Programme* (Add on course) in *Mushroom cultivation* was also sanctioned by UGC in 2011. The Department is contributing to the development of curriculum for undergraduate Botany education in the University through participation in academic bodies. For details, see the college website: **www.nsscollegemanjeri.in**

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invited lectures

invited lectures

1. **Dr. Sankar S.**

   Former Scientist, Kerala Forest Research Institute (KFRI), Peechi, Kerala

   Landscape units: A biogeographical approach to assessment and conservation of biodiversity in the Western Ghats of Kerala

2. **Sri. Radhakrishnan C.**

   Former Addl. Director, Zoological Survey of India (ZSI), Western Ghats Regional Centre, Kozhikode, Kerala

   Origin & Biogeography of Western Ghats

3. **Dr. Karunakaran P.V.**

   Principal Scientist, Salim Ali Centre for Ornithology & Natural History (SACON), Coimbatore, Tamil Nadu

   Vegetation types and Phytogeography of Western Ghats

4. **Dr. Manju C. Nair**

   Assistant Professor in Botany, Zamorin's Guruvayurappan College, Kozhikode, Kerala

   Bryophyte Diversity of Western Ghats

5. **Dr. Rajesh K.P.**

   Assistant Professor in Botany, Zamorin's Guruvayurappan College, Kozhikode, Kerala

   Pteridophyte Diversity of Western Ghats

6. **Dr. Sasidharan N.**

   Dr. B.P. Pal fellow; Former Scientist, Kerala Forest Research Institute (KFRI), Peechi, Kerala

   Higher Plants Diversity of Western Ghats

7. **Dr. Rajmohana K.**

   Scientist, Zoological Survey of India (ZSI), Western Ghats Regional Centre, Kozhikode, Kerala

   Invertebrate Diversity of Western Ghats

8. **Dr. Muhamed Jafer Palot**

   Assistant Zoologist, Zoological Survey of India (ZSI), Western Ghats Regional Centre, Kozhikode, Kerala

   Vertebrate Faunal Diversity of Western Ghats

9. **Dr. Bindu S.**

   Director, KIRTADS, Chevayur, Kozhikode, Kerala

   Tribal Diversity of the Kerala part of Western Ghats & conservation of Ethnic knowledge

10. **Dr. Vijayan V.S.**

    Former Chairman, Kerala State Biodiversity Board, Trivandrum; Former Director, SACON, Coimbatore; Madhav Gadgil Committee Member

    Importance of the conservation of Western Ghats

11. **Prof. Prasad M.K.**

    Former Pro-Vice-Chancellor of Calicut University; Former President of the Kerala Sasthra Sahitya Parishath; Member of the Board of the Millennium Ecosystem Assessment

    Biodiversity and Food Security

Landscape units: A biogeographical approach to assessment and Conservation of biodiversity in the Western Ghats of Kerala

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Abstract

For the purpose of biodiversity assessments, forest eco-restoration, watershed management and conservation natural landscape subunits, basins and ecosystem boundaries have to be identified. Landscape subunits can be identified by topography. River basin boundaries can be identified on the basis of drainage directions but in most cases ecosystem boundaries within watersheds are already disrupted. Nair (1990) has identified 11 landscape units in the Kerala Western Ghats. The importance of these units is discussed in the context of biodiversity conservation.

Key words: Biogeography, Biodiversity, Landscape units, Western Ghats, Kerala

Introduction

The Western Ghats is a long coastal hill chain extending from 8° N to 21° N latitude along the west coast of Peninsular India. But it is a very narrow hill range stretching between 73°E and 77°E longitude. The Western Ghats is the main watershed divide in the Indian Peninsula south of Narmada. The average elevation of this hill range is less than 1500m. Most of the higher reaches are south of the Brahmagiris (12°N) along the Kerala-Tamil Nadu portion of the Ghats. The highest peak Anaimudi (2695 m) is in the Idukki district of Kerala. The Western Ghats runs through six States in India extending from the Dangs district in southern Gujarat to near Kanyakumari in Tamil Nadu. By controlling the rainfall and runoff, this hill range has a decisive influence on the human survival in South India. All the major rivers flowing through six Southern States originate in the Ghats. Most of the benchmark moist forests in South India and the richest assemblage of biodiversity in Peninsular India are in this tract. It is also the habitat for a number of distinct tribal societies.

For the State of Kerala, more than half its geographical area is taken up by the Western Ghats. The main hill range and its spur hills cover more than 20,000 sq km in Kerala.

The topography of the hills and its weather and climate decide the nature of the ecosystems that evolves upon it. The hills and the hill ecosystems together control the form and function of the rivers originating from them. The rivers, the soils and the nutrient cycles sustained by them will decide the nature of agriculture and the culture of the human inhabitants of the area.

The Western Ghats has a complex topography. There are the various segments of the Ghats, each with its distinct configuration, special characteristics and names. This hill range has a western and an eastern face. There are a few large eastern spur ranges and a lesser number of shorter western spurs. There are extensive east sloping plateau as well as some smaller west sloping plateau. The larger number of torrential west flowing rivers and the big east flowing peninsular rivers have carved out very many extensive valley systems on the Ghats. The impact of the main monsoon is on the western face where the rainfall is very high. The moderating influence of the sea is also felt more closely on the western face. Hence, there are extensive climax forest ecosystems covering these slopes. There is only one total discontinuity in the Western Ghats i.e. the Palakkad Gap (10° 30′N – 10° 50′N, 76° 35′E – 76° 55′E) where for a length of about 45km there are no hills.

Kerala part of Western Ghats

In general it can be stated that the western face of the Western Ghats is sheer while the eastern face slopes more gently down to the Deccan Plateau. But this does not apply to the southern part of the Ghats south of Wayanad. But in some locations a plateau breaks the sheer Ghat face.

The Eastern Ghats, a more discontinuous set of hill ranges running along the east coast moves inland in the northern part of Tamil Nadu and approaches very closely the Western Ghats at the northeastern corner of the Nilgiris. This junction is located approximately at 10°35′N and 76°50′E. The southern terminal part of the Eastern Ghats is called the Biligirirangan Hills. These two hill ranges are separated by the deep gorge of the Moyar River. In Kerala the western face of the Ghats is broken into two or three steps in some locations. In such reaches of the Ghats, the first step commences from the base of the Ghats and goes steeply up to a height ranging from 700 to 900 m. In three locations the main crestline dips straight down to the western plains. They are in the Agasthyamalais, in the western face of the Nilgiris along the Karimpuzha River in Nilambur and in the Kannur Ghats. The western outer face of the Ghats initially rises up to a crestline located at elevations of about 800 to 1000 m.To the east of this outer crestline in most locations there would be a valley or a narrow plateau draining towards the west. Then the western slope again rises up to the main watershed line located around 1500 m. This is usually the main ridge crest. If the main ridge is still higher, there would be a second smaller valley or plateau located at around 1800m elevation. In such cases the crestline would be above 2000m.

The rainfall is highest along the western face, the terrain is very broken and it was originally heavily forested and uninhabited. These rainforests have the highest biodiversity. But since the middle of the 20th century these slopes have become accessible for the people in the plains. Hence the maximum extent of forest fragmentation and degradation has also happened along these slopes. These slopes exert the greatest influence on the west draining rivers and on the plains of Kerala. Most of the Protected Areas in the State are also located along these slopes.

Subunits of the Kerala part of Western Ghats

For the purpose of forest ecorestoration, watershed management and biodiversity conservation natural landscape subunits, basins and ecosystem boundaries have to be identified. Landscape subunits can be identified by topography. River basin boundaries can be identified on the basis of drainage directions but in most cases ecosystem boundaries within watersheds are already disrupted. There must have been forest continuity between all the subunits till recently which is essential for the ecological security of the State.

Subunit I - The Ashambu Hills or the Agasthyamalai Ranges (8°15′N – 9°5′N Lat. , 77°5′E – 77°35′E Long.)

The southernmost section of the Western Ghats is called the Ashambu Hills or the Agasthyamalai Ranges. It is the most composite part of the Ghats extending from the Aramboli Pass in the south in the Kanyakumari District in Tamil Nadu to the Punalur-Tenmala-Ariyankavu Gap in the north in the Kollam District in Kerala. This is a narrow section of the Ghats with an average elevation of 1500m. There are only a couple of peaks higher than 1800 m.

There are no spur hills on the eastern slopes of the Agasthyamalais but there are long spur hills radiating towards the northwest from the main ridge. At its northern end near the Ariyankavu Pass there is a broad area of low hills and valleys drained by the Kallada, Ithikkara and the southern tributaries of Achankovil Rivers. Further north is the Pandalam Hills.

The Ashambu Hills has less than one third of its area within Kerala, the rest being in Tamil Nadu. The southern most part of the western face of this range is in the Kanyakumari district. This is the only area where the entire western face of the Ghats is in Tamil Nadu. The eastern face of the Agasthyamalais in Tamil Nadu falls within the Kalakkadu-Mundanthurai Tiger Reserve. The Tambraparni River drains most of the eastern slopes of this hill range. This landscape subunit has a low elevation plateau around Mundanthurai located at less than 300 m. There is a higher plateau around Kakkachi in the Kalakkad Hills further south. There are seven large dams in the Tamil Nadu part of the Agasthyamalais and three in the Kerala portion.

Neyyar, Karamana, Vamanapuram and Kallada Rivers drain the Kerala portion of this hill range. The catchment area of the Neyyar River upstream of the Neyyar irrigation dam has been constituted into a Wildlife Sanctuary covering 128 sq km area. Immediately to the north of it the contiguous 53 sq km area in the catchment of Peppara dam has also been constituted into a Wildlife Sanctuary. Closer to the Ariyankavu Pass, the catchment forests of the Kallada dam enclosing an area of 100sq km forms the Shenduruny Wildlife Sanctuary.

The Kani tribal community lives along the western slopes and in a small section of the eastern slopes. The forest area in the Kerala portion continues across the crestline into Tamil Nadu all along the eastern boundary. Forests also extend to the south into the Kanyakumari district. Towards north across the Ariyankavu Pass there is only tenuous forest continuity into the Tamil Nadu portion. But in Kerala, there is a broad link with the northern Pandalam Hills. The once broad forest vegetation link between the Agasthyamalai landscape subunit and the northern Pandalam Hills subunit is cut through by the Kollam-Shenkotta road and rail link. This junction of the two landscape units is a very potential area from the point of view of biodiversity protection and requires critical attention. Because the crestline of the Ghats is low climatic influences have resulted in a great range of habitats supporting biodiversity not occurring anywhere in the southern Ghats.

The entire Ashambu landscape unit falls within the Thiruvananthapuram and Kollam districts. The forest area is within the Thiruvananthapuram, Thiruvananthapuram Wildlife, Tenmala, Chenduruny Wildlife and Punalur Forest Divisions. This landscape subunit, especially along its northwestern portion has extensive areas of Reserved Forest leased out for cultivation of cash crops to the Rehabilitation Corporation (Rubber), Plantation Corporation (Rubber), Oil Palm India Ltd., Farming Corporation and Forest Development Corporation.

The Ashambu landscape subunit of the Western Ghats in Kerala is about 800 sq km in area. At least 600 sq km of it is forestland and currently 280 sq km of it is within the Protected Area Network. It is the most compact and minimally fragmented part of the western slope forests in the entire Kerala Western Ghats. This section of the Ghats has the minimum number of rainless months and hence the evergreen forests are very well developed. Along the northwestern edge of the Agasthyamalais low spurhills project far towards the west and this area forms one of the widest hilly midland tracts in Kerala. Ithikkara Ar originates from this tract. Neyyar irrigation reservoir with inter-State water requirements, Peppara dam supplying drinking water to Trivandrum and Kallada, the largest irrigation dam in Kerala, are all located in this landscape subunit. Vamanapuram River draining the mid part of this landscape subunit is possibly the only river in the State with the entire hill catchment area under natural forest vegetation.

Subunit II – The Pandalam Hills (9°5′N – 9°35′N Lat., 76°55′E – 77°17′E Long.)

This subunit of the Western Ghat landscape commences from the ill-defined Ariyankavu Gap. There are only a series of low east-west hill ranges linking this subunit with the southern Ashambu Hills. The crestline of the main Ghats (the watershed line) comes down to a height of about 500 m in the Ariyankavu Gap. After the Gap towards the north the crestline rises up to more than 1000 m in elevation, but approaching Kottavasal at the head of the Achankovil Valley it again dips down to less than 500 m. North of the Achankovil Valley, the main crestline rapidly rises to a height of 1800m. A high spur hill starts from Devarmalai located in the main crestline and thrust out towards west separating the Kallar sub-basin of Achankovil River from the Kallar, Chinnakakkiyar and Kakkiyar sub-basins of the Pamba River. The Pandalam Hills are the most heavily and still almost completely forested part of the entire Western Ghats. Its eastern border north of Ariyankavu Pass is the well-defined scarp face along the eastern edge of the Western Ghats facing Tamil Nadu. Across the State boundary towards east in Tamil Nadu, there is only a very narrow strip of forest vegetation on the Ghat slope.

The main Western Ghat ridge reaching the Chokkampatti Mala bifurcates. The main Western Ghat crestline which is also the watershed divide runs due north. An almost equally high distinct ridge branches off towards northwest initially and then turns north separating the Pandalam Hills from the Upper Valley of Periyar. This ridge at its northern end skirts around Pachakkanam and gradually merges with the southwestern edge of the Peermade Plateau. Peermade Plateau is the junction of the northwestern edge of the Pandalam Hills, the northwestern edge of the Upper Periyar basin and the Idukki Sub-Plateau area of the Cardamom Hills.

There are extensive low elevation foothills along the southwestern edge of the Pandalam Hills reaching far into the midlands. This segment of the Ghats has the most extensive forested foothill zone. The Pandalam Hills also has the most extensive western slope forests extending from the base of the Ghats to elevations reaching up to almost 2000 m. Achankovil and Pamba Rivers drain most the area. Manimala River originates from the northwestern edge of the Peermade Plateau where the Pandalam Hills end. But forest vegetation stops abruptly south of Pambanar and only phoenix grasslands extend discontinuously further north up to the Kottayam-Kumily road. Towards east, mid elevation grasslands extend all along the Peermade Plateau up to the Mullaperiyar dam. In the rest of the area, forests of the Pandalam Hills are continuous with the vegetation of the Periyar Tiger Reserve which falls within the Cardamom Hills landscape subunit. Along the southwest corner of Pandalam Hills, the lower reaches of the foothill forests are extensively fragmented by plantations of teak, eucalyptus and by private enclosures all along the lower Achankovil and Pamba Valleys.

The Malampandarams, Uralis, Mala Arayas are the tribal communities in this part of the Ghats. There are eight dams within this section of the Ghats. The Sabarimala temple is in its northeastern portion. Roads to the Achankovil Valley, Moozhiyar, Kakki and to Sabarimala cut across the forests on the western outer face. The Kottayam-Kumily road skirts its northern edge. The Moozhiar-Kakki dam-Anathodu-Vandiperiyar road traverses it from south to north. There are extensive teak plantations all along the foothills towards northwest, west and south. There are some eucalyptus plantations higher up along the edge of the Peermade Plateau. Oil palm plantations and rubber plantations on the leased forestlands cover extensive areas along its southwest corner adjacent to the Punalur-Ariyankavu Pass area. In spite of all these extensive and repeated forest fragmentations and degradations, the Pandalam Hills along with the contiguous Upper Periyar Valley forests form the most extensive evergreen forest tract in Kerala Western Ghats and potentially the richest in biodiversity in the entire Western Ghats in Peninsular India.

The Pandalam Hills fall within the Kollam, Pathanamthitta and Kottayam districts. Tenmala, Achankovil, Punalur, Konni, Ranni Forest Divisions as well as a portion of the Periyar Tiger Reserve West Division fall within the Pandalam Hills. The eastern slopes of this section of the Western Ghats are mostly very dry deciduous forests or scrub. No perennial stream originates from the entire length of this Ghat segment.

Out of its geographical spread of about 1800 sq km, 1500 sq km area is forest land and about 300 sq km of it is extremely rich benchmark ecosystems with unique biodiversity protection potential. This section of the Ghats has only a very narrow steep slope descending into the Tamil Nadu plains on its eastern edge and these eastern slopes extending over about 300 sq km has forest cover over less than 200 sq km. Most of the forests of the Pandalam Hills fall within the western slope of the Western Ghats. At least a part of it is relatively undisturbed forests. The Pamba Basin has the most extensive mid elevation grasslands in the Kerala Western

Ghats. Excepting a portion of the Periyar Tiger Reserve, there are no other Protected Areas within this unit. Its biodiversity value could possibly be the highest, comparable to the New Amarambalam Reserved Forest in the Nilambur slopes. The large number of dams located within this tract warrants special watershed ecorestoration treatment for their catchment slopes.

Sub unit III – The Cardamom Hills (9°15'N – 10°0'N Lat. , 76°45'E – 77°25'E Long.)

The central portion of the Western Ghats in Kerala is called the Cardamom Hills. This is mostly a west draining 700 – 1000 m high plateau. The southern boundary of the Cardamom Hills separating it from the Pandalam Hills is the ridge dividing the Pamba Basin from the Periyar Basin. The southwestern corner of the Cardamom Hills extends west as the Peermade Plateau. The headward erosion of the Azhutha and Pamba Rivers has cut deep into the flanks of the Peermade Plateau. North of this landscape subunit and extending along the western edge of the Western Ghats, parallel to the main Periyar channel, is the Idukki section of the Cardamom Hill subunit. The northern border of the Cardamom Hills abuts onto the High Ranges. This part of the Cardamom Hills is higher and is more undulating. The rest of the Cardamom Hill tract is a very gently undulating plateau located at elevations of around 1000m.

The Cardamom Hills form a natural composite landscape subunit. Most of it is in Kerala excepting one spur hill called the High Wavies projecting east from its southeast corner. It is in Tamil Nadu. The High Wavies is the source of the east flowing Vaigai River. Unlike the Pandalam Hills, most of the western boundary of the Cardamom Hills is sharply set off from the Kerala plains by steep scarp faces. The eastern border of this landscape subunit is again sharply demarcated by precipitous scarp faces rising up from the Tamil Nadu plains. The upper reaches of the eastern slopes have heavy moist forest vegetation and the lower reaches are drier.

The upper catchments of Periyar extend as a wedge deep into the northeastern corner of the Pandalam Hills. This is a section of the Cardamom Hills which extends deep into but is clearly separated from the Pandalam Hills. The main Western Ghat watershed line forming the eastern border of the Cardamom Hills is highest where the High Wavies branch off from it slightly to the southeast of the Kumily gap. Some peaks of the High Wavies reach elevations of over 1900m along the State border. Further south, the ridge along the watershed line is heavily forested. It is called the Sivagiri Range and extends south up to Chokkampatti Mala which is at the junction of Achankovil, Pamba and Periyar River basins. The southern boundary of the Cardamom Hills runs along a westerly spur hill starting from the Chokkampatti Mala which initially runs north and then turns northwest almost parallel to the Sivagiri Range. This ridge separates the basin of Pamba from Periyar. North of Pachakkanam, this ridge loses height, and it continues along Arjunankotta where it turns north and merges with the Peermade Plateau. From its source near Chokkanpattimala initially Periyar flows north between these two heavily forested ridges. The valley floor is at an elevation of 1000m and the ridges on either side are often reaching 1800m. This valley of Periyar at its source and the valley of Kunthi River i.e. Silent Valley are the only two forested higher valleys in the Western Ghats left intact even now. Approaching Mullaperiyar dam the forest vegetation gives way to extensive grasslands which now cover most of the area around the reservoir.

There is a poorly defined ridge running from near Chakkupallam north of Kumily in the State border extending southwest to near Vallakkadavu which partly segregates the upper reaches of Periyar from the rest of the Cardamom Hills. Immediately downstream of Mullaperiyar dam, Periyar cuts through this ridge. This ridge forms the northeastern and northern border of the Peermade Plateau. There is no forest left in this ridge but extensive tea plantations and eucalyptus plantations cover the entire area. Pamba and Azhutha tributaries of the Pamba River originate from the south-western part of this ridge where it merges with the Peermade Plateau.

The 777sq km Periyar Tiger Reserve is located mostly within this southern most part of the Cardamom Hills. The western portion of the Periyar Tiger Reserve extends into the Pandalam Hills along both the northern as well as southern faces of a ridge separating Pamba and the Azhutha Rivers. The main segment of Cardamom Hills extends towards east from the Periyar River Channel to the State border as a fairly smooth plateau. There is no forest left in this tract.

To the west of the main Periyar River the western edge of the Cardamom Hills forms a small but distinct subunit called the Idukki Sub-plateau. This is the lower western edge of the Cardamom Hills sloping towards the north. It is separated from the rest of the Cardamom Hills by the deep channel of the Periyar River. It extends north from near Ayyappankoil to near Neriyamangalam. Its western border is the clearly demarcated scarp face of the Ghats descending to the plains of Kerala. It ends in the north by the main channel of Periyar along the Neriyamangalam – Panamkutty axis. The catchment of Kattappana Ar located beyond the southeastern corner of the Idukki reservoir is also part of this sub-section. A southwest to northeast ridge called the Chekuthan Mala separates the Idukki Sub-plateau from the Peermade Plateau as well as the main mass of Cardamom Hills. Its eastern boundary is a northwest to southeast ridge (the Kalyanathandu-Puliyanmala ridge) separating the Idukki reservoir from the Kallar tributary of Periyar which drains the main Cardamom Hills. The Idukki Sub-plateau is at an average elevation of 700m. Its western boundary is the sharply defined western edge of the Ghats descending to the plains of Thodupuzha. This 900-1000m high western crestline separates the Periyar catchment from the Meenachil and Moovattupuzha drainage basins. The Idukki Sub-plateau was heavily forested till the 1950s but now only three small fragments of forest vegetation alone remain. The largest is within the Idukki Wildlife Sanctuary. This Sanctuary cover an area of 77 sq km and is located between the two arms of the 'Λ' shaped Idukki reservoir. Most of this Protected Area is fire degraded vegetation, a mosaic of succession stages with small remnants of original evergreen forests of special biodiversity value. Along the western slope and north of Kulamavu there is a small island of forest vegetation at the source of Veloorpuzha (a tributary of Moovattupuzha). This is part of the western slope forests and is a remnant of the original vegetation of the Thodupuzha Reserved Forest. Along the northwestern edge of the Idukki Sub-plateau, to the north of the Nagaramparamudi, there is another strip of forest extending northwest to southeast parallel to the Neriyamangalam – Idukki road and to the south of it.

The forests along the western crestline, to the west of the Idukki reservoir is extremely fragmented and degraded. The Thodupuzha - Moolamattom-Kulamavu road and the Kulamavu-Painavu-Neriyamangalam road cut through it. There are scattered enclosures of tribal settlements and many pockets of encroachments. On the western outer face of the Western Ghats starting from the Kottayam-Kumily road and extending all the way north to the Moolamattom-Kulamavu road, there is no forest left. Only extensive tea plantations and degraded rocky or grassy blanks cover these slopes. The Erattupetta-Vagamon road and the Kottayam-Kumily road traverse it from west to east. Roads from Elappara and Kuttikkanam to Vagamon as well as to Kattappana pass through this section. The western edge of this part of the Idukki Sub-plateau particularly the source of the Meenachil River is an ecologically fragile zone that has been devastated. From near Vagamon, a northwesterly long spur hill, the Kudayathoor hill range, extends into the plains of the Kottayam district. This ridge separates the watershed of Meenachil in the south from the northern Moovattupuzha Basin. There are no natural forests in this ridge. But located at the source of the Meenachil and the Moovattupuzha Rivers this area has critical watershed value.

The main Periyar River, part of it now submerged under the Idukki reservoir, drains the Cardamom Hills. There is no viable vegetation continuity between Idukki Sub-plateau and the other units of Western Ghats. To the northwest across the main Periyar, it has a fragile severely threatened vegetation continuity with the Malayattoor Reserved Forest.

There is a tiny stream, a tributary of Vaigai, also called Periyar which starts from the east of Chakkupallom in Kerala. This is a small part of the east draining Vaigai catchment included in Kerala. The eastern border of the Cardamom Hills between Theni and Kambam are precipitous scarps descending to the Madurai plains. Although labeled Reserved Forests, there is no forest vegetation left along this entire stretch. The crestline here, in comparison with the rest of the main watershed line of the Cardamom Hills and the High Ranges, is low reaching up to only about 1000 m. Hence the desiccating climatic influence of the Ramnad and Madurai plains affects the relatively low (700 m) Cardamom Hill part of the Kerala Western Ghats. This effect has now become very adverse due to the absence of insulating moist forest vegetation along the plateau and the eastern scarp face. The northern boundary of the Cardamom Hills is the high Munnar saddle running east to Chokkanad Mala and further on to the Kolukkumala on the eastern edge of the Ghats. This part of the Cardamom Hills extending northwest below the Munnar Plateau along Panniyar is higher than the southern part and is more undulating. It extends far to the west towards Adimali and Deviar. Towards northwest the Cardamom Hills is not sharply demarcated from the Lower Periyar Valley subunit of the Western Ghats.

The forest vegetation discontinuity extending from near Kumily in the south till the High Range Plateau in the north, a distance of more than 75 km, is the widest ecological rupture the Western Ghats has suffered in recent times. The geological discontinuity of the Palakkad Gap which also resulted in the forest discontinuity is only 45km wide.

The mid portion of the Cardamom Hills is on the average about 800m high and slopes from east to west. It is drained by Chinnar (also called Perinjankutty Ar). The northern edge of the Cardamom Hills on the other hand slopes steeply to the south and is drained by Panniyar. The Cardamom Hill subunit is drier than all other west sloping parts of the Western Ghats. It has no significant extent of natural forests remaining anywhere. At the turn of the 20th century, it was fully covered by evergreen forests. Towards the southwest in the Chekuthan Mala ridge, some cardamom lease lands still have the canopy trees of the original forest. There are also tiny remnants of sholas on the eastern crestline and small patches of uncultivated or abandoned cardamom forests scattered all over. The best known among these remnants is the Mathikettan Shola along the northeastern corner which is the last residual bit of about 2000 ha of evergreen forests in the entire Cardamom Hills. This has been notified as a National Park. The Cardamom Hills must have been ecologically comparable to the Pandalam Hills a century ago. But now after the Attappady Plateau it must be the most devastated segment of the Kerala Western Ghats. The Mannan, Mala Araya, Urali and Malampandaram are the main tribal communities found in these hills.

This hill range has an extent of over 2500 sq km within Kerala. The southeastern edge of the Cardamom Hills ends abruptly along a scarp face at the State border. Along the Kambam-Kumily axis there is a long spurhill, the High Wavies, projecting towards the northeast into Tamil Nadu. The High Wavies are essentially two long parallel high ridges with the valley of the Vaigai River in between. The High Wavies cover an area of 1500sq km and only its western edge falls within Kerala. This biodiversity rich part of the Ghats falls within the Periyar Tiger Reserve.

The Cardamom Hills had forests of exceptional biodiversity value. They were also the vital catchment forests of the main Periyar River. But now there is practically no forest left in the entire plateau. There is only an extremely fragmented stretch of forestland along the western slopes covering less than 500sq km area. All the forests in this subunit fall in the Kottayam, Kothamangalam and Munnar Forest Divisions, in the Periyar Tiger Reserve as well as in the Idukki Wildlife Division. Most of the area of the Cardamom Hills falls within the Idukki district though a small part of the western slopes are in Kottayam and Ernakulam districts. The western slopes of the Cardamom Hills have the highest priority for ecorestoration management in southern Kerala.

Subunit IV – The High Range Plateau (10°0′N – 10°15′N Lat. , 76°55′E – 77°15′E Long.)

The High Range Plateau is located around Munnar and Devikulam. It has an average elevation of about 1800 m and it drains to the south through Muthirapuzha into Periyar. The high Rajamala-Anaimudi-Umayamala part of the main Anamalai ridge forms its northern boundary. There is a spur ridge starting from the main Anamalai ridge and running south immediately to the west of Munnar which continues on to Parvathi Mala. This spur forms the western boundary of the High Range Plateau and separates it from the Lower Periyar Valleys located further to the west. The eastern edge of the High Range plateau runs north from Kolukkumala, which is at the junction of the High Range Plateau with the Cardamom Hills, and continues onto the Top Station along the State border.

The Palani Hills or the Kodaikanals is an extensive spur starting from near Top Station and extending eastward. The Vattavada part of the Anjanad Valley falls to the north of Top Station in between the Palanis and the High Range subunit. The High Range subunit is essentially the south and west draining slopes of the main Anamalai ridge. The Palani Hills are located to its southeast and the Lower Periyar Valleys are to its west. The Cardamom Hills are located to its south. All the northern slopes of the main Anamalai ridge falling within Kerala drain into Idamalayar and Pooyamkutty Ar. The lower valleys of Idamalayar and Pooyankutty Ar constitute a distinct landscape subunit called the Lower Periyar Valleys. Wedged between the junction of the Anamalais and the Palanis is the main Marayoor part of the Anjanad Valley.

The High Range Plateau has been almost totally transformed by tea plantations and hydel dams. The original forest was mostly of the Shola-Grassland type. This tract falls entirely within the Idukki district. Forests in here are within the Munnar Forest Division and the Munnar Wildlife Division. The Eravikulam National Park (77 sq km) and the recently notified Shola National Parks as well as the Kurinji Sanctuary are within this unit. There are five large existing hydel reservoirs within this tract and there is the proposed Pallivasal Replacement Scheme which would submerge the Munnar town and its vicinity. This subunit of the Kerala Western Ghats still has the largest extent of shola-grassland ecosystem in the Western Ghats scattered within it. The total extent of this subunit is about 1000 sq km. The Anamalai Hills continue into Tamil Nadu and extends over an area of about 1000 sq km. The entire forest area in Tamil Nadu falls within the Anamalai Wildlife Sanctuary which is proposed to be raised to the status of a National Park. From the biodiversity value, this unit is of special importance because of its specialized high altitude flora and fauna. But it is a severely disturbed part of the Kerala Western Ghats. There is no extensive unmodified part of the landscape left excepting the Eravikulam National Park. There are extensive discontinuous grassy ridge tops scattered all over the Kannan Devan concession lands of considerable biodiversity value. But during the 1975-1990 period most of them were planted up with wattle and subsequently damaged by fire. Uncontrolled building activity and other ill effects of urbanization as a consequence of tourism development are threatening the Munnar Valley and a few other locations in this subunit.

Subunit V – The Lower Periyar Valleys (10°0′N – 10°18′N Lat. , 76°40′E – 77°0′E Long.)

The exceedingly violent impact of very heavy rainfall on a probably geologically unstable part of the Western Ghats where there is extensive faulting has caused accelerated weathering and erosion, carving out a complex of deep valleys on the western face of the High Range Plateau. This topographically complex segment of the Western Ghats extends from near Neriyamangalam in the southwest to Panamkutty in the southeast along the main Periyar River and it continues north up to the watershed divide between the Periyar and the Chalakkudy Basins. Its eastern border is the main Anamalai ridge. This deeply dissected western slope of the Western Ghats is named the Lower Periyar Valleys and has geographical as well as ecological characteristics found nowhere in the Western Ghats. To the south of this subunit is the Idukki sub-plateau and to the southeast, the Cardamom Hills. The western edge of Panniyar and Muthirapuzha Basins form the eastern border of this subunit. The Parvathimudi-Umayamala ridge forms the northeastern corner of the Lower Periyar Valleys. Towards north, the Lower Periyar Valleys extend up to the ridge separating Sholayar from the Idamala River. Within this subunit there are a series of deep west-sloping valleys where the valley floors are often located at elevations less than 300 m. Separating these valleys are a jumble of steep hills and flat topped plateaux with scarp faces rearing up to elevations of around 900-1500 m. The Idamala and Pooyamkutty Rivers drain most of the area while its southern edge drains into the main Periyar. This tract is almost entirely forested and the forests extend northwest between Periyar and Chalakkudy rivers along the plains almost up to Kalady. There are a few large enclosures within this tract such as Mankulam. There are also a large number of smaller tribal and other settlements. The 25 sq km Thattakkad Sanctuary is located at the junction of the main Periyar with the Idamala River and a small portion of the western edge of the Eravikulam National Park fall within the Lower Periyar Valleys. The natural forest vegetation continues north across the Idamala reservoir into the Chalakkudy Basin and towards the southwest into the Idukki Sub-plateau. The forest habitat continuity into Eravikulam is a transitional zone of low land evergreens, through montane evergreen to shola-grassland system. The source of the Idamala tributary of Periyar is in Tamil Nadu in the Upper Neerar part in the Anamalai Hills. This tract is also a part of the same landscape unit where forest ecosystems merge into shola-grassland ecosystems. It is included in the Indira Gandhi Wildlife Sanctuary in Tamil Nadu. This part of the Western Ghats is very rich in biodiversity. It is ecologically extremely complex and fragile. Settlements of the Muthuva, Mannan and Mala Araya tribal communities are found in these forests.

The huge Idamala Hydro-electric Project has already submerged most of the Idamala Valley and the larger Pooyamkutty H.E.P. also is proposed within this tract. Currently the KSEB is constructing one of the dams associated with the Pooyamkutty Project namely the Mankulam dam. This landscape subunit is the most important reed resource area for the paper and rayon industries in the State. There are extensive teak and eucalyptus plantations along the northwestern edge of this segment which has been worked extensively for its forest resources and is severely degraded. There are cardamom plantations along its eastern border with the High Range Plateau as well as the Cardamom Hills. This subunit of the Western Ghats has along with the New Amarambalam in the Chaliyar Basin, and some parts of the Pandalam Hills, the last remaining low valley forest in Kerala. The priority consideration in its management must be biodiversity protection and watershed protection.

The western slope forests of the Lower Periyar Valleys fall in the Kothamangalam, Malayattoor, Munnar and Mankulam Special Division areas. The northern edge of the unit is within the Vazhachal Division. A small part of the Eravikulam National Park and the Thattekkad Bird Sanctuary are also in this unit. Administratively the Lower Periyar Valleys are in the Idukki and Ernakulam districts.

The Lower Periyar Valleys extend over 1200 sq km in area. A small portion of the upper reaches of the Idamala River extends into Tamil Nadu which is less than 250sq km in extent. More than 1000 sq km of this subunit is forested. This is one of the most valuable and fragile western slopes of the Western Ghats in Kerala. Although it is heavily forested in patches, there is the heavy damage inflicted by the Idamala dam. There is continuous exploitation of reeds and widespread forest encroachment. The forests along the lower reaches towards Malayattoor have been most severely degraded in the past by timber working. Yet the forests in the

Pooyamkutty Basin within this subunit are the only remaining forested catchment in the entire Periyar Basin apart from the area upstream of Mullaperiyar dam.

Subunit VI – The Anjanad Valley (10°7′N – 10°23′N Lat. , 77°5′E – 77°18′E Long.)

A portion of the drainage basin of the east flowing Amaravathy River, a tributary of Cauvery, is located along the northeastern corner of the Idukki district. This area is called the Anjanad Valley. It is formed by the valley of Pambar joined by Chinnar on the left flank and Athi Oda on the right flank. Actually there are three valleys opening towards Tamil Nadu which join together near Chinnar. The slopes of these deep valleys descend from elevations of around 2400m in the west to less than 400 m at their eastern end. In the middle of the Pambar Valley there is the small Marayoor Plateau located at 900 m elevation. The eastern slopes of the Western Ghats here are among the steepest with the elevation of the crestline often exceeding 2500m. While the higher ridges receive more than 3500mm of rainfall the lower reaches located at less than 450m have rainfalls as low as 600 mm. The altitudinal and climatic gradients create here a variety of vegetation zones compressed into a short west to east transect not found anywhere else in the Western Ghats.

The Chinnar Wildlife Sanctuary (90sq km) is located within this subunit. Across the border to the north, forests in Tamil Nadu are part of the Anamalai Wildlife Sanctuary. The Anjanad Valley falling in Kerala is part of the Idukki district. The Munnar – Udumalpet road and the Marayoor – Sethu Parvathypuram road traverse the eastern slopes of the Western Ghats in this subunit. The Muthuva and the Hill Pulaya tribal communities inhabit the forests.

The Anjanad Valley covers about 400sq km area in Kerala and the adjacent Kukkal Valley and the main Amaravathy Valley (both in Tamil Nadu) together cover about 300sq km. An eastern spurhill of the Western Ghats i.e. the Palani or Kodaikanal Hills forms the south western border of the Anjanad Valley. This hill range covering about 1500 sq km has only a small portion of its western edge falling within Kerala. There are tiny residual sholas along its northern and southern edges which would cover an area of about 200sq km. There are drier forests down the northern slopes and more moist vegetation along the Manjampatty-Kukkal Valleys downstream of Athi Oda.

Subunit VII – The Nelliyampathy Hill Ranges (10°10′N – 10°35′N Lat. , 76°22′E – 76°50′E Long.)

This extensive contiguous forest habitat extending from the High Range Plateau and reaching up to the southern lip of the Palakkad Gap is topographically a very heterogeneous unit. This landscape subunit is drained primarily towards the west by the Chalakkudy River. The Nelliyampathy Hills is a gently southwest sloping part of the Western Ghats forming the southern and southeastern lip of the Palakkad Gap. The arc of the Anamalai Hills extends all along its eastern and southeastern border. A spur hill extending from near Valparai in Tamil Nadu project far to the west into the Kerala part and separates the Nelliyampathies from the Idamala Valley which is a part of the Lower Periyar Valleys subunit further south. The northern outer slopes of the Nelliyampathies are drained by Gayathri puzha, a tributary of Bharathapuzha. The northeastern outer slopes are drained by Aliyar which joins Chittoor puzha which in turn is a tributary of the Bharathapuzha. The northwestern outer slopes and the long spur hill extending towards Vazhani separating the Palakkad plains from the Thrissur midlands are drained by Karuvannur and Keecheri Rivers.

The Nelliyampathy Hills extend from southwest to east along the Palakkad Gap and then curl southeast in an arc to end near Top Slip. South of Top Slip, the much higher Anamalai Range continues in a broad sweep to the southeast through Tamil Nadu till they re-enter Kerala at the junction of Anjanad Valley, the High Range Plateau and the Lower Periyar Valleys subunits of the Kerala Western Ghats. The northwestern slopes of the

Anamalais are drained by the Chalakkudy River. The Nelliyampathies and the Anamalais together enclose a vast west-opening amphitheater. The main Nelliyampathy Hill Range has a number of spur hills extending from the east to west. The Karappara Valley at an average elevation of 1000m is in between the two northern spur ridges. Immediately to the south of Karappara Valley is the Kuriarkutty valley which is at a lower elevation of 800m. South of Kuriarkutty Valley is the Parambikulam amphitheatre at an elevation of about 500 m. Along the southern rim of the Parambikulam Basin, there are again two parallel east-west ridges reaching elevations of 1400m with the Sholayar River flowing between them.

The upper reaches of the main Karappara Valley are mostly cardamom, coffee and tea plantations. Teak plantations covering more than 100 sq km have replaced natural vegetation extensively in the Kuriarkutty Valley as well as the Parambikulam area. There are three dams located within the Parambikulam amphitheatre namely the Peruvaripallam Dam, the Thoonakadavu Dam and the Parambikulam Dam which are part of the Parambikulam-Aliyar Project. The Parambikulam Wildlife Sanctuary (285 sq km) is located in the Parambikulam amphitheatre. The Sholayar Valley to the south of Parambikulam has been submerged under the Upper and Lower Sholayar reservoirs, the former in Tamil Nadu and the latter in Kerala. Further downstream, after the confluence of its main tributaries and the formation of the main Chalakkudy River, there is the Poringalkuthu reservoir. In this part of the Western Ghat western slopes more than 300 sq km of forests have been cleared and planted with teak and eucalyptus during the 1960s and 1970s spread over Chalakkudy, Vazhachal and Parambikulam Forest Divisions. There have been extensive plantation failures and over the years these sites have degraded to fallows. The upper reaches of Sholayar and the Parambikulam Ar are in Tamil Nadu. There are four dams in the western side of this subunit in Kerala and four in the higher reaches in Tamil Nadu. Extensive forest areas have been converted to cash crop and tree plantations along the lower Chalakkudy Valley as well as in its upper reaches around Valparai. The Anamalai Wildlife Sanctuary encloses most of the remaining forests in the Tamil Nadu part of this landscape unit. The western outer slopes of the Nelliyampathies drained by the Chimmony and Mupply Rivers (tributaries of the Karuvannur River) have been declared as the Chimmony Wildlife Sanctuary (90sq km) around the Chimmony dam. Contiguous with and north of Chimmony Sanctuary, catchment areas of Manalipuzha (another tributary of Karuvannur River) along with the catchment areas of Vazhani dam have been constituted into the Peechi-Vazhani Wildlife Sanctuary (125 sq km).

This was an extremely rich landscape unit of the Western Ghats which was subjected to extensive severe disturbance during the past half a century. But some forests still remain which are rich in biodiversity. A number of dams, forest plantations, cash crop plantations, roads etc. have broken up the climax natural forests of this tract into small scattered islands. The Chalakkudy – Anamalai road runs east – west along the southern portion of this segment. There is an extensive network of roads within the Karappara Valley linking up the estates. Parambikulam Valley has an extensive road network. There are also roads into the various lower valleys on the western edge.

In the Nelliyampathy subunit, the southern segment of the Western Ghats south of the Palakkad Gap terminates abruptly. There is a 45 km wide forest discontinuity along the Palakkad Gap in the Bharathapuzha basin before forests reappear on the northern lip in the Malampuzha catchments. There is no possibility of re-establishing a vegetation corridor linking the forests on either side of the Gap. Along the base of the northern outer slopes of Nelliyampathies which is drained by Gayathripuzha there are four medium irrigation dams namely Mangalam, Pothundi, Chulliyar and Meenkara. These slopes forming the catchment of the Gayathripuzha is almost totally denuded of forest vegetation. There are Kada, Muthuva and Malaya settlements in these forests. Forests are within the Chalakkudy, Vazhachal, Thrissur, Nemmara Divisions and Peechi-Vazhani and Parambikulam Wildlife Divisions. This landscape subunit falls within the Thrissur and Palakkad districts in Kerala.

Geographically the total extent of the area in Kerala within this Western Ghats subunit would be approximately 2500 sq km. More than 1800 sq km of it is administratively with the Forest Department. At present Protected Areas cover about 500sq km of forests in Kerala. Along with the Agasthyamalais the Nelliyampathy subunit also has a significant extent of west sloping crestline reaches of Western Ghats in Tamil Nadu. More than 600 sq km area of the Nelliyampathies, both on the western and on the eastern slopes are in Tamil Nadu and it is part of the Anamalai Wildlife Sanctuary. In spite of extensive habitat degradation, the extent of forest remaining and their biodiversity value make it one among the most valuable parts of the Western Ghats. There are a large number of dams located within this landscape subunit. Hence, there is need for a comprehensive watershed management programme for this tract with focus on ecorestoration of forests.

Subunit VIII – The Palakkad Hills and The Attappady Plateau (10°48′N – 11°5′N Lat. , 76°20′E – *76°50′E Long.)*

Between the Palakkad Gap and the Nilgiris to the north, there is a complex of ridges and plateaux. Along the northern rim of the Palakkad Gap, the Western Ghats rises up abruptly from the plains to a narrow high east-west ridge extending from Madukkarai in Tamil Nadu, past Walayar, towards west to Elival Mala, gradually rising up to more than 2000 m in elevation. From Elival, the main ridge (which is also the main watershed line in the Western Ghats) turns abruptly north and continues along the western boundary of Attappady. It comes down to a low saddle hardly 500 m high near Mukkali and it again rears up to a high-ridge meeting the Nilgiris at Anginda at an elevation of 2400m. This ridge separates the drainage basin of Kunthipuzha (a tributary of Bharathapuzha) flowing through the Silent Valley forests from Bhavani (tributary of Cauvery) flowing through the Attappady Reserved Forest.

From Walayar all the way west to Elival, the crest of this hill range is heavily forested and drains into the Walayar and Malampuzha Rivers. There are three irrigation dams at the base of this hill range namely Kanjirapuzha, Malampuzha and Walayar. The northern face of this ridge in Tamil Nadu is also forested and drains into the Noyil Basin. Around the Elival Mala, in the highest reaches, there is a knot of high ridges separated by deep valleys radiating west, southwest and northwest. The Chenath Nair Reserved Forest in Kerala occupies part of these forested ridges. North of Elival Mala also there is another cluster of high ridges drained by the Siruvani (tributary of Bhavani) towards the northeast. These are also heavily forested and constitute the Muthikulam Hills or Siruvani Hills (Attappady R.F. Compartment No. VI). While the main watershed line continues along the western edge of the Siruvani Hills and descends to less than 1000 m elevation, forming the western boundary of Attappady, another high spur hill skirting the Muthikulam Hills along its eastern edge runs through the eastern edge of Attappady towards the northeast. This ridge forms the State boundary. This ridge is called Varadimala and it abruptly terminates in the Perumalmudi on the Kerala – Tamil Nadu border near Anaikatty. Kodungarapallam, the third tributary of Bhavani draining the southeastern edge of Attappady originates from this ridge and flows north along the State border.

To the northwest of Mukkali, located at a higher elevation, is a small sub-plateau of about 90 sq km through which the Kunthi River flows towards the south. This is the Silent Valley Plateau. The western edge of the Silent Valley Plateau has a series of 1500-1900 m hills which abruptly descends to the Malappuram plains. These slopes have been added to the Silent National Park as its buffer zone. The Silent Valley Plateau is located at an elevation of 1000 m and it is the core area of the Silent Valley National Park (89sq km). While the southern outer slopes of the Silent Valley Plateau are drained by Bharathapuzha, the western outer slopes drain into

Kadalundi and the northern slopes into Chaliyar. The Palakkad Hills have a unique weather and climate due its proximity to the Gap and to its elevation. The area has natural climax forests (stunted montane evergreen forests) of potential high biodiversity value. The Palakkad Hills to the south and west, the Muthikulam Hills and the Varadimala Ridge to the east and the main Nilgiris to the north enclose the second largest east draining plateau in the Kerala Western Ghats. This is the Attappady Plateau. This landscape subunit is linked to the northern Nilambur Slope Forests across the Kottapuzha. Irula, Muduga and Kurumba tribal communities inhabit the Attappady Plateau.

The subunit falls within the Palakkad district with a small portion of it in the northwestern edge falling within the Malappuram district. The Palakkad Division, Mannarkkad Division, the South Nilambur Division and Silent Valley Wildlife Division cover the forest.

The Palakkad Hills and the Attappady Plateau together occupy about 1600 sq km area. Attappady Plateau excluding the Nilgiri slopes and the Muthikulam Hills cover less than 350 sq km area. Forests cover about 500-600 sq km area. The Palakkad Hills are topographically and ecologically the most complex part of the Western Ghats western slopes. The remaining forest areas including Silent Valley have exceptional biodiversity value. But all the forests in these steep slopes are subjected to extreme degradative pressure. Because it forms the catchment of Bharathapuzha these slopes need highest priority protection and ecorestoration management.

Subunit IX – The Nilambur Slope Forests (11°5′N – 11°35′N Lat. , 76°2′E – 76°33′E Long.)

The Nilgiri Mountains, the most extensive eastern spur ridge of the Western Ghats is an uplifted block of rock. It has sheer faces along the southwest, south, northeast and north. The Kerala State border runs along part of the southern crestline, along the northern edge of Attappady. The border then continues along the southwestern edge of Nilgiris separating Silent Valley and New Amarambalam forests from the Nilgiri grasslands in Tamil Nadu. Beyond the source of the Karimpuzha tributary of Chaliyar, the Nilgiris come down to the Mysore plateau in steps. The north and northwest continuation of the Nilgiris forms a lower plateau at an elevation of 800m which now falls within Tamil Nadu, Kerala and Karnataka States. The Tamil Nadu part is called Gudalur and the Kerala portion Wayanad and the northwestern edge projects into the Nagarhole National Park part of Karnataka. The Gudalur and the southeast corner of Kerala Wayanad drain into Chaliyar while the rest of the area drains into Kabini.

The western face of the Nilgiris descends abruptly from heights of over 2000 m in the Avalanche - Kunda areas to the Nilambur plains located at less than 50 m elevation. These slopes are heavily forested. The southwestern face of Gudalur and the southern face of Wayanad and the northern face of Silent Valley Plateau are all drained by Chaliyar and its tributaries. The entire western face of the Western Ghats in this subunit was very heavily forested till recently. Even now there are two extensive forest tracts in this area, one along the catchment areas of Karimpuzha (the New Amarambalam Reserve) and the other the slopes of the Camel's Hump Mountains. During the last few decades extensive deforestation has reduced the forest cover in this landscape subunit into a much smaller and narrower belt. Yet it remains one of the least explored and of very high potential value in conserving the biodiversity of the Western Ghats.

Northeast of New Amarambalam, in the Gudalur part of Tamil Nadu, practically all the forests have been destroyed during the second half of the 20th century. The Nilambur Slope Forests in Kerala do not continue across the State boundary. The entire Gudalur tract north up to Panthalur and Devala and further to the eastern boundary of Wayanad district was private forest which was occupied during the 1960-1980 period and cleared. In the Kerala slopes, forest vegetation continues towards north and west beyond the Nilambur - Gudalur road and it extends all the way to the main Chaliyar River. This belt is also becoming fragmented by settlements between Munderi and Devala. There are many enclosures and extensive eucalyptus plantations considerably reducing the width of the Nilambur Slope Forests in this part of the Ghats.

Along the southwestern edge of Wayanad, south of Meppadi, the edge of Wayanad steeply ascends to a narrow north-south ridge which has peaks reaching up to 2000 m. This ridge projects far to the south and is called the Camel's Hump Mountains. This hill range also drains into the main Chaliyar River. It was a heavily forested part of the Nilambur slopes till recently where the forests extended from the base of the hills at less than 40 m elevation all the way up to the crest of the ridge which is higher than 2000 m. The Cholanaikar, Pathinaikar, Kattunaikar and Paniyar are the main tribal communities living in these forests.

The Western Ghat watershed line and the State boundary do not correspond along the eastern edge of the Chaliyar basin. Most of the forests along the eastern edge of Chaliyar basin in the Gudalur area in Tamil Nadu were converted to tea plantations for rehabilitating Sri Lankan repatriates during the late 1970s. The Chaliyar basin in Kerala falls within the Malappuram, Kozhikode and Wayanad districts. Nilambur South and North Forest Divisions, a small portion of the South Wayanad Division and a portion of Kozhikode Division cover the forests of this tract.

The total extent of this Western Ghats landscape subunit would be approximately 1500 sq km. 500 – 600 sq km of it is still forest land. Old Reserved Forests cover only about 320 sq km. More than 250sq km of the forest in two unconnected segments remaining in this landscape subunit has rich biodiversity potential. The Nilambur Slopes of the Western Ghats in spite of extensive deforestation still has more Ghat slope forests surviving than in any other stretch in Malabar. Some reaches of these slopes still have contiguous stretch of forests extending from the plains to the highest ridges. It is also the very sensitive catchment slopes of Chaliyar. This is the only segment of the Western Ghats where the western outer face rises up more than 2000 m in a continuous unbroken sheer face open to the onslaught of the monsoon.

Subunit X – The Wayanad (11°35'N – 12°0'N Lat. , 75°40'E – 76°3'E Long.)

The gently east sloping Wayanad Plateau draining into the Kabini (a tributary of the Cauvery) is a natural landscape subunit of the Western Ghats. It is the larger of the two main plateaux in Kerala situated to the east of the main watershed line. Wayanad Plateau has a total extent of about 2200 sq km located at an average elevation of 900m. Towards the east, it merges with the Mysore Plateau and towards northwest it continues into the Coorg Wayanad. Towards southeast, Kerala Wayanad continues into the Gudalur area at the foot of the Nilgiris. Towards west, the high rising Nilgiris come down directly to the Nilambur plains in a steep scarp face. Towards the northwest, the Nilgiris initially descends to the Wayanad Plateau and then only to the Kozhikode or Kannur plains.

Practically the whole of Wayanad was forested till the 1940s. But extensive forest clearance for settlements since then has reduced Wayanad forests into two belts along the west and east borders of the plateau. The eastern segment along the inter-State boundary is a belt of deciduous forest contiguous with the adjacent and far more extensive forests of Tamil Nadu and Karnataka. The Wayanad Wildlife Sanctuary (344sq km) is located in this belt. There is a much narrower already fragmented belt of forests along the western crestline of the plateau (the main watershed line of the Western Ghats) which is mostly evergreen forests. These two belts of forests, practically encircles the Wayanad Plateau and towards south it continues on to the Nilambur slope forests. Towards north, it is linked with the Brahmagiri Ghat forests and then on to forests further north in Coorg. The eastern ring of forest is broken at Pulpally, but forest continuity exists across the Kabini River and the State border through forests in Nagarhole in Karnataka.

The forests in the western face in the Camel's Hump Mountains continue across the Meppady Ghat to a slender belt of forest along the Vythiri Hills, then on to the Lady Smith Reserved Forest. Fragments of forests occur along the western edge of Wayanad beyond the Tariyode Peak, Banasuran Peak and then on to the Periya Reserve. Though this western arm of the Wayanad Plateau forests is repeatedly fragmented, degraded and under tremendous pressure, it must have been extremely rich in biodiversity and is still the most important remaining catchment forest of Kabini. The Western Ghat western slope forests on the edge of Wayanad plateau receive the highest recorded rainfall in Kerala. The western fragmented belt of forest draining into Kabini is mostly contiguous with the forest along the western outer slopes of Wayanad draining into Kozhikode plains.

The Wayanad western edges crest line, which is also the main watershed line of the Western Ghats, has an average elevation of 1000-1500 m above sea level. It is here that the Western Ghat watershed line approaches closest to the sea. The Wayanad slopes descend steeply to the Kozhikode plains. These slopes were fully forested till the 1960s. But most of this has been destroyed and only an extremely attenuated strip of natural vegetation remains close to the crestline. This forest strip extends in the south from the Nilambur Ghat forests along Vythiri and further north to the Kannavam Reserve. The forest belt widens along the northwestern edge of Wayanad in the Kannavam Periya area. The forest belt then continues northeast along the Bavalipuzha catchment crossing the Thalasseri - Mananthavadi road and links up with the Kottiyoor Reserve on the southern slopes of Brahmagiris. The Kottiyoor forest has a tenuous vegetation continuity with the Tirunelli and Kambamala Reserves in the Wayanad Plateau towards east. Towards west it is contiguous with the Aralam forest which is in the next subunit of Kerala Western Ghats, the Kannur slopes. Beyond Iruttipuzha this forest belt narrows abruptly remaining as a strip along the State border and stops before Koottupuzha. On the western outer slopes of Wayanad, apart from Kannavam, a small part of Periya Reserved Forest and the small Pillaperuvanna and Pannikottoor Malavarams are the only Reserved Forests. The 55sq km Aralam Wildlife Sanctuary partly within the Kottiyoor Reserve and partly within the Aralam Vested Forest forms the only Protected Area in this forest belt. The Peruvannamoozhi dam, the Kakkayam dam and the Pazhassi dam are located in this tract.

These Ghat forests are extremely fragile and are already severely degraded. But they are the critical catchments of Korapuzha, Kuttiyadi, Mahe, Thalasseri, Anjarakandi and Valapattanam Rivers. This unit falls within the Kozhikode, Wayanad and Kannur Districts. Wayanad South, Wayanad North, Kozhikode and Kannur Forest Divisions cover the area.

The geographical area of this Western Ghats landscape subunit excluding the Wayanad Plateau would be approximately 1000 sq km. There is about 300 sq km of forests along the western slopes of Wayanad. Wayanad Plateau has about 1000 sq km of forests all along its western edge draining into Kabini. The forest continuity along the upper catchments of Valapattanampuzha from the northwestern edge of Wayanad into the southeastern edge of Kannur district is a very tenuous but most important corridor. This tract has special significance in biodiversity conservation and watershed protection. The Wayanad western slope and the east draining Wayanad Plateau forests at its western edge form a narrow strip, perhaps the most devastated and vulnerable forest tract in the Western Ghats of Kerala. Only a nominal strip of crestline forests remains. Biologically this tract is poorly studied. This part of the Ghats receives very heavy rainfall and the rainy season is shorter than in southern Kerala. Seven large rivers originate from this limited length of the Ghats. Along the eastern edge of Wayanad from south to north all along the inter-state border all the remaining forests are part of Protected Areas.

Subunit XI – The Kannur Ghats (11°50'N – 12°10'N Lat. , 75°40'E – 75°50'E Long.)

North of the Kottiyoor Reserved Forest in the Valapattanam River Basin there is no significant extent of forest left in Kerala. The State boundary deviates to the west from the main watershed line from the junction point of the district boundaries of Wayanad and Kannur with Coorg. Most of the forested ridges are further to the east from the State boundary within the Kodagu District or in the Dakshina Kannada District of Karnataka. Valappattanam, Kariangode and Chandragiri Rivers originate from the Coorg Ghat forest. In Kerala there are only very small scattered bits of Reserved Forests in lateritic midland hillocks, most of which are less than 200m in elevation scattered in the plains of Kannur and Kasargod districts. All the Ghat forests in the northern Kannur district have been cleared during the past half a century by settlers. The only fairly large forest area remaining in the western slopes of the Western Ghats in the Kannur district is along the southeastern corner of the district along its boundary with Wayanad within the Valapattanam River catchment. This forest is contiguous with the Wayanad slope forests but it has no continuity towards north in Kerala. Geographically the Western Ghat western slopes in Kannur district form a distinct subunit. It is the outer slopes of the Brahmagiri segment of the Western Ghats extending in an arc beginning from near Tholpetty in Wayanad and extending west to Karimala at the head of the Kottiyoor Valley and then swinging northwest and then north separating the Coorg Plateau from the Kannur plains. The upper reaches of the Bavalipuzha tributary of Valapattanampuzha originating from the Brahmagiris have the Kottiyoor Reserved Forest and the adjacent Aralam Wildlife Sanctuary. This forest belt continues across the State border into the Kodagu Ghats. In Kerala further north there is a small bit of forest along the slopes of the Pythalmala. Apart from these fragments, for the entire length of the Kannur district, the western slopes of the Western Ghats have been denuded of forests. 13 west flowing rivers of Kerala originate from this part of the Western Ghats. The lower reaches of all these rivers are subjected to tidal ingress for a considerable distance inland. But some of the remaining small Reserved Forests along the State border have contiguity with larger forest areas in Karnataka. All the forests in this tract are within the Kannur Forest Division and the Aralam Wildlife Division.

The Kannur Ghat area would cover about 1800 sq km beginning from the border of Wayanad and extending north to Koottupuzha Valley. This includes the western edge of some spur hills projecting into the Kasargod district. But forest in the Ghat region in Kerala covers less than 200sq km. There is no forest segment of potential long-term viability and adequate extent anywhere in the plains in these two districts. The Kannur part of the Western Ghat western slopes is exceptional in that the entire stretch of the western slopes of the Ghats is occupied excepting a tiny portion of the south-eastern corner. The agricultural lands in the very heavy rainfall steep western slopes face serious environmental problems.

Origin and Biogeography of Western Ghats

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Abstract

The Western Ghats constitute a 1600 km long, about 45 – 65 million years old mountain chain that runs along the Western edge of the Deccan Plateau separating the Plateau from a narrow coastal plain along the Arabian Sea. The formation of the Western Ghats starts with the splitting of the Peninsular India from the Gondwanaland about 150 million years ago and its approximately 10,000 km northward drift. By the time the peninsular India ended its northward drift that lasted about 100 million years and collided with the Asian mainland, the Western Ghats were very much in place.

The Western Ghats is characterized by its remarkable wealth of Phylogenetic (Gondwana) and geographical (Asiatic) relicts, Pleistocene relicts of the Himalaya, endemics, ancient and phylogenetically older groups and by the presence of ecologically anomalous humid tropical groups. It harbours some of the most biodiverse, endangered and unique habitats in the peninsular India. Most of peninsular India's endemic species occur here. The several enclaves, particularly the evergreen forest ecosystems of the southern Western Ghats have acted over the years as 'refugia' for species, as the surrounding areas have steadily gone drier. These characteristics make the Western Ghats biologically rich and diverse and qualify as one among the 34 Biodiversity Hot Spots in the world.

Key words: Western Ghats, Origin, Biogeography

Introduction

The Western Ghats, also known as '*Sahyadri*', constitute a 1600 km long, about 45 – 65 million years old mountain chain that runs along the Western edge of the Deccan Plateau, separating the Plateau from a narrow coastal plain along the Arabian Sea. The Western Ghats originate from the south of the Tapti River in Gujarat and extends up to Kanyakumari, the southernmost tip of the Indian Peninsula running through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala, ending at Kanyakumari. The Western Ghats comprise the major portion of the Western Ghats-Sri Lanka Hotspot (Fig. 1), one of the 34 global biodiversity hotspots for conservation identified by the 'Conservation International'. It is also a World Heritage Site, recognized by UNESCO on July 1, 2012.

The Western Ghats are much older than the Himalaya and represents geomorphic features of immense importance with unique biophysical and ecological processes. Its forest ecosystems influence the Indian weather pattern as well. Majority of the perennial rivers in Peninsular India originate in the Western Ghats, thus the Ghats functioning as a major life supporting system in India. It is one among the four watersheds of India and form the catchment area for complex riverine drainage systems that drain almost 40% of India. The Western Ghats are an area of rich biodiversity exhibiting high degrees of endemism. Although the total area is less than 6 percent of the land area of India, the Western Ghats contains more than 30 percent of all plant, fish, herpetofauna, bird, and mammal species found in India (Bawa *et. al*, 2007).

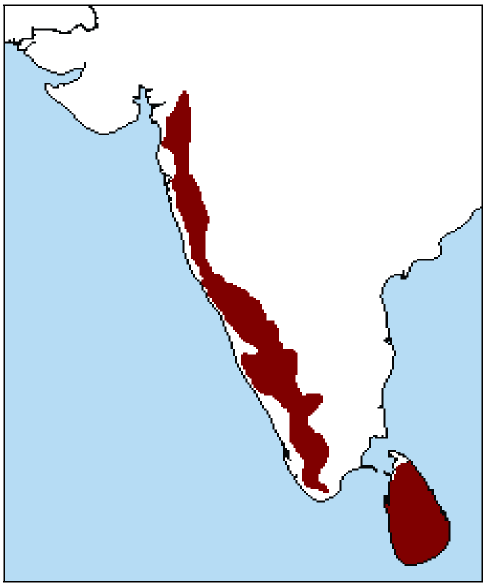

Fig. 1: Western Ghats-Sri Lanka Hotspot

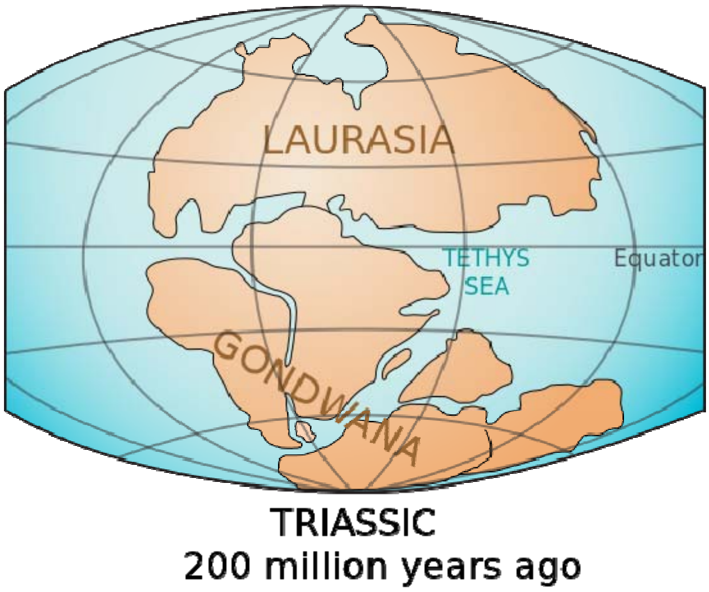

Fig. 2: Indian Peninsula breaking away from the Gondwanaland

Origin of Western Ghats

The formation of the Western Ghats is much linked with the splitting of the Indian Peninsula (as Indo-Madagascan plate) from the Gondwanaland (Fig. 2) and its northward movement due to the plate tectonic forces that induce continental drift (Mani 1974; Briggs 1989, 2003; Hedges 2003). Subsequent to breaking away from Gondwanaland, the Indian plate further broke away from Madagascar ca. 84–96 Mya (Briggs 2003), rapidly drifted northward and collided with Eurasia between 55.5 and 66 Mya, moving approximately 5,000 km at a speed of 20 cm per year. Thus, initially the Indo-Madagascan plate was isolated from Africa, and then the Indian plate was isolated from both Madagascar and Africa for extended periods of time.

As the Indian Plate drifted away, it slipped over the head of a stationary mantle plume (columns of buoyant molten rock materials rising through earth's mantle), a deep seated volcanic hot-spot of about 200 – 300 km across in the region of today's Reunion islands, about 700km east of Madagascar in the Indian Ocean. This produced chains of volcanoes with explosions extending over 1, 00,000 to 2, 00, 000 years, finally resulting in several domal upliftments. The heat beneath generated basaltic magma, which rose into lithosphere (Mantle-Plume theory), causing uplift by crustal arching. It also tilted the Indian Plate in an easterly direction. It was this event that happened million years ago that resulted in the uplift of the Western Ghats. It also resulted in a series of volcanic eruptions until around 65 million years ago, generating the extensive Deccan Traps. These volcanic episodes to a great extent moulded the Northern Western Ghats. The India-Madagascar-Seychelles separations appear to coincide with the eruption of the Deccan basalts, perhaps an expression of the initiation of the Reunion hotspot. This series of eruptions are estimated to have lasted for about 30,000 years in total and is also believed to have produced a kind of "Nuclear Winter", causing the extinction of Dinosaurs (Keller *et. al.*, 2009).

As a result of the uplift, the Peninsular India broke along the central axial region of weakness coinciding with the track of upliftment and the western segment drifted westward into the sea (a process known as faulting), giving rise to the present day hill chain, the Western Ghats and the west coast. This happened during the Eocene (between 45 and 65 million years ago), even before India became part of the Asian mainland. By the time the peninsular India ended its northward drift that lasted about 100 million years and collided with the Asian mainland resulting in the obliteration of the Tethys Sea and the rise of the Himalaya, the Western Ghats was very much in place.

Biogeography of Western Ghats

The floral and faunal composition of any region is closely interlinked with the physiographic evolution of that region. Stretching along the western edge of India, the Western Ghats is a unique mountain range that harbours an incredible diversity of flora and fauna.

Geologically the Ghats fall into two sections. North of the river Kali is the Deccan trap country of relatively fragile rocks and flat hill tops. These hills with a terrace-like profile are made of fragile basaltic rocks due to successive lava flows, the result of the same volcanism that gave rise to the Deccan traps. These formations are called *traps* because of the step-like or terraced appearance (Fig. 3) of their outcrops. The hills do not rise much beyond 1500 m in this tract. South of Kali is the region of Precambrian Archean crystalline rocks which are much harder. The hills tend to be rounded, taller and rise to 2000 m or more (Fig. 4), reaching a height of 8842 ft (2695 m) at the Anamudi peak in Idukki District of Kerala State.

As regards the biodiversity, the forests in the southern part of Western Ghats are richer than those in the northern sections and retain the original vegetation, having not undergone the volcanism that the northern part has undergone. Thus, the moist forests, streams and rivers in the southern part of the Ghats support greater diversity than those in the north.

Fig. 3: The terraced appearance of norther part of Western Ghats

Fig. 4: Hills of Southern Western Ghats

Biogeography of Western Ghats cannot be viewed in isolation from that of the rest of India. It is closely correlated with its complex geomorphologic evolution, the beginning of which may be traced back to the fragmentation of the ancient Gondwanaland and the drift of Peninsular India from Madagascar. As India drifted away from the Gondwanaland, the drifting India functioned as a biotic ferry (Fig. 5), carrying with it, a representative Gondwanan biota.

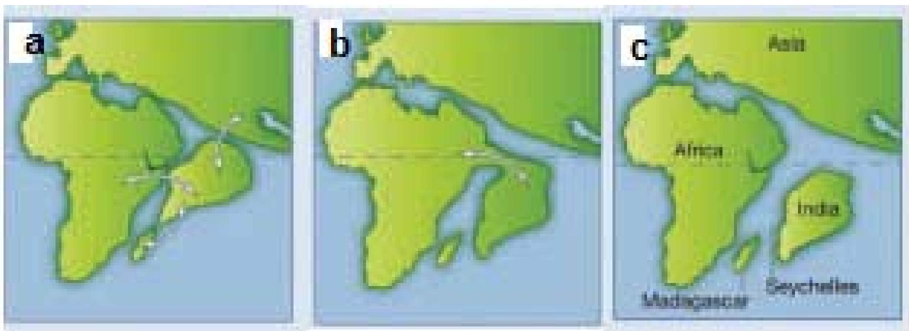

Fig. 5: Drift of Peninsular India from Madagascar, as a biotic ferry

Therefore, the flora and fauna that differentiated in the Peninsular India that was insular at that time were the original flora and fauna of India, a complex that arose (autochthonous) from the ancient Gondwanan flora and fauna. After India smashed into the Eurasian Plate establishing land connections with Asia, gateways for exchange of biotic elements opened up and faunal/floral influx and outflux started taking place. There were four major routes for the influx and their four corresponding Amphitheatres of differentiation, evolution and radiation of floras and faunas, which profoundly influenced the biogeographical evolution of India (Fig. 6).

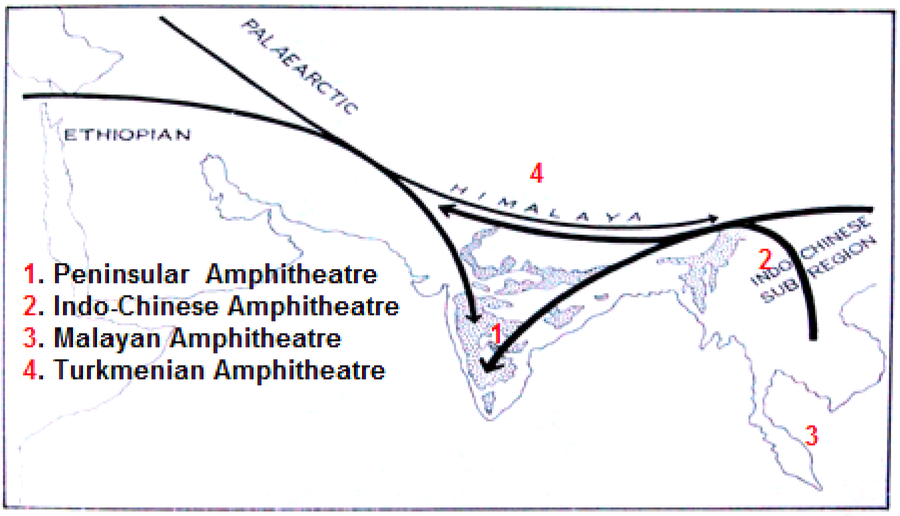

Fig. 6: Routes of the main-streams of faunal influx in the Indian subregion and the major Amphitheatres of differentiation, evolution and radiation of floras and faunas in India

After drifting away from the Gondwanaland, the Indian plate was isolated from both Madagascar and Africa for extended periods of time. This period of isolation resulted in the evolution of interestingly high levels of endemism and unique faunal elements. Some examples are the highly diverse and largely endemic uropeltid snakes and caecilian amphibians (Wilkinson *et.al.*, 2002), which have undergone bouts of speciation in the Western Ghats, in isolation (Mani 1974). The bulk of amphibians in India are derived from the ancient Gondwana stock. The recently discovered Purple frog, *Nasikabatrachus sahyadriensis* (Fig. 7) from the Western Ghats of Kerala is a relict from the ancient Indo-Madagascan plate (Biju and Bossuyt 2003). It has its living relatives only in the Seychelles Islands, 3000 km south of India, near Madagascar. Yet another example for the Gondwanan affinity in Western Ghats can be seen in the lamellibranch molluscan family Aetheriidae, represented in India by *Acostaea* (*Pseudomulleria*) *dalyi*, reported only from Western Ghats. The family, *Aetheriidae* is known to occur in India, Madagascar, Tropical Africa and Tropical America.

Some of the examples for the Indo-Chinese/Malayan affinities seen in Peninsular India and the Western Ghats are the discontinuous distribution of the fresh-water fish family Balitoridae that includes the interesting genera *Bhavania, Travancoria* (endemic in the Peninsula) and *Balitora.* They are found in the Indo-Chinese/Malayan areas and thereafter only in Peninsular India. Similarly, the reptilian genus *Drac*o, a genus of flying lizards, represented by about a dozen species, of which *Draco dussumieri* is a geographical relict in the west and southwest corner of the Peninsula. *Draco norvilli* extends from Indo-China to the Naga Hills in the north-east. Among birds, *Buceros bicornis* and the genus *Batrachostomus* exhibit discontinuous distribution in Western Ghats and the Indo-Chinese/Malayan areas.

As far as the Palearctic connection in the Western Ghats is concerned, we have the remarkable example of the Nilgiri tahr*, Nilgiritragus hylocrius* (Fig. 8), in southern Western Ghats, while its relative, the Himalayan tahr, *Hemitragus jemlahicus,* in found in the Himalaya.The Palearctic elements are believed to have reached the high hills of Western Ghats during the Pleistocene glaciations.

Fig. 7: *Nasikabatrachus sahyadrensis*

Fig. 8: Nilgiri tahr, *Nilgiritragus hylocrius*

According to the theory of Pleistocene glaciation put forward by Medlicot & Blanford, lowering of atmosphereic temperature during the Pleistocene glaciation times resulted in the retreat of the northern biota to equator. Subsequently, when the atmosphere became warm, after the retreat of the Pleistocene glaciers from the Himalayan valleys, the biota moved towards the higher parts of South Indian hills where they are found now as Pleistocene relicts. As regards the discontinuous distribution of certain fauna is concerned, the Vicariance theory explains that after the opening up of the Assam gateway, the intrusive fauna spread all over the new territory. Subsequently, the rise of Himalaya, and the resultant climatic changes that brought in dessication in large areas of India, wiped out the intrusive fauna in several areas and those that could migrate to the hill forests survived, exhibiting the present day discontinuity (Hora's Satpura Hypothesis is not discussed here since it has no geological backing).

The Western Ghats is characterized by its remarkable wealth of Phylogenetic (Gondwana) and geographical (Asiatic) relicts, Pleistocene relicts of the Himalaya, endemics, ancient and phylogenetically older groups and by the presence of ecologically anomalous humid tropical groups. The most important concentration and isolation of both the Peninsular autochthonous and the intrusive exotic faunal elements, the endemics of the ancient groups and the geological and phylogenetic relicts are found in the great horsts (high hills) of Western Ghats.

The Western Ghats harbour some of the most biodiverse, endangered and unique habitats in the peninsular India, including the tropical lowland and montane evergreen forests and montane grasslands. The Western Ghats play a crucial role in all the discussions dealing with the biogeography of peninsular India because most of peninsular India's endemic species occur there.

The hills of Western Ghats are embedded in a landscape that has much drier climatic conditions and are in isolation from other moist areas. The several enclaves, particularly the evergreen forest ecosystems of the southern Western Ghats have acted over the years as 'refugia' for species, as the surrounding areas have steadily gone drier. Therefore, many of the original Gondwana relicts, the autochthonous fauna of Peninsular India, the transmigrant Palearctic, Indo-Chinese and Malayan faunal elements and some Himalayan relicts that reached India during the glacial period have found refugium in the Western Ghats forests. These combinations make the Western Ghats biologically rich and diverse and qualify as one among the 34 Biodiversity Hot Spots in the world.

References

1. **Bawa, K.S., Das, A., Krishnaswamy, J., Karanth, K.U., Kumar, N.S. and Rao, M. 2007.** *Ecosystem Profile: Western Ghats and Sri Lanka Biodiversity Hotspot - Western Ghats Region*. Critical Ecosystems Partnership Fund, Virginia.
2. **Biju, S.D. & F. Bossuyt, 2003**. New frog family from India reveals an ancient biogeographical link with the Seychelles. *Nature* 425: 711 - 714.
3. **Briggs, J. C. 1989.** The historic biogeography of India: Isolation or contact?; *System. Zool.* 3: 322–332.
4. **Briggs, J. C. 2003.** The biogeographic and tectonic history of India; *J. Biogeogr.* 30: 381–388.
5. **Hedges, S. B. 2003.** The coelacanth of frogs; *Nature (London)* 425: 669–670.
6. **Keller, G. Sahni, A. and Bajpai, *S.* 2009.** Deccan volcanism, the KT mass extinction and dinosaurs. *J. Biosci.* 34 (5): 709–728.
7. **Mani, M. S. (ed.). 1974.** Biogeography of Peninsula; in *Ecology and biogeography in India* (The Hague: Dr W Junk Publishers) pp 614–646.
8. **Wilkinson, M, Sheps, J. A, Oommen, O. V and Cohen, B. L. 2002.** Phylogenetic relationships of Indian caecilians (Amphibia: Gymnophiona) inferred from mitochondrial rRNA gene sequences; *Mol. Phylog. Evol.* 23: 401–407.

Vegetation types and Phytogeography of Western Ghats

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Abstract

The heterogeneity of species and its assemblages in the Western Ghats (WG) is more influenced by the abundance and distribution of seasonal rainfall than the atmospheric temperature. The presence of red, lateritic, black and humid soils both in the windward and leeward side of the Ghats reveals the complexity of geological process and changes that occurred in one of the oldest mountain ranges of the country. The major vegetation groups include the equatorial (Indo-Malayan Origin) wet evergreen, semi evergreen, moist deciduous, dry deciduous, thorny scrubs, montane sub tropical wet forests, montane wet temperate forests, etc. The true evergreen forest is found in the windward side encapsulated with moist deciduous in the west and more drier formations in the eastern aspect. The high plateaus in the Western Ghats are specked with their own realm of botanic identity (species of *Rhododendron*, *Mahonia*, *Ilex,* etc*)* that shows affinities with high ranges in the far north and east of India. Phytogeographically the Western Ghats has been divided into four regions such as (i) from River Tapti to Goa, (ii) River Kalindi to Coorg, (iii) the Nilgiris, and (iv) south of Nilgiris, i.e., Anamalai, Palni and Cardamom Hills. All the above mentioned regions of the WGs, though the northern parts do not represent true tropical evergreen formations, shows floristic affinities with Indo-Malayan Assam, Khasi, Naga, Eastern Himalayas and Ceylon. The prominent Malayan groups are *Sterculiaceae, Meliaceae, Tiliaceae, Myrtaceae, Melastomaceae, Vitaceae, Piperaceae, Orchidaceae, Araceae*, etc. The balsams which are highly represented in the southern Western Ghats have its affinities with Eastern Himalayas. The conifer *Nageia wallichiana* of the Peninsula is known only from Myanmar and Malaya. Extending the affinity it is found that the palm, *Bentinckia condapanna* has a congener in the Nicobar Island. Phytogeographically Clarke (1898), Hooker (1907) and Chatterjee (1940) placed the Western Ghats under '*Malabar'* where as Prain (1903) on the basis of humidity and dryness, placed under *India Aquosa*. The paper discusses the different vegetation types, phytogeographically significant species found in the most prominent formations and the theories that revolve around them.

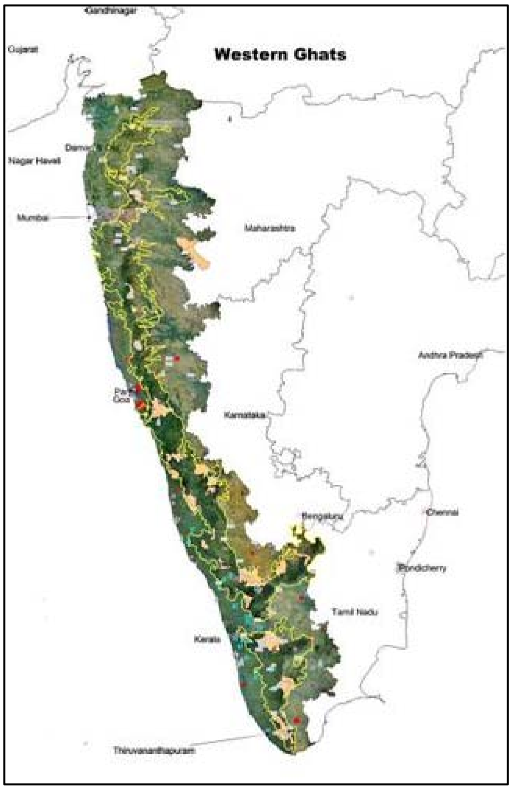
Key words: Western Ghats, Vegetation types, Phytogeography

Introduction

Biogeographically Western Ghats is the most important region and one of the hotspots for the speciation in the tropics. It is situated in the confluence of the afro-tropical and Indomalayan biotic zones of the world which signifies the characteristic nature of the floral elements of this region. Phytogeography, the science of distribution of plants with respect to a geogrpahcial region is very important in the context of plant science studies since it explains the characteristic species assemblages in each geographical region that has evolved with the micro environmental conditions. It also helps in tracing the history of speciation in plant kingdom. The heterogeneity of species and its assemblages in the Western Ghats (WG) is more influenced by the abundance and distribution of seasonal rainfall than the atmospheric temperature. The presence of red, lateritic, black and humid soils both in the windward and leeward side of the Ghats reveals the complexity of geological process and changes that occurred in one of the oldest mountain ranges of the country (Subramanyam and Nayar, 1974). As a result, the floral elements of the Ghats have assembled in a unique and characteristic manner resulting into different vegetation types and many of the elements are restricted to these vegetation types thus making important endemic centres of the world. Hence this paper discuss the different types of vegetation evolved and their floral affinities with other geographic regions.

Western Ghats

The Western Ghats constitute a practically unbroken hill chain (with the exception of the Palakkad Gap) or escarpment running in a north-south direction, for about 1600 km parallel to the Arabian sea coast, from the river Tapti (about 21^0 16′N) down to just short of Kanyakumari (about $8^0$19′ N) at the tip of the Indian peninsula; a hill chain that is extremely rich in biodiversity and crucial for the security of water resources of Peninsular India. Although the total area is less than 6 percent of the land area of India, the WG contains more than 30 percent of all plant, fish, herpetofauna, bird, and mammal species found in India. The Ghats descend steeply to the coastal plains on the west, but merge gently through a series of hills with the Deccan plateau. Geologically the Ghats fall into two sections (i) north of the river Kali is the Deccan trap with relatively fragile rocks and (ii) south of Kali with Precambrian archean crystalline rocks. The WG acts as a barrier to the moisture laden winds coming from the west and to receive heavy precipitation of 2000 mm or more a year in the windward side. And to the leeward sides of the Ghats is a region of rain shadow; much drier than the western face. And there is south-north variation of rainfall too, where south receives over 8–9 months a year but restricted to 4 months in the northern parts of the Ghats. The Western Ghats recognized as among the several global, hotspots of biodiversity along with its geographical extension in the wet zone of Sri Lanka are now also considered one of the eight '*Hottest hot spots'* of Biodiversity (Myers *et al.* 2000).



The great topographic heterogeneity (from sea level to 2695 m at its highest point, the Anaimudi peak; lateritic plateaus) and a strong rainfall gradient (annual precipitation of <50 cm in sheltered valleys in the east to >700 cm along west-facing slopes) combine to give rise to a tremendous diversity of life forms and vegetation types, including tropical wet evergreen forest, montane stunted evergreen forest (shola) and grassland, moist deciduous and dry deciduous forest, dry thorn forests, and grassland. Many of these are critical habitats for plants and animals: for instance, the lateritic plateaus of Maharashtra harbour unique floral elements as well as provide seasonal foraging grounds for large mammals such as gaur; the shola forests and grasslands of the southern Western Ghats are unique as well as highly vulnerable to future climate change; the riparian vegetation along the numerous east and west-flowing rivers and streams of the Ghats shelter high levels of plant and animal diversity in addition to acting as corridors, while the relict lowland dipterocarp forests and *Myristica* swamps to the west are highly threatened.

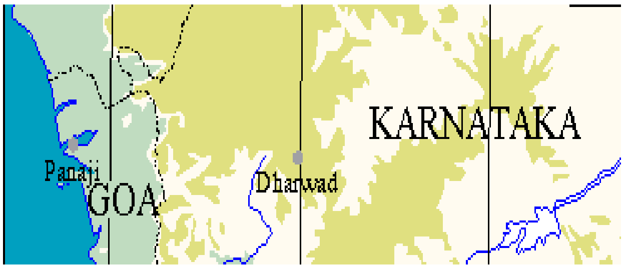
The importance of the Western Ghats in terms of its biodiversity can be seen from the known inventory of its plant and animal groups, and the levels of endemism in these taxa (Gunawardene *et al.,* 2007). Nearly 5000 species of flowering plants or about 27% of the country's total species are known from the Ghats. Of 645 species of evergreen trees (>10 cm dbh), about 56% is endemic to the Ghats. Among the lower plant groups, the diversity of bryophytes is impressive with 850-1000 species; of these 682 species are mosses with 28% endemics and 280 species are liverworts with 43% endemics. Among the invertebrate groups, about 350 (20% endemic) species of ants, 330 (11% endemic) species of butterflies, 174 (40% endemic) species of odonates (dragonflies and damselflies), and 269 (76% endemic) species of mollusks (land snails) have been described from this region (Daniels, 2001). The known fish fauna of the Ghats is 288 species with 41% of these being endemic to the region. The Western Ghats are particularly notable for its amphibian fauna with about 220 species of which 78% are endemic; the recent discovery of a new genus of frog, *Nasikabactrachus sahyadriensis*, with Indo-Madagascan affinity, in the southern Western Ghats affirms the importance of the region in harbouring these ancient Gondwanan lineages. Similarly, the Ghats are unique in its caecilian diversity harbouring 16 of the country's 20 known species, with all 16 species being endemic. Of the 225 described species of reptiles, 62% are endemic. Over 500 species of birds and 120 species of mammals are also known from this region. The Western Ghats region harbours the largest global populations of the Asian elephant, and possibly of other mammals such as tiger, dhole, and gaur. The Western Ghats also harbour a number of wild relatives of cultivated plants, including pepper, cardamom, mango, jackfruit and plantain. This biological wealth has paid rich dividends over the years towards the social and livelihood security of the people.

Phytogeographical classification of India and Western Ghats

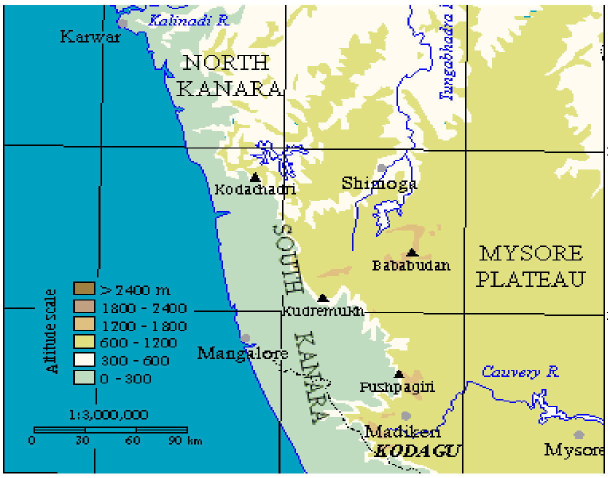
Hooker (1907) analysed the phytogeographical regions of the India on the basis of species content of the families in each botanical province and classified the botanical regions of British India as (i) Eastern Himalaya, (ii) Western Himalaya, (iii) Indus Plain, (iv) Gangetic Plain, (v) Malabar, (vi) Deccan, (vii) Ceylon and Maldives, (viii) Burma and (ix) the Malay peninsula. He brought the mountain ranges of Western Ghats under the botanical region of Malabar which include the humid stretch mountain along the west coast. Clarke (1898) proposed the following phytogeogrpahical provinces for India; (i) Western Himalaya, (ii) India deserta, (iii) Malabarica, (iv) Ceylon, (v) Coromandelia, (vi) Gangetic Plain, (vii) East Himalaya, (viii) Assam, (ix) Ava, (x) Pegu and (xi) Malay Peninsula. Followed to this, Prian (1903) classified the phytogeographic region on the basis of humidity/dryness. Accordingly the phytogeographic regions are (i) India deserta, (ii) India diluvia, (iii) India aquosa, (iv) India vera, (v) India subaquosa, and (vi) India littorea. The wet forests of Western Ghats falls under the *India aquosa* category since it receives the full wrath of south west monsoon. Chatterjee (1940) after studying the endemic species of the Dicotyledons, recognizes the following botanical regions (i) Western Himalaya, (ii) Indus Plain, (iii) Malabar, (iv) Deccan, (v) Gangetic Plain, (vi) Eastern Himalaya, (vii) Assam, (viii) Central Himalaya, (ix) Upper Burma and (x) Lower Burma. It is evident from the above mentioned phytogeographical classifications that placing Malabar or Western Ghats as a separate entity by all the phytogeogrpahers indicate its unique floral assemblages. Hooker (1907) after studying the flora of this region observed that most distinctive character of the Malabar flora in contrast to the other botanical regions are primarily the presence of *Guttiferae, Dipterocarpaceae, Myristicaceae, Palmae* and *Gramineae*.

Although Western Ghats exhibits a characteristic floral congregation, within the Ghats there are distinct floral regions such as (i) the Ghats from the River Tapti to Goa, (ii) from river Kalinadi to Coorg, (iii) Nilgiris and (iv) Southern Western Ghats comprising Anamalai, Palni, Cardamom and Agasthyamalai Hills.

i. **Western Ghats from River Tapti to Goa**: This northern most part of the Ghats is dominated by mountain chains rising to 1000 m abruptly. Along the western sides there are deep ravines and canyons and on the eastern side there are flat topped spurs intersected by valleys. The spur hills towards the eastern sides are sloppy and less in elevation. This region receives the rainfall from June to September. The major vegetation types are scrub jungle moist deciduous, dry deciduous and evergreen. The scrub jungle and moist deciduous are in the foot hills at an elevation of 200-500 m and dry deciduous is distributed between 500-1100 m elevations. The evergreen formations in this region of the Western Ghats are very distinct compared to the rest of the southern sides (Qureshi, 1965). The evergreen trees in this region are characteristically short with no distinct tier or canopies of tropical evergreen forests. They look more like tropical montane formations but distinct from them due to the less humid nature. Some of the common species found in this formations are *Amoora lawii, Walsura trijuga, Toona ciliata, Alstonia scholaris, Pongamia pinnata, Caryota urens, Miliusa tomentosa, Syzygium cumini, Gnetum ula,* etc. The herbaceous flora are dominated by balsams, Begonias, etc.

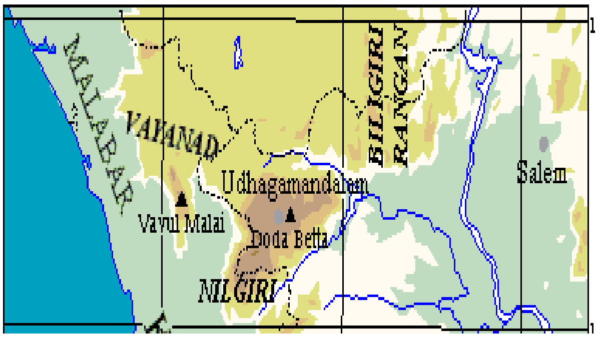


ii. **Western Ghats from River Kalinadi to Coorg**: This part of the WG was formed by the Deccan lava flow to the Archaeans and the change is marked by series of breaches in the mountain wall by the rivers Kalinadi, Gangavali-Bedti, Tadri and Sharavati. The Maharashtra part of this ghats was around 1000 m elevation and extends to an estimated length of about 350 km. Kudremuk (2071 m) stand tall in this region of the Western Ghats with deep valleys and gorges in the area making it inaccessible compared to the northern region. Faulting and differential erosion make this region an extremely dissected tract and in some areas the Ghat forest reach down to the sea. The main vegetation types in this region are scrub forests, moist deciduous and wet evergreen. The heavy rainfall (2000-3000 mm), high atmospheric humidity, warm temperature and non-seasonality support the luxuriant growth of evergreen forests here. The forest exhibits distinct layers with characteristic species like in rain forests of the rest of the World. The first tier composed of 30-45 m, the second tier around 15-30 m , the third 10-15 and the fourth tier below 10 m. The uppers stories are formed by species such as *Tetrameles nudiflora, Elaeocarpus tuberculatus, Dysoxylum malabaricum, Dipterocarpus indicus,* with huge buttresses. The second storey is marked with *Alstonia scholaris, Artocarpus lakoocha, Strychnos nux-vomica, Xanthophyllum flavescens,* etc. The third tiers are characterized by *Callicarpa tomentosa, Flacourtia montana, Memecylon* sps., *Ixora arborea, Psychotria* etc. The undergrowths are dominated with *Calycopteris floribunda, Psychotria, Calamus* sp., *Smilax* sp., *Gnetum ula, Allophyllus* etc. The moist deciduous formation with any tiers in this stretch also very characteristic with species such as *Briedelia squamosa, Butea*

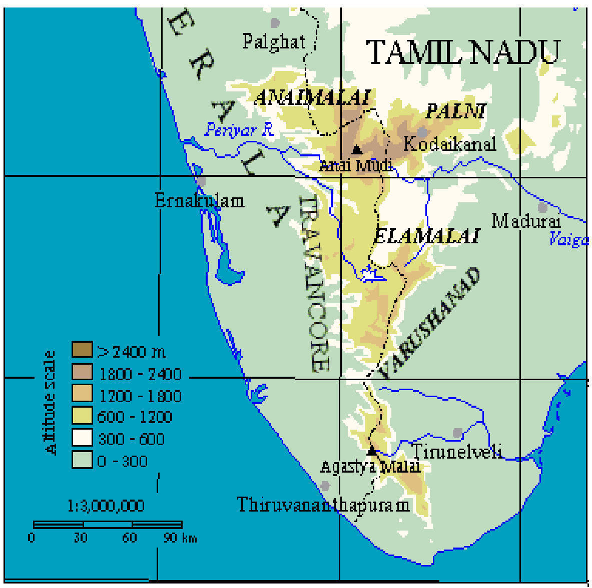


monosperma, Dillenia pentagyna, Kydia calycina, Diospyros montana, Gmelina arborea, Grewia tiliaefolia, Mallotus philipensis, Pterocarpus marsupium, etc. The scrub jungle in this region consists of mainly thorny species with few stunted, crooked and malformed trees. Some of the common species are *Capparis* sp., *Carissa congesta, Cassia auriculata, Cipadessa baccifera, Dodonea viscosa, Flacourtia indica, Pavetta indica,* etc. The common tree species observed are *Anogeissus latifolia, Buchanania lanzan, Semecarpus anacardium, Santalum album, Radermachera xylocarpa*, etc.

iii. **The Nilgiris**: The Nilgiris which form a compact plateau of about 2600 km^2, is an elevated and highly dissected massif. It ends up at the southern side with Palghat Gap (about 35 km), the only discontinuity in the entire Western Ghats. The Moyar Gorge cuts the Nilgiris from Mysore plateau and this landmass is sandwiched between River Moyar and River Bhavani. With high annual average rainfall (1250 to 4000 mm), the Nilgiris harbour many specific and unique life forms, one of the important centers of endemism in the entire Western Ghats. The vegetation in the Nilgiris is very unique with rolling grasslands and stunted evergreen formations in the valleys, glens and folds locally called *shola.* The *shola* forests which are evergreen in nature are comprised of both tropical and extra tropical elements (Meher-Homji, 1967). The *shola* forests are very characteristic with stunted evergreen formations of not more 10-15 m high with umbrella-shaped canopy and luxuriant growth of mosses, lichens, epiphytes, orchids and climbers. The grasslands are also very unique with specific assemblages of floral elements compared to the grasslands of lower elevations. The most conspicuous species of the *shola* are *Michelia nilgirica, Ilex wightiana, I. denticulata, Meliosma wightii, Mahonia leschenaultii, Gordonia obtusa, Microtropis ramiflora, Schefflera racemosa, Rhododendron arboreum,* etc. The under growths are dominated by *Maesa indica, Osbeckia leschenaultii, Psychotria* sp., *etc.* Some of the common orchids found in the *shola* are *Aerides,* species of *Habenaria, Calanthe* etc. The grassland lying outside the shola forests are also characterized by certain species such as *Hypericum mysurense, Rhodomyrtus tomentosa, Gaultheria fragrantissima, Rubus* sp. ,*Hedyotis* sp., *Strobilanthes* sp. *etc.*



iv. **Western Ghats south of Palghat Gap (Anamalai, Palni, Cardamom and Agasthyamalai Hills):** The topography of these hills are more complex than the Nilgiris, where the highest peak is represented by Anaimudi (2697 m) and the lowest region is marked by Thattekkad (around 100 m) in Kerala. Such a varied physiography contributes extensively to the geomorphology of this hill tract and there are many valleys and ridges contributing to the richness of the vegetation in this area. The area is well received with precipitation ranging more than 6 months from June onwards dotted with summer or



interim rains. The front to the Palghat Gap is remarkably steep and in the east remarkably straight. The upper re-entrant are also remarkably abrupt as are the Cardamom Hills and their protrusions like Varushanad Hills. The hills are longest in the south west direction making the broadest part of the Ghats. The stretch shows both mature as well as juvenile (Nair, 1991) relief types. The extensive almost level surface and plateau are the examples of the mature land forms and while the steep mountains and escarpments dissected by erosion are characteristic of juvenile forms. The hills in this tract are characterized by different vegetation types such as evergreen forests, semi-evergreen, moist deciduous, montane grassland and shola complex, and in the leeward side the formations are largely of dry deciduous and scrub jungle. Since the southernmost parts of the Ghats are exposed to oceanic wind and prolonged wet days, endemism is high in the Agasthyamala region (Henry *et al* 1978) compared to Anamalais and Nilgiris. The wet evergreen forests in this tract are characterized by the presence of many Dipterocarp members representing the far south distribution of this Indo-Malayan group. The top canopy includes *Mesua ferrea, Aglaia roxburghiana, Polyalthia fragrans, Diospyros microphylla, Palaquium ellipticum, Cullenia exarillata, Calophyllum* sp., *Canarium strictum,* etc. The lower storey comprises of species such as *Garcinia* sp., *Holigarna* sp., *Syzygium* sp., *Antidesma menasu, Xanthophyllum arnotianum, Ardisia* sp., *Aporosa lindleyeana*, etc. The presence of the only south India confer, *Podocarpus wallichianus* is very significant. The high elevation grassland and shola are very much similar to the Nilgiris and there are many common species between these regions and other parts of the world such as Ceylon.

The moist deciduous formations in this tract has many valuable timber species such as *Tectona grandis, Terminalia* sp., *Dillenia pentagyna, Dalbergia latifolia, Pterocarpus marsupium,* etc. Other important species are *Sterculia guttata, Stereospermum chelanoides, Kydia calycina, Olea dioica, Cassia fistula, Nothopodytes foetida*, etc. The dry deciduous forests found on the leeward side of this tract are spotted with *Santalum album, Ficus* sps., *Cassia fistula, Emblica officinalis, Grewia tiliaefolia, Ailanthus excelsa, Albizzia* sps., *Acacia* sps., *Diospyros montana, Mitragyna parviflora*, etc. The species of *Capparis, Flacourtea, Grewia, Phyllanthes*, are common among shrubs. Most of the climbers are *Ventilago, Cayratia, Ipomoea, Dalbergia, Glycine* etc.

Vegetation in the Western Ghats

The broad classification of vegetation does not, however, coincide with the geological landscapes, but seems to be more associated with topography and climatic conditions, particularly the length of the dry season. There are four major forest types in the Western Ghats: evergreen, semi-evergreen, moist deciduous, and dry deciduous. Together the forests cover approximately 20 percent of the total area of the Western Ghats. Among the four broad vegetation types, moist deciduous forests occupy the largest area followed by semi-evergreen, dry deciduous, and finally evergreen. The majority of the area under moist forest types falls within the southern states of Kerala and Karnataka. Together they account for 80 percent of the evergreen forest and 66 percent of the moist deciduous forests in the Western Ghats (IIRS, 2002).

i. Evergreen Forests

These forests occur within a 200-1,500-meter elevational range and 2,500 to 5,000 millimeter rainfall range. They vary widely along the length and breadth of the Western Ghats. A broad distinction can be made between the northern evergreen forests and the southern evergreen forests. The Wayanad evergreen forests of Kerala represent a transition zone from the moist *Cullenia* dominated forests in the south Western Ghats to the northern drier Dipterocarp forests (Rodgers and Panwar, 1988). The habitat types of the southern Western Ghats tropical evergreen forests also include the wet montane evergreen forests and *shola*-grassland complexes in the higher elevations (1900-2200 meters). The montane evergreen forests are diverse, multistoried and rich in epiphytes, with a low canopy at 15 to 20 meters (Puri *et al.,* 1989; Ganesh *et al.,* 1996). More than half the tree species found in these forests are endemic, especially among the families *Dipterocarpaceae* and *Ebenaceae*. The majority of the fifty endemic plant genera are also monotypic. The distribution of richness and endemism is not uniform within this forest type, with some areas having higher concentrations of endemics than others. The evergreen forests are distributed in all the Western Ghats States.

ii. Semi-Evergreen Forests

Semi-evergreen forests occur primarily in the states of Maharashtra, Goa, and Karnataka in the Western Ghats, within an altitudinal range of about 300-900 meters (IIRS, 2002). This forest type includes secondary evergreen Dipterocarp forests, lateritic semi-evergreen forests, bamboo brakes, and riparian forests as described by Champion and Seth (1968). The structure and composition of these forests varies widely from north to south and especially from east to west. The dominant species include: *Terminalia paniculata, Aporusa lindleyana, Olea dioica, Syzygium* spp., *Mesua ferrea, Vateria indica, Elaeocarpus tuberculatus, Celtis timorensis, Hopea parviflora, Lagerstroemia microcarpa, Holigarna arnottiana, Hydnocarpus laurina, Memecylon umbellatum*, and *Careya arborea*. These forests also tend to have high levels of tree diversity and endemism (IIRS, 2002).

iii. Moist Deciduous Forests

The moist deciduous forest type occupies the largest area within the Western Ghats. It occurs within an altitudinal range of 500-900 meters in areas with mean annual rainfall of 2,500-3,500 millimetres. Based on the moisture regime, moist deciduous forests are divided into primary or secondary moist deciduous types. The primary moist deciduous forests generally occupy the rainfall zone of 1500 to 2000 mm, as a transition between wet evergreen and dry deciduous forests. The secondary moist deciduous forests occur within the potential area of wet evergreen formations, where the rainfall is more than 2000 mm. The swath of moist deciduous forests is very narrow on the steeper, windward side of the mountain range, where the southwest monsoon rains promote wet evergreen forests. On the less steep leeward side, the drier conditions caused by the rain shadow result in a broader, uneven swath of moist deciduous forests that extend further into the Deccan Plateau. Rainfall on the leeward side is influenced by complex landforms, with some areas receiving less than one-fifth of the 3,000 millimeters or more of annual precipitation that is deposited higher in the mountains.

Although the stand structure and floristic composition are almost similar in both the types, the relative dominance of certain species varies. Floristically, the secondary moist deciduous forests comprises of deciduous species like *Dillenia pentagyna, Albizzia odoratissima, Terminalia bellirica, Tabernaemontana heyneana, Strychnos nux-vomica,* and *Alstonia scholaris,* is relatively more common than in the primary forests. *Xylia xylocarpa* is found abundant as in primary moist deciduous. *Tectona grandis*, which is extensively planted, has also been found mixed with other species in dense formations. In the dense forests, often the under storey are dominated by evergreen species like *Ixora brachiata, Olea dioica, Persea macrantha, Dimocarpus longan, Flacourtia montana, Macranga peltata* etc.

iv. Dry Deciduous Forests

The dry deciduous forests occur on the leeward side of the Western Ghats within an elevational range of 300-900 meters in areas of 900-2,000 millimeters mean annual rainfall. The tall Western Ghats mountain range intercepts the moisture from the southwest monsoon, so that the eastern slopes and the Deccan Plateau receive relatively less rainfall, from 900 to 1,500 millimeters. The undulating hillsides have very shallow soils. Thorny plants become more common in areas where grazing pressure is high.

Although not exceptionally outstanding for biological richness or endemism by itself, the dry deciduous forests are contiguous with the moist deciduous forests that lie along the foothills of the southern extent of the WG and provide valuable wildlife habitat. Two of India's most important elephant conservation areas, the Nilgiris-Eastern Ghats and the Anamalais-Nelliampathis (Sukumar, 1989) and one of the most essential landscapes for global tiger conservation (Wikramanayake *et al.,* 1999) extend across this region. Hence, these forests together with the moist deciduous forests and montane evergreen forests provide important, contiguous habitat landscape for conservation of Asia's largest terrestrial herbivore and predator.

Other Vegetation Types

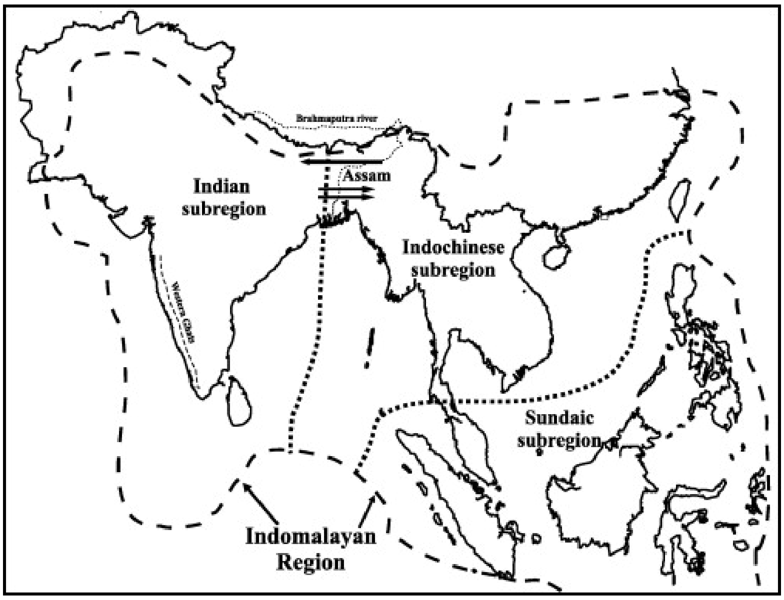
Other vegetation types that occur in the Western Ghats include:

- Scrub jungles located in areas 200-500 meters in elevation with 300-600 millimeters of annual rainfall. This vegetation type is dominated by short trees (15-20 meters high). The dominant genera are *Acacia, Euphorbia, Capparis, Grewia, Canthium, Dodonaea, Altalantia, Carissa, Albizia, Sterculia, Ixora, Zizyphus, Opuntia, Dichrostachys* and *Diospyro,* among others (Nair and Daniel, 1986).
- Savannas located in areas 1,700-1,900 meters in elevation with medium to high rainfall. The dominant genera are *Chrysopogon, Arundinella, Eulalia, and Heteropogon*, among others (Nair and Daniel, 1986).
- High rainfall savannas located in montane areas. The vegetation consists of herbaceous to shrubby cover: *Ligustrum, Rhododendron, Anaphalis,* and *Phlebophyllum*, among others (Nair and Daniel, 1986).
- Tropical dry evergreen forests. These forests are characterized by the absence of typical evergreen species such as *Palaquium* sp. , *Cullenia* sp. etc. They are largely distributed in the less rainfall areas where considerable wetness is affected due to geomorphological characteristics. The common species in the formation are species of *Diospyros*, *Kingiodendron*, *Mitrephora*, *Olea*, etc. They are mainly distributed in the states of Maharashtra, Tamil Nadu and Karnataka.
- Peat bogs located above 2,000 meters in high rainfall areas. Vegetation consists of grasses, sedges and mosses: *Carex, Cyanotis, Cyperus,* and *Eriocaulon*, among others (Daniel, 2001).
- *Myristica* swamps, which are a unique vegetation type in the Western Ghats occurring from sea level to around 600 meters in elevation in areas with medium to high rainfall. The dominant genera are *Myristica, Knema, Hydnocarpus,* and *Lophopetalum* (Nair and Daniel, 1986).

Pascal (1988) has described the vegetation of the Western Ghats based on bioclimate. He has described different gradients in the climate both east to west and north to south for rainfall, length of dry season, temperature-altitude variation and climatic relation for endemism. Accordingly he described 19 floristic types across the Western Ghats compared to the four types of Champion and Seth (1968). These floristic types are denoted with low elevation, medium elevation and high elevation evergreen forests with distinct floristic elements.

Floristic characteristics and phytogeographic affinities

The Western Ghats flora is predominantly Indo-Malayan in origin and there are other elements such as Indoafrican, Paleotropical, Indolankan, Neotropic, Pantropic and endemic and unknown sources (Suresh and Sukumar, 1999). The Malayan families that are well represented in the Western Ghats are *Sterculiaceae, Anacardiaceae, Meliaceae, Myrtaceae, Melastomaceae, Vitaceae, Orchidaceae, Araceae, Tiliaceae, Vitaceae,* *Gesneriaceae, Piperaceae, Scitamineae, Dipterocarpaceae,* etc. Many of the phytogeographcially chareacterisitc species are locked in the cool uplands of the Western Gahts such Nilgirirs, Palnis, Anamalais, and Cardamom Hills. The geological process and other forces has driven the floral elements into such 'safe' pockets of the Ghats for its sustenance. The best examples for such phytogeogrpahic affinities are reported from the shola-grassland formation of the Ghats by various studies (Razi, 1955; Meher-Homji; 1972; Suresh and Sukumar, 1995; Karunakaran, 1997). Meher-Homji mentioned the following species of different phytogeographic region distributed in the montane vegetation.



Daphniphyllum glaucescens and *Eurya japonica* are the two species the range of which extending to high latitudes of Korea and Japan. The tree-fern *Cyathea latebrosa* is an Indo-Malayan species which is distributed over Himalayas, (Sikkim, Bhutan and Khasia Mountains up to 1600 m) and on South Indian hills. *Symplocos* is well distributed over tropical Asia and America but at higher altitudes (Razi, 1955-56). *Cinnamomum, Elaeocarpus, Litsea, Phoebe, Schefflera, Cyathea, Elaeagnus, Lonicera, Meliosma* and *Pittosporum* are represented by many species in the cloud-forests of tropical mountains. The sub-genus *Epigyium*, to which all the Indian species of *Vaccinium* belong, is mainly Indo-Malayan. The distribution of the species of shola fringes shows that they have their distribution range extending into the Himalayas or in the countries of higher latitudes like China, Japan, Korea. Examples are: *Berberis tinctoria, Eurya japonica, Gaultheria fragrantissima, Photinia notoniana, Rapanea wightiana, Symplocos spicata, Ternstroemia japonica, Turpinia cochinchinensis, Viburnum coriaceum.* The specific distributions of *Hypericum mysorense, Rhodomyrtus tomentosa* and *Ilex wightiana* reveal these as species restricted to the higher altitudes of Western Ghats and Ceylon (Karunakaran 1997).

The floral elements of the grasslands of higher elevations also shows its distributional characteristics with other phytogeographic regions (Karunakaran, 1997). There are 28 species common to the Western Himalaya, and (Kala *et al.*, 1997), for eg., *Anemone rivularis, Anisomeles indica, Polygonum chinense, Juncus bufonius, Luzula multifora, Phoenix humilis, Cyperus sanguinolentus,* and *Gentiana pedicellata*. It was found that 30 species were common to the high altitude grasslands (*Patanas*) of Sri Lanka and grasslands of Eravikulam National Park (Dassanayake & Fosberg, 1983). Some of them are *Desmodium triquetrum, Osbeckia aspera, Bidens pilosa, Blumea alata, Conyza bonariensis, Emilia sonchifolia, Campanula fulgens* and *Oxalis corniculata*. Similarly the Yercaud hill of the Eastern Ghats, has sixty four common species (Blasco, 1970; Rao, 1974; Meher-Homji, 1975) such as *Bidens pilosa, Blumea alata, Conyza bonariensis, Emilia sonchifolia, Sonchus wightianus, Polygonum chinense, Anemone rivularis, Cyclea peltata, Linum mysorense, Impatiens chinensis, Eriocaulon robustum, Disperis nilagherrensis, Habenaria rariflora, H. longicorniculata* and *Lilium wallichianum*. The Khasi and Naga hill ranges (North east India) and the grasslands of Eravikulam National Park have 35 common species (Mani, 1974; Shetty & Vivekanandan, 1971; Haridasan & Rao, 1987) which include *Bidens pilosa, Exacum atropurpureum, Campanula fulgens, Thalictrum javanicum, Anemone rivularis, Urena lobata, Triumfeta pilosa, Flemingia strobilifera*, and *Desmodium triquetrum*.

Such a wide distribution of species in the higher reaches of Western Ghats increase the curiosity of the plants distribution and geographical continuity as an intriguing topic for biologists across the country.

Theories behind the phytogeography

Phytogeographic affinities of Western Ghats have been explained by several authors. These explanations were based on the following major theories: (1) Pleistocene Glaciation Theory (Medlicott & Blanford, 1879), (2) Satpura Hypothesis (Hora, 1949), (3) based on birds and animals (Blasco, 1970, 1971).

The *Pleistocene Glaciation Theory* (Medlicott & Blanford, 1879) stresses on the change of climate (temperature) in the peninsular region with glacial movement, as a result of which, floral and faunal elements that were in the temperate Himalaya migrated towards Western Ghats through the low mountain stretches which were free from ice. The presence of Nilgiri tahr (*Hemitragus hylocrius*), the congeneric of Himalayan tahr (*H. jemlahicus*), on the hill slopes of the Western Ghats strongly supports this view. The main criticism to this theory is the total absence of conifers naturally in the south Indian mountain tops despite the successful pine plantations.

Blasco (1970, 1971) questioned the glaciation theory by saying that such direct contacts between the various high peaks due to the glaciation would have been impossible due to long distances. He emphasised the role of migratory birds for the distribution of species. But most of the migratory birds are largely insectivorous or omnivorous (Ridley, 1990). Therefore, it is unlikely that birds would have carried seeds from temperate regions to the Western Ghats. Meher-Homji (1967, 1972) also questions zoochorous migration of plants to the Western Ghats since they differ at the species level.

Hora (1949) emphasized the role of humidity which may be more important than temperature for the discontinuous distribution of species. This makes the important postulate of the *Satpura Hypothesis* which envisaged that during Pleistocene, the Satpura and Vindhyan ranges had an altitude of 1500-2000 m., forming a continuous range of mountains between the Eastern Himalaya and the northern Western Ghats. The high rainfall (above 2500 mm) supported this migration. The migration route was from Assam and Eastern Himalayas to the plateau of Chota Nagpur across the Garo-Rajmahal gap. The migration from Chota Nagpur to south India and Ceylon was probably along the Vindhya-Satpura-Western Ghat route. He explained that the present day climate and topography are not suitable for migration of plants and animals from Assam and Eastern Himalaya but such favourable conditions existed in the Pliocene and Pleistocene periods. The palynological studies carried out in the Palnis and Nilgiris established the role of Pleistocene Glaciation in the distribution of plant species on high altitudes of the Western Ghats, with evidence of pollen grains of Pleistocene flora (Vasanthy, 1988).

Based on the foregoing discussions, it can be concluded that land connections between Himalayas and Western Ghats in the past were responsible for species migration. But no single theory holds good in explaining the phytogeographical affinities of two distinct areas. The major gaps in all the postulates are (i) though the ecological conditions are adequate for many temperate species, none of the pines have been reported from south, (ii) the absence of obligate frugivorous migratory birds from the Himalaya to the Western Ghats to facilitate zoochory, (iii) the suggested geological period of migration, (iv) the antiquity of the Western Ghats over the Himalaya. Thus considering the young age of Himalaya, the Western Ghats might have been the species donor rather than the receiver.

References

1. **Blasco, F. 1970.** Aspects of the Flora and ecology of savannas of the south Indian hills. *J. Bombay Nat. Hist. Soc.* 67. 522-534.
2. **Blasco, F. 1971.** Montagnes du sud de l'Inde. Forests, Savanes, Ecologie. Inst. Fr. Pondicherry. *Tr. Sect. Sci. Tech.* 11: 1-436.
3. **Champion, H.G. and Seth, S.K. 1968.** *A revised survey of forest types of India.* Forest Research Institute, New Delhi.
4. **Chatterjee D. 1940.** Studies on the endemic Flora of India and Burma. *J. Asiat. Soc. Bengal* 5: 19-67
5. **Clarke, C.B. 1898.** Sub-areas of British India, Illustrated by the detailed distribution of Cyperaceae in that empire. *J. Linn. Soc. (Botany)* 34: 1-146.
6. **Daniels, R.J.R. 2001.** *National Biodiversity Strategy and Action Plan: Western Ghats Eco-region*. Report submitted to Ministry of Environment and Forests,Government of India
7. **Dassanayake, M.D., & F.R. Foseberg.1983.** *A revised handbook to the Flora of Ceylon*. Vol I-II. Oxford & IBH Publishing Co. New Delhi.
8. **Ganesh T., Ganesan, R., Devy, M.S., Davidar, P., and Bawa, K.S. 1996.** Assessment of plant biodiversity at a mid elevation evergreen forest of Kalakkad-Mundanthurai Tiger Reserve, Western Ghats, India. *Current Science* 71(5): 379-392.
9. **Haridasan, K and Rao. 1987.** *Forest flora of Meghalya*, Vol. I & II. Botanical Survey of India. pp. 937.
10. **Henry, A.N., K. Vivekanandan and N.C. Nair. 1978.** Rare and Threatened Flowering Plants of South India, *J. Bombay Nat. Hist. Soc.* Vol. 75.
11. **Hooker, J.D. 1907.** Sketch of the Flora of British India. *Imperial Gazetteer of India* (3) 1: 157-212
12. **Hora, S.L. 1949.** Satpura Hypothesis of the distribution of Malayan fauna and flora to Peninsular India. *Pro. Nat. Inst. Sci. India*. 15: 309-313.
13. **IIRS, 2002.** *Biodiversity Characterization at Landscape Level in Western Ghats India Using Satellite Remote Sensing and Geographic Information Systems.* Indian Institute of Remote Sensing. National Remote Sensing Agency, Department of Space, Government of India. Dehra Dun
14. **Kala, C.P., G.S. Rawat and V.K. Uniyal 1997.** *Ecology and conservation of the Valley of Flowers National Park, Garhwal Himalaya.* Project Report. Wildlife Institue of India, Dehra Dun
15. **Karunakaran, P.V. 1997.** *Ecological Studies on the grasslands of Eravikulam National Park, Kerala.* Ph. D. Thesis Submitted to Saurashtra University, Gujarat. pp 192.
16. **Mani, M.S. (ed). 1974.** *Ecology and Biogeography in India*. Dr. W. Junk b.v. Publ., The Hague
17. **Medlicott, H.B. and W.T. Blanford. 1879.** *A Manual of geology of India*. 2 Vols. Calcutta. pp 374-375
18. **Meher-Homji, V.M. 1967.** Phytogeography of the south Indian hill stations. *Bull. Torrey. Bot. Club*. 94: 230-42.
19. **Meher-Homji, V.M. 1972.** Himalayan plants on South Indian hills: Role of Pleistocene glaciation vs. long distance dispersal of *Sci. & Cult*. 38: 8-12.
20. **Meher-Homji, V.M. 1975.** On the montane species of Kodaikanal, South India, *Phytocoenologia* 2(1-2): 114-129
21. **Nair, S.C. 1991.** *The Southern Western Ghats- A Biodiversity Conservation Plan*. INTACH, New Delhi.
22. **Nair, N.C. and Daniel, P. 1986.** The floristic diversity of the Western Ghats and its conservation: a review. *Proc. Indian Acad Sci.* (Animal Sci./Plant Sci.) Suppl: 127-163.
23. **Pascal, J.P. 1988.** *Wet evergreen forests of the Western Ghats of India: Ecology, structure, floristic composition and succession*. French Institute of Pondicherry, India
24. **Prain D. 1903.** *Bengal Plants.* Vol. I & II. Calcutta

25. **Puri, G.S., Gupta, R.K. and Meher-Homji, V.M.P.S. 1989.** *Forest Ecology*, Volume 2. New Delhi, India: Oxford & IBH Publishing Company.
26. **Qureshi, I.M. 1965.** *Tropial rainforests of India and ther silvicultural and ecological aspects.* Symposium on Ecological research in Humid Tropics Vegetation, Kuching, Sarawak. 120-136.
27. **Rao, R.R. 1994.** *Biodiversity in India,* Bishen Singh Mahendra Pal Singh, Dehradun pp 315
28. **Razi, B.A. 1955.** The phytogeography of the Mysore hilltops. *J. Mysore Univ*. 14: 87-107.
29. **Rodgers W.A. and Panwar H.S. 1988.** *Planning a wildlife protected area network in India.* WII, Dehradun.
30. **Shetty, B.V. and K. Vivekanandan. 1971.** Studies on the vascular flora of Anaimudi and surrounding regions, Kottayam District, Kerala. *Bull. Bot. Surv. India*. 13: 16-42.
31. **Subramanyam K. and M.P. Nayar, 1974.** *Vegetation and Phytogeogrpahy of the Western Ghat*s. In Mani, M.S. (ed). 1974: Ecology and Biogeography in India. Dr. W. Junk b.v. Publ., The Hague
32. **Sukumar, R. 1989.** *The Asian Elephant: Ecology and management*. Cambridge: Cambridge University Press. pp251
33. **Sukumar, R., H.S. Suresh and R. Ramesh. 1995.** Climate change and its impact on tropical montane ecosystems in southern India. *J. of Biogeography*. 22: 533-536.
34. **Vasanthy, G. 1988.** Pollen analysis of late quaternary sediments: evolution of upland savanna in Sandynallah (Nilgiris, South India). *Review of Plaeobotany and Palynology.* Vol.55: pp.175-192.
35. **Ridley, H.N. 1990.** *The dispersal of plants throughout the world*. Bishen Singh & Mahendra Pal Singh, Dehradun, pp 440-514.
36. **Wikramanayake, E. D., Dinerstein, E., Robinson, J. G., Karanth, K.U, Rabinowitz, A., Olson, D., Matthew, T., Hedao, P., Conner, M., Hemley, G. and Bolze, D. 1999.** *Where can tigers live in the future? A framework for identifying high priority areas for the conservation of tigers in the wild.* In Riding the Tiger: Tiger conservation in human dominated landscapes (Editors: J. Seidensticker, S. Christie and P. Jackson), Cambridge.

Current status and distribution of Bryophytes of the Western Ghats, India

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Abstract

Bryophytes are diverse and distinct group of primitive plants, with about 25,000 species distributed the world over making it the second largest group of land plants next to the flowering plants. They are considered as "amphibians" of plant kingdom owing to their preference to aquatic and other wet habitats. According to latest molecular and morphological studies the Bryophytes had been given the subkingdom status and and given the name status Bryophytina or bryobiophytina. The group includes three distinct lineages – *Marchantiophyta* (liverworts), *Anthocerotophyta* (hornworts) and *Bryophyta* (mosses). Among these mosses form the most prevalent group among the Bryophytes, being the most speciose and with their structural and morphological complexities. They are abundantly distributed across the different ecosystems, growing on varied substrates such as rocks, tree barks, side walls, concrete structures, forest floors and other moisture areas.

The Western Ghats is one of the major phytosociological areas having different vegetation types and rich in diversity of moss flora, which lie parallel to the west coast of India. The Western Ghats accommodates major vegetation types of the area such as Tropical Wet Evergreen forests, West Coast Tropical Semi-Evergreen forests, Southern Tropical Moist Deciduous forests, Southern Tropical dry deciduous forests, Southern Montane wet Temperate Forests and Plantations. All these forest types are enriched by a great variety of bryophytes.

Over these years, the authors have made systematic collection of more than 5000 bryophyte specimens for herbarium from different areas along with the field data such as locality, date, altitude, microhabitat, substratum, form and structure, associated species, etc. The present paper summarises the diversity of the bryophytes of Western Ghats.

Introduction

Bryophytes are diverse and distinct group of primitive plants, with about 25,000 species distributed the world over making it the second largest group of land plants next to the flowering plants. They are considered as "amphibians" of plant kingdom owing to their preference to aquatic and other wet habitats. According to latest molecular and morphological studies the Bryophytes had been given the subkingdom status and given the name status Bryophytina or bryobiophytina. The group includes three distinct lineages – Marchantiophyta (liverworts), Anthocerotophyta (hornworts) and Bryophyta (mosses). Among these mosses form the most prevalent group among the Bryophytes, being the most speciose and with their structural and morphological complexities. They are abundantly distributed across the different ecosystems, growing on varied substrates such as rocks, tree barks, side walls, concrete structures, forest floors and other moisture areas.

The Western Ghats is one of the major phytosociological areas having different vegetation types and rich in diversity of moss flora, which lie parallel to the west coast of India. The Western Ghats accommodates major vegetation types of the area such as Tropical Wet Evergreen forests, West Coast Tropical Semi-Evergreen forests, Southern Tropical Moist Deciduous forests, Southern Tropical dry deciduous forests, Southern Montane wet Temperate Forests and Plantations. All these forest types are enriched by a great variety of bryophytes.

The bryophytes, being the major part of the *bryosphere*, play significant roles in the ecosystem dynamics in most of the ecosystems of the world (Lindo & Gonzalez, 2010). However, it may be one of the least studied plant groups in the Western Ghats. The present paper is an attempt to collate the details on the bryophyte diversity of the Western Ghats.

The first record of the bryophyte from the Western Ghats can be traced back to Van Rheede's monumental work *Hortus Indicus Malabaricus*. He described and illustrated one bryophyte, as '*poovan-peda*' (in volume 12 as tab. 37, p. 71.1693), which later was assumed as *Bryum dichotomum* Dickson. The earlier studies on the bryophytes of the Western Ghats are scanty and limited to random collection in the 19th century. The first attempt to explore the bryophytes of the Western Ghats started by some of the earlier settlers in the Nilgiri hills. Montagne (1842a,b) reported 66 species of mosses and 34 species of liverworts from the Nilgiri Hills (Tamil Nadu) in *Cryptogamae Nilgherienses.* Müller (1853) reported 56 species of mosses from the Nilgiris in *Musci Neilgherrensis*. Mitten (1859) reported over 700 species in his *Musci Indiae Orientalis*, of which 145 were from Tamil Nadu. Subsequently, Mitten (1861) reported 26 species of liverworts from Tamil Nadu in *Hepaticae Indiae Orientalis*. The 20th century also witenessed some bryophyte studies such as those of Dixon (1914) who reported 35 species of mosses from the Nilgiris. From the Western Ghats of Madurai (Tamil Nadu), Potier de la Varde (1922–1924) reported 48 species in his *Musci Madurensis*, 49 species in *Nouvelles herborisations dans le sud de l'Inde* (1925) and 7 species in *Musci novi Indici* (1928). Dixon and Potier de la Varde's (1927) treatment on Indian bryophytes, *Contribution à la flore bryologique de l'Inde meridionale* also include many species from the Wester Ghats of Tamil Nadu. They (1930) also reported 56 species from Tamil Nadu in *Nouvelle contribution à la flore bryologique de l'Inde*. Another major contribution was made by Foreau (1961, 1964), who listed 368 species of mosses from the Palni hills (W. Ghats of Madurai) which included 95 new species and 15 new varieties.

The earlier studies on the bryophytes of Kerala are scanty and limited to random collection reports by earlier workers, especially of the European and north Indian bryologists. The works of Dixon (1914), Bruehl (1931), Chopra (1938), Ellis (1989), etc. are major among them. Other bryologists such as Stephani (1900–1924), Benedix (1953), Udar (1976), Udar and Srivastava (1975, 1977), Asthana and Srivastava (1991), Asthana *et al.* (1995), Nath and Asthana (1998), Singh (1994, 2002), Srivastava and Srivastava (2002), etc. also recorded many species of liverworts from Kerala, Tamil Nadu and Karnataka. Gangulee's monumental work *Mosses of eastern India and adjacent regions* (1969–1980) provides information on the habitats and distribution of south Indian mosses. He occasionally mentions the occurrences of some species in Tamil Nadu, Kerala, Kanataka, but without exact localities.

Importance of Bryophytes

Eventhough the bryophytes is a paraphyletic assemblage, composed of three lineages, *viz.*, liverworts, hornworts and mosses, they perform important roles in most of the ecosystems. They usually acting as space fillers in the ecosystem not only add visual richness to the natural beauty, but also plays key roles in the ecosystem dynamics such as nutrient and water recycling, soil protection, preventing leaching, making suitable microhabitats for the germination and establishment of seedlings and sporelings, providing food and shelter to many invertebrates, etc. They are the primary form of carbon storage in many ecosystems and are important in nutrient sequestration, water retention, regulation of soil temperature and pH. These have been used as experimental models and as biomonitors and bioindicators of heavy metal pollution. They are also important in preventing soil erosion and nutrient leaching. In addition to this, they are economically important being the source of food, medicine, preservatives, energy sources, etc. They can also be used as potential system in pollution monitoring and other experimental purposes. The evolutionary significance due to the prominence of gametophytes and other ecological preferences make them an ideal group for detailed studies.

Materials and Methods

Bryophyte taxonomy includes many steps, every steps are equally important to make the study complete. The steps are collection, preservation, investigation, identification, and taxonomic description.

a. Collection

It is the most important step in the study of the bryophyte taxonomy. Systematic collection of bryophytes from the Western Ghats was done during 2000-2012 for morphologic and taxonomic study. Field trips were undertaken with all necessary items required such as bryophyte Herbarium packets, field book, specimen bottles, hand lens, sharp edged knife, scalpel, news paper, pen/pencil, slip pad, collection bag and altimeter.

Some bryophytes are very delicate and attached to the substratum very firmly, hence collected by scraping out from the substratum and soil particles were removed by leaving a thin film attached. Epiphytic species were collected by scraping the bark, as far as possible. High canopy species were collected from the fallen leaves and branches. Corticolous and lithophytic species were collected along with the substratum. Two or more species usually grow together and hence were collected by giving the same field number. They were separated later by giving sub members after careful examination. Dry specimens were put directly in to the paper packets, others were dried by keeping in news paper folders. Field data including, date, locality, habitat, altitude, etc. were noted down in the field book. The specimens kept in paper packets usually remain fresh and alive for some days and so that it can be examined alive, which later dried and stored in the herbarium. Identification of specimens is done later after careful examination using literatures.

b. Preservation

Taxonomic study depends largely upon the type, quality and condition of the preserved specimens in the herbarium. For the preservation of mosses no extraordinary techniques are required. But the specimens should be dried properly and kept in suitable herbarium packets for their further taxonomic studies.

As the life cycle of mosses consists of two distinct phases, the gametophyte and sporophyte, a complete herbarium needs both these phases for identification. Dried specimens were preserved in paper packets. They regain their original shape and size, and to some extent colour also, when wet. Moss herbarium packets are made by folding thick paper of standard quality 5″x 4″ sized packets. The field data such as collection number, date, locality, altitude, habitat and collectors name were copied on to the herbarium label. The binomial and family name were also added to the labels. These labels were affixed to the upper flap of herbarium packets. These packets were then placed in folders inside the almirah according to the classification system of Buck and Goffinet (2008). Properly labelled packets were deposited in the Zamorin's Guruvayurappan College Herbarium (ZGC) and Malabar Botanical Garden (MBGS).

c. Investigation and identification

Fresh materials were subjected to study, whenever possible, for identification. External morphological features were studied under a stereo dissection microscope and internal features by a compound microscope. Size of leaves, capsule and cells were measured by micrometry. Identification of specimens was done by referring authentic literatures. The specimens were also compared with the herbarium specimens from different herbarias of the world.

Bryophyte diversity and status in the Western Ghats

Currently, about 2500 taxa of bryophytes are reported from India, comprising about 722 taxa of liverworts in 128 genera and 52 families, 36 taxa in 6 genera and 2 families of hornworts and about 1623 taxa in 342 genera and 57 families of mosses (Lal, 2005).

In the recent years the bryophyte studies of the Western Ghats regained momentum with the launching of the Life Scape Project of the Center for Ecological Science of Indian Institute of Science during 1995-2000. The orientation and training imparted as part of this programme made some researchers to continue with detailed bryophyte documentation. A few researchers such as Manju (alias M.C. Nair, 2001-2012), Daniels (2001-2010) and Bhat (2009), etc extended their studies as part of the doctoral thesis and reported more than 900 species from the Western Ghats.

The data on the bryophyte diversity of the Nilgiris is more as this area has been explored in a bit more intensively. Most of the bryophyte species represented in Southern India appears to be at the Western extreme of an Indo-Pacific or Indo-Malesian distribution, and a few possess a distribution centered in Africa (Ellis, 1992). Out of the 990 species known from the Western Ghats, about seven species *viz*., *Riccia poihaiana* A.E.D.Daniels & P.Daniel, *Riccia velimalaiana* A.E.D.Daniels & P.Daniel, *Metzgeria nilgiriensis* S.C.Srivast. & Udar, *Metzgeria raoii* Srivast. & Srivast., *Amphidium gangulii* Nair *et al*., *Trichostomum wayanadense* Nair *et al*. and *Fissidens kammadensis* Manju *et al*. are endemic to the Western Ghats (Table-1).

The present paper is an attempt to accumulate the details on the bryophyte diversity of the Western Ghats. Preliminary checklists or reports are available for states such as Kerala, Karnataka, Goa and Tamil Nadu. However, no such data is available for other states such as Maharashtra and Orissa. Hence the present list is far from complete and it may represent only a fraction of the actual diversity of this group. When compared to the estimated diversity of the bryophyte flora of Western Ghats (*ca.* 2000 spp.), the present position reveals the pathetically poor condition of the bryological studies.

Conservation of Bryophytes of the Western Ghats

Conservation is mainly discussed among the celebrity species such as tigers, elephants, birds, butterflies, orchids, etc. Plant groups such as bryophytes were never considered by the resource managers, conservationists and policy makers while formulating the conservation strategies. This neglect is the main reason for the lack of proper information base on the lower group of plants. The survival of most of the bryophytes is directly related to the health of the natural habitats. The undisturbed primary forests usually offer high level of protection by providing, the necessary microclimates and substrata needed for the bryophytes to colonize and diversify. Disturbaces at micro or minor levels itself may alter the microclimate of the area, influencing the growth patterns of the smaller plants such as bryophytes. Unhealthy practices such as constructions, conversion into plantations, changes in the cultivation patterns, collection of firewood, NWFPs, grazing, etc. in the forest areas largely caused severe habitat destruction. It is found that the anthropogenic activities seriously altered the microclimate of even the remote and inaccessible shola forest areas causing problems such as opening up of canopy, increasing the light intensity to the lower strata, etc and altered the community structure beyond resilience capacity (Chandrasekhara *et al.,* 2005). The bryophytes also respond to such changes by altering the species composition. Shade loving species may be replaced by light tolerant species, and changing the pattern and survival of associated organisms. Such cryptic changes are ongoing in many parts of the Western Ghats (Daniels & Kariappa, 2007). This may lead to the great loss of biodiversity in the near future itself. Increse in the levels of environmental pollution also may enhance the habitat degradation and loss of species. However, no detailed assessment of the bryophyte species and their habitats had been attempted in India. A baseline data is not even available in this line. It is high time to conduct detailed study on the diversity and ecological significance of bryophytes of the Western Ghats, and also seriously consider the conservation of this group. Intensive and extensive exploration should be undertaken for the detailed documentation of the bryoflora and their habitats in the Western Ghats. The rare, endangered elements may be identified and conserved with due care. Attempts for *ex-situ* conservation also may be tried by introducing bryophytes to gardens, etc. This would be helpful in creating awareness among the various sectors of society.

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References

1. **Asthana, A.K. and Srivastava, S.C. 1991.** Indian Hornworts (A taxonomic study). *Bryophytorum Bibliotheca* 42: 1-158.
2. **Asthana, G., Srivastava, S.C. and Asthana, A.K. 1995.** The genus *Cheilolejeunea* in India. *Lindbergia* 20: 125-143.
3. **Benedix, E.H. 1953.** Indomalayische *Cololejeuneen. Feddes Repertorium, Beihefte* 134: 1-88.
4. **Bhat, V.C. 2009.** Mosses of Western Ghats and Coastal belt of Karnataka- A taxonomic study. Ph.D. Thesis, Mangalore University.
5. **Bruehl, P. 1931.** A census of Indian mosses with analytical keys to the genera. *Records of the Botanical Survey of India* 13(1): 1-135; 13(2): 1-152.
6. **Chandrasekhara, U.M., P.K. Muraleedharan and V. Sibichan. 2005.** Anthropogenic Pressure on Structure and Composition of a Shola Forest in Kerala, India. Journ. Mountain Sci. 3: 58-70.
7. **Chopra, R.S. 1938.** Notes on Indian Hepatics I. South India. *Proceedings of the Indian Academy of Sciences*, *Ser B*, 7: 239-251.
8. **Daniels, A. E. D. 2010.** Checklist of the bryophytes of Tamil Nadu, India, *Archiv Bryol.* 65:
9. **Daniels, A.E.D and P. Daniel. 2003.** Addition to the bryoflora of Peninsular India. *Indian J. For.* 26(4): 389-396.
10. **Daniels, A.E.D. and Kariyappa, K.C. 2007.** Bryophyte diversity along a gradient of human disturbance in the southern Western Ghats. *Curr. Sci.* 93: 976-982.
11. **Daniels, A.E.D. 2001.** *Cololejeunea furcilobulata* (Berrie *et* Jones) Schuster and *Heteroscyphus argutus* (Reinw. *et al.*) Schiffn. from Mahendragiri hills of Kanyakumari district of South India. *In:* V. Nath & A.K. Asthana (eds.) *Perspectives in Indian Bryology*, pp. 301-307, Bishen Singh Mahendrapal Singh, Dehra Dun.
12. **Daniels, A.E.D. 2003.** Studies on the bryoflora of the Southern Western Ghats, India. Ph.D. Thesis, Manonmaniam Sundaranar University.
13. **Dixon, H.N. and Potier de la Varde, R. 1927.** Contribution à la flore bryologique de l'Inde méridionale. *Archives de Botanique, Bulletin Mensuel* 1(8-9): 161-184.
14. **Dixon, H.N. and Potier de la Varde, R. 1930.** Nouvelle contribution à la flore bryologique de l'Inde. *Annales de Cryptogamie Exotique* 3: 168-193.
15. **Dixon, H.N. 1914.** Report on the mosses collected by C.E.C. Fischer and others from south India and Ceylon. *Records of the Botanical Survey of India* 6(3): 75-91.

16. **Ellis, L.T. 1989**. A taxonomic revision of *Calymperes* in southern India and neighbouring islands. *Journal of Bryology* 15: 697-732.
17. **Ellis, L.T. 1992.** Towards a moss flora of Southern India. *Bryobrothera* 1: 133-136.
18. **Foreau, G. 1961.** The moss flora of the Palni Hills. *Journal of the Bombay Natural History Society* 58: 12-47.
19. **Foreau, G. 1964.** Miscellaneous Notes: Some South Indian Mosses. *Journal of the Bombay Natural History Society* 61: 223-226.
20. **Gangulee, H.C. 1969-1980.** Mosses of Eastern. India and adjacent regions Fasc. 1-8. pp. 1- 2145, Bischen Singh Mahendra Pal Singh, Dehra Dun.
21. **Lal, J. 2005.** *A Checklist of Indian Mosses*. Bishen Singh Mahendrapal Singh, Dehra Dun.
22. **Lindo, Z. and Gonzalez, A. 2010.** The Bryosphere: An Integral and Influential Component of the Earth's Biosphere. *Ecosystems* 13: 612–627.
23. **Manju, C. N. 2004.** Bryophytes from Kakkayam, In: Biodiversity study of Kakkayam. *Malabar Trogon* 2: 2
24. **Manju C.N., Rajesh, K.P. and Madhusoodanan, P.V. 2008.** Checklist of the Bryophytes of Kerala, India. *Tropical Bryology Research Report* No. 7: 1-24.
25. **Manju, C. N. and K.P. Rajesh. 2009.** Bryophyte diversity in the high altitude grasslands of the Western Ghats. *Acta Botanica Hungarica* 51(3-4): 329-335.
26. **Manju C.N., Rajesh, K.P. and Madhusoodanan, P.V. 2009.** Bryophyte Diversity in Kerala Part of Agasthyamalai Biosphere Reserve in Western Ghats. *Taiwania* 54: 57-68.
27. **Manju, C.N., Rajesh, K.P. and Madhusoodanan, P.V. 2009.** Contribution to the bryophyte flora of India: the Aralam Wildlife Sanctuary in the Western Ghats. *Archive for Bryology* 42: 1-12.
28. **Mitten, W. 1859.** Musci Indiae Orientalis, an enumeration of the mosses of the East Indies. *Journal of the Proceedings of the Linnean Society, supplement to Botany* 1: 1-171.
29. **Mitten, W. 1861 [1860].** Hepaticae Indiae Orientalis. *Journal of the Proceedings of the Linnean Society, Botany* 5: 89-128.
30. **Mittermeier, R.A. and Werner, T.B. 1990.** Wealth of Plants and Animals in Megadiversity countries. *Tropicus* 4(1): 4-5.
31. **Montagne, C. 1842a.** Cryptogamae Nilgherienses seu plantarum cellularium in montibus peninsulae indicae Neel-Gherries dictis a Cl. Perrottet collectarum enumeratio. Musci. *Annales des Sciences Naturelles; Botanique, sér. 2*, 17: 243-256.
32. **Montagne, J.P.F.C. 1842b.** Cryptogamae Nilgherienses Plantarum cellularium in montibus peninsulae Indicae *Neel-Gherries* dictis à cl. Perrottet collectarum Enumeratio, Hepaticae. *Annales des Sciences Naturelles, Botanique* 2, 18: 12-17.
33. **Müller, C. 1853 [1854].** Musci Neilgherrenses. *Botanische Zeitung (Berlin)* 11: 17-24, 33-40, 57-62.
34. **Nair, M.C. and Madhusoodanan, P.V. 2001.** Contribution to the bryophyte flora of Eravikulam National Park, Kerala. *J. Econ. Taxon. Bot.* 25: 569-574.
35. **Nair, M.C. and Madhusoodanan, P.V. 2002.** Studies on the bryophyte flora of Kerala (South India) - An introduction. *J. Econ. Taxon. Bot.* 26(3): 697-708.
36. **Nair M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2005.** Little known *Plagiochila* (Dum.) Dum. (Plagiochilaceae: Hepaticae) from India. *Geophytology* 35: 39-44.
37. **Nair, M.C. and Madhusoodanan, P.V. 2006.** A preliminary survey of the Bryophyte flora of Vellarimala in Western Ghats of Kerala. *Indian J. Forestry* 29(2): 191-196.
38. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2006.** Addition to the bryoflora of Peninsular India. *J. Econ. Taxon. Bot.* 30 (2): 221-224.

39. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2006.** Bryophytes of Chinnar Wildlife Sanctuary (South India)- a preliminary account. *Geophytology* 36: 7-15.
40. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2007.** The genus *Philonotis* Brid. (Bartramiaceae: Bryopsida) in Peninsular India. *Folia Malaysiana* 18(1): 21-31.
41. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2007.** Three new bryophyte records for Peninsular India. *Indian J. For.* 30: 349-352.
42. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2008.** Bryophytes of Kakkayam Forests in the Western Ghats and its conservation. *Geophytology* 37: 59-63.
43. **Nair, M.C., Rajesh, K.P. and Madhusoodanan, P.V. 2008.** Ecological observations on the bryophytes of Eravikulam National Park, South India. *Geophytology.* 37: 51-53.
44. **Nath, V. and Asthana, A.K. 1998.** Diversity and distribution of genus *Frullania* Raddi in South India. *Journal of the Hattori Botanical Laboratory* 85: 63-82.
45. **Pocs, T., Nair, M.C. Rajesh, K.P. and Madhusoodanan, P.V. 2007.** Liverwort (Marchantiopsida) records from the Western Ghats (Kerala State, Peninsular India). *Acta Botanica Hungarica* 49(1-2): 121-129.
46. **Potier de la Varde, R. 1922.** Musci Madurenses. *Revue Bryologique* 49: 33-44.
47. **Potier de la Varde, R. 1923.** Musci Madurenses (suite). *Revue Bryologique* 50: 17-27; 72-79.
48. **Potier de la Varde, R. 1924.** Musci Madurenses (suite et fin). *Revue Bryologique* 51: 10-14.
49. **Potier de la Varde, R. 1925.** Nouvelles herborisations dans le Sud de l'Inde (1er note). *Revue Bryologique* 52: 37-43.
50. **Potier de la Varde, R. 1928.** Musci novi indici. *Annales de Cryptogamie Exotique* 1: 37-47.
51. **Rheede, H.A. Van. 1678-1703.** *Hortus Indicus Malabaricus*. (English Translation Manilal, K.S. 2004. Kerala University, Thiruvananthapuram.)
52. **Singh, D.K. 1994.** Distribution of family Notothylaceae in India and its phytogeographical significance. *Advances in Plant Sciences Research* 2: 28-43.
53. **Singh, D.K. 2002.** *Notothylaceae of India and Nepal (A morpho-taxonomic revision).* Bishen Singh Mahendra Pal Singh, Dehra Dun.
54. **Srivastava, A. and Srivastava, S.C. 2002.** *Indian Geocalycaceae (Hepaticae): a taxonomic study.* Dehra Dun, India: Bishen Singh Mahendra Pal Singh, Dehra Dun.
55. **Stephani, F. (1901-1906).** *Species Hepaticarum* 2: 1-615. Genève et Bale, Georg et Cie, Lyon.
56. **Stephani, F. (1907-1909).** *Species Hepaticarum* 3: 1-693. Genève et Bale, Georg et Cie, Lyon.
57. **Stephani, F. (1917-1925).** *Species Hepaticarum* 6: 1-763. Genève et Bale, Georg et Cie, Lyon.
58. **Udar, R. and Srivastava, S.C. 1975.** Notes on South Indian Hepaticae I. *Journal of the Bombay Natural History Society* 72: 401-406.
59. **Udar, R. and Srivastava, S.C. 1977.** Notes on South Indian Hepaticae 2. The genus *Herberta* Gray. *Journal of the Bombay Natural History Society* 74: 255-263.
60. **Udar, R. 1976.** *Bryology in India*: In Pama Primlane, (ed.), Chron. Bot. New Delhi.

Table1: Preliminary list of Bryophytes of the Western Ghats

MARCHANTIOPHYTA (Liverworts)

1. *Aneura pinguis* (L.) Dumort.
2. *Archilejeunea apiculifolia* Steph.
3. *Archilejeunea minutilobula* Udar & U.S.Awasthi
4. *Asterella khasyana* (Griff.) Grolle
5. *Asterella leptophylla* (Mont.) Grolle
6. *Asterella wallichiana* (Lehm.) Grolle
7. *Athalamia pusilla* (Steph.) Kashyap
8. *Bazzania intermedia* (Lindenb. & Gottsche) Trevis.
9. *Bazzania orientalis* (Steph.) Parihar
10. *Bazzania pearsonii* Steph.
11. *Bazzania sumbavensis* (Gottsche ex Steph.) Steph.
12. *Bazzania tricrenata* (Wahlenb.) Lindb.
13. *Bazzania tridens* (Reinw., Blume & Nees) Trevis.
14. *Calypogeia arguta* Nees & Mont ex Nees
15. *Calypogeia azurea* Stotler et Crotz
16. *Calypogeia lunata* Mitt.
17. *Calypogeia tosana* (Steph.) Steph.
18. *Caudolejeunea reniloba* (Gott.) Steph.
19. *Cephalozia hamatiloba* Steph. subsp. *siamensis* (N.Kitag.) Váňa
20. *Cephalozia pandei* Udar & Kumar
21. *Cephaloziella kiaerii* (Austin) S.Arnell
22. *Cephaloziella willisana* (Steph.) N. Kitag.
23. *Cheilolejeunea birmensis* (Steph.) Mizut.
24. *Cheilolejeunea ghatensis* Asthana *et al.*
25. *Cheilolejeunea intertexta* (Lindenb.) Steph.
26. *Cheilolejeunea krakakammae* (Lindenb.) R.M.Schust.
27. *Cheilolejeunea laeviuscula* (Mitt.) Steph.
28. *Cheilolejeunea mariana* (Gottsche) B.Thiers & Gradst.
29. *Cheilolejeunea serpentina* (Mitt.) Mizut.
30. *Cheilolejeunea subopaca* (Mitt.) Mizut.
31. *Cheilolejeunea trapezia* (Nees) Kachroo & R.M.Schust.
32. *Cheilolejeunea udarii* G.Asthana, S.C.Srivast. & A.K.Asthana
33. *Chiloscyphus coadunatus* (Sw.) J.J.Engel & R.M.Schust.
34. *Chiloscyphus concretus* (Mont.) J.J. Engel & R.M. Schust.
35. *Chiloscyphus kurzii* (Sande Lac.) J.J.Engel & R.M.Schust.
36. *Chiloscyphus muricatus* (Lehm.) J.J.Engel & R.M.Schust.
37. *Chiloscyphus polyanthos* (L.) Corda
38. *Chiloscyphus profundus* (Nees) J.J.Engel & R.M.Schust.
39. *Chonecolea schusteri* Udar & A.Kumar
40. *Cololejeunea appressa* (A.Evans) Benedix
41. *Cololejeunea cardiocarpa* (Mont.) A.Evans
42. *Cololejeunea ceratilobula* (P.C.Chen) R.M.Schust.
43. *Cololejeunea furcilobulata* (Berrie & Jones) R.M. Schust.
44. *Cololejeunea hasskarliana* (Lehm. & Lindenb.) Steph.
45. *Cololejeunea lanciloba* Steph.
46. *Cololejeunea latilobula* (Herzog) Tixier
47. *Cololejeunea longifolia* (Mitt.) Benedix
48. *Cololejeunea madothecoides* (Steph.) Benedix
49. *Cololejeunea minutissima* (Sm.) Schiffn.
50. *Cololejeunea nilgiriensis* G.Asthana & S.C.Srivast.
51. *Cololejeunea planissima* (Mitt.) Abeyw. var. *planissima*
52. *Cololejeunea pseudofloccosa* (Horik.) Benedix
53. *Cololejeunea raduliloba* Steph.
54. *Cololejeunea spinosa* (Horik.) S.Hatt.
55. *Cololejeunea udarii* G.Asthana & S.C.Srivast.
56. *Conocephalum conicum* (L.) Underw.
57. *Cyathodium aureonitens* (Griff.) Mitt.
58. *Cyathodium cavernarum* Kunze
59. *Cyathodium smaragdinum* Schiffn.
60. *Cyathodium tuberculatum* Udar & D.K.Singh
61. *Cyathodium tuberosum* Kashyap
62. *Cylindrocolea tagawae* (Kitag.) Schust.
63. Drepanolejeunea angustifolia
64. *Drepanolejeunea angustifolia* Grolle
65. *Drepanolejeunea sikkimensis* (Udar & U.S.Awasthi) Grolle
66. *Drepanolejeunea ternatensis* (Gottsche) Steph.
67. *Dumortiera hirsuta* (Sw.) Nees
68. *Exormotheca ceylonensis* Meijer
69. *Exormotheca tuberifera* Kashyap
70. *Fossombronia himalayensis* Kashyap
71. *Fossombronia indica* Steph.
72. *Fossombronia japonica* Schiffn.
73. *Fossombronia pusilla* (L.) Dumort.
74. *Fossombronia wondraczekii* (Corda) Dumort. ex Lindb.
75. *Frullania acutiloba Mitt.*
76. *Frullania apiculata* (Reinw., Blume & Nees) Dumort.
77. *Frullania arecae* (Spreng.) Gottsche
78. *Frullania calcarata* Aongstr.
79. *Frullania campanulata* Sande Lac.
80. *Frullania ceylanica* Nees
81. *Frullania debilis* Steph. ex S.Hatt.
82. *Frullania densiloba* Steph. ex A.Evans
83. *Frullania ericoides* (Nees) Mont.
84. *Frullania evoluta* Mitt.
85. *Frullania gaudichaudi* var. *ceylonica*
86. *Frullania gaudichaudii* (Nees & Mont.) Nees & Mont. var. *gaudichaudii*
87. *Frullania inflexa* Mitt.
88. *Frullania muscicola* Steph.
89. *Frullania neurota* Taylor
90. *Frullania nodulosa* (Reinw., Blume & Nees) Nees
91. *Frullania polyptera* Taylor
92. *Frullania ramuligera* (Nees) Mont.
93. *Frullania riojaneirensis* (Raddi) Spruce
94. *Frullania serrata* Gottsche
95. *Frullania squarrosa* (Reinw. et al.) Nees
96. *Frullania tamarisci* (L.) Dumort. subsp. *moniliata* (Reinw., Blume & Nees) Kamim.
97. *Frullania tamarisci* (L.) Dumort. subsp. *obscura* (Verd.) S.Hatt.
98. *Frullanoides tristis* (Steph.) van Slageren
99. *Gongylanthus indicus* S.C.Srivast. & P.K. Verma
100. *Gottschelia schizopleura* (Spruce) Grolle
101. *Herbertus aduncus* (Dicks.) S.F.Gray
102. *Herbertus armitana* (Steph.) H.A. Mill.
103. *Herbertus capensis* (Steph.) Sim.
104. *Herbertus dicranus* (Taylor ex Gottsche, Lindenb. & Nees) Trevis.
105. *Heteroscyphus argutus* (Nees) Schiffn.
106. *Heteroscyphus coalitus* (Hook.) Schiffn.
107. *Heteroscyphus orbiculatus* A.Srivast. & S.C.Srivast.
108. *Heteroscyphus palniensis* A.Srivast. & S.C.Srivast.
109. *Heteroscyphus perfoliatus* (Montin) Schiffn.
110. *Heteroscyphus splendens* (Lehm. & Lindenb.) Grolle
111. *Jackiella ceylanica* Schiffn. ex Steph.
112. *Jackiella javanica* Schiffn. var. *cordifolia* Schiffn.
113. *Jubula hattorii* Udar & V. Nath
114. *Jubula hutchinsiae* (Hook.) Dum. subsp. *javanica* (Steph.) Verd.
115. *Jungermannia appressifolia* Mitt.
116. *Jungermannia macrocarpa* Steph.
117. *Jungermannia obliquifolia* (Schiffn.) Vana
118. *Jungermannia tetragona* Lindenb.
119. *Jungermannia truncata* Nees
120. *Lejeunea cavifolia* (Ehrh.) Lindb.
121. *Lejeunea discreta* Lindenb.
122. *Lejeunea eifrigii* Mizut.
123. *Lejeunea exilis* (Reinw. *et al.*) Grolle
124. *Lejeunea flava* (Sw.) Nees
125. *Lejeunea helenae* (Pears.) Pear.
126. *Lejeunea lowriana* Steph.
127. *Lejeunea neelgherriana* Gottsche
128. *Lejeunea obfusca* Mitt.
129. *Lejeunea pallide-virens* S.Hatt.
130. *Lejeunea perrottetii* Steph.
131. *Lejeunea punctiformis* Taylor

132. *Lejeunea stevensiana* (Steph.) Mizut.
133. *Lejeunea subacuta* Mitt.
134. *Lejeunea subolivacea* Mizut.
135. *Lejeunea tuberculosa* Steph.
136. *Lejeunea wightii* Lindenb.
137. *Lepidozia erosa* Steph.
138. *Lepidozia reptans* (L.) Dumort.
139. *Leptohymenium tenue* (Hook.) Schwaegr.
140. *Leptolejeunea balansae* Steph.
141. *Leptolejeunea elliptica* (Lehm. & Lindenb.) Schiffn.
142. *Leptolejeunea maculata* (Mitt.) Schiffn.
143. *Lethocolea javanica* (Schiffn.) Grolle
144. *Leucolejeunea xanthocarpa* (Lehm. & Lindenb.) A.Evans
145. *Liochleana subulata* (A.Evans) Schljakov
146. *Lopholejeunea abortiva* var. *doliiformis* Awasthi *et al.*
147. *Lopholejeunea indica* Udar & Awasthi
148. *Lopholejeunea javanica* (Nees) Schiff.
149. *Lopholejeunea nigricans* (Lindenb.) Schiffn.
150. *Lopholejeunea sikkimensis* Steph.
151. *Lopholejeunea subfusca* (Nees) Steph.
152. *Lunularia cruciata* (L.) Dumort. ex Lindb.
153. *Mannia foreaui* Udar & V. Chandra
154. *Marchantia emarginata* Reinw., Blume & Nees subsp. *emarginata*
155. *Marchantia kashyapii* Udar & Shaheen
156. *Marchantia linearis* Lehm. & Lindenb.
157. *Marchantia paleaceae* Bertol.
158. *Marchantia palmata* Reinw., Nees & Blume
159. *Marchantia papillata* Raddi subsp. *grossibarba* (Steph.) Bischl.
160. *Marchantia pappeana* Lehm. subsp. *robusta* (Steph.) Bischl.
161. *Marchantia polymorpha* L.
162. *Mastigolejeunea auriculata* (Wilson & Hook.) Schiffn.
163. *Mastigolejeunea auriculata* (Wilson & Hook.) Schiffn. var. *ciliata* (U.S.Awasthi & Udar) A.E.D.Daniels & P.Daniel
164. *Mastigolejeunea humilis* (Gottsche) Schiffn.
165. *Mastigolejeunea indica* Steph.
166. *Mastigolejeunea ligulata* (Lehm. & Lindenb.) Schiffn.
167. *Mastigolejeunea repleta* (Taylor) A.Evans
168. *Metzgeria consanguinea* Schiffn.
169. *Metzgeria crassipilis* (Lindb.) A.Evans
170. *Metzgeria decipiens* (C. Massal.) Schiffn.
171. *Metzgeria furcata* (L.) Corda
172. *Metzgeria lindbergii* Schiffn.
173. *Metzgeria lutescens* Steph.
174. *Metzgeria nilgiriensis* S.C.Srivast. & Udar
175. *Metzgeria raoii* Srivast. & Srivast.
176. *Microlejeunea punctiformis* (Tayl.) Steph.
177. *Microlejeunea ulicina* (Taylor) Steph.
178. *Notoscyphus darjeelingensis* Udar & A.Kumar
179. *Notoscyphus lutescens* (Lehm.) Mitt.
180. *Notoscyphus pandei* Udar & Kumar
181. *Notoscyphus paroicus* Schiffn.
182. *Pallavicinia ambigua* (Mitt.) Steph.
183. *Pallavicinia lyellii* (Hook.) S.Gray.
184. *Pellia epiphylla* (L.) Corda
185. *Plagiochasma appendiculatum* Lehm. & Lindenb.
186. *Plagiochasma cordatum* Lehm. et Lindenb.
187. *Plagiochasma intermedium* Lindenb. & Gottsche
188. *Plagiochasma japonicum* (Steph.) C.Massal.
189. *Plagiochasma microcephalum* (Steph.) Steph.
190. *Plagiochasma pterospermum* C.Massal.
191. *Plagiochasma rupestre* (J.R.Forst. & G. Forst.) Steph.
192. *Plagiochila nepalensis* Lindenb.
193. *Plagiochila arbuscula* (Bridel ex Lehmann & Lindenb.) Lindenb.
194. *Plagiochila asplenioides* subsp. *ovalifolia* (Mitt.) Inoue
195. *Plagiochila beddomei* Steph.
196. *Plagiochila bischleriana* Grolle & M.L.So
197. *Plagiochila chinensis* Steph.
198. *Plagiochila devexa* Steph.
199. *Plagiochila durelii* Schiffn.
200. *Plagiochila elegans* Mitt.
201. *Plagiochila flexuosa* Steph.
202. *Plagiochila frondescens* (Nees) Lindenb.
203. *Plagiochila fruticosa* Mitt.
204. *Plagiochila ghatiensis* Steph.
205. *Plagiochila gracilis* Lindenb. et Gottsche
206. *Plagiochila indica Mitt. ex Steph.*
207. *Plagiochila khasiana* Mitt.
208. *Plagiochila palangiensis* S.C.Srivast., K.K.Rawat & P.K. Verma
209. *Plagiochila parvifolia* Lindenb.
210. *Plagiochila peradenyensis* Schiffn.
211. *Plagiochila pulcherrima* Horik.
212. *Plagiochila sciophila* Nees
213. *Plagiochila semidecurrens* (Lehm. & Lindenb.) Lindenb.
214. *Plagiochila singularis* Schiffner
215. *Plagiochila sisparensis* Steph.
216. *Plagiochila spinulosa* (Dicks.) Dumort.
217. *Plagiochila subtropica* Steph.
218. *Plagiochila wightii* Nees ex Lindenb.
219. *Plagiochila yulongensis* Pippo
220. *Plicanthus birmensis* (Steph.) R.M.Schust.
221. *Porella acutifolia* (Lehm. & Lindenb.) Trevis.
222. *Porella caespitans* (Steph.) Hatt.
223. *Porella campylophylla* (Lehm. & Lindb.) Trevis. subsp. *campylophylla*
224. *Porella campylophylla* (Lehm. & Lindb.) Trevis. subsp. *lancistipula* (Steph.) S.Hatt.
225. *Porella chinensis* (Steph.) S.Hatt. var. *chinensis*
226. *Porella chinensis* (Steph.) S.Hatt. var. *irregularis* (Steph.) S.Hatt.
227. *Porella kashyapii* (R.S.Chopra) Kachroo
228. *Porella madagascariensis* (Nees & Mont.) Trevis.
229. *Porella perrottetiana* (Mont.) Trevis. var. *perrottetiana*
230. *Porella pinnata* (Dick.) Lindb.
231. *Porella plumosa* (Mitt.) Inoue
232. *Ptychanthus striatus* (Lehm. & Lindenb.) Nees
233. *Radula auriculata* Steph.
234. *Radula fulvifolia* (Hook.f. & Taylor) Gottsche, Lindenb. & Nees
235. *Radula grandifolia* Steph.
236. *Radula japonica* Gottsche & Steph.
237. *Radula javanica* Gottsche
238. *Radula kurzii* Steph.
239. *Radula madagascariensis* Gottsche
240. *Radula nilgiriensis* Udar & D.Kumar
241. *Radula obscura* Mitt.
242. *Radula onraedtii* K.Yamada
243. *Radula pandei* Udar & Kumar
244. *Radula perrottetii* Gottsche ex Steph.
245. *Radula tabularis* Steph.
246. *Reboulia hemisphaerica* (L.) Raddi.
247. *Riccardia levieri* Schiffn.
248. *Riccardia multifida* (L.) S.Gray
249. *Riccardia perssonii* S.C.Srivast. & Udar
250. *Riccardia santapaui* Udar & S.C.Srivast.
251. *Riccardia tenuicostata* Schiffn.
252. *Riccia billardieri* Mont. & Nees ex Gottsche, Lindenb. & Nees
253. *Riccia coracina* Jovet-Ast
254. *Riccia crozalsii* Levier
255. *Riccia crystallina* L.
256. *Riccia discolor* Lehm. & Lindenb.
257. *Riccia fluitans* L.
258. *Riccia frostii* Austin
259. *Riccia gangetica* Ahmad
260. *Riccia grollei* Udar
261. *Riccia huebeneriana* Lindenb.
262. *Riccia melanospora* Kashyap
263. *Riccia poihaiana* A.E.D.Daniels & P.Daniel
264. *Riccia sorocarpa* Bisch.
265. *Riccia stricta* (Gottsche, Lindenb. & Nees) Perold
266. *Riccia velimalaiana* A.E.D.Daniels & P.Daniel
267. *Riccia warnstorfii* Limpr.
268. *Ricciocarpus natans* (L.) Corda
269. *Schiffneriolejeunea polycarpa* (Nees) Gradst.

270. *Schiffneriolejeunea pulopenangensis* (Gott.) Gradst.
271. *Schistochila aligera* (Nees & Blume) Jack & Steph.
272. *Solenostoma nilgiriensis* (A.Alam, A.Kumar & S.C.Srivast.) Váňa & D.G.Long
273. *Solenostoma tetragonum* (Lindenb.) R.M.Schust.
274. *Solenostoma truncatum* (Nees) R.M.Schust.
275. *Spruceanthus polymorphus* (Sande- Lac.) Verd.
276. *Spruceanthus semirepandus* (Nees) Verd.
277. *Targionia hypophylla* L.
278. *Targionia indica* Udar & A.Gupta
279. *Targionia lorbeeriana* K.Müll.
280. *Taxilejeunea parvistipula* Steph.
281. *Telaranea indica* (S.C.Srivast. & P.K. Verma) A.E.D.Daniels & P.Daniel
282. *Trichocolea tomentella* (Ehrh.) Dumort.
283. *Trichocolea udarii* D.K.Singh
284. *Trocholejeunea sandvicensis* (Gottsche) Mizut.

ANTHOCEROTOPHYTA (Hornworts)

1. *Anthoceros angustus* Steph.
2. *Anthoceros bharadwajii* Udar & A.K.Asthana
3. *Anthoceros crispulus* (Montin) Douin
4. *Anthoceros erectus* Kashyap
5. *Anthoceros macrosporus* Steph.
6. *Anthoceros subtilis* Steph.
7. *Folioceros mangaloreus* (Steph.) D.C.Bharadwaj
8. *Folioceros pandei* Udar & Shaheen
9. *Folioceros spinisporus* (Steph.) Bharadwaj
10. *Folioceros udarii* A.K.Asthana & S.C.Srivast.
11. *Notothylas dissecta* Steph.
12. *Notothylas indica* Kashyap
13. *Notothylas levieri* Schiffn. ex Steph.
14. *Phaeoceros laevis* (L.) Prosk. subsp. *laevis*
15. *Phaeoceros laevis* subsp. *Carolinianus*

BRYOPHYTA (Mosses)

1. *Acanthorrhynchium papillatum* (Harv.) M.Fleisch.
2. *Acroporium hermaphroditum* (Müll.Hal.) M.Fleisch.
3. *Aerobryidium aureonitens* (Hook. ex Schwägr.) Broth.
4. *Aerobryidium filamentosum* (Hook.) M.Fleisch.
5. *Aerobryopsis longissima* (Dozy & Molk.) M.Fleisch.
6. *Aerobryopsis membranacea* (Mitt.) Broth.
7. *Aerobryum speciosum* (Dozy. & Molk.) Dozy. & Molk.
8. *Amphidium gangulii* Nair *et al.*
9. *Anacamptodon validinervis* Dixon & P.de la Varde
10. *Anoectangium aestivum* (Hedw.) Mitt.
11. *Anoectangium bicolor* Ren. & Cardot
12. *Anoectangium stracheyanum* Mitt.
13. *Anoectangium stracheyanum* Mitt.
14. *Anoectangium thomsonii* Mitt.
15. *Anomobryum auratum* (Mitt.) A.Jaeger
16. *Anomobryum filiforme* var. *concinatum* (Spruc.) Amann.
17. *Anomobryum julaceum* (Schrad. ex P.Gaertn., B.Mey. & Scherb.) Schimp.
18. *Anomobryum schmidii* (Müll.Hal.) A.Jaeger
19. *Anomobryum subnitidum* Cardot & P.de la Varde
20. *Aptychella delicata* (M.Fleisch.) M.Fleisch.
21. *Aptychella tenuiramea* (Mitt.) Tixier
22. *Archidium birmannicum* Mitt. ex Dixon
23. *Archidium microthecium* Dixon & P.de la Varde
24. *Archidium ohioense* Schimp. ex Müll.Hal.
25. *Atrichum aculeatum* Cardot & P. Varde
26. *Atrichum flavisetum* Mitt.
27. *Atrichum longifolium* Cardot & Dixon ex Gangulee
28. *Atrichum obtusulum* (C.Mueller) A.Jaeger
29. *Atrichum pallidum* Renauld & Cardot
30. *Atrichum subserratum* (Harv. & Hook.f.) Mitt.
31. *Atrichum undulatum* (Hedw.) P. Beauv. var. *subserratum* (Hook.) Par.
32. *Barbella convolvens* (Mitt.) Broth.
33. *Barbella cubensis* (Mitt.) Broth.
34. *Barbella determesii* (Renauld & Cardot) M.Fleisch.
35. *Barbella enervis* (Thwaites & Mitt.) M.Fleisch.
36. *Barbella flagellifera* (Cardot) Nog.
37. *Barbella pendula* (Sull.) M.Fleisch.
38. *Barbella spiculata* (Mitt.) Broth.
39. *Barbella tenax* (Müll.Hal.) Broth.
40. *Barbellopsis trichophora* (Mont.) W.R.Buck
41. *Barbula arcuata* Griff.
42. *Barbula consanguinea* (Thwaites & Mitt.) A.Jaeger
43. *Barbula dharvarensis* Dixon
44. *Barbula indica* (Hook.) Spreng.
45. *Barbula javanica* Dozy & Molk.
46. *Barbula tenuirostris* Brid.
47. *Barbula vardei* R.S.Chopra
48. *Bartramia brevifolia* Brid. subsp. *brevifolia*
49. *Bartramia heterophylla* (Mitt.) C.Mueller
50. *Bartramia leptocarpa* (Mitt.) C.Mueller
51. *Bartramia madurensis* Dixon & P.de la Varde
52. *Bartramia subulata* Bruch & Schimp.
53. *Bartramidula bartramioides* (Griff.) Wijk & Margad.
54. *Bartramidula dispersa* Cardot & Potier de la Varde
55. *Bartramidula roylei* (Hook.f.) Bruch & Schimp.
56. *Bellibarbula recurva* (Griff.) R.H.Zander
57. *Brachymenium acuminatum* Harv.
58. *Brachymenium bryoides* Hook. ex Schwägr.
59. *Brachymenium capitulatum* (Mitt.) Paris
60. *Brachymenium exile* (Dozy & Molk.) Bosch & Sande Lac.
61. *Brachymenium fischeri* Cardot & Dixon
62. *Brachymenium leptophyllum* (Bruch & Schimp. ex Müll.Hal.) Bruch & Schimp.
63. *Brachymenium leptostomoides* (Müll.Hal.) A.Jaeger
64. *Brachymenium longicolle* Ther.
65. *Brachymenium nepalense* Hook.
66. *Brachymenium nepalense* Hook.
67. *Brachymenium ochianum* Gangulee
68. *Brachymenium pendulum* Mont.
69. *Brachymenium pulchrum* Hook.
70. *Brachymenium scabridens* (Mitt.) Broth.
71. *Brachymenium systylium* (Müll.Hal.) A.Jaeger
72. *Brachymenium walkeri* Broth.
73. *Brachythecium buchananii* (Hook.) A.Jaeger
74. *Brachythecium nitidissimum* Dixon & P.de la Varde
75. *Brachythecium procumbens* (Mitt.) A.Jaeger
76. *Brachythecium rutabulum* (Hedw.) Schimp.
77. *Brachythecium salebrosum* (Hoffm. ex F.Weber & D.Mohr) Schimp.
78. *Braunia secunda* (Hook.) Bruch & Schimp.
79. *Breutelia dicranacea* (Müll.Hal.) Mitt.
80. *Breutelia microdonta* (Mitt.) Broth.
81. *Brothera leana* (Sull.) Müll.Hal.
82. *Brotherella curvirostris* (Schwaegr.) M. Fleisch.
83. *Bryhnia decurvans* (Mitt.) Dixon
84. *Bryhnia nepalensis* Takaki
85. *Bryocrumia vivicolor* (Broth. & Dixon) W.R.Buck
86. *Bryoerythrophyllum inaequalifolium* (Taylor) R.H.Zander
87. *Bryoerythrophyllum wallichii* (Mitt.) P.C.Chen
88. *Bryosedgewickia densa* (Hook.) Biz. & P.Vard.
89. *Bryum alpinum* Huds. ex With.
90. *Bryum apalodictyoides* C.Mueller
91. *Bryum apiculatum* Schwägr.
92. *Bryum argenteum* Hedw. var. *argenteum*
93. *Bryum argenteum* Hedw.var. *australe* Rehmann ex Dixon
94. *Bryum argenteum* var. *lanatum* (P. Beauv.) Hampe.
95. *Bryum badhwarii* Ochi
96. *Bryum bicolor* Dicks
97. *Bryum billardierei* Schwägr.
98. *Bryum capillare* Hedw.
99. *Bryum cellulare* Hook.

100. *Bryum coronatum* Schwägr.
101. *Bryum junghuhnianum* Hampe ex Dozy & Molk.
102. *Bryum lamprostegum* Müll.Hal.
103. *Bryum neelgheriense* Mont.
104. *Bryum pachycladum* Cardot ex P.de la Varde
105. *Bryum paradoxum* Schwägr.
106. *Bryum plumosum* Dozy. & Molk.
107. *Bryum porphyroneuron* var. *erythrinum* (Mitt.) M.Fleisch.
108. *Bryum pseudotriquetrum* (Hedw.) Schwaegr.
109. *Bryum retusifolium* Cardot & P.de la Varde
110. *Bryum rugosum* C.Mueller
111. *Bryum salakense* Cardot
112. *Bryum tuberosum* Mohamed & Damanhuri.
113. *Bryum uliginosum* (Brid.) Bruch & Schimp.
114. *Bryum vellei* var. *robustum* Dixon & P. Varde
115. *Bryum wightii* Mitt.
116. *Callicostella papillata* (Mont.) Mitt.
117. *Calymperes afzelii* Sw.
118. *Calymperes erosum* C.Mueller
119. *Calymperes graeffeanum* Müll.Hal.
120. *Calymperes hampei* Dozy & Molk.
121. *Calymperes lonchophyllum* Schwaegr.
122. *Calymperes motleyi* Mitt. ex Dozy & Molk.
123. *Calymperes punctulatum* Hampe
124. *Calymperes sundarbanense* Gangulee
125. *Calymperes tenerum* Müll.Hal. var *tenerum*
126. *Calymperes tenerum* Müll.Hal. var. *teniolata* Gangulee
127. *Calyptothecium auriculatum* (Dixon) Nog.
128. *Calyptothecium hookeri* (Mitt.) Broth.
129. *Calyptothecium oxyphyllum* Dixon & P.de la Varde
130. *Calyptothecium recurvulum* (Broth.) Broth.
131. *Calyptothecium symphysodontoides* Dixon & P.de la Varde
132. *Calyptothecium wightii* (Mitt.) M.Fleisch.
133. *Campylodontium flavescens* (Hook.) Bosch & Sande Lac.
134. *Campylodontium perplicatum* (Ther. & P. de la Varde) Broth.
135. *Campylopodium griffithii* (Mitt.) Broth.
136. *Campylopodium khasianum* (Griff.) Par.
137. *Campylopodium phascoides* (Müll.Hal.) Paris
138. *Campylopus andreanus* Cardot & P.de la Varde
139. *Campylopus atrovirens* De Not.
140. *Campylopus aureus* Bosch & Lac.
141. *Campylopus comosus* (Schwägr.) Bosch & Sande Lac.
142. *Campylopus eberhartdii* Paris
143. *Campylopus ericoides* (Griff.) A.Jaeger
144. *Campylopus erythrognaphalus* (C.Mueller) A. Jaeger
145. *Campylopus flagellifer* (Müll.Hal.) A.Jaeger
146. *Campylopus flexuosus* (Hedw.) Brid.
147. *Campylopus gracilis* (Mitt.) A.Jaeger
148. *Campylopus involutus* (Müll. Hal.) A. Jaeger
149. *Campylopus laetus* (Mitt.) A.Jaeger var. *madurensis* Thér. & P.de la Varde
150. *Campylopus nivalis* (Brid.) Brid.var. *nivalis*
151. *Campylopus pilifer* Brid.
152. *Campylopus recurvus* (Mitt.) A.Jaeger
153. *Campylopus richardii* Brid.
154. *Campylopus savannarum* (Müll.Hal.) Mitt.
155. *Campylopus schimperi* J.Milde
156. *Campylopus schmidii* (C.Mueller) A. Jaeger
157. *Campylopus sinensis* (Müll.Hal.) J.-P.Frahm
158. *Campylopus subfragilis* Ren. & Cardot
159. *Campylopus umbellatus* (Schwägr. & Gaudich. ex Arn.) Paris
160. *Campylopus zollingerianus* (Müll.Hal.) Bosch & Sande Lac.
161. *Ceratodon purpureus* (Hedw.) Brid. var. *purpureus*
162. *Ceratodon purpureus* (Hedw.) Brid. var. *stenocarpus* (Bruch & Schimp.) Dixon
163. *Chaetomitriopsis glaucocarpa* (Schwaegr.) M.Fleisch.
164. *Chameleion peguense* (Besch.) L.T. Ellis & A. Eddy
165. *Chionoloma bombayense* (Müll.Hal.) P.Sollman
166. *Chionostomum rostratum* (Griff.) C.Mueller
167. *Chrysocladium retrorsum* (Mitt.) M.Fleisch.
168. *Claopodium nervosum* (Harv.) M.Fleisch.
169. *Claopodium assurgens* (Sull. & Lesq.) Cardot
170. *Claopodium pellucinerve* (Mitt.) Best
171. *Claopodium prionophyllum* (C.Mueller) Broth.
172. *Clastobryum indicum* (Dozy & Molk.) Dozy & Molk.
173. *Clastobryum patentifolium* Dixon & P. Varde
174. *Codonoblepharon pungens* (Müll.Hal.) A.Jaeger
175. *Cryptoleptodon pluvinii* (Brid.) Broth.
176. *Cryptopapillaria chrysoclada* (C.Mueller) M. Menzel
177. *Cryptopapillaria feae* (C.Mueller ex M.Fleisch.) M. Menzel
178. *Cryptopapillaria fuscescens* (Hook.) A.Jaeger
179. *Ctenidium lychnites* (Mitt.) Broth.
180. *Cyathophorella adiantum* (Griff.) M.Fleisch.
181. *Diaphanodon blandus* (Harv.) Ren. & Cardot
182. *Diaphanodon procumbens* (C.Mueller) Ren. & Cardot
183. *Dicranella amplexans* (Mitt.) A. Jaeger
184. *Dicranella divaricata* (Mitt.) A. Jaeger
185. *Dicranella heteromalla* (Hedw.) Schimp.
186. *Dicranella stricticaulis* Cardot & P.de la Varde
187. *Dicranodontium denudatum* (Brid.) E.Britton
188. *Dicranodontium uncinatum* (Harv.) A.Jaeger
189. *Dicranolejeunea gilva* Steph.
190. *Dicranoloma brevisetum* (Dozy & Molk.) Paris
191. *Dicranoloma subreflexifolium* (C.Mueller) Paris
192. *Dicranum dilatinerve* Cardot & P. Varde
193. *Dicranum psathyrum* Klazenga
194. *Didymodon constrictus* (Mitt.) K. Saito
195. *Didymodon fallax* Hedw.
196. *Didymodon rigidulus* Hedw.
197. *Didymodon rufescens* (Mitt.) Broth.
198. *Diphyscium fasciculatum* Mitt.
199. *Diphyscium involutum* Mitt.
200. *Diphyscium mucronifolium* Mitt.
201. *Distichium capillaceum* (Hedw.) Bruch & Schimp.
202. *Distichophyllum mniifolium* (Hornsch.) Sim
203. *Distichophyllum montagneanum* (C.Mueller) Bosch & Sande-Lac.
204. *Distichophyllum schmidtii* Broth.
205. *Distichophyllum succulentum* (Mitt.) Broth.
206. *Ditrichum amoenum* (Thwaites & Mitt.) Paris
207. *Ditrichum apophysatum* Hamp. & Gangulee
208. *Ditrichum darjeelingense* Ren. & Cardot
209. *Ditrichum difficile* (Duby) M. Fleisch.
210. *Ditrichum tortipes* (Mitt.) Kuntze var. *strictum* Dixon & P.de la Varde
211. *Ditrichum tortipes* (Mitt.) Kuntze var. *tortipes*
212. *Dryptodon fuscoluteus* (Hook.) Ochyra & Żarnowiec
213. *Dryptodon indicus* (Dixon & P.de la Varde) Ochyra & Żarnowiec
214. *Duthiella declinata* (Mitt.) Zant.
215. *Duthiella wallichii* (Mitt.) C.Mueller
216. *Ectropothecium andrei* Cardot & P.de la Varde
217. *Ectropothecium buitenzorgii* (Bel.) Mitt.
218. *Ectropothecium chamissonis* (Hornsch.) A.Jaeger
219. *Ectropothecium compressifolium* (Mitt.) A.Jaeger
220. *Ectropothecium cyperoides* (Hook. ex Harv.) A.Jaeger
221. *Ectropothecium dealbatum* (Reinw. & Hornsch.) A. Jaeger
222. *Ectropothecium densum* Dixon & P.de la Varde
223. *Ectropothecium drepanocladioides* Broth. & P.de la Varde
224. *Ectropothecium laevigatum* Thwaites & Mitt.
225. *Ectropothecium sikkimense* (Ren. & Cardot) Ren. & Cardot
226. *Ectropothecium zollingeri* (Müll.Hal.) A.Jaeger
227. *Entodon chloropus* Renauld & Cardot
228. *Entodon flavescens* (Hook.) A.Jaeger
229. *Entodon macropodus* (Hedw.) C.Mueller
230. *Entodon myurus* (Hook.) Hampe
231. *Entodon obtusatus* Broth.
232. *Entodon plicatus* C.Mueller
233. *Entodon rubicundus* (Hook.) A.Jaeger & Sauerb.
234. *Entodontopsis nitens* (Mitt.) W.R. Buck
235. *Entodontopsis wightii* (Mitt.) W.R.Buck & Ireland
236. *Entosthodon buseanus* Dozy & Molk.
237. *Entosthodon diversinervis* Müll.Hal.
238. *Entosthodon perrottetii* (Podp.) Müll.Hal.

239. *Entosthodon physcomitrioides* (Mont.) Mitt.
240. *Entosthodon pilifer* Mitt.
241. *Entosthodon planifolius* Thwaites & Mitt.
242. *Entosthodon submarginatus* Müll.Hal.
243. *Entosthodon wichurae* M.Fleisch.
244. *Erpodium mangiferae* Müll.Hal.
245. *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris
246. *Eurhynchium riparioides* (Hedw.) Jennings
247. *Eurhynchium swartzii* (Turner) Curn.
248. *Eurhynchium vagans* (A.Jaeger) E.B.Bartram
249. *Exostratum blumii* (Nees ex Hampe) L.T.Ellis
250. *Fabronia assamica* Dixon
251. *Fabronia goughii* Mont.
252. *Fabronia madurensis* Dixon & P.de la Varde
253. *Fabronia minuta* Mitt.
254. *Fabronia pusilla* Raddi
255. *Fabronia schensiana* C.Mueller
256. *Fabronia schmidii* Müll.Hal.
257. *Fabronia secunda* Mont.
258. *Fissidens amplifolius* Dixon & P.de la Varde
259. *Fissidens angustiusculus* Dixon & P.de la Varde
260. *Fissidens anomalus* Mont.
261. *Fissidens asperisetus* Sande-Lac. var. *andamanensis* Gangulee
262. *Fissidens asplenioides* Hedw.
263. *Fissidens beckettii* Mitt.
264. *Fissidens bryoides* Hedw. var. *bryoides*
265. *Fissidens ceylonensis* Dozy & Molk. var. *acutifolius* Dixon & P.de la Varde
266. *Fissidens ceylonensis* Dozy & Molk. var. *ceylonensis*
267. *Fissidens crenulatus* Mitt. var. *crenulatus*
268. *Fissidens crispulus* Brid. var. *crispulus*
269. *Fissidens crispulus* Brid. var. *robinsonii* (Broth.) Z.Iwats. & Z.H.Li
270. *Fissidens curvatoinvolutus* Dixon
271. *Fissidens curvatus* Hornsch.
272. *Fissidens diversifolius* Mitt.
273. *Fissidens dubius* P.Beauv.
274. *Fissidens excedens* Broth.
275. *Fissidens firmus* Mitt.
276. *Fissidens flaccidus* Mitt.
277. *Fissidens ganguleei* Nork.
278. *Fissidens gardneri* Mitt.
279. *Fissidens grandifrons* Brid.
280. *Fissidens griffithii* Gangulee
281. *Fissidens hollianus* Dozy & Molk.
282. *Fissidens hyalinus* Hook. & Wilson
283. *Fissidens incognitus* Gangulee
284. *Fissidens involutus* subsp. *curvatoinvolutus* (Dixon) Gangulee
285. *Fissidens jungermannioides* Griff.
286. *Fissidens kalimpongensis* Gangulee
287. *Fissidens kammadensis* Manju *et al.*
288. *Fissidens karwarensis* Dixon
289. *Fissidens kurzii* C.Mueller
290. *Fissidens longtonianus* Z. Iwats. & Tad. Suzuki
291. *Fissidens lutescens* Broth.
292. *Fissidens macrosporoides* Dixon & P.de la Varde
293. *Fissidens microdictyon* Dixon & P.de la Varde
294. *Fissidens mittenii* Par.
295. *Fissidens orishae* Gangulee
296. *Fissidens pellucidus* Hornsch.
297. *Fissidens perumalensis* Dixon & P.de la Varde
298. *Fissidens pulchellus* Mitt.
299. *Fissidens schmidii* C.Mueller
300. *Fissidens serratus* Müll.Hal.var. *serratus*
301. *Fissidens subangustus* M.Fleisch.
302. *Fissidens subbryoides* Gangulee
303. *Fissidens subpulchellus* Nork.
304. *Fissidens teraicola* Müll.Hal.
305. *Fissidens virens* Thwait. & Mitt.
306. *Fissidens walkeri* Broth. var. *elimbatus* (Broth.) Dixon
307. *Fissidens walkeri* Broth. var. *walkeri*
308. *Fissidens zollingeri* Mont.
309. *Floribundaria chrysonema* (C.Mueller) Broth.
310. *Floribundaria floribunda* (Dozy & Molk.) M.Fleisch.
311. *Floribundaria thuidioides* M.Fleisch.
312. *Floribundaria walkeri* (Ren. & Cardot) Broth.
313. *Foreauella orthothecia* (Schwaegr.) Dixon & Vard.
314. *Forsstroemia indica* (Mont.) Paris
315. *Funaria excurrentinervis* Cardot & P.de la Varde
316. *Funaria hygrometrica* Hedw. var. *calvescens* (Schwaegr.) Mont.
317. *Funaria hygrometrica* Hedw. var. *hygrometrica*
318. *Funaria perrottetii* (Podp.) Broth.
319. *Funaria pulchra* Dixon & P.de la Varde
320. *Funaria sinuatolimbata* Cardot & P.de la Varde
321. *Funaria subimmarginata* Cardot & P.de la Varde
322. *Garckea flexuosa* (Griff.) Margad. & Nork.
323. *Garowaglia plicata* (Brid.) Bosch. & Sande-Lac.
324. *Gemmabryum acuminatum* (Harv.) J.R. Spence & H.P. Ramsay
325. *Glossadelphus anisopterus* (Cardot & P.de la Varde) Broth.
326. *Glossadelphus ivoreanus* (Mitt.) M.Fleisch.
327. *Grimmia funalis* (Schwägr.) Bruch & Schimp.
328. *Grimmia longirostris* Hook.
329. *Groutiella goniorrhyncha* (Dozy & Molk.) E.B.Bartram.
330. *Groutiella tomentosa* (Hornsch.) Wijk & Margad.
331. *Gymnostomiella vernicosa* (Hook. ex Harv.) M.Fleisch. var. *vernicosa*
332. *Gymnostomiella vernicosa (*Hook.) M.Fleisch. var. *tenerum* (C.Mueller ex Dusen) Arts
333. *Handeliobryum setschwanicum* Broth.
334. *Haplocladium microphyllum* (Hedw.) Broth. subsp. *virginianum* (Brid.) Reimers
335. *Haplocladium vestitum* Dixon & P. Varde
336. *Hedwigidium integrifolium* (P.Beauv.) Dixon
337. *Herpetineuron toccoae* (Sull. & Lesq.) Cardot
338. *Himantocladium cyclophyllum* (Müll. Hal.) M.Fleisch.
339. *Himantocladium flagelliferum* (Broth.) Broth.
340. *Himantocladium loriforme* (Bosch & Sande- Lac.) M.Fleisch.
341. *Himantocladium plumula* (Nees) M.Fleisch.
342. *Himantocladium rugulosum* (Mitt.) M. Fleisch.
343. *Holomitrium densifolium* (Wilson) Wijk. & Margad.
344. *Homalia trichomanoides* (Hedw.) Schimp.
345. *Homaliadelphus targionianus* (Mitt.) Dixon & P.de la Varde
346. *Homaliodendron exiguum* (Bosch. & Sande-Lac.) M.Fleisch.
347. *Homaliodendron flabellatum* (Sm.) M.Fleisch.
348. *Homaliodendron microdendron* (Mont.) M.Fleisch.
349. *Homaliodendron montagneanum* (Müll.Hal.) M.Fleisch.
350. *Homaliodendron obtusatum* (Mitt.) Gangulee
351. *Homalothecium sericeum* (Hedw.) Schimp.
352. *Hookeria acutifolia* Hook. & Grev.
353. *Hydrogonium consanguineum* (Thwait. & Mitt.) Hilp.
354. *Hymenostomum edentulum* (Mitt.) Besch.
355. *Hymenostylium recurvirostrum* (Hedw.) Dixon var. *aurantiacum* (Mitt.) Gangulee.
356. *Hymenostylium recurvirostrum* (Hedw.) Dixon var. *recurvirostrum*
357. *Hymenostylium validinerve* Dixon & P. Varde
358. *Hyophila comosa* Dixon
359. *Hyophila grandiretis* Dixon & P.de la Varde
360. *Hyophila involuta* (Hook.) A.Jaeger.
361. *Hyophila mollifolia* Dixon & P.de la Varde
362. *Hyophila nymaniana* (M.Fleisch.) M.Menzel
363. *Hyophila rosea* R.S. Williams
364. *Hyophila spathulata* (Harv.) A.Jaeger
365. *Hyophila validinervis* Cardot & P.de la Varde
366. *Hyophila viridula* Cardot & P.de la Varde
367. *Hypnum cuppressiforme* ssp. *imponens* (Hedw.) Boulay
368. *Hypnum plumaeforme* Wilson
369. *Hypnum sikkimense* Ando
370. *Hypnum subimponents* subsp. *ulophyllum* (C.Mueller) Ando
371. *Hypopterigium aristatum* Bosche & Sande-Lac.
372. *Hypopterygium flavolimbatum* Müll.Hal.
373. *Hypopterygium tamarisci* (Sw.) Brid. & C.Mueller

374. *Isopterygium albescens* (Hook.) A.Jaeger
375. *Isopterygium andamanicum* Gangulee
376. *Isopterygium elegans* (Brid.) Lindb.
377. *Isopterygium lignicola* (Mitt.) A.Jaeger
378. *Isopterygium pohliaecarpum* (Sull. & Lesq.) A. Jaeger
379. *Isopterygium serrulatum* M.Fleisch.
380. *Isopterygium undulatum* Dixon & P.de la Varde
381. *Jaegerina stolonifera* Müll.Hal. var. *incrassata* P.de la Varde
382. *Juratzkaea indica* Broth. & P.de la Varde
383. *Lepidopilidium furcatum* (Thwaites & Mitt.) Broth.
384. *Leptophascum leptophyllum* (Müll.Hal.) J.Guerra & M.J.Cano
385. *Leptotrichella denticulata* (Cardot & P.de la Varde) Ochyra
386. *Leptotrichella schmidii* (Müll.Hal.) Ochyra
387. *Leskea consanguinea* (Mont.) Mitt.
388. *Leskea perstricta* Dixon
389. *Leucobryum aduncum* Dozy & Molk.
390. *Leucobryum bowringii* Mitt.
391. *Leucobryum candidum* (Brid. ex P.Beauv.) Wilson.
392. *Leucobryum cucullifolium* Cardot
393. *Leucobryum humillimum* Cardot
394. *Leucobryum javense* (Brid.) Mitt.
395. *Leucobryum juniperoideum* (Brid.) C.Mueller
396. *Leucobryum mitteni* Besch.
397. *Leucobryum nilghiriense* C.Mueller
398. *Leucobryum wightii* Mitt.
399. *Leucodon secundus* (Harv.) Mitt.
400. *Leucoloma amblyacron* Müll.Hal. ex Besch.
401. *Leucoloma amoene-virens* Mitt.
402. *Leucoloma insigne* (Müll.Hal.) A.Jaeger
403. *Leucoloma malabarense* Besch. ex Ren. & Cardot
404. *Leucoloma molle* (Müll.Hal.) Mitt.
405. *Leucoloma nitens* (Thwaites & Mitt.) A.Jaeger
406. *Leucoloma taylorii* (Schwägr.) Mitt.
407. *Leucoloma tenerum* Mitt.
408. *Leucomium strumosum* (Hornsch.) Mitt.
409. *Leucophanes glaucum* (Schwägr.) Mitt.
410. *Leucophanes octoblepharioides* Brid.
411. *Levierella neckeroides* (Griff.) O'Shea & Matcham
412. *Lindbergia koelzii* R.S.Williams
413. *Lopidium struthiopteris* (Brid.) M.Fleisch.
414. *Macgregorella indica* (Broth.) W.R.Buck
415. *Macrocoma tenuis* (Hook. & Grev.) Vitt subsp. *sullivantii* (Müll.Hal.) Vitt
416. *Macromitrium bistratosum* E.B. Bartram
417. *Macromitrium calymperoideum* Mitt.
418. *Macromitrium hamatum* Dixon
419. *Macromitrium incurvifolium* (Hook. & Grev.) Schwägr.
420. *Macromitrium japonicum* Dozy & Molk.
421. *Macromitrium lingulatum* Cardot & P.de la Varde
422. *Macromitrium moorcroftii* (Hook. & Grev.) Schwaegr.
423. *Macromitrium muellerianum* Mitt.
424. *Macromitrium nepalense* (Hook. & Grev.) Schwaegr.
425. *Macromitrium perrottetii* C.Mueller
426. *Macromitrium polygonostomum* Dixon & P.de la Varde
427. *Macromitrium schmidii* Müll.Hal.
428. *Macromitrium serpens* (Bruch ex Hook. & Grev.) Brid.
429. *Macromitrium sulcatum* (Hook.) Brid.
430. *Macromitrium tenerum* Kurz
431. *Macromitrium turgidum* Dixon
432. *Macrothamniella pilosula* (Mitt.) M.Fleisch.
433. *Macrothamnium macrocarpum* (Reinw. & Hornsch.) M.Fleisch.
434. *Mesonodon flavescens* (Hook.) W.R.Buck
435. *Meteoriopsis formosana* Nog.
436. *Meteoriopsis reclinata* (C.Mueller) M.Fleisch.
437. *Meteoriopsis squarrosa* (Hook. ex Harv.) M.Fleisch.
438. *Meteoriopsis squarrosa* var. *longicuspis* Nog.
439. *Meteorium buchananii* (Brid.) Broth.
440. *Meteorium helminthocladum* (C.Mueller) M.Fleisch.
441. *Meteorium humile* (Lindb.) Mitt.
442. *Meteorium polytrichum* Dozy & Molk.
443. *Meteorium subpolytrichum* (Besch.) Broth. subsp. *subpolytrichum*
444. *Microcampylopus khasianus* (Griff.) Giese & J.-P.Frahm
445. *Microdus assamicus* Dix.
446. *Mielichhoferia schmidii* Müll.Hal.
447. *Mittenothamnium reptans* (Hedw.) Cardot
448. *Mnium rostratum* Schrad.
449. *Myurium acuminatum* (Dixon & P.de la Varde) S.He & Snider
450. *Nanothecium foreaui* Dixon & P.de la Varde
451. *Neckera aequalifolia* Müll.Hal.
452. *Neckera andrei* Thér. & P.de la Varde
453. *Neckera goughiana* Mitt.
454. *Neckera himalayana* Mitt.
455. *Neckera pennata* Hedw. var. *pennata*
456. *Neckera pennata* Hedw. var. *rhytidiodonta* Dixon & P.de la Varde
457. *Neckera semicrispa* Cardot & P.de la Varde
458. *Neckeropsis andamana* (C.Mueller) M.Fleisch.
459. *Neckeropsis exserta* (Hook. ex Schwägr.) Broth.
460. *Neckeropsis fimbriata* (Harv.) M.Fleisch.
461. *Neckeropsis lepineana* (Mont.) M. Fleisch.
462. *Neobarbella comes* (Griff.) Nog.
463. *Neodicladiella pendula* (Sull.) Buck
464. *Noguchiodendron sphaerocarpum* (Nog.) Ninh & Pócs
465. *Octoblepharum albidum* Hedw.
466. *Oedicladium rufescens* (Reinw. & Hornsch.) Mitt.
467. *Oreoweisia laxifolia* (Hook.f.) Kindb.
468. *Orthotrichum firmum* Venturi
469. *Oxyrrhnchium vagans* (A.Jaeger) Ignatov & Huttenen
470. *Oxyrrhynchium muelleri* (A.Jaeger) Broth.
471. *Oxyrrhynchium ovatum* Cardot & P.de la Varde
472. *Oxyrrhynchium schleicheri* (R.Hedw.) Roll.
473. *Oxystegus cylindricus* (Bruch ex Brid.) Hilp.
474. *Oxystegus indicus* (Dixon & P. de la Varde) Hilp.
475. *Palamocladium leskeoides* (Hook.) E.Britton
476. *Papillaria crocea* (Hampe) A.Jaeger
477. *Papillaria fuscescens* (Hook.) A. Jaeger
478. *Papillaria leuconeura* (Müll.Hal.) A.Jaeger
479. *Pelekium bifarium* (Bosch & Sande- Lac.) M. Fleisch.
480. *Pelekium contortulum* (Mitt.) Touw
481. *Pelekium fuscatum* (Besch.) Touw
482. *Pelekium gratum* (P.Beauv.) Touw
483. *Pelekium investe* (Mitt.) Touw
484. *Pelekium velatum* Mitt.
485. *Pelekium versicolor* (Hornsch. ex Müll.Hal.) Touw
486. *Penzigiella cordata* (Hook. ex Harv.) M.Fleisch.
487. *Philonotis angusta* Mitt.
488. *Philonotis anisoclada* Cardot & P. Varde
489. *Philonotis dispersa* (Cardot & P. de la Varde) D.G. Griffin & W.R. Buck
490. *Philonotis falcata* (Hook.) Mitt.
491. *Philonotis fontana* (Hedw.) Brid.
492. *Philonotis hastata* (Duby) Wijk & Margad.
493. *Philonotis macrocarpa* (Müll.Hal) Mitt.
494. *Philonotis mollis* (Dozy & Molk.) Mitt.
495. *Philonotis rigida* Brid.
496. *Philonotis secunda* (Dozy & Molk.) Bosch & Sande- Lac.
497. *Philonotis seriata* Mitt.
498. *Philonotis subrigida* Cardot & P.de la Varde
499. *Philonotis thwaitesii* Mitt.
500. *Philonotis tomentella* Molendo
501. *Philonotis turneriana* (Schwägr.) Mitt.
502. *Phyllodon scutellifolius* (Besch.) W.R.Buck
503. *Physcomitrium coorgense* Broth.
504. *Physcomitrium eurystomum* Sendtn.
505. *Physcomitrium insigne* Dixon & P.de la Varde
506. *Physcomitrium repandum* (Griff.) Mitt.
507. *Pilotrichopsis ferruginea* (Mitt.) Broth.
508. *Pinnatella alopecuroides* (Mitt.) M.Fleisch.
509. *Pinnatella calcutensis* M.Fleisch.
510. *Pinnatella foreauana* Thér. & P.de la Varde
511. *Pinnatella minuta* (Mitt.) Broth.

512. *Plagiobryum cellulare* (Hook.) J.R.Spence & H.P.Ramsay
513. *Plagiomnium maximoviczii* (Lindb.) T.J.Kop.
514. *Plagiomnium rhynchophorum* (Harv.) T.J.Kop.
515. *Plagiomnium succulentum* (Mitt.) T.J.Kop.
516. *Plagiothecium neckeroideum* Schimp. var. *madurense* Dixon & P.de la Varde
517. *Plagiothecium neckeroideum* Schimp. var. *sikkimense* Renauld & Cardot
518. *Plagiothecium vesiculariopsis* Dixon & P.de la Varde
519. *Platydictya madurensis* (Cardot & P.de la Varde) R.S.Chopra
520. *Platygyriella kirtikarii* (Cardot & Dixon) W.R. Buck.
521. *Pleuridium denticulatum* (Müll.Hal.) Mitt.
522. *Pleuropus nilgheriensis* (Mont.) Cardot
523. *Pogonatum aloides* (Hedw.) P.Beauv.
524. *Pogonatum decolyi* Broth ex Gangulee
525. *Pogonatum hexagonum* Mitt.
526. *Pogonatum leucopogon* Ren. & Cardot
527. *Pogonatum microstomum* (Schwaegr.) Brid.
528. *Pogonatum neesii* (Müll.Hal.) Dozy
529. *Pogonatum patulum* (Harv.) Mitt.
530. *Pogonatum perichaetiale* (Mont.) A.Jaeger subsp. *perichaetiale*
531. *Pogonatum subtortile* (Müll.Hal.) A.Jaeger
532. *Pogonatum urnigerum* (Hedw.) P.Beauv.
533. *Pohlia camptotrachela* (Renauld & Cardot) Broth.
534. *Pohlia elongata* Hedw.
535. *Pohlia flexuosa* Harv.
536. *Pohlia gedeana* (Bosch & Sande- Lac.) Gangulee
537. *Pohlia trematodontea* (Müll.Hal.) Broth.
538. *Pottia watsonii* R.S.Chopra
539. *Pseudoleskeopsis zippelii* (Dozy & Molk.) Broth.
540. *Pseudotaxiphyllum distichaceum* (Mitt.) Z.Iwats.
541. *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z.Iwats.
542. *Pseudotrachypus wallichii* (Brid.) W.R.Buck
543. *Pterigynandrum julaceum* (Schwägr.) Müll.Hal.
544. *Pterobryopsis acuminata* (Hook.) M.Fleisch.
545. *Pterobryopsis aurantia* (C.Mueller) M.Fleisch.
546. *Pterobryopsis auriculata* Dixon
547. *Pterobryopsis crassicaulis* (C.Mueller) M.Fleisch.
548. *Pterobryopsis divergens* (Mitt.) Nog.
549. *Pterobryopsis flexipes* (Mitt.) M.Fleisch.
550. *Pterobryopsis gedehensis* M.Fleisch.
551. *Pterobryopsis orientalis* (Müll.Hal.) M.Fleisch. subsp. *orientalis*
552. *Pterobryopsis scabriuscula* (Mitt.) M.Fleisch.
553. *Pterobryopsis schmidii* (Müll.Hal.) M.Fleisch.
554. *Pterobryopsis tumida* (Dicks. ex Hook.) Dixon
555. *Ptychomitrium tortula* (Harv.) A.Jaeger
556. *Ptychostomum angustifolium* (Brid.) J.R.Spence & H.P.Ramsay
557. *Pylaisia falcata* Schimp.
558. *Pylaisia speciosa* (Mitt.) Wilson ex A.Jaeger
559. *Pylaisiadelpha capillacea* (Griff.) B.C.Tan & Y.Jia
560. *Pyrrhobryum spiniforme* (Hedw.) Mitt.
561. *Racomitrium heterostichum* (Hedw.) Brid.
562. *Racomitrium subsecundum* (Hook. & Grev. ex Harv.) Mitt.
563. *Racopilum cuspidigerum* (Schwägr.) Ångstr. var. *cuspidigerum*
564. *Racopilum intermedum* Hampe
565. *Racopilum orthocarpum* Wilson ex Mitt.
566. *Racopilum schmidii* (Müll.Hal.) Mitt.
567. *Radulina borbonica* (Bél.) W.R.Buck
568. *Regmatodon orthostegius* Mont.
569. *Rhachithecium perpusillum* (Thwaites & Mitt.) Broth.
570. *Rhamphidium madurense* Dixon & P.de la Varde
571. *Rhaphidorrhynchium leptorrhynchioides* (C.Mueller) Broth.
572. *Rhaphidostichum brevisetum* E.B.Bartram
573. *Rhaphidostichum cucullifolium* (Cardot & Dixon) Broth.
574. *Rhaphidostichum subleptocarpum* (Thér. & P.de la Varde) Broth.
575. *Rhodobryum aubertii* (Schwägr.) Thér.
576. *Rhodobryum commersonii* (Schwägr.) Paris
577. *Rhodobryum giganteum* (Schwägr.) Paris
578. *Rhodobryum roseum* (Hedw.) Limpr.
579. *Rhynchostegiella humillima* (Mitt.) Broth.
580. *Rhynchostegiella leiopoda* Dixon & Cardot
581. *Rhynchostegium brachythecioides* Dixon & P.de la Varde
582. *Rhynchostegium celebicum* (Sande Lac.) A.Jaeger
583. *Rhynchostegium herbaceum* (Mitt.) A.Jaeger
584. *Rhynchostegium hookeri* A. Jaeger
585. *Rhynchostegium javanicum* (Bél.) Besch.
586. *Rhynchostegium megapolitanum* (Blandow ex F.Weber & D.Mohr) Schimp.
587. *Rhynchostegium muelleri* A.Jaeger var. *muelleri*
588. *Rhynchostegium riparioides* (Hedw.) Cardot
589. *Rhytidiadelphus triquetrus* (Hedw.) Warnst.
590. *Schistidium apocarpum* (Hedw.) Bruch & Schimp.
591. *Schlotheimia grevilleana* Mitt.
592. *Schlotheimia rugifolia* (Hook.) Schwägr.
593. *Schoenobryum concavifolium* (Griff.) Gangulee
594. *Schwetschkea applanata* (Thwaites & Mitt.) Broth.
595. *Schwetschkeopsis elongata* (Dixon & P.de la Varde) W.R.Buck & H.A.Crum
596. *Sciuro-hypnum plumosum* (Hedw.) Ignatov & Huttunen
597. *Scopelophila cataractae* (Mitt.) Broth.
598. *Sematophyllum angusticuspis* Broth.
599. *Sematophyllum humile* (Mitt.) Broth.
600. *Sematophyllum saproxylophilum* (Müll.Hal.) M.Fleisch.
601. *Sematophyllum sebillei* (Broth. & Thér.) R.S.Chopra
602. *Sematophyllum subhumile* (C.Mueller) M.Fleish.
603. *Sematophyllum subpinnatum* (Brid.) E.Britton
604. *Sematophyllum subsimplex* (Hedw.) Mitt.
605. *Semibarbula orientalis* (F.Weber) Wijk. & Margad.
606. *Solmsiella biseriata* (Austin) Steere
607. *Sphaerothecium reconditum* Thwaites & Mitt.
608. *Splachnobryum assamicum* Dix.
609. *Splachnobryum obtusum* (Brid.) C.Mueller
610. *Stereophyllum anceps* (Bosch & Sande- Lac.) Broth.
611. *Stereophyllum ligulatum* A. Jaeger
612. *Stereophyllum radiculosum* (Hook.) Mitt.
613. *Stereophyllum subacuminatum* Dixon & P. Varde
614. *Stereophyllum tavoyense* (Hook. ex Harv.) A. Jaeger
615. *Stereophyllum wightii* (Mitt.) A.Jaeger
616. *Symblepharis vaginata* (Hook. ex Harv.) Wijk & Margad.
617. *Symphyodon angustus* (Müll.Hal.) A.Jaeger
618. *Symphyodon complanatus* Dixon
619. *Symphyodon orientalis* (Mitt.) Broth. ex Paris
620. *Symphyodon perrottetii* Mont.
621. *Symphyodon pygmaeus* (Broth.) S.He & Snider
622. *Symphysodontella involuta* (Thwait. & Mitt.) M.Fleisch.
623. *Syntrichia fragilis* (Taylor) Ochyra
624. *Syntrichia princeps* (De Not.) Mitt.
625. *Syrrhopodon gardneri* (Hook.) Schwägr.
626. *Syrrhopodon leucophanoides* Cardot & P.Vard.
627. *Syrrhopodon prolifer* Schwägr. var. *prolifer*
628. *Syrrhopodon semiliber* (Mitt.) Besch.
629. *Taxiphyllum minutirameum* (Müll.Hal.) H.A.Mill. & D.R.Sm.
630. *Taxiphyllum subretusum* (Thwaites & Mitt.) O'Shea
631. *Taxiphyllum taxirameum* (Mitt.) M.Fleisch.
632. *Taxithelium nepalense* (Schwaegr.) Broth.
633. *Taxithelium kerianum* (Broth.) Broth.
634. *Tayloria indica* Mitt.
635. *Tayloria subglabra* (Griff.) Mitt.
636. *Thamniopsis utacamundiana* (Mont.) W.R.Buck
637. *Thamnobryum alopecurum* (Hedw.) Nieuwl. ex Gangulee
638. *Thamnobryum parvulum* (Mitt.) R.S.Chopra
639. *Thamnobryum subseriatum* (Hook. ex Harv.) Nog. & Z.Iwats.
640. *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.
641. *Thuidium glaucinum* (Mitt.) Bosch & Sande- Lac.
642. *Thuidium plumulosum* (Dozy & Molk.) Dozy & Molk.
643. *Thuidium pristocalix* (C.Mueller) A. Jaeger.
644. *Thuidium tamariscellum* (C.Mueller) Bosch. & Sande-Lac.
645. *Thuidium tamariscinum* (Hedw.) Schimp.
646. *Thysanomitrion leioneuron* Thér. & P.de la Varde
647. *Timmia megapolitana* Hedw.
648. *Timmiella anomala* (Bruch & Schimp.) Limpr.

649. *Timmiella barbuloides* (Brid.) Mönk.
650. *Toloxis semitorta* (Müll.Hal.) W.R.Buck
651. *Tortella tortuosa* (Hedw.) Limpr.
652. *Trachycladiella sparsa* (Mitt.) M.Menzel
653. *Trachyloma indicum* Mitt. var. *indicum*
654. *Trachyphyllum inflexum* (Harv.) A.Gepp
655. *Trachyphyllum jeyporense* Thér. & Dixon
656. *Trachypodopsis serrulata* (P.Beauv.) M.Fleisch. var. *crispatula* (Hook.) Zanten.
657. *Trachypus bicolor* Reinw. & Hornsch. var. *bicolor*
658. *Trachypus bicolor* Reinw. & Hornsch. var. *hispidus* (Müll.Hal.) Cardot
659. *Trachypus flexicaulis* (Wilson) Mitt.
660. *Trachypus humilis* Lindb. var. *humilis*
661. *Trachypus humilis* Lindb. var. *tenerrimus* (Broth. ex Herzog) Zanten
662. *Trematodon conformis* Mitt.
663. *Trematodon longicollis* Michx.
664. *Trematodon schmidii* Müll.Hal.
665. *Trichosteleum stissophyllum* (Hampe & C.Mueller) A. Jaeger
666. *Trichostomum hyalinoblastum* (Broth.) Broth.
667. *Trichostomum minusculum* Dixon & P. Varde
668. *Trichostomum tenuirostre* (Hook. & Taylor) Lindb.
669. *Trichostomum tortelloides* (Broth. & Dixon) R.H. Zander
670. *Trichostomum wayanadense* Nair *et al.*
671. *Ulota schmidii* (Müll.Hal.) Mitt.
672. *Vesicularia dubyana* (C.Mueller) Broth.
673. *Vesicularia firma* Dixon & P.de la Varde
674. *Vesicularia nitidula* Cardot & P.de la Varde
675. *Vesicularia reticulata* (Dozy & Molk.) Broth.
676. *Vesicularia subpilicuspis* Cardot & P.de la Varde
677. *Vesicularia vesicularis* (Schwaegr.) Broth.
678. *Warburgiella isopterygioides* Dixon & P.de la Varde
679. *Warburgiella leptocarpa* (Schwägr.) M.Fleisch.
680. *Warburgiella leptorhynchoides* (Mitt.) M.Fleisch.
681. *Warburgiella perviridis* Dixon & P.de la Varde
682. *Weissia controversa* Hedw.
683. *Weissia edentula* Mitt.
684. *Weissia macrospora* Cardot & P.de la Varde
685. *Weissia minuta* (Dixon & P.de la Varde) M.N.Aziz & Vohra
686. *Wijkia surcularis* (Mitt.) H.A.Crum
687. *Wilsoniella decipiens* (Mitt.) Alston in Dixon
688. *Zygodon acutifolius* Müll.Hal
689. *Zygodon intermedius* Bryol.
690. *Zygodon reinwardtii* (Hornsch.) A.Braun
691. *Zygodon tetragonostomus* A.Braun ex Bruch, Schimp. & W.Gümbel

Diversity of Pteridophytes in Western Ghats

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Abstract

Pteridophytes (also known as ferns and fern allies) represent the earliest vascular land plants originated some 3000 million years ago and some of them survived all the geological and climatological turbulences occurred from time to time, without much changes in their morphology. They remain primitive tracheophytes bereft of flowers and seeds and propagate through haploid spores and exhibit independent alternation of generations.

Ecologically they adapt to almost all possible situations from tropics to temperate regions except in the polar regions and deserts. In India, Pteridophyte diversity is more in the Himalayas and in the Western Ghat regions. Altogether 310 species are reported from India of which ca. 300 spp. are found in the Western Ghats. Ecologically they adapt to almost all possible habitats. Among the pteridophytes of Western Ghats, 27 species are endemics and about 170 species are considered to be RET plants.

Key words: Western Ghats, Pteridophyte, Diversity, Endemism

Introduction

It turned as a pleasant surprise to the world, when the leading pteridologists such as Pryer *et al.* (2001) proved that *Psilotum* and *Equisetum* are true ferns. Supported by molecular genetic evidences, they shattered the good old believes in biology. They also demanded for correcting the basic biology text books, which were teaching us since long, that *Psilotum* and *Equisetum* are fern-allies, and never can be ferns. It was followed by the appearance of a revised classification scheme for the extant ferns (Smith *et al.*, 2006, 2008). All these happened in the recent past, in the last 5 or 6 years. The recent years are thus marked in the history of biology as landmarks. It was also witnessed the appearance of masterpiece publications such as *Biology and Evolution of Ferns and Lycophytes* (Ranker and Haufler, 2008) and *Fern Ecology* (Meheltreter *et al.*, 2010), which accumulated the most modern perspectives on the subject. In the coming years these may be celebrated as *magnus opus*, in Pteridology. The recent past thus has established a new era of exploring the genetics and evolution of ferns and lycophytes. It also caused in regaining vigorous interest among the scientist, and general public at large, towards the ferns and fern allies.

The recent developments in the taxonomic concepts of this group have caused ripples in Indian scenario also. The taxonomic rearrangements on this group, made in the recent past demand for a closer re-examination of many species in its wild habitats. For example, the finding such as '*Angiopteris evecta*' does not occur in Indian subcontinent is yet to be widely appear in the Indian texts. It is one of the well known and widely distributed species in the mesic habitats of the Western Ghats. Fraser-Jenkins (2008c) proved that the specimens referred under this name from India belong to two different species *viz., A. indica* and *A. helferiana*. The case of '*A. evecta*' is a typical example. However, careful search in the wild and proper documentation only could prove the significance of the occurrence of these species, not much known from India. Same is the case with the common bracken fern, incorrectly referred as *Pteridium aquilinum,* a species does not occur in the Asia, but for *P. revolutum.* It also points out the urgent need for thorough explorations.

Even though we have advanced a bit in the documentation of the ferns and fern allies of the Western Ghats, the recent developments strongly demands for a different approach. The paradigm shift is so strong to question the credibility of our documentation. The recent synthesis, especially on the ecological aspects, put forwarded by Meheltreter *et al.* (2010) also reveals the lacunae in our understanding of this group in the Indian context and in the Western Ghats, in particular. It is assumed that the India region is blessed with the rich diversity of more than 1200 pteridophytes. The Western Ghats, is also equally rich with more than 300 pteridophytes. However, our knowledge on their biology is far from complete. It is evident from the fact that, there is no proper document on the form and growth pattern of the gametophytes of them. Details on the structure and their biology of most of them are not known. Such baseline data is an essential prerequisite for proper conservation planning and better utilization.

The Western Ghats and its Pteridophyte diversity

It is the 1600 km long chain of hills of Peninsular India, ranging from the Tapti river basin of the southern Gujarat to the Kanyakumari of Tamil Nadu. It is one of the most significant geological structure, which controls the climate and culture of the Paninsular Indian states of Gujarat, Maharashtra, Karnataka, Kerala and Tamil Nadu. It offers innumerable microhabitats for the luxuriant growth of flora, including the pteridophytes.

The first reference on the pteridophytes of Southern India could be traced back to Van Rheede's (1703) monumental work, '*Hortus Malabaricus*'. It contains illustrated account of 15 pteridophytes (Madhusoodanan & Rejani, 1994). Later Linnaeus (1753) referred them in his '*Species Plantarum*'. Col. Richard Henry Beddome, a British Botanist and an ardent lover of ferns, published his outstanding works as *Ferns of Southern India* (1863), *Ferns of British India* (1865-1870), *Handbook of Ferns of British India, Ceylon and Malaya Peninsula* (1883). These works, still remain as authentic source books on the pteridophytes of the area. The works of Holttum (1938, 1949, 1971, 1973, 1974, 1978 and 1984) also influenced the Indian pteridology. Alston (1945) has recorded about 58 species of *Selaginella* from India, of which 14 species were from the Western Ghats.

Mainly due to the drier nature, the diversity of the pteridophytes is comparatively lesser in the northern part of the Western Ghats. The forests of Gujarat and Maharashtra, are deciduous, and hence not suitable for the moisture dependant pteridophytes. The diversity of the group is maximum in the moist southern part of the Western Ghats, especially in the states of Kerala and Tamil Nadu.

Blatter and d'Almeida (1922) worked on the Ferns of Bombay. They provided a strong and sound foundation for the pteridological research in India. Shaikh *et al.* (2012) recorded *Osmunda heugeliana* from Ghanabi of Satara district in northern Maharashtra. Patil et al. (2012) enumerated 41 species of ferns of the hills of northern Maharashtra.

Datar and Lakshminarasimhan (2010) documented 47 species of pteridophytes of the Western Ghats in Goa. Rajagopal and Bhat (1998) summarised the pteridophyte diversity of the Karnataka state. Later some rare ferns such as *Helminthostachys zeylanica* (by Shenoy and Kuman, 2007) and *Schizaea digitata* (by Shenoy and Krishnakumar, 2009) were also recorded from the state as new records.

Prof. B.K. Nayar made remarkable contribution to the Indian pteridology, especially in the fields of anatomy, morphology, palynology, etc. He trained his students also in the detailed documentation of the pteridophytes, especially of Kerala part. The *Fern flora of Malabar*, prepared by Nayar and Geevarghese (1993) contains detailed account of 170 species of ferns from Malabar region.

Prof. Madhusoodanan, a student of Prof. B.K. Nayar, continued the studies on various aspects of pteridolophytes of southern India. He (1991) listed the rare and endangered ferns and fern allies of the Western Ghats of Kerala, and discussed its conservation. Revisionary studies of several families done by Madhusoodanan and his students resulted in recording many novelties. They have brought out documents on pteridophyte groups such as Adiantaceae (Madhusoodanan & Sevichan, 1991), Polypodiaceae (Nampy & Madhusoodanan, 1992, 1998), Thelypteridaceae (Leena & Madhusoodanan, 1992, 1994, 1998), Cheilanthoid ferns (Jyothi & Madhusoodanan, 1993), Lomariopsidaceae (Majeed *et al.* (1994, 1995), Hymenophyllaceae (Hameed *et al.*, 2003), Aspleniaceae (Azeez *et al.*, 2008), Pteridaceae (Sreenivas, 2011; Sreenivas & Madhusoodanan, 2012), etc. Nampy (2000) described a new species of fern, *Bolbitis thommankuthiana,* from Kerala, which Fraser-Jenkins (2008) consider synonymous with *B. semicordata* (Baker) Ching. In the recnt years, Nisha *et al.* (2010) described a *Selaginella* from Lakkidi, as *S. lakkidiana.*

The scientists of Botanical Survey of India, lead by N.C. Nair also made invaluable contribution towards the documentation of the pteridophyte diversity of Kerala. Nair and Bhargavan (1980) prepared a detailed review on the pteridological studies of the Peninsular India. It contains references of many old literatures on pteridophytes of South India. Nair *et al.* (1988, 1990 a & b, 1994) had brought out a detailed account on the ferns and fern-allies of Kerala, which contains 250 taxa.

Scientist from other research institutions such as Kerala Forest Research Institute (KFRI), Tropical Botanical Garden & Research Institute (TBGRI), etc also contributed their share towards the documentation of the pteridophyte diversity of the area. Sequiera (1998) made a detailed study on the epiphytic pteridophytes of Kerala part of the Western Ghats. Mathew *et al.* (1999) provided an account of the ethnomedical importance of some Pteriodophytes of Kerala. Antony *et al.* (2000) described 18 rare, endangered and threatened ferns from Chemunji hills of the Western Ghats in Kerala. Antony *et al.* described two new species of *Selaginella* from the Agasthyamala hills of Thiruvananthapuram district as *Selaginella camusii* (2002) and *Selaginella agastyamalayana* (2007), which Fraser-Jenkins (2008c) doubts as synonymous with *S. reticulta* or *S. proniflora* and *S. cataractarum* respectively. Easa (2003) summarised data on the pteridophyte diversity of Kerala. Sujanapal and Sasidharan (2009) recorded ethnobotanical information on 17 taxa of pteridophytes from Parambikulam wild life sanctuary.

Father Manickam and his team carried out extensive studies on the Pteridophyte diversity of the Tamil Nadu state. *The fern flora of Palni hills, South India* (1986) and *Ecological studies on the fern flora of the Palni Hills, South India* (1984) have been published by him. He (1989) also presented an account on the ferns of the Western Ghats. Manickam and Irudayaraj (1988) studied the cytology of 100 species of ferns from the Western Ghats of South India. The book, *Pteridophytic flora of the Western Ghats-South India* by Manickam and Irudayaraj (1992) is one of the best source book on the subject from the area. It presents illustrated accounts of 256 pteridophytes from the Western Ghats, south of Palghat gap. Manickam and Rajkumar (1999) described the polymorphic ferns of the Western Ghats. Benniamin and Manickam (2008) made a phytogeographical analysis of the pteridophytes of the Western Ghats.

Irudayaraj and Ganapathi (2000) discussed the conservation status of the rare and endangered fern *Elaphoglossum commutatum* from Kothayar hills in Kanniyakumari district of Tamil Nadu. A new species, *Polystichum manickamianum*, was described by Benniamin *et al.* (2008) from the Agasthyamala hills of Tamil Nadu. It was later reported from the Kerala part of the Western Ghats also (Antony & Mohanan, 2010). Maridas and Raju (2010) reviewed the conservation status of 272 species of ferns and fern-allies distributed in the Western Ghats.

Fraser-Jenkins in (2008a,b&c) critically analysed the pteridophyte flora of India, and sorted out the true endemics from the pseudo-endemic species. It is assumed that 27 pteridophyte species are endemic to the Western Ghats. Most of the species earlier reported as endemics from the area, was later found either as synonymous or with extended distribution range. Chandra *et al.* (2008) updated the status of the rare and endangered pteridophytes of the country, of which more than 100 are with narrow distribution in the Western Ghats.

The pteridophytes of the Western Ghats, shows great degree of variation in the form and structure. It varies from the minute *Trichomanes kurzii* and *T. agasthianum* of few millimeters to the large tree ferns such as *Sphaeropteris crinita* and *Alsophila nilgirensis*. Some others such as *Lygodium flexuosum, L. microphyllum* and *Stenochlaena palustris*, may climb up to the upper canopy through their fronds or rhizomes. The rare climbing fern, *Arthropteris palisotii* is confined to the evergreen forests. Some ferns such as *Microgramma lycopodioides, Ctenopterella blechnoides, Oreogrammitis austroindica, Prosaptia alata* and *Dryopteris austroindica* are very rare and assumed as extinct, due to the lack of recent records. This also indicate the need for detailed search in the wild for possible relocation.

List of Pteridophytes Endemic to the Western Ghats
(after Fraser-Jenkins, 2008 and others)

1. *Alsophila nilgirensis* (Holttum) R.Tryon
2. *Asplenium exiguum* Bedd.
3. *Asplenium rivulare* Fras.-Jenk.
4. *Athyrium parasnathense* (C.B. Clarke) Ching *ex* Bir
5. *Bolbitis presliana* (Fée) Ching
6. *Bolbitis semicordata* (Baker) Ching
7. *Bolbitis subcrenatoides* Fras.-Jenk.
8. *Dryopsis scabrosa* (Kunze) Holttum & P.J.Edwards
9. *Dryopteris austroindica* Fras.-Jenk.
10. *Dryopteris odontoloma* (Bedd.) C. Chr.
11. *Elaphoglossum beddomei* Sledge
12. *Elaphoglossum nilgiricum* Krajina *ex* Sledge
13. *Elaphoglossum stigmatolepis* (Fée) T.Moore
14. *Huperzia nilagirica* (Spring.) R. D. Dixit
15. *Lindsaea malabarica* (Bedd.) Baker
16. *Oreogrammitis austroindica* (Parris) Parris (No recent collections)
17. *Oreogrammitis pilifera* (Ravi & J. Joseph) Parris
18. *Osmunda huegeliana* C.Presl
19. *Polystichum manickamii* Benniamin, Fras.-Jenk. & Irud.
20. *Polystichum palniense* Fras.-Jenk.
21. *Polystichum subinerme* (Kunze) Fras.-Jenk.
22. *Pteris perrottetii* Hieron.
23. *Selaginella cataractarum* Alston
24. *Selaginella lakkidiana* Nampy et al.
25. *Selaginella radicata* (Hook. & Grev.) Spring
26. *Selaginella tenera* (Hook & Grev.) Spring
27. *Trichomanes agasthianum* (Madhus. & C.A. Hameed) C.A. Hameed, K.P. Rajesh & Madhus.

List of Rare, Endangered Pteridophytes of the W. Ghats (after Chandra *et al.*, 2008)

1. *Aleuritopteris thwaitesii* (Mett. *ex* Kuhn) Saiki
2. *Aleuritopteris wollenweberi* Fras.-Jenk.
3. *Alsophila nilgirensis* (Holttum) R.Tryon
4. *Anogramma leptophylla* (L.) Link
5. *Araiostegia hymenophylloides* (Blume) Copel.
6. *Arthropteris palisotii* (Desv.) Alston
7. *Asplenium affine* Sw.
8. *Asplenium apogamum* N.Murak. & Hatan.
9. *Asplenium auritum* Sw.
10. *Asplenium exiguum* Bedd.
11. *Asplenium grevillei* Wall. *ex* Hook. & Grev.
12. *Asplenium pellucidum* Lam.
13. *Asplenium prolongatum* Hook.
14. *Asplenium rivulare* Fras.-Jenk.,
15. *Asplenium scalare* Rosenst.
16. *Asplenium serricula* Fee
17. *Athryium cumingianum* (C.Presl) Ching
18. *Athyrium praetermissum* Sledge
19. *Blechnum melanocaulon* (Brack.) T.C. Chambers & P.A. Farrant subsp. *pallens* T.C. Chambers & P.A. Farrant
20. *Bolbitis presliana* (Fee) Ching
21. *Bolbitis semicordata* (Baker) Ching
22. *Botrychium daucifolium* Wall. *ex* Hook. & Grev.
23. *Ctenopterella blechnoides* (Grev.) Parris
24. *Cyrtomium micropterum* (Kunze) Ching
25. *Davallia denticulata* (Burm.f.) Mett. *ex* Kuhn
26. *Davallia repens* (L.f.) Kuhn
27. *Diplazium beddomei* C.Chr.
28. *Diplazium muricatum* (Mett.) Alderw.
29. *Diplazium sylvaticum* Sw.
30. *Diplazium travancoricum* Bedd.
31. *Dryopsis ferruginea* (Baker) Holttum & P.J.Edwards
32. *Dryopteris austroindica* Fras.-Jenk.
33. *Dryopteris deparioides* (T. Moore) Kuntze subsp. *deparioides*
34. *Dryopteris odontoloma* (Bedd.) C.Chr.
35. *Dryopteris sledgei* Fras.-Jenk.
36. *Elaphoglossum angulatum* (Blume) T.Moore
37. *Elaphoglossum beddomei* Sledge
38. *Elaphoglossum nilgiricum* Krajina *ex* Sledge
39. *Elaphoglossum stigmatolepis* (Fee) T.Moore
40. *Helminthostachys zeylanica* (L.) Hook.
41. *Huperzia ceylanica* (Spring) Trevis.
42. *Huperzia nilagirica* (Spring) R.D.Dixit
43. *Huperzia phlegmaria* (L.) Rothm.
44. *Huperzia phyllantha* (Hook. & Arn.) Holub
45. *Huperzia vernicosa* (Hook. & Grev.) Trevis.
46. *Hymenophyllum acanthoides* (Bosch) Rosenst.
47. *Hymenophyllum denticulatum* Sw.
48. *Hymenophyllum gardneri* Bosch
49. *Lastreopsis tenera* (R.Br.) Tindale
50. *Leptochilus thwaitesianus* Fee
51. *Lindsaea bouillodii* Christ
52. *Lindsaea malabarica* (Bedd.) Baker
53. *Lindsaea venusta* Kaulf. *ex* Kuhn
54. *Lycopodium wightianum* (Wall. *ex* Hook. & Grev.) Holub
55. *Lygodium longifolium* (Willd.) Sw.

56. *Marattia fraxinea* Sw.
57. *Microgramma lycopodioides* (L.) Copel.
58. *Microlepia hallbergii* (d'Almeida) C.Chr.
59. *Microlepia majuscula* (E.J.Lowe) T.Moore
60. *Microsorum zippelii* (Blume) Ching
61. *Oleandra musaefolia* (Blume) C.Presl
62. *Ophioglossum gramineum* Willd.
63. *Ophioglossum lusitanicum* L.
64. *Ophioglossum nudicaule* L.
65. *Ophioglossum parvifolium* Grev. & Hook.
66. *Ophioglossum pendulum* L.
67. *Oreogrammitis attenuata* (Kunze) Parris
68. *Oreogrammitis austroindica* (Parris) Parris
69. *Oreogrammitis pilifera* (Ravi & J.Joseph) Parris
70. *Osmunda huegeliana* C.Presl.
71. *Dryopsis ferruginea* (Baker) Holttum & P.J.Edwards
72. *Dryopteris austroindica* Fras.-Jenk.
73. *Dryopteris deparioides* (T. Moore) Kuntze subsp. *deparioides*
74. *Dryopteris odontoloma* (Bedd.) C.Chr.
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120. *Lygodium longifolium* (Willd.) Sw.
121. *Marattia fraxinea* Sw.
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123. *Microlepia hallbergii* (d'Almeida) C.Chr.
124. *Microlepia majuscula* (E.J.Lowe) T.Moore
125. *Microsorum zippelii* (Blume) Ching
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128. *Ophioglossum lusitanicum* L.
129. *Ophioglossum nudicaule* L.
130. *Ophioglossum parvifolium* Grev. & Hook.
131. *Ophioglossum pendulum* L.
132. *Oreogrammitis attenuata* (Kunze) Parris
133. *Oreogrammitis austroindica* (Parris) Parris
134. *Oreogrammitis pilifera* (Ravi & J.Joseph) Parris
135. *Osmunda huegeliana* C.Presl.
136. *Pellaea boivinii* Hook.
137. *Pellaea falcata* R.Br.
138. *Pellaea longipilosa* Bonap.
139. *Phymatosorus longissimus* (Blume) Pic.Serm.
140. *Pleopeltis macrocarpa* (Bory *ex* Willd.) Kaulf.
141. *Polystichum anomalum* (Hook. & Arn.) J.Sm.
142. *Polystichum manickamianum* Benniamin, Fras.-Jenk. & Irud.
143. *Polystichum subinerme* (Kunze) Fras.-Jenk.
144. *Prosaptia alata* (Blume) Christ
145. *Prosaptia contigua* (G.Forst.) C.Presl
146. *Prosaptia obliquata* (Blume) Mett.
147. *Psilotum nudum* (L.) P. Beauv.
148. *Pteridrys syrmatica* (Willd.) C.Chr. & Ching
149. *Pteridrys zeylanica* Ching
150. *Pteris geminata* Wall. *ex* J.Agardh
151. *Pteris heteromorpha* Fee
152. *Pteris mertensioides* Willd.
153. *Pteris multiaurita* J.Agardh
154. *Pteris quadriaurita* Retz.
155. *Pteris tripartita* Sw.
156. *Pyrrosia ceylanica* (Giesenh.) Sledge
157. *Schizaea dichotoma* (L.) Sm.
158. *Schizaea digitata* (L.) Sw.
159. *Selaginella cataractarum* Alston
160. *Selaginella miniatospora* (Dalz.) Bak.
161. *Sphaeropteris crinita* (Hook.) R.Tryon
162. *Taenitis blechnoides* (Willd.) Sw.
163. *Tapeindium pinnatum* (Cav.) C. Chr
164. *Tectaria zeilanica* (Houtt.) Sledge
165. *Thelypteris beddomei* (Baker) Ching
166. *Thelypteris confluens* (Thunb.) C.V.Morton
167. *Thelypteris paludosa* (Blume) K.Iwats.
168. *Thelypteris thwaitesii* (Hook.) C.F.Reed
169. *Tomophyllum perplexum* (Parris) Parris
170. *Trichomanes agasthianum* (Madhus. & C.A.Hameed) C.A.Hameed, K.P.Rajesh & Madhus.

References

1. **Alston, A.H.G. 1945.** An enumeration of the Indian species of *Selaginella. Proc. Natnl. Inst. Sci. India. Scientific Publs*. 1 – 162.
2. **Antony, R., Khan, A. E. S. and Nair, G. S. 2007.** *Selaginella agastyamalayana* (Selaginellaceae: Pteridophyta), a new species from South India. *Fern Gazette* 18: 27-29.

3. **Antony, R., Khan, A.E.S. and Thomas, J. 2000.** Rare, endangered and threatened ferns from Chemunji hills, Kerala. *J. Econ. Taxon. Bot.* 24: 413-415.
4. **Antony, R., Kumar, E. S. S. and Khan, A. E. S. 2002.** *Selaginella camusii*, a new species of Selaginellaceae from India. *Nordic J. Botany* 22: 337-340.
5. **Azeez, K., Kurup, V.V.K. and Madhusoodanan, P.V. 2008.** *Spleenworts (Asplenium* L., *Pteridophyta) of South India*. Malabar Natural History Society, Calicut.
6. **Beddome, R.H. 1863-1864.** *The Ferns of Southern India*. Ganz brothers Madras. Reprint ed. 1970. Today and Tomorrows Printers and Publishers, New Delhi.
7. **Beddome, R.H. 1865-1870.** *The Ferns of British India*. Vol. 1&2. Ganz Bros., Madras. Reprint Ed. 1973. Oxford & IBH Publishing Co., New Delhi.
8. **Beddome, R.H. 1883.** *A handbook of the ferns of British India – Ceylon and Malaya Peninsula*. Thacker Spink & Co., Calcutta.
9. **Benniamin, A. and Manickam, V. S. 2008.** Phytogeographical analysis of pteridophytes from Western Ghats, South India. pp. 193-198. *In:* S. C. Verma, S. P. Khullar and H. K. Cheema (eds.). *Perspectives in Pteridophytes*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
10. **Benniamin, A., Fraser-Jenkins, C. R. and Irudayaraj, V. 2008.** *Polystichum manickamianum* (Dryopteridaceae), a new species from South India. *Novon* 18: 287-293.
11. **Blatter, E. and D'Almeida, J.F. 1922.** *Ferns of Bombay.* D.B. Tharaporevala Sons & Co., Bombay.
12. **Chandra, S., Fraser-Jenkins, C.R., Kumari, K.A. and Srivastava, A. 2008.** A summary of the status of threatened pteridophytes of India. *Taiwania* 53: 170-209.
13. **Datar, M. N. and Lakshminarasimham, P. 2010.** Habitat based pteridophyte diversity from Western Ghats of Goa, India. *Phyto taxonomy* 10: 70-76.
14. **Easa, P.S. 2003.** *Biodiversity Documentation for Kerala, Part: 5 Pteridophytes*. KFRI Handbook No.17, Kerala Forest Research Institute, Peechi.
15. **Fraser-Jenkins, C. R. 2008a.** Endemics and pseudo-endemics in relation to distribution patterns of Indian pteridophytes. *Indian Fern J.* 25: 1-45.
16. **Fraser-Jenkins, C. R. 2008b.** Endemics and Pseudo-endemics in relation to the distribution pattern of Indian pteridophytes. *Taiwania* 53: 264-292.
17. **Fraser-Jenkins, C. R. 2008c.** *Taxonomic revision of three hundred Indian subcontinental pteridophytes with a revised census-list a new picture of fern-taxonomy and nomenclature in the Indian subcontinent*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
18. **Fraser-Jenkins, C. R. and Dulawat, C. S. 2008.** A summary of Indian cheilanthoid ferns and the discovery of *Negripteris* Chiov., an Afro- Arabian fern-genus new to India. *Fern Gazette*
19. **Hameed, C.A., Rajesh, K.P. and Madhusoodanan, P.V. 2003.** *Filmy Ferns of South India.* Penta Books Publishers & Distributors, Calicut.
20. **Holttum, R. E. 1938.** The ecology of tropical Pteridophytes. *In*: F. Verdoorn (ed.). *Manual of Pteridology.* Pp. 420-50. Martinus Nijhoff, The Hague.
21. **Holttum, R. E. 1947.** A revised classification of leptosporangiate ferns. *Bot. J. Linn. Soc. Bot.* 58: 123-158.
22. **Holttum, R. E. 1949.** The classification of ferns. *Biol. Rev.* 24: 267-296.
23. **Holttum, R. E. 1971.** Studies in the family Thelypteridaceae. III. A new system of genera in the Old World. *Blumea* 19: 17–52.
24. **Holttum, R. E. 1973.** Posing the problems. *In*: Jermy, A. C., Crabbe, J. A. and Thomas, B. A. (eds.), *The Phylogeny and Classification of the Ferns*. Academic Press, London. [Bot. J. Linn. Soc. 67(suppl. 1)]. Pp. 1–10.

25. **Holttum, R. E. 1974.** Taxonomy of Indian Ferns. *Phytomorphology* 24: 314-321.
26. **Holttum, R. E. 1978.** *A revised flora of Malaya- Ferns of Malaya.* Government Printing Office, Singapore.
27. **Holttum, R. E. 1984.** Studies on the fern genera allied to *Tectaria* - a commentary on recent schemes of classification. *Fern. Gaz.* 12(6): 313-319.
28. **Irudayaraj, V., Ganapathi, A. 2000.** Rediscovery of rare and endangered fern *Elaphoglossum* c*ommutatum* (Mett). Aldrew. (Lomariopsidaceae: Pteridophyta). *J. Econ. Taxon. Bot.* 24: 254-256.
29. **Jyothi, P.V. and Madhusoodanan, P.V. 1993.** Cheilanthoid ferns of South India. *J. Econ. Tax. Bot.* 17: 31-36.
30. **Leena, K.R. and Madhusoodanan, P.V. 1992.** Ecology and Distribution of Thelypteroid ferns of South India. *Indian Fern J.* 9: 174-183.
31. **Leena, K.R. and Madhusoodanan, P.V. 1994.** Taxonomy of Thelypteroid ferns of South India. *Acta Bot. Indica* 22: 31-36.
32. **Leena, K.R. and Madhusoodanan, P.V. 1998.** Pteridophyte flora of Wynad district. Kerala. A preliminary survey on ecology and distribution. *J. Econ. Tax. Bot.* 22: 35-41.
33. **Linnaeus, C. 1753.** *Species Plantarum.* Laurentii salvi, Holmiae. Pp. 1073-1077.
34. **Madhusoodanan, P.V. 1991.** Rare and endangered ferns and fern-allies of Western Ghats of Kerala. In: Karunakaran (ed.) *Proc. Symp. on Rare/Endangered and endemic plants of the Western Ghats.* pp. 103-107.
35. **Madhusoodanan, P.V. and Sevichan P.J. 1991.** The genus *Adiantum* in Kerala. *J. Econ. Tax. Bot.* 15: 143-144.
36. **Madusoodanan, P.V. and Rejani, A. 1994.** Reinvestigation of the present status of the ferns and fern-allies of *Hortus Malabaricus. Indian Fern J.* 11:12-19.
37. **Majeed, K.K.A., Leena K.R. and Madhusoodanan, P.V. 1994.** Ecology and Distribution of Lomariopsid ferns of Kerala. *J. Plant. Envt.* 10: 71-74.
38. **Majeed, K.K.A., Leena, K.R. and Madhusoodanan, P.V. 1995.** The genus *Elaphoglossum* (Lomariopsidaceae) in Kerala. *J. Econ. Tax. Bot.* 18: 661-664.
39. **Manickam, V.S and Rajkumar, D.S., 1999.** *Polymorphic Ferns of the Western Ghats-South India.* Bishen Singh Mahendra Pal Singh, Dehra Dun.
40. **Manickam, V.S. 1984.** *Ecological studies on the fern flora of the Palni Hills (South India).* Today and Tomorrow's Printers & Publishers, New Delhi.
41. **Manickam, V.S. 1986.** *Fern flora of Palani Hills (South India).* Today and Tomorrow's Printers and Publishers, New Delhi.
42. **Manickam, V.S. 1989.** Ferns of the Western Ghats (South India). *In*: K.H. Shiny and K.V. Kramer (eds.) *Proc. Intern. Symp. Systematic Pteridology*, Beijing, China, pp. 181-192.
43. **Manickam, V.S. and Irudayaraj, V. 1988.** *Cytology of Ferns of the Western Ghats – South India*. Today and Tomorrow's Printers & Publishers, New Delhi.
44. **Manickam, V.S. and Irudayaraj, V. 1992.** *Pteridophytic flora of the Western Ghats-South India.* B.I. Publications, New Delhi.
45. **Maridass, M., Raju, G. 2010.** Conservation status of pteridophytes of Western Ghats, South India. *Indian J. Bot.* I (special issue): 42-57.
46. **Mathew, P.J., Mathew, D., Unnithan, C.M., Pushpangadan, P. 1999.** Ethnomedical information of some Pteridophytes of Kerala sector of Western Ghats. *In*: Sasikumar, B., Krishnamurti, B., Rema, J., Ravindran, P.N., Peter, K.V. (eds.). *Biodiversity Conservation and Utilization of Spices, Medicinal and Aromatic Plants*. Indian Institute of Spices Research, Calicut.

47. **Mehltreter, K., Walker, L.R. and Sharpe, J.M. 2010.** (eds.). *Fern Ecology.* Cambridge University Press, U.K.
48. **Nair, N. C., Ghosh, S. R. and Bhargavan, P. 1988.** Fern-allies and ferns of Kerala, India Part 1. J. Econ. Tax. Bot. 12:171-209.
49. **Nair, N. C., Ghosh, S. R. and Bhargavan, P. 1992a.** Fern-allies and ferns of Kerala. Part II. J. Econ. Tax. Bot. 16: 251-283.
50. **Nair, N. C., Ghosh, S. R. and Bhargavan, P. 1992b.** Fern-allies and ferns of Kerala. Part III. J. Econ. Tax. Bot. 16: 501-550.
51. **Nair, N. C., Ghosh, S. R. and Bhargavan, P. 1994.** Fern-allies and ferns of Kerala. Part IV. J. Econ. Tax. Bot. 18: 449-476.
52. **Nair, N.C., Bhargavan P. 1981.** The studies on the ferns of Peninsular India. *J. Indian Bot. Soc.* 55: 52-55.
53. **Nampy, S. 2000.** *Bolbitis thommankuthiana* (Lomariopsidaceae). A new species of fern from India. *Sida* 19(1): 133-135.
54. **Nampy, S. and Madhusoodanan, P. V. 1998.** *Fern Flora of South India: Taxonomic Revision of Polypodioid Ferns.* Daya Books, New Delhi.
55. **Nampy, S. and Madhusoodanan, P.V. 1992.** Polypodioid ferns of South India. *Indian Fern J.* 9: 204-220.
56. **Nayar, B.K. and Gevarghese, K.K. 1993.** *Fern Flora of Malabar.* Indus Publishing Co., New Delhi.
57. **Nisha, P., Nampy, S. and Joby, P. 2010.** *Selaginella lakkidiana* sp. nov. (Selaginellaceae) from India. Nordic. J. Bot. 28(6): 665-666.
58. **Patil, S., Mahamuni, R. and Dongare, M. 2012.** Diversity of ferns in the hills of northern Western Ghats, Maharashtra, India. *Indian Fern J.* 29: 158-163.
59. **Pryer, K.M., Schneider, H., Smith, A.R., Cranfill, R. Wolf, P.G., Hunt, J.S., and Spipes, S.D. 2001.** Horsetails and ferns are a monophyletic group and the closest living relatives to seed plants. *Nature* 409: 618-622.
60. **Rajagopal, P.K. and Bhat, K.G. 1998.** Pteridophytic flora of Karnataka State, India. *Indian Fern J.* 15: 1-28.
61. **Ranker, T.A. and Haufler, T.A. (eds.). 2008.** *Biology and Evolution of Ferns and Lycophytes.* Cambridge University Press.
62. **Schneider, H., Schuettpelz., Pryer, K. M. Cranfill, R., Magallen, S. and Lupia, R. 2004.** Ferns diversified in shadow of angiosperms. Nature 428: 553-557.
63. **Sequiera, K.M. 1998.** Diversity, systematics, distribution, and taxonomy of epiphytic pterydophytes of Kerala part of Western Ghats, South India. *Indian Fern J.* 15: 106-130.
64. **Shaikh, S.D., Patil, S.M, Jadhav, S.B. and Dongare, M. 2012.** The royal fern – *Osmunda heugeliana* L. from Northern Maharashtra (India). *Indian Fern J.* 29: 86-88.
65. **Shenoy, H. S. and Krishnakumar, G. 2009.** A note on the occurrence of *Schizaea digitata* (L.) Sw. in a lowland evergreen forest of Dakshina Kannada in Karnataka. *J. Econ. Taxon. Bot.* 33 Suppl. S: 54-56.
66. **Shenoy, H. S. and Kuman, K. 2007.** *Helminthostachys zeylanica* (L.) Hook. (Ophioglossaceae): a new record to Karnataka, India. *Indian Fern J.* 24: 164-166.
67. **Smith, A.R., Preyer, K.M., Schuettpelz, E., Korall, P., Scheider, H. and Wolf, P.G. 2006.** A classification of extant ferns. *Taxon* 55(3): 705-731.
68. **Smith, A.R., Pryer, K.M. Schuettpelz, E., Korall, P., Schneider, H. and Wolf, P.G. 2008.** Fern classification. *In*: T.A. Ranker and C.H. Haufler (eds.). *Biology and Evolution of Ferns and Lycophytes*. Cambridge University press, U.K. pp. 45-67.
69. **Sreenivas, V. K. 2011.** Taxonomic studies on the genus *Pteris* L. (Pteridaceae) in South India. Ph.D. Thesis. Dept. of Botany, Calicut University.

70. **Sreenivas, V. K. and Madhusoodanan, P. V. 2012.** *Pteris reptans* (Pteridaceae) – a new record for India. Fern Gaz. 19(1): 25-29.

71. **Sujanapal, P. and Sasidharan, N. 2009.** Diversity and Ethnobotanical uses of pteridophytes in Parambikulam Wild life sanctuary, Kerala, South India. *J. Econ. Taxon. Bot.* 33(1): 109-119.

72. **Van Rheede, H.A. 1678-1703.** *Hortus Indicus Malabaricus*. Amsterdam. (Indian Reprint Bishen Singh Mahendra Pal Singh, Dehra Dun).

Higher Plants Diversity of Western Ghats

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Abstract

The Western Ghats or the Sahyādris constitute a mountain range along the western side of India. The range starts near the border of Gujarat and Maharashtra, south of the Tapti river, and runs approximately 1,600 km through the states of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu, ending at Kanyakumari, at the southern tip of Peninsular India. The Western Ghats covering an area of 180,000 sq. km, constitute about 6 per cent of the land area of India and contain more than 30% of the biodiversity recorded from India. The southern Western Ghats, comprising Kerala, parts of Karnataka and Tamila Nadu is considered as the richest region with respect to biodiversity and endemism. The forests of Kerala are situated along the Western Ghats. The area under forest cover is estimated to be 11309.5032 sq.km (Kerala Forest Dept., 2013). The paper highlights the flowering plants diversity of southern Western Ghats with emphasis on Kerala.

Key words: Western Ghats, Kerala, higher plants, diversity

Introduction

The Western Ghats covering an area of 180,000 sq.km, constitute about 6 per cent of the land area of India and contain more than 30% of the biodiversity recorded from India. The Western Ghats, recognized as World Heritage Site by UNESCO is one of the world's ten "Hottest biodiversity hotspots" and has over 5000 species of flowering plants. The high rain fall, great variation in the altitudinal range in the mountains and diverse soil types favoured the formation of diverse habitats rich in species diversity. Anamudi peak (2,695 m) in Kerala is the highest peak in the Western Ghats. Doddabetta in the Nilgiri Hills (2,637 m) is the second highest peak. The other major peaks are ChembraPeak 2,100 m, Banasura Peak (2,073 m,) Vellarimala (2,200 m) and Agasthyamala 1,868 m are also in Kerala. Mullayanagiri (1,950 m) is the highest peak in Karnataka. The northern portion of the narrow coastal plain between the Western Ghats and the Arabian Sea is known as the Konkan Coast or Konkan, the central portion is called Kanara and the southern portion, the Malabar region or Malabar Coast. The Biligirirangan Hills lies at the confluence of the Western and Eastern Ghats. The southern Western Ghats, comprising Kerala, parts of Karnataka and Tamila Nadu is considered as the richest region with respect to biodiversity and endemism. Nayar (1996) has recognized six hotspot centers of endemic plants viz. Shimoga-Kanara, Nilgiris-Silentvalley, Wayand-Kodagu (Nilgiri Biosphere), Palni Hills, Anamalai and High Ranges and Agasthyamaiai Hills.

Phytogeography

The Malabar Coast, well known in the history of plant resource studies in Asia is remarkable for the luxuriant growth of tropical forests. Hooker (1907) classified the botanical regions of the erstwhile British India in to 9 regions based on species distribution. The Malabar region is one among them consisting of Western Ghats and the west coasts. Clarke (1898) proposed 11 phytogeographical provinces for the British India. He also recognized the Western Ghats as a separate province 'Malabarica'. Prain (1903) classified the phytogeograpic region based on moisture regimes into 6 regions. According to him 'India Aquosa' comprises the tropical rainforests along the Western Ghats. Chatterjee (1940) based on endemism among Dicotyledonous plants of the India-Burma region, recognized 10 botanical regions. He treated Malabar as a botanical region with a high percentage of endemism. All the above classifications recognized the Malabar region of the Western Ghats as a distinct phytogeographic region.

Topography

The Kerala State lies along the south-west corner of Peninsular India, between 80 18' and 120 48' N latitude and 740 52' and 770 22'E longitude. The boundaries of the State are the Lakshadweep sea in the west, Tamilnadu in the south and east and Karnataka in the north. The State has an area of 38,863 km2, which is about 1.18 percent of the total area of the country and is administratively divided into 14 districts. Due to the long tract of Western Ghats along the eastern side and Arabian sea along the western side, the physiography of the State is highly diversified. The State has a complex topography with mountains, valleys, ridges and scarps. The altitude varies from sea level to 2695 m above msl. Based on the altitude, the land is divided into high ranges (above 750 m asl; highlands (between 75-750 m asl); midland (between 7.5-75 m asl) and lowlands (below 7.5 m asl). The highlands with an average height of 900 m have several peaks over 1,800 m and constitute about 43 per cent of the land area followed by midland (42 percent); high ranges (15 per cent) and lowland (10 per cent). A narrow strip of land bordering the sea constitutes the low land area of the State and this region holds the back waters and estuaries. Mangroves and coastal vegetation are confined to this region. Parallel to the coastal strip, there is wider more or less undulating midland zone. Most of the human activities and agricultural settlements are located in this region. The natural vegetation is rather scanty and occurring as small refugees. These two regions constitute the major human habitats in the State. Wider eastern highland region constitutes the important region with regard to the Biodiversity. This region is highly undulating and has a complex geography compared to the other zones. These mountain ridges are continuous from north to south except the 30 km wide gap in the Palakkad district. These mountain chains influence the climate of the State to a greater extent.

Vegetation

The varied topographical features, high rainfall and geologic conditions have favoured the formation of different ecosystems from shola forests on the mountain valleys to the mangrove forests along sea coasts and estuaries. The most outstanding feature of the State is the formation of tropical rainforests along the windward side of the Southern Western Ghats, which is lying parallel to the west coast. A small extent of area of the State is along the rain shadow region the Western Ghats, where the vegetation is dominated by dry deciduous forests and scrub jungles. The wet lands are mostly confined to the low land region of the State. Champion and Seth (1968) recognised 26 forest types in Kerala of which the major ones are the west coast tropical evergreen, west coast semi-evergreen, southern moist mixed deciduous, southern dry mixed deciduous, southern montane wet temperate forests, southern subtropical hill forests, southern montane wet temperate grasslands and littoral forests (mangroves). Certain edaphic types recognised are Bamboo brakes, Cane brakes, Reed brakes, Euphorbiaceous scrub jungles, laterite thorn forests and Myristica swamp forests. Based on dynamics they recognised secondary forests such as secondary evergreen, secondary moist deciduous, secondary dry deciduous, etc.

Review and Discussion

The renewed interest in the systematic studies on biodiversity during the last three decades has resulted in the discovery of several new and interesting plants recorded from the Western Ghats. According to the checklist compiled by the author, there are 5,094 taxa (4606 species; 110 subspecies; 370 varieties; 8 forma) under 1537 genera belonging to 221 families so far recorded from Kerala (Sasidharan, 2012.) The dominant families with respect to endemic species are Rubiaceae (135), Poaceae (128), Orchidaceae (118), Fabaceae (Leguminosae) (102), Acanthaceae (101), Balsaminaceae (71), Asteraceae (66), Euphorbiaceae (62), Melastomataceae (53) and Lauraceae (54). Arborescent families like Dipterocarpaceae, Lauraceae, Clusiaceae and Annonaceae exhibit a relatively higher percent of endemism. Among the genera, Impatiens ranks first in the number of endemic species with 71 species followed by Strobilanthes (37), Dimeria (25), Crotalaria (26), Eriocaulon (27), Vernonia (23), Sonerila (21) and Syzygium (19). Out of the 5094 taxa, 880 are exotics introduced as agriculture, forestry, horticulture, garden plants as well as accidentally entered species. As many as 1,418 taxa are additions to the *Flora of Presidency of Madras*, of which 355 are new and 1,063 new records of occurrence to the flowering plants of Kerala. Most of the important cultivated crops are exotics. Exotic species such as *Chromolaena odorata, Lantana camara, Mikania micrantha, Adenophora ageratina, Hyptis capitata* and *Mimosa diplotricha var. inermis* have extensively invaded the degraded forest areas and wastelands. Many of these species are New World elements. *Parthenium hysterophorus* established mostly in the low rainfall areas. *Eichhornia crassipes, Alternanthera philoxeroides, Limnocharis flava* and *Pistia stratiotes* are now common in the water bodies and wetlands. The district wise analysis based on the studies shows that Idukki is the most species rich district with 3336 taxa, though the district has no seacoast and backwaters. Alappuzha district has the largest number of aquatic species. The district has no forests and the flora is dominated by grasses and sedges. The lowest number of flowering plants was recorded from Kasaragod.

References

1. **Champion H.G. and S.K. Seth, 1968.** A Revised Survey of the Forest Types of India. Govt. of India Press, Delhi.
2. **Chatterjee D., 1940.** Studies on the endemic flora of India and Burma. J. Asiat. Soc. Bengal 5: 19-67.
3. **Clarke C.B., 1898**. On the soil sub-areas of British India. J. Linn. Soc. London 34: 1-146.
4. **Forest area of Kerala:** Published in the internet. www.forest.kerala.gov.in/ acsessed on 6.2.2013.
5. **Gamble J.S. and C.E.C. Fischer, 1915-1936.** The Flora of the Presidency of Madras. Adlard & Son Ltd., London.
6. **Hooker J.D., 1907.** Sketch of the Flora of British India. Imperial Gazetteer of India (3) 1, 4: 157-212.
7. **Nayar M.P., 1996.** Hot Spots of Endemic Plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute, Trivandrum.
8. **Prain D., 1903.** Bengal Plants, 1 & 2. Botanical Survey of India, Calcutta. (reprint ed. 1963).
9. **Sasidharan N., 2012.** Flowering Plants of Kerala ver. 2. DVD. Kerala Forest Research institute, Peechi, Thrissur.

Invertebrate Diversity of Western Ghats

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Abstract

Owing to the rich floral and faunal elements, and also exhibiting high levels of endemism, the Western Ghats along with Srilanka, constitute the Western Ghats-Sri-Lanka Biodiversity Hotspot, one of the thirty-four Biodiversity hotspots of the world. The invertebrate diversity of Western Ghats is far less explored, when compared to the vertebrate fauna. Through literature survey, as well as by direct discussions with experts in the relevant fields, it has been attempted here, to provide an insight regarding the overall status and diversity of invertebrates of Western Ghats. However, much of the studies among invertebrates have been focused mainly on insects, the glamour groups like butterflies and odonates, in particular. We also have significant data on snails, spiders, scorpions and centipedes of the region. It is rather interesting to note that endemicity is considerably high in many invertebrate groups like odonates, land snails, spiders and termites, where as it is quite low in freshwater snails and butterflies. Western Ghats invertebrate fauna in general, shows African, Oriental and Palearctic affinities, with the Oriental affinity staying much prominent, as per certain records. The status, diversity and distribution patterns of many invertebrate groups in the region have been altered towards the recent, by several human induced factors like changes in land use pattern, spread of monoculture plantations and presence of introduced as well as invasive species. Efforts and projects oriented specifically towards the conservation of invertebrates of the region, in light of their richness, high species diversity and endemism are yet to be evolved.

Key words: Western Ghats, Invertebrates, diversity, endemism

Introduction

The Western Ghats along with SriLanka, constitute the Western Ghats-Sri-Lanka Biodiversity Hotspot, one of the richest of the thirty-four Biodiversity hotspots of the world. The varied habitat assemblages ensure richness as well as vast diversity in floral and faunal elements, and also high levels of endemism.

Data on the invertebrate diversity of Western Ghats is scanty, as the region is far less explored, when compared to the megabiota, the vertebrates. Hence through literature survey, as well as by direct discussions with experts in the relevant fields, it has been attempted here, to provide an insight on the overall status and diversity of invertebrates of Western Ghats.

Diversity and endemism

In Western Ghats, much of the studies among invertebrates have been focused on insects, the glamour groups like butterflies and odonates, in particular. Only scattered and scanty information prevail on other insect groups. However, inventorying of species are currently ongoing in groups like Earthworms, Molluscs, Spiders, Centipedes and Scorpions. Endemicity is considerably high in many invertebrate groups like land snails (77%) and Odonates (69%), where as it is quite low among freshwater snails (36%), spiders (33.7%) and butterflies. Land snails having 77% endemism top the list (Table 1).

Earthworms are prominent among soil organisms, since they have a significant role in maintaining the physical structure of soil and in organic matter dynamics, both influencing plant growth. The earthworm diversity of Western Ghats is quite impressive. 219 species have been documented from the Western ghats and adjacent coastal area, which amounts to 52.4% of the total earthworm fauna of India (Mohan *et al,* 2011).

As per Sudhi *et al*, 2009, spiders from Western Ghats constitute a total of 270 species in 138 genera grouped in 39 families. Compared to other parts of the country, the spider fauna of Western ghats is less known. Six genera namely- *Diplothele* and *Sasonichus* of the family Barychelidae*; Annandaliella, Haploclastus, Poecilotheria* and *Thrigmopoeus* of the family Theraphosidae, are reported as endemics of the region.

Molluscs comprise the second largest invertebrate group and are amongst the most successful, next only to insects . Like amphibians and reptiles, the land snails show a very high percentage of endemicity. Members of genera- *Cyclophorus*, *Diplommantina* and *Alycaeus* are totally endemic to the Western Ghats. *Indrella, with I. ampulla,* is a mono-specific endemic genus of the area, and has variable colour morphs. The endemicity of land snails in the Western Ghats is the second highest after amphibians. The Western Ghats harbour 92% and 41% of the family and genera respectively occurring in India. Among the 23 families, 63 % of the land snail fauna of the Western Ghats belong to three families Subulinidae, Ariophantidae and Cyclophoridae. Common generalist species include *Mariaella dusumieri, Achatina fulica*, *Laevicaulis alte, Semiperula* sp., *Cecilioides bensoni, Kaliella barrackporensis* and occur in human habitation and plantations in very high abundance.(Aravind *et al* 2005; Madhyastha and Aravind, 2013)

The Western Ghats has relatively less diverse butterfly species- an area comparable to its size in southeast Asia or tropical Africa, may have twice the number. Further, endemism at higher taxonomic levels such as genera, is extremely low in the area, *Parantirrhoea,* being the only genus that is endemic to the Western Ghats. The area also lacks unique butterfly faunal elements (Kunte 2008).

Only 36 of the 332 butterfly species found in the Western Ghats are endemic (11%). Of the six families, Lycaenidae with more than 100 species constitute the largest butterfly family in Western Ghats (Rajmohana and Radhakrishnan 2008). Though a few endemic species like *Troides minos Parantirrhoea marshallii, Zipaetis saitis*, *Papilio buddha* and *Appias wardii* are listed in schedule II and have legal protection, many rare ones like *Eurema nilgiriensi* have not been included in the WPA schedules (Kunte 2008).

Among Odonates, the anisopteran families Libellulidae and Gomphidae and also the Zygopteran family Coenagrionidae, are the most species-rich in the Western Ghats; however the families with a high percentage of endemism are Platystictidae, Protoneuridae, Lestidae, Chlorocyphidae, Gomphidae, Cordulegasterdiae and Corduliiidae. The Zygopteran (Damselfly) genera namely, *Phylloneura, Melanoneura, Esme, Calocypha*, and the Anisopteran (Dragonfly) genera namely, *Epithemis* and *Davidioides* are endemic to this zone. Endemism is higher in Zygoptera than in Anisoptera (Rajmohana and Radhakrishnan 2008).

Of the 660 ant species known from India, nearly 250 species under 62 genera are known from Western Ghats (personal communication Verghese T). The arboreal ant community in Western ghats is dominated by genera like *Oecophylla*, *Camponotus*, *Polyrhachis* and *Crematogaster* and can even be encountered on the tree canopies. However, the forest floor is dominated by *Harpegnathos*, *Diacamma*, *Platythyrea* and a few other ponerine ant genera. Members of *Aenictus*, *Cerapachys*, and *Strumigenys* often frequent rotten logs, leaf litter and soil (Antweb, 2013).

Tropical forest canopies are among the most species rich terrestrial habitats and are considered the heart of biotic diversity. Yet very few efforts have been made to assess this diversity globally and in India as well. Exploring the tree canopies in Western ghats is sure to register the presence of a number of hitherto unrecorded invertebrate species. Canopy fogging in Kodagu distyrict (Karnataka) in 2004-05, by Institute of

Wood Sciences and Technology, could collect thousands of arthropod species. Two trees alone revealed 104 species of beetles. *Isometrus* sp., an interesting species of slender scorpions having long pedipalps & flattened body, much suited to arboreal life was reported as new to science. The instance formed the first report of canopy scorpions from outside the Amazonian forest.

Termites are an ecologically and economically important insect group. Of the 271 species of termites known from India, 132 are present in Western ghats (CES, 2013). *Odontotermes is* the most common genus and *O. obesus*, the mount building termite is the commonest species.

Taxa	Species in India	Species in Western Ghats	Number of endemic species
Butterflies	1501	332	36
Odonates (Dragonflies & Damselflies)	499	176	67
Land Snails	1488	269	204
Termites	271	132	No data
Praying mantis	184	53	No data
Ants	660	Nearly 250	No data
Scorpions	113	Nearly 30	No data
Centipedes	90	23	4
Spiders	1520	271	91

Table 1: Diversity and status of selected invertebrate groups

Faunal affinities

The invertebrate fauna of Western Ghats in general, shows African, Oriental and Palearctic affinities, with the Oriental affinity staying much prominent. Faunal affinities have been thoroughly worked out only in a few groups.

As per Sudhi *et al*, 2008, the spider fauna of the Western Ghats can be divided into three- an ancient African lineage, later Southeast Asian migrant and an endemic part. The biogeographical analysis showed that four genera have affinities to African region and 18 have affinities to Southeast Asian region. Another 20 genera were found common to Africa, Western Ghats and Southeast Asian regions and 90 genera were cosmopolitan in distribution.

As far as molluscs of Western Ghats are concerned, several of the land snails are believed to be Gondwana relict, separated from Africa and Madagascar some 80 million years ago. The families *Cyclophoridae* and *Diplommatinidae* are well represented throughout the Oriental Region. They are found in plenty both in the Himalaya and the Western Ghats, explaining a link between the two fauna, while Genera *Tortulosa* and *Corilla* are represented only in the Western Ghats and Sri Lanka.

As per an analysis by Kunte 2011, 128 genera (78%) had their origin in the Oriental Region, 33 genera (20%) in the African Region and 24 genera (15% in the Australian Region. Holarctic and Palearctic together 5%. , while only 4% had their origin in Western Ghats.

Contrary to Holloway's hypothesis, biogeographic models other than plate tectonics, such as island-hopping, explains biogeography of the Western Ghats butterflies. As per the analysis, of the 164 butterfly genera in the Western Ghats, 129 had affinities to the Oriental and 33 to the African Region, confirming the strong Oriental element in the Western Ghats. As per the analysis, most of the genera inhabiting moist forests were centred in the Oriental Region, but the dry habitat butterfly fauna was a mix of Oriental, African and Eremic (Saharan and central Arabian) elements. There were also a few moist forest elements from the African Region.

Human interference

Along the Ghats, several anthropogenic activities like construction works, clearing of forests, pollution etc. have pushed many invertebrate groups to the brink of extinction. Their status, diversity and distribution patterns have been altered towards the recent due to factors like changes in land use pattern, spread of monoculture plantations and presence of introduced as well as invasive species.

Next to habitat degradation, invasive alien species are considered the major threat leading to species extinction. The giant Aftrican snail *Achatina fulica,* the hymenopteran gall wasps - *Leptocybe invasa* on *Eucalyptus*, and *Quadrastichus erythrinae* on Erythrina in pepper plantations, the Papaya mealy bug- *Paracoccus marginatus*, a tiny hemipteran bug attacking a variety of economically important tropical fruits and ornamentals, the eriyophid coconut mite - *Aceria guerreronis*, and the Tiger mosquito- *Aedes albopictus,* the vector of a series of fatal diseases, are some of the notable and much talked about invasive aliens of the recent in the area. Three species of dry wood termites - *Cryptotermes domesticus*, *C.dudleyi* and *C. havilandy* causing destruction to dead wood and structural timbers, listed among global invasive species, have their distribution in Western ghats.

Invertebrate conservation

Efforts and projects oriented specifically towards the conservation of invertebrates of the region, in light of their richness, high species diversity and endemism are yet to be evolved. Developing species inventories and evolving base-line data on different faunal groups, raising awareness among the people, sensitizing them on the role and need of invertebrates in maintaining ecosystem services will generate a better understanding on these faunal elements. Such actions can eventually lead to a shift in the approach of the public towards these groups, finally leading to their conservation.

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References

1. **Antweb 2013.** http://www.antweb.org/india.jsp, accessed on 12/2/2013
2. **Aravind N.A., K.P. Rajashekhar and N.A. Madhayystha. 2005.** Species diversity, endemism and distribution of land snails of the Western Ghats, India. *Records of the Western Australian Museum,* Supplement 68 : 31–38.
3. **CES, 2013.** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/?q=node/73 accessed on 12/2/2013.
4. **Kunte, K. J. 2008.** The Wild Life (Protection) Act and conservation prioritization of butterflies of the Western Ghats, southwestern India. *Curr. Sci.*, 94: 729– 735.
5. **Kunte, K. J, 2011.** Biogeographic origins and habitat use of the butterflies of the Western Ghats, south-western India. *In* D. R. Priyadarshan, K. A. Subramanian, M. S. Devy & N. A. Aravind (eds.) *Invertebrates in the*

Western Ghats - Diversity and Conservation. Ashoka Trust for Research in Ecology and the Environment, Bengaluru. *In press*.

6. **Mohan M., Chamdran, M. S. S. & Ramasamy, E. V. 2011.** Vulnerable earthworms species identified from Nilgiri Biophere Reserve. *Int. J. Zool. Res.,* 7 (6): 410-413.
7. **N.A. Madhyastha* and N.A. Aravind 2013.** Theme Paper on Land Snails of the Western Ghats, http://www.academia.edu/1799871/Thematic_paper_on_land_snails_of_WG_FINAL, accessed on 13/2/2013.
8. **Rajmohana and Radhakrishnan 2008.** *Western Ghats - A hotspot of biological wealth*. Published Zoological survey of India. 32 pages.
9. **Sudhikumar AV, J. P. Maelfait, L. Lens and P. A. Sebastian 2009.** African and Southeast Asian elements in Spiders fauna of the Western Ghat of India. *Contributions to Natural History*, (Bern) 23(1): 165 – 170.

Vertebrate Faunal Diversity of Western Ghats

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Abstract

Western Ghats is recognized as one of the most important centers of vertebrate faunal diversity in the Indian subcontinent. It is the unique topography, tropical climate and the geographical spread of Western Ghats that has created a wide range of habitats which suit a rich assemblage of faunal wealth. Among the vertebrates, birds represent the largest number of species (508 species), followed by fishes (290spp), reptiles (203spp), mammals (137spp) and amphibians (181spp). Of the 137 species of mammals known from Western Ghats, 16 (11.7%) are endemic to the region. Chiroptera along with Insectivora and Rodentia constitute more than 66% of the mammalian fauna of the region. With distinct climatic and vegetation zones, the Western Ghats is home to 508 species of birds. Of these, 16 species (3%) are endemic to the region. Altogether 203 species of reptiles belonging to 77 genera under 18 families have been recorded from the Western Ghats. Of these, 124 species (61.08%) are endemic to the zone. The list includes a species of crocodile, 7 species of turtles & tortoises, 89 species of lizards and 106 species of snakes. Of the 181 species of amphibian known from the Western Ghats, 159 species (87.84%) are endemic to the region. Among Amphibia, the family Rhacophoridae popularly called 'the old world tree frogs or bush frogs' are the most diverse in the region. A total of 290 species of fishes were recorded from Western Ghats, of which 118 (41%) are endemic to the area. An analysis of distributional patterns shows that southern Western Ghats are more species-rich than the northern and central regions. Family Cyprinidae, which includes the carps and true minnows form the most speciose group among fishes. Twelve genera of freshwater fishes namely *Betadevario*, *Dayella*, *Horabagrus*, *Horalabiosa, Hypselobarbus*, *Indoreonectes*, *Lepidopygopsis*, *Longischistura*, *Mesonoemacheilus*, *Parapsilorhynchus*, *Rohtee* and *Travancoria*, are endemic to the Western Ghats.

Key words: Western Ghats, Vertebrates, Diversity, Endemism

Introduction

Western Ghats, a 1600 km long mountain chain, encompassing an area of 1,60,000 km^2, running parallel to the west coast of India, along the Arabian Sea, is one of the global biodiversity hot spots. The unique topography, tropical climate and the geographical spread of Western Ghats has created a wide range of habitats that suit a rich assemblage of faunal wealth. Western Ghats is recognized as one of the most important centers of vertebrate faunal diversity in the Indian subcontinent. There was no concerted effort to compile the available information on various groups of animals in the Western Ghats, which is considered as a biodiversity hotspot. The region has an estimated total of 305 vertebrate endemics which forms above 0.9% of the world's total (Swengel, 1990 & 1993). Hence, we made an attempt to compile the faunal diversity of vertebrate fauna of the Western Ghats through existing literature and studies. Among the vertebrates, birds represent the largest number of species (508 species), followed by fishes (290 spp), reptiles (203 spp), mammals (137 spp) and amphibians (181 spp) (Table 1).

Table 1: The details of vertebrates recorded from India and Western Ghats

Group	India	Western Ghats
Mammals	397	137
Birds	1232	508
Reptiles	518	203
Amphibians	311	181
Fishes	800	290

Mammals

Altogether 137 species of mammals under 77 genera in 29 families belonging to 10 orders are known from Western Ghats, 16 (11.7%) are endemic to the region (Nameer et al, 2001). Chiroptera is the largest order with 52 species in seven families, followed by rodents (31 species in 3 families), Carnivora (25 species in 7 families), Artiodactyla (11 species in 4 families), Insectivora (9 species in 2 families), Primates (5 species in 2 families), Lagomorpha (1sps in 1 family) and Scandentia, Proboscidea, Pholidota and Lagomorpha with one species each in one family. Chiroptera along with Insectivora and Rodentia constitute more than 66% of the mammalian fauna of the region. The bat fauna of Western Ghats belongs to two suborders, eight families and 25 genera. Microchiroptera is the largest suborder contributing to 88% of bat species (46 species) with seven families, of which Vespertilionidae is the most abundant family contributing 40% of the bat fauna of the Western Ghats. Family Hipposideridae (containing leaf nosed bats) is the second dominant family with 14% total of species. Of the 52 species 84% are insectivorous, 12% are frugivorous and 2% are carnivorous (Korad et al, 2007). The suborder Megachiroptera represented with 6 species of fruit bats from Western Ghats. Of these, Salim Ali's Fruit Bat, *Latidens salimalii* is endemic to the Western Ghats. Nearly 35% of the bat fauna of the Western Ghats are threatened globally or nationally. Two of the endemic Primate species- Nilgiri Langur, *Tachypithecus johnii* and Lion-tailed Macaque, *Macaca sielnus* - are known from a few populations in evergreen patches of southern Western Ghats. The most endangered ungulate, Nilgiri Tahr, *Nilgiritragus hylocrius* also known from 20 odd localities in higher elevations between Nilgiris and Ashambu Hills in southern Western Ghats. The Malabar Civet, *Viverra civettina* is considered to be one of the world's rarest mammals and listed in 'Critically endangered' category of the IUCN is found exclusively in southern Western Ghats. The murines Bonhote's Mouse, *Mus famulus,* Nilgiri Long-tailed Tree-mouse, *Vandelueria nilgrica* and Sahyadri Forest Rat, *Rattus satarae* form the endemics of the tropical rain forests in the Western Ghats.

Avifauna

With distinct climatic and vegetation zones, the Western Ghats is home to 508 species of birds. Of these, 16 species (3%) are endemic to the region. Both the Western Ghats and the island of Sri Lanka are considered as Endemic Bird Areas by Bird Life International (Sattersfield et al., 1998). Of the 16 endemics, seven are found all along the entire length of the Ghats. Five of the endemics are particularly associated with wet temperate sholas and subtropical broad leaf hill forest. The Nilgiri Laughingthrush *G. cachinnans*, is restricted to just the Nilgiri Hills, where it replaces the more widespread Grey-breasted Laughingthrush *G. jerdoni.* Species like Nilgiri Pipit *Anthus nilghiriensis* and Broad-tailed Grassbird, *Schoenicola platyura* are restricted to the montane grassland ecosystems of the southern Western Ghats. In recent years, many of our endemic species are included in the threatened category of IUCN Redlist.

Reptiles

Since the publications of Gunther, 1864, Boulenger, 1890 and Smith, 1931,1935, 1943, our knowledge on the reptile fauna of the Western Ghats has been enriched further by the publications of Sharma (1977, 1981, 1998, 2002, 2007), Inger *et al.*, 1984,1987, Murthy (1985, 1994, 2010), Das (1991, 1997, 2003), Tikader & Sharma (1992), Daniels and Daniels (1992), Das & Bauer (2000), Das & Sengupta (2000), Daniel (2001), Daniels (2000, 2001), Whitaker and Captain (2004), Mukherjee and Bhupathy (2007), Gower and Winkler (2007), Manamendra-Arachchi *et al.* (2007), Krishnan (2008), Giri (2008), Giri & Bauer (2008), Giri, *et al.* (2009a), Giri *et al.*(2009b), Van Rooijen and Vogel (2009), Vasudevan, K (2009), Venugopal (2010) and Agrawal *et al.,* (2011). Altogether 203 species of reptiles belonging to 77 genera under 18 families have been recorded from the Western Ghats. Of these, 124 species (61.08%) are endemic to the zone. The list includes a species of crocodile, 7 species of turtles & tortoises, 89 species of lizards and 106 species of snakes (Table 2).

Table 2: Diversity composition and endemism in reptiles of Western Ghats

Reptile Groups	Diversity in India	Diversity in W. Ghats	Endemic to W. Ghats	% Endemism
Crocodiles	3	1	-	-
Turtles	34	7	2	28.6%
Lizards	202	89	56	62.9%
Snakes	279	106	66	62.2%
Total	**518**	**203**	**124**	**61.08%**

Crocodylia (Crocodiles)

The Family Crocodylidae is represented by a single species, the Marsh Crocodile (*Crocodylus palustris*). Though wide spread in distribution, the Marsh Crocodile is threatened with extinction. Human population has decimated the natural populations of Marsh Crocodiles in most of their old ranges in the Western Ghats. Nevertheless, there are still small protected populations of the species in Chinnar Wildlife Sanctuary (WLS), Waynad WLS and Parambikulam Tiger Reserve (TR) in Kerala and Bhadra TR and in the riverine areas of Cauvery and other major rivers in Karnataka. The species is known to be hunted for skin trade and for body parts in domestic as well as international markets. The species is listed in the Schedule-I of the Indian Wildlife (Protection) Act of 1972 and Appendix-I of the CITES.

Chelonia (Turtles & Tortoises)

There are 7 species of chelonians (turtles & tortoises) belonging to 7 genera under 3 families reported from Western Ghats. Among them, the Cochin Cane Turtle (*Vijayachelys silvatica*) and the Travancore Tortoise (*Indotestudo forstenii*) are endemic to Western Ghats. Both the endemics are known only from the States of Tamil Nadu, Kerala and Karnataka. The Leith's Softshell Turtle (*Nilssonia leithii*) is reported only from a very few rivers in Western Ghats and is endemic to Peninsular India. The Indian Star Tortoise (*Geochelone elegans*) is restricted to the drier tracts of the Country and is known only from very few localities in Western Ghats. Pet trade is one of the major threats to these tortoises and large number of animals is illegally collected from their habitats, for local, national and international pet markets. Even though the larger soft-shell turtles are known mainly from the coastal areas of the country, the Leith's Soft-shell Turtle (*Nilssonia leithii*) and Giant Soft-shell Turtle (*Pelochelys cantorii*) are reported from the rivers of foothills of Western Ghats. Freshwater turtle species are being heavily exploited for its flesh and eggs and for their supposedly medical properties. Species such as the Indian Flapshell Turtle (*Lissemys punctata*), Giant Softshell Turtle (*Pelochelys cantorii*) and the Cochin Cane Turtle are listed in Schedule-I of the Indian Wildlife (Protection) Act, 1972.

Sauria (Lizards)

Altogether 89 species of lizards belonging to 22 genera under 6 families have been recorded from the region, of which 56 are endemic to the Western Ghats. The most dominant family is Gekkonidae (Geckos) represented with 41 species followed by Scincidae (Skinks) with 23 species and Agamidae (Calotes) with 14 species. The genera *Ristella* and *Kaestlea* are entirely endemic to Western Ghats and represented with 4 and 5 species respectively. A few undescribed species of lizards have been discovered through recent studies (Das & Bauer, 2000; Bauer,2002; Giri *et al*, 2003; Mukherjee *et al*, 2007; Manamendra-Arachchi et al. 2007; Giri, 2008; Giri & Bauer ,2008; Krishnan, 2008; Giri *et al,* 2009). The Agamid *Draco dussumieri*, the only south Indian Flying Lizard, is fairly well distributed in the Western Ghats. The Genus *Cnemaspis,* commonly called Dwarf Day Geckoes, contain maximum number of species endemic to the Western Ghats. Of the 19 species of Day Geckos known from the Western Ghats, 16 are endemic to the Ghats. Among them, *Cnemaspis sisparensis* is considered critically endangered (Sarkar, 2011). Very little is known of these small forest geckoes which are largely tree-dwelling. Recently, a taxonomic review of the distribution of Indian lizards was published by Venugopal (2010). Based on this review work, *Cnemaspis kandiana* (Kelaart, 1852), *Cnemaspis anaikattiensis* (Mukherjee et al., 2005) and *Chalcides pentadactylus* Beddome (1870) are not included in the present list.

Serpentes (Snakes)

Of the 106 species of snakes belonging to 42 genera under 7 families are recorded from Western Ghats, 66 species are endemic to the Ghats (62.2%). Many of the endemics are from the family Uropeltidae, a group of burrowing snakes, represented by 35 species. It is however, cryptic and its diversity is not well understood. Most of them are known only from their type localities. The only comprehensive study available on uropeltid snakes in the recent past is that of Rajendran (1985). He emphasized the need for conservation of this unique family which is vanishing due to habitat destruction and land use changes in the Western Ghats. Much of their habitats in the Western Ghats have been replaced by plantations of tea, wattle, pine and eucalyptus.

The most diverse snake family in the Western Ghats is Colubridae, represented with 49 species followed by Uropeltidae with 35 species. The genus *Xylophis* is endemic to Western Ghats and represented by 3 species. All the five major venomous snakes known from India, *viz.* King Cobra, *Ophiophagus hannah*, Indian Cobra, *Naja naja*, Russel's Viper, *Daboia russelli*, Saw-scaled Viper, *Echis carinata* and the Indian Krait, *Bungarus caeruleus* are fairly well represented in Western Ghats. The world's largest venomous snake the King Cobra is mainly seen in the low land evergreen or moist deciduous forests in the Ghats, while, the Saw-scaled Viper is mostly distributed in the drier areas of the Ghats. The family Viperidae is also represented with 6 species of Pit vipers from Western Ghats. Of these, 5 species are endemic to southern India and the Hutton's Pit Viper (*Tropidolaemus huttoni*) is extremely rare and known only from the two specimens collected from High wavy Mountains of Tamil Nadu in southern Western Ghats (David and Vogel, 1998). In the recent past, 7 new species of snakes were also described from the southern part of Western Ghats - *Oligodon nikhili* (Whitaker and Dattatri, 1982), *Eryx whitakeri* (Das,1991), *Xylophis captaini* (Gower and Winkler, 2007*), Lycodon flavicollis* (Mukherjee and Bhupathy, 2007) *Dendrelaphis ashoki* (Vogel and Rooijen, 2011), *Dendrelaphis girii* (Vogel and van Rooijen,

2011) and *Calliophis castoe* (Smith et al., 2012). Of the seven new species of snakes, *Eryx whitakeri* is widely distributed from Goa to Kerala, where as all the other new species are known only from the vicinity of their type locality.

Amphibians

India is known to have 311 species of amphibians (Dinesh *et al.,* 2010) among the 6638 species amphibians reported from the World (Frost, 2010). Western Ghats harbours 181 species of amphibians, under 27 genera and 11 families. Of these, 157 species are frogs and 24 species, caecilians. Of the 181 species of amphibian known from the Western Ghats, 159 species (87.84%) are endemic to the region. Among amphibia, the family Rhacophoridae popularly called 'the old world tree frogs or bush frogs' are the most diverse in the region. Discovery of amphibians in Western Ghats was initiated during the year 1799 and it continued in a slow pace till the year 2000. However, the last decade of the 20th century marked the spurge in amphibian discovery mainly credited to the work of Biju and his team, who discovered more than 30 species new to science and a new family Nasikabatrachidae. One of the interesting recent discoveries from the region pertains to that of a new species of frog of the Indo-Madagascan line, namely, the Purple or Pig-nosed Frog, *Nasikabatachus sahyadrensis*. 16 species of Western Ghat frogs- Anamalai Flying Frog, *Rhacophorus psuedomalabaricus*, Gundia Indian Frog*, Indirana gundia*, Kerala Indian Frog, *Indirana phrynoderma*, Kottigehar Bubble-nest Frog, *Micrixalus kottigeharensis*, Amboli Bush Frog, *Psuedophilautus amboli*, Chalazodes Bubble-nest Frog, Raorchestes *chalazodes*, Small Bush Frog, *Raorchestes chotta*, Green-eyed Bush Frog, *Raorchestes chlorosoma*, Griet Bush Frog *Raorchestes grieti*, Kaikatt's Bush Frog, *Raorchestes kaikatti*, Mark's Bush Frog, *Raorchestes marki*, Munnar Bush Frog *Raorchestes munnarensis*, Large Ponmudi Bush Frog, *Raorchestes ponmudi*, Resplendent Bush Frog *Raorchestes resplendens* and the Sushil's Bush Frog, *Raorchestes sushili* are listed in the Critically endangered category of the IUCN Redlist (Anonymous, 2011).

Fishes

A total of 290 species of fishes were recorded from Western Ghats, of which 118 (41%) are endemic to the area. An analysis of distributional patterns shows that southern Western Ghats are more species-rich than the northern and central regions. Family Cyprinidae, which includes the carps and true minnows form the most speciose group among fishes. Twelve genera of freshwater fishes namely *Betadevario*, *Dayella*, *Horabagrus*, *Horalabiosa,* *Hypselobarbus*, *Indoreonectes*, *Lepidopygopsis*, *Longischistura*, *Mesonoemacheilus*, *Parapsilorhynchus*, *Rohtee* and *Travancoria*, are endemic to the Western Ghats.

Studies indicate that several species of fishes are endangered and many facing the threat of extinction. Experts are of the opinion that the alteration of the river hydrology by the construction of impoundments is one of the major reasons for the decline of hill stream fishes. The population of the highly specialized loaches dwindled in the upper streams. The unsustainable mode of exploitation is attributed to decline of the low land species. Surveys indicate that *Channa* sp (Snake head), *Puntius* (Carps), *Clarias* (catfish)*, Wallag* (Freshwater shark) declined considerable within in the last two decades due to fishing by dynamiting and fish poisoning. The land reclamation by earth filling reduced the available habitat also a threat to the species. The application of the insecticides and pesticides removed several species from the niche. Heavy siltation during the monsoon raises serious concern in Northern Kerala. Large-scale sand mining and pollution in several rivers (especially Periyar) made the habitat totally unsuitable for the fishes.

The principal threat to the vertebrate fauna in Western Ghats is due to habitat destruction caused by anthropogenic activities. Forest fire, burning of ground vegetation for agricultural practices and over-grazing of cattle and uncontrolled use of chemical fertilizers, pesticides, and herbicides also disturb the habitats. Yet another threat is the increasing demand for skin of animals and body parts for alleged medicinal properties and commercial purposes. Many of the vertebrate species are exported for illegal pet trade in international market. Water pollution, damming of rivers, channelization and sand mining, illegal methods of fishing are known to affect the populations of aquatic animals, especially fishes, frogs and turtles. Rapid urbanisation and developmental activities in the Ghats also poses threat to the fauna in general. Road kills and habitat fragmentation adds significantly to the loss of herpetofauna from the fragile forest ecosystems in the Western Ghats.

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References

1. **Alfred, J.R.B., Das, A.K. and Sanyal, A.K. (Eds.) 1998.** *Faunal Diversity in India.* Zoological Survey of India, Calcutta.
2. **Anonymous. 2011.** *Critically endangered animal species of India*. 1-22. Published by the director Zoological Survey of India.
3. **Swengel, F.B. 1990.** A checklist of endemic vertebrates of the Western Ghats region .*Nilgiri Tahr*. North American Regional stud Book. Minnesota Zoological garden, USA. 4-13.
4. **Swengel, F.B. 1993.** Endemic vertebrates of the of the Western Ghats region- An update. *Nilgiri Tahr*. North American Regional stud Book update. Minnesota Zoological garden, USA. 12-13.
5. **Aengals, R., Sathish Kumar, V.M. and M.J. Palot. 2011.** Updated Checklist of Indian Reptiles. http://zsi.gov.in/checklist/Checklist%20of%20Indian%20 Reptiles.pdf (online version).
6. **Agrawal, I., Giri, V.B. and A.M. Bauer. 2011.** A new cryptic rock-dwelling *Hemidactylus* (Squamata: Gekkonidae) from South India. *Zootaxa*, 2765: 21-37.
7. **Bauer, A. M. 2002**. Two new species of *Cnemaspis* (Reptilia: Squamata: Geckonidae) from Gund, Uttar Kannada India. *Mitteilungen Hamburg Zoological Museum & Institution*. 99: 155-167.
8. **Boulenger, G.A. 1890.** *The fauna of British India including Ceylon and Burma: Reptilia and Batrachia.* London, viii+541pp.
9. **Daniels, A.E.D and R.J.R. Daniels. 1992.** An account of the herpetofauna in Western Ghats of Kanyakumari district of Tamilnadu. *Cobra,* 10:3-7.
10. **Daniel, J C. 2002.** *The Book of Indian Reptiles*. Bombay Natural History Society, Bombay, 141pp.
11. **Daniels, R.J.R. 2000.** Reptiles and Amphibians of Karnataka. *Cobra*, 42:1-11.
12. **Daniels, R.J.R. 2001.** Reptiles and Amphibians of Karnataka. *Cobra*, 44:11-17.
13. **Daniels, R.J.R. 2001.** Amphibians and reptiles of the Tamilnadu Eastern and Western Ghats. *Cobra*, 43:1-8.
14. **Das, I. 1991.** A new species of *Eryx* (Boidae: Serpentes: Squamata) from south-western India. *J. Bombay Nat. Hist. Soc.,* 88 (1): 92-97.
15. **Das, I. 1991.** A new Species of *Mabuya* from Tamil Nadu State, southern India (Squamata: Scincidae). *Journal of Herpetology,* 25(3): 342-344.
16. **Das, I. 1997a.** Checklist of the Reptiles of India with English Common name *Hamadryad*, 22: 32-45.
17. **Das, I. & A.M. Bauer. 2000.** Two new species of *Cnemaspis* (Sauria: Gekkonidae) from southern India. Russian *Journal of Herpetology,* 7(1): 17-28.

18. **Das, I. 2003.** Growth of Knowledge on the Reptiles of India, with an Introduction to Systematics, Taxonomy and Nomenclature. *J. Bombay nat. Hist. Soc.*, 100 (2&3): 447-501.
19. **David, P and G. Vogel. 1998.** Redescription of *Trimeresurus huttoni* SMITH, 1949 (Serpentes: Crotalinae) with a discussion of its relationships. *Hamadryad,* 22 (2): 73-87.
20. **Dinesh, K.P., Radhakrishnan, C. and A. Zachariah. 2010.** A checklist of Amphibia of Kerala. *Malabar Trogon.* Vol 8 (1): 8-13.
21. **Dinesh, K.P., C. Radhakrishnan, K.V. Gururaja and G. Bhatta. 2009.** An annotated checklist of Amphibia of India with some insights into the patterns of species discoveries, distribution and endemism. *Records of Zoological Survey of India, Occasional Paper* No. 302: 1-152pp.
22. **Giri, V.B. 2008.** A new rock dwelling *Hemidactylus* (Squamata: Gekkonidae) from Maharashtra India. *Hamadryad* 32: 25–33.
23. **Giri, V.B. & M. A. Bauer. 2008.** A new ground-dwelling *Hemidactylus* (Squamata: Gekkonidae) from Maharashtra with a key to the *Hemidactylus* of India. *Zootaxa,* 1700: 21-34.
24. **Giri, V.B., A.M. Bauer, R. Vyas & S. Patil. 2009a.** New Species of Rock-Dwelling Hemidactylus (Squamata: Gekkonidae) from Gujarat, India. *Journal of Herpetology,* 43(3): 385–393
25. **Giri, V.B., A.M. Bauer & K.S. Gaikwad. 2009b.** A new ground-dwelling species of *Cnemaspis* Strauch (Squamata: Gekkonidae) from the northern Western Ghats, Maharashtra, India. *Zootaxa,* 2164: 49-60.
26. **Gower, D.J. & J. D. Winkler. 2007.** Taxonomy of the Indian snake *Xylophis* Beddome (Serpentes: Caenophidia) with description of a new species. *Hamadryad,* 31(2):315-329.
27. **Gunther C.L.C Albert. 1864.** *The Reptiles of British India.* Published by Oxford &IBH Publishing Co. New Delhi. 452pp.
28. **Korad, V., Yardi, K., and Raut, R. 2007.** Diversity and distribution of bats in the Western Ghats of India. *Zoos' Print Journal*, 22, 2752-2758.
29. **Inger, R.F., Shaffer, H.B., Koshy, M and R. Bakde. 1984.** A report on the collection of amphibians and reptiles from Ponmudi, Kerala, south India*. J. Bombay nat. Hist. Soc.*, 81:406-427 and 551-570.
30. **Inger, R.F., Shaffer, H.B., Koshy, M and R. Bakde. 1987.** Ecological structure of a herpetological assemblage in south India. *Amphibia- Reptilia*, 8:189-202.
31. **Krishnan, S. 2008.** New Species of *Calotes* (Reptilia: Squamata: Agamidae) from the Southern Western Ghats India. *Journal of Herpetology,* 42(3): 530-535.
32. **Manamendra-Arachchi, K., S. Batuwita & R. Pethiyagoda. 2007.** A taxonomic revision of the Sri Lankan day-geckos (Reptilia: Gekkonidae: *Cnemaspis*), with description of new species from Sri Lanka and southern India. *Zeylanica,* 7 (1): 9-122.
33. **Murthy, T.S.N. 1985.** Classification and distribution of the Reptiles of India. *The Snake,* 17: 48-71.
34. **Murthy, T.S.N. 1985.** A field guide to the Lizards of Western Ghats. *Rec. zool. Surv. India. Occ. Paper* No.72, 51pp.
35. **Murthy, T.S.N. 1994.** An updated hand list of the reptiles of India. *Cobra,* 17: 17-37.
36. **Murthy, T.S.N. 2010.** *The Reptile Fauna of India.* Published by B.R. Publishing Corporation, New Delhi.
37. **Mukherjee, D & S. Bhupathy. 2007.** A new species of wolf snake (Serpentes: Colubridae: *Lycodon*) from Anaikatti Hills, Western Ghats, Tamil Nadu, India. *Russian Journal of herpetology,* 14(1):21- 26.
38. **Molur, S. & S. Walker. 1998**. (Eds). Report of BCCP CAMP on Reptiles of India. Zoo Outreach Organisation, Coimbatore, India, 65pp.
39. **Pradhan, M.S. 2008.** Reptilia. In: *Fauna of Goa, State Fauna Series*, 16: 281-364. Zoological Survey of India, Kolkata.

40. **Radhakrishnan, C. 1998.** Reptiles. In: *Natural Resources of Kerala*. (Eds.) WWF- India, Kerala Chapter, Thiruvananthapuram.
41. **Rajendran, M.V., 1985.** *Studies in uropeltid snakes*. Madurai (India): Publication Division, Madurai Kamaraj University, VI (unnumbered) + 132 pp.
42. **Vogel, G and J. van Rooijen. 2011.** A new species of *Dendrelaphis* (Serpentes: Colubridae) from the Western Ghats – India" . *Taprobanica* **3** (2): 77–85
43. **Sarkar. J. 2011.** Critically endangered Indian animals. *Current Science*, 100 (11): 1608-1609.
44. **Sattersfield, A.J., Crosby, M.J., Long A.J and D.C. Wege. 1998.** Endemic Bird Areas of the World-Priorities for Biodiversity Conservaiton. Birdlife Conservation Series No.&. Birdlife International. U.K. 846pp.
45. **Sharma R.C. 1977.** A new lizard of the genus Riopa Gray (Scincidae) from Tamil Nadu, India. *Records of the Zoological Survey of India,* 73(1-4): 41-44.
46. **Sharma, R.C. 1981.** *Hemidactylus porbandarensis,* a new geckonid lizard from Gujarat India. *Bulletin of the Zoological Survey of India,* 4(1): 1-2.
47. **Sharma, R.C.1998.** *Fauna of India and the adjacent countries–Reptilia (Testudines and Crocodilia). Vol.***I**. (Published by the Director, Zoological Survey of India, Kolkata).196pp. The Western Ghats.
48. **Sharma, R.C.2002.** The *fauna of India and the adjacent countries. Reptilia (Sauria). II* (Published by the Director, Zoological Survey of India, Kolkata). 430pp.
49. **Sharma, R.C.2007.** The fauna of India and the adjacent countries. *Reptilia (Serpentes) -111* Published by the Director, *Zool. Surv. India*, Kolkata.410pp.
50. **Smith, M.A. 1931.** *The fauna of British India including Ceylon and Burma, including the whole of Indo-Chinese Sub--Region: Vol.1.Loricata, Testudines* Taylor and Francis, London. (Reprinted 1974, 1995 by Today and Tomorrow's Printers and Publishers, NewDelhi).
51. **Smith, M. A. 1935.** *The fauna of British India including Ceylon and Burma, including the whole of Indo-Chinese Sub—Region:* Vol II. Sauria. Taylor and Francis, London. (Reprinted 1974, 1995 by Today and Tomorrow's Printers and Publishers, NewDelhi).
52. **Smith, M. A. 1943.** *The fauna of British India including Ceylon and Burma, including the whole of Indo-Chinese Sub—Region: Vol III. Serpentes*. Taylor and Francis, London. (Reprinted 1974, 1995 by Today and Tomorrow's Printers and Publishers, NewDelhi).
53. **Smith, E.N, Ogale, H, Deepak, V and V.B. Giri. 2012.** A new species of coralsnake of the genus *Calliophis* (Squamata: Elapidae) from the west coast of Peninsular India. *Zootaxa*. 3437: 51-68.
54. **Tikader, B.K & R.C. Sharma. 1992.** *Handbook of Indian Reptiles*. Zoological Survey of India, Calcutta. 250pp+ 42plates.
55. **Van Rooijen, J. & G.Vogel. 2009.** A multivariate investigation into the population systematics of *Dendrelaphis tristis* (Daudin, 1803) and *Dendrelaphis schokari* (Kuhl, 1820): revalidation of *Dendrophis chairecacos* Boie, 1827 (Serpentes: Colubridae). *The Herpetological Journal*, 19: 193-200.
56. **Venugopal, P.D. 2010.** An updated and annotated list of Indian lizards (Reptilia: Sauria) based on a review of distribution records and checklist of Indian reptiles. *Journal of Threatened Taxa,* 2 (3):725-738.
57. **Venugopal, P.D. 2010.** Addentum to *An updated and annotated list of Indian lizards (Reptilia: Sauria) based on a review of distribution records and checklists of Indian Reptiles*. *Journal of Threatened Taxa, 2*(4):848.
58. **Whitaker, R and S, Dattatri. 1982.** A new species of *Oligodon* from the Palni Hills, South India (Serpentes: Colubridae). *J. Bombay Nat. Hist. Soc.*, 79 (3): 630-631.

59. **Whitaker, R. and Captain, A. 2004.** *Snakes of India. The Field Guide*. Draco Books. Chengalpattu, Tamil Nadu, xiv+479, pls, text-figs.

60. **Vasudevan, K. (Ed.). 2009.** *Freshwater Turtles and Tortoises of India*. ENVIS Bulletin: Wildlife and Protected Area, Vol1. 2(1). Wildlife Institute of India. Dehradun. Pp.177.

61. **Vogel, G. and J.Van Rooijen 2011.** Contributions to a Review of the *Dendrelaphis pictus* (Gmelin, 1789) Complex (Serpentes: Colubridae)—3. The Indian Forms, with the Description of a New Species from the Western Ghats. *Journal of Herpetology,* 45 (1): 100-110.

62. **Vyas, R. 1998.** The reptiles of Gujarat state: Updated distribution. *Tiger Paper,* 25(1): 8-14.

Tribal Diversity of the Western Ghats and Conservation of Traditional Knowledge System

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Abstract

Conservation of Western Ghats is the management of its biodiversity, which is a home of thousands of species of flora and fauna and the indigenous population who have been playing a great role in preserving its biodiversity for centuries. Western Ghats constitute a range of hills running parallel to the Arabian Sea with a length of about 1300 km and passing through the States of Kerala, Tamilnadu, Karnataka, Goa and Maharashtra. The forests of Western Ghats can be mainly grouped into two types: Tropical moist forests and Tropical dry forests. The Kerala part of the Western Ghats covers about 450 km long stretch, accounting for 56 percent of the geographical area of the State The eco specific and ethno specific Scheduled Tribes are inhabitants of this region

India's first Forest Policy dates back to over hundred years.Under the British Rule the Sate established monopoly control over Forests , reserved large tracts for extraction of timber and other developmental activities and encouraged plantation of commercially profitable species. After independence, state monopoly over forests continued with extension and strengthening of the British Policies. Even curtailment of local peoples who are the original autochthones of the region the right to collect ntfp gave hurdles to forest conservation. . Further with the degradation of forests, the life of local people, who live inside or in the periphery of forest land depending on its sustenance deteriorated,. Only when the preservation need coincides with the interest of the local community can forests be effectively protected. The effective implementation of the participatory forest management promotes regeneration, management, protection of degraded forest tracts etc.

The major tribal belts of Kerala are Wayanad, Attappady and Idukki Districts, bordering Karnataka and Tamilnadu. They belong to different economic categories and vary in population from less than 400 members like the Cholanaickan of Nilambur to more than 90,000 like the Paniyan of Wayanad. The hills have recently witnessed a very comprehensive conservation prioritization and planning exercise by the Western Ghats Ecology Expert Panel (WGEEP), which suggests an intelligent and democratic zonation plan with varying levels of exploitation. The tribal communities inhabiting the Western Ghats are a treasure trove with regard to their traditional agricultural practices, plant life, animal life , culinary recipes etc. The tribals have coexisted with nature for centuries in quiet harmony with rich traditional knowledge and cultural life. The Convention of Biodiversity in 2012 pledges to 'integrate traditional knowledge and practices of indigenous and local communities relevant for conservation of Biodiversity. This paper explores the various tribal communities of Kerala and the steps taken for the conservation of their traditional knowledge system.

Key words: Conservation, Bio-Diversity, Scheduled Tribes, Traditional Knowledge, Forest Rights Act

Conservation of the Western Ghats, WGEEP Report and the issues

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Abstract

Western Ghats, one of the 35 hotspots and one of the 10 "hottest spots" of biodiversity in the world, serves as a huge water tank for the states through which it is passing through, apart from all other ecosystem services that they offer. 28 crores of people living in the Western Ghats' states depend mainly on the Ghats for water for drinking and irrigation. However, the rise of plantations in the high ranges debilitated the ecology of Kerala, as they came up at the cost of gorgeous rainforests that clad the high ranges giving salubrious climate, copious rain; birth to 41 west flowing rivers and thus playing a vital role in the hydrological cycle linking the highland, midland and coastal areas that lay the foundation for sustainable development in Kerala. Degradation started since the 1800s; the evergreen forests have been reduced merely to 7.5%; in Karnataka, Kerala and Tamil Nadu alone 40% of original primary forest was lost. Indiscriminate grazing, illegal hunting, over-exploitation of NTFPs, plantations, human settlements by encroachments, pollution from chemical industries in the vicinity of forests, man-made fire, illegal quarrying & mining, excessive tourism, and construction of dams are some of the other major threats.

Realising these growing threats to the Western Ghats ecosystem, the Ministry of Environment and Forest appointed the Western Ghats Ecology Expert Panel (WGEEP) to suggest ways and means to restore the ecology of the Ghats while ensuring the livelihood of the people living there.

The WGEEP considered the entire Western Ghats as an Ecologically Sensitive Area. For the purpose of conservation and sustainable development, a layered approach was suggested; most significant area, moderately significant area and less significant area – Ecologically Sensitive Zone 1, 2 and 3 respectively. Major parameters used for the zoning are, biological, geological, historical, cultural, social, contiguity of habitats to the existing PAs and, catchments around the origin of rivers. The entire Western Ghats was divided into 2200 grids (9 x 9 km) and, a score (1 to 10) was given for each of the parameter depending on its presence in each quadrate. Average of the score obtained by each quadrate decides the Zone; if the score is <3 it falls in ESZ3, > 3 but less than < 5 in Zone2 and, > 5 up to 10 in Zone 1.

Activities encouraged, discouraged and banned in each of the Zone are given. However, the final decision to demarcate each zone and the activities to be undertaken is vested with the Local Self Governments. The report is giving only a scientific support system to take decision on sustainable development while promoting nature conservation. The very philosophy of the WGEEP Report is that both conservation and development should be inclusive of people. There are no recommendations for translocation of people either for conservation or for development. It gives measures for encouraging organic farming, while discourages all kinds of polluting industries. All activities which are detrimental to the people and ecosystem are either discouraged or banned. On the whole, the report centres on improving the livelihood of the people ensuring ecological security.

Key words: Western Ghats, threats, conservation, WGEEP report, recommendations

Biodiversity and Food Security

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Abstract

Hunger and poverty are the two worst problems affecting humanity in South Asia and sub- Saharan Africa. Implementation of United Nation's millennium development goals for the last 5 years did not make expected results towards alleviation of these issues. Apart from conventional breeding programmes, exploration, conservation, sustainable utilization and equitable sharing of the benefits of biodiversity and utilization of traditional knowledge on agribiodiversity utilization would go a long way towards fulfillment of MDGs. For example, indigenous salt resistant varieties of rice, energy and nutrient rich tubers such as sweet potato have tremendous potential in food security in the above mentioned nations. Exploration of Agrobiodiversity might lead to enhancement of productivity, development of new varieties of crops such as climate resilient varieties, preparation of value-added commercial products and employment generation. An action plan comprising law, planning, administration and research for strengthening application of Agrobiodiversity for socio-economic development is suggested.

Key words: Agrobiodiversity, conservation, hunger, poverty, food security

Introduction

From the earliest days of domestication of plants for human use about 12000 years ago, agricultural biodiversity has played a pivotal role in sustaining and strengthening food, nutrition, health and livelihood security all over the world. In spite of enormous progress made in enhancing crop productivity through mendelian and more recently molecular breeding , more than 800 million children, women and men are under-nourished. The majority of them are in South Asia and Sub-Saharan Africa, *areas of the globe that are rich in endemic agricultural biodiversity.* Reducing hunger and poverty by half by the year 2015 is the first of the UN Millennium Development Goals (MDGs), which represent a global common minimum programme for universal human security and well-being. An assessment made five years after the adoption of the MDGs indicates that progress in reducing hunger and poverty is inadequate.

- 230 million people in rural India are undernourished.
- They account for 27% of the world's under-nourished population – the highest for any country.
- Almost 40% children below 3 are under-weight and 45% are stunted.
- Incidence of anaemia has gone up since 2001 from 74% to 78% in children below 5 and from 52% to 56% in young women.
- 40% women suffer from chronic energy deficiency.
  (Report on the State of Food Insecurity in Rural India WFP&MSSRF 2008)

Who are the Hungry? Where are they?

- South Asia and Sub-Saharan Africa are the major hunger spots.
- 50% of the hungry belong to rural small farmer households.
- 10% are pastoralists, fisher folk and forest users.
- 20% are rural landless
- 20% live in urban areas.

Hunger is classified into Endemic hunger, Hidden hunger, Transient hunger. Endemic hunger is caused by protein-energy malnutrition. Hidden hunger is caused by deficiencies of iron, iodine, zinc, Vitamin A, and other micronutrients in the diet. Transient hunger is caused by drought, floods, and other natural disasters. These can be overcome through an integrated strategy for the conservation and sustainable and equitable use of agricultural biodiversity.

Even during the titanic tsunami of 26th December 2004, land races of rice were found in coastal Tamil Nadu, which could survive seawater inundation. Many life-saving crops like tubers and legumes were cultivated in the past and we urgently need to rekindle such dying wisedom and take steps to save vanishing crops , which can help to heal the wounds inflicted by natural or man-made calamities. Women, in particular, are the holders of such traditional knowledge and the critical role women the conservation and sustainable management of agricultural biodiversity needs to be strengthened and revitalized. Tropical fruits, beta-carotene rich sweetpotato and other vegetable crops can help to fight Vitamin A deficiency in children. In other words agricultural biodiversity provides uncommon opportunities for developing decentralized and local specific community food security systems involving field gene-banks, seed-banks and grain-banks developed and managed by local men and women. This approach will further help to enlarge the food security basket by including nutrition-rich but under-utilized crops, like ragi, bajra etc. This is the most sustainable and affordable pathway to achieving the MDG in relation to elimination of hunger and poverty.

Agricultural biodiversity provides the crucial raw material for improving the productivity and quality of crops, livestock and fish. Goals such as “health for all” and “fish for all” can be achieved only by conserving medicinal plants and genetic diversity in fish. Agro-biodiversity also offers opportunities, especially to the landless poor for entrepreneurial initiatives which will generate employment and income from a range of value-added foods, medecines, nutracenticals, bio-food and other products. Such opportunities are of particular value, since today inadequate income and purchasing power are the major causes of food insecurity at household level. The potential for agrobiodiversity for coping with climate change is not well appreciated. In short the flagship role played by agrobiodiversity in overcoming hunger in an environmentally, economically and socially sustainable manner is yet to be widely realized and integrated with national and global strategies for achieving the MDGs. Better nutrition is also vital for fighting pandemics like HIV/AIDS and tuberculosis since a drug-based approach alone will not lead to the desired results. The health foods of tomorrow will be mostly the under-utilized crops of today.

Agricultural bio-diversity and cultural diversity have feedback for poems, songs and drama. Community-led food security systems based on the conservation, cultivation and consumption of Local foods thus help to preserve cultural and ethnic diversity in crop and culinary preferences. Thus agricultural biodiversity confers multiple benefits – ecological, economic, nutritional and cultural.

What actions are required?

1. Incorporate agro-biodiversity conservation and sustainable use in national and state development plans.
2. Introduce legislative measures to use land and other natural production resources to enhance the ability of all to make use of agro-biodiversity and its associated traditional knowledge for promoting off-farm employment and income generation in harmony with traditional rights, cultural identity, ecosystem integrity and gender equity.
3. Recognise and reward invaluable contributions of rural and indigenous people in the conservation and enhancement of agricultural biodiversity and confer social prestige and economic benefits to its primary conservers.
4. Promote local markets and facilitate access to international markets for products of agricultural biodiversity.
5. Ensure that food and nutrition support safety-net programmes, especially food-aid and school feeding programmes as well as food-banks, are fostering greater dietary diversity by broadening the food basket with more indigenous crops as grants of national nutritional policy.
6. Restructure research and development priorities to enhance productivity, profitability and value chain development of wider range of agricultural biodiversity including hither to neglected species thereby generating an economic stake in the conservation.

poster presentations

Diversity of Odonates along the Chaliyar River Basin, Kerala

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Abstract

Odonates are most diverse group of insects usually found near water bodies and their presence indicates the overall well being of an ecosystem. A study was conducted to analyse the diversity of Odonates along the Chaliyar river basin, Kerala. The areas selected include Nedungayam, Chaliyarmukku, Vettupara and lower areas of Chaliyar river. From the study areas, a total of 23 species of Odonates were reported. Among them, 11 species were dragonflies and 12 species were damselflies. Dragonflies reported comes under a single family Lubellulidae (Skimmers), while damselflies comes under 4 families; viz. *Coenagrionidae* (Marsh darts) with 6 species, *Protoneuridae* (Bamboo tails) with 1 species, *Calopterigidae* (Glories) with 3 species and *Platycnemididae* (Bush darts) with 2 species.

Key words: Odonates, Chaliyar river, Kerala

Introduction

Dragonflies and damselflies, collectively called odonates, are one of the most common insects flying over forests, fields, meadows, ponds & rivers. Their life history is closely linked with water bodies. Odonates being predators both at larval and adult stages play a significant role in the wetland ecosystem. Adult odonates feed on mosquitoes, black flies, and other blood sucking flies and act as an important biocontrol agent. They act as scavengers of atmosphere. The larval and adult dragonflies are good indicators of a healthy ecosystem.

Kumar and Prasad (1981) made a very good input to Indian odontology by studying ecology, zoogeography, and taxonomy of odonates from Western Himalaya. Varghees and Kakkasery (1998) reported 28 species of odonates from Trissur district, Kerala. Prasad and Varshney (1995) made a check list of Indian odonata which was a comprehensive data about 499 species of dragonflies and damselflies from India. Subramanian and Sivaramakrishnan (2002) reported 176 species from Western Ghats and nearby areas, of which 67 are endemic to the region. An updated systematic list of the odonates known so far from the state of Kerala details 137 species spread over 79 genera and 31sub families within 12 families (C. Radhakrishnan & K.G. Emiliyamma, 2003). K.G. Emiliyamma and Radhakrishnan (2002) reported 43 species of odonates from Thiruvananthapuram district and K.G. Emiliyamma (2005) reported 31 species from Kottayam district. David .V.Raju (2010) recorded 45 species from Kuttanad wetland.

Chaliyar River is the fourth largest river in Kerala, originates in the Western Ghats range at Elambalari Hills located near Cherambadi town in Nilgiri district. Chaliyar River was in the news a few years ago because of the ecological damage caused by a pulp factory at Mavoor, Kozhikode district. Odonates act as bioindicators, biocontrollers and integral part of food web. Information pertaining to biodiversity and biological attributes of insects is very important in conservation programmes. Not so much work has been done on diversity of odonates along Chaliyar River.

Materials and Methods

Odanates of the Chaliyar River were studied during December 2011 to June 2012. Best time to watch Odonates is during midday. Random method was adopted for sampling. Collections were made by hand picking or by using butterfly net. Most of the Odonates were caught, photographed and then released back to the habitat. A Digital Auto focus 10.2 Mega pixel (optical zoom 10X) and 5 Mega pixel (optical zoom 5X) cameras were used for taking high quality macro images of the entire insects and their body parts which would help in identification.

Most of the species were identified by visual counter methods. Specimens were identified with the help of standard reference field guides such as "Dragonflies of India" by K.A Subramanian. Some important features such as colour patterns of eye, mandible, labrum, wings, legs, abdomen and thorax were noted in a rough book, immediately after they were caught. Species which could not be identified in the field were identified later by experts. The colour patches on wings, venation on wings, abdomen, thorax, head, leg and the structure and shape of anal appendages were useful information for the identification for the specimen. Three sites were selected during study period as upper (Nedungayam Chaliyar mukku), middle (Vavoor Vettupara), and lower (Paruthipara) area near Chaliyar river.

Results and Discussion

A total of 23 species including 11 species of dragonflies and 12 species of damselflies were recorded from the Chaliyar River and its tributaries during the period of study. The dragonflies observed during the study belonged to a single family Libellulidae [Skimmers]. The damselflies observed during the study comes under 4 families; Coenagrionidae [Marsh darts] with 6 species, Protoneuridae [Bambootails] with 1 species, Calopterigidae [Glories] with 3 species and Platycnemididae [Bush darts] with 2 species (Fig. 1)

Table 1: Distribution of dragonflies along Chaliyar River

Sl. No	Common name	Scientific name	Family
1.	Ditch jewel	*Brachythemis contaminata*	Libellulidae
2.	Ruddy marsh skimmer	*Crocothemis cervilia*	Libellulidae
3.	Asiatic blood tail	*Lathrecista asiatica*	Libellulidae
4.	Fulvous forest skimmer	*Neurothemis fulvia*	Libellulidae
5.	Pied paddy skimmer	*Neurothemis tulia*	Libellulidae
6.	Crimson-tailed marsh hawk	*Orthetrum pruinosum*	Libellulidae
7.	Green marsh hawk	*Orthetrum Sabina*	Libellulidae
8.	Blue-tailed yellow skimmer	*Palpopleura sexmaculata*	Libellulidae
9.	Rufous marsh glider	*Rhodothemis rufa*	Libellulidae
10.	Crimson marsh glider	*Trithemis aurora*	Libellulidae
11.	Little blue marsh hawk	*Brachydiplax sobrina*	Libellulidae

Table 2: Distribution of damselflies along Chaliyar river

Sl. No	Common name	Scientific name	Family
1.	Pigmy dartlet	*Agriocnemis pygmaea*	Coenagrionidae
2.	Orange-tailed marsh dart	*Ceriagrion cerinorubellum*	Coenagrionidae
3.	Orange marsh dart	*Ceriagrion rubiae*	Coenagrionidae
4.	Golden dartlet	*Ischnura aurora*	Coenagrionidae
5.	Blue grass dartlet	*Pseudagrion microcephalum*	Coenagrionidae
6.	Saffron-faced blue dart	*Pseudagrion rubriceps*	Coenagrionidae
7.	Yellow bush dart	*Copera marginipes*	Platycnemididae
8.	Blue bush dart	*Copera vittata*	Platycnemididae
9.	Black bamboo tail	*Prodasineura verticalis*	Protoneuridae
10.	Stream glory	*Neurobasis chinensis*	Calopterigidae
11.	Clear-winged forest glory	*Vestalis gracilis*	Calopterigidae
12.	River heliodor	*Libellago lineate*	Calopterigidae

A. *Lathrecista asiatica* (male), **B.** *Neurothemis tulia* (female), **C**. *Rhodothemis rufa* (male)

A. *Palpopleura sexmaculata* (female), **B**. *Rhodothemis rufa* (female), **C**. *Neurothemis fulvia* (male)

A. *Brachythemis contaminata,* **B**. *Crocothemis servilia,* **C**. *Trithemis aurora*

A. *Orthetrum sabina*, **B.** *Neurothemis tulia*, **C.** *Orthetrum pruinosum*

A. *Ischnura aurora*, **B.** *Ceriagrion rubiae*, **C.** *Ceriagrion cerinorubellum*

A. *Pseudagrion microceephalum*, **B.** *Pseudagrion rubriceps*, **C**. *Prodasineura verticalis*

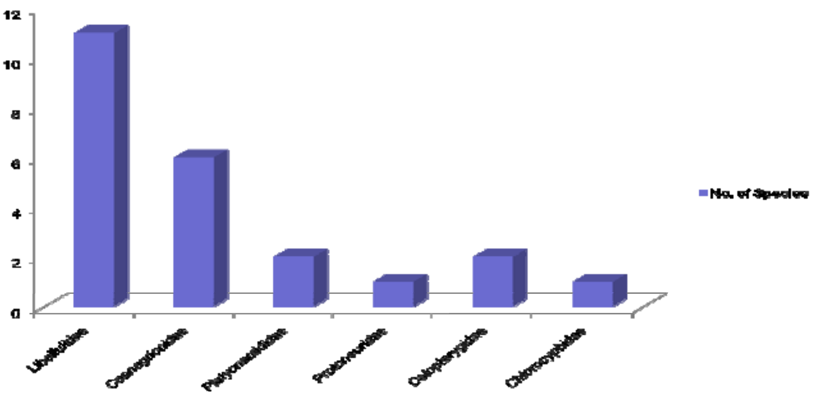
A. *Libellago lineata*, **B.** *Neurobasis chinensis*, **C.** *Agriocnemis pygmaea*

The dragonflies observed during the study period come under the family Libellulidae. It is most diverse group of dragonflies and breeds in a variety of aquatic habitats like puddles, ponds, marshes, rivers, domestic storage tank and aquaria. Out of the 11 species observed *Brachythemis contaminata* is a dragonfly of polluted water. Of the many visits *Neurothemis fulvia* and *Diplocodes trivialis* was observed only during the first visit[December]. *Neurothemis tulia* and *Orthetrum Sabina* and *Orthetrum pruinosum* were observed during all visits[December-june]. Their flight season is throughout the year*. Trithemis aurora* was observed during all visits except first visit.

Neurothemis tulia is a conspicuous species of ponds, marshes and paddy fields. Their flight is slow and weak. It was observed in stagnant waters during the study. *Orthetrum pruinosum* is a very common dragonfly of wells, ponds, ditches, tanks and rivers. It was the only dragonfly observed in lower region of Chaliyar tributaries near Paruthippara.

During last two visits, *Vestalis apicalis* and *Vestalis gracilis* cannot be reported from all three sites. It was observed during the February-march months. They were not reported from vettupara during the study period. Orthetrum and Tulia species were most notable dragonfly along Nedungayam region during all the visits of study period. The presence of glories, clubtails, torrent darts, reed tails and Bambootails are good indicators of riverine system (Subramanian, 2005). Two species of glories [*Neurobasis chinensis, Vestalis gracilis*] were observed from Nedungayam. Thus it indicates that it is less polluted than Vettupara area. 12 species of damselflies were observed during the study. In the present study, more species were observed from Chaliyar mukku and Nedungayam. During some season, more number of species were observed from Vettupara region. Clearing up of the forest areas, filling up of low land, particularly of water bodies in the name of development and polluting water bodies lead to the elimination of these insects. After proper analysis it has to be determined whether these areas need any conservation.

Fig. 1: Family wise Distribution of Odonates along Chaliyar River Basin



References

1. **David, V. Raju. 2010.** Odonates of the Kuttanad Wetland Ecosystem.
2. **Emiliyamma, K.G. 2010.** *On* the Odonata fauna of Kottayam District, Kerala.
3. **Emiliyamma, K. G. and C. Radhakrishnan. 2002.** Addition to the Odonata (insects) of Thiruvananthapuram District, Kerala *Zoos Print Journal* 17(10); 914—917.
4. **Emiliyamma, K.G, C. Radhakrishnan, And Muhammed Jafar Palot. 2005.** Pictorial handbook on common Dragonflies and Damselflies of Kerala1 *Zoological Survey of India, Kolkata*.
5. **Kumar, A. and M. Prasad. 1981.** Field Ecology, Zoogeography and Taxonomy of the Odonata of Western Himalaya, India. *Records of the Zoological Survey of India,* occasional paper No.20-1 - 115.
6. **Lahiri, A.R. 1979.** Odonata (Insecta) from different States of North Eastern India. Oriental Insects, 13 (1 and 2):119-132.
7. **Prasad, M. and R.K. Varshney 1995.** A check list of the Odonata of India including Data on Larval Studies Oriental Insect, 29: 384-428.
8. **Radhakrishnan, C. and Emiliyamma, K.G. 2003**. Odonata (Insecta) of Kerala: A systematic database.
9. **Subramanian, K.A. 2005**. Dragonflies and Damselflies of Peninsular India: A Field Guide, *Indian Academy of Science, Banagalore.*
10. **Subramanian, K.A. 2002.** A Nature Watch, *Indian Institute of Science, Bangalore.*
11. **Subramanian, K.A. and K.G. Sivaramakrishnan. 2002.** Conservation of Odonata Fauna in Western Ghat.
12. **Varghees, S. and R.K. Kakkassery. 1998.** Studies of Dragonflies and Damselflies from Thrissur district, Kerala.

Diversity and Hydrochemical Parameters of Planktonic Algae of selected Temple ponds of Mahe (U.T. of Puducherry)

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Abstract

The study of the Algal diversity and the Hydro chemical parameters of selected temple ponds of Mahe showed the presence of 41 Algal species. The Mahe proper pond showed 1 Cyanophyceae, 10 Chlorophyceae and 1 Bacillariophyceae member. The Palloor pond showed 5 Cyanophyceae, 8 Chlorophyceae and 4 Bacillariophyceae members. The Pandakkal pond showed 5 Cyanophyceae, 11 Chlorophyceae and 2 Bacillariophyceae members. It is very much clear that Chlorophyceae was the most dominant class of Algae in all the three stations. Less number of Cyanophyceae and Bacillariophyceae in all the 3 stations indicated that serious pollution has not happened in the selected sites.

The atmospheric temperature was constant in all the three locations but the temperature of the water was slightly high in Pandakkal pond as was the conductivity. Highest P^H was shown by the Mahe proper region. Total hardness was more in Pandakkal region and the least was represented in Mahe region. Dissolved oxygen was more in Palloor region than the other two regions as was the BOD. High diversity of algae in this site can be attributed to these factors. The Nitrate content was equal in all the three regions. Sulphate content was highest in Mahe region and the Phosphate content was highest in Pandakkal region

Key words: Temple ponds, Mahe, Planktonic algae, hydrochemical parameters

Kadalundy Community Reserve- Stopover Habitat for Avian Migrants, Conservation Concern

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Abstract

Conservation of migratory birds necessitates protecting suitable stopover habitat along migratory routes as well as destination habitats. The diversity and various components that are determine the composition of avian group was subjected to comprehensive analysis and objective study at the Kadalundy Bird sanctuary, first national community Reserve. Main recourse has been made to direct observation and total count method. Among the total species observed, 91.59 % species were distant migrants, 1.46% local migrants and 6.93 % were residents. The percentage of occurrence of sea birds was higher than Shore birds and terrestrial birds. The physical and biological aspects were taken into consideration for frequency studies in terms of presence and abundance of birds. The availability of mudflats got exposed by low tide, water level, abundance of macrobenthic organisms have a significant control on habitat selection of feathered bipedal at Kadalundy.

The Charadriformes reach the estuary by the month of September and their frequency become high during November and started to decline by the end of July. For migratory birds, timing of arrival on the breeding grounds can strongly influence breeding success through improved access to higher quality resources and breeding locations and increased numbers of potential breeding attempts. Among Shore birds, Lesser Sand Plover and Greater Sand Plover were dominant and Brown headed Gull and Black headed Gull contributed bulk proportion among Sea birds. The anthropological interference affected the estuarine bed, mangroves considerably decline density and abundance of different fauna, avian migrants in particular. The loss of mudflats reduced the availability of macrobenthos led to the fall in migrant species. The human pressure like destruction of mangroves, husk rutting, sand mining, sewage disposal, mussel collection, construction works, were major factors that contributed decline of the migrants. Hence stopover habitat is indispensable for conservation of winter migrants.

Key words: Charadriformes, Estuary, Mangroves, Macrobenthos

A preliminary study on Malacofauna along Chaliyar River Basin

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Abstract

River Chaliyar is one of the West flowing rivers of Kerala originating from the Illambari hills of Tamilnadu. A study was conducted from December 2010 to July 2011 in Chaliyar River Basin to document Malacofauna of the area. During the study, 17 species of molluscans belonging to 15 families were recorded. Among them, 9 species were gastropods and 8 species were bivalves. In the upstream region, the species *Lymnaea luteola* was dominant. In the middle stream region, *Lamellidans marginalis, Pila virens, Villorita cyprinoides* were the dominant species. The species *Meretrix casta* was very abundant in the down stream region. It was observed that in fresh water, the diversity and distribution of mollusc was scanty where as they were rich in estuarine habitat. This study was anhumble attempt to document the Malacofauna along the Chaliyar river basin which may help in further conservation and management activities in these areas.

Key words: Malacofauna, Chaliyar river, estuary, conservation

Introduction

Mollusca is the second largest animal phylum next to arthropoda which comprises more than 10,000 living species. The phylum is divided into seven classes, namely Aplacophora, monoplacophora, scaphopoda, Gastropoda, Pelecypoda, polyplacophora and cephalopoda. Molluscs are widely distributed in both time and space. They may be found on land, in fresh water and in the sea. In ocean they occur in three zones, viz, benthic, pelagic and littoral. The maximum number of species occurs in the littoral zone. Very few are benthic or pelagic. Many species are seen in the south eastern coast of India (Hornell, 1922, 1951). Each species has a specific pattern of distribution eg: *Trochus, Conus, Bursa* etc occur in the mesolittoral zone. The predominance of a species at a place mostly depends on the feeding ground, temperature and the water quality. Depending on the substratum, the various habitats where shells occur can be classified as sand beaches, rocky shores, mud-flats, mangroves and coral reefs. Many species are seen in the sunderbans mangroves (Nandi& Chaudary, 1983). There is scarcely any portion of the world without molluscan life, except in regions of extreme cold.

The Western Ghats, as a potential bio-geographic tract or territory, has gained the acclaim of one among the 34 globally identified biodiversity hotspots. The Western Ghats form one of the watersheds of India, feeding the perennial rivers. Almost all the torrential streams at an altitude of 1500-2000m harbour several species of aquatic insects, fishes, molluscs etc in their specialized microhabitats. Chaliyar is one of the west flowing rivers originating from the Western ghats and experiences 3 different seasons, the north east monsoon from September to December, dry season from January to may and south west monsoon during june to august. Altitudinal gradient ranges from 11 to 2066m above mean sea level. Originating from the Illambari hills in Tamilnadu it flows 169km towards west emptying into the Arabian Sea.

Rajendra G. Mavinkurve *et.al.* (2004) have been studied the land and fresh water molluscs of Western ghats. During their studies for the last three and a half years they were able to report 190 species of land snails with twenty new reports for the region. But the alarming factor is that twelve genera reported earlier were not encountered in their survey.

They were able to record forty species of fresh water molluscs and three new reports from the region. In this scenario the present study is quite significant and is a humble attempt to study the molluscan diversity of Chaliyar River. It also may help in further conservation activities in these areas.

Materials and Methods

The study was carried out from October, 2011 to June, 2012 along the Chaliyar River, which is one of the west flowing rivers originating from the Western ghats and experiences 3 different seasons, the north east monsoon from September to December, dry season from January to may and south west monsoon during june to august. Altitudinal gradient ranges from 11 to 2066m above mean sea level. Originating from the Illambari hills in Tamilnadu it flows 169km towards west emptying into the Arabian Sea. The samples were collected twice in a month. For the easy collection of specimes, the study area is divided in to three regions. These regions includes; upstream region (Nedumkayam and Chaliyar mukku), middle stream region (Vavoor and Vettupara) and downstream region (Kallai).

Most of the molluscans are sufficiently large and conspicuous. So they were easily handpicked. Both dead and live specimens were collected and the shell fragments discarded. During the collection care has been taken to collect the live specimens. The leaves and branches of plants carefully searched out and the snails were picked with hand.

Since shells are the main criteria for identification, shells were also collected. To obtain small species, weeds were shaken out under the water. Bivalves are benthic forms, lived partly buried in the soft bottom and they were collected by dredge. Under the rocks are keenly observed. Proper care has been taken to reduce the disturbances of the molluscs. Maximum care is taken to avoid the damage to soft body parts. And the relevant data were noted from the field. After the collection, shelled molluscs are kept in a container of fresh water and closed the mouth of the container, tightly. The animal residing inside the shells will be asphyxiated. After that, specimens were thoroughly washed and they were kept in 70% alcohol for few hours. Then the specimens were washed thoroughly and dried properly.

The collected specimens were identified with the assistance of scientist, Ashokan (CMFRI, Calicut) and Muhammed Jafer Palot (Assistant Zoologist, Z S I, Calicut). The pictorial, *The book of Indian Shells* (Deepak Apte, 1998) and *Hand book of Indian fresh water molluscs* (Ramakrishna, Anirudha Dey, 2007) were also used for the identification.

Results and Discussion

A total of 17 species of molluscs were identified from the study area and they were belong to16 genera; Class gastropoda with 9 species and bivalves with 8 species. 17 species of molluscs identified were comes under 15 families (Table 1). From the upstream region of Chaliyar, 5 species were identified (table 2). They were noticed throughout the study period. In the up stream region of chaliyar; *Thiara rudis* (thiaridae), *Bellamya bengalensis* (viviparidae), *Paludomus annandalei* (Pleuroceridae), *Lymnaea luteola* (lymnaeidae) and *Indoplanorbis exustus* (Planorbidae) were identified. Presence of these species reflects that the up stream region is highly pure.

3 species were obtained from the middle stream region (Table 2). The species found in this region are; *Lamellidens marginalis* (unionidae), *Villorita cyprynoides* (corbiculidae) and *Pila virens* (ampullariidae), in which *Lamellidens marginalis* and *villorita cyprinoides* were dominant. Highest number of molluscs were obtained

from the lower stream region. And the identified species of this region includes; *Babylonia spirata (*Buccinidae), *Turritella duplicata* (Turritellidae), *Bursa tuberculata* (Bursidae), *Donax scortum* (Donacidae), *Paphia species* (Veneridae), *Meretrix meretrix* (Veneridae), *Arca species* (Arcidae), *Perna virdis* (Mytilidae) and *Meretrix casta* (Veneridae). *Perna virdis* and *Meretrix casta* were dominated in the down stream region (Table 2). In this 3 species namely; *Meretrix meretrix* , *Meretrix casta* and *Paphia species* coming under the same family, Veneridae.

The Western Ghats are home to 257 terrestrial molluscs with relative endemism of 73% demanding priority for conservation planning. The terrestrial habitats are exclusively inhabited by the class gastropoda and fresh water habitats by gatropoda and bivalvia. Molluscs play a significant role as links in food chains as detritus feeders, improving bottom sediments and soil condition. Some molluscs are habitat specialists.

Molluscs are richly seen in estuaries. From the downstream region, 9 species were obtained. Estuary provides greater support to number of species. From the down stream region, 9 species were recorded. They are *Babylonia spirata, Turritella duplicata, Bursa tubercula, Villorita cyprinoides, Donax scortum, Paphia species, Meretrix casta, Mertrix meretrix, Arca species* and *Perna virdis. Meretrix casta* was dominant in the down stream region. The identified molluscs fall under the classes gastropoda and bivalvia. Among them 9 species were gastropods and 8 species were bivalves. Subba Rao (1989) revealed the presence of 19 gastropod species from Kerala. More number of species were identified from the down stream region, whichconnection with the sea, it flows to the Arabian sea and meets at “estuary”.

There are 5070 species of marine and non marine molluscs living in the wild India. In which 3371 species are marine forms and 1671 species are non-marine. This includes 1488 terrestrial species in 140 genera and 183 fresh water species in 53 genera. Molluscs have high economic importance. Extractions of some species like *Villorita cyprinoides* and *meretrix casta* are used as anti viral drugs (Anil Chatterji *et.al*, 2002). Some species like *lamellidens marginalis, perna virdis, paphia species* etc are edible. Edible mussel *Perna virdis* of the family mytilidae is a food resource of great potential. The distribution of these molluscs is likely to influence the availability of food. Seasonal changes have great influence on the diversity and distribution of malacofauna in tropical and subtropical waters. Aquatic macro invertebrates play a significant role in responding to a variety of environmental conditions of rivers and streams and therefore may be used as bio-indicators for water quality assessments. Now the use of benthic macro invertebrates as bio-indicators is gaining more importance as these can be easily caught and seen with naked eyes.

Bivalves are notorious for their ability to bio-concentrate pesticides and heavy metals. *Villorita cyprinoides* is a best example for this (Siva Prasad, 2007). Extensive harvestation from the wild population could be the potential threat of these species. Large scale mining causes a serious threat to aquatic fauna by destructing their breeding ground. The Chaliyar River is polluted by Birla group since last many decades. Macro benthos living in the river was exposed to the chemical pollution. The double impact alleged to have problems to aquatic organisms as the result of discharge of toxic effluents from the Gwalior Rayons factory (Grasim industry) to the river. But the impacts of sulphides are still remaining. According to Ramakrishna and Dey (2007), *Bellamya bengalensis* can tolerate a maximum level of salinity 0.2 mg/ml. Presence *of Bellamya bengalensis, Indoplanorbis exustus, Thiara rudis, Paludomus annandalei* etc in the up stream region of Chaliyar river shows that the upper region is highly pure. Even then, their diversity is affected due to anthropogenic activities.

Table 1: List of Mollusc species recorded from the study area.

Sl No	Species	Genera	Family	Order	Class
1	*Babylonia spirata*	Babylonia	Buccinidae	Neogastropoda	Gastro poda
2	*Bellamya bengalensis*	Bellamya	Viviparidae	Mesogastropoda	
3	*Pila virens*	Pila	Ampullariidae	Mesogastropoda	
4	*Thiara rudis*	Thiara	Thiaridae	Mesogastropoda	
5	*Paludomus annandalei*	Paludomus	Pleuroceridae	Mesogastropoda	
6	*Lymnaea luteola*	Lymnaea	Lymnaeidae	Basommatophora	
7	*Indoplanorbis exustus*	Indoplanorbis	Planorbidae	Basommatophora	
8	*Turritella duplicata*	Turritella	Turritellidae	Mesogastropoda	
9	*Bursa tuberculata*	Bursa	Bursidae	Mesogastropoda	
10	*Lamellidens marginalis*	Lamellidens	Unionidae	Unionoida	Bivalvia
11	*Villorita cyprinoides*	Villorita	Corbiculidae	Veneroida	
12	*Donax scortum*	Donax	Donacidae	Veneroida	
13	*Paphia species*	Paphia	Veneridae	Veneroida	
14	*Meretrix meretrix*	Meretrix	Veneridae	Veneroida	
15	*Meretrix casta*	Meretrix	Veneridae	Veneroida	
16	*Arca species*	Arca	Arcidae	Arcoida	
17	*Perna virdis*	Perna	Mytiloidae	Mytiloida	

Table 2: Check List of Molluscs recorded from the study area

Sl. No	Species	Family	Site 1	Site 2	Site 3
1	*Babylonia spirata*	Buccinidae			✓
2	*Bellamya bengalensis*	Viviparidae	✓		
3	*Pila virens*	Ampullariidae		✓	
4	*Thiara rudis*	Thiaridae	✓		
5	*Paludomus annandalei*	Pleuroceridae	✓		
6	*Lymnaea luteola*	Lymnaeidae	✓		
7	*Indoplanorbis exustus*	Planorbidae	✓		
8	*Turritella duplicata*	Turritellidae			✓
9	*Bursa tuberculata*	Bursidae			✓
10	*Lamellidens marginalis*	Unionidae		✓	
11	*Villorita cyprinoides*	Corbiculidae		✓	
12	*Donax scortum*	Donacidae			✓
13	*Paphia species*	Veneridae			✓
14	*Meretrix meretrix*	Veneridae			✓
15	*Meretrix casta*	Veneridae			✓
16	*Arca species*	Arcidae			✓
17	*Perna virdis*	Mytildae			✓

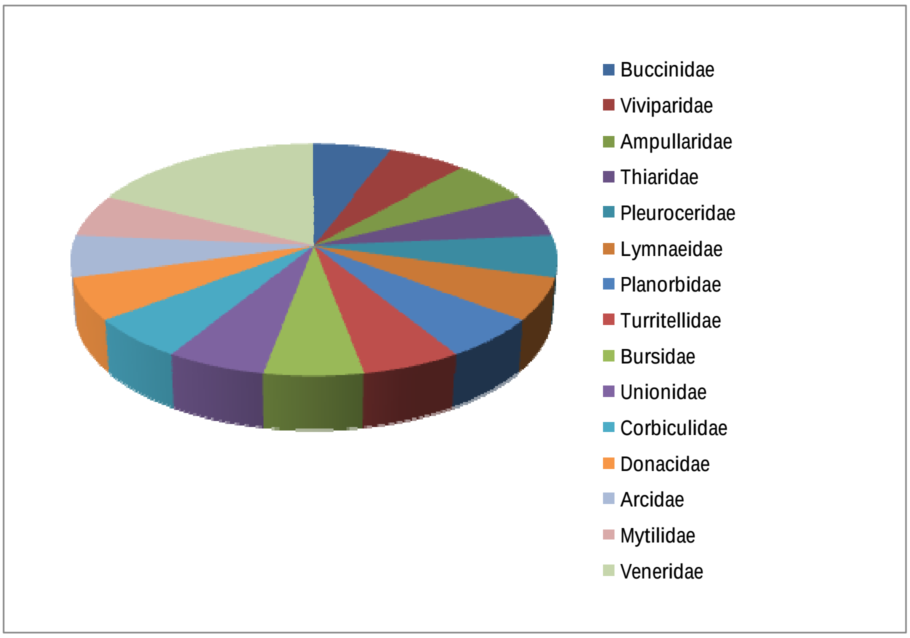

Figure 1: Species diversity of Molluscs by family

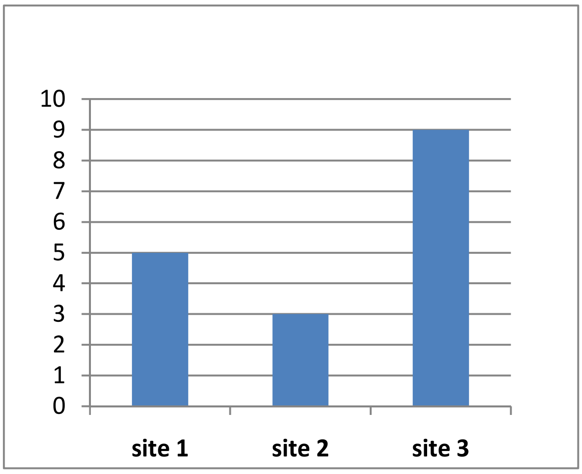

Fig. 2: Species diversity of Molluscs in different sites

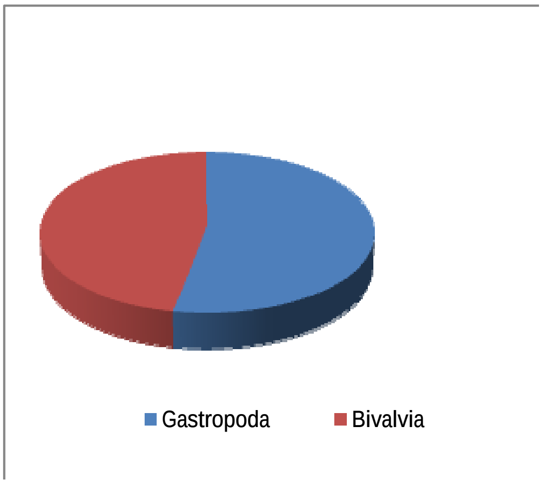

Fig. 3: Species diversity of Molluscs by class

Babylonia spirata

Bellamya bengalensis

Pila virens


Paludomus annandalei


Thiara rudis


Lymnaea luteola


Indoplanorbis exustus


Turritella duplicata


Bursa tuberculata


Lamellidens marginalis


Villorita cyprinoides


Meretrix casta


Meretrix meretrix


Arca species


Perna virdis

Conclusion

Chaliyar and its tributaries act as a complex ecosystem. Any alteration in this ecosystem upsets natural equilibrium. Sewage disposal from houses and industries, sand mining, fishing, over harvesting of edible molluscs etc are the serious threats faced by the molluscs of Chaliyar. Chaliyar also receives a lot of pollutants from different sources like domestic sewage, slaughter house waste, waste disposal from nearby industries etc. This may change charecteristics of water and it adversely affects the living beings as well as entire ecosystem. Now the molluscan species are facing serious threats due to pollution, uncontrolled harvesting of edible species, large scale sand mining etc. Therefore it is necessary to make continuous census. So that they can be accessible for scientists who are interested in developing management plans to protect aquatic resources. Thus, this paves many prospects for future study.

References

1. **Abbasi, S.A. 1997.** *Wetlands of Indian ecology and threats*. Vol 3. 103pp
2. **Anil Chatterji *et al.* 2002.** Indian marine bivalves : Potential source of antiviral drugs. 2(10): 25.
3. **Deepak Apte. 1998**. *The Book of Indian Shells*, Bombay Natural History Society, Oxford University Press, Mumbai, 115 pp.
4. **Gopakumar, K. 1998.** Quality control of molluscan products, CMFRI Bulletin, 42(2) pp 391-394
5. **Hornell, James. 1922.** *The common molluscs of South India. Ibid. 14: 97-215.*
6. **Hornell, James. 1949.** The study of Indian mollusca. *J. Bombay nat. Hist .Soc.* 48 (2): 34p
7. **Hornell, James. 1951.** Indian Molluscs 96 pp. *Bombay Natural Hitory Society. Bombay*
8. **Nandi, S. and A. Choudury. 1983.** Qualitative studies on the benthic macro fauna of Sagar Island Intertidal zones, Sunderbans, Mahasagar 16 (3): 409-414.
9. **Radhakrishnan. C; Gopi, K.C; Jafer Palot. 2006.** Mangroves and their faunal associates in Kerala with special reference to Northern Kerala, *Rec. Zoo Surv. India.* Occ. Paper No. 246: 1-81.
10. **Rajendra G. Mavinkurve *et al*. 2004.** Non marine molluscs of Western Ghats. A status review. Zoos' print journal 19 (12): 1708-1711.
11. **Ramakrishnan, Anirudha Dey. 2007.** Indian Fresh water mollusks, ISBN 978-81-8171-146-5
12. **Subha Rao.1989.** Hand book, freshwater molluscs of India*. Zool. Surv. of India*. 9: 1-289.
13. **Shailendra Sherma *et al.* 2010.** Biodiversity and abundance of benthic macro invertebrates community of Kishanpura lake, Indore (Madhya Pradesh) India. 2(10) 57-67.

Preliminary survey of soil macro and meso Arthropods along Chaliyar river banks

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Abstract

A great variety of organisms exist in the soil and litter above it. The diversity of animals that inhabit in different soil type is so complex. The major role of soil organisms is their participation in soil formation, humifacation and decomposition. The present study was carried out in 3 different habitats along Chaliyar from November 2011 to June 2012 to explore the diversity of soil arthropods. Soil samples were collected from different habitats by once in a month. A total of 114 specimens of soil arthropods were collected from three different habitats belonged to four major arthropodan classes with thirteen different orders. Class *Insecta* was the prominent group comprising seven orders with seventeen different families. *Coleoptera* was the most prominently represented order comprising six families. Second dominant order was *Hymenoptera*, followed by *Hemiptera*. Remaining orders viz. *Diptera, Dictyoptera, Orthoptera* and *Thysanura* exhibited comparitively lesser diversity.

Key words: Chaliyar, *Insecta, Coleoptera, Hymenoptera, Hemiptera, Diptera, Dictyoptera, Orthoptera, Thysanura*.

Introduction

The soil is an extremely dynamic, complex and highly heterogenous system that allows the development of an extremely large number of ecological habitats. It is the home of an array of complex soil fauna that perform important function for the ecosystem. (Gardi and Jeffery,2009). The most dominant group of soil organisms are microorganisms (fungi and bacteria), followed by huge variety of animals such as nematodes,arthropods,enchytraeids and earthworms(Jeffery *et al* ,2010). According to Hole(1981)there are at least twelve kinds of activities by which the soil animals affect the soil. The most dominant group of soil organisms are microorganisms (bacteria and fungi), followed by huge variety of animals such as nematodes, arthropods, enchytraeids and earth worms(Jeffery *et al*,2010). In the soil these organisms have central functions in organic matter decomposition, the nutrient cycle, the enhancement of soil structure and control of soil organisms including crop pests (Moore and Walter,1988). They also contribute to the regulation of atmospheric composition and climate,water quality and quantity and the reduction of environmental pollution (Lavelle *et al*, 2006). In Kerala, a detailed study was not yet happened about the diversity of soil dwelling forms. Biodiversity studies of soil dwelling organisms in mangroves was reviewed by Sunil kumar (1999). The relationship between soil organisma and agriculturalfield was studied by Kerala land use board (1995) and Kumar (2005 & 2006). A recent study on soil macrofaunal assemblage in selected land use system was coducted by Mujeeb Rahman(2010). Chaliyar is one of the major and the fourth longest river in Kerala that originates from the Western Ghats and enriched with diverse flora and fauna. Even though the biodiversity studies on the riparian habitats of Chaliyar and its tributaries are very much limited. Hence a preliminary survey was under taken to investigate the soil macro and meso arthropods along three different habitats of Chaliyar river banks.

Metholodology

The study was carried out along the banks of three major tributaries of Chaliyar river viz. upper stream with forest ecosystem (Nedumkayam and Chaliyarmukku - Plate 1) middle stream with open field (Vavoor and Vettupara) and the lower stream with bushes and shrubs(Paruthippara) between November 2011-June 2012. The soil samples with litter fauna was collected in polythene bags from the above selected areas with the help of a shovel and immediately brought to the laboratory. The collected sample is subjected to extraction through Berlese funnel method (Plate 1). Specimens were collected in specimen tube with 70% alcohol which is placed under the tip of extraction funnel. Collected specimens were transferred separately into separate specimen bottles and preserved in 70% alcohol for further studies. In the present study the identification was made only up to the order and family level.

Study area - Nedumkayam

Berlese Funnel Apparatus

Results and Discussions

Organic matter decomposition in soil is performed by a dynamic system of soil fauna and their synergistic interactions play a very important role in enhancing the nutrient release (Banerjee,1972. , Bhandari and Somani,1994). Saprophagous soil animals are the "key" for mobilization of nutrients "locked" in microbial and higher plant tissues. (Gupta and Sekhon,1994). Proper understanding on the contribution of different faunal groups to the ecosystem process are required for developing environmentally sound management practices and strategies to safeguard the biodiversity and soil fertility. For that adequate taxonomic foundation is needed on which ecologists can work, and more particularly good identification is needed in studying various aspects of the soil fauna.

In the present study a total of 114 specimens of soil arthropods collected from the three study areas along the Chaliyar river banks which belonging to four major arthropod classes and 13 different orders (Fig. 1,Table 1). Out of the 114 specimens collected, 73 belong to Class Insecta, which are classified up to the family level. A total of 17 families of insects belonging to seven different orders were recorded from the study areas. Among the total number of insects collected, some of them are insect larvae. From the different orders recorded it was observed that Order Coleoptera is the most diverse with six families and 37% of total insect population collected from the three study areas. This was followed by Order Hymenoptera with 24%, Order Hemiptera with 13% and the remaining orders viz Diptera, Dictyoptera, Orthoptera and Thysanura constitute less than 10% each of the total insect population (Fig. 2 & Table 2).

About 32 insects were collected from the Study area 1, which belongs to 6 orders with 13 families. Order Coleoptera and Hymenoptera are recognized as the dominant group comprising 5 and 3 different families respectively. A total of 13 families were recorded from site 1 and it was observed that this area is more diverse when compared to the others. Study area 2 consists of comparatively lesser diversity of soil insects than the other two areas. It includes a total of 8 different families within 5 orders. Being an open field, insects of order Orthoptera and Hemiptera were observed more . A total of 10 different families belong to 6 different orders were recorded from study area 3. It was comparatively more diverse than the faunal composition of area 1 and less than that of area 2 (Plate 2).

The diversity and abundance of Soil Insects (meso and macro) tend to vary with different habitats (Anu and Thomas, 2006). In the present study also the forest habitat (Site-1) support more abundant and diverse soil insects compared to the other two areas. The other two areas support comparatively less diversity of soil insects. This may be due to the human interference that results in disturbance of soil texture. It is well known and documented that high soil organic matter content is usually beneficial for most soil animal groups (Bandyopadhyaya *et al.* 2002). The forest ecosystem with undisturbed soil harbors high diversity and abundance of soil insects. Increased leaf litter composition and humid environment provide a much suitable condition for the rich and diverse fauna in the forests (Hazra,1982). This in turn supports the development of rich flora also. Similar results were observed in the present study in which forest habitat supports higher diversity of soil meso and macro arthropods

Indiscriminate lopping of trees, land uses, introduction of plantation of exotics, establishment of hydro electric and irrigation projects, as well as cattle grazing are some of the major disturbances to the soil ecosystems (Mujeeb Rahman 2010). Low diversity of obligate soil dwelling insects in the open field (study area 2) may be due Diversity and abundance of soil organisms decreases due to heavy population pressure to increased sand mining, cattle grazing, and other anthropogenic activities that disturbs the soil texture. The leaf litter fall was found to be very limited in this area due to lack of vegetation cover and these may be the reasons for the less diversity of soil insects in the open field habitat. Studies of MCkay and Kladivko (1985) also showed that, the greater the intensity and frequency of disturbances the lower the population density or biomass of soil fauna.

The type of soil also plays a prominent role in the diversity of faunal composition in the study areas. Humus is a mixture of tiny solid particles and soluble compounds that are too chemically complex to be used by most organisms. This mixture plays an important role in improving the physical and chemical properties of soil (Catherine *et al.*). Forest habitat with humus rich soil supports higher diversity of soil insects in this study. The diversity of soil insect fauna is intermediate in study area 3 as compared to the other two areas. This may be due to moderate vegetation type, less microhabitat and other effects of human inhabitance in this area.

Table1: Check list of number and diversity of specimens collected from the study areas

Sub-Phylum	Class	Order	Number of Specimens
Chelicerata	Arachnida	Araneae	10
		Acari	8
Crustacea	Malacostraca	Decapoda	3
Myriapoda	Chilopoda	Lithobiomorpha	1
	Diplopoda	Spirobolida	4

Sub-Phylum	Class	Order	Number of Specimens
Hexopoda	Entognatha	Collembola	15
	Insecta	Coleoptera	25
		Diptera	2
		Dictyoptera	5
		Hemiptera	9
		Hymenoptera	16
		Insect Larvae	5
		Orthoptera	6
		Thysanura	5
Total	**6**	**13**	**114**

Table 2: Check list of total number and families of insects collected from the study areas

Sl. No.	Order	Families	No. of specimens
1	**Coleoptera**	Carabidae	2
		Curculionidae	6
		Nitidulidae	2
		Scarabidae	7
		Staphylinidae	6
		Tenebrionidae	2
2	**Dictyoptera**	Blattidae	5
3	**Diptera**	Bombyliidae	2
4	**Hemiptera**	Cicadidae	1
		Pyrrhocoridae	6
		Reduviidae	2
5	**Hymenoptera**	Chalicididae	3
		Formicidae	10
		Vespidae	3
6	**Orthoptera**	Acrididae	3
		Gryllidae	3
7	**Thysanura**	Lepismatidae	5
TOTAL		**17**	**68**

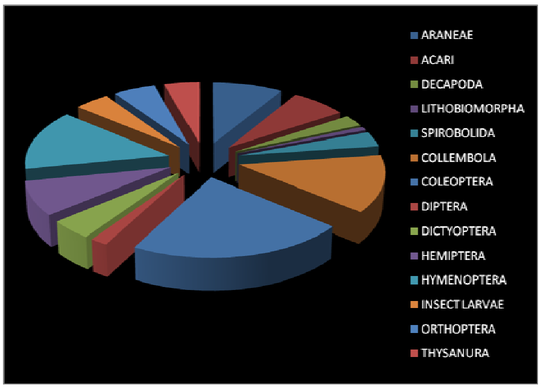


Fig. 1: Percentage of soil arthropods by class

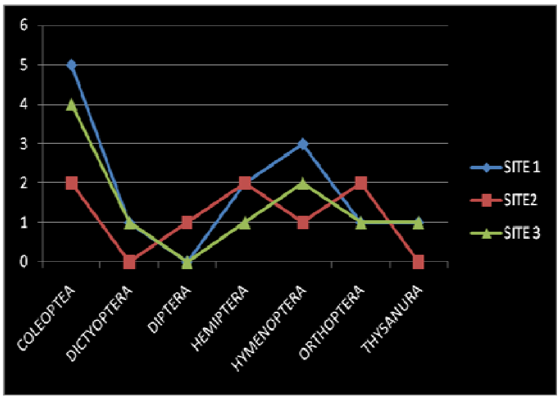


Fig. 2: Comparitive diversity of soil insects

Meso and Macro Arthropods in different habitats

Order - <u>Coleoptera</u>


Family: *Carabidae*


Family: *Curculionidae*


Family : *Nitidulidae*


Family : *Tenebrionidae*

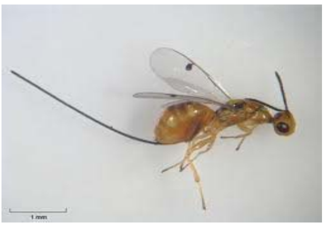
Order - <u>Hemiptera</u>


Family: *Bombyliidae*


Family: *Reduvidae*


Family: *Pyrrhocoridae*

Order - <u>Hymenoptera</u>


Family: *Chalicidae*


Family: *Vespida*


Family: *Formicida*

Order - <u>Orthoptera</u>


Family: *Gryllidae*


Family: *Acrididae*

Order - <u>Thysanura</u>


Family: *Lepismatidae*

References

1. **Anu, A. and Thomas, S.K. (2006).** Litter arthropod diversity and community structure in an evergreen forest in the Wayanad region of Western Ghats. Entomon 31: 3181-190.
2. **Bandyopadhyaya, I. Choudhuri, D.K. & Ponge J.F. (2002).** Effects of some physical factors and agricultural practices on Collembola in a multiple cropping programme in West Bengal (India). European Journal of Soil Biology 38: 111-117.
3. **Banerjee, S. (1972).** Microarthropods and humus formation. Journal of Indian Society of Soil Science, 20, 403-405.
4. **Bhandari, S.C and L. L Somani (1994).** *Ecology and biology of Soil organisms. .* Agrotech Publishing Academy,pp. 272.
5. **Gardi, C and S.Jeffery (2009).** *Soil biodiversity.*European commission joint research centre,Institute for environment and sustainability,Land management and natural hazards unit.DOI 10.2788-7831.
6. **Gupta, R. P and G.K. Sekhon. 1994.** Useful Microbial Association in Rhizosphere. In:Bhandari,S.C and L. L Somani(eds)*Ecology and biology of Soil organisms. Agrotech Publishing Academy.27-37*
7. **Hazra, A.K. (1982).** Soil and litter arthropod fauna of Silent Valley, Kerala: apreliminary report. *Journal of Soil Biology & Ecology,* 2, 73-77.
8. **Hole, F.D. (1981).** Effects of animals on soil Geocderma, 25, 75-112.
9. **Jeffery,S., Gardi,C., Jones,A., Montanarella,L., Marmo,L., Miko,L., Ritz,K., Peres,G., Rombke,J and Vander Puttan, W.H. (2010).** *European Atlas of Soil* .European Commission,Publication Office of the European Union.
10. **KSlUB (Kerala State land Use Board). 1995**. Land Resources of Kerala State. Vikas Bhavan, Thiruvananthapuram, 209p.
11. **Kumar, B.M. 2005**. Land use in Kerala: Changing scenarios and shifting paradigms. Journal of Tropical Agriculture, 42 (1-2) 1-12.
12. **Kumar, B.M. and Nair, P.K.R. (Eds.). 2006.** Tropical Homegardens: A Time-Tested example of Sustainable Agroforestry. Advances in Agroforestry-3. Springer, Dordrecht, the Netherlands, 380p.
13. **MacKay, W. P. Silva, S. Lightfoot, D.C. Pagani, M.I. & Whitford, W.G. (1986).** Effects of increased soil moisture and reduced soil temperature on a desert soil arthropod community. Am. Midl. Nat. 116: 45-56.
14. **Mujeeb Rahman, P. 2010.** Soil macrofaunal assemblage in selected Land use systems in kerala: Spatial pattern and structural dynamics. Cochin University.
15. **Sunil Kumar, R. (1999).** A review of biodiversity studies of soil dwelling organisms in Indian Mangroves. Zoo's print Journal, 15(3), 221-227.
16. **Wallwork, J.A. (1976).** *The Distribution and Diversity of Soil Fauna.* Academic Press, London.

Lichen flora in the Kerala part of Western Ghats – an overview

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Abstract

Lichens are the most successful symbiotic organisms on earth and can grow on anything and anywhere. Western Ghats, one of the mega centres of endemism in India play an important role in maintaining the diversity of macro and micro floras of peninsular India and hold a good number of lichens in its various microclimatic pockets. Kerala with many endemic hotspots also hold rich lichens in its diverse habitats with about 23% of the total lichen flora occurring in India. The present paper gives an idea about the status of lichen flora and its various micro and macro habitats of Kerala.

Key words: Lichen, Kerala, Western Ghats

Potential Ornamental Brake ferns in the Western Ghats of South India

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Abstract

16 taxa of ornamental Brake ferns collected and studied from the Western Ghats of South India, their descriptions, cultivation methods and colour photographs are provided.

Key words: *Pteris*, Brake fern, Ornamental

Introduction

The genus *Pteris* (Pteridaceae) is commonly known as 'Brake ferns' and is a large, pantropical genus established by Linnaeus (1753) with 19 species. It is estimated to contain about 250 species (Tryon *et al.*, 1990) in the world and 50 species (Fraser-Jenkins, 2008) in India. The majority of members of *Pteris* in India are found in the East Himalayan region of N.E. India and Western Ghats of South India. Western Ghats, one of the biodiversity rich areas of the world, harbors luxuriant ferns and lycophytes. Recently, 26 Brake ferns have been reported from the Western Ghats of South India (Sreenivas, 2011) though Manickam and Irudayaraj (1992) reported about 15 species. The brake ferns have been used as food, source of important metabolites, biologically active compounds, antibiotics, candidates for phytoremediation and aesthetics. Recently, Abraham *et al.* (2012), reported about 20 potential ornamental ferns including *Pteris argyrea* from Nilgiri hills of Western Ghats. During the study, about 16 brake ferns are found to be potential ornamental plants and some of them (e.g. *P. argyrea, P. multifida, P. vittata, P. ensiformis* var. *victoriae*, etc.) are commonly cultivated in India. A few species are available in shops, gardens and nurseries across the world.

Materials and methods

The present study is based on the materials collected from different parts of South India including Biosphere reserves, National Parks, and Wild life sanctuaries during May 2007 to April 2010. Habit, habitat, morphological characters, *etc.*, were observed in the field itself and fresh specimens were brought to the laboratory for further analyses. Detailed morphological descriptions were made from the mature, well developed plant materials based on 3-5 different accessions except a few. Microscopic observations were made with stereomicroscope with drawing device (Nikon SMZ 800) and Image analyser (Nikon Eclipse E400). Photographs were taken with the help of NIKON D100 SLR digital camera. At least one sample of each species is cultivated in the Calicut University Botanical Garden.

Results and Discussion

During the study, about 26 taxa of *Pteris* could be collected from various parts of south India. Of which 16 taxa were recognized as potential ornamental ferns and their descriptions and photographs (Plate-1) were provided.

Descriptions of the Taxa

Pteris argyraea T. Moore [Plate-1A]

Height 90-150 cm. Lamina bipinnate, 25-35 cm long x 18-25 cm broad, ovate-lanceolate. Pinnae 5-7 pairs, 18-22 cm long x 2.5-3 cm broad, subopposite or alternate, lanceolate, entire, adaxially green with white stripe along either side of mid-rib, pale green abaxially, basal pinnae bipartite. Pinnules 18-24 pairs, 1.4-1.7 cm long x 5-6 mm broad, oblong, entire, obtuse-rounded, sinus *c.* 2 mm away from costa, 0.5-1.5 mm apart, glabrous. Spores brown, *c.* 30 x 45 µm, trilete-tetrahedral, verrucate.

Habitat: Usually present in wet evergreen forest floors at high altitudes.

Altitude: 600m-2100m.

Distribution: Java, India (South India: Karnataka, Kerala & Tamil Nadu) and Sri Lanka.

Notes: It is commonly known as "Silver brake" due to its white striations along either side of the midrib. This fern grows well in shady and moist places and suitable for outdoor decorations.

Pteris blumeana J. Agardh [Plate-1B]

Height 40-60 cm. Lamina bipinnate, 30-35 cm long x 18-25 cm broad, oblong, dark green above and pale green below, subcoriaceous. Pinnae 4-10 pairs, 10-15 cm long x 1.5-3 cm broad, opposite to subopposite, lanceolate, acuminate, green, regular arrangement, basal pinnae bipartite. Pinnules 25-36 pairs, 1.2-1.6 cm long x 2-4 mm broad, oblong, margin entire, obtuse, sinus near to costa, *c.* 1 mm apart, pink spinules on distal part of segment, regular arrangement of segments. Spores brown, *c.* 35 x 40 µm, trilete-tetrahedral, verrucate.

Habitat: This is a rare species seen in earth cuttings and rock crevices in shady forests.

Altitude: 400m-2000m.

Distribution: India (South India: Kerala & Karnataka), Java, Myanamar, Singapore, Vietnam and Thailand.

Note: The attractive carmine red stipe makes the fern beautiful and can be cultivated in pots.

Pteris cretica L. [Plate-1C]

Height up to 100 cm. Lamina pinnate, 30-40 cm long x 15-25 cm broad, ovate-lanceolate, green, coriaceous. Pinnae dimorphic, fertile one is narrower than sterile one, 5-6 pairs, 18-22 cm long x 1.7-2 cm broad (sterile), 12-20 cm long x 6-7 cm broad (fertile), opposite-subopposite, lanceolate, acuminate, cuneate, margin distinctly serrate, bipartite, glabrous. Spores brown, *c.* 45 x 55 µm, trilete-tetrahedral, verrucate.

Habitat: A rare species present only in moist evergreen forest above 1300m.

Altitude: 1300m-2100m.

Distribution: Australia, China, India (South India: Tamil Nadu), Islands of Mediterranean Sea, Japan, Madagascar, Nepal, North and South America, Philippines and Taiwan.

Notes: The "Cretan brake" is one of the most widely cultivated of all ferns, being almost pantropic. It is a high altitude fern with pinnate frond ideal for indoor gardening. It prefers the moist and humid conditions for luxuriant growth.

Pteris cretica var. albolineata Hook. [Plate-1D]

Height up to 50 cm. Lamina pinnate, 12-20 cm long x 5-8 cm broad, ovate-lanceolate, green, subcoriaceous. Pinnae dimorphic, 1-2 pairs, 4-7 cm long x 1-1.5 cm broad (sterile), opposite, ovate-oblong,

cuneate, acute-acuminate, margin distinctly serrate, glabrous, green above with white band along either side of midrib, basal pair bipartite.
Habitat: Seen as cultivated fern in Gardens.
Altitude: Sea level-700m.
Distribution: England, India (South India: Kerala) and Indonesia.
Notes: A horticulture variant, commonly cultivated in India due to its white stripes along the midribs of pinnae. It is growing in many gardens both in indoor and outdoor decorations.

Pteris ensiformis Burm.f. [Plate-1F]

Height 30-45 cm. Lamina pinnate, dimorphic, 15-25 cm long x 10-16 cm broad, ovate to deltoid, membranaceous. Pinnae 3-5 pairs, terminal pinnae larger than lateral pinnae; lateral pinnae 9-10 cm long x 4-5 mm broad (fertile), 7-9 cm long x 2-3 mm (sterile), opposite or subopposite, lanceolate-ensiformis, apex acute-acuminate, crenate-crenulate, green above, pale green below, pinna more or less adnate to rachis, lower pinnae deeply lobed, ovate, lobes up to 5 pairs, glabrous. Spores brown, *c*. 45 x 50µm, trilete-tetrahedral, verrucate.
Habitat: Usually seen in fully shaded areas to partially shaded areas of forests.
Altitude: 350m-2000m.
Distribution: Australia, Borneo, China, India (South India: Andhra Pradesh, Kerala & Tamil Nadu), Malaysia, Philippines and Sri Lanka.
Note: The "Sword Brake", common in cultivation, is a native of Asia.

Pteris ensiformis var. victoriae Baker [Plate-1E]

Height 50-65 cm. Lamina pinnate, dimorphic, 30-40 cm long x 20-25 cm broad, ovate, membranaceous, fertile one narrower than sterile one. Pinnae 3-4 pairs, subopposite, terminal pinnae larger than lateral ones; lateral pinnae 14-16 cm long x 4-5 mm broad, lanceolate (fertile), 3-6cm long x 5-9 mm (sterile), apex acute-acuminate, serrulate, glabrous, lower pinnae deeply lobed, lobes up to 5 pairs, green above with white band along either side of midrib, pale green below. Spores brown, *c*. 35 x 40µm, trilete-tetrahedral, abortive and misshapen spores.
Habitat: Usually seen as a cultivated plant in gardens.
Altitude: Sea level-1100m.
Distribution: Australia, China, England, India (South India: Karnataka and Kerala), Java, Malaysia, Philippines and Polynesia.
Note: Widely used brake fern for indoor as well as outdoor gardening. It is characterized by its white band along the midrib and is not known in the wild.

Pteris heteromorpha Fee [Plate-1G]

Height 30-50 cm. Rhizome short, creeping, 3-5 cm long x 3-5 mm thick, cylindrical, scaly. Lamina pinnate, 20-25 cm long x 15-18cm broad, ovate, green, subcoriaceous. Pinnae 4-5 pairs, 7-15 cm long x 2.2-2.8 cm broad, heteromorphic, opposite, lower pairs petiolate, upper pair adnate to rachis, lanceolate (generally), green, acute (rarely apiculate), entire (rarely wavy), glabrous, pinnae laterally lobed (4-9 pairs) at base, lobes oblong, obtuse, 9-10 cm long x 2.5- 3 cm broad (in some cases very short lobes are present), terminal pinna large and base lobed. Spores brown, *c*. 50 x 60 µm, trilete-tetrahedral, rugate, broad equatorial ridge.
Habitat: Seen in evergreen forests.
Altitude: 400-900m.

Distribution: India (South India: Andhra Pradesh, Karnataka & Kerala), Myanmar and Philippines.
Note: A potential ornamental brake fern can be cultivated in moist, shady places.

Pteris longipes D. Don [Plate-1H]

Height up to 100 cm. Lamina bipinnate, 35-40 cm long x 25-30 cm broad, ovate or broadly ovate, green, basal pair ternately divided, subcoriaceous. Pinnae 10-16 pairs, 7-10 cm long x 1.5- 2.5 cm broad, opposite or subopposite, oblong-lanceolate, 7-12 pairs of accessory pinnae on lower ternately divided pinna. Pinnules 13-18 pairs, 9-12 mm long x 3-4 mm broad, oblong, obtuse, margin entire, apex crenate, sinus up to costa, 0.5-1 cm apart, prominent spinules on costule. Spore brown, *c*. 40 x 45 µm, trilete- tetrahedral, verrucate.
Habitat: In shaded floors of evergreen forests.
Altitude: 600m-1500m.
Distribution: India (South India: Karnataka, Kerala & Tamil Nadu), Java, Nepal, New Guinea, Philippines, Sri Lanka and Taiwan.
Note: This species can be utilized as ornamental ferns, both as interior and exterior plants, due to its magnificent frond architecture.

Pteris mertensioides Willd. [Plate-1K]

Height 250-300 cm. Lamina bipinnate, 160-175 cm long x 80-100 cm broad, ovate, upper surface green, lower pale green, membranaceous (thin). Pinna 20-25 pairs, 40-50 cm long x 5-6 cm broad, alternate, linear-lanceolate, acute, basal pinnae bipartite, glabrous. Pinnules 45-55 pairs, 2-3 cm long x 4-5 mm broad, oblong, acute, margin crenate, only apex crenate in fertile ones, sinus up to costa, 2-3 mm apart, triangular sinus, glabrous. Spores pale brown, *c*. 35 x 40 µm, trilete-tetrahedral, tuberculate, broad equatorial flange girdling the spore.
Habitat: A rare and elegant species present in shady evergreen forests.
Altitude: 400m-1300m.
Distribution: India (South India: Kerala & Tamil Nadu), Malaya, Myanmar, Polynesia, Siam, Sri Lanka and Thailand.
Notes: One of the elegant *Pteris* can be grown at the centre of lawns. The large, bipinnate, hanging frond gives the fern a splendid nature.

Pteris multiaurita J. Agardh [Plate-1J]

Height up to 120 cm. Lamina pinnate, 35-50 cm long x 20-30 cm broad, ovate or oblong, green, leathery. Pinnae dimorphic, fertile one is narrower than sterile one, 8-12 pairs, 5-15 cm long x 5-7 mm broad (sterile), 12-18 cm long x 7-9 mm broad (fertile), subopposite, lanceolate, acuminate, cuneate, apex crenate, all are bipartite, glabrous (fertile). Spores brown, *c*. 35 x 40 µm, trilete-tetrahedral, rugate.
Habitat: Seen in shady areas of evergreen forests.
Altitude: 100m-2100m.
Distribution: India (South India: Kerala & Tamil Nadu) and Sri Lanka.
Note: It can be used as house plant and also grown in gardens due to its attractive pinnae.

Pteris multifida Poir. [Plate-1L]

Height 15-30 cm. Lamina pinnate, dimorphic, fertile fronds 25-32 cm height, sterile frond 12-20 cm height, ovate, green. Pinnae 2-3 pairs, opposite, lanceolate, terminal pinna larger than lateral pinnae, terminal pinna 15-16 cm long x 6-8 mm broad, lateral pinna 6-9 cm long x 4-5 mm broad (fertile), 5-6 cm long x 4-5 mm

broad (sterile), margin wavy or serrate, apex acute-acuminate, serrate or serrulate, glabrous, thin, papyraceous, pinna decurrent to form a winged rachis, lower pinnae multifidus. Spores brown, *c.* 40 x 45 µm, trilete-tetrahedral, misshapen spores, rugate ornamentation.
Habitat: Grows in walls of wells, brick walls, and rocky edges, *etc*.
Altitude: Sea level (± 5m).
Distribution: China, India (South India: Kerala), Japan, Korea, Sri Lanka and Taiwan.
Notes: This species is commonly known as "Spider brake" due to its elongated slender divisions of the pinnae. Sreenivas and Madhusoodanan (2010) reported it from Peninsular India as a new record.

Pteris otaria Bedd. [Plate-1M]

Height 76-80 cm. Lamina bipinnate, 30-38 cm long x 10-16 cm broad, lanceolate, green, subcoriaceous. Pinnae 6-8 pairs, 8-11 cm long x 2-3 cm broad, opposite or subopposite, lanceolate, green, basal pair bipartite. Pinnules 7-12 pairs, 1-2 cm long x 3-4 mm broad, oblong, margin entire, apex crenate, sinus *c.* 1 mm from costae, *c.* 1.5 mm apart, basal pinnules reduced at acroscopic side, spinules along the costule. Spores brown, *c.* 30 x 35 µm, trilete-tetrahedral, rugate.
Habitat: Fully exposed area as well as partially exposed areas such as earth cuttings, forest floors, *etc*.
Altitude: 10m-1000m.
Distribution: India and Sri Lanka (South India: Kerala and Tamil Nadu).
Note: It can be used for outdoor decorations due to its reduced acroscopic pinnules.

Pteris pellucida C. Presl [Plate-1N]

Height up to 70 cm. Lamina pinnate, 20-30 cm long x 15-25 cm broad, deltoid, green, coriaceous. Pinnae 3-4 pairs, 15-20 cm long x 2-2.5 cm broad (sterile), 24-28 cm long x 2.5-3.5 cm broad (fertile), opposite or subopposite, lanceolate, terminal pinna larger than lateral ones, entire, apex acuminate, glabrous, pinnae base adnate to stipe, basal pair not bipartite, green. Spores brown, *c.* 30 x 35 µm, trilete-tetrahedral, verrucate.
Habitat: Seen in fully exposed as well as shaded forest areas.
Altitude: 50m-1500m.
Distribution: China, Japan, India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Myanmar and Thailand.
Notes: It is widely distributed throughout the Western Ghats of South India. So that it can be cultivated very easily in all climate conditions, as indoor and outdoor plants.

Pteris scabripes Wall. ex J. Agardh [Plate-1P]

Height 50-90 cm. Lamina pinnate, 15-35 cm long x 10-20 cm broad, ovate or broadly ovate, dark green, subcoriaceous. Pinnae terminal one larger than lateral ones, 3-9 pairs, 10-25 cm long x 9-12 mm broad, opposite or subopposite, linear-lanceolate, acute or acuminate, cuneate, petiolate, entire, apex crenate, basal pair bipartite, glabrous, dark green above, pale green below. Spores brown, *c.* 50 x 55 µm, trilete-tetrahedral, verrucate.
Habitat: In shaded areas of the evergreen forests.
Altitude: 800m-2000m.
Distribution: China, India (South India: Karnataka, Kerala & Tamil Nadu), Malaysia, Myanmar and Thailand.
Note: This can be used as a house plant due its charming pinnae.

Pteris tripartita Sw. [Plate-1Q]

Height up to 300 cm. Lamina compoundly bipinnate, basal pair tripartite, 100-125 cm long x 70-90 cm broad, ovate, green, subcoraceous. Pinnae 15-20 pairs, 10-20 cm long x 3-4 cm broad, opposite- subopposite, lanceolate, pinna-apex 3-4 cm. Pinnules 12-22 pairs, 1.5-2.0 cm long x 4-5 mm broad, oblong, obtuse, apex crenate, sinus *c.* 3 mm away from costae, 3-4 mm apart, glabrous. Spores brown, *c.* 30 x 40 µm, trilete-tetrahedral, verrucate.

Habitat: Grows in evergreen and shola forests near stream banks.

Altitude: Above 2000m.

Distribution: Australia, China, Fiji, India (South India: Tamil Nadu), Indonesia, Java, Malaysia, Philippines, Sri Lanka, Thailand, Tropical Africa and Vietnam.

Note: Trisect brake or Giant brake, one of the largest and most beautiful species of ferns can be grown out of doors only.

Pteris vittata L. [Plate-1R]

Height 45-120 cm. Lamina pinnate, 45-90 cm long x 6-40 cm broad, obovate, green, subcoriaceous. Pinnae 10-28 pairs, 5-25 cm long x 5-9 mm broad, opposite or subopposite, sessile, linear-lanceolate, entire, acute, base cordate, margin and apex crenate or crenulate except soral region, pinnae gradually reduces towards base, not bipartite at base, green. Spores brown, *c.* 50 x 55 µm trilete-tetrahedral, bisculpate.

Habitat: Grows in partially exposed areas such as road sides, earth cuttings, walls of old buildings, *etc*.

Altitude: Sea level-1500m.

Distribution: Cameroon, China, Ghana, India (South India: Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Nepal, New Guinea and Philippines.

Note: Chinese Brake, commonly grows in many gardens and houses.

Cultivation methods

Growing from Spores

The Brake ferns can be cultivated form spores that are collected from sori, which are set along the submarginal areas on the undersides of fronds. The spores are collected by picking a frond and keeping it between two sheets of white paper. If ripe, the spores should drop within 24 hours and leave a pattern on the paper. Frequently, the spores are intermingled with sporangia and it has to removed before sowing. It is better to use a clean plastic tray with sterilized soil and vermi-compost. The spores are dusted on the top of the soil and then placed under cool white fluorescent lights for 12-14 hours a day. The spores must be out of direct sunlight. Depending upon the species, the spores will grow into a carpet of prothallia, which are small, green, heart-shaped structures. Water is applied as mist to hasten fertilization. The sporelings are then transferred to mini-greenhouse. They are then transplanted into pots, and finally moved out doors when they are four to six inches tall depending, of course, on the season.

Growing adult Plants

Almost all ferns enjoy heavy degree of shade when compared with other garden plants. Though naturally they do not grow in complete darkness, but it is always worth a try of a few in the gardens really dark corners. In the case of brake ferns, better to use rhizome with single frond for propagation. Usually earthen pots filled with sawdust and soil (2:1) can be used along with proportionate cow dung for cultivating brake ferns. As other ferns, most of the brake ferns prefer moist, humid conditions at the initial stage of planting. After establishment these plants can be shifted to out of door, but care should be taken to avoid direct sunlight in most of the cases for a few weeks.

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References

1. **Abraham, S., Ramachandran, V.S. & Sofia, C. 2012.** Potential ornamental Ferns from Nilgiris, Tamil Nadu. Adv. Appl. Sci. Res. 3: 2388-2391.
2. **Fraser-Jenkins, C. R. 2008.** *Taxonomic revision of three hundred Indian subcontinental pteridophytes with a revised census-list.* Bishen Singh Mahendra Pal Singh, Dehra Dun.
3. **Linnaeus, C. 1753.** *Species Plantarum*. Laurentii Salvii, Holmiae. Pp. 1073-1077.
4. **Manickam, V. S. & Irudayaraj, V. 1992.** Pteridophyte Flora of the Western Ghats. 1-653. South India. B.I. Publications, New Delhi.
5. **Sreenivas, V. K. & Madhusoodanan, P. V. 2010.** *Pteris multifida* – a new record from Peninsular India. *Acta Bot. Hung*. 52: 425-427.
6. **Sreenivas, V. K. 2011.** Taxonomic studies on the genus *Pteris* L. (Pteridaceae) in South India. Ph.D. Thesis, University of Calicut.
7. **Tryon, R. M., Tryon, A. F. & Kramer, K. U. 1990.** *Pteridaceae*. Pp. 230-256 in: Kramer, K. U. & Green, P. S. (eds.), in: Kubtizki, K. (ed.), *The Families and Genera of Vascular Plants Vol.1. Pteridophytes and Gymnosperms*. Springer Verlag, Berlin.

PLATE-1. ORNAMENTAL BRAKE FERNS

Floral biology of a few *Bauhinia* species from Western ghats

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Abstract

Bauhinia, commonly known as cow's paw, is a pantropical genus of the family Caesalpiniaceae. The floral characteristics of four species of *Bauhinia* (*B. acuminata,* a shrub, growing to a height of 3 meters with white corolla; *B. phoenicea,* a large climbing shrub with orange colored corolla; *B. tomentosa*, a small tree with yellow corolla; *B. variegata*, a medium sized tree with pink corolla) were investigated during one complete flowering cycle (August - January). The plants were collected from part of Western Ghats, at a height of 1250 meter above sea level in the south east of Karuvarakundu, Malappuram, closely bordered by the mountain ranges on its east. The pollination and reproductive system of all the four species were studied during the peak of flowering. The morphological characters like calyx, corolla, androecium, gynoecium, gynophore, ovary, style, stigma, ovules, hypanthium etc. and the aspects of floral biology like anthesis, pollen number per anther, pollen viability, number of ovules, pollen ovule ratio, nectar secretion, pollinator activity, type of pollination etc. were studied. The variations in these parameters were studied thoroughly and compared between plants. This genus exhibits a considerable amount of morphological and ecological variations that throw light on the breeding systems and evolution.

Key words: *Bauhinia,* Caesalpiniaceae, Floral biology

Introduction

The Western Ghats constitute a mountain range along the western side of India. The area is one of the world's ten "Hottest biodiversity hot spots" and has over 5000 species of flowering plants. The hilly district of Malappuram falls among the northern districts of Kerala, closely bordered by the mountain ranges of the Western Ghats on its east, and flanked by the Arabian Sea on the West.

Bauhinia, commonly known as 'cow's paw' or 'orchid tree' is a relatively large genus of the family Caesalpiniaceae with a pantropical distribution. The genus consisting of trees, climbers and shrubs is distributed in a wide range of geograhical locations. *Bauhinia* trees typically reach a height of 6-12 m and their branches spread 3-6 m outwards. The lobed leaves usually are 10-15 cm across. The five-petaled flowers are 7.5-12.5 cm diameter, generally in shades of red, pink, purple, orange, or yellow, and are often fragrant. (CSIR, 1952; Kirthikar & Basu, 1991; Manjunatha *et al,* 2004 ; Sahu & Gupta, 2012) The tree begins flowering in August/Septembr and often continues to flower up to January/February. The genus possesses medicinal, anti – ulcer and antimicrobial properties (Valdir, 2009; Swarnalatha *et al*, 2010; Patidar *et al,* 2011). Very few data (Nelson *et al*, 1984) is available on the floral biology and breeding systems of the genus *Bauhinia*. The present study is an attempt to analyze the floral characteristics of *Bauhinia*, which provide the preliminary information on the breeding systems and the line of evolution in the genus.

Materials and methods

Four species of *Bauhinia* (*B. acuminata, B. phoenicea, B. tomentosa* and *B. variegata*) collected from part of Western Ghats fencing Karuvarakundu, Malappuram District, Kerala, were used for the study. The collections were made during the peak of flowering (September-October).

1. *Bauhinia acuminata* is a species native to tropical southeastern Asia. The common names of this species include '*Dwarf white bauhinia*', 'white orchid-tree' and 'snowy orchid-tree'. It grows 2-3 meters tall. The leaves are bilobed, and are 6 to 15 centimeters long and broad, with the apical cleft up to 5 cm deep; the petiole is 1.5 to 4 centimeters long.

2. *Bauhinia phoenicea* is commonly known as '*Scarlet Bauhinia'* It is a large climbing shrub found in the Western Ghats. Alternately arranged leaves are ovate, oblong, tip rounded, bi-lobed, and base heart-shaped. Leaves are 8.5-14 cm long, 5-10 cm wide, prominently nerved. Flowers are scarlet red, borne in few-flowered corymbs in leaf axils or at the end of branches.

3. *Bauhinia tomentosa* is usually a scrambling, many-stemmed shrub or small tree reaching 4 -6 m height, the branches often drooping, with many slender twigs (Anon, 1986; Orwa *et al*, 2010). Leaves deeply divided for almost half their length, with a small apical appendage between the lobes; each lobe is oval to almost elliptic. Flowers bell-shaped, up to 7 cm long, beautiful and distinctive, pendulous, solitary, with large, lemon-yellow petals, 1-3 of which have a dark maroon patch at the base and turning a veined reddish brown with age.

4. *Bauhinia variegata* is a species native to southeastern Asia. Common names include 'orchid tree', 'camel's foot tree' and 'mountain-ebony'. It is a small to medium-sized tree growing to 10–12 m tall, deciduous in the dry season. The leaves are 10–20 cm long and broad, rounded, and bilobed at the base and apex. The flowers are conspicuous, bright pink or white, 8–12 cm diameter, with five petals.

Floral morphology

Floral morphology of different floral parts like calyx, corolla, androecium, gynoecium, gynophore, ovary, style, stigma, ovules, hypanthium *etc*. were observed thoroughly and measured to compare between plants. (Figs 1-2).

Floral biology

Other phenomena like anthesis, pollen number per anther, pollen viability, number of ovules, pollen ovule ratio, nectar secretion and pollinator activity and type of pollination also were studied thoroughly. The variations in these parameters were studied and recorded during the peak of flowering (Table 3). The pollen viability was calculated by the staining procedure using acetocarmine and glycerine. Pollen ovule ratio was calculated by the method of Cruden (1977).

Results

The morphological and biological characteristics of all the species studied were recorded in Tables1-3. All the species were self-compatible. Both self and cross pollinations were observed.

1. *Bauhinia acuminata*

The inflorescence is a raceme, with few (3-10) flowers, axillary, appearing cymose; peduncle short, pubescent as inflorescence axis; bracts and bracteoles linear, pubescent. Flower buds acutely tapering and ending in 5 linear calyx teeth. Hypanthium tubular. Calyx spathe open on one side, shortly 5-toothed. Petals white, obovate-elliptic, sessile. Fertile stamens 10 in 2 whorls, subequal, anthers yellow, oblong. Ovary prominently stalked, pubescent or almost glabrous; style long; stigma peltate, and remained receptive for 8-9 hrs after anthesis. The average lengths of each floral organ are reported in Table1-2. The plant showed 98% pollen viability and the flowers produced rich nectar. Pollen ovule ratio was comparatively higher. The floral biology showed features associated with chiropterophily (bat pollination), such as nocturnal anthesis, whitish flowers positioned outside the foliage, and high pollen and nectar production.

2. *Bauhinia phoenicea*

The Inflorescence is a raceme, few flowered, terminal. Flower buds fusiform, smooth, subsessile. Calyx open as a spathe into 2 lobes. Petals orange red, oblanceolate, clawed. Fertile stamens 5; filaments long as petals, slender. Staminodes 5 and small. Ovary stalked, puberulent; style curved; stigma small and remained receptive for 8 -10 hrs after anthesis. Bright colour and moderate amount of nectar were the features attracting the pollinators. The plant showed 98% pollen viability

3. Bauhinia tomentosa

Trees flower in their 2nd year and are usually very floriferous, bearing flowers during August-February. The flowers from this tree, rich in pollen and nectar, attract various insects such as butterflies and bees the Inflorescence is a lateral raceme, 1-3-flowered; pedicel short; bracts and bracteoles linear, Flower buds fusiform, puberulent. Hypanthium turbinate. Calyx split spathaceously at anthesis. Petals light yellowish, subequal, broadly obovate, subsessile. Fertile stamens 10, unequal; filaments, puberulent at base. Ovary stalked, tomentose; style slender, glabrous; stigma peltate, small, remained receptive for 8 -10 hrs after anthesis. The plant showed 100% pollen viability. Rich production of nectar also was observed. Pollen ovule ratio was the highest among all the species studied.

4. *Bauhinia variegata*

The Inflorescence is a raceme, few flowered, corymb like, terminal. Flower buds fusiform, smooth, subsessile. Calyx open as a spathe into 2 lobes. Petals purplish oblanceolate, clawed. Fertile stamens 3; filaments long as petals, slender. Staminodes 5 and small. Ovary stalked, puberulent; style curved; stigma small and remained receptive for 8 -10 hrs after anthesis. Rich production of nectar and 100% pollen viability were recorded. This species showed lowest pollen ovule ratio.

Table 1: Floral Morphology of *Bauhinia*

	Pedicel (cm)		**Sepal** (cm)		**Petal** (cm)		**Filament** (cm)		**Anther** (cm)		**Pollen** (μm)	
	x	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**
B. acuminata	1.25	0.11	1.66	0.23	5.06	0.15	2.2	0.13	0.17	0.31	66	0.21
B. phoenicea	1.01	0.02	1.32	0.31	3.65	0.21	1.98	0.24	0.45	0.33	62.5	0.33
B. tomentosa	1.03	0.31	1.53	0.12	4.25	0.11	1.72	0.12	0.16	0.05	67	0.25
B. variegata	1.32	0.14	2.33	0.03	5.26	0.12	3.75	0.15	0.66	0.07	68.9	0.15

Table 2: Floral Morphology of *Bauhinia* (contd.)

	Hypanthium (cm)		**Gynophore** (cm)		**Ovary** (cm)		**Style** (cm)		**Stigma** (cm)		**Ovule** (cm)	
	x	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**	**x**	**σ**
B. acuminata	0.38	0.09	1.12	0.06	1.03	0.06	1.96	0.18	0.11	0.03	0.06	0.21
B. phoenicea	0.42	0.36	0.72	0.32	1.2	0.22	0.93	0.22	0.11	0.33	0.09	0.01
B. tomentosa	0.41	0.05	0.54	0.05	1.26	0.19	0.98	0.18	0.13	0.05	0.08	0.02
B. variegata	0.45	0.05	1.09	0.36	1.51	0.07	1.65	0.14	0.14	0.05	0.89	0.10

Table 3: Floral biology of *Bauhinia*

Species	Anthesis	Pollen no/ anther	Pollen viability (%)	No of ovules	Pollen /ovule ratio (P/O)	Nectar secretion	Pollinator activity	Pollination
B. acuminata	Mid night	~3000	98%	9	333	Rich	Bats, butterflies, bees & wasps	Self & cross
B. phoenicea	Early morning	~2500	98%	9	277	Moderate	Butterflies & bees	Self & cross
B. tomentosa	Early morning	~3500	100%	10	350	Rich	Butterflies bees & moths	Self & cross
B. variegata	Morning	~3000	100%	14	214	Rich	Butterflies bees & wasps	Self & cross

Fig. 1. A *Bauhinia acuminata*

Fig. 1. B *Bauhinia phoenicea*

Fig. 1. C *Bauhinia tomentosa*

Fig. 1. D *Bauhinia variegata*

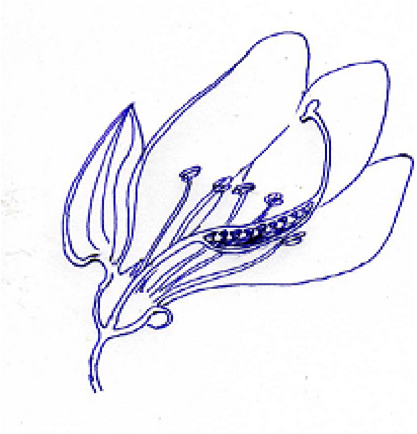

Fig. 2 . A *Bauhinia acuminata* - flower L S

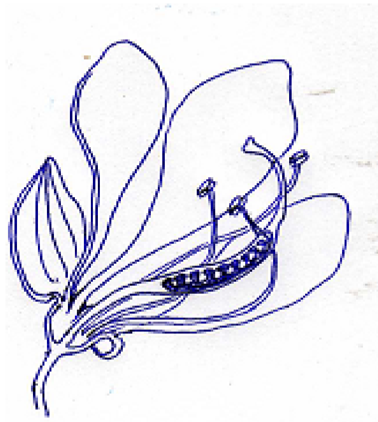

Fig. 2 . B *Bauhinia phoenicea* - flower L S

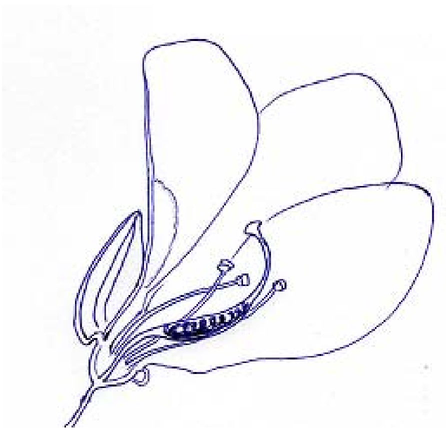

Fig. 2 . C *Bauhinia tomentosa* - flower L S

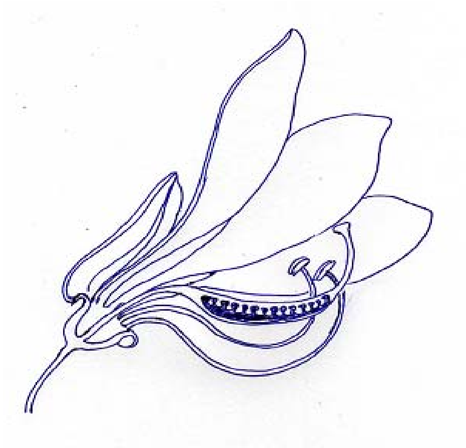

Fig. 2 . D *Bauhinia variegata* - flower L S

Discussion

The floral biological features associated with chiropterophily were observed in *B. acuminata*. They were nocturnal anthesis, whitish flowers positioned outside the foliage, and high pollen and nectar production. All other species with attractive colours, rich production of nectar etc favoured insect pollination. It is generally accepted that differences in breeding systems tend to be correlated with successional stages. Plants of later successional stages like tropical forest trees tend to be xenogamous. The pollen ovule ratio also is correlated with breeding systems, otogamous flowers having lower P/O than xenogamous flowers.

References

1. **Anon. 1986.** The useful plants of India. Publications & Information Directorate, CSIR, New Delhi, India.
2. **CSIR, 1952.** The Wealth of India: Raw Material: A Dictionary of Indian Raw Material and Industrial Products New Delhi 2: 56-57.
3. **Cruden R. W. 1977.** Pollen ovule ratios: a conservative indicator of breeding systems in flowering plants. Evolution 31: 32-46.
4. **Kirthikar K. R. & Basu B. D. 1991.** Indian Medicinal Plants 3rd Ed. pp. 898-90.
5. **Manjunatha B. K., Krishna V. & Pullaiah T. 2004.** Flora of Davanagere District: Karnataka, India. Pp.159.

6. **Nelson R., Claudia S., Nereida X. E. & Thirza R. 1984.** Floral Biology and Breeding System of *Bauhinia benthamiana* Taub . (Leguminosae), a Bat-Pollinated Tree in Venezuelan " Llanos. American Journal of Botany 71(2):273-280.
7. **Orwa C, Mutua A, Kindt R, Jamandass R & Anthony S. 2010.** Agroforestree Database: A tree reference and selection guide, version 4.0. Available from: http://www.worldagroforestry.org /sites/treedbs/treedatabases.asp [cited 2010 Jan 31]
8. **Patidar L. N., Bhargava P., Bhadauria R. S. & Ravichandran N. 2011.** Anti-ulcer Activity of aqueous extract of *Bauhinia tomentosa* linn. leaves Advanced Research in Pharmaceuticals and biological Vol 1(1).
9. **Sahu G, Gupta P.K. 2012.** A review of *Bauhinia variegata* Linn. International Research Journal of Pharmacy (1).
10. **Swarnalatha D., Madhu K.B.,. Satyanarayana T., & Mallikarjuna R. P. 2010.** Antimicrobial activity of *Bauhinia tomentosa* and *Bauhinia* vahlii roots Pharmacogn Mag. 6(23): 204–207.
11. **Valdir C. F. (2009)** Chemical Composition and Biological Potential of plants from the genus *Bauhinia*. Phytotherapy Research 23:1347–54.

Tribal Knowledge of Western Ghats: A study on the Knowledge System of selected Tribal Communities of Kerala

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Abstract

The Western Ghats span an area of 51185 Sq. Km, parts of Kerala, Tamil Nadu, Karnataka, Maharashtra and Goa. About 42.7 per cent of this area is situated in Kerala. The Western Ghat region in Kerala is endowed with rain forests and rich potential water resources. This region is very significant in Kerala not only on account of its rich natural resources but also because of the human habitation, particularly tribal habitation. There are 36 tribal communities inhabiting in the western Ghats region. The tribal inhabited area can categorize into Wayanad, idukki, Attappady, Nilambur, Kasaragod, and Travencore areas. The major tribal communities are Paniya, Kurichyer, Mavilan, Muthuvan, Kanikkar, Kattunaickan etc.

The forest based communities have their own adaptation to the environment. The food gathering and food collection techniques are different from communities to communities. Each ethnic group has classification on flora and fauna. The tubers, roots, fruits, animals and medicinal herbs are identified based on their eco system. The Cholanaickans of Nilambur area calssified the tubers as *solavenni, ikkuvenni, noorai, eranni,pathivenni and nara.*The Mavilan of Kasaragod termed as *mudukka, pallathrae, naara,venni* etc. The tribal knowledge system can be classified as ecological knowledge, agricultural knowledge, medicinal knowledge and technical knowledge.

Key words: Tribals, knowledge systems, Kerala, Western Ghats

A review study on Butterfly Fauna in India

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Abstract

This study is to present an overview of studies on butterflies from different regions of India; it aims at identifying knowledge gaps and suggests areas of research priorities in butterfly related studies. Studies on butterflies were collected from different sources by data mining. Characteristics such as year of study, study area, species recorded and subject areas were analyzed so as to understand the overall trend of butterfly studies in India. Of the total studies analyzed here, 60% were carried out between 2000- 2012. Butterfly diversity is highest in North east and East India, but the number of studies were less here. More studies were found to be concentrated around southern India. As far as study area is concerned, maximum studies are performed in protected areas and forest regions, whereas few studies are noted in other ecosystems. Database on subject distribution revealed that Status /Diversity /Checklist studies dominate followed by Bio-ecological studies.This review focus the suitable regions in India and study areas where more focus should be given for further research.

Key words: Butterflies, India

Ferns and Lycophytes of Kakkavayal Forest (*Vanaparvam*) in the Western Ghats of Kozhikode District, Kerala, India

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Abstract

An account of 28 species of Pteridophytes including 25 Ferns and three Lycophytes of Kakkavayal forest (*Vanaparvam*) in the Western Ghats of Kozhikode District, Kerala is provided.

Key words: Kakkavayal, Vanaparvam, Ferns, Lycophytes

Introduction

The Kakkavayal Forest in the Western Ghats of Calicut (Kozhikode) district of Kerala is a left-over forest patch, now recovered to a great extent from the heavy habitat degradation due to over exploitation of the recent past. It now lies amidst the human habitations, cultivated fields and plantations. However, it supports good assemblage of flora and fauna. More than 290 species of angiosperms, which include 117 tree species, 51 shrubby members, 66 climber species, 58 herbaceous elements, 14 grass species, seven sedge species and two orchid species are known to occur in this small forest patch of 111 ha. Among these 59 species are endemic to the Southern Western Ghats (Augustine *et al.*, 2010). One species of Gymnosperm (*Gnetum edule*) is also present in the area. Manju et al. (2011) recorded 40 species of Bryophytes 40 species from such as small area. The area also supports rich assemblages of Butterflies (158 species with 7 endemics, Dragonflies (27 species), Damselflies (16 species), Fishes (14 species with 5 endemics), Amphibians (15 species with 8 endemics), Reptiles (27 species), Birds (106 species) and Mammals (30 species). The presence of rare animals such as Slender Loris, Pangolin, King Cobra, Indian Cobra, Common Krait, the Russell's Viper, etc also proves its high conservation potential (Augustine *et al.*, 2010). Considering the significance of the area, the Kerala Forest Department has initiated a conservation park, namely *Vanaparvam*. It now serves as a centre for *in situ* conservation and nature education. The present paper is an account of the Ferns and Lycophytes in this unique patch of Reserve Forest of the Western Ghats of Calicut (Kozhikode) district of Kerala.

Study area

This account on the area is mainly based on Augustine *et al.* (2010). Kakkavayal and the adjoining forests constitute an integral part of the Western Ghats, the well known biodiversity 'hot spot' of the country endowed with diverse habitats harbouring rich diversity of species. It lies in the catchments of Chaliyar river, one of the major rivers in northern Kerala (Map 1). These forests were under private possession prior to 1971. During that period, hectic activities took place in the entire accessible reaches, for timber and other forest produces. These factors along with continued biotic interferences have ultimately caused depletion of luxuriant and diverse tropical evergreen forests from these areas, leaving forests only on the steep slopes as a narrow strip. Now secondary growth has established in most of the area due to the protection given by the Kerala Forest Department, after it came into the possession and ownership of the Government of Kerala.

Vanaparvam, the vested forest item number 107, and lies between 11^{o}30' and 11^{o} 31' North latitude and 75^{o} 57' to 75^{o}58' longitude is coming under the jurisdiction of Puthupady East Beat of Kanalad Section of Thamarassery Range in the Kozhikode Division. It is on the lap of Wayanad Plateau, at about 2 km away from Eengapuzha town, which is towards north of Thamarassery in the Western Ghats in the Kozhikode district of Kerala. The Kakkavayal area is on the foothills of Waynad, adjoining the Kakkad and Kolamala. The main stream of the area, *Pathiparathodu*, originating from the Athikodumala area is flowing through the Park. The richness of these perennial streams and several small springs provided an ideal habitat for various kinds of plants and animals. The area with a total of 111.40 ha, surrounded on all parts by human habitation and plantations, is now a refuge for many species of animals and a repository for the rare and endemic plant species.

Climate is warm humid tropical, typical of this part of the Western Ghats, with the temperature varies from 18^{o} C to 31^{o} C. The average rainfall varies from 1950 to 3130 mm, with the major part received during the South-West Monsoon. The average humidity is in between 50% to 60%. The topography is highly undulating and the altitude ranges from 50 m to 300 m above MSL. The Soil is loamy and deep in many places and shallow in the steep slopes. Rocky out crops are seen in some places. Vegetation of the area is mixed deciduous forest with *Xylia-Terminalia-Mallotus* association. In some places there are patches of semi-evergreen forests with *Vateria-Holligarna-Drypetes* association. The soil depth is low especially along the sheer cuttings and rocks. The trees founds in those parts are with low growth.

Map of the study area - Kakkavayal

The presence of varied habitats such as forest covered slopes, marshy fields, perennial stream and its wet banks, etc and the sharp altitudinal gradient, within a short span of area offers immense opportunities for ferns and lycophytes also to colonise. The list of 28 species of pteridophytes recorded during the survey is presented here. It includes minute filmy ferns adapted to the wet rocks of the stream to the tree fern, and highlight the conservation significance of the area.

A. FERNS

1. **Adiantum latifolium** Lam., Common in marshy area.
2. **Adiantum philippense** L., Common in land cuttings, or slopes
3. **Alsophila gigantea** Wall. ex Hook., Rare along the streamlet

4. **Angiopteris indica** Desv., Rare along the streamlet
5. **Blechnum orientale** L., along the marshy area
6. **Bolbitis appendiculata** (Willd.) K.Iwats., on rocks/boulders along the streams and in the forest floors
7. **Bolbitis x prolifera** (Bory) C.Chr. & Tardieu, in forest floor
8. **Ceratopteris thalictroides** (L.) Brong., common in marshy area
9. **Cheilanthes tenuifolia** (Burm.f.) Sw., on land cuttings
10. **Trichomanes intramarginale** Hook. & Grev., rare on the boulders along the stream
11. **Drynaria quercifolia** (L.) Js.Sm., on trees and rocks
12. **Leptochilus decurrens** Blume, on boulders of stream
13. **Leptochilus pteropus** (Blume) Fras.-Jenk. subsp. **minor** (Bedd.) Fras.-Jenk., on boulders of stream
14. **Lindsaea ensifolia** Sw.
15. **Lygodium flexuosum** (L.) Sw., on land cuttings
16. **Nephrolepis multiflora** (Roxb.) F.M.Jarret ex C.V.Morton, along the marshy area
17. **Parahemionitis cordata** (Roxb. ex Hook. & Grev.) Fraser-Jenk., on forest floor & land cuttings
18. **Pityrogramma calomelanos** (L.) Link, near the garden area
19. **Pteris confusa** T.G.Walker, on land cuttings and forest floor
20. **Pteris pellucida** C.Presl, on land cuttings and forest floor
21. **Pteris vittata** L., on land cuttings
22. **Pyrrosia lanceolata** (L.) Farw., on bark of trees
23. **Stenochlaena palustris** (Burm.f.) Bedd., along marshy area
24. **Tectaria wightii** (C.B.Clarke) Ching, on land cuttings
25. **Thelypteris parasitica** (L.) Tardieu., on forest floor

B. LYCOPHYTES

26. **Selaginella ciliaris** (Retz.) Spring, on land cuttings
27. **Selaginella delicatula** (Desv. *ex* Poir.) Alston, on land cuttings
28. **Selaginella tenera** (Hook. & Grev.) Spring, on land cuttings

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References

1. **Augustine, J., Rajesh, K.P., Kumar, K.K. Manju, C.N., Balakrishnan, V.C., Zacharia, A., Palot, J., Vijayakumar, T.N., Balakrishnan, V., Sathyan, M., Gayathri, S. and Saji. 2010.** *Biodiversity of Vanaparvam conservation park, Kakkavayal, Thamarasserry Range, Kozhikode District, Kerala*. Report by Malabar Natural History Society, Calicut.
2. **Manju, C.N, Rajesh, K.P., Jitha, S. Reshma, P.K. and Prakashkumar, R. 2011.** Bryophyte diversity of Kakkavayal Reserve Forest in the Western Ghats of India. *Archive for Bryology* 108: 1-7.

oral presentations

Ethnoveterinary practices and use of herbal medicines for the treatment of skin diseases in cattle: a study in Ajoor village, Nilgiri district, Western ghats of Tamil nadu, India.

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Abstract

Ethno-veterinary medicine is the treasure of knowledge found in rural India which could be an alternative and sustainable solution to this challenge. This study records indigenous medicinal plant utilization in treating skin diseases of cattle population and this study was carried out in Ajoor village, Nilgiri District between January 2010 and December 2012. Ethnoveterinary data were collected using pre-structured questionnaires, interviews and field observations with elderly persons, cattle owners, traditional healers and house wife's. A total of 12 ethnoveterinary preparations were studied in which 24 plant species belonging to 20 families were documented in the area. Some of the ethnoveterinary medicinal plants are *Azadirchta indica*, *Allium sativum* and *Curcuma longa, etc.,* the most frequently used plant parts were leaves (33.33%), followed by oils (29.17%) and rhizomes (25.0%). Most of the medicinal species were collected from the nearby areas of the locality. The low cost and almost no side effects of these preparations make them adaptable by the local community.

Keywords: Ethnoveterinary medicines, Traditional healers, skin diseases, Nilgiri, Western Ghats, Tamil Nadu.

Ethnobotanical survey on the tribals of Topslip, Anamalai Hills, Western Ghats, India

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Abstract

From early days of civilizations man is dependent on plants for their day to day needs and one of the important one after food is their medicinal use. Even now nearly 80% of world population use traditional systems of medicine for curing different ailments. Ethnic knowledge is usually passed on to generation by mouth to ear. With changing lifestyle younger generation is less interested in plants, making the knowledge base more vulnerable to get wiped off in due course of time, thus necessitating the urgent need for their documentation. We did a fast sweep survey of the ethnobotanical knowledge of tribes in the Valparai Plateau of Indira Gandhi Wildlife Sanctuary. Tribals living in the region include Mudugar, Kadar, Malasar and Irular. Information on use of plants was collected by personal interviews with elderly people in the hamlet, medicine men, tribal chieftain. Study shows that they make use of 45 species of flowering plants for treating various diseases, of which major portion forms herbaceous forms (19 species), followed by shrubs (10), climbers (10), trees (5) and epiphyte (1). Based on the parts used as medicine there were total of 51 uses and of this leaf stands top with 19 uses, followed by whole plant use (10), root (7) and others. In depth study will bring out more information, hitherto unknown to science.

Keywords: Ethnobotany, medicinal plants, traditional knowledge, tribe, Western Ghats, Anamalai, Topslip.

Introduction

The Western Ghats hill range of India, recognized as a global biodiversity hotspot, also contains impressive cultural diversity including a number of tribal communities. This study uses past records and primary field research to describe aspects of ethnic identity, social change, demography, livelihoods, and resource use among three tribal communities in the Anamalai hills along the Western Ghats Mountains of southern India. Kadar, Muthuvar, and Malasar communities across 190 households in 8 settlements located adjacent to rainforests in the Indira Gandhi Wildlife Sanctuary were studied to examine current modes of existence vis-à-vis their past and the use of rainforest patches they live within. The traditional ethnomedical knowledge has been descending from generation to generation with constant updating through trial and error method. World Health Organization (WHO) has shown great interest in documenting the use of medicinal plants from tribes in different parts of the world (Dev, 1997).

The World Health Organization (WHO) estimates that more than 80% of health care needs in these countries are met through traditional health care practices (Chendurpandy *et al.*, 2010). The people in developing countries depend on Tribal medicine, because it is cheaper and more accessible than Orthodox Medicine (OM) (Sofowora, 1993; Luoga *et al.*, 2000; World Health Organization, 2002). Traditional medicine is also acceptable than OM because, it blends readily into the people's socio-cultural life (Tabuti *et al.*, 2003).

The various tribal sects of India are repositories of rich knowledge on various uses of plant enetic resources, which have hitherto remained unknown (Khoshoo, 1996). But of later, due to several developmental activities around tribal areas which are after all not related to their welfare, the tribal people are losing their traditional identity resulting in a good deal of loss of such treasures of plant genetic resources (Shankar, 1995). In view of the harmful developments, the UN declared the year 1993 as the "International Year of Indigenous people" based on the recommendation of the Rio de Janeiro Earth Summit. The studies on the relationship between the aboriginal or primitive people and their surroundings including a critical evaluation of some of the important plants used by the tribes have received considerable attention in recent years (Das et al., 1989).

Study area

The Indira Gandhi Wildlife Sanctuary (earlier known as the Anamalai Wildlife Sanctuary, 987 km^2, 10° 12' N to 10° 35' N and 76° 49' E to 77° 24' E) is located in the Valparai plateau fringed largely by tea estates. The altitude within the sanctuary ranges from 220 m in the foothills along the northern fringes to 2,513 m in the Grass Hills at the southern portion of the reserve. Different parts of the region experience widely varying rainfall ranging from 700 mm in the eastern reaches to more than 4000 mm in the western ranges mostly during the southwest monsoon. The region is drained by perennial rivers such as the Konalar, Varagaliar, Karuneerar, Chinnar and Amaravathi and numerous freshwater streams. A number of reservoirs (Aliyar, Upper Aliyar, Kadamparai, Sholayar, Upper and Lower Nirar, Thirumurthy and Parambikulam), are at least partly within the Indira Gandhi Wildlife Sanctuary. The tribes still their curative plants, food and food additive plants by gathering whole plants, leaves, roots, rhizomes, tubers and also occupied in seasonal collection of honey, bee wax, fire woods and some minor forest products.

Methodology

The present study was carried out through intensive and extensive filed visit around Topslip hilly regions during various seasons from 2010 to 2011. The ethnobotanical data (local name, medicinal uses and mode of consumption) were collected through interviews and discussions among the tribal practitioners in and around the study area. The curative plants were identified based on local names, photographs and sample specimens were collected for the preparation of herbarium. The collected specimens were identified taxonomically using The Flora of Presidency of Madras (Gamble, 1996); The Flora of Tamilnadu and Carnatic (Mathew, 1983).

Results and Discussion

The survey of 45 aromatic and medicinal plants 43 genera belongs to 32 families reported to be employed in the treatment of various snake bite, rheumatism, skin diseases, fever, cough, cold wound healing, injuries like cuts, burns, bruises, sores are using *Abrus precatorius, Aloe vera, Begonia malabarica, Calotropis gigantea, Cleome viscosa, Euphorbia hirta* are commonly used by them (Table-1). The part of the plant most frequently used was the aerial part (29.3%) and the leaves (20.7%). The remedies were mainly prepared as a decoction (47.5%) and an infusion (28.6%). Different parts of aromatic plants such as leaves, bark, flower, stem, root, rhizome, tuberous, fruits and seeds are being used for various medicinal purposes. Araceae (4 species each), Asclepiadaceae and Acanthaceae (3 species), Papilionaceae, Rutaceae, Aristolochiaceaae, Amaranthaceae, Vitaceae and Capparidaceae, (2 species each), Malvaceae, Liliaceae, Zingiberaceae, Lythraceae, Meliaceae, Scrophulariaceae, Cucurbitaceae, Agavaceae, Annonaceae, Mimosaceae, Alangiaceae, Ancistrocladaceae, Begoniaceae, Basellaceae, Chenopodiaceae, Nyctanginaceae, Oxalidaceae, Caricaceae, Sapindaceae, Commelinaceae, Tiliaceae, Lamiaceae, Fabaceae and Euphorbiaceae (1 species each).

Wild survey of aromatic and medicinal plants revels that the ethnic people as well as the other inhabitants of the study area have considerable traditional knowledge on wild edible plants and their utilization. *Cardiospermum halicacabum*, *Annona muricata*, *Aristolochia bracteata* and *Azadirachta indica* are used to treat rheumatism. *Agave americana*, *Alpina calcarata*, *Cissus quadrangularis* are used to treat stomach disorders. *Aloe vera* is used as therapeutics. These plant medicines used as therapeutic agent of a paramount importance in addressing health problems of traditional communities and third world countries as well as industrialized societies (Cano and Volpato, 2004).

Table1: List of ethnomedicinal plants collected and documented in Topslip, Anaimalai Hills, Western Ghats of Tamilnadu

Sl. No	Botanical name & Family	Local name	Habit	Part Used	Ethnomedicinal uses/mode of consumption
1.	*Abrus precatorius* L. (Papilionaceae)	Kundumani	Climber	Leaf, root, seed	Poisonous bites
2.	*Abutilon indicum* L. Sweet (Malvaceae)	Thoothi	Shrub	Leaf	Relief from ear ache
3.	*Acacia caesia* (L.) Willd. (Mimosaceae)	Vellinjal	Shrub	Bark	To treat scabies, rashes and ringworm infection
4.	*Acalypha racemosa* Heyne ex Baill. (Euphorbiaceae)	Sirusinni	Shrub	Leaf	To get relief from indigestion
5.	*Achyranthus aspera* L. (Amaranthaceae)	Naiuruvi	Herb	Leaf, root	To treat dog bites
6.	*Acorus calamus* L. (Araceae)	Vasambu	Herb	Rhizome	Giddiness
7.	*Aegle marmelos* L. (Rutaceae)	Vilvam	Small tree	Leaf, bark, fruit	Constipation and dysentery, appetite, digestion
8.	*Agave americana* L. (Agavaceae)	American aloe	Herb	Root	To treat many digestive ailments, including ulcers, stomach, mouth, eye inflammations, bronchitis, arthritis, menstrual problems, as well as for cuts and wounds
9.	*Alangium salvifolium* L. *f* (Alangiaceae	Alangi	Small tree	Fruit	Toothbrush and foetid smell
10.	*Aloe vera* (L) Burm.f. (Liliaceae)	Sotru katrallai	Herb	Whole plant	Regulate menses
11.	*Alpina calcarata* Roscoe. (Zingiberaceae)	Chitaratai	Herb	Rhizome	To get relief from stomach disorder.
12.	*Amaranthus hypochondriacus* L. (Amaranthaceae)	Prince-of-Wales feather	Herb	Whole plant	It is used internally in the treatment of diarrhoea and excessive menstruation, vaginal discharges, nosebleeds and wounds and treat abundant menses
13.	*Ammannia baccifera L.* (Lythraceae)	Blistering Ammannia	Herb	Whole plant	To treat eczema.
14.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson (Araceae)	Kattukarun ai	Herb	Tuber	Used to relief from bleeding piles, carminative, restorative, stomachic and tonic
15.	*Anaphyllum beddomei* Engler. (Araceae)	Keerikilang u	Herb	Rhizome	For eczema and scabies
16.	*Ancistrocladus heyneanus* Wall. ex (Ancistrocladaceae)	Malvaduda madky		Leaf	To treat rheumatism.
17.	*Andrographis paniculata* Wall ex Nees (Acanthaceae)	Neelavemb u	Herb	Whole plant	Used for snake bite
18.	*Annona muricata* L. (Annonaceae)	Prickly custard apple	Shrub	Whole plant	To relieve liver ailments, leprosy, cough, diarrhea, dysentery and indigestion, skin afflictions and rheumatism and treat nervousness
19.	*Aristolochia brecteata* Retz.	Aaduthinna	Climber	Leaf	To treat eczema, scabies, ringworm

	(Aristolochiaceae)	palai			infection and snake bite
20.	*Aristolochia krysagathra* Sivaranjan & Pradeep (Aristolochiaceae)	Aaduthinna palai	Climber	Leaf	Used to reduce excessive body heat and rheumatism
21.	*Atalantia monophylla* Corr. (Rutaceae)	Kattu elemitchai	Shrub	Leaf and fruit	kapha, vata, flatulance, colic, hemiplegia, arthritis, skin diseases, bacterial infections and malignancy
22.	*Azadirachta indica* A Juss. (Meliaceae)	Vepamaram	Tree	Whole plant	To treat rheumatic complaints
23.	*Bacopa monnieri* (L.) Pennell. (Scrophulariaceae)	Nirbrahmi	Herb	Whole plant	Diuretic, nervous tonic, heart tonic, Immuno-modulator, adaptogen, cerebral activator, anti-asthmatic, anti-epileptic, anti-ulcer, to get relief from pain on the knees
24.	*Barleria cristata* L. (Acanthaceae)	Philippine violet.	Shrub	Whole plant	To treat anemia, toothache, and inflammatory disorders
25.	*Basella rubra* L. (Basellaceae)	Kodippasali	Climber	Leaf	Anaemia and increase in the WBC
26.	*Begonia malabarica* Lam. (Begoniaceae)	Rattha choori	Shrub	Whole plant	To cure arthritis and common joint pains
27.	*Beta vulgaris* L. (Chenopodiaceae)	Beet	Herb	Root	To treat fever, jaundice, menstrual disorders and tumors
28.	*Biophytum sensitivum* (L.) DC (Oxalidaceae)	Manivattipa tchilai	Herb	Leaf	Treat skin rashes and eczema.
29.	*Boerhaavia diffusa* L. (Nyctaginaceae	Vethalamai	Herb	Leaf	To treat scabies and ringworm infection
30.	*Borassus flabellifer* L. (Arecaceae)	Panaimara m	Tree	Root and young rachis	Toothbrush and Toothache
31.	*Cajanus cajan* (Linn.) Millsp. (Fabaceae)	Thuvarai	Shrub	Leaf, young stem, seeds	Toothbrush, gingivitis, stomatitis
32.	*Calotropis gigantea* R.Br. (Asclepiadaceae)	Erukku	Shrub	Leaf	Rheumatic joints.
33.	*Capparis zylanica* L. (Capparidaceae)	Muruvilikod i	Herb	Stem	To treat eczema and dandruff
34.	*Cardiospermum haicacabum* L. (Sapindaceae)	Mudakatha n	Climber	Leaf	Swelling joints and rheumatic
35.	*Carica papaya* L. (Caricaceae)	Pappali	Small tree	Fruit	To cause abortion
36.	*Cayratia pedata* Juss. (Vitaceae)	Turi lota	Climber	Root	To treat fever, laxative, cancer, anemia, jaundice and tooth ache
37.	*Ceropegia spiralis* Wight. (Asclepiadaceae)	Spiral ceropegia	Climber	Tuber	Indigestion
38.	*Ceropigia juncea* Roxb. (Asclepiadaceae)	Pulicham	Climber	Stem	To cure stomach ulcer
39.	*Cissus quadrangularis* L. (Vitaceae)	Perandai	Climber	Young stem	Stomachache and body swelling
40.	*Cleome viscosa* L. (Capparidaceae)	Naikaduku	Epiphyte	Leaf and Seeds	Jaundice, Stimulant and carminative.
41.	*Coccinia indica* Wight & Arn. (Cucurbitaceae)	Kovaikai.	Climber	Leaf	To cure diabetes
42.	*Coleus aromaticus* Benth. (Lamiaceae)	Karpuravalli	Herb	Leaf	To cure cough, cold and liver tonic
43.	*Commelina benghalensis* L. (Commelinaceae)	Dew Flower	Herb	Whole plant	Diuretic, anti-inflammatory, leprosy, swelling of the skin, laxative
44.	*Corchorus aestuans* L. (Tiliaceae)	Bilimbines chaka	Herb	Leaf	Leprosy, itching and rat poisoning
45.	*Crotalaria mysorensis* Roth. (Papilionaceae)	Malain Thanke	Herb	Root	Stomach pain and stomach ulcer

Conclusions

The findings of the investigation envisage that the herbal medication have excellent potentiality to treat various ailments. Villager's chiefly demand on the herbs for all disorders. They are perceptive of the plant medicines for familiar diseases such as asthma, diabetes, jaundice, leprosy, antipyretic, skin diseases, dysentery, cancer, rheumatism, diarrhea and cough. This preliminary study focused on documenting most of the ethnomedicinal plants used by the tribal community in Topslip, Anamalai Hills, Western Ghats of Tamilnadu to facilitate conservation efforts.

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References

1. **Dev, S. 1997.** Ethnotherapeutics and modern drug development: The potential of Ayurveda. *Current Science*; 73: 909–928.
2. **Chendurpandy, P, V.R. Mohan and C. Kalidass. 2010.** An ethnobotanical survey of medicinal plants used by the Kanikkars tribe of Kanyakumari District of Western Ghats, Tamil Nadu for the treatment of skin diseases*. J. Herbal medicine and Toxicology*, 4: 179-190.
3. **Sofowara, A. 1993.** Medicinal plants and traditional medicine in Africa, 2nd ed. Spectrum Books Ltd. Ibadan.
4. **Louga, E.J., E.T.F. Witkowski and K. Balkwill, 2000.** Differential utilization and ethnobotany of trees in Kitulanghalo forest reserve and surrounding communal lands, Eastern Tanzania. *Economic Botany*, 54: 328-343.
5. **Tabuti, J.R.S., S.S. Dhillion and K.A. Lye, 2003.** Traditional medicine in Bulamogi country, Uganda: its practitioners, users and viability. *J. Ethnopharmacology*, 85: 119-129.
6. **World Health Organization (WHO), 2002.** WHO traditional medicine strategy 2002. World Health Organization, Geneva. WHO/EDM/TRM/2002.1.
7. **Khoshoo, T.N. 1996.** India needs a National biodiversity conservation board. *Current Science*, 71: 506-513.
8. **Shankar, R. 1995.** Tribal community in India and PGR, In: Farmer's rights and plant genetic resources recognition and reward: A dialogue. (Ed.) Swaminathan, M.S. Million India Limited Madras, India pp.106-111.
9. **Das, P.C., A.S. Mandal and C.N. Islam, 1989.** Antiinflammatory and antimicrobial activity of seed kernels of Mangifera indica. *Fitoterapia*, 60: 240-253.
10. **Gamble, J.S. 1996.** The Flora of Presidency of Madras, (Adland & Son Ltd, London).
11. Mathew, K.M 1983. The flora of the Tamil Nadu Carnatic, (The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli).
12. **Cano, J.H. and Volpato, G.J., 2004.** Herbal mixtures in the traditional medicine of Eastern cuba. *Journal of Ethnopharmacology*, 90: 293-316.

Pteridophytes of Kurichiyarmala Forest, South Wayanad Forest Division, Kerala

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Abstract

The pteridophytes are an ancient group of plants which do not produce flowers and seeds. Wayanad harbour a great variety of ferns and fern allies due to its peculiar climate. The members of pteridophytes constitute a conspicuous element of flora of Wayanad district and these flourish well during the rainy season and are at their best from August to November. The study was conducted in Kurichiyarmala forest area (2552 ha.) of Wayanad district, which includes shola forest, evergreen forest, grass land and marshy area. A floristic survey was carried out during 2010-2012 and preferential environment and substrata were noted. The present paper records 62 species of pteridophytes distributed along 40 genera and 20 families. Family *Pteridaceae* showed maximum diversity represented by 11 species. The pteridophytes found in the study area were endowed with abundance and luxuriant occurrence of all ecological groups such as Terrestrials, Epiphytes, Hydrophytes, Lithophytes and Rheophytes.

Key words: Pteridophytes, Kurichiyarmala, South Wayanad

Introduction

Wayanad is situated at the Southern end of Deccan plateau and remains a strange mosaic of forests, plantations, agricultural holdings, paddy fields and human settlements. The district was carved out, from the parts of Kozhikode and Kannur districts. It lies between north latitude 11°26'28" and 11°48'22" and east longitude 75° 46'38" and 76 °26'11". This district comprises a great variety of ferns and fern allies due to the peculiar biogeography.

The members of pteridophytes constitute a conspicuous element in the flora of Wayanad district. These plants flourishes well during the rainy season and are at their best from August to November. Pteridophytes grow in different habitats such as on moist or dry rocks and boulders, on tree trunks, as hydrophytes in water pools, on forest floor and borders, along perennial streams in deep ravines, inside dark gorges and grasslands in sunny situations. The global diversity of pteridophytes is yet not very clear. The pteridophytes which dominated the earth during carboniferous are survived today by about 12,000 species comprising 305 genera. Amongst of which most numerous are the homosporous ferns comprised of approximately 11,500 species, where as rest 500 as fern-allies known globally (Singh, *et al.,* 2010). About 110 genera and 600 species are found in India (Sukumaran, *et al*., 2009).

The first illustrated account on the ferns of Peninsular India is that of van Rheede (1703), who has included illustrations of a few ferns and ferns allies (16 taxa) from the Malabar Coast. Manickam and Irudayaraj (1992) reported about 256 species of pteridophytes from Western Ghats of South India. Nayar and Geevargheese (1993) gave elaborate descriptions of 170 species of ferns. In Wayanad, a little work has been done so far on the pteridophytes. Beddome (1863-64) described and illustrated 19 ferns from Wayanad. A preliminary report on the ecology and distribution of 119 Pteridophytes of Wayanad has been done by Leena and Madhusoodanan (1998).

The present study was conducted in Kurichiyarmala forest which lies between 11°35.769′ N latitude and 75° 58.787′ E longitudes, which comes under Kalpetta forest range of South Wayanad Forest Division. It is located at Pozhuthana Village and covers an area of 2252 Hectors. The landscape is drained by small perennial as well as annual streams. Actually it is a vested forest, which includes shola forest (patches of high-altitude forest separated from one another by undulating grassland), ever green forest, grass land, marshy area and tea plantations (Figure 1). It is a hilly terrain, with altitude ±1600 m msl. Before 1971, the forest area was under private ownership. As per Land Reformation Act (1971), it is declared as vested forest. Now it is under Kerala Forest Department.

Figure 1. Kurichiyarmala

Materials and Methods

The present study was carried out to understand the pteridophyte flora of Kurichiyarmala forest, South Wayanad Forest Division, Kerala. Field trips were conducted during 2010-2012 for the collection of Pteridophyte specimens and observation of characters. Habit, habitat, morphological characters, *etc*., were observed in the field itself. During the field visit, specimens were collected for identification and herbarium preparation. The specimens were identified with the help of available literature, comparing with authentic specimens lodged in herbarium at University of Calicut (CALI), Tropical Botanic Garden and Research Institute (TBGRI), Thiruvanathapuram, as well as consultation with experts. Voucher specimens were prepared using standard techniques and the specimens were deposited with the Herbarium of M. S. Swaminathan Research Foundation (MSSRF), Kalpetta. Ecological nature and economic importance of the collected plants were also noted. All the identified species of fern allies have been classified and arranged according to Fraser-Jenkins, (2009) and for ferns; classification of Smith *et al.,* (2006) was followed. The list of 62 species of pteridophytes together with their family and habitat is shown in Table 1 and photographs of some species are shown in Figures 2 & 3.

Results and Discussion

A total of 20 families, 39 genera and 62 species of pteridophytes were found in Kurichiyarmala forest. Among this, three of them are fern allies (*Lycopodiella cernua, Huperzia squarrosa, Selaginella involvens).* The pteridophytes were found in the study area endowed with abundance and luxuriant occurrence of all ecological groups such as Terrestrials (38 species), Epiphytes (6 species), Epiphytes/ lithophytes (10 species), Hydrophytes

(1 species), Rheophytes (2 species). Epiphytes/ lithophytes/ terrestrial (4 species). Most of them share more than one substratum (*Asplenium* sps. *Trichomanes plicatum, Pyrrosia sp., Lepisorus sp., etc.).* Rheophytes like *Osmunda huegeliana* and *Trigonospora ciliata* are found along the banks of forest streams and they inundated during rainy season. They are found attached to boulders to withstand the rapid water flow. Thelypteridaceae like *Pseudocyclosorus ochthodes* prefer marshy area. The epiphytes / lithophytes are found in the mossy covering of the substratum (*Grammitis*, *Araiostegia*). Members of Polypodiaceae are the chief constituents of the epiphytic flora. Some ferns are confined strictly to occur in fissures and crevices in grass lands *(Athyrium falcatum, Athyrium solenopteris, Cheilanthus anceps, Phymatosorus montana, Dryopteris austroindica)*. Species occurs on exposed rocks and grass lands are mostly seasonal, where as the habitats with higher moisture contents are perennial pteridophyte. Epiphytes like *Lepisorus amaurolepidus, Lepisorus nudus, Pyrrosia porosa, Araiostegia pulchra* and terrestrial ferns such as *Nephrolepis cordifolia*, *Dryopteris cochleata* and *Christella dentata* are found in tea plantations.

The study revealed that the family Pteridaceae is the largest family represented by 11 species and followed by Polypodiaceae and Dryopteridaceae (10 species each) and Thelypteridaceae (6 species). Among the 62 species listed, three species of them are known to be beneficial (*Diplazium esculentum, Parahemionitis cordata, Pithyrogramma calomelanos)* and one species is weed (*Pteridium revolutum)*. Young leaves of *Diplazium esculentum* used as vegetables. Leaf juice of *Parahemionitis cordata* used to cure ear ache and crushed leaves of *Pithyrogramma calomelanos* used to cure wounds.

A few threatened ferns of India like *Dryopteris austro-indica,* (Critically Endangered, at risk), *Botrychium daucifolium, Osmunda huegeliana, Bolbitis semicordata* (Rare), *Elaphoglossum beddomei* (Near threatened) were collected from the study area (Fraser-Jenkins, 2008). *Elaphoglossum beddomei*, *Bolbitis semicordata, Dryopteris austro-indica* are endemic to South India and *Osmunda huegeliana* is endemic to South India and Central India. *Athyrium falcatum, Athyrium solenopteris, Cheilanthus anceps, Dryopteris austroindica etc*. are terrestrials ferns occur under shade of boulders among grass lands. The major threat to the species is forest fire during dry season in grass lands. As per earlier reports, *Dryopteris austro-indica,* very rarely growing in the Shevaroy hills (Tamil Nadu) of Western Ghats. This species could never be collected again since its original collections, neither from its type locality nor elsewhere. According to Chadha *et al.,* 2008, it is probably extinct from Shevaroy hills, Nilgiri. During present study, it was observed that the population of this fern severely fragmented and area of occupancy is estimated to be less than 3 km^2. The habitats in which these spices occur are fragile and need to be protected for their conservation. A live collection of pteridophytes is established at MSSRF to conserve the fragile plant groups.

Table 1. Lists of pteridophytes from Kurichiyarmala forest, South Wayanad Forest Division

No	Family	Botanical name	Habitat
1	**Lycopodiaceae**	1. *Lycopodiella cernua* (L.) Pic. Serm.	T
2		2. *Huperzia squarrosa* (G. Forst) Trevis.	E
3	**Selaginellaceae**	3. *Selaginella involvens* (Sw.) Spring	E/L
4	**Ophioglossaceae**	4. *Botrychium daucifolium* Wall. ex Hook. & Grev.	T
5	**Equisetaceae**	5. *Equisetum ramosissimum* Desf.	H
6	**Osmundaceae**	6. ***Osmunda huegeliana* Presl	R
7	**Marratiaceae**	7. *Angiopteris evecta* (G. Forst.) Holttum.	T
8	**Hymenophyllaceae**	8. *Trichomanes plicatum* (Bosch) Bedd.	E/L

9	**Gleicheniaceae**	9. *Dicranopteris linearis* (Burm.f.) Underw.	T
10	**Cyatheaceae**	10. *Cyathea spinulosa* Wall. ex Hook.	T
11	**Dennstaedtiaceae.**	11. *Pteridium revolutum* (Blume) Nakai	T
12	**Pteridaceae**	12. *Adiantum concinnum* Willd.	T
13		13. *Adiantum philippense* L.	T
14		14. *Adiantum raddianum* C. Presl.	T
15		15. *Cheilanthes anceps* Blanf.	T
16		16. *Cheilanthes bullosa* Bedd.	T
17		17. *Cheilanthes tenuifolia* (Burm.f.) Sw.	T
18		18. *Parahemionitis cordata* (Roxb. ex Hook. & Grev.) Fraser-Jenk.	T
19		19. *Pityrogramma austro-americana* Domin.	T
20		20. *Pityrogramma calomelanos* (L.) Link	T
21		21. *Pteris longipes* D. Don	T
22		22. *Pteris argyraea* T. Moore	T
23	**Aspleniaceae**	23. *Asplenium cheilosorum* Kunze ex Mett.	T/L/E
24		24. *Asplenium decresens* Kunze	T/L/E
25		25. *Asplenium formosum* Willd.	T/L/E
26		26. *Asplenium yoshinagae* subsp. *indicum* (Sledge) Fraser-Jenk.	T/L/E
27	**Thelypteridaceae**	27. *Christella dentata* (Forsk.) Brownsey & Jermy	T
28		28. *Christella hispidula* (Decnc.) Holttum	T
29		29. *Macrothelypteris torresiana* (Gaud.) Ching	T
30		30. *Pseudocyclosorus ochthodes* (Kunze) Holttum	T
31		31. *Sphaerostephanos subtruncata* (Bory) Holttum	T
32		32. *Trigonospora ciliata* (Benth.) Holttum	R
33	**Woodsiaceae**	33. *Athyrium falcatum* Bedd.	T
34		34. *Athyrium hohenackarianum* (Kunze) T. Moore	T
35		35. *Athyrium solenopteris* (Kunze) T. Moore	T
36		36. *Diplazium esculentum* (Retz.) Sw.	T
37	**Blechnaceae**	37. *Blechnum orientale* L.	T
38	**Dryopteridaceae**	38. *Arachniodes aristata* (G. Forst.) Tindale	T
39		39. *Arachniodes tripinnata* (Goldm.) Sledge	T
40		40. *Bolbitis appendiculata* (Willd.) K. Iwats	T
41		41. *Bolbitis asplenifolia* (Bory) K. Iwats.	T
42		42. **Bolbitis semicordata* (Baker) Ching	E
43		43. **Dryopteris austro-indica* Fraser - Jenk.	T

44		44. *Dryopteris cochleata* (D. Don) C. Chr.	T
45		45. *Dryopteris hirtipes* (Blume) Kunze	T
46		46. *Dryopteris sparsa* (Buch.- Ham. ex D. Don) Kunze	T
47		47. **Elaphoglossum beddomei* Sledge	T
48	**Davaliaceae**	48. *Davallia trichomanoides* Blume	E
49		49. *Araiostegia pulchra* (D. Don) Copel.	E
50	**Lomariopsidaceae**	50. *Nephrolepis cordifolia* (L.) C. Presl	T
51	**Tectariaceae**	51. *Tectaria wightii* (C. B. Clarke) Ching	T
52		52. *Tectaria coadunata* (Wall. ex Hook. & Grev.) C.Chr.	T
53	**Polypodiaceae**	53. *Grammitis pilifera* Ravi & Joseph	E/L
54		54. *Grammitis attenuata* Kunze	E/L
55		55. *Lepisorus amaurolepidus* (Sledge) Bir & Trikha	E/L
56		56. *Lepisorus nudus* (Hook.) Ching	E/L
57		57. *Leptochilus bahupunctika* (Nayer, Madhus. & Molly) Nampy	E
58		58. *Leptochilus decurrens* Blume	E/L
59		59. *Microsorum membranaceum* (D. Don) Ching	E/L
60		60. *Pyrrosia lanceolata* (L.) Farwell	E
61		61. *Pyrrosia porosa* (C. Presl) Hovenkamp	E/L
62		62. *Phymatopteris montana* (Sledge) Pic. Serm.	E/L

T = Terrestrial, **H** = Emergent Hydrophytes, **L** = Lithophytes, **E** = Epiphytes, **R** = Rheophytes,
***** = Endemic to South India, ****** = Endemic to South India & Central India

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References

1. **Beddome, R. H. 1883.** A handbook to the Ferns of British India, Ceylon and Malaya Peninsula, Culcutta
2. **Beddome, R. H. 1863-64.** The ferns of southern India, Madras. Thacker Spink & Co. Culcutta
3. **Chandra, S., Fraser-Jenkins, C. R., A. Kumari & A. Srivastava. 2008**. A summary of the status of threatened pteridophytes of India. Taiwania, 53(2): 170-209.
4. **Fraser-Jenkins, C. R. 2008.** Endemics and Pseudo-Endemics in Relation to the Distribution Patterns of Indian Pteridophytes. Taiwania, 53(3): 264-292.
5. **Leena, K. R. & P. V. Madhusoodanan. 1998.** Pteridophyte flora of Wayanad district, Kerala- A preliminary survey on ecology and distribution. J. Econ. Tax. Bot., 22: 149-155.
6. **Manickam, V.S. & V. Irudayaraj. 1992**. Pteridophyte flora of Western Ghats of South India. B. I. Publication, New Delhi.

7. **Nampy, S. & P.V. Madhusoodanan. 1998.** Fern Flora of South India: Taxonomic Revision of Polypodioid ferns. Daya publishing House, Delhi.
8. **Nayar, B. K. & K. K. Geevarghese. 1993.** Fern Flora of Malabar. Indus publishing company, New Delhi, India
9. **Rheede, H. A. van. 1703.** Hortus malabaricus. Amsterdam. Vol. 12.
10. **Chadha, J., H Chander & B. Kumar. 2008.** Endemic Pteridophytes of India: Distribution and Threat Status. PP.229-232. In: Rawat, G.S. (Ed.). 2008. Special Habitats and Threatened Plants of India. ENVIS Bulletin: Wildlife and Protected Areas, Vol. 11(1). Wildlife Institute of India, Dehradun, India
11. **Smith, A. R., K. M. Pryer, E. Schuettpelz, P. Korall, H. Schneider & P. G. Wolf. 2006.** A classification for extant ferns. Taxon. 55(3):705-731.
12. **Sukumaran, S., S. Jeevam & A. D. S. Raj. 2009.** Diversity of pteridophytes in miniature sacred forests of Kanyakumari District, Southern Western Ghats. Ind. Jour. For., 32(2):283-290.

Figure 2. A) *Asplenium cheilosorum*
B) *Asplenium decrescens*
C) *Asplenium formosum*
D) *Asplenium yoshinagae subsp. indicum*
E) *Araiostegia pulchra*
F) *Angiopteris evecta*
G) *Pteris longipes*
H) *Adiantum concinnum*
I) *Pteris argyraea*
J) *Dryopteris austroindica*
K) *Bolbitis asplenifolia*
L) *Bolbitis semicordata*

Figure 3. *A) Equisetum ramosissimum*
B) Lycopodiella cernua
C) Cheilanthes bullosa
D) Athyrium falcatum
E) Pyrrosia porosa
F) Arachniodes aristata
G) Trigonospora ciliata
H) Osmunda huegeliana
I) Phymatopteris montana
J) Elaphoglossum beddomei
K) Cyathea spinulosa
L) Botrychium daucifolium

Conservation of Spring Resources in the Western Ghats: Focus on its Quality and Management for preserving the biodiversity

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Abstract

Conservation and management of water resources are highly warranted to preserve the biodiversity in the Western Ghats in view of climate change and wide spectrum of human interventions. Springs are untapped resources of drinking water occurring when the ground water flows naturally out to the surface owing to a physical state that obstructs its flow under the Earth, or when water table intersects the surface. In the present study, our intention is to locate, map and address the spring resources along the Western Ghats regions of Kottayam and Idukki districts of Kerala. Study provides valuable information of spring diversity; as most of the contact springs are perennial in nature with considerable water potential even in summer season. But the rheocrene types are peripheral and seasonal feeding and would also have good water potential. Springs in the study area are generally acidic in nature with pH ranging from 4.8 to 6.8 with an average of 5.8. The chemical quality of water satisfies BIS/WHO (2006) drinking water specifications except the pH. Low value of electrical conductivity (22.1-330.4 µS/cm) indicates the low range of dissolved salts. Increased nutrient fluxes are observed in certain springs. Microbial pollution is rarely observed, especially in human settlement areas. The dissolved heavy metals such as Zn, Pb and Cd were noticed and it may be due to geological as well as anthropogenic factors. In general, the results showed the potability of spring waters, but still need decentralized steps to distribute these resources effectively in local areas. The conservation of springs will also help to sustain the biodiversity of spring locality.

Key words: Spring, Western Ghats, Biodiversity, Physico-chemical Parameters, Natural Resources

Introduction

Contrary to the general belief that Kerala is a water surplus region, the State has been experiencing severe drinking water scarcity due to population increase, urbanization, industrialization and unscientific agricultural activities (Narendra Babu *et.al.,* 2008). All the conventional water resources are under severe strain (CWRDM, 1988) and the availability of good quality water is a serious problem even during the monsoon as well. Therefore, it is very urgent and essential to identify nonconventional water resources and develop them as alternate drinking water sources in order to maintain this reserve for current and future generations. Western Ghats, one of the most heavily populated Biodiversity Hotspots in the world which provide and support 400 million people through water for drinking together with food and resources (Molur *et al.*, 2011). As citation regarding the freshwater resources in this region, especially springs is rare, a preliminary attempt has been made to evaluate the hydrology and its drinking water potential of this highly potential resource of Central Kerala, which lies in the Southern Western Ghats Region(SWGR) in an environmental outlook.

Methodology

The scientific aspects of the spring research project can be outlined as: location & mapping, sample collection, analysis (both *insitu* and lab) and interpretation (binary & ternary model). Based on a set of properties, springs are selected for seasonal monitoring of Physico-chemical characteristics and discharge potential. Water temperature, pH and Electrical Conductivity (EC) were measured *in situ* using thermo-scientific Eutech probe (Waterproof CyberScan PCD 650). Dissolved Oxygen (DO) values were determined by Winkler's method (Winkler, 1883). Standard chemical analysis (APHA, 2001) was carried out for nutrients such as phosphorous, silicate, nitrite, nitrate, Total Nitrogen (TN) and Total Phosphorous (TP). Spectrophotometric method (UV-visible, model Shimadzu UV-1800, Japan) was applied for obtaining nutrient values. The microbiological characteristics have been carried out by the method, also adopted from APHA (2001).

Study Area and Geology

Study area lies between $9^{0}03'$ and $10^{0}23'$ North Latitude and $76^{0}37'$ and $77^{0}30'$ East Longitude and covers an aerial extent of nearly 9995 km^2 in Central Kerala. The dominant geologic feature of the area belongs to quartz-feldspar-hypersthene granulite (charnockite), Charnockite gneiss and hypersthene diopside gneiss(GSI, 1995) (Fig.1) The next dominant categories are hornblende gneiss, hornblende-biotite and quartz-mica gneiss. Pink granite gneiss also has a significant share.

Results and Discussion

a. Spring Diversity and Hydrochemistry

During the preliminary field work in Central Kerala, a total of 80 springs are identified and located. They belong to various classes (Fetter, 1980) and types (Steinman, 1915) (Fig.2). The vital spring types are: Contact springs, Joint springs and Fracture springs in genesis; And Rheocrene, Helocrene and Limnocrenes types are recognized as well. From the geomorphic observation, the most dominant spring types are contact springs and rheocrenes. Most of the contact springs are perennial in nature with rich water potential even in summer season and the rheocrenes are seasonal feeding, peripheral springs with high water potential. The diversity of springs in central Kerala reveals diverse hydrogeologic environments.

Around 31 spring waters are collected for a detailed hydrogeochemical evaluation based on a set of properties, as a preliminary assessment. Spring water in the study area is generally acidic (4.81-6.67) in nature with pH ranging from 4.81 to 6.67 with an average of 5.77. The chemical quality of water satisfies WHO (2006) drinking water specifications except the pH (Table 1). EC is an indirect measure of ionic strength and mineralization of natural water. EC of pure water is around 0.05 µs/cm (Hem, 1991). Here, EC ranges from 22.14 to 330.4 µs/cm with an average of 57.5 µs/cm, indicated the low range of dissolved salts disclose the swift movement through the bearing geology/aquifers. Total Dissolved Solids (TDS), which is generally the sum of dissolved ionic concentration, varies between 15.81 to 236 mg/L with an average of 41.06 mg/L. The Characterization of some possible geochemical processes and chemical evolution affecting the water genesis were carried out with important pattern recognition techniques namely Piper (1953) and Durov (1948) diagrams using the software Aquachem 4.0 *version*. Low concentrations of nutrients (Fig.5) are reported in these spring sources. The dissolved heavy metals such as Zn (0.006-4.432µg/L), Pb (BDL-0.184µg/L), Cd (BDL-0.002µg/L) and Cu(BDL-0.887µg/L)were noticed in spring waters and it may be due to diverse geo-enviro factors.

b. Major Ions and Water types

During the present study, the major ions are in the order of Cl(34-81%)>HCO_3(11-49%)>Ca(4-16%)>Na(0-12%)>K(0-5%)>SO_4(0-3%)>Mg(<2%)>NO_3(<2%).Among cations, Ca and Na are the primary ions (Fig. 3), while the Cl and HCO_3 are the dominant anions. The classification of waters by Piper (1953) trilinear diagram(Fig.4) and Langguth (1966) explain the dominant share of spring sources have normal earth alkaline water/earth alkaline water with increased portions of alkalis with prevailing sulphate or chloride and the prime hydrochemical facies/water types (Fig.5)(Morgan and Jankowsky, 2003; Hobbs et.al., 2008) belongs to Ca–Cl–HCO_3, Na-Cl-HCO_3**,** Ca-Na-Cl-HCO_3 and Na-Ca-Cl/Ca-Na-Cl. Amongst, the Ca–Cl–HCO_3 which is strongly influenced by ions input from crystalline granite and gneiss rocks. Na+ and HCO_3 concentrations come mainly from weathering of alkali-feldspars from rocks related with the recharge areas; the Na-Cl-HCO_3 found in the deep fractured aquifers (Morgan and Jankowsky, 2003); Ca-Na-Cl-HCO_3 are characterized by the mixing of deeper ground waters and ion exchange reactions in the shallow quaternary aquifer and the Na-Ca-Cl/Ca-Na-Cl reveal the spring waters associated with hydrocarbons (Hobbs *et al.,* 2008), which recharged beyond the chronological aridity conditions prevailed throughout the state. Durov (1948) diagram displays some possible geochemical processes signifies the water genesis. The fields and lines on the diagram show the classifications of LIoyd and Heathcoat (1985). Durov diagram (Fig. 6) suggests the spring water of the study area is Cl dominant anion and Na dominant cation, indicate that the ground waters be related to reverse ion exchange of Na-Cl waters and a small percentage of spring sources exhibiting dissolution & mixing influences.

c. Quality assessment and water potential

Spring water is generally acidic (4.81-6.67) in nature; disclose the spring water that percolates through soil in the study area having poorly buffered catchments, usually those with hard igneous rocks, tends to be dominated by dissolved organic acids and can produce pH values in watercourses as low as 4.0. EC ranges from 22.14 to 330.4 µs/cm with an average of 57.5 µs/cm, indicated the low range of dissolved salts disclose the swift movement through the bearing geology/aquifers. TDS generally the sum of dissolved ionic concentration, varies between 15.81 to 236 mg/L with an average of 41.06 mg/L. Nutrients also noted low concentrations (Fig.7). Most of the spring sources are affected by microbial pathogens; the microbial analysis reveals that Total coliform (TC) and Escherichia coli (EC) were identified in some samples. The presence of Coliform indicating the anthropogenic contamination of springs and which exceeds the permissible limits in few locations(Fig.8) in Pattumudi-Peerumedu, Chathanappanal-Koorappada, Parapetti, Seethathodu areas which were being used intensively for domestic purposes. Although the chemical quality satisfies BIS/WHO (Table1) drinking water standards except pH. Our earlier studies confirmed the potential of spring sources(Narendra Babu et.al., 2008) of Southern Kerala for supplying more than 30% drinking water to the common water pool for achieving 24x7 water supply schemes. Present study also confirms the springs are definitely a highly potential resource; around 23 lakh Lpd (litres per day) from the 31 springs evaluated.

d. Major Geochemical Processes identified

The Rain water chemistry (27%) and the silicate weathering (24%) are the most dominant geochemical processes identified in the study area (Fig.9). The next dominant natural factors/geochemical processes which influence the quality of spring water is granitic weathering (19%), plagioclase weathering (15%) and cation exchange (15%).

Table1: Comparative evaluation of the springs of Central Kerala

Parameters	BIS (2007)	WHO (2007)	Springs of Central Kerala
Colour	5 HU	Pt.scale 5	<2HU
Odour	Agreeable	Un objectionable	Agreeable
pH	6.5- 8.5	7.0- 8.5	***4.81-6.67***
Turbidity	10 NTU	2.5 JTU	0.09-13.0
TDS	500 mg/l	500 mg/l	15.81-236.0
Nitrate	45 mg/l	45 mg/l	0.0003-0.0015
Sulphate	200 mg/l	200 mg/l	0.00-0.59
Chloride	250 mg/l	200 mg/l	9.52-34.29
Hardness	300 mg/l	200 mg/l	0.00-18.0
Calcium	75 mg/l	75 mg/l	0.80-5.61
Magnesium	30 mg/l	30 mg/l	0.00-0.0729

e. Key Issues Noticed

Lack of awareness among public is the key factor noticed in the study area. Unscientific agricultural/developmental activities in spring head region are to restrict. Irrational land use changes curtains the 'Spring boils' and adversely affecting the spring flow and availability. Lack of proper approach pathway towards Spring region absolutely affects the local population. Insanitary is a common scene in the spring environs and the crux of the problem of Spring fed basin. Lack of spring fed catchment area protection measures. >20% of observed springs are on the verge of destruction. In the coming future, the disappearance of springs might be affected; due to large scale groundwater withdrawals from aquifers is not unique to our study regions with low rainfall and low natural aquifer recharge; in accordance with climatic change variability. This will affect the regional lowering of the potentiometric surfaces of intermediate aquifer system, which will recharge the spring discharge and also the spring fed basin.

f. Management Strategies

Educate students, citizens, and local leaders about the values, function, and protection needs of springs. This strategy will spread awareness of the impact that citizens living in spring recharge basins can have on spring water quality. Landowners, citizens and government working as a team can make a difference. Form and support Spring Basin Working Groups (Fig. 10) to engage citizens and agencies in the protection and restoration of spring water quality and quantity.

Conclusions

- Although the study reveals acidic pH, the low range of dissolved salts, other physico-chemical parameters are well within the permissible limits
- The spring water can be developed as an alternate drinking water source if it is properly maintained and preserved by applying minimal treatment(*only after pH correction and proper disinfection*)

- Our earlier studies confirmed the potential of spring sources(Narendra Babu *et.al.,* 2008) in Trivandrum and Kollam for supplying more than 30% drinking water to the common water pool for achieving 24x7 water supply schemes.
- Adaptation measures and strategies have to be practiced with additional help of enforcing laws and also a spring protection working group should be formed.

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References

1. **APHA 2001.** Revisions to Standard Methods for the Examination of Water and Wastewater.(Supplement). American Public Health Association, Washington DC.
2. **BIS. 200).** Bureau of Indian Standards, http://www.cfeindia.org/misc/cola-indepth/cola 2006/pdf/BIS-standard.pdf.
3. **CWRDM, 1988.** Springs in Kerala: an inventory, Centre for Water Resource and Development, Kozhikode, p.178.
4. **Durov, C. A. 1948.** Natural waters and graphic representation of their composition. Akad.Nauk U.S.S.R. Doklady, 59, 87-90.
5. **Fetter C.W., 1980.** Applied hydrogeology.2nd edition. Pearson Education, Upper Saddle River, New Jersey.p 249.
6. **GSI. 1995.** Geological and mineral map of Kerala. *Geol. Sur. of Ind.* Hobbs, L. M., et al. 2008, ApJ, 680, 1256
7. **Karina Morgan, K. and Jankowsky. J. 2003.** Saline groundwater seepage zones and their impact on soil and water resources in the Spicers Creek catchment, central west, New South Wales, Australia. Environmental Geology (2004) 46:273–285.DOI 10.1007/s00254-004-0977-4.
8. **Langguth, H.R. 1966.** Groundwater nerhaltissein. Bereichdes. velbertersatües Der- 'Minister for Ernährung land. WistschaftandFörstern. NRW, Dusseldorf, 127.
9. **Lloyd, J.W. and Heathcote, J.A. 1985.** Natural Inorganic Hydrochemistry in Relation to Groundwater. Clarendon Press, Oxford.
10. **Narendra Babu. K, Padmalal. D, Maya. K, L. Smitha, R.S. Baiju, M.I. Sreejith, V.S. Renjini, B.R. Rajesh and Liji. T.M. 2008.** Hydrochemical Characterization and Drinking Water Potential of the Coastal Springs of Southern Kerala. CESS Project Plan 256. 156p.
11. **Piper, 1953.** A Graphic procedure in the geochemical interpretation of water analysis, US Geological Survey of ground water note 12.
12. **Steinman P., 1915.** Praktikum der Süßwasserbiologie. Teil 1: Die Organismen des fließendenWassers. Borntraeger, Berlin, p 184.
13. **WHO. 2007.** WorldHealthOrganization, http;//www.who.ing/water_sanitation_health/dwq- /gdwq 05-06.pdf.
14. **Winkler L.W. 1883.** Die Bestimmung in Wassarg elosten sauerstoffes. Dusche Chem Qes Ber. 21:2843–55.

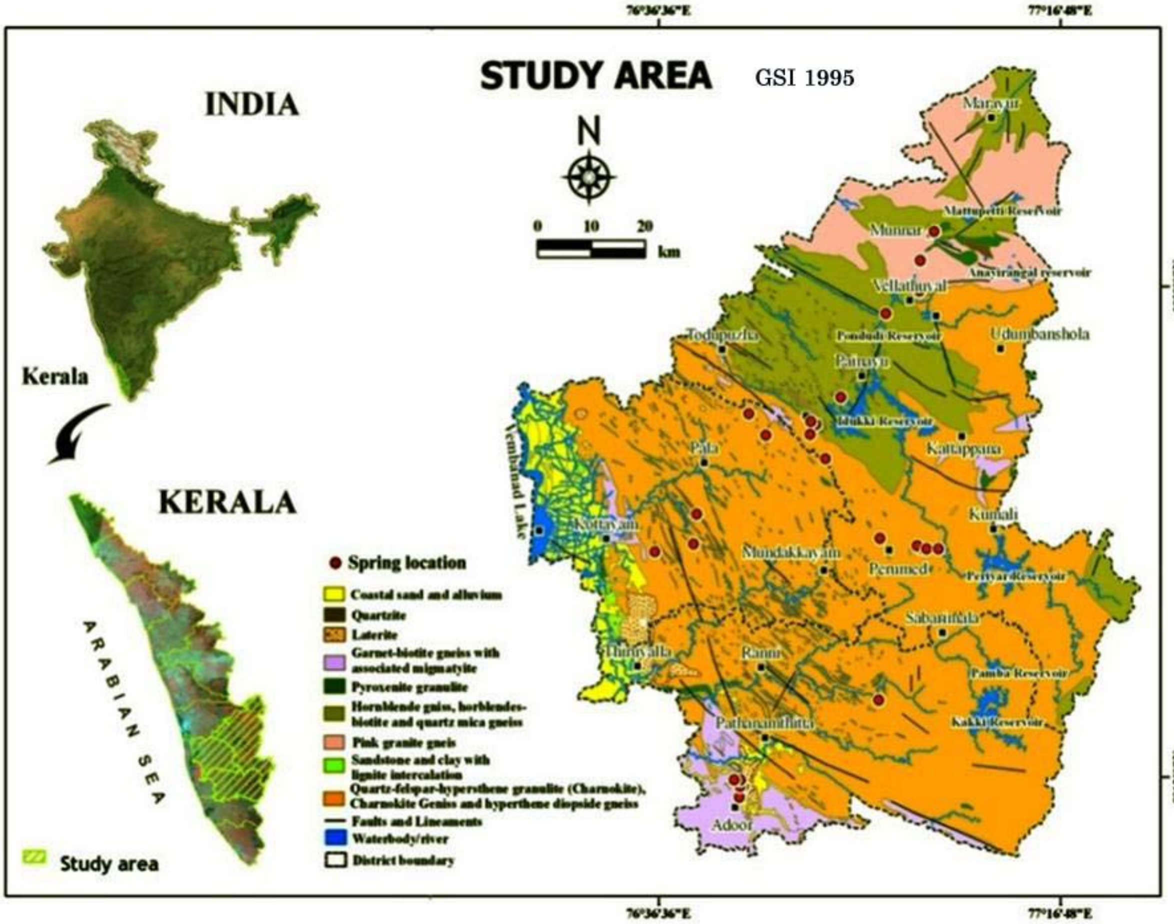
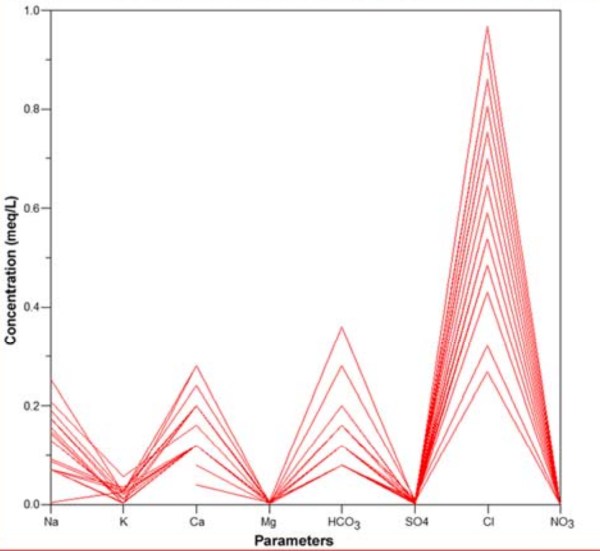


Fig.2 The observed spring typology of Central Kerala (Babu *et al*, 2008, Fetter, 1980)

Fig.3
The major ion concentration of the Springs of Central Kerala



Piper diagram showing the relative percentage of major ions of spring waters

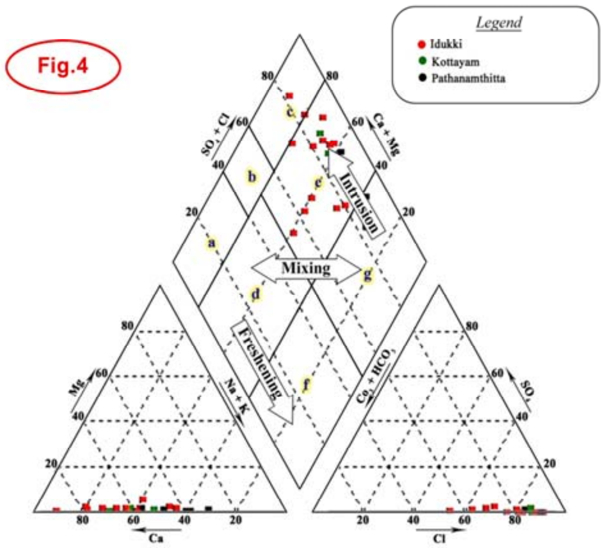


Fig.5
Dominant hydrochemical facies/water types in pie diagrams

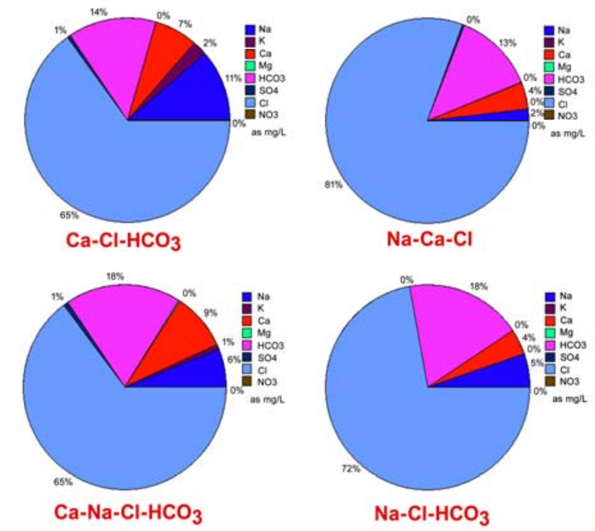


Fig.6
Durov diagram:
Suggest processes of reverse ion exchange, dissolution & mixing

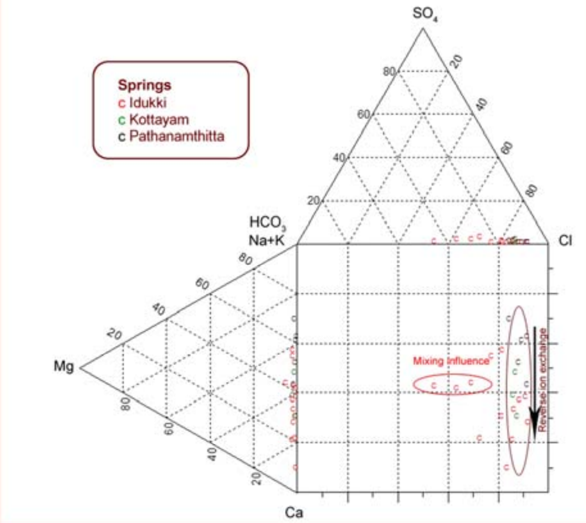


Fig.7

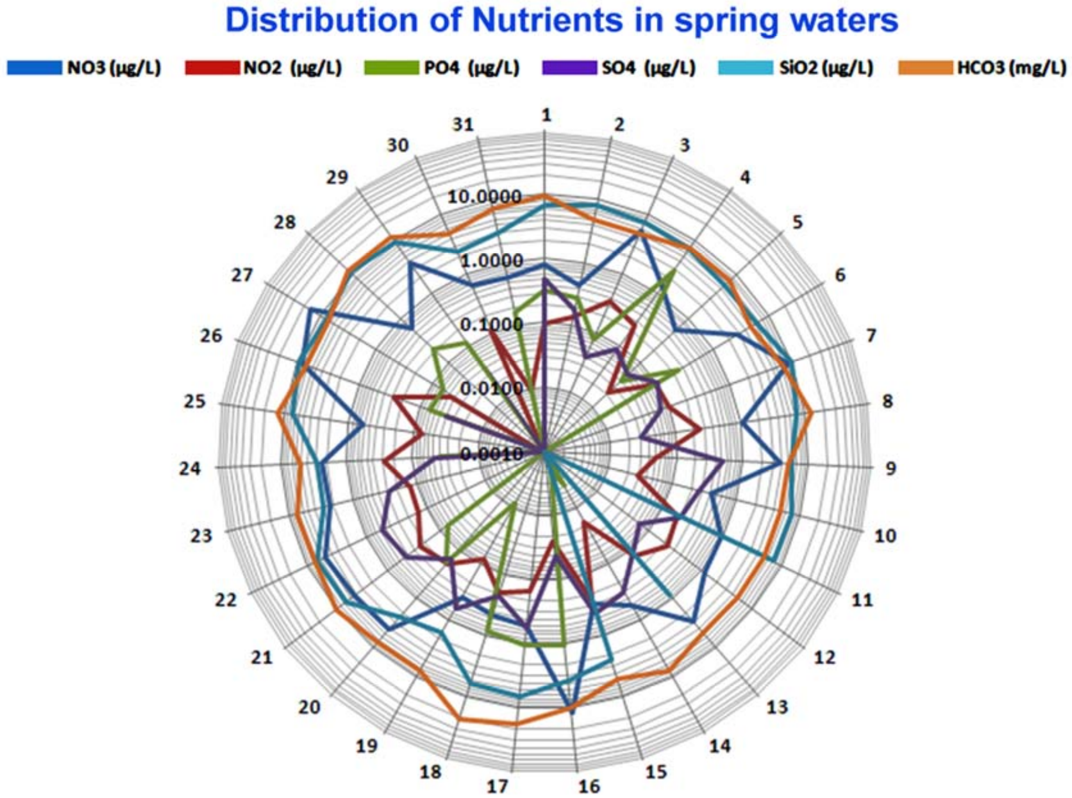
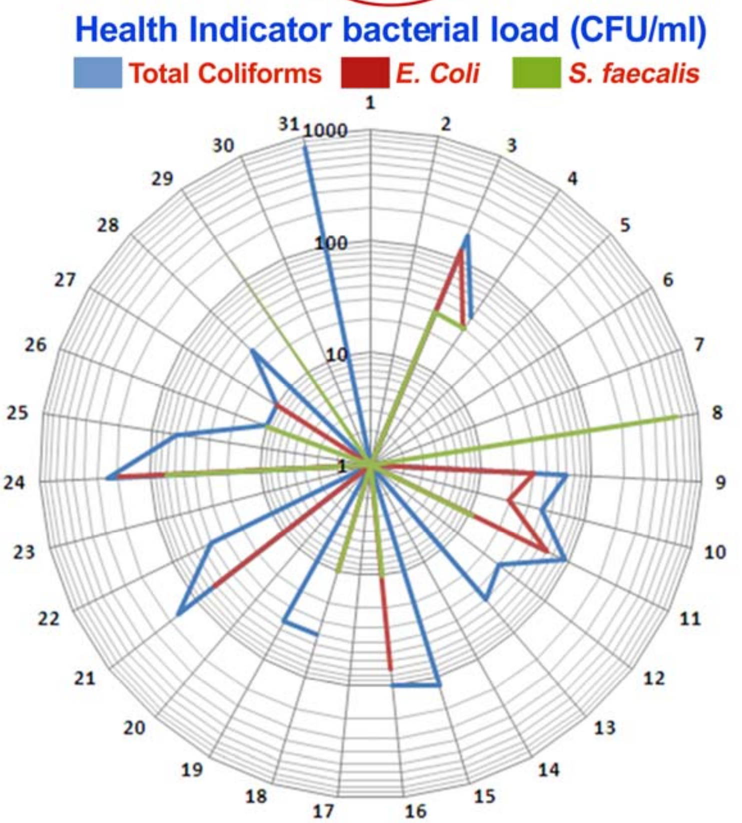
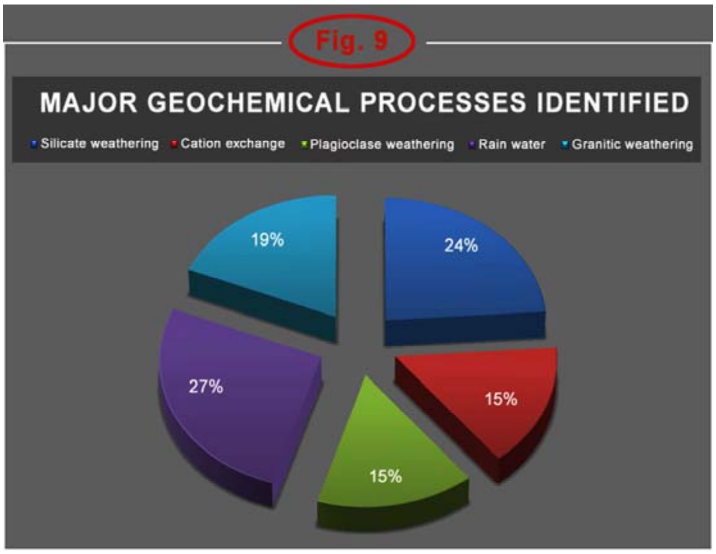

Distribution of Nutrients in spring waters
NO3 (µg/L)
NO2 (µg/L)
PO4 (µg/L)
SO4 (µg/L)
SiO2 (µg/L)
HCO3 (mg/L)
10.0000
1.0000
0.1000
0.0100
0.0010
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Fig.8


Health Indicator bacterial load (CFU/ml)
Total Coliforms
E. Coli
S. faecalis
1000
100
10
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31



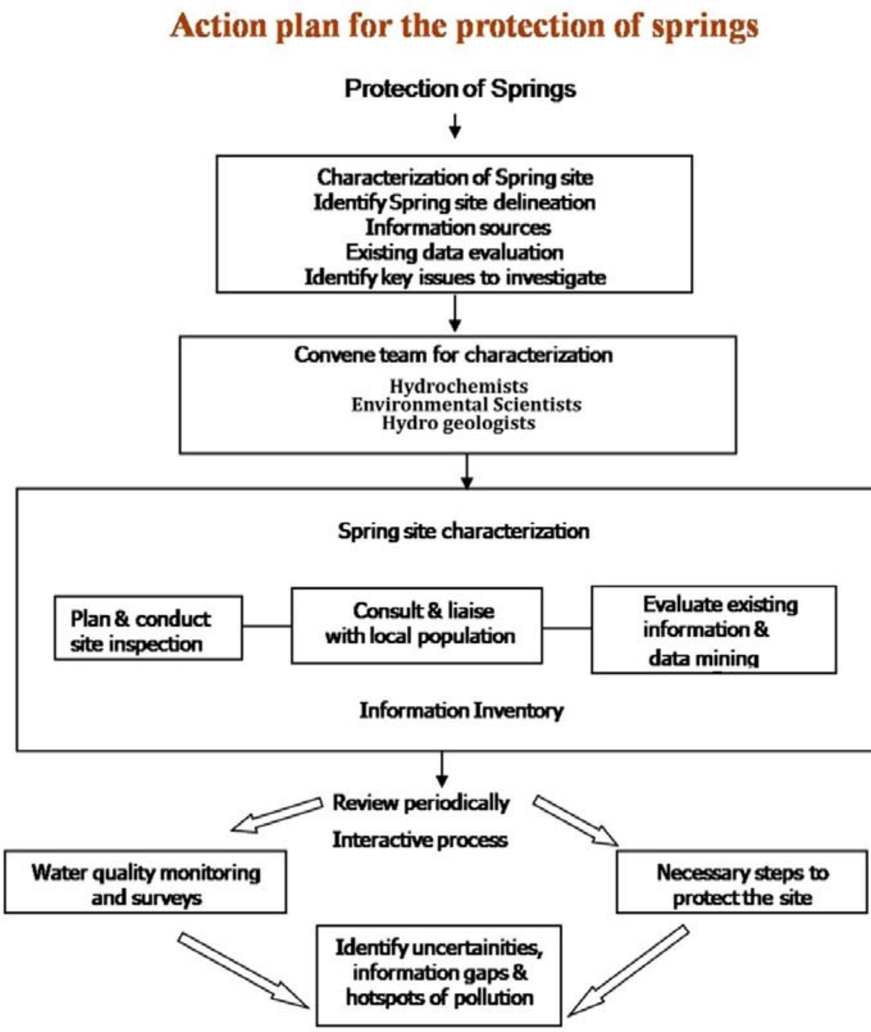


Fig. 10: Action plan for the protection of Springs

Plant Diversity in the Wetland Habitats in Mahe, U.T. of Puducherry

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Abstract

Surveys of the wetland habitats and the associated plant diversity have been undertaken. The study yielded 46 species belonging to 43 genera and 29 families. Of these, 20 species are Dicotyledons, 18 species are Monocotyledons and 8 species are Pteridophytes.

Key words: Wetlands, Plant diversity, Conservation, Angiosperms, Pteridophytes

Introduction

Wetlands have been ranked as the third most productive ecosystems of the world and are considered as "the kidneys and lungs" of the landscape. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. The multiple roles of wetland ecosystems and their value to humanity have been increasingly understood and documented in recent years. This has led to large expenditure to restore lost or degraded hydrological and biological functions of wetlands. But it is not enough, the raise is on to improve practices on a significant global scale as world's leaders try to cope with the accelerating water crisis and the effects of climate change.

The ability of wetlands to adapt to changing conditions, and to accelerating rates of change, will be crucial to human communities and wildlife everywhere as the full impact of climate change on our ecosystem lifelines is felt. In addition, wetlands are important, and sometimes essential, for the health, welfare and safety of people who live in or near them. The convention on wetlands signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the frame work for National action and International cooperation for the conservation and wise use of wetlands and their resources. According to the Ramsar Convention (Article 1.1), wetlands are defined as: "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters" (Chowdhery and Murti, 2000).

The biodiversity assessment of wetland habitats has not been carried out extensively. Attempts are not even made to utilize the valuable plant wealth of the wetlands. A few plants such as rice are extensively studied and utilized. Other plants are considered as weeds. A good number of wetland plants which we consider as weeds are utilized in other parts of the country (Ansari & Krishnan, 2006). The biodiversity of other habitats are extensively studied and majority of them are utilized in sustainable manner. There are concerted efforts going on for the protection of the terrestrial plants, which face extinction. However, wetland plants are extensively destroyed due to habitat modification and destruction. Therefore, it is essential to have a documentation and detailed study of wetland plants in and around us before they are lost.

Mahe, a part of biodiversity rich Western Ghats is a unique undulating land mass; covering an area of 9 sq. km., is holding a heavy population load. It also forms a unique ecotone, having associations with marine, estuarine and fresh water ecosystems. Like any other developing area, Mahe is also facing ecological stress of various kinds; mainly in the areas of wetland habitats. The wetland habitats of the area are depleting due to various reasons. It is therefore, highly essential to document the plant wealth of these fragile ecosystems before they are lost. A review of the literature pertaining to the botanical studies of the area (Nordenstam, 2009; Jisha, 2001, 2005; Pradeep & al., 2006, Sasikala & Rahina, 2009, Sasikala & al., 2009) revealed that a comprehensive documentation is lacking in this aspect. Therefore, the present study has been undertaken to survey various wetland habitats, collection and identification of wetland plants, assessment of the anthropogenic pressures and preparation of management plans for the conservation of wetland habitats.

Materials and Methods

The present study has been undertaken by arranging regular field trips. During the field trips attempts were made to locate various wetland habitats. Representative samples of the plants were collected and processed for herbarium following routine herbarium techniques (Jain & Rao, 1977). The collected plant specimens were critically examined, identified and assigned to their respective families, genera and species. The identification of the samples was done with the help of floras (Gamble, 1957;, Ramachandran & Nair, 1988; Manickam & Irudayaraj, 1992; Sasidharan, 2004) and other relevant literatures (Subramanyam, 1962). In addition, observations were also made in respect of the anthropogenic pressures. All the observations are documented photographically. The identified plants are enumerated in detail and are arranged alphabetically.

Results and Discussion

The present study yielded 46 species belonging to 43 genera and 29 families. Of these, 20 species belongs to Dicotyledons, 18 species belongs to Monocotyledons and 8 species belongs to Pteridophytes (Tables 1 & 2).

Table 1: Floristic Analysis

Plant Group	Family	Genera	Species
Dicot	14	18	20
Monocot	7	17	18
Pteridophyte	8	8	8
Total	**29**	**43**	**46**

Table 2: Enumeration of the species

(a) Angiosperms

Sl. No.	Name of the species	Family
1	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae
2	*Ammannia baccifera* L.	Lythraceae
3	*Bacopa monnieri* (L.) Pennell)	Scrophulariaceae
4	*Centella asiatica* (L.) Urban	Apiaceae
5	*Coix lacryma-jobi* L.	Poaceae
6	*Colocasia esculenta* (L.) Schott	Araceae
7	*Commelina diffusa* Burm.f.	Commelinaceae
8	*Cryptocoryne spiralis* (Retz.) Fisch.ex Wydler	Araceae
9	*Cyperus haspan* L.	Cyperaceae
10	*Cyperus iria* L.	Cyperaceae
11	*Eclipta prostrata* (L.) L.	Asteraceae

12	*Eichhornia crassipes* (Mart.) Solms.	Ponterderiaceae
13	*Eleocharis retroflexa* (Poir.) Urban ssp. *chaetaria* (Roem. & Schult.) Koyama	Cyperaceae
14	*Fimbrystylis miliacea* (L.) Vahl	Cyperaceae
15	*Fuirena ciliaris* (L.) Roxb.	Cyperaceae
16	*Heliotropium indicum* L.	Boraginaceae
17	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae
18	*Hygrophila schulli* (Buch.-Ham.) M.R. & S.M. Almeida	Acanthaceae
19	*Hygrophila triflora* (Roxb.) Fosb. & Sachet	Acanthaceae
20	*Hypolytrum nemorum* (Vahl) Spreng.	Cyperaceae
21	*Lagenandra toxicaria* Dalz.	Araceae
22	*Limnophila heterophylla* (Roxb.) Benth.	Scrophulariaceae
23	*Lobelia alsinoides* Lam.	Companulaceae
24	*Ludwigia prostrata* Roxb.	Onagraceae
25	*Monochoria vaginalis* (Burm.f.) Presl	Pontederiaceae
26	*Nesaea cordata* Hiern	Lythraceae
27	*Nymphaea nouchali* Burm.f.	Nymphaeaceae
28	*Nymphaea pubescens* Willd.	Nymphaeaceae
29	*Nymphoides indica* (L.) O. Ktze.	Gentianaceae
30	*Pandanus odoratissimus* L.f.	Pandanaceae
31	*Persicaria glabra* (Willd.) Gomez	Polygonaceae
32	*Rotala rotundifolia* (Buch.-Ham.ex Roxb.) Koehne	Lythraceae
33	*Sacciolepis indica* (L.) A. Chase	Poaceae
34	*Schoenoplectus articulatus* (L.) Palla	Cyperaceae
35	*Syzygium caryophyllatum* (L.) Alston	Myrtaceae
36	*Thunbergia fragrans* Roxb.	Acanthaceae
37	*Uticularia aurea* Lour.	Lentibulariaceae
38	*Vallisneria natans* (Lour.) Hara	Hydrocharitaceae

(**b**) **Pteridophytes**

Sl. No.	Name of the species	Family
1	*Acrostichum aureum* L.	Pteridaceae
2	*Azolla pinnata* R.Br.	Azollaceae
3	*Ceratopteris thalictroides* (L.) Brongn.	Parkeriaceae
4	*Cyclosorus interruptus* (Willd.) H.	Thelypteridaceae
5	*Lygodium microphyllum* (Cav.) R. Br.	Lygodiaceae
6	*Marsilea minuta* L.	Marsileaceae
7	*Salvinia molesta* Mitch.	Salviniaceae
8	*Stenochlaena palustris* (Burm.f.) Beddome	Blechnaceae

The present study revealed that Mahe still posses a wide range of wetland habitats. The diversity of many indigenous wetland floras is seriously affected due to certain invasive elements such as *Eichhornia* *crassipes* and *Salvinia molesta*. Wetlands of Mahe are subjected to anthropogenic pressures of various kinds. This is mainly due to increase in population load and increase in the demand of land for various developmental activities. Most often the wetlands are treated as wastelands and people throw waste into these and pollute them seriously.

Conclusions

One of the major concerns in biodiversity conservation is habitat modification or destruction. This can be addressed by conserving representative habitat types whereby we can conserve our valuable diversity for sustainable utilization and for future generations.

Tackling the issue of wetland conservation and management in Mahe is a sensitive one, as most of the wetlands are owned by private parties. Management of the existing wetlands can only be achieved through awareness programmes, organized with the help of local residents, interested NGO's and like minded people. Since Mahe forms a unique ecotone, having associations with marine, estuarine and fresh water ecosystems, depletion of wetlands will result in the destruction/migration of biodiversity. Hence "representative wetlands" need to be maintained or conserved to preserve the associated flora and fauna. This can be accomplished by providing some incentives to the owners of the wetlands.

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References

1. **Ansari, R. and Krishnan, P.M. 2006.** Aquatic Plants of Kerala in R. Ansari and G. Jeeja *Plants and Plant Science in Kerala*, Malabar Botanical Garden, Kozhikode.
2. **Chowdhery, H.J. and Murti, S.K. 2000.** *Plant Diversity and Conservation in India - An Overview*. Dehradun.
3. **Gamble, J.S. and Fischer, C.E.C. 1957** (reprint edition). *Flora of Presidency of Madras* (Vol. 1 - 3). Adlard and Sons, London.
4. **Jain, S.K. and Rao, R.R. 1977.** *A Handbook of Field and Herbarium Methods*. New Delhi.
5. **Jisha, P. 2001**. *Studies on Medicinal Plants in Mahe Region*. M.Phil. thesis, Pondicherry Central University.
6. **Jisha, V. 2005.** *Sacred Groves of Mahe*. M.Phil. thesis, Pondicherry University.
7. **Manickam, V.S. and Irudayaraj, V. 1992.** *Pteridophyte Flora of the Western Ghats – South India*. New Delhi.
8. **Nordenstam, B. 2009.** Linnaeus's Global Project - The exploration of the world's flora. *Rheedea* 19: 1 - 11.
9. **Pradeepkumar, G. and Ravindran, C.P. 2006.** Tree wealth of Mahe (U.T. of Pondicherry) A preliminary survey. *Ecol. Env. & Cons*. 12 (3): 417 - 420.
10. **Ramachandran, V.S. and Nair, V.J. 1988.** *Flora of Cannanore*. Botanical Survey of India, Calcutta.
11. **Sasidharan, N. 2004.** *Flora of Kerala. Biodiversity Documentation for Kerala*. Part 6. Flowering plants. KFRI, Kerala, India.
12. **Sasikala, K. and Rahina, K. 2009.** Exotic flora of Mahe, U.T. of Puducherry. *Eco- chronicle* 4(2): 101 - 106.

13. **Sasikala, K., Girishkumar, E. & Krishnaveni, C. 2009.** A preliminary survey of the wild edible plants of Mahe, U.T. of Puducherry. 158 - 163. *Proc. National Seminar on Recent Trends in the conservation and utilization of underutilized wild edible plants*. Bharathiar University, Coimbatore.
14. **Sasikala, K., PradeepKumar, G., Arisdason, W., Girish Kumar, E. and Ravindran, C.P. 2009.** A Preliminary Analysis of the Flora of Mahe, Union Territory of Puducherry. *Eco-Chronicle* 4(4): 219 - 228.
15. **Subramanyam, K., 1962.** *Aquatic Angiosperms*. CSIR, New Delhi.

Endemic and RET plant diversity in selected Sacred groves of Kozhikode district, Kerala

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Abstract

Sacred groves are one of the finest examples of traditional *in situ* conservation practices, which dates much prior to the modern concept of wildlife reserves. These are the last shelters of natural forests, indicators of the rich vegetation that had existed in the past, act as abode of rare and endemic organisms, treasure trove of medicinal plants as well as most important refuge to a vast variety of wild yams, pepper and mango. Extensive floristic explorations carried out throughout Kozhikode District to explore the endemic as well as RET plant diversity in sacred groves resulted in the documentation of 45 endemic plants coming under 40 genera and 25 families. Of these, 12 fall under different RET categories. Utmost striking feature is that only four endemic species are common to the groves studied while 20 are restricted to any one of the groves. Percentage of endemic plants is between 15 and 19. These also act as the refugia of 29 well known phytomedicines and 9 wild edible food resources. Like the other groves of Kerala, a vast variety of anthropogenic activities are the major threat for the gene pool of these fragile ecosystems. Thus conservation of biodiversity of these sacred groves is an urgent need.

Key words: Sacred groves, Kozhikode, Endemic, RET plants, Threats

Introduction

Conservation of pristine vegetation in the form of sacred groves dates much prior to the modern concept of wildlife reserves. Sacred groves are found in a wide range of ecological situations (Gadgil & Vartak, 1976). These are the last shelters of natural forests, indicators of the rich vegetation that had existed in the past, act as abode of rare and endemic organisms, treasure trove of medicinal plants as well as most important refuges to a vast variety of wild yams, pepper and mango (Chandran *et al.*, 1998; Chandrashekara & Sankar, 1998; Deb *et al.*, 1997; Pushpangadan *et al.*, 1998; Gokhale *et al.*, 1998; Prasad & Raveendran, 2011, 2012 a & b). Thus, groves are the repositories of biological wealth of the nation (Malhotra *et al.*, 2001). About 60 % of the regenerating species in them are medicinally important and nearly 40% medicinal plants are unique to them (Boraiah *et al.*, 2003). Endemic plants are the population with narrow ecological restrictions. Endemic species of any geographical region throw light on the biogeography of the area, areas of extinction and evolution of the flora (Ramesh & Pascal, 1991). Identification and documentation of endemic as well as RET species is important in the conservation of biodiversity as these have specific ecological niches (Varghese & Menon, 1999). In Kerala, sacred groves are mainly distributed in plains, numbering about 2000 (Malhotra *et al.*, 2001) of which 578 are in North Malabar (Jayarajan, 2002). At present, most of the sacred groves are on a path of gradual decline owing to various socio-economic factors (Bhandari & Chandrashekar, 2003). Like other groves of Kerala, sacred groves of Kozhikode is also facing the threat of extinction from a vast variety of anthropogenic activities. Present studies were mainly aimed at the exploration of endemic plant diversity and the threats to them.

Materials and methods

Area selected for study is Kozhikode District ($11^0$08' N & $11^0$50' N and $75^0$30' E & $76^0$08' E) of Kerala, located to the North east of Kerala. Vegetation is of secondary semi-evergreen type. The climate is typical warm-humid tropical type with mean temperature range of 22 – 37° C and relative humidity between 70% and 90%. Extensive floristic explorations were carried out from January 2009 to December 2011 throughout Kozhikode District of Kerala. Five famous sacred groves namely *Poyili*, *Vallikattu*, *Pishari*, *Vadakke nagakotta* and *Muchukunnu* with an extent of over 2 acres were selected for detailed study. The floristic diversity of these groves was documented and identified with the help of regional floras, checklists (Hooker, 1897; Gamble & Fischer, 1936; Manilal & Sivarajan, 1982; Mathew, 1984; Ramachandran & Nair, 1988; Bhat, 2003; Sasidharan, 2011; Anilkumar *et al.,* 2005, Nayar *et al.*, 2006) and herbaria. The voucher specimens were deposited at the SSC herbaria. In order to expose the economic importance, knowledgeable local people were personally interviewed with questionnaire and data sheets. The data gathered and statuses of the plants were ascertained by referring authentic publications (Kirtikar & Basu, 1935; Anonymous, 1976; Nadkarni, 1954; Chopra *et al.*, 1956; Ambasta, 1986; Jain, 1991; Sivarajan & Balachandran, 1994; Warrier *et al.*, 1994; IUCN, 2010).

Results and discussion

A comparative account of endemic plants, their distribution and status are shown in Table 1. From the present investigation, it is clear that these groves act as germplasm store house of 45 endemic plants coming under 40 genera and 25 families. Only four plants namely *Holigarna arnottiana* Hook. f., *Ixora brachiata* Roxb. ex DC., *Memecylon randerianum* SM & MR Almeida and *Mussaenda belilla* Buch.-Ham. are common to the groves studied while seven are common to four groves, five common to three groves and nine to two groves. Utmost striking feature is that 20 plants are restricted to any one of the groves. Of these 45 endemic plants, 12 fall under different RET categories as there are 8 vulnerable, two low risk, critically endangered *Vateria indica* L. and rare *Arisaema leschenaultia* Blume. The number and percentage of endemic plants in each grove is given in Table 2. *Vallikattu kavu* accounted for 34 endemic plants which was the maximum and *Pishari kavu* (19%) for maximum endemic plant percentage. *Vadakke nagakotta* was least both in number (8) and percentage (15%) of endemic plants. Out of the 12 RET plants 11 are highly traded for medicinal purposes. Personal interview with the local knowledgeable people and authentic literature reference revealed that these also act as the refugia of 29 well known phytomedicines and 9 wild edible food resources.

Table 1 – Endemic and RET plants

Sl. No.	Plant Name	Sacred Groves					Status
		Py	Va	Ps	Vn	Mu	
1	*Actinodaphne bourdillonii*		x				
2	*Aganope thyrsiflora*					x	
3	*Amorphophallus commutatus*		x			x	
4	*Anaphyllum wightii*		x				M
5	*Arisaema leschenaultii*		x			x	R
6	*Artocarpus hirsutus*	x	x	x		x	M, E, V
7	*Briedelia scandens*					x	M, E
8	*Bulbophyllum sterile*		x			x	M, E

9	*Canthium rheedei*	x		x		x	
10	*Capparis rheedei*	x					M, V
11	*Chionanthes mala-elengi*		x				
12	*Cinnamomum malabatrum*	x	x	x	x		M, E
13	*Connarus wightii*	x	x				
14	*Dalbergia horrida*	x	x	x		x	M
15	*Dendrobium ovatum*	x	x				M
16	*Diospyros candolleana*	x	x	x		x	M
17	*Euonymous indicus*	x					
18	*Flacourtia montana*	x					M, E
19	*Holigarna arnottiana*	x	x	x	x	x	M, E
20	*Holigarna ferruginea*		x				
21	*Hopea parviflora*	x					M, V
22	*Hopea ponga*	x	x			x	M, V
23	*Hydnocarpus pentandra*	x	x		x		M, V
24	*Ixora brachiata*	x	x	x	x	x	M
25	*Ixora lanceolaria*	x					
26	*Ixora polyantha*		x				
27	*Jasminum malabaricum*	x	x	x		x	M, E
28	*Kammetia caryophyllata*					x	
29	*Knema attenuata*	x	x				M, LR
30	*Lagerstroemia microcarpa*		x				M
31	*Litsea coriacea*	x	x				M
32	*Litsea ghatica*	x	x		x		
33	*Meineckia parvifolia*					x	
34	*Memecylon randerianum*	x	x	x	x	x	M
35	*Mussaenda belilla*	x	x	x	x	x	M
36	*Myristica malabarica*	x	x				M, E, V
37	*Ophiorrhiza eriantha*		x				
38	*Premna glaberrima*		x				
39	*Salacia fruticosa*	x	x		x	x	M, E
40	*Santalum album*		x			x	M, V
41	*Strobilanthes ciliatus*		x				M, V
42	*Tabernaemontana heyneana*	x	x	x		x	M, LR
43	*Terminalia paniculata*					x	M
44	*Vateria indica*		x				M, CR
45	*Zingiber cernuum*	x	x			x	M

Py – *Poyili*, **Va** – *Vallikattu*, **Ps** – *Pishari*, **Vn** – *Vadakke nagakotta*, **Mu** – *Muchukunnu*, **M** – Medicinal,
E – Edible, **V** – Vulnerable, **R** – Rare, **LR** – Low risk, **CR** – Critically endangered.

Table 2: Number and Percentage of Endemic plants

Sacred Grove	Total No. of Plants	Endemic Plants	Percentage
Muchukunnu	123	22	18
Pishari	57	11	19
Poyili	157	26	17
Vadakke Nagakotta	54	8	15
Vallikattu	193	34	18

Conclusions

This much richness in species diversity makes these groves biological hotspots. Like other groves of Kerala, anthropogenic activities like collection of firewood, dumping of waste and many antisocial elements are the major threats for the gene pool of these fragile ecosystems. Their presence in agriculture lands, grazing, fragmentation and erosion of religious beliefs are also the added influence of anthropogenic activities. Thus, conservation of biodiversity of these sacred groves is an urgent need. For effective conservation fencing of the outer perimeter to prevent tress passing, total ban on the exploitation of natural resources from them, allowing entry to those who come for worship and posting security to guard the entry point are recommended.

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References

1. **Ambasta, S. P. 1986.** *The Useful Plants of India.* Publication & Information Directorate, CSIR, New Delhi.
2. **Anilkumar, N., Sivadasan, M. and Ravi, N. 2005.** *Flora of Pathanamthitta.* Daya Publishing House, Delhi.
3. **Anonymous. 1976.** *Wealth of India – Raw materials*, Vols. 11 Vols. Publication & Information Directorate, CSIR, New Delhi.
4. **Bhandari, M. J. and Chandrashekar, K. R. 2003.** Sacred groves of Dakshina Kannada and Udupi districts of Karnataka. *Current Science*. 85 (12): 1655 – 1656.
5. **Bhat, K. G. 2003.** *Flora of Udupi.* Indian Naturalist (R), Udupi.
6. **Boraiah, K. T., Vasudeva, R., Bhagwat, S. A. and Kushalappa, C. G. 2003.** Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state- managed reserve forests ?. *Current Science*. 84 (6): 804 – 808.
7. **Chandran, M. D. S., Gadgil, M. and Hughes, J. D. 1998.** Sacred groves of the Western Ghats, In: Ramakrishnan, P. S., Saxena, K. G. and Chandrashekara, U. M. (eds.) *Conserving the Sacred for Biodiversity Management*. Oxford and IBH Publishing Co., New Delhi, pp. 211 – 232.
8. **Chandrashekara, U. M. and Sankar, S. 1998.** Structure and Function of sacred groves: Case studies in Kerala, In: Ramakrishnan, P. S., Saxena, K. G. and Chandrashekara, U. M. (eds.) *Conserving the Sacred for Biodiversity Management*. Oxford and IBH Publishing Co., New Delhi, pp. 323 – 336.
9. **Chopra, R. N., Nayar, S. L. and Chopra, I. C. 1956**. *Glossary of Medicinal Plants.* Publication & Information Directorate, CSIR, New Delhi.

10. **Deb, D., Deuti, K. and Malhotra, K. C. 1997.** Sacred grove relics as bird refugia. *Current Science.* 73 (4): 815 – 817.
11. **Gadgil, M. and Vartak, V. D. 1976.** The sacred groves of Western Ghats in India*. Economic Botany*. 30: 152 – 160.
12. **Gamble, J. S. and Fischer, C. E. C. 1936.** *Flora of Presidency of Madras,* 3 Vols. Adlard & Son Ltd., London.
13. **Gokhale, Y., Velankar, R., Chandran, M. D. S. and Gadgil, M. 1998.** Sacred woods, grasslands and waterbodies as self-organized systems of conservation, In: Ramakrishnan, P. S., Saxena, K. G. and Chandrashekara, U. M. (eds.) *Conserving the Sacred for Biodiversity Management*. Oxford and IBH Publishing Co., New Delhi, pp. 365 – 398.
14. **Hooker, J. D. 1897.** *Flora of British India,* 7 Vols. Reeve and Co., London.
15. **IUCN. 2010.** *IUCN Red List categories,* IUCN Publications, Switzerland.
16. **Jain, S. K. 1991.** *Dictionary of Indian Folk Medicine and Ethnobotany.* Deep Publications, New Delhi.
17. **Jayarajan, M. 2004.** *Sacred groves of North Malabar.* Discussion Paper No. 92, KRPLLD.
18. **Kirtikar, K. R. and Basu, B. D. 1935.** *Indian Medicinal Plants,* 4 Vols. Lalit Mohan Basu, Allahabad.
19. **Malhotra, K. C., Gokhale, Y. and Chatterjee, S. 2001.** *Cultural and ecological dimensions of sacred groves in India.* Indira Gandhi Rashtriya Manav Sangrahalaya, Bhopal.
20. **Manilal, K. S. and Sivarajan, V. V. 1982.** *Flora of Calicut.* Bishen Singh Mahendra Pal Singh, Dehra Dun.
21. **Mathew, K. M. 1984.** *The Flora of Tamilnadu Carnatic,* 3 Vols. The Rapinat Herbarium, St Joseph's College, Thiruchirapalli.
22. **Nadkarni, K. M. 1954.** *Indian Materia Medica*, 2 Vols. Popular Prakashan Pvt. Ltd., Bombay.
23. **Nayar, T. S., Beegam, A. R., Mohanan, N. and Rajkumar, G. 2006.** *Flowering Plants of Kerala.* TBGRI, Palode.
24. **Prasad, K. S. and Raveendran, K. 2011.** Endemic Plant Diversity in Selected Sacred Groves of Kannur District, Kerala. *Ecology, Environment and Conservation.* 17 (1): 141 – 144.
25. **Prasad, K. S. and Raveendran, K. 2012a.** Endemic Plant Diversity in Selected Sacred Groves of Kasaragod District, Kerala. *International Journal of Plant, Animal and Environmental Sciences.* 2 (4): 240 – 244.
26. **Prasad, K. S. and Raveendran, K. 2012b.** Sacred Groves of North Malabar: Refugia of Endemic and Rare Medicinal Plants. *Plant Sciences Feed.* 2 (10): 154 – 158.
27. **Pushpangadan, P., Rajendraprasad, M. and Krishnan, R. N. 1998.** Sacred groves of Kerala: A synthesis of art of knowledge, In: Ramakrishnan, P. S., Saxena, K. G. and Chandrashekara, U. M. (eds.) *Conserving the Sacred for Biodiversity Management*. Oxford and IBH Publishing Co., New Delhi, pp. 193 – 210.
28. **Ramachandran, V. S. and Nair, V. J. 1988.** *Flora of Cannanore*. BSI, Calcutta.
29. **Ramesh, B. R. and Pascal, J. P. 1991.** *Distribution of endemic arborescent evergreen species in the Western Ghats*. pp. 20 – 29. Proceedings of the symposium on rare endangered and endemic plants of the Western Ghats (India). Kerala Forest Department, Thiruvananthapuram.
30. **Sasidharan, N. 2011.** *Flowering Plants of Kerala.* ver. 2. 0. KFRI, Peechi.
31. **Sivarajan, V. V. and Balachandran, I. 1994.** *Ayurvedic Drugs and their Plant source.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
32. **Varghese, A. O. and Menon, A. R. R. 1999.** Ecological niches and amplitudes of rare, threatened and endemic trees of Peppara Wildlife Sanctuary. *Current Science*. 76 (9): 1204 – 1208.
33. **Warrier, P. K., Nambiar, V. P. K. and Ramankutty. 1994.** *Indian Medicinal Plants – A Compendium of 500 species.* 5 Vols. Orient Longman Ltd., Madras.

Conservation of *Heliotropium keralense* –a globally endangered and endemic medicinal plant through *in vitro* techniques

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Abstract

An efficient protocol was established for the rapid micropropagaion and conservation of *Heliotropium keralense* from root explants. Murashige and Skoog's (MS) medium supplemented with BA (4.0 mg/L) and Kn (4.0 mg/L) was the most effective combination for the induction of multiple shoots. MS medium supplemented with 0.5mg/litre IBA was suitable for the rooting of shoots. Plantlets with fully expanded leaves and well-developed roots were hardened under controlled conditions within 20 days and eventually established in the field. Morphologically there was no detectable variation between *in vitro* raised and naturally grown plants.

Key words: *Heliotropium keralense,* conservation, *in-vitro* techniques

Introduction

Heliotropium keralense is an important endemic medicinal plant of Kerala (Sasidharan & Sivarajan, 1966 and Sivarajan & Balachandran, 1994). The plant belongs to IUCN globally Endangered red list category (Nayar, 1996 and Biswas, 2006). The plant is useful in the treatment of worms, skin diseases, scorpion and snake poisoning, asthma, cough, anaemia, insanity and epilepsy (Sivarajan & Balachandran, 1994 and Tiwari et al., 2001). Efficient micropropagation protocol of important red listed plants is an essential requirement for their conservation and mass multiplication (Tyagi & Prakash, 2001). The present paper describes a protocol which can be used for the rapid multiplication and *ex situ* conservation of *Heliotropium keralense.*

Materials and Methods

Roots of *Heliotropium keralens* were collected from plants growing in the Calicut University campus. The explants were washed thoroughly under tap water, followed by treatment with 5% Extran (v/v) (Merck) for 5 minutes and subsequently washed 3 times with sterile water. The explants were surface disinfected with 0.1% Mercuric chloride solution for 10 minutes and after decanting the sterilant, explants were washed with sterile double distilled water. The explants were then cultured on nutrient medium under aseptic conditions.

The surface sterilized explants were cultured on semi-solid MS medium containing 3% sucrose and 0.8% agar, supplemented with varying concentrations and combinations of Benzyl Adenine (BA), Kinetin (Kn). *In vitro* raised shoots were excised and cultured on MS medium supplemented with 0.5 mg/litre Indole 3-Butyric Acid (IBA).

The pH of the medium was adjusted to 5.7, prior to autoclaving at a pressure of 15 psi for 15 minutes. Cultures were incubated at 25 ± 2°C under 16h photoperiod at 1000 lux light.

Plantlets with well developed root and shoot systems were taken out from the culture tubes, and after thorough washing with sterilized water, were transferred to plastic cups containing sterile sand and soil (1:1) mixture. These were subjected to acclimatization by covering them with polythene bags and kept in green house at 90% relative humidity. Successfully hardened plantlets were eventually established in natural soil.

Results

Direct multiple shoot regeneration from the root explants of *Heliotropium keralense* in relation to growth regulators supplemented in MS medium is summarised in Table 1. BA was found to be as the essential cytokinin for direct shoot regeneration from the root explants of *Heliotropium keralense* (Figure 1 A). Kn did not evoke any response when tested alone. However a combination of BA (4.0 mg/l) and Kn (4.0mg/l) (Figure 1 B & C) was most effective for direct shoot regeneration from root explants. Indole butyric acid at (0.5 mg/l) in MS medium was found as effective for rooting of *H. keralense* shoots (Figure 1 D) and produced highest number of roots (25/shoot) with high frequency (90%).

Plantlets with well developed shoot and root systems formed in cultures were taken out and acclimatized in natural soil (Figure 1 E). Out of the 420 plants transferred to the field, 391 plants survived and grown into mature plants. Micropropagated plants were morphologically similar to normal field grown plants.

Figure 1

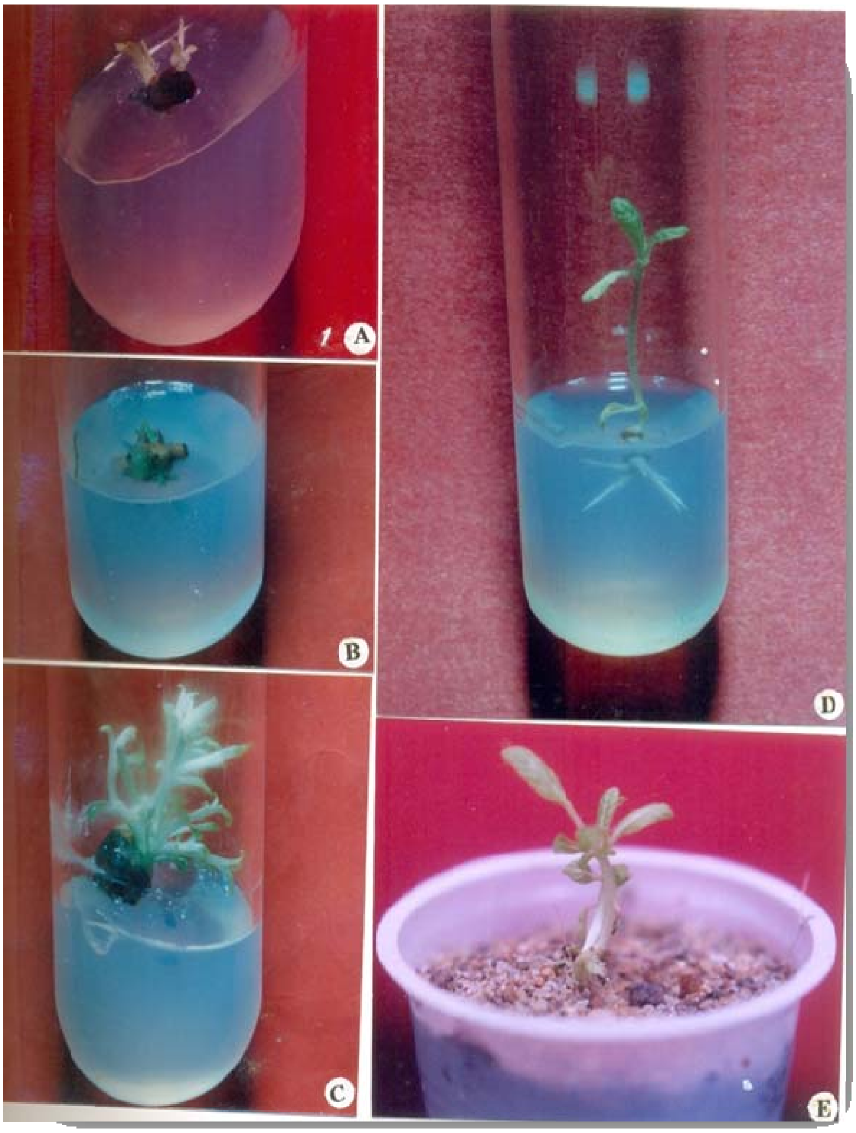

Table 1: Effect of growth regulators on shoot induction from the root exptants of *Heliotropium keralense*

Growth regulators [1] (mg/ liter)	% of response	No. of shoots / 1 cm of Root explant	Shoot length (crn)"
BA			
1.0	–		
2.0	–		
3.0	30	1.8±0.11	3.2±0.61
4.0	40	2.12±0.21	3.1±0.34
5.0	40	2.04±0.08	2.85±0.14
Kn			
1.0	–	–	–
2.0	–	–	–
3.0	–	–	–
4.0	–	–	–
BA + Knn			
2.0+2.0	–	–	–
3.0+3.0 .0	30	4.6	3.1±0.46
4.0+4.0	55		2.9±0.25
5.0+5.0	55		2.86±0.17

Data from 20 replicates in two experiments (Mean±SE); - No Response; Growth period 50 days

Conclusions

Our results showed that BA was highly effective than Kn for the multiple shoot induction of *H. keralense.* The stimulative effect of BA over Kn in direct shoot regeneration was reported earlier in many medicinal plants (Babu *et al.*, 2003; Julani *et a1.*, 1999; Sahoo and Chand 1998; Tiwari *et al.*, 2001; Jagadishchandra *et al.*, 1999; Komalavally & Rao, 1997; Naik *et al.,* 1999; Vincent *et al.*, 1998 and Ulubelde *et al.*, 1991).

Present studies also demonstrated efficacy of IBA for the rooting of *in vitro* raised shoots of *H. keralense.* Similar results showing efficacy of IBA in *in vitro* rooting was reported in many plant species (Andoh et al., 2005; Das & Rout, 2002; Echeverrigaray et al., 2000; Faisal &Anis, 2003 and Fracaro & Echeverrigaray, 2001). The protocol described here would be useful for the conservation and rapid multiplication of *H. keralense* .

References

1. **Andoh,Y. Yahara, S. & Yoshizawa, N. 2005.** *In vitro* regeneration of the medicinal plant *Phellodendron amurense* Rupr. Through excised leaves. Pl. Cell Tiss. Org. Cult. 80: 43-50.
2. **Babu, K.N. Sajna, A. Minoo, D. John, C.Z. Mini.P M. Tushar, K.V. Rema & Ravindran, P.N. 2008** Micropropagation of Camphor tree *(Cinnamomum camphora).* Pl. Celi Tiss. Org. Cult. 74: 179-183.
3. **Biswas, S. 2006.** Indian biodiversity for the present millennium: global prospects and perspectives. Satish Serial Publishers ,India, pp 25.
4. **Das, G. & Rout, G.R. 2002.** Direct plant regeneration from leaf explants of *Plumbago,* Pl. Cell Tiss. Org. Cult. 68: 311-314.

5. **Echeverrigaray, S. Bias, S. Fracaro, F. & Sarafini 2000.** Clonal micropropagation of Roman Charnomile *(Anthemis nobilis* L.). 1. of Herbs, Spices & Medicinal plants. 7 (2): 35-41.
6. **Faisal, M. & Anis, M. 2003.** Rapid mass propagation of *Tylophora indica* Merill via leaf callus culture. Pl.Cell.Tiss. Org. Cult.75, 125-129
7. **Fracaro, F. & Echeverrigaray, S. 2001**. Micropropagation *of Cunila galiodes,* a popular medicinal plant of South Brazil, Pl. Cell Tiss. Org. Cult. 64: 1-4.
8. **Jagadhishchandra, K.S. Rachappaji, S. Gowda. K. R.D & Tarasaraswathi KJ 1999.** In vitro propagation of Pisonia alba (L)Sapanogae(lettuce tree) a threqatened species.Phytomorphology. 49: 43-47.
9. **Juliani (Jr.) H.R., Koroch A.R., Juliani H.R. & Trippi V.S. 1999.** Micropropagation of *Lippia junelliana* (Mold.) Tronc., Pl. Cell Tiss. Org. Cult. 59: 175-179.
10. **Komalavalli, N., & Rao, M.N. 1997**. *Invitro* micropropagation Gymnema *elegans* W&A, a rare medicinal plant. Indian J. Exp. Biol. 1088-1092
11. **Naik S.K., Pattnaik S.S. & Chand, P.K. 1999.** In vitro propagation of pomegranate *(Punica granatum* L) through axillary shoot proliferation from nodal explants of mature tree. Scient. Hortic. 79: 175-183.
12. **Nayar, M. P. 1996.** Hot spots of endemic plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute Publishers, Trivandrum ,India pp 96.
13. **Sahoo, Y. & Chand, P.K. 1998.** Micropropagation of *Vitex negundo* L. a woody aromatic medicinal shrub, through high frequency axillary shoot proliferation. Pl. Cell Rep. 18: 301-307.
14. **Sasidharan. N. & Sivarajan, V.V. 1966.** *Flowering plants of Thrissur forest* (Western Ghats, Kerala, India) Scientific Publishers; Jodhpur, India, pp. 303-304
15. **Sivarajan V.V. & Balachandran, I.1994.** *Ayurvedic drugs and their plant resources*. Oxford and IBH publishing Co. Ltd., New Delhi.
16. **Tiwari. V. Tiwari, K.N. & Singh, B.D. 2001.** Comparative studies of cytokinins on in vitro propagation of *Becopa monnieri..* Pl. cell Tiss. Org. Cult. 66: 9-16.
17. **Tyagi R.K. & Prakash, S. 2001.**Clonal propagation and in vitro conservation of Jojoba (*Simmondsia chinensis* (Link) Schneider).Indian J.Plant Genet.Resour.14:298-300.
18. **Ulubelde, M. Ekim, M. & Tan, A. 1991.** The aromatic medicinal plants in Turkey. In; Raychanduri SP (eds.) Recent Advances in Medicinal, Aromatic and spices Crops .. Today and Tomorrow's Printers and Publishers, New Delhi.
19. **Vincent, K.A. Martin, K.P. & Hariharan, M. 1998**. In vitro culture studies on *Kampferia galanga* L. In; Khan IA and K hanum A (Eds.). Role of Biotechnology in Medicinal and Aromatic Plants. Ukaaz. Publ. Hyderabad, India.

Seed germination studies in *Ipomoea mauritiana* Jacq. (Convolvulaceae) - a threatened and commercially important medicinal plant for conservation

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Abstract

Ipomoea mauritiana Jacq. commonly known as "*Palmuthukku*" in Malayalam and "*Vidari*" in Sanskrit belonging to the family *Convolvulaceae*. The seed germination studies of this plant with 15 different types of seed treatment were carried out.

Key words: *Ipomoea mauritiana,* Seed germination, medicinal, conservation

Introduction

The demand for traditional herb medicine is increasing very rapidly mainly because of the harmful effects of synthetic chemical drugs. The world Health Organization (WHO) estimated that 80% of the population of developing countries depend on traditional systems of medicine, mostly plant based product for their primary health care. The global clamor for more herbal ingredients creates possibilities for the local cultivation of medicinal and aromatic crops as well as for the regulated and sustainable harvest of wild plants. Such endeavors could help raise more rural employment in the developing countries, boost commerce around the world and perhaps contribute to the health of millions (Chatterjee, 1982). This requires availability of quality planting material in sufficient quantity, which can be made possible through collection, conservation, evaluation of ecotypes and supply of seed material of such improved types from reliable sources (Fransworth *et al.,* 1975).

Ipomoea mauritiana Jacq. belonging to the family Convolvulaceae is an annual extensive perennial climber with large ovoid and tuberous roots. This species is widely distributed throughout the world and the tubers are commonly used in Kerala for the treatments of hypolipodemic, hypogycemic, for debility, to increase secretion of milk, poor digestion, tuberculosis, enlarged liver etc. It was also found to have alterative, aphrodisiac, cholagogue, demulcent, diuretic, rejuvenative actions (Udayan & Indira Balachandran, 2009).

Materials and Methods

The seeds of *Ipomoea mauritiana* Jacq. were collected from the *Centre for Medicinal Plants Research* (KAU), Odakkali of Ernakulum district of Kerala on 18th August 2010. Seeds were hand extracted from the ripe fruits immediately after harvest and air-dried. The seeds were sown in germination trays filled with soilless media consisting of cocopeat, vermiculate and perlite in 3:1:1 ratio. Design of the experiment is *Completely Randomized Design* (CRD). Four replication is attempted, each replication consisting of 10 seeds. Parameters like germination percent shoot length, root length, height of plant, number of leaves and vigour index were recorded. The mean number of normal seedlings produced was recorded and expressed as germination percentage. Vigour Index was computed by adopting the formula (Abdul Baki and Anderson, 1970; Fig 1).

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total Number of seeds}} \times 100$$

Vigour Index = Germination % x Mean length of Root and Shoot.

Results and Discussion

15 different types of seed treatment were carried out with duration as shown below: **(Fig. 1)**

1. **T1** - Fresh seeds (Control);
2. **T2** - Cold water treatment (C.W.T) 18 hours;
3. **T3** - Hot water treatment (H.W.T) 18 hours;
4. **T4** - Boiling water treatment (B.W.T) instant dip
5. **T5** - 20% Sulphuric acid (20% H2SO4) 1 hour;
6. **T6** - Concentrated Sulphuric acid (Con. H2SO4) instant dip;
7. **T7** - Mechanical Scarification (M.S) 3 - 5 minutes;
8. **T8** - Mechanical Scarification + Gibberlic acid 100ppm (M.S + G.A 100 ppm) 18 hours;
9. **T9** - Mechanical Scarification + Gibberlic acid 500ppm (M.S + G.A 500 ppm) 18 hours;
10. **T10** - Potassium nitrate - 0.2 % (KNO3)18 hours;
11. **T11** - Thiourea -2 % 18 hours;
12. **T12** - Hydrogen peroxide - 30 % (H2O2) 30 minutes;
13. **T13** - Cow milk (C.M) 18 hours;
14. **T14** - CowurineC.U) 18 hours;
15. **T15** - Kinetin 500 18 hours.

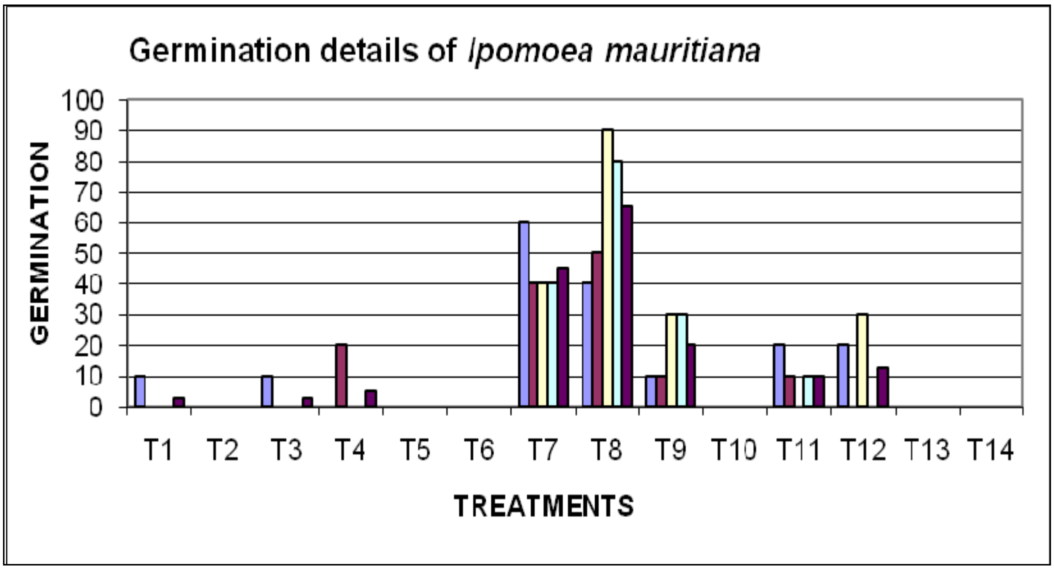

Table 1: Germination details

TREATMENTS	7 DAS*					14 DAS*					21 DAS*			
	R1	R2	R3	R4	Mean	R1	R2	R3	R4	Mean	R1	R2	R3	R4
T1	0	0	0	0	0	0	0	0	0	0	10	0	0	0
T2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T3	0	0	0	0	0	0	0	0	0	0	10	0	0	0
T4	0	0	0	0	0	0	10	0	0	2.5	0	20	0	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T7	40	20	10	10	20	60	40	40	40	45	60	40	40	40
T8	20	30	40	50	35	40	50	90	80	65	40	50	90	80
T9	10	0	30	20	15	10	10	30	30	20	10	10	30	30
T10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T11	0	0	0	0	0	0	0	0	0	0	20	10	0	10
T12	0	0	0	0	0	0	0	0	0	0	20	0	30	0
T13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T14	0	0	0	0	0	0	0	0	0	0	20	0	30	0
T15	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS – Days after sowing

In *Ipomoea mauritiana* Jacq., germination was maximum in seeds treated with mechanical scarification followed by dipping in Gibberellic acid 100 ppm for 18 hours (65%) and mechanically scarified seeds showed 45% germination percentage against 2% in untreated. After the study the plants were handed over to concerned organization for planting in its natural habitat. Today, many medicinal plants face extinction or severe genetic loss, and also too much emphasis has been put on the potential for discovering new wonder drugs.

Table 2: Vigour Index

TREATMENTS	56 DAS*				95 DAS*			
	R1	R2	R3	R4	R1	R2	R3	R4
T1	45	0	0	0	114	0	0	0
T2	0	0	0	0	0	0	0	0
T3	68	0	0	0	131	0	0	0
T4	0	110	0	0	0	229	0	0
T5	0	0	0	0	0	0	0	0
T6	0	0	0	0	0	0	0	0
T7	540	368	372	374	1110	808	960	896
T8	196	263	464	504	648	850	1580	1612
T9	66	58	189	167	182	168	629	710
T10	0	0	0	0	0	0	0	0
T11	192	92	0	108	424	219	0	217
T12	163	0	239	0	425	0	675	0
T13	0	0	0	0	0	0	0	0
T14	0	0	0	0	0	0	0	0
T15	0	0	0	0	0	0	0	0

* DAS – Days after sowing

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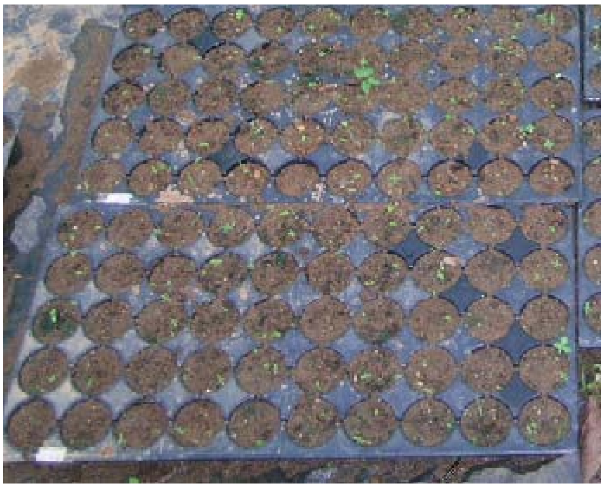
References

1. **Abdul–Baki, A.A. and J.D. Aderson. 1970.** Viability and Leaching of Sugar from germinating barley crop. *Cropsci.* 10: p.p.31-34
2. **Chaterjee, S.K. 1982.** *Hand Book of Medicinal Plants*. Pointer publisher, Jaipur, India
3. **Fransworth, N. R. and D. D. Sojarto. 1975.** Medicinal plant in therapy. *Jour. Pharm. Sci.* 64: 535- 598, 3717- 754.
4. **Udayan P.S. and Indira Balachandran. 2009.** *Medicinal Plants of Arya Vaidya Sala Herb Garden,* Arya Vaidya Sala, Kottakkal, Kerala.

Fig. 1 – ***Ipomoea mauritiana*** Jacq.

Habit

Tubers



Seeds showing 14 days after sowing (DAS)

Seeds showing 95 days after sowing (DAS)

Genetic diversity of cultivated legumes in Wayanad district, Kerala

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Abstract

Legumes are vegetable which are rich source of vitamins and minerals. These belong to the family Leguminosae. The present study was carried out in the Wayanad district of Kerala, which lies between $11^0 26'28''$ to $11^0 48'22''$ north latitudes and $75^0 46'38''$ to $76^0 26'11''$ east longitudes. Field visits were made in order to locate the plants and surveys were conducted to collect and identify materials. Data such as local name, locality, uses etc. were recorded. During field trip, seeds and photographs of the all plants were collected and this will help to the easy identification of legumes in Wayanad district. Collected specimens were identified with the help of floras and consulting with experts. During the present study 7 genus, 8 species, 2 sub-species and 52 varieties of legumes were recorded. It includes cultivated and wild varieties of legumes. The seven genera are *Cajanus, Canavalia, Glycine, Lablab, Phaseolus, Psophocarpus* and *Vigna.* Legumes are important because they fix atmospheric nitrogen and increase fertility of the soil. Some of them are used as manure, forage and medicine. Now adays, the cultivation of traditional varieties are less due to the introduction of hybrid varieties, in this time, the conservation of traditional varieties are more important.

Key words: Legumes, diversity, conservation, Wayanad, Kerala

Introduction

Legumes are vegetables, which are rich source of vitamins and minerals than other nutrients. The seeds and pods of several legumes are used as greens and vegetables. They contain more protein content than any other vegetable product. The pulses form an important item in India where the majority of the populations are vegetarians (Pandey, 2005). The pulses production increased in Kerala only after 1945. In Wayanad their production increased only after the immigration of South Thiruvithamkoor. Many varieties of Legumes are cultivated in Wayanad as food crops.

The legumes or pulses belong to the family '*Leguminosae*'. A '*legume*' fruit is a simple dry fruit that develops from a simple carpel and usually dehisces (opens along a seam) on two sides. A common name for this type of fruit is a '*pod*'. They contain more protein content than any other vegetable product (Mohan & Janardhanan, 1994). The high protein content is related with the presence of the root nodules of legume containing nitrogen fixing bacteria. The pulses are also important in animal nutrition to which they contribute by their seeds, hulls and the green parts. Due to these qualities the pulse crops are most important. So the study about the pulse crops is important in our life. The study is an attempt to document the genetic diversity of legumes in Wayanad. This study helped us to find out what are the varieties of pulse crops cultivated in study area.

The present study held at Wayanad district of Kerala. The folk etymology of the word says it is combination of Vayal (Paddy) and Naad (land), making it 'The Land of Paddy Fields'. There are many indigenous tribes in this area. It is set high on the majestic Western Ghats with altitudes ranging from 700 to 2100 m. It lies between north latitude $11^0 26'28''$ and $11^0 48'22''$ and east longitude $75^0 46'38''$ and $76^0 26'11''$. It is bounded on the east by Nilgiris and Mysore districts of Tamil Nadu and Karnataka respectively, on the north by Coorg district of Karnataka, on the south by Malappuram and on the west by Kozhikode and Kannur. The distance from the mean sea level and the amount of forest cover creates a pleasant climate in the region. Generally, the year is divided into four seasons; cold weather (December to February) hot weather (March to May) South-West monsoon (June to September) and North-East monsoon (October to November). During the hot weather the temperature goes up to a maximum of 35^{0}C (95^{0}F) and during the cold weather the temperature goes down to 10^{0}C (50^{0}F). Wayanad has the largest population of aborigine people in Kerala. The native Adivasis mainly consist of various sects like *Paniyas, Kurumas, Adiyars, Kurichyas, Ooralis, Kattunaikkans* etc. They are mainly dependent on agriculture. Most of the traditional varieties of legumes are cultivated by tribal people.

Materials and Methods

The study was mainly intended to locate the varieties of legumes in Wayanad. Field visits were made in order to locate the plants and surveys were also conducted to collect materials. To observe various characters of varieties like habits, flower colour, size of pods, colour of testa etc. The data such as local name, locality, and uses were recorded. A key for the identification of major genus was made using vegetative characters and few reproductive characters. The differences in the flavor and overall quality of dry beans are associated with the colour, size and shape of the seeds which define the specific bean class (Adams & Bedford, 1973).

Results and Discussion

During the present study, under the subfamily Papilionoidae, 7 genus, 8 species 2 subspecies and 52 varieties were collected from the study area. It includes traditional and hybrid varieties.

From the study area, 8 species and 2 sub-species under 7 genera were collected. They are, *Cajanus cajan* with 1 variety; *Canavalia ensiformis* with 2 varieties; *Glycine max* with 1 variety; *Lablab purpureus* with 3 varieties; *Phaseolus lunatus* with 5 varieties; *Phaseolus vulgaris* with 8 varieties; *Psophocarpus tetragonolobus* with 1 variety; *Vigna unguiculata* with 7 varieties; *Vigna unguiculata* contain two sub-spceies, *Vigna unguiculata* ssp. *catjang* with 2 varieties and *Vigna unguiculata* ssp. *sesquipedalis* with 22 varieties. Most dominating species are *Vigna unguiculata, Vigna unguiculata* ssp. *sesquipedalis* etc. *Vigna unguiculata* ssp. *sesquipedalis* is the largest species with 22 varieties located in this area. The collected varieties are given in the Table 1.

Table 1: List of varieties

No.	Species	Local name	Distinguishing Characters
I.	***Cajanus cajan*** (L.) Millsp.	1. Thuvara payar	1. Seeds cream with red dots
II.	***Psophocarpus tetragonolobus*** DC.	1. Chathurapayar	2. Seeds reddish brown
III.	***Canavalia ensiformis*** (L.) DC	1. Vallivaloram 2. Kuttivaloram	3. Seeds dark rose 4. Seeds white
IV.	***Glycine max*** (L.) Merrill.	Soybean	5. Seeds cream
V.	***Phaseolus lunatus*** (L.)	1. Kadamkodi 2. Mochakotta 3. Brown kadamkodi 4. Red kadamkodi 5. Yellow mochakotta	6. Flowers violet & seeds black 7. Flowers white & seeds black- cream 8. Flowers violet & seeds brown 9. Seeds red 10. Flowers yellow & seeds purple
VI.	***Phaseolus vulgaris*** L.	1. Chedibeans 2. Nadan beans 3. Vallibeans	11. Seeds dark violet 12. Seeds light rose 13. Seeds black 14. Seeds cream

		4. Kuttibeans 5. Pullibeans 6. French beans	15. Seeds cream 16. Seeds light brown 17. Seeds cream with black 18. Seeds dark brown
VII.	***Lablab purpureus*** L.	1. Vellamara 2. Brown amara 3. Kuttineyamara	19. Seeds black 20. Seeds brown 21. Seeds brown & cream
VIII.	***Vigna unguiculata*** (L.) Walp.	1. Kuttipayar 2. Vithapayar	22. Seeds white & black 23. Seeds black 24. Seeds white & brown 25. Seeds dark cream 26. Seeds cream & light brown 27. Seeds dark brown 28. Seeds ash coloured
IX.	***Vigna unguiculata*** ssp. ***catjang***	1. Chenapayar	29. Seeds red 30. Seeds cream
X.	***Vigna unguiculata*** ssp. ***sesquipedalis***	**Vallipayar with green pod:** 1. Killichundan payar 2. Kolekuthi payar 3. Kanjikuzhi payar 4. Kuruthola payar 5. Lolavalli payar 6. Pathinetumaniyan 7. Pavizhamaniyan payar 8. Piriyanpayar 9. Pullipayar 10. Thathammachundan payar 11. Vallipayar **Vallipayar with brown or violet colour pod:** 1. Violet payar 2. Brown payar	 31. Seeds reddish brown 32. Seeds cream coloured 33. Seeds cream & dark brown 34. Seeds dark brown 35. Seeds cream & brown 36. Seeds cream & ash coloured 37. Seeds dark brown 38. Seeds black 39. Seeds cream & brown 40. Seeds dark red 41. Pod thinner, 40-42 cm long and seeds light brown 42. Pod thicker, 45-47 cm long and seeds light brown 43. Seeds black 44. Pods dark green with brown striations and seeds black 45. Seeds cream & brown 46. Pod thick and seeds reddish brown 47. Pod thin and seeds reddish brown 48. Pods light green, tips dark violet and rose & seeds brown 49. Pods light green, tips yellow colour and seeds black 50. Pods dark violet and seeds black 51. Pods brown and seeds light brown 52. Pods brown and seeds dark red

In Wayanad, the traditional varieties of pulses are the Chena payar (*Vigna unguiculata* ssp. *catjang)*, Amara payar (*Lablab purpureus)* and Mochakotta (*Phaseolus lunatus)*. But nowadays, the Amara payar and Mochakotta are cultivated only by the tribal people especially the Paniyas and Kurumas. The pods of the Amara payar and Mochakotta are not used as vegetable instead seeds are used. Even though, Chena payar is highly nutritious, presently it is rarely cultivated due to the entry of high yielding varieties of *Vigna unguiculata*. Chenapayar is one among the pulses which can fix a large amount of Nitrogen (information from Kuruma tribe).

In Beans, mainly the hybrid varieties are cultivated and traditional varieties are rarely cultivated. Beans need more shade for their optimum growth. Leaves are not used for cooking purposes because of its bitter taste. Other than the food purpose they have some economical importance. They are used as medicine, manure and fodder. *Psophocarpus tetragonolobus* and *Cajanus cajan* are used as medicine. *Cajanus cajan,* 2 varieties of *Canavalia ensiformis*, 5 varieties of *Phaseolus lunatus,* 3 varieties of *Lablab purpureus,* 3 varieties of *Vigna unguiculata* are used as fodder. *Cajanus cajan,* 2 varieties of *Canavalia ensiformis*, 6 varieties of *Phaseolus vulgaris* are used as fodder. They fix atmospheric nitrogen and make it available to plants with help of Rhizobium bacteria present in root nodules of legumes (Peter, 2007).

Nowadays, the cultivation of traditional varieties are less due to the introduction of hybrid varieties. In this context, the conservation of traditional varieties becomes more important, because pulses form very important food item in our daily life. Therefore, this work serves to be a pictorial guide for the identification of pulses cultivated in Wayanad indicating their properties too.

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References

1. **Adams, M. W. & C. L. Bedford. 1973.** *Brediing food legumes for improved processing and consumer acceptance properties*. In: Nutritional improvement of food legumes by breeding. Ed. Milner, M. Protein Advisory Group. United Nations, New York. pp. 65-84.
2. **Ad Hoc Panel. 1979.** *Tropical legumes Resources for the Future*. National Academy of Science, Washington.
3. **Anilkumar, N., M. Sivadasan & N. Ravi. 2005.** *Flora of Pathanamthitta, Western Ghats, Kerala, India*. Daya publishing house. Delhi.
4. **Anon. 1991.** *The Wealth of India*. Publication and Information Directorate, CSIR, New Delhi.
5. **Anonymous. 1980.** *Nutritive value of Indian Food*. National Institute of Nutrition, ICMR, Hyderabad.
6. **Babu, C. R., Subodh. K. Sharma & B. M. Johri. 1985.** Leguminosae - Papilionoideae. Tribe-Phaseoleae. *Bulletin of the Botanical Survey of India*, Vol.XXVII, Nos.1-4, pp.1-28.
7. **Bishwajit Choudhury. 1967.** *Vegetables.* National Book trust, India.
8. **Bose, T. K., T. K. Maity., V. A. Parthasarathy & M. G. Som. 2003.** *Vegetable Crops*, Vol.II Naya Udyog, Kolkata.
9. **Chanda, K. L. Ph.D. 2001.** *Hand book of Horticulture*. ICAR, New Delhi.
10. **Duke, J. A. 1981.** *Hand book of Legumes of World Economic Importance*. Plenum Press, New York.
11. **Gamble, T. S. 1925.** Volumn.I. *Flora of the Presidency of Madras*. Bishen Singh Mahendra Singh Dehra Dun.
12. **Gary, D. K. 2004.** *Role and scope of arid legumes in crop diversification*. ICAR Winter School: 24th Nov. to 14th Dec.
13. ***Hand book of Agriculture*. 2005.** Indian Council of Agricultural Research, New Delhi.
14. **Hooker, J. D. 1990.** *Flora of British India*. Vol. II, L.Reeve and Co., London.
15. **Joseph. H. Hulse. 1994.** *Science, Agriculture and Food Security*. National Research Council. Canada.
16. **Manilal, K. S. & V. V. Sivarajan. 1982.** *Flora of Calicut*. Bishen Singh Mahendrapal Singh, Dehradun.
17. **Marc Borget. 1992.** *Food Legumes*. CTA-MAC Millan.
18. **Mohan, V. R. & K. Janardhan. 1994.** *Chemical composition and nutritional evaluation of raw seeds of six rice bean varieties*. J Ind Bot Soc 73: 259-263.

19. **Nayar, M. P. 1985.** *Flowering Plants of India*. Botanical Survey of India.
20. **Pandey, B. P. 2005.** *Economic Botany*. S. Chand & Company Ltd., New Delhi.
21. **Peter, K. V. 2007.** *Vegetable crops*. Horticulture Science series-4. New India Publishing Agency, New Delhi.
22. **Samba Morty, A. V. S. S. & W.S. Subrahmanyan. 1989.** *A text book of Economic Botany*. Wiley Eastern Limited, New Delhi. pp. 55-70.
23. **Sanjappa, M. 1992.** *Legumes of India*. Bishen Sing Mahendra Pal Sing in Dehra Dun.
24. **Saxena, S. 1994.** *Journal of Food Science Technology*, 31: 145-147.
25. **Schaefer, M. J. & D. J. Love. 1992.** *Journal of Food Quality*, 15:336-339.
26. **Sing, C. 1983.** *Modern Techniques of Raising Field Crops*. In: Legume Research 32(4) 250-254, 2009.
27. **Thamburaj, S. & Narendra Sing. 2005.** *Text book of Vegetables, Tuber Crops and Species*. Indian Council of Agricultural Research, New Delhi.

Figures of varieties:

Cajanus cajan

Lablab purpureus

Kuttivaloram - Flower & Pod

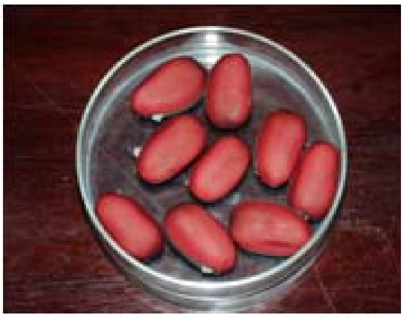
Canavalia ensiformis

Glycine max

Vigna unguiculata

Psophocarpus tetragonolobus

Phaseolus vulgaris



Vallivaloram - Seed

Kuttivaloram - Seed

Vallivaloram - Pod

Vallivaloram - Pod & Seed

Kuttivaloram – Pod & Flower


Kuttipayar - Seed


Kuttipayar - Seed

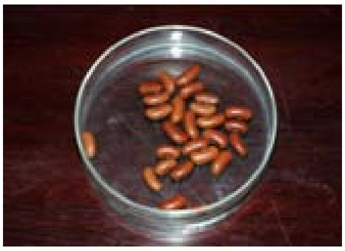

Kuttipayar - Flower


Kuttipayar - Seed

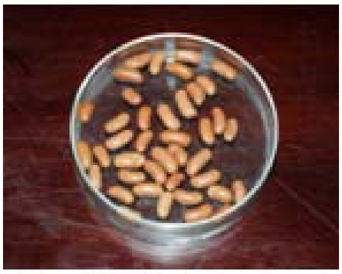

Kuttipayar - Seed


Kuttipayar - Seed


Pullibeans - Seed


French beans - Seed


Kuttibeans - Seed


Vallibeans - Seed


Chedibeans - Seed


Vallibeans - Seed


Kuttibeans - Seed


Vallibeans - Seed


Kuttibeans - Flower

Lichen diversity in the high altitude ecosystems of the Kerala part of Western Ghats

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Abstract

India supports about 12 percent of the total 20,000 lichens of the world. It is estimated that about 2450 species under 297 genera are reported from the temperate and sub temperate regions of Himalayas, Western Ghats, Eastern Himalayas and Andaman islands. Being situated in a hottest of hotspots of endemism and supports diverse vegetation, Kerala holds rich lichens in its diverse habitats. Unfortunately, only part of Kerala has been explored for the study of lichens and constitutes about 463 species composed of 18% of the total lichens occurring in India. Among the vegetation types in Kerala, high altitude ecosystems such as Montane wet temperate forests and Montane wet grasslands hold more macrolichen species. The present paper deals with the macrolichen diversity in the shola-grassland ecosystems of the Kerala part of Western Ghats such as Silent Valley National Park, Eravikulam National Park, Anaimudi shola National Park, Kannan Devan Hills, etc. with their distribution, species richness, etc.

Key words: Macrolichens, diversity, high altitude ecosystems, Western Ghats

Introduction

Tropical forests in the world are the main framework of ecosystem structure and function in terms its biological diversity. These tropical forests are probably the most species rich in all terrestrial ecosystems (Myers, 1992). Western Ghats, one of the mega centres of endemism in India plays an important role in maintaining the diversity of macro and micro floras of peninsular India. As in the case of higher plants, Western Ghats with its varied type of vegetation hold a good number of lichens in its various micro climatic pockets. It is estimated that around 949 species of lichens are distributed in its mountain ranges which runs through the states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Nayaka & Upreti, 2006). This update after the consolidation of 771 species of lichens from this area by Kumar and Sequiera (1999) harbours almost 45 per cent of the total lichen flora of India.

With three hotspot endemic centres and variety of ecosystems, Kerala also have plenty of lichens in its diverse habitats. However, only fragmentary work has been done from the Kerala region until the works of Kumar (2000) who has reported 253 species of macrolichens from Kerala part of Western Ghats, and Sequiera (2003), who recorded 236 species of lichens from Silent Valley National Park within an area of 90 km^2 only. Among different vegetation types occuring in the Kerala part of Western Ghats, high altitude vegetations such as montane wet temperate forests and montane wet grasslands of the area play a major role in the distribution and richness of the lichen species especially the macrolichens. The arboreal elements as well as the rocks in these vegetations have been fully clad with variety of lichens.

Study area

Kerala lies between $8^0 18'$ and $12^0 4'$ North latitude and between $74^0 52'$ and $77^0 22'$ East longitude. The entire area covers an area of approximately 38,863 km^2 and is bounded by Western Ghats Mountains in the east and Arabian Sea in the West. Physiographically the state is divisible into 4 zones such as coastal belt, the midlands, hilly uplands and the highlands. The forest areas of Kerala fall under Malabar Botanical region classification and supports tropical rain forests, tropical moist deciduous forests, tropical dry deciduous forests, montane temperate forests, riparian forests and low and high altitude grasslands. The present study area, montane temperate forests fall within the physiographically recognised high land zone. High altitude areas of different regions such as Silent Valley National Park, part of Eravikulam National Park, Mannavan shola area of Anaimudi shola National Park, montane forests of Silent Valley Estate, Munnar and other parts of Kannan Devan Hills were surveyed for the lichen study.

Materials and Methods

Extensive field surveys were conducted in different localities of high altitude vegetation for the inventory. Standard identification procedure such as morphological, micro chemical colour tests and *Thin Layer Chromatography* (TLC) were followed. Special attention was paid to record data relating to their habit, habitat, associations, synecological features and their host trees. Montane wet temperate forests and montane wet grasslands of Silent Valley National Park was selected for the detailed community structure studies.

Results and Discussion

Species richness

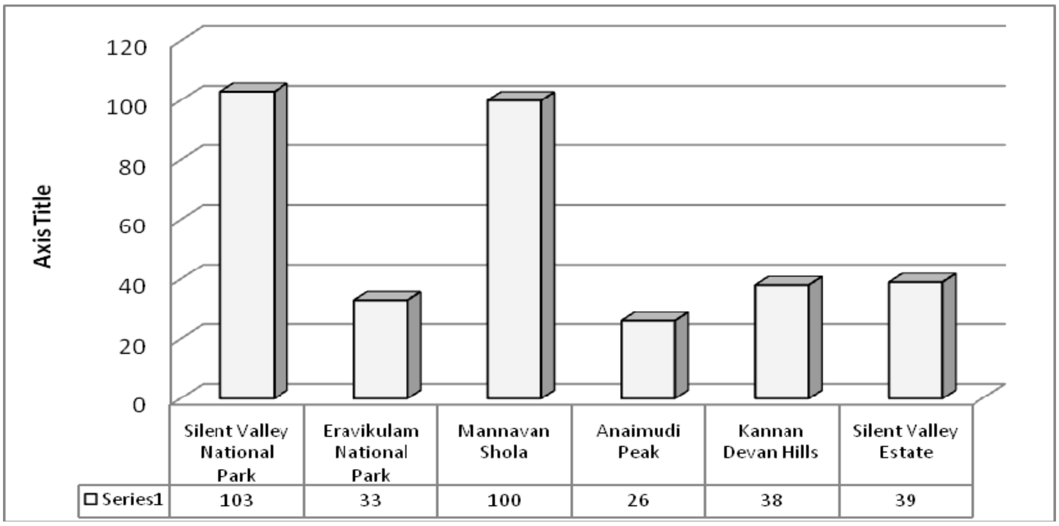
The critical study of the specimens collected from different localities of high altitude vegetations such as montane wet temperate forests and montane wet temperate grasslands revealed that there are 196 species of lichens under 39 genera belonging to 16 families and one lichen imperfectii (*Leprocaulon pseudoarbuscula*) were recorded. Among them, the genus *Usnea* dominated with 38 species followed by *Heterodermia* (20 species), *Hypotrachyna* (18 species), *Leptogium* (17 species) *Parmotrema* (14 species), *Cladonia* (10 species), *Sticta* 10 (species), etc. Families such as *Parmeliaceae, Usneaceae, Physciaceae, Collemataceae, Stictaceae*, etc. are dominated with more than 10 species distributed in these type vegetations.

Regarding the different localities surveyed during the present study, montane wet temperate forests and montane wet temperate grasslands of Silent Valley National Park dominated with 103 species under 25 genera followed by Mannavan shola area of Anaimudi shola National Park (100 species), Silent Valley Estate of Munnar (39 species), shola forests of Kannan Devan hills (38 species) part of Eravikulam National Park (33 species) and part of Anaimudi peak (26 species). Figure 1 shows the pattern of abundance of species in each locality in the study area. The current status of lichens in the high altitude habitats such as montane wet temperate forests and montane wet temperate grasslands constitutes about 8% of the total lichen flora present in the Indian subcontinent and about 43% of the total lichen flora present in the whole of Kerala.

The distribution of lichens in the state of Kerala mainly depends on the vegetation types existing in the region. Even though different forest areas of Kerala has not been explored thoroughly for the lichen study, it is evident from the present data that the state of Kerala, which occupies only 1% of geographical area of India, is immensely rich in lichens, especially the macrolichens when compared to other states of India (Sequiera, 2012). An exhaustive survey through the various ecosystems in Kerala would definitely give more number of species from Kerala. This is understandable by the study of Kumar (2000) and Sequiera (2003). Unfortunately, in Kerala, inventory of lichens has not received much attention till today.

In all the localities majority of lichens are corticolous. Species of the arboreal elements such as *Syzygium, Litsea, Neolitsea, Elaeocarpus, Symplocos, Pittosporum, Photinia, Turpinia, Cinnamomum, Ligustrum, Microtropis*, etc play a major role in the distribution of macrolichens in montane wet temperate forests and tree species such as *Rhododendron arboreum* subsp. *nilagiricum*, *Gaultheria fragrantissima, Gnidia glauca, Vaccinium sp.*, etc distributed in the montane wet grasslands provide suitable substratum for the macrolichens to establish. The macro and micro climatic factors and bark characteristics of trees in these vegetations provide suitable micro habitat for the lichens to grow. Factors like rainfall, temperature, humidity and other microclimatic factors prevalent in these high altitude vegetations particularly the trees with characteristic rough bark with more water holding capacity are found to be responsible for the distribution of all type of lichens in these forests.

Fig. 1: Pattern of abundance of species in each locality in the study area



According to Halonen *et al.* (1991) and Bruiteg (1993), form of precipitation, fog, mist may cause humid condition which will affect the holding factors of trees which supports all the morphological forms of lichens including both foliose and fruiticose lichens. Relatively small difference both in microclimate and macroclimate caused by the forest structure had an effect on the lichen vegetation. Macrolichens such as *Baeomyces sorediifer*, *Canoparmelia pustulascens, Dirinaria aegialita, D. africana*, *Pilophorous awasthianum*, *Rhizoplaca sp.*, *Stereocaulon austroindicum,* and some of the *Cladonia* species are found to be exclusively as saxicolous or terricolous genre. The species *Dermatocarpon vellerium* always associated with either water dripping rocks or on the rocks in streams. Species with hollow medulla such as *Hypogymnia pseudobitteriana*, *H. vittata* and *Menegazzia terebrata* were found to be very rare and came across only in Mannavan shola area of Anaimudi shola National Park.

Community structure and composition

Detailed community study of macrolichens occurring in the high altitude vegetations of Silent Valley National Park revealed that, the species *Heterodermia togashii* emerged as the most important species in the montane wet temperate forests followed by *Leptogoium denticulatum, Heterodermia japonica, H. leucomela* subsp. *boriyii*, *H. leucomela, Sticta filicina* and others (Fig. 2). With regard to the families, Collemataceae came on top as the important family followed by Physciaceae, Parmeliaceae and others. Speceis such as *Leptogium pichneum, L. austroamericanum, Parmeliella tryptophylla, Heterodermia leucomela* subsp. *boriyii* and *H.*

togashii were found to be most frequent and well distributed in this vegetation type. The analysis of the microhabitat such as tree trunks and rocks shows that the species *Heterodermia togashii* and *Leptogoium denticulatum* were the important species in tree trunks and in the rock substratum, all the four species observed in this microhabitat has equal importance.

The species *Heterodermia togashii* shows a wide range of microhabitat preferences in montane wet temperate forests and shows its high tolerance to micro and macro environmental conditions. Most of the important species recorded in this vegetation are lichens with green algal photobionts. These lichen species are light adaptive, they prefer to grow on the tree trunks and canopy branches. Lichens with blue green algal photobiont members like, *Sticta filicina, Parmeliella tryptophylla* and others also possess wide microhabitat preferences, which show their light adaptivity and wide ecological tolerance in that habitat. According to John (1992) a particular species tends to prefer a particular habitat or even microhabitat and dominate in them. This is due to the fact that they respond solely to environmental gradients of light, temperature and humidity or to interspecific competition. Their reliance on specific microhabitats makes them ideal indicator species of specific habitats and potentiality of environmental change (Fryday, 1997).

The species *Usnea bornmuelleri* emerged as the most important species in montane wet grasslands vegetation (Fig. 3). *Usnea rigidula* comes next followed by *Rhizoplaca sp., Usnea subchalybaea, Usnea vegae* and others. As expected, the family Usneaceae found to be the important species followed by Physciaceae, Parmeliaceae and others. With regard to the microhabitat specification, the rock substratum which is the dominant microhabitat for the lichens in these rolling grasslands, the species *Usnea bornmuelleri* shows highest value in terms of its importance followed by *Rhizoplaca sp., Usnea rigidula, U. vegae* and others. However, in the tree trunks, the species *Usnea subchalybaea* emerged as the importance one followed by *Heterodermia togashii, Usnea bornmuelleri, Heterodermia dactyliza* and others.

In the montane grasslands fruticose members are important and dominant. Although tree microhabitat possesses foliose and fruticose members, the distribution of species in this vegetation is determined by rock microhabitat. High wind condition, foggy atmosphere, high rainfalls are favourable for the growth of these lichens in these vegetations. Environmental factors to a great extent influence the lichen community in a particular niche. Environmental gradients will be functionally decisive in every area, which are characterised by macro, meso and micro gradients. Patterns of long enduring environmental gradients occur with respect to many factors such as, exposure to wind, light intensity, humidity, substratum, host species and macro climatic factors like, temperature and rainfall, age and composition of the forest (Sequiera, 2003).

Conclusions

The study confirms that high altitude ecosystems like montane wet temperate forests and montane wet grasslands are rich and diverse with regard to the lichens. Data on the locality specific abundance are important for the implementation of any biodiversity conservation programme. Kerala, with an extensive cover of forest area which has not been adequately surveyed for the inventory of lichens and hence is the possibility of many as yet unrecorded species still surviving in protected pockets of the forests. Therefore, it is important to assess the occurrence of least studied group in specific localities and only thorough exploration in the area will lead to a better understanding of the lichens occurring in this region.

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Fig. 2: Relative importance of macrolichens in the montane wet temperate forests

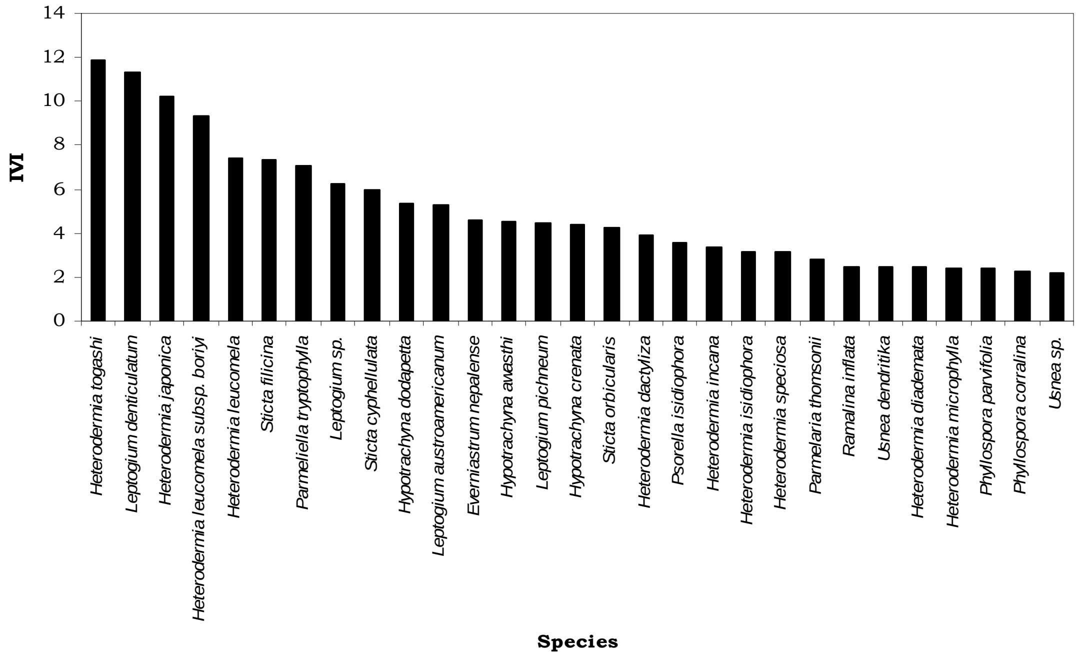
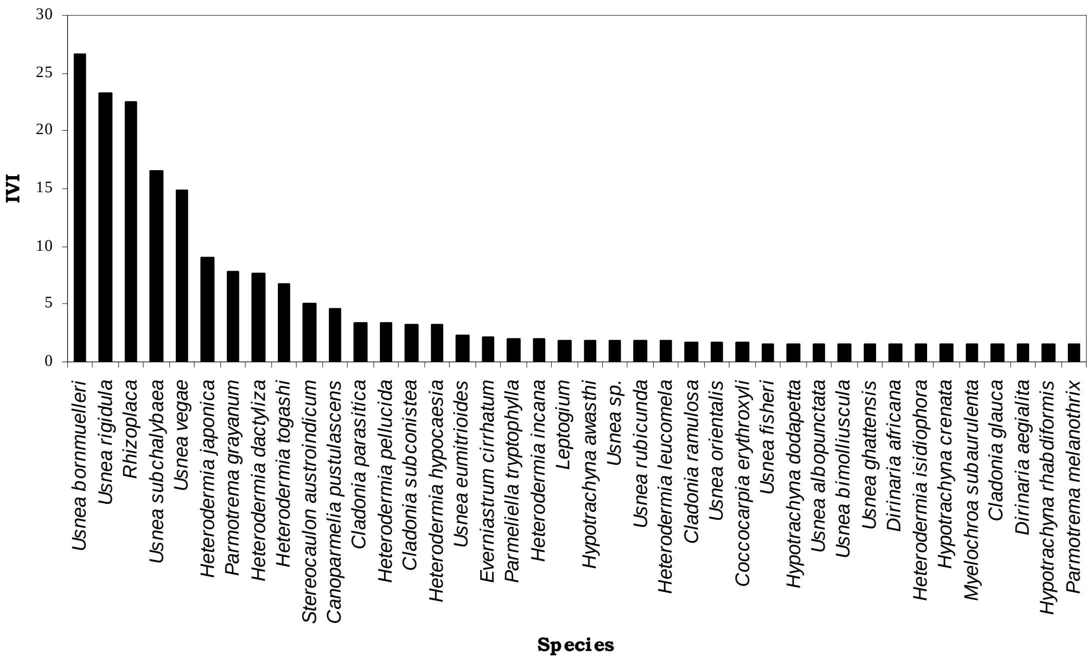


Fig. 3: Relative importance of macrolichens in the montane wet grasslands



References

1. **Bruiteg, I.E. 1993.** Large scale survey of the distribution and ecology of common epiphytic lichens on *Pinus sylvestris* in Norway. *Ann. Bot. Fenn.*, 30: 161-179.
2. **Fryday, A. M. 1997.** Montane lichens in Scotland. *Bot. J. Scotland*, 49: 367 – 374.
3. **Halonen, P., M. Hyvärinen and M. Kauppi 1991**. The epiphytic lichen flora of conifers in relation to climate in the Finnish middle boreal subzone. *Lichenologist*, 23: 61-72.
4. **John, E.A. 1992.** Distribution patterns and inter thalline interactions of epiphytic foliose lichens. *Canadian J. Bot.*, 70: 818-823.
5. **Kumar, M. 2000.** Lichen (Macrolichen) flora of Kerala part of Western Ghats. *KFRI Research Report* No. 194. Kerala Forest Research Institute, Peechi, Thrissur, Kerala.
6. **Kumar, M. and S. Sequiera 1999.** Lichens of Western Ghats: An overview. *In*: K.G. Mukerji, B.P. Chamola, D.K. Upreti and R.K. Upadhyay (Eds.) *Biology of Lichens*. Aravali Books International, New Delhi. pp. 297-331.
7. **Myers, N. 1992.** The biodiversity challenge: expanded 'hotspots' analysis. *Environmentalist*, 10: 243-256.
8. **Nayaka, S. and D.K. Upreti. 2006.** *Status of lichen diversity in Western Ghats, India*. *Sahyadri E- News. Newsletter No. 16*. ENVIS, CES, IISc. Bangalore.
9. **Sequiera, S. 2003.** *Taxonomy and Ecology of Lichens of Silent Valley National Park, Southern Western Ghats, India*. Ph.D. Thesis, FRI, Dehra Dun.

Spatio-temporal changes of forests in the Western ghat region of Neyyar and Karamana basins, Thiruvananthapuram district: a GIS based analysis

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Abstract

The multiple roles of forest ecosystem and their value to humanity have been increasingly understood and well documented. Unfortunately, in spite of important progress made in recent decades, forests subjected to drastic deterioration consequent to demographic pressure and unscientific and improper exploitation for various resources. One of the important pre-requisite for the conservation and management of forests is the information on the areal extent of forests, their Spatio-temporal changes and the present status. To derive the temporal changes, thematic maps depicting the spatial distribution of past existed forests and present forests were prepared from toposheets and imageries by digitization and overlaying analysis. In the present GIS based study, it is found that more than 50% of the forests have been lost during a time span of 95 years. Forests are gift of nature and each one has the responsibility to conserve them. It is recommended that a buffer zone should be created all along the foothills of the Western Ghats to protect the core forest area from further deterioration.

Key words: Spatio-temporal changes, GIS, Neyyar, Karamana, Thiruvananthapuram

Introduction

The Western Ghats or the Sahyādri constitute a mountain range along the western side of India. It is a *UNESCO World Heritage Site* and is one of the eight *Hottest Hotspots of Biodiversity* in the world. The range runs north to south along the western edge of the Deccan Plateau, and separates the plateau from a narrow coastal plain along the Arabian Sea. The range starts near the border of Gujarat and Maharashtra, south of the Tapti river, and runs approximately 1,600 km through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanyakumari, at the southern tip of India. These hills cover 1,60,000 km^2 and form the catchment area for complex riverine drainage systems that drain almost 40% of India.

Kerala State in South India covers an area of 38,863 km^2. The total forest area in the state is 10,336 km^2 (1995), forming 26.5% of the total geographic area. There are six National parks with a total area of 558.16 km^2. There are fourteen Wildlife sanctuaries with a total area of 1,891.07 km^2. Together the protected area totals 2,449.23 km^2, which cover 23.7% of the total forest area and 6.3% of the geographical area of Kerala State.

The Western Ghat region of Kerala covers 450 km (28.12%) out of the total length of 1600 km. The Kerala region (Sahyadri) of Western Ghats comprises of 31 out of 63 taluks in the State encompassing 72% of the total geographical area of the State and around 50% of the State's population. The region covers 80 out of 152 Block Panchayats and 537 out of 999 Grama Panchayats in the State. The population of this region increased from 68.8 lakhs in 1971 to 158.16 lakhs in 2001 (Provisional). The density of population in this region is 565 per sq. km as against the State average of 819 per sq. km. (WGDC, 2000). The Western Ghats play an important role in providing substantial rainfall in the state. The 'Sahyadri' is the birthplace of 44 major rivers flowing through the state. The rich natural forests of this region are a treasure house of plants, animals and minerals. The influence of Western Ghats has been remarkable in the maintenance and preservation of ecology of the state. Kerala part of Western Ghats is rich in biodiversity and vital for environmental protection and considered to be a repository of rare and endangered flora and fauna. Even though the land area of Kerala is only 1.2 % of India, the forest cover is 2.3% of the national average.

Ecosystems sustain the earth's entire storehouse of species and genetic diversity. Plants and animals in the natural environment are very sensitive to changes in climate. The ecosystems that are most likely to be affected by this change are the ones in the higher altitudes, and elevations. The major forest types represented in the State include the dry deciduous, moist deciduous, semi-evergreen, evergreen and shola forests. Within these four major forest types are also several subtypes and derivatives, differing in species composition and vegetation characteristics. Mountain forests have been identified as being especially at risk from the environmental destruction caused by climate change due to deforestation problems. Species that live in the higher zones, are forced to move higher up to find a suitable habitat thus reducing the area in which they can live. If the rate of deforestation continues to accelerate, then the extinction of some mountain plants and animals is certain. Migratory corridors of animals are shrinking. Factors such as food sources are shrinking and human animal conflict for food and water are likely to increase. Deforestation may bring about a shift in their feeding points and disruptions to their habitats. Hence, deforestation is one of the major environmental issues that warrant special attention.

This paper deals with the environmental degradation problems caused by the depletion of forests that lead to degradation of two river basins- Neyyar and Karamana which drain through the Trivandrum district, Kerala state. The forest ecosystems in the Western Ghat region of Neyyar and Karamana basins of Thiruvananthapuram district have been selected for this study with an objective of finding out its spatial changes over the last few decades in order to suggest sustainable conservation measures.

Study area

Location and Extent

Two river basins – the Neyyar and Karamana - of southern Kerala (Thiruvananthapuram district) were selected for the present study (Fig. 1). The Neyyar and the Karamana river basins lies between 8° 15′ to 8° 45′ North latitudes and 76° 50′ to 77° 20′ East longitude and is located in the Thiruvananthapuram district of Kerala state. The study area is bordered by Neyyattinkara and Nedumangad *Taluks* in North, Arabian Sea in the West and Tamilnadu in the East and South. The river basins have a total area of 1190 Sq. Km. The Neyyar and Karamana river basin spreads over 45 panchayats, and two municipalities (Neyyattinkara and Nedumangad) and Thiruvananthapuram corporation. Of the 45 panchayats, falling in eight blocks, 18 of them are located in Neyyar basin and the remaining 19 lies in Karamana basin. Five panchayats such as Kattakkada, Poovachal, Pallichal, Maranalloor and Balaramapuram. are shared by both the basins. The Vithura, Panavoor and Pothencode in Karamana basin extend into the Vamanapuram basin.

Physiography

The Neyyar river originates from Agasthya hills of Western Ghats at an elevation of about 1860 m above msl and flows into the Arabian Sea. The general elevation ranges from 750m in the upper region, 60m in the middle region to less than 2 m in the lower region. The broad landforms include medium hills and isolated hillocks at the upper region, lateritic mounds and lateritic uplands at the middle region and coastal landforms at the lower region of the watershed.

Karamana river originates from Chemmunji mottai (Nedumangad hills) of Western Ghats at an elevation of about 1717 m above msl and merges into the Arabian Sea near Thiruvallom. The general elevation ranges from 310 m in the upper region, 60 m in the middle region and less than 4 m in the lower region. The broad landforms in the upper region of the basin include high hills and low hills with isolated hillocks. The middle region consists of lateritic mounds and isolated hillocks. Gently sloping coastal landforms are seen in the lower region.

Materials and methods

To derive temporal changes, thematic maps depicting the spatial distribution of previously existed forests were prepared from the *Survey of India* toposheets of 1905 (1: 63360), 1965 (1: 50000), 1980 (1: 25000). The forested areas were traced out from these toposheets and bring together in their corresponding scales and the recent data (2000) pertaining to the forest area prepared from the LISS III satellite imageries. All the maps were digitized following uniform scale and overlaid in GIS software for the detailed analysis of the variation in areal extension of forests over the years. Maps showing the extent of degradation and Spatio-temporal changes of forests were prepared in the GIS platform (Fig. 2)

Results and discussion

Deforestation

Forest is a renewable resource and contributes substantially towards economic development. Forests play a major role in enhancing the total quality of the environment. But, the density of virgin forests in the Western Ghats, which is known for its rich bio-diversity, has been decreasing over the years. The forest ecosystem of the study area, once known for its plethora of plant and animal species, is now subjected to drastic deterioration consequent to unscientific and improper exploitation for various resources. The encroachment of local people residing nearby areas and planters also aggravated the rate of destruction of these forests (Krishnakumar, 2002).

In 1946, the total forest area in the State accounted for 33% of its total geographical area and now the forested area has been come down to 12%. According to one estimate, the total forest area in the Thiruvananthapuram district is 498.67 sq. km. (Forest Statistics, 2000). Table 1 shows the variation in the areal extension of forests in Neyyar and Karamana river basins over the years.

Table 1: Extent of forest area in Neyyar and Karamana basins (in sq. km)

Year	Neyyar Basin		Karamana Basin		Total	
	Area	*% age*	*Area*	*% age*	*Area*	*% age*
1905	170.0	34	222.05	32.2	392.05	26.3
1965	112.5	22.5	131.71	19.1	244.21	16.4
1980	68.5	13.7	99.3	14.4	167.8	11.3
2000	51.02	10.2	41.05	6	92.0	6.2

Fig. 2 shows the trend of deforestation in Neyyar and Karamana basins during the period 1905 - 2000. In 1905, area under natural vegetation in Neyyar and Karamana basins was about 33%. (Neyyar = 34%, Karamana = 32.2%). This has come down to 22.5% in Neyyar basin and 19.1% in Karamana basin in 1965. By 1973, it again diminished into 13.7% of the Neyyar basin, while it is 14.4% in Karamana basin. The rate of deforestation has been slowed down considerably in recent years. In 2000, it is 10.2% and 6% and the natural vegetation at present in the area amounts to 51 sq. km in Neyyar basin and it is 41 sq. km in Karamana basin. It is observed that more than 50% of the evergreen forests have been lost during a time span of 95 years.

The construction of dams at Peppara (Karamana river) and Neyyar (Neyyar river) imposed destruction of the forest wealth. The people lived in valleys encroached the core areas of the forests. This encroachment was done after cutting and firing the trees. The planters nearby the forest areas also adopted the same method of encroachment. However, if proper afforestation programme is not taken up in the degraded area on warfooting, the problem will remain unsolved, affecting the net fresh water availability. The Neyyar and Peppara reservoirs are considerably silted up due to the decrease in vegetative cover in its provenance zone (CESS, 1996). The forest plantations works are also progressing at several localities. Encroachment within the forest area is one of the major causes of deforestation.

Deforestation is done the higher altitude to accommodate plantation crops like tea and coffee, and at the lower altitudes it is done for hosting rubber. Forest plantations have also contributed to clearing off natural vegetation. Although effect of deforestation is yet to be fully realised, there are evidences for its control over the micro-climatic changes, nutrient loading transfer mechanisms, etc., water availability in the river basins. It is felt necessary to develop/create a buffer zone all along the foothills of the Western Ghats to protect the core forest area from further deterioration. Protection of forest and its regeneration are essential not just to maintain biodiversity but to preserve the soil resources of the catchment area too.

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References

1. **CESS, 1996.** Natural Resources Inventory for Thiruvananthapuram district, Kerala. Report submitted to the State Committee on Science, Technology and Environment, Govt. of Kerala.
2. **State Planning Board, Kerala 2000**. First step in formulation of a district plan – Case study of Thiruvananthapuram district, People's plan Campaign,. *Development perspective (2000).*
3. **Economic Review of Kerala, 2001.** State Planning Board, Thiruvananthapuram, Kerala State.
4. **Forest Statistics**. **2000.** Statistical details of the forest of Thiruvananthapuram district, Kerala State Department of Forest and Wildlife.
5. **Krishnakumar, 2002.** Environmental degradation of Neyyar and Karamana river basins of Southern Kerala. Ph.D thesis (unpublished), University of Kerala
6. **WGDC, 2000.** Report on Western Ghat Development Programme. State Planning Board, Govt. of Kerala.

Fig 1: Location map of study sites

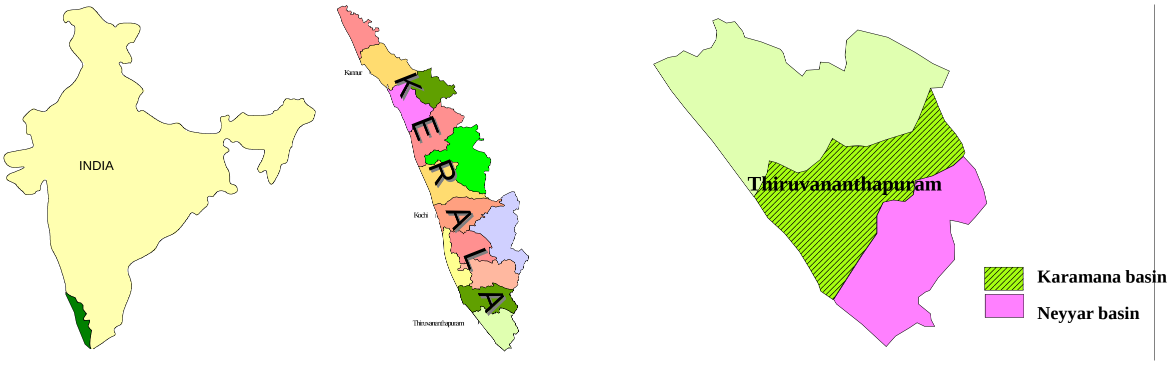
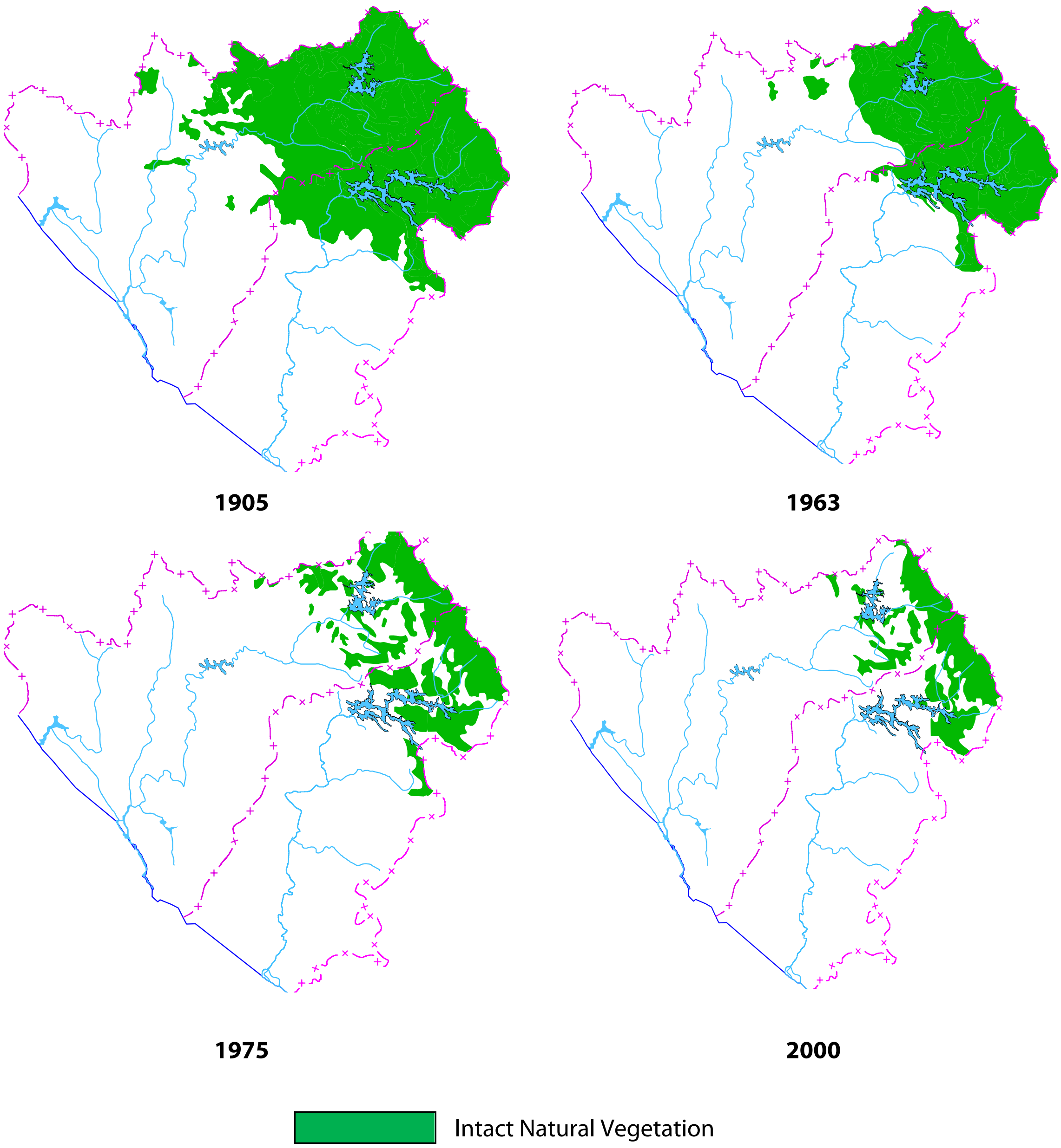


Fig. 2: Deforestation in Neyyar and Karamana Basins



The impact of roads on wildlife in the Western Ghats of Kerala; Current knowledge and future perspectives

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Abstract

The linear trespasses especially roads through the forested landscapes is a major cause of wildlife mortality and fragmentation. The ecological impacts of roads on nature is recognised globally. Kerala having a wide net work of roads and most of this partially or by a large bisects the forests in the Southern Western Ghats. We conducted a preliminary survey on the impact of roads on wildlife at Nilambur-Nadugani Ghat road which bisects an evergreen mixed forest patch of Southern Western Ghats. The seven month study revealed a data of 526 individual kill of forest fauna from large mammals to invertebrates. This preliminary survey undoubtedly pinpoints the immediate need of proper road ecology studies and management. Here we review and analyse the studies conducted in Kerala part of Western Ghats to provide the general guidelines to reduce the animal–vehicle collision including the implementation of locally feasible construction practices like under-paths, tunnels, and wildlife crossings etc for newly proposed roads through ecologically important areas.

Key words: Western Ghats, roads, tunnels, under-paths

Introduction

The fast pace developmental modifications on a geographical region elicit a wide range of ecological impacts. Linear encroachments like roads, highways, railway, power lines, etc., are imposing much pressure on the tropical species (Laurence *et al*., 2009).The adverse effects ranging from habitat loss, fragmentation (Burnett 1992; Carr and Fahrig, 2001), road mortality (Das *et al.,* 2007; Row *et al.,* 2007; Shiwiff *et al*., 2007). Although the road mortality of wildlife has been observed worldwide, the efforts to mitigate the impacts of roads is restricted to few African and European countries. However, in recent years, studies on the impact and management practices were also started in several Asian countries too.

India is having the second largest road networks with over 43,20,000 km and 0.66 km of road per square kilometre of total land (NHAI, 2012). Many of the highways bisect the ecologically important areas and evidently creating the hazards of road mortality of wildlife. The effect of road mortality on wildlife and to its habitat (Vijayakumar *et al*., 2001; Das *et al*., 2007) has been recognised by Government and other non-government organisations. The banning of night traffic through Mudumalai- Bandippur highway is one of the positive level policy actions from the government due to the road mortality impact studies (Baskaran & Boominathan, 2010) by several agencies or groups.

Kerala is the state having 1,45,704 km of roads (4.2 % of India's total), and most of the roads are closely knitted with the forest or rural habitat. This translates to about 4.62 km of road per thousand populations (IBEF, 2010), when compared to a national average of 2.59 km's. The state having 9 national highways and 42 state highways (NHAI, 2012) and many of these highways are more or less touching or bisecting the forested landscapes of Kerala.

The Western Ghats, the treasure of biological diversity of India extends to over 1600 km ranging from Tapti River to the southernmost Kanyakumari. The terrain and thick forests hindered the transportation and communication through this region for a long time. During the British rule, the ventures started to establish transportation and other construction activities (WGEEP report, 2011). In recent decades the construction of roads and railway crossings happened in a most rapid fashion and the proposals without proper planning has resulted in forest fragmentation and habitat loss to several flora and fauna.

This paper is an attempt to review the studies conducted to understand the impacts of roads on the wildlife in the Southern Western Ghats part of Kerala. The mitigation measures needed for the conservation of wildlife impacted by the roads is also discussed.

Methodology

In this study, the existing research works and other possible information on the road impact on wildlife of Southern Western Ghats were analyzed. The search included research reports, journal articles, popular articles, personal communications etc. The mitigation measures employed in different countries for minimising or avoiding road mortality of wildlife were also compiled. With the help of such existing models, the tropical forest feasible management practises are also discussed for reducing roadkill and related impacts.

Results

The study reviewed 9 research reports on road related wildlife mortality in the Southern- Western Ghats region. Apart from pure scientific citations, several personal communication reports and other press, media related data were also included in this study.

The broad-level impacts of road includes wildlife mortality, habitat loss and degradation, habitat fragmentation and barrier effect, passage for alien invasive species and spreading, genetic effects on animals, landslides and erosion, roads through closed canopy forests which hinders the movement of arboreal animals, impacts on natural flows and aquatic systems, road as an ecological trap, influence on animal behaviour, people movement and related pollution, impacts on local and indigenous people etc. (Raman, 2011).

While analysing the road mortality assessment studies conducted in India, a major part happened in the Southern Western Ghats side. The recent studies and policies implemented indicates a serious approach towards this issue. The road related impact studies on wildlife, especially roadkill were conducted in various forested landscapes of this region. Here measures to categorise and analyse the studies and information available on various taxa are attempted. The behaviour, ecology and movement of various groups of animals largely influence their exposure towards the roadkill (Laurence *et al.*, 2009). A wide range of fauna from invertebrates to mammals are vulnerable to vehicular collision and most of the time end up with their kills.

Herpeto fauna

The impact of road traffic on the herpetofauna is poorly understood in the Western Ghats (Gokula, 1997; Vijayakumar *et al.*, 2001). Mukherjee (2007) reported 133 individuals that were killed by vehicular traffic on the Coimbatore–Anaikatty State highway (SH-3), India. During the sampling, 65 (49%) were Snakes and 68 individuals were Lizards (51%). In the study of reptiles of the Muthikkulam reserve forest by Balakrishnnan (2007) reported 171 roadkilled individuals. In that study, he also observed a high mortality (64) of Uropeltid snakes during the rainy season. The similar patterns of roadkills were observed at Indira Ghandhi Wildlife Sanctuary (Kumara *et al.*, 2000). In another study, relationship of roadkill rate and vegetation type on herpetofauna were observed at Anamalai Hills (Kumara *et al.*, 2000; Vijayakumar *et al.*, 2001). Vijayakumar *et al.*

(2001), recorded killing of 73 reptiles belonging to 24 species with an observation of several endemic species. The study at Mudumalai Tiger reserve, which is having State highways and interstate highways connecting 3 states Kerala, Karnataka and Tamil Nadu; recorded 40 individuals of reptiles coming under 16 species (Baskaran & Boominathan, 2010). Roadkill of 17 reptiles were recorded from Bandipur Forest range by Rao & Girish (2007). The activities like crossing of road between habitats and the basking nature for thermo regulation may making them more exposed to road mortality (Vijayakumar *et al*., 2001).

Amphibians

In most of the studies, the road mortality rate of Amphibians observed in great extends. In a study conducted at Anamalai hills of Southern Western Ghats (Vijayakumar *et al.,* 2001), observed a mass kill of 311 amphibians coming under 8 genera. In that study, they observed the mass movement of Amphibians during the rainy season, which leads to vehicle collision in higher rates and more Amphibian kill observed on the roads that passing through Coffee plantations and forest patches. Rao & Girish (2007) reported 7 amphibian kills from Banipur- Nagarhole forest road. In another roadkill research carried out in Mudumalai Tiger reserve, Baskaran & Boominathan (2010) recorded a kill of 96 amphibians belonging to 3 species, which constitutes 53 % of the total kill observed. In a study at Thalaguppa–Kathalekan road (NH 206) ,Seshadri encountered a kill of 144 individuals of 13 species. The mass movement during heavy rain making them more vulnerable to roadkill (Goosem, 1997; Vijayakumar *et al*., 2001).

Mammals and Birds

While analysing the road mortality studies of Southern Western Ghats, almost all studies reports a considerable record of Mammal and Bird mortality. Baskaran & Boominathan (2010), observed a total kill of 32 mammals under 9 species from Bandipur Tiger reserve, which includes big mammals like Leopards, Wild Boar, Sambar Deer, Chital, Macaques, Langurs etc. In that study they observed a kill of 12 birds belonging to 8 species. In another case study, Sanjay Gubbi reported the kill of Tiger, Elephant Calf, Rusty spotted Cat and other Mammals from the Bandipur Tiger reserve. Rao & Girish (2007), also reported road mortality of 2 birds and 2 Mammals from Bandipur– Nagarhole region. Poor eye sight of many mammals, perplexed response towards the approaching speedy vehicle etc. makes them more prone to death.

Invertebrates

Road mortality studies of invertebrates are not much highlighted from the Southern Western Ghats region. The study conducted by Rao & Girish (2007), analysed the Invertebrate mortality of three select locations. In this study they selected two roads from two National parks (Bandipur & Nagarahole) and one suburb, grass/scrub land (Ring road). A high degree mortality of Dragonflies and Butterflies were observed from the localities; with more kill on Sundays because of heavy traffic. They observed the kill of other groups of insects like ants, leaf/plant hoppers, bees, wasps, termites etc. Because of the practical difficulties for enumeration, these groups were not counted during this study. Their observation is that, the increased kill of Butterflies and Dragonflies is because of the seasonal migration.

Other personal observations and reports on roadkills

- Kill of a female elephant by a collision with State transport bus on Chamraj Nagar- Sathyamangalam route, Karnataka (2012).
- Kill of a Leopard cat from Wayanad, Kerala (Sathyan Meppayur).

- Kill of a Fox from Bandipur National Park (Sathyan Meppayur).
- Kill of a Jackal from Bekalam Road (Amaya Gopalan).
- Kill of a Leopard from Bangalore NICE road (2011).

A case study of road mortality of forest fauna of Nadugani (SH -28) of Southern Western Ghats, Kerala

The pattern and impact of vehicular transportation on forest fauna of Nadugani Ghat road (11^0 26′ 13′′ N Latitude, 76^0 2′ 43′′ E Longitude) which bisects a mixed evergreen patch of Southern Western Ghats was assessed. The State highway-28 connects Kerala and Tamil Nadu. The study was carried out from November 2008 to June 2009 by sampling road kills from the beginning of the Ghat road to the Tamilnadu border checkpost, covering an area of 11km. The Ghat road traverses through four forest types viz., Bamboo forest, Moist-deciduous forest, Semi and Evergreen forest within the small stretch. This highway is one of the shortest and cheapest route for transporting goods and services between Kerala, Tamil Nadu and Karnataka.

Sampling was done between 6–8 AM for seven months on all Thursdays and Fridays. The species, location of the specimen and the time of sampling were recorded. In order to avoid repetition, recorded specimens were removed immediately from the spot. The study revealed a roadkills of 527 forest dwelling creatures which includes 129 Mammals, 161 Reptiles, 209 Invertebrates, 24 Amphibians and 3 Birds.

In the study, we encountered the road mortality of wide variety of mammals, reptiles and invertebrates. Mammals include Wild boar, Civets, Spiny-Dormouse, Porcupines and several rodents. The reptilian fauna includes Pit Vipers, Pythons, Indian Kraits, Sand-boas, Cobras, Shield tails, Trinket snakes, Dracos, Vine Snakes, Monitor lizards and several other Lizards. Invertebrates included Annelids to Bugs, Butterflies, Scorpions, Tarantulas (58 kills in one day observed) etc. Roadkills of three species of birds which includes Malabar Whistling thrush and Barn Owl were also noted.

The habitat peculiarities and geographical location, supports a wide range of fauna and animal activity in this region. Two active Elephant corridors are located within this small patch. Most of the time the speedy vehicles and heavy night traffic of goods trucks were the major observed causes of road mortality of animals. After the night traffic ban through Muthumalai- Bandipur road, the road kill incidents were reduced to a great extent. We observed a sudden decline in the kill of forest dwelling creatures, especially Reptiles and Mammals. The study report was presented at Young Ecologist Talk and Interact (YETI), IISC, Bangalore (2010) and one detailed study article was published based on the study on Mathrubhumi weekly (March,2012) by E. Unnikrishnan. All this evoked positive response from the common people and from the scientific community towards this issue. Various scientific bodies and institutions started their work on the road impact assessment on wildlife in Kerala.

Table 1: Observed roadkill data for a period of 7 Months

Animal Group	Roadkill Data
Invertebrates	209 individuals of almost 35 identified species
Amphibians	25 Individuals of almost 5 identified species
Reptiles	161 individuals of almost 36 identified species
Birds	3 individuals of 3 species
Mammals	129 individuals of 9 species
TOTAL	**527 individuals**

Mitigation measures to reduce impacts of roadkill

The proper assessment and management plans are needed to reduce the impact of road mortality of wildlife. The implementation of feasible construction practices and well studied plans for newly proposed roads are needed. Many of the foreign countries implemented various methods and allied constructions to reduce or check the roadkill.

The prevention measures suggested by the T.R. Shankar Raman report for the *National Board of Wildlife* (2011) follows certain instructions for newly proposed roads:

- Strict banning of off-roads through protected areas and critical habitats, grasslands, meadow habitats, open habitats.
- Complete ban of nigh traffic through Tiger reserves (having a existing provision in the law; section 38V, Wildlife protection act,1972)
- The newly proposed projects which do not incorporate any priority for the wildlife- friendly design and crossing structures in a protected or critical habitat should not be permitted. At the planning stage itself, such projects needed to include protection action plans in their main budget.

Along with this above mentioned preventive measures, internationally proved construction practises also can be implemented to reduce the roadkill impact to wildlife. The following mitigation measures can be implemented to our forest roads and other protective area crossings:

- **Wildlife crossings**: Includes over-paths and under-paths across the bisecting road. For employing such construction a proper survey and study of that ecosystem is needed for the successful passage of the animals.
- **Speed Breakers**: To reduce the speed of vehicle and collision with animals, speed breakers are needed to construct on appropriate locations especially on the long stretches of cross roads and the places where there is more animal activity
- **Fencing**: In some areas fencing along roads working good for preventing the animal vehicle collision
- **Sign Boards**: Sign boards are needed to inform the passenger about the animal activity and this will effectively help the driver to reduce the speed and avoid collision.
- **Awareness Campaigns**: The proper awareness campaigns to the passengers about the animal movement and activity will help the protection of animals from collision. Awareness especially to routine drivers of trucks and public transport for vigilant driving through such protected areas will certainly reduce the kill. The roadkill reported from the southern part of Western Ghats, revealing that most of the collisions happened because of the speedy huge trucks and public transport vehicles (Reference from various studies, reports personal observations).

Through proper planning and sustainable developmental activities, we can effectively check the impacts of linear intrusions especially roads through our critical habitats.

References

1. **Baskaran, N. and D. Boominathan. 2010.** Road kill of animals by highway traffic in the tropical forests of Mudumalai Tiger Reserve, southern India. *Journal of Threatened Taxa* 2(3): 753-759.
2. **Burnett, S. 1992.** Effects of a rainforest road on movements of small mammals: mechanisms and implications. *Wildlife Research* 19: 95-104.
3. **Carr, L.W. & L. Fahrig. 2001.** Effect of road traffic on two amphibian species of differing vagility. *Conservation Biology* 15: 1071–1078.

4. **Das, A., M.F. Ahmed, B.P. Lahkar and P. Sharma. 2007.** A preliminary report of reptilian mortality on road due to vehicular movements near Kaziranga National Park, Assam, India. Zoos' Print Journal 22(7):2742-2744.
5. **Gokula, V. 1997.** Impact of vehicular traffic on snakes in Mudumalai Wildlife Sanctuary. *Cobra* 27: 26
6. **Goosem, M. 1997.** internal fragmentation: The effects of roads, highways and power line clearings on movements and mortality of rainforest vertebrates. In: Laurance, W.F. and Bierregaard Jr,R.O. (eds.) *Tropical Forest Remnants*. University of Chicago Press., Chicago, Illinois.
7. **Kumara, H.N., Sharma, A.K., Kumar, A. and Singh, M. 2000**. Road Kills of wild fauna in Indira Gandhi Wildlife Sanctuary, Western Ghats, India: Implications for management. *Biosphere Conserv*., 3: 41-47.
8. **Laurance, W.F., Goosem, M. and Laurance, S.G. 2009.** Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution* 24: 659-669.
9. **Mukherjee, D. 2007.** Resource utilization patterns of reptiles in the tropical dry mixed deciduous forest of Anaikatty Hills, Western Ghats, India. Ph.D. Dissertation, Bharathiar University, Coimbatore, India. 150 pp.
10. **Raman, T.R.S. 2011.** Farming ecologically sound policy on linear intrusions affecting wildlife habitats. Background paper for the National Board for Wildlife. Submitted to the Standing Committee of the National Board for Wildlife during its 21st meeting on January 2011.
11. **Rao R.S.P. and M.K.S Girish. 2007.** Roadkills: Assessing insectcasualities using flagship taxon. Current Science 92(6): 830-837
12. **Row, J.R., G. Blouin-Demers & P.J. Wheatherhead. 2007.** Demographic effect of road mortality in black rat snakes (*Elaphe obsolete*). *Biological Conservation* 137: 117-124.
13. **Seshadri K. S., Amit, Y. and Gururaja K. V. 2009.** Roadkills of amphibians in different land use areas from Sharavathi river basin, central Western Ghats, India. *Journal of Threatened Taxa* 1(11):549-552.
14. **Vijayakumar, S.P., K. Vasudevan and N.M. Ishwar, 2001.** Herpetofaunal mortality of roads in the Anamalai Hills. Southern Western Ghats. Hamadryad 26(2):253-260.
15. **WGEEP report. 2011.** Report of the Western Ghats ecological expert panel , part 1. Submitted to the Ministry of Environment and Forests, Government of India.

Distribution of a few Rubiaceae in Malappuram, Kozhikkode, Palakkad and Thrissur districts, Kerala

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Abstract

Detailed botanical studies carried out from different selected localities of Thrissur, Palakkad, Kozhikkode and Malappuram districts of Kerala, which yielded a total of 80 wild, cultivated and naturalised taxa covering 98 field numbers. This will provide information on Rubiaceae plants that exist in the areas with reliable information on the presence, distribution in general along with their uses.

Key words: Rubiaceae, Malappuram, conservation, species recovery

Introduction

The Rubiaceae is a family of flowering plants, variously called the coffee family, madder family, or bedstraw family. The group contains many commonly known plants, including the economically important Coffee (*Coffea*), Quinine (*Cinchona*), and Gambier (*Uncaria*), and the horticulturally valuable Madder (*Rubia*), West Indian jasmine (*Ixora*), Partridge berry (*Mitchella*), *Morinda, Gardenia*, and *Pentas*. Members of the coffee family tend to be concentrated in warmer and tropical climates around the world. Currently, there are about 611 genera and more than 13,000 species in the Rubiaceae. This makes it the fourth largest family of flowering plants by number of species, and fifth largest by number of genera. According to the World Rubiaceae checklist, 611 genera and 13,143 species were currently accepted as of 2009. Rubiaceae are an easily recognizable family characterized by opposite leaves that are simple and entire, with interpetiolar stipules, tubular sympetalous corollas and an inferior ovary.

The present work is as a part of M.Sc. project work and the result of eight months of field study, collection, and critical analysis of the Rubiaceae species available in the home gardens, *ex-situ* and *in-situ* sites of Kozhikkode, Malappuram, Palakkad and Thrissur districts of Kerala.

Area of Study

The present study deals with the documentation and collection of Rubiaceae members distributed in the selected areas viz. Sree Krishna College campus, Ariyannur, Guruvayur, Amala Research Institute, Amala nagar (*ex-situ* site), Vellanipacha forest, Pattikkad, Thali (*in-situ* site) of Thrissur district; Siruvani forest area (in situ site) of Palakkad district and Calicut University Botanical Garden and Herbal Garden, Kottakkal (*ex-situ* sites) of Malappuram district and Kakkayam forest and Kakkodi riparian forest (*in-situ* site) of Calicut district. The documentation and collection also includes from the home gardens of all the four districts.

Review of Literature

The state has been floristically well studied even from the pre-Linnaean period. Pioneering floristic work done during the seventeenth century resulted in the monumental contribution of van Rheede's *Hortus Indicus Malabaricus* (1678-1703). The other early publications are '*Flora of British India*' (Hooker, 1872-1897), '*The Forest Trees of Travancore* (Bourdillon, 1908), *The Flowering Plants of Travancore* (Rama Rao, 1914) and

'*Flora of the Presidency of Madras*' (Gamble, 1915-1936). Such works have given an impetus to the Indian botanists to publish many checklists, short papers, district floras and eventually the state flora. To mention a few, *Flora of Calicut* (Manilal & Sivarajan, 1982), *Flora of Cannanore* (Ramachandran & Nair, 1988), *Flora of Silent Valley Tropical Rain Forests of India* (Manilal, 1988), *Flora of Palghat District* (Vajravelu, 1990), *Flora of Thiruvananthapuram* (Mohanan & Henry, 1994), *Flowering Plants of Thrissur Forest* (Sasidharan & Sivarajan, 1996), *Flora of Nilambur* (Sivarajan & Matthew, 1997), *Flora of Agasthyamala* (Mohanan & Sivadasan, 2002), *Flora of Pathanamthitta* (Anil Kumar *et al.*, 2005), *Flora of Kerala* (Daniel, 2005) *Flowering plants of Kerala* (Nayar *et al.*, 2006), *Flora of Alapuzha district, Kerala* (Sunil & Sivadasan 2009). In Kerala, a total of 241 species of this family were reported which includes 2 subspecies and 23 varieties distributed in plains, waste lands, mangroves, moist deciduous, deciduous, semi evergreen, evergreen and shola forests. Among them 23 species which were exotic are now naturalized or cultivated (Sasidharan, 2004).

Materials and Methods

The present work is the result of eight months of field study, collection, critical analysis of the Rubiaceae species available in the home gardens, *ex situ* and *in situ* sites from Thrissur, Palakkad Kozhikkode and Malappuram districts of Kerala. These studies were undertaken from October 2011 to May 2012 as to collect the flowering and fruiting materials of almost all the species. The collection and preparation of herbarium were restricted to 50 species. The remaining species were recorded in the field data book. All the 80 plants were photographed from the study areas.

Two specimens of 50 species were collected and these were systematically numbered and tagged for herbarium preparation, other 30 species were recorded in the field data book only and herbaria were not prepared. Important field data like, habit, phenology of the plant, colour, texture and smell of flowers and leaves, associated plants, abundance, local names and local uses available were also noted. Each species in fresh condition were critically studied with the help of floras like, *Flora of Presidency of Madras* (Gamble, 1915-1936); *Flowering plants of Thrissur district* (Sasidharan & Sivarajan, 1996); *Flowering plants of Palakkad district* (Vajravelu, 1990) *Flora of Calicut* (Manilal & Sivarajan, 1982); *Flora of Nilambur* (Sivarajan & Philip Mathew, 1997) and provisional determination were made. The species were poisoned, processed and labeled, by standard herbarium methods given by Santapau (1955) and Jain & Rao (1977).

The correct identity of the species were then confirmed by further critical studies with the help of floras and old authentic herbarium materials available at *Kerala Forest Research Institute* (KFRI), Peechi, Thrissur and *Calicut University Herbarium* (CALI). The recent nomenclature with common synonyms were noted. The specimens were incorporated in the Herbarium of Sree Krishna College, Guruvayur.

Results and Discussion

The present work yielded a total of 80 wild, cultivated and naturalised taxa covering 98 field numbers (Table 1). These taxa belong to 42 genera covering 3 climbers, 21 herbs, 2 lianas, 29 shrubs, 2 straggling shrubs, 1 sub-shrub, 1 un-shrub and 21 trees. Among them, 69 species which includes 22 endemics were reported to be used in different systems of medicines viz. Ayurveda (27); Folk (55); Homoeopathy (2); Modern or Allopathic (7); Siddha (21); Tibetan (4) and Unani (13). Among the 69 species, 30 plants were used only in Folk, 3 plants only in Ayurveda, 5 plants in Ayurveda and Folk, 5 plants in Folk and Siddha. This data coupled with studies on threat assessment and trade may also guide informed and focused conservation actions like species recovery etc.

The need for further research on the Rubiaceae is substantial. For some regions the extent of ignorance is alarming and there is a clear lack of fundamental data, particularly in the Old World Tropics including Western

Ghats. The current classification of the family is unstable, although great progress is being made with molecular systematics. There are numerous unresolved generic complexes (including the subfamilies, tribes, and subtribes), many undescribed genera, and several hundred undescribed species. Therefore a revisionary study of Rubiaceae from Western Ghats is necessary for the present situation.

Table 1: List of Rubiaceae species collected

A: Ayurveda; **F:** (Folk); **H**: (Homeopathy); **M**: (Modern); **S**: Siddha; **U**: Unani; **T**: Tibetan

Sl. No.	Botanical name	Habit	Med Tag	Endemism
1	**Aidia densiflora** (Wall.) Masam.	Tree	F	
2	**Benkara malabarica** (Lam.) Tirveng.	Shrub	F	
3	**Canthium angustifolium** Roxb.	Shrub	FS	
4	**Canthium coromandelicum** (Burm. f.) Alston	Shrub	F	
5	**Canthium neilgherrense** Wight	Shrub	0	Endemic
6	**Canthium rheedei** DC.	Shrub	F	Endemic
7	**Canthium travancoricum** (Bedd.) Hook. f.	Shrub	0	Endemic
8	**Catunaregam spinosa** (Thunb.) Tirveng.	Tree	ASTU	
9	**Chassalia curviflora** (Wall. ex Kurz) Thw. var. **ophioxyloides** (Wall.) Deb & Krishna	Shrub	F	
10	**Coffea arabica** L.	Tree	AFHSU	
11	**Dentella repens** (L.) J. R. & G. Forst. var. **repens**	Herb	F	
12	**Diodella teres** (Walter) Small	Herb	0	
13	**Gardenia jasminoides** Ellis	Shrub	F	
14	**Gardenia resinifera** Roth	Tree	ASU	
15	**Geophila repens** (L.) Johnst.	Herb	AF	
16	**Haldina cordifolia** (Roxb.) Ridsd.	Tree	AF	
17	**Hamelia patens** Jacq.	Shrub	F	
18	**Hedyotis neesiana** Arn.	Herb	0	
19	**Hymenodictyon obovatum** Wall.	Tree	FS	Endemic
20	**Hymenodictyon orixense** (Roxb.) Mabb.	Tree	AFS	
21	**Ixora brachiata** Roxb. ex DC.	Tree	F	Endemic
22	**Ixora coccinea** L.	Shrub	AFSU	
23	**Ixora elongata** Heyne ex G. Don	Shrub	F	Endemic
24	**Ixora finlaysoniana** Wall. ex G. Don	Tree	0	
25	**Ixora javanica** (Blume) DC.	Shrub	0	
26	**Ixora lanceolaria** Colebr.	Shrub	F	Endemic
27	**Ixora malabarica** (Dennst.) Mabb.	Shrub	F	Endemic
28	**Ixora nigricans** R. Br. ex Wight & Arn.	Shrub	F	
29	**Ixora pavetta** Andr.,	Tree	F	
30	**Ixora polyantha** Wight	Un Shrub	0	Endemic
31	**Knoxia sumatrensis** (Retz.) DC. var. **sumatrensis**	Herb	F	
32	**Lasianthus jackianus** Wight	Shrub	0	Endemic
33	**Mitracarpus hirtus** (L.) DC.	Herb	F	
34	**Mitragyna parvifolia** (Roxb.) Korth.	Tree	AFU	
35	**Mitragyna tubulosa** (Arn.) Hav.	Tree	M	Endemic
36	**Morinda citrifolia** L.	Tree	AFSU	

37	**Morinda pubescens** J. E. Smith	Tree	AFS	
38	**Morinda umbellata** L.	Climber	AFS	
39	**Mussaenda erythrophylla** Schum. & Thonn.	Shrub	0	
40	**Mussaenda frondosa** L.	Strag Shrub	AFSU	Endemic
41	**Mussaenda glabrata** (Hook.f.) Hutch. ex Gamble	Strag Shrub	F	Endemic
42	**Mussaenda philippica** A. Rich.	Shrub	F	
43	**Neolamarckia cadamba** (Roxb.) Bosser	Tree	AFTU	
44	**Neonauclea purpurea** (Roxb.) Merr.	Tree	M	Endemic
45	**Neurocalyx calycinus** (R. Br. ex Bennett) Robins.	Herb	0	Endemic
46	**Ochreinauclea missionis** (Wall. ex G. Don) Ridsd.	Tree	F	Endemic
47	**Oldenlandia auricularia** (L.) K. Schum.	Herb	AF	
48	**Oldenlandia corymbosa** L. var. **corymbosa** Hook. f.	Herb	ASU	
49	**Oldenlandia diffusa** (Willd.) Roxb.	Herb	F	
50	**Oldenlandia herbacea** (L.) Roxb.	Herb	AFHS	
51	**Oldenlandia umbellata** L.	Herb	FS	
52	**Ophiorrhiza brunonis** Wight & Arn. var. **brunonis**	Sub shrub	A	Endemic
53	**Ophiorrhiza mungos** L.	Herb	AFSTU	
54	**Oxyceros rugulosus** (Thw.) Tirveng.	Liana	M	
55	**Paederia foetida** L.	Climber	AU	
56	**Pavetta brunonis** G. Don	Shrub	0	Endemic
57	**Pavetta indica** L. var. **indica**	Shrub	AFS	
58	**Pavetta indica** L. var. **tomentosa** (Roxb. ex J. E. Smith) Hook. f.	Shrub	AF	
59	**Pavetta zeylanica** (Hook. f.) Gamble	Shrub	AFS	
60	**Pentas lanceolata** (Forssk.) Deflers	Shrub	F	
61	**Pseudaidia speciosa** (Bedd.) Tirveng.	Liana	F	
62	**Psilanthus travancorensis** (Wight & Arn.) Leroy	Shrub	AF	
63	**Psychotria flavida** Talbot	Shrub	F	Endemic
64	**Psychotria nigra** (Gaertn.) Alston var. **nigra**	Shrub	M	
65	**Psydrax dicoccos** Gaertn. var. **dicoccos**	Tree	F	
66	**Psydrax umbellata** (Wight) Bridson	Tree	F	
67	**Richardia scabra** L.	Herb	F	
68	**Rubia cordifolia** L.	Climber	AFSTU	
69	**Saprosma glomeratum** (Gard.) Bedd.	Shrub	F	Endemic
70	**Spermacoce articularis** L. f.	Herb	A	
71	**Spermacoce hispida** L.	Herb	AFS	Endemic
72	**Spermacoce latifolia** Aubl.	Herb	M	
73	**Spermacoce ocymoides** Burm.f.	Herb	F	
74	**Spermacoce pusilla** Wall.	Herb	F	
75	**Spermacoce remota** Lam.	Herb	A	
76	**Spermacoce verticillata** L.	Herb	M	
77	**Tamilnadia uliginosa** (Retz.) Tirveng. & Sastre	Tree	FSU	
78	**Tarenna alpestris** (Wight) Balakr.	Shrub	F	Endemic
79	**Tarenna asiatica** (L.) O.Ktze. ex K. Schum.	Shrub	FS	
80	**Wendlandia thyrsoidea** (Schult.) Steud.	Tree	M	

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References

1. **Anilkumar, N., Sivadasan M. and Ravi. N. 2005.** *Flora of Pathanamthitta, Western Ghats, Kerala, India,* Daya Publishing House, Delhi
2. **Bourdillon, T.F. 1908.** *The Forest Trees of Travancore*. Govt. Press, Trivandrum.
3. **Bridson, D.M., Forman, L. 1991.** *The Herbarium Handbook.* Royal Botanic Gardens, Kew.
4. **Daniel, P. 2005.** *Flora of Kerala.* Vol. 1. Botanical Survey of India, Calcutta.
5. **Fosberg F.R., Sachet M .M. 1965.** *Manual for Tropical Herbaria* (Reg.Veg. 39). IAPT, Utrecht, The Netherlands.
6. **Jain, S.K. and R.R. Rao, 1977.** *A Handbook of Field and Herbarium Methods.* Today & Tomorrow, New Delhi.
7. **Manilal, K.S. 1988.** *Flora of Silent Valley Tropical Rain Forests of India*. Calicut University, Calicut.
8. **Manilal, K.S. and V.V. Sivarajan 1982.** *Flora of Calicut*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
9. **Mohanan, M and A.N. Henry, 1994**. *Flora of Thiruvananthapuram, Kerala.* Flora of India – Series 3, Botanical Survey of India.
10. **Mohanan, N and M. Sivadasan, 2002.** *Flora of Agasthyamala.* Bishen Singh Mahendra Pal Singh, Dehra Dun.
11. **Nayar T S, Rasiya Beegam A, Mohanan N and Rajkumar G. 2006.** *Flowering plants of Kerala.* Tropical Botanical garden Research Institute, Palode, Thiruvananthapuram
12. **Prain D 1903.** *Bengal Plants*. 1: 400-425. Botanical Survey of India, Calcutta.
13. **Rama Rao, M. 1914.** *Flowering Plants of Travancore*. Govt. Press., Trivandrum.
14. **Ramachandran, V.S. and V.J. Nair, 1988.** *Flora of Cannanore District*. Botanical Survey of India, Calcutta.
15. **Ravikumar, K. and D.K. Ved. (Assisted by R. Vijaya Sankar and P.S. Udayan) 2000.** *Illustrated Field Guide of 100 Red-Listed Medicinal Plants of Conservation Concern in Southern India*. FRLHT Bangalore.
16. **Sasidharan, N 2004.** Biodiversity documentation for Kerala Part 6 *Flowering Plants*. Kerala Forest Research Institute, Peechi, Kerala.
17. **Sasidharan, N. and V.V. Sivarajan, 1996.** *Flowering Plants of Thrissur Forest (Western Ghats, Kerala, India).* Scientific Publishers, Jodhpur.
18. **Sivarajan, V.V. and Philip Mathew, 1997.** *Flora of Nilambur (Western Ghats, Kerala).* Bishen Singh Mahendra Pal Singh, Dehra Dun.
19. **Sunil, C.N. and Sivadasan M. 2009.** *Flora of Alapuzha district*. Daya publishers, New Delhi.
20. **Udayan P.S. and Indira Balachandran, 2009.** *Medicinal Plants of Arya Vaidya Sala Herb Garden*, Arya Vaidya Sala, Kottakkal, Malappuram.
21. **Vajravelu, E. 1990.** *Flora of Palghat District, including Silent Valley National Park, Kerala*. Botanical Survey of India, Calcutta.

Plants used for wound healing by the *Kalari* practitioners of North Malabar, Kerala

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Abstract

Kalaripayattu is one of the oldest forms of Indian martial arts, involving rigorous body exercises for neuro-muscular coordination, balance, stamina and flexibility. Since *Kalari* practice involves rigorous body sequences like twists, strikes, kicks and warfare, injuries and wounds are inevitable. Hence the science of *Kalari* incorporated effective treatments using locally available drugs for cure of wounds, bruises, dislocations and fracture. During extensive Ethno botanical studies carried out from 2009 to 2011 in North Malabar region of Kerala, 27 *Kalari Gurukkals* were personally interviewed with questionnaire and data sheets to document the wound healing plants and their properties. Present enumeration documented 31 plants falling under 29 genera and 21 families, used for 16 topical wound healing formulations. Correct botanical identity of the plants, family, vernacular names, morphology of the useful parts and detailed mode of use are also tabulated.

Key words: *Kalari*, North Malabar, Wound healing, Plants

Introduction

Kalaripayattu is most graceful and one of the oldest Indian martial art form of the state of Kerala. It involves rigorous body exercises for neuro-muscular coordination, balance, stamina and flexibility, there by disciplining one's physical body and imparting mental balance (Zarrilli, 1994, 1998). Wounds are inescapable events in life. In simpler terms, wound is the disruption of cellular and anatomic continuity of a tissue due to physical, chemical, thermal, microbial or immunological insult to the tissue (Bennet, 1988). Proper healing of wounds is essential for the restoration of disrupted anatomical continuity and disrupted functional status of the skin. Plants and their extracts have immense potential for the management of wounds. These are purportedly safe as hyper sensitive reactions are rare. These natural agents induce healing and regeneration of the lost tissue by multiple mechanisms. Medical treatment of wound includes either topical or oral administration of drugs (Savanth & Shah, 1998). Wound healing herbs encourage blood clotting, fight infection and accelerate the healing of wounds. These are the plants with antiseptic, astringent, anti-inflammatory, antimicrobial or bio-stimulator properties (Jaiswal *et al.*, 2004; Raina *et al.*, 2008). Since *Kalari* practice involves rigorous body sequences like twists, strikes, kicks, grappling and weaponry, injuries and wounds are inevitable. Hence the science of *Kalari* incorporated effective treatments using locally available drugs for cure of wounds, bruises, dislocations and fracture. This is the healing based on empirical knowledge of the observations and the experience over millennia. The objective of the present study was to conduct a detailed Ethno botanical survey of the phytomedicines used for wound healing by the *Kalari* practitioners of North Malabar region of Kerala.

Materials and Methods

Extensive ethno botanical studies were carried out from 2009 to 2011 throughout the North Malabar (11^0 08′ N to 12^0 48′ N & 74^0 52′ E to 76^0 08′ E) region of Kerala to elucidate the different plants used by the *Kalari* practitioners to treat wounds. During the survey, 27 *Kalari Gurukkals* of varied age group were personally interviewed with questionnaire and data sheets to document the wound healing plants and their properties. Both oral and written (Prior informed consent – PIC) consent were taken from them as per the CBD guidelines to publish the results of the study in the interest of the society. During the field visits, data regarding the specificity in drug collection, form of usage, detailed method of drug preparation, dosage, drug administration, restrictions if any, duration of treatment, response of patient and complications if any, were collected. Collected information was authenticated by repeated queries, cross-checking with other healers and by interviewing the beneficiaries. Collected plants were identified with the help of regional floras (Gamble & Fischer, 1936; Manilal & Sivarajan, 1982; Mathew, 1984; Ramachandran & Nair, 1988; Bhat, 2003; Sasidharan, 2011; Anilkumar *et al.,* 2005) and herbaria. Voucher specimens were deposited at Sir Syed College Herbarium for future reference.

Results and Discussion

From present enumeration it is clear that the *Kalari Gurukkals* make use of 31 plants which falls under 29 genera and 21 families to heal wounds effectively. They make use of these plants for 16 medial formulations meant for topical application. Correct botanical identity of the plants, family, vernacular names, morphology of the useful parts and usage are given in Table 1.

Table 1: Plants used for wound healing

Sl. No	Botanical Name & Family	Vernacular Name	Formulation
1	*Abrus precatorius* L. (Papilionaceae)	Kunnikkuru	Leaf + *Naregamia alata* leaf+ *Erythrina variegata* leaf + *Desmodium motorium* leaf (paste)
2	*Achyranthes aspera* L. (Amaranthaceae)	Kadaladi, Vankadaladi	Leaf (paste)
3	*Allium cepa* L. (Liliaceae)	Chuvannulli	Bulb + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Piper betle* leaf + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
4	*Aloe vera* (L.) Burm. f. (Liliaceae)	Kattarvazha	Leaf + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Piper betle* leaf + *Allium cepa* bulb + *Pongamia pinnata* bark + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
5	*Areca catechu* L. (Arecaceae)	Adakkamaram, Kavungu	Fruit (juice)
6	*Artocarpus heterophyllus* Lam. (Moraceae)	Pilavu, Plavu	Leaf + salt (paste)
7	*Asparagus racemosus* Willd. (Liliaceae)	Sathavari	Rhizome + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Piper betle* leaf + *Allium cepa* bulb + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil (oil)
8	*Calotropis gigantea* (L.) R. Br. (Asclepiadaceae)	Erikku	Whole plant (latex)
9	*Cocos nucifera* L. (Arecaceae)	Thengu	Oil + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Piper betle* leaf + *Pongamia pinnata* bark + *Allium cepa* bulb + *Aloe vera* leaf + *Asparagus racemosus* rhizome juice (oil)
10	*Curcuma longa* L. (Zingiberaceae)	Manjal	Rhizome (powder)
11	*Desmodium motorium* (Houtt.) Merr. (Papilionaceae)	Thozhukanni, Ramanama paccha	Leaf + *Naregamia alata* leaf+ *Erythrina variegata* leaf + *Abrus precatorius* leaf (paste)
12	*Desmodium triflorum* (L.) DC. (Papilionaceae)	Nilamparanda	Whole plant + *Psidium guajava* bark + *Sida rhombifolia* leaf + *Tamarindus indica* leaf + *Sesamum orientale* seed oil (oil)
13	*Erythrina variegata* L. (Papilionaceae)	Murikku	Leaf + *Naregamia alata* leaf + *Abrus precatorius* leaf + *Desmodium motorium* leaf (paste). Root + *Moringa pterygosperma* root + *Spermacoce articularis* whole plant + *Allium cepa* bulb + *Piper betle* leaf + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice

14	*Indigofera tinctoria* L. (Papilionaceae)	Neelayamari	Leaf + *Mimosa pudica* leaf (paste)
15	*Leucas aspera* (Willd.) Link. (Lamiaceae)	Thumba	Leaf (juice)
16	*Mimosa pudica* L. (Mimosaceae)	Thottalvadi	Leaf + *Indigofera tinctoria* leaf (paste). Leaf (juice)
17	*Moringa pterygosperma* Gaertn. (Moringaceae)	Muringa	Root + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Allium cepa* bulb + *Piper betle* leaf + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
18	*Murraya koenigii* (L.) Spreng. (Rutaceae)	Kariveppila	Leaf + salt (paste)
19	*Mussaenda frondosa* L. (Rubiaceae)	Vellila	Leaf + *Piper nigrum* fruit (paste)
20	*Naregamia alata* Wight & Arn. (Meliaceae)	Nilanaragam	Leaf + *Erythrina variegata* leaf + *Abrus precatorius* leaf + *Desmodium motorium* leaf (paste)
21	*Piper betle* L. (Piperaceae)	Vettila	Leaf + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Allium cepa* bulb + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
22	*Piper nigrum* L. (Piperaceae)	Kurumulaku	Fruit + *Mussaenda frondosa* leaf (paste)
23	*Pongamia pinnata* (L.) Pierre (Papilionaceae)	Ungu, Pongu	Bark + *Spermacoce articularis* whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Piper betle* leaf + *Allium cepa* bulb + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
24	*Psidium guajava* L. (Myrtaceae)	Pera, Perakka	Bark + *Desmodium triflorum* whole plant + *Sida rhombifolia* leaf + *Tamarindus indica* leaf + *Sesamum orientale* seed oil (oil)
25	*Sesamum orientale* L. (Pedaliaceae)	Ellu	Seed oil + *Desmodium triflorum* whole plant + *Psidium guajava* bark + *Sida rhombifolia* leaf + *Tamarindus indica* leaf (oil)
26	*Sida rhombifolia* L. (Malvaceae)	Kurunthotti	Leaf + *Desmodium triflorum* whole plant + *Psidium guajava* bark + *Tamarindus indica* leaf + *Sesamum orientale* seed oil (oil)
27	*Spermacoce articularis* L. f. (Rubiaceae)	Tharthavel	Whole plant + *Erythrina variegata* root + *Moringa pterygosperma* root + *Allium cepa* bulb + *Piper betle* leaf + *Pongamia pinnata* bark + *Aloe vera* leaf + *Cocos nucifera* oil + *Asparagus racemosus* rhizome juice (oil)
28	*Tamarindus indica* L. (Caesalpiniaceae)	Valampuli	Leaf + *Desmodium triflorum* whole plant + *Psidium guajava* bark + *Sida rhombifolia* leaf + *Sesamum orientale* seed oil (oil)
29	*Terminalia chebula* Retz. (Combretaceae)	Kadukka	Fruit (paste)
30	*Tinospora sinensis* (Lour.) Merr. (Menispermaceae)	Kattamruthu	Whole plant (paste)
31	*Vernonia cinerea* (L.) Less. (Asteraceae)	Poovamkurunthala	Leaf (juice)

Of the 16 formulations, seven were poly herbal formulations while the rest are single drugs. Among different plant parts used, leaves are the dominant form as leaves of 16 plants are used for tissue healing, followed by whole plant (4), fruit (4), rhizome (2), root (2), bark (2) and bulb of *Allium cepa* L. Half of the formulations were plant paste while the rest are juices (4), oil (2), *Calotropis gigantea* (L.) R. Br. latex and *Curcuma longa* L. rhizome powder. All these plants are well known for their therapeutic efficacy. *Aloe vera* (L.) Burm. f. has a dramatic ability to heal wounds as it is rich in glycoprotein and water (96 %). Its role as an anti-inflammatory drug and wound healer is already well known (Raina *et al.*, 2008; Patil *et al.*, 2009). Curcumin is the active constituent in turmeric which is responsible for its antibacterial, antifungal, anti-inflammatory and analgesic properties (Chopra *et al.*, 1986; Srimal *et al.*, 1971; Tugnaiyat *et al.*, 2000). Presence of high amount of vitamin – A and proteins also make the turmeric one of the best drugs for wound healing (Jaiswal *et al*., 2004; Mondal & Chauhan, 2000; Patil *et al*., 2009; Das *et al*., 2012). Anti-inflammatory, antibacterial and counter irritant properties of *Moringa pterygosperma* Gaertn. are due to the moringine, moringinine and pterygospermin, making them much useful in wound healing (Jaiswal *et al*., 2004; Singh *et al*., 2001; Patil *et al*., 2009; Das, 1997; Begum & Nath, 2000; Udupa *et al*., 1994a & b; Hukkeri *et al*., 2006). Wound healing properties of *Calotropis gigantea* (L.) R. Br. (Jaiswal *et al*., 2004; Chettri *et al*., 1992; Patil *et al*., 2009; Begum & Nath, 2000; Reddy *et al*., 2003; Rajesh *et al*., 2005), *Erythrina variegata* L. (Jaiswal *et al*., 2004; Mondal & Chauhan, 2000; Pal & Jain, 1997; Thomas & Britto, 2003), *Mimosa pudica* L. (Patil *et al*., 2009; Das *et al.,* 2012), *Achyranthes aspera* L. (Patil *et al.,* 2009); *Abrus precatorius* L. (Bhatt *et al*., 2002; Katewa *et al*., 2004; Binu, 2009), *Areca catechu* L. (Patil *et al*., 2009; Padmaja *et al.,* 1994) and *Piper betle* L. (Sarma *et al*., 2002; Thomas & Britto, 2003) were also already known to the world. All these Ethno botanical and pharmacological studies strongly support the authenticity of present elucidation.

Conclusions

As primary objective of *Kalari* is learning about human body, *Kalari* practitioners are much knowledgeable in the field of traditional medicine and massage. They often provide massages and medical formulations to the students and the patients to increase their physical flexibility or to treat the wounds and injuries. *Kalari* practitioners of North Malabar make use of 31 plants based on the observations and the experience over millennia for treating the wounds effectively. Now days, the knowledge of the healing plants is mostly confined to the elder persons and the medical tradition is dying out fast without patronage. Hence present compilation will help the pharmacologists to understand the exact part of the plant and its exact use in the traditional system, which can serve as a potential source for drug discovery and also may pave the way for conservation of these important herbs.

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References

1. **Anilkumar, N., Sivadasan, M. and Ravi, N. 2005.** *Flora of Pathanamthitta.* Daya Publishing House, Delhi.
2. **Begum, D. and Nath, S. C. 2000.** Ethnobotanical review of medicinal plants used for skin diseases and related problems in Northeastern India. *Journal of Herbs, Spices and Medicinal Plants.* 7: 55 – 93.
3. **Bennet, R. G. 1988.** *Fundamentals of Cutaneous Surgery.* C. V. Mosby, St. Louis.
4. **Bhat, K. G. 2003.** *Flora of Udupi.* Indian Naturalist (R), Udupi.
5. **Bhatt, D. C., Mitaliya, K. D., Mehta, S. K. and Joshi, P. N. 2002**. Notes on some Ethnomedicinal plants of Paccham Hills of Kachh District. *Gujarat Ethnobotany*. 14: 34 – 35.
6. **Binu, S. 2009.** Medicinal plants used by the tribals in Pathanamthitta District of Kerala for treating cuts and wounds. *Indian Journal of Botanical Research.* 5 (1 & 2): 137 – 142.
7. **Chettri, R., Rai, B. and Khawas, D. B. 1992.** Certain medicinal plants in the folklore of Darjeeling and Sikkim Hills. *Journal of Economic and Taxonomic Botany*, Additional Series No. 10: 393 – 398.
8. **Chopra, R. N., Nayar, S. L. and Chopra, I. C. 1986.** *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.

9. **Das, A. J., Athar, M., Rawat, D. S. and Das, P. J. 2012.** Ethno medicinal survey of medicinal plants used to cure wounds in Darikal Gaon of Tezpur in Assam, North East India. *International Research Journal of Pharmacy.* 3 (2): 193 – 195.
10. **Das, S. N. 1997.** A study on the Ethnobotany of Karauli & Sawai Madhapur Districts, Rajasthan. *Journal of Economic and Taxonomic Botany.* 21: 587 – 605.
11. **Gamble, J. S. and Fischer, C. E. C. 1936.** *Flora of Presidency of Madras,* 3 Vols. Adlard & Son Ltd., London.
12. **Hukkeri, V. I., Nagathan, C. V., Karadi, R. V. and Patil, B. S. 2006.** Antipyretic and wound healing activities of *Moringa oleifera* Lam. in rats. *Indian Journal of Pharmaceutical Sciences*. 68: 124 – 126.
13. **Jaiswal, S., Singh, S. V., Singh, B. and Singh, H. N. 2004.** Plants used for tissue healing of animals. *Natural Product Radiance*. 3 (4): 284 – 292.
14. **Katewa, S. S., Chaudhary, B. L. and Jain, A. 2004.** Folk herbal medicines from tribal area of Rajasthan India. *Journal of Ethnopharmacology.* 92: 41 – 46.
15. **Manilal, K. S. and Sivarajan, V. V. 1982.** *Flora of Calicut.* Bishen Singh Mahendra Pal Singh, Dehra Dun.
16. **Mathew, K. M. 1984.** *The Flora of Tamilnadu Carnatic,* 3 Vols. The Rapinat Herbarium, St Joseph's College, Thiruchirapalli.
17. **Mondal, M. K. and Chauhan, J. P. S. 2000.** A survey of ethno-veterinary medicine practices in West Bengal. *Indian Journal of Veterinary Medicine.* 20 (1): 90 – 91.
18. **Padmaja, P. N., Bairy, K. L. and Kulkarni, D. R. 1994.** Pro-healing effect of betel nut and its polyphenols. *Fitoterapia.* 65: 298 – 300.
19. **Pal, D. C. and Jain, S. K. 1997.** *Tribal Medicine.* Naya Prakash Publishers, Calcutta.
20. **Patil, S. B., Naikwade, N. S., Kondawar, M. S., Magdum, C. S. and Awale, V. B. 2009.** Traditional uses of plants for wound healing in the Sangli District, Maharashtra. *International Journal of Pharm Tech Research,* 1 (3): 876 – 878.
21. **Raina, R., Prawez, S., Verma, P. K. and Pankaj, N. K. 2008.** Medicinal plants and their role in wound healing. *Vet Scan.* 3 (1): 1 – 7.
22. **Rajesh, R., Raghavendra, G. C. D., Nataraju, A., Dhananjaya, B. L., Kemparaju, K. and Vishwanath, B. S. 2005.** Procoagulant activity of *Calotropis gigantea* latex associated with fibrinogenolytic activity. *Toxicon.* 46: 84 – 92.
23. **Ramachandran, V. S. and Nair, V. J. 1988.** *Flora of Cannanore*. BSI, Calcutta.
24. **Reddy, P. R., Rao, P. P. and Prabhakar, M. 2003.** Ethnomedicinal practices amongst Chenchus of Nagarjunasagar Srisailam Tiger Reserve (NSTR), Andhra Pradesh – plant remedies for cuts, wounds and boils. *Ethnobotany.* 15: 67 – 70.
25. **Sarma, S. K., Bhattacharya, B. K. and Devi, B. 2002.** Traditional use of herbal medicine by Modahi tribe of Nalabari District of Assam. *Ethnobotany.* 14: 103 – 111.
26. **Sasidharan, N. 2011.** *Flowering Plants of Kerala.* ver. 2. 0. KFRI, Peechi.
27. **Savanth, S. S. and Shah, R. A. 1998.** *Text Book and Atlas of Dermatology and Cosmetology.* ASCAD, Mumbai. pp: 12 – 17.
28. **Singh, G., Khate, K., Bujarbaruah, K. M., Mondal, S. K., Pal, D. T. and Kumar, S. 2001.** Phytomedicines used for animal treatment by tribals in remote area Nagaland. *Indian Veterinary Medicine Journal.* 25 (3): 291 – 292.
29. **Srimal, R. C., Khanna, N. M. and Dhawan, B. N. 1971**. A preliminary report on anti-inflammatory activity of curcumin. *Indian Journal of Pharmacology.* 3: 10.

30. **Thomas, J. and Britto, J. D. 2003.** Ethnobotanical study in Wyanad District of Kerala. *Journal of Economic and Taxonomic Botany.* 27: 915 – 924.
31. **Tugnaiyat, A. K., Bhargava, M. K., Chandrapuria, V. P., Pandey, S. K. and Quadiri, M. A. 2000.** Efficacy of *Curcuma longa* and *Helianthus annus* on tissue repair in calves: Clinical and biochemical studies. *Indian Journal of Veterinary Surgery.* 21 (2): 76 – 78.
32. **Udupa, S. L., Udupa, A. L. and Kulkarni, D. R. 1994a.** Anti-inflammatory and wound healing properties of *Aloe vera*. *Fitoterapia.* 65: 144 – 145.
33. **Udupa, S. L., Udupa, A. L. and Kulkarni, D. R. 1994b.** Studies on anti-inflammatory and wound healing properties of *Moringa oleifera* and *Aegle marmelos*. *Fitoterapia.* 65: 119 – 123.
34. **Zarrilli, P. B. 1994.** Actualizing power and crafting a self in *Kalarippayattu* – A South Indian martial art and the Yoga and Ayurvedic paradigms. *Journal of Asian Martial Arts.* 3 (3): 10 – 50.
35. **Zarrilli, P. B. 1998.** *When the body becomes all eyes: Paradigms, discourses and practices of power in Kalarippayattu, a South Indian martial art.* Oxford University Press, Oxford.

Ethnobotanical information from the Kurumba Tribes of Attappady forest of Palakkad District, Kerala, India

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Abstract

The paper enumerates the traditional uses of 46 plants used by the Kurumba tribe of Edavaniyoor Attappady forest of Palakkad district, Kerala, India. Information on the medicinal uses gathered from the tribes, together with their botanical identity is presented in this paper.

Key words: Ethnobotany, Kurumba trie, Attappady, Palakkad

Introduction

India's ethnic cultural and genetic diversity is of remarkable interest due to the peculiarity of its social structure and breeding patterns in the different populations. It has a population of one billion plus, with 631 cultural, ecological and economic traits, which are assigned to 4635 ethnic communities. Kerala, the southernmost state of India, is known for its biodiversity reserve, high cultural heterogeneity and high rate of literacy. There are about 35 ethnic communities scattered in Kerala mostly in or along the Western Ghats forests, such as Adiyan, Kaadar, Muduvan, Paniyar, Malapandaram, Chola Naikkar, Kattu Naikkar, Kaani, Kurumba, etc. The Kurumbas were perhaps the earliest inhabitants of Attappady. There is a strong case that they have moved down from the Nilgiris, with the colonization of the area by Badugas. After an initial period of nomadic life, they must have taken up shifting cultivation and then organized into hamlets in forest areas. Tribals contributes 41% of total Attappady population. Out of 187 tribal hamlets in the Attappady block, there are only 19 Kurumba hamlets and it makes only 6 % of the total tribal population. Due to low development and literacy rate, Kurumbas are considered as a primitive tribal group. The language spoken by them is a mixture of Canaries, Tamil and Malayalam. Tribals, mostly animists, have their own religion which is different from Hindu religion. They believe in ghosts and spirits. Apart from their own God, the Kurumbas worship many dieties of Hindu pantheon and observe many Hindu festivals. (Anonymus, 1971).

The houses in a hamlet, made up of grass, bamboo and mud, are generally built in a row. A house is often compartmentalized and each compartment is allotted to one family. Kurumbas maintain a community life by sharing labour and food with others in the hamlet as and when required. The community is divided into clans (Kula) and marriage within the clan is strictly prohibited. Just like caste status in Hindu religion, the clan status is hereditary. For instance, Moopan is always selected from a particular clan (Aru Moopar) and after his death, the position is passed on to his eldest son. The tribals of Attappady in general and the Kurumbas in particular, prefer a nuclear family consisting of father, mother and children. Father is the head of the family whose words are final in many family matters. Kurumbas follow a patriarchal system in which the male children share the property of the parents, including farm implements and weapons. In order to strengthen the family ties, the marriages are often arranged with uncle's (mother's brother) or aunt's (father's sister) son or daughter. The custom relating to marriage in Kurumba community is simple and is initiated by the boy himself. He informs his intention to marry a particular girl to the Moopan who intimates this to boy's parents. A group consisting of Moopan, parents of the boy and one member from each clan visits the girl's house to call on her. Similarly, another group from girl's house visits the boy's house. After this visit, the marriage takes place within a few days. A nominal amount is paid to girl's parents as bride price during the marriage, which is nonrefundable at any circumstances. After the marriage, the new couple lives together in a separate house. Divorce and remarriages are permitted in the community (KFRI, 1991).

Rituals relating to death of a person are very simple, but continue till cremation which is carried out at the third day of the death. As part of rituals, dance is performed by members of the hamlet, aiming to make the soul of the dead happy. The death anniversary is observed for salvation of the soul in which a feast is given to the relatives of the dead. Relationship with past governs the way of life (Vidyasagaran & Anilkumar, 2009).

Study Area

The Edavaniyoor is a Kurumba tribal hamlet in Pudur Grama Panchayath, Attappady Block which falls under the jurisdiction of Mannarkkad taluk in Palakkad district of Kerala State. Edavaniyoor Kurumba hamlet is located in a valley of Varaharpallam tributary of river Bhavani, with easy access to water. This isolated hamlet which is situated very far away from the vehicle points has to be accessed by foot only for about ten kilometers from the last vehicle point. Thirty families are living in the Edavaniyoor tribal settlement. The study area is located in Mannarakkad Forest division of Palakkad district in Kerala situated at 11°05ˈ N latitude and 75°27ˈ E longitude with an altitude ranging from 880-2200 m above sea level (Plate 1). The temperature goes down up to 8°C during the winter seasons and rises up to 29°C during the summer months. The annual rainfall ranges from 3000-5000 mm. The forest types are mixed deciduous, semi-evergreen and evergreen with comparatively undisturbed patch of Tropical evergreen rain-forest (Champion & Seth, 1968). Floristic studies of the Attapady including Silent Valley, were carried out by Manilal *et al.*, (1988), who described 966 species belonging to 559 genera of 134 families and Vajarvelu (1990) who published the '*Flora of Palghat district*' including Attapady forest, which enumerated 1355 species belonging to 732 genera of 146 families.

Materials and Methods

The present paper adds up further to the initiative on documentation of traditional knowledge by giving the uses on 46 plant species. In order to explore the medicinal wealth, an ethno-botanical exploration was carried among the Kurumba Tribes of Attappady. During the survey, we visited Edavaniyoor tribal settlement and the areas nearby. The guide, Linkan S/o Bachan, aged 58, who belongs to Edavaniyoor tribal settlement gave the major share of knowledge. He explained the medicinal uses and gave the local names for every plant collected. The plants were tagged and the information entered in the field data book together with important botanical notes. Herbarium sheets were prepared for all the species, authenticated and the voucher specimens are deposited in the CMPR herbarium.

Results and Discussion

During the survey, 46 plant species used by the tribal community of that area for primary healthcare are identified (Plate 2). The species are arranged in alphabetical order with details such as botanical name, family, habit, voucher number, local name, part used and medicinal uses. Due to lack of proper documentation, the traditional knowledge is getting lost day by day. Hence, proper documentation and preservation of the tribal knowledge on medicinal plants have to be carried out. The application of most of the plants recorded is either lesser known or hitherto unknown to the outside world. On the basis of this survey, pharmacological screening can be done to all the taxa represented here to find out the potentiality of the information as provided by the tribals.

Table 1: List of plants used by Kurumba tribes of Edavaniyoor

No	Botanical Name	Family	Habit	Local Name	Part used	Uses	Method of Use
1	*Acacia caesia* (L.) Willd.	Mimosaceae	Climber	Sinka	Bark	Headache	Good medicine for headache. Crushed bark is applied on the forehead
2	*Achyranthes aspera* L. *Amaranthus spinosus* L. *Calotropis gigantea* (L.) R. Br. *Aerva lanata* (L.) Juss.	Amaranthaceae Amaranthaceae Asclepiadaceae Amaranthaceae	Herb Herb Shrub Herb	Irrumulli, Cheera, Errukku, Kallipuvu	Twigs	Worship	Young twigs with ash is use for "Kani" in Pongal celebrations
3	*Ageratina adenophora* (Spreng.)King & Robins.	Asteraceae	Herb	Ammbuk ana	Leaves	Worm infestation	To cure worm infestation in children
4	*Anogeissus latifolia* (Roxb. ex DC.) Wall.	Combretaceae	Tree	Vegga	Bark	Cough	Chewing of bark gives relief from cough and gets better breathing
5	*Bauhinia malabarica* Roxb.	Caesalpiniacea e	Tree	Ashamar am	Bark	Making of ropes	Bark crushed and used for make local ropes
6	*Briedelia retusa* (L.) A. Juss.	Euphorbiaceae	Tree	Gonja	Bark and leaves	Rheumatis m	Ground bark and leaves is applied over painful area
7	*Cajanus albicans* (Wight & Arn.) van der Maesen	Fabaceae	Climber	Parivasa ppa	Leaves and root	Itch	Ground roots and leaves are applied on infected portions
8	*Calotropis gigantea* (L.) R. Br.	Asclepiadaceae	Shrub	Errukku	Leaves	Rheumatis m	Slightly heated leaves are pressed on the painful area
9	*Canavalia africana* Dunn	Fabaceae	Climber	Killara	Root	Precaution s after Delivery	Root juice is given to the mothers seven days after delivery as a preventive measure for other diseases.
10	*Catunaregam spinosa* (Thunb.) Tirveng.	Rubiaceae	Shrub to Small tree	Kara	Fruits	Fish Poison (Icthyotoxi ns)	Poisonous fruits are mashed and mixed in stagnant pools or streams
11	*Chloroxylon swietenia* DC.	Rutaceae	Tree	Porincha	Leaves	Fish Poison	Crushed leaves are mixed in stagnant pools or streams
12	*Chromolaena odorata* (L.) King & Robins	Asteraceae	Shrub	Kammpa ny	Leaves and young stem	Wounds	Juice of leaves and stem are smeared on wounds for easy healing.
13	*Chromolaena odorata* (L.) King & Robins *Lantana camara* L. + Lime	Asteraceae Verbenaceae	Shrub Shrub	Kammpa ny, Paralu	Leaves	Wounds	The three items are ground well and applied on wounds
14	*Clematis gouriana* Roxb. ex DC.	Ranunculaceae	Climber	Nikadi	Leaves	Cold	Crushed leaves are inhaled
15	*Cycas circinalis* L.	Cycadaceae	Shrub	Eentu	Seeds and tender leaves	Food preparatio ns	Flour of mature seeds is used for making pasta. Tender leaves used for Curry preparations
16	*Cyclea peltata* (Lam.) Hook. f. & Thoms.	Menispermace ae	Climber	Padakkiz angu	Leaves and Roots	Hair Growth; Against Leech bites	Crushed leaves are smeared on head for hair growth. Roots are dipped in coconut oil for 3 months, and the oil is applied over legs to avoid leech bites. More suitable during raining season.
17	*Dalbergia latifolia* Roxb.	Fabaceae	Tree	Veeti, Etti	Bark juice	Stomach pain	Bark juice is a good remedy for intestinal infections. Medicine must be drunk two times for two days
18	*Desmodium repandum* (Vahl) DC.	Fabaceae	Herb	Kaduppu kodi	Leaves	Internal bleeding	Leaves juice is good to heal internal bleeding of stomach
19	*Dioscorea oppositifolia* L.	Dioscoreacae	Climber	Erraikodi	Tubers	Edible	Tubers cooked in water are edible
20	*Furcraea foetida* (L.) Haworth	Agavaceae	Shrub	Kathala	Leaves	Rope making	Crushed leaves are used for making local ropes
21	*Gloriosa superba* L.	Liliaceae	Climber	kodakizh angu	Tubers	Poison	Poisonous tubers if eaten will cause death

22	*Glycosmis pentaphylla*(Retz.) DC.	Rutaceae	Shrub	Malakulukki	Root	Stomach ache	Ground root juice mixed with water are given two or more times a day
23	*Grewia tiliifolia* Vahl	Tiliaceae	Tree	Chadachi	Bark	Shampoo	Crushed bark used as local shampoo
24	*Helicteres isora* L.	Sterculiaceae	Shrub	Edampiri - Valampiri	Root	Stomach pain	Ground root juice is mixed with water and given to patients
25	*Hemidesmus indicus* (L.) R. Br.	Periplocaceae	Climber	Nannari	Root	Taste/ flavour maker	Added to coffee for flavour
26	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	Climber	Kurukkathikodi	Root	Swelling	Juice of root bark applied on swellings. Also used against the wounds developed by *Odian* (a ghost believed by Kurumbas)
27	*Jatropha curcas* L.	Euphorbiaceae	Shrub	Thonda	Exudation	Headache	Exudation applied on fore head for sudden relief
28	*Mallotus philippensis* (Lam.) Muell.- Arg.	Euphorbiaceae	Tree	Kathivettu	Bark	Toothache	Ground bark applied on affected tooth.
29	*Mangifera indica* L. *Gmelina arborea* Roxb. *Capsicum frutescens* L.	Anacardiaceae Verbenaceae Solanaceae	Tree Tree Herb	Mavu, Gooli, Kanthari mulaku	Bark and root	Wounds of cattle	Barks of *Mangifera indica, Gmelina arborea* and roos of *Capsicum frutescens* are ground together and applied
30	*Mucuna pruriens* (L.) DC.	Fabaceae	Climber	Naikurana	Seeds	Menses Bleeding	Seeds are eaten to reduce bleeding during menses period
31	*Ocimum americanum* L.	Lamiaceae	Herb	Thulasi	Roots and leaves	Tooth ache	Ground roots and leaves are pressed on the affected tooth
32	*Persicaria chinensis* (L.) Gross.		Shrub	Gonglesappa	Leaves	Acidity	Drinking leaf juice gives sudden relief from stomach ache caused by acidity
33	*Plumbago zeylanica* L.	Combretaceae	Shrub	Charenda	Leaves	Food	Leaves used for curry preparation
34	*Senna hirsuta* (L.) Irwin & Barneby	Caesalpinaceae	Shrub	Thakara	Root	Stomach pain	Root juice mixed with water is used for drinking
35	*Sida acuta* Burm.f.	Malvaceae	Herb	Kulamaru	Leaves	Swelling	Ground leaves smeared on the swelling. Twigs are commonly used for making broom sticks
36	*Solanum torvum* Sw.	Solanaceae	Shrub	Chunnda	Leaves	Curry preparation	Leaves used for curry preparation
37	*Tectona grandis* L.	Verbenaceae	Tree	Thekku	Tender leaves	Burns	Tender leaves fried in oil are applied on burns to reduce pain and easy healing
38	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Tree	Thanni	Seeds	Edible	Endosperm is edible
39	*Tridax procumbens* L.	Asteraceae	Herb	Railgooda sappu	Leaves	Wounds	Crushed leaves is good for wound healing caused by metal utensils
40	*Wrightia tinctoria* (Roxb.) R. Br.	Apocynaceae	Tree	Pala	Bark	For milk preservation	Bark dipped in milk will make it a semisolid one, within few hours , without changing taste. Used by shepherds, to preserve milk.
41	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae	Climber	Juli	Fruit & bark	Edible; Against Leech bite	Ripe fruits are edible. Crushed bark are applied on foot, to prevent leech bites
42	*Ziziphus rugosa* Lam.	Rhamnaceae	Shrub	Juli	Fruit	Edible	Ripe fruits are edible

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References:

1. **Anonymus. 1971.** *Village Survey Monographs*: Tribal Areas. Vol. VII, part VI, G. Census of India, Govt. of India, New Delhi.
2. **Champion, H.G. and S.K. Seth. 1968.** *A Revised Survey of the Forest Types of India*. Forest Research Institute, Manager of Publications, Delhi.
3. **Kerala Forest Research Institute. 1991.** Studies on Human and Eco-Restoration of Attappady Valley, KFRI Project Report. Peechi, Thrissur.
4. **Manilal, K.S. (Assisted by T. Sabu, C. Sathish Kumar & C.R. Suresh) 1988.** *Flora of Silent Valley*. The Mathrubhumi Press, Calicut.
5. **Vidyasagaran, K. and K. A. Anilkumar. 2009.** Structural Analysis and Plant Diversity of Natural and Protected areas of Attappady, Project Report, College of Forestry, Kerala Agricultural University.

Figure I

Figure 2

Fig. 1: A Kurumba tribal man explaining the use of *Tridax procumbens* L. used for healing of wounds.

Fig. 2: A Kurumba tribal woman sitting in front of her house

Plate - 1

Bauhinia racemosa Lam.

Calotropis gigantea (L.) R. Br.

Catunaregam spinosa (Thunb.) Tirveng.

Chloroxylon swietenia DC.

Clematis gouriana Roxb. ex DC.

Cycas circinalis L.

Desmodium repandum (Vahl) DC.

Gloriosa superba L.

Grewia tiliifolia Vahl

Helicteres isora L.

Hemidesmus indicus (L.) R.Br.

Ocimum americanum L.

Plate - 2

Taxonomic survey of the genera *Cryptocoryne* Fischer ex Wydler and *Lagenandra* Dalzell (Araceae) in Peninsular India

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Abstract

The genus *Cryptocoryne* is endemic to tropical Asia extending from India in the west to the Philippines in the east, onwards to Malaysia, through Indonesia to Papua New Guinea. The genus is with five species and one variety in Peninsular India, viz. *C. cognata* Schott, *C. consobrina* Schott, *C. retrospiralis* (Roxb.) Kunth, *C. sivadasanii* Bogner and *C. spiralis* (Retz.) Fischer *ex* Wydler and one variety viz. *C. spiralis* var. *cognatoides* (Blatter *et* McCann*)* Yadav, Patil *et* Bogner. *C. consobrina* and *C. sivadasanii* are of restricted distribution and confined to the states of Kerala and Karnataka while *C. congata* and *C. spiralis* var. *cognatoides* are confined to Karnataka and Maharashtra states. The genus *Lagenandra* is confined to the Indian Subcontinent with its distribution extending from Sri Lanka in the south to tropical northeastern India with one species in Bangladesh. The genus is with five species and one variety in peninsular India, viz. *L. keralensis* Sivad. *et* Jaleel, *L. meeboldii* (Engl.) C. E. C. Fisch., *L. nairii* K. Ramamurthy *et* R. Rajan, *L. ovata* (L.) Thwaites, and *L. toxicaria* Dalzell, and one variety, viz. *L. toxicaria* var. *barnesii* C. E. C. Fisch.

Key words: *Cryptocoryne*, *Lagenandra,* taxonomy, Peninsular India

Introduction:

The genus *Cryptocoryne* is characterized with linear lanceolate leaves and inconspicuous inflorescences. The spadix is included in the basal tubular portion of the spathe. The pistillate flowers are few in number and are arranged in a single whorl and united forming a syncarp. The staminate flowers have horn-like tubular projections at the top of the anther lobes. The genus has about 50 species distributed in tropical areas of Asia and the Malesian archipelago (Mayo *et al.,* 1997). In India, it is represented by 6 species. The genus *Lagenandra* is characterized by leaves with long cylindric, basally sheathing petiole; lamina elliptic-ovate to oblong-lanceolate. Spathe differentiated into a basal tube with united margins and an upper open, ovate-acuminate, smooth or vertically ribbed within the tube, tube and limb separated by an auricular flap of the spathe; The genus is represented by 15 species and is confined to the Indian Sub continent with its distribution extending from Sri Lanka to tropical north-eastern India with one species *L. gomezii* (Schott) Bogner *et* Jacobson, in Bangladesh. In India the genus is represented by six species. *Lagenandra undulata* is the only species confined to the north eastern India. *Lagenandra gomezii* was collected only once in 1828 from Sylhet of erstwhile British India, which is now in Bangladesh. It is a peculiar species and for a long time considered as a species of the genus *Cryptocoryne* (Schott,1860; Engler,1920; Dewit,1990), but Bogner and Jacobson (1989) after re-examination of the type material, showed that it is a true *Lagenandra*. Two species, viz. *L. undulata* and *L. gomezii* have a more northern distribution, while all others are found in South India and Sri Lanka. *Lagenandra* has a disjunct distribution with a large gap between South India on one end and Assam and Bangladesh on the other. *L. keralensis* show more advanced characters and it could be treated as the most highly advanced species and the connecting link between the genera *Lagenandra* and *Cryptocoryne* (Sivad. *et* *al*, 2001). *Cryptocoryne consobrina* Schott closely resembles *C. sivadasanii* (Bogner, 2004). The typical habitats of the constituent species are mostly the beds and banks of streams and rivers with usually not too rapidly flowing water. They also occur in seasonally inundated forest pools or marshy areas.

CRYPTOCORYNE Fischer ex Wydler.
Type: *Cryptocoryne spiralis* (Retz.) Fischer ex Wydler. (*Arum spirale* Retzius)

Cryptocoryne cognata Schott, Bonplandia 5: 222. 1857, Prodr. Syst. Aroid. `16. 1860; Engler in DC., Mon. Phan. 2: 629. 1879; in Engler, Pflanzenr11.23F (73): 247. 1920; Hooker, Fl. Brit. India 6: 494. 1893; Cooke Pres. Bombay 2. 819. 1908; De Wit, Het Aquarium 31 (2): 31. 1960; Patil, Yadav & Dixit, Aqua Planta 17 (2): 59-65. 1992.
Type: India, Concan, Law, s.n., (Holo-K)

Rhizome thick, short ca. 2.0 cm long and 1 cm thick, brown in colour. Leaves ca. 15 cm long; Petioles ca. 8 cm, long, green with sometimes a reddish tinge, green towards lamina, sheathed up to 2.6- 8 cm, rarely the whole petiole is sheathed. Lamina ca. 10 cm long and 3.25 cm wide, broadly lanceolate, base and tip narrowed, broadest in the lower third or in the middle, margins entire to undulate. Peduncle ca. 3 cm long, white. Spathe ca.17.2 cm long; kettle ca. 4.2 cm long, in the lower part ca. 0.6 cm wide, white or light pinkish coloured, upper tube ca. 1.7 cm long and 0.48 cm wide at base, spathe margins forming the tube pressed to each other, but not fused; limb ca. 11 cm long and 0.9 cm wide, always seen above the ground level, collar present at base of limb, yellow to white, with purple spots, limb purple coloured and warty within, purplish green on the outside, 1 to 2 times spirally twisted. Spadix ca. 4.5 cm long; female portion ca. 0.4 cm long, female flowers ca. 6 in number; stigma sessile; ovary with ca. 11 ovules with sub basal placentation; the number of olfactory bodies varies from 6 to 12; sterile naked interstice ca. 3.6 cm, long; male portion ca. 0.32 cm long.
Distribution: Endemic in South West India. There are two known localities in Maharashtra State, in Ratnagiri District in the villages Phansop and Pali; in Sindhudurg district in the villages of Pimpalwadi. The species is also reported from Goa.
Specimens examined: Maharashtra State: Ratnagiri Distr., Bhatia, 22 August 1990, *K.S. Patil 0328D-F* (CALI); Ratnagiri Distr., Bhatia, Sept.1990, *K.S.Patil 0329A* (CALI); Ratnagiri Distr. Bhatia sept.1990, *S.R. Yadav 0329B* (CALI); Sindhudurg District, Vaibhavwadi, 6 Nov.1998, *CU 79915*; Goa: Dicholi 7 Nov. 1998, *CU 79916*. (CALI).

Cryptocoryne consobrina Schott, Bonplandia 5: 222. 1857; Prodr. Syst. Aroid. 16. 1860; Engler in DC. Monogr. Phan. 2: 626. 187; Hook.f.,Fl.Brit. India 6:493.1893; Engler, Pflanzenr. IV. 23F (73): 247. 1920; Fischer in Gamble, Fl. Pres. Madras 1575.1931, in Hooker's Icon. Pl. 34:t. 3305.1939; De Wit, Het Aquarium 31 (5): 112. 1960; Misc. Pap. Landbouwhogeschool 6: 265.1970; Aquarienpfl. 142. 1971; Rataj, Stud. CSAV 3: 42.1975; Jacobsen, Cryptocoryner 54. 1979; Cook, Aqua. Wet. Pl. India 55.1996. Sivadasan, Aqua Planta 10 (2): 3. 1985.
Type: 'Maisor & Carnatic', 'Nilgherries', Herb. Ind. Or. *Hooker f. &Thomson, 'Madras Coll. No. 34* (Holo-K; Iso-L, GH) .

Rhizomatous creeping perennials. Rhizome ca. 0.8 cm thick and with transverse nodal ridges. Leaves usually dimorphic; lower submerged leaves petiolate, petiole ca. 4 cm long; leaf blade linear-lanceolate, base acuminate, margins undulate, apex acuminate, dark coloured, upper emergenet leaves petiolate, petiole ca. 2.5 cm long; leaf blades linear-lanceolate, base cuneate, margins entire, apex acute to acuminate, uniformly green, thick, midrib thick. Inflorescence with peduncle ca. 0.2 cm long, up to 8 cm during infructescence; spathe with basal slightly swollen cylindrical tube ca. 2.2 cm long and 7 mm diam., light pink and deep purple within; transverse septum roofing the kettle creamy in colour with many purple spots; upper tube ca. 7.0 cm long and

3.5 mm in diam., slightly twisted, with a collar around the mouth and purplish spots at the throat within and down below, and an apical , expanded, ovate lanceolate, long-acuminate limb portion of ca. 4.0 cm long and 0.8 cm broad, sometimes refluxed, tip 1-2 times twisted, greenish brown outside, usually yellowish green within with purplish spots, verrucose, margins with purple warty teeth-like projections. Spadix enclosed in the tube, ca. 1.8 cm long with conoid pistillate portion at base to ca. 2.5 mm, followed by a sterile naked interstice of ca. 8 mm long, creamy with purple spots, staminate portion ellipsoid, ca. 3.0 mm long, and a terminal sterile appendix of ca. 1mm long. Female flowers 5-6 at the base , connate in a whorl, each ca. 2.5 mm long and 4 mm broad, 1-locular, stigma sessile, circular with central depression and short papillate; ovules ca. 15 in each ovary; few neuter flowers present just above the pistillate portion. Male flowers ca. 70, each with a single bithecal sessile purplish stamen, each theca with marginal rim and a terminal tubular horn with an apical pore. Infructescence conoid, ca. 15 mm long and 10 mm broad; seeds numerous, ellipsoid.

Distribution: South West India; near streams and river banks in dry deciduous forests, endemic to southern parts of Karnataka and central and northern parts of Kerala in India.

Specimens examined: Karnataka: Cauvery Nissargadama, ca. 1,000 m above MSL., Coorg Dist., Karnataka state, ca. 1,000m MSL, 27 Jan 2006, *C.N. Sunil 4102* (plants with inflorescences) (CALI) ; 03 Mar 2007, *C.N. Sunil 4237* (plants with fruits) (CALI); Cauvery Nissargadama, Karnataka state 5th March 2012 *Abdul Jaleel RAK* 145 (SS college Herbarium, Karimbam) *Kerala*: Parambikulam river, cochin, 11 Dec. 1934, Barnes 953 (MH); *Barnes 958, 960, 961, 962* (K); *Barnes s.n.* (NY) ; Karappara River , cochin, Dec. 1934; Karappara river, near Kuriarkutti, Kochin, 14 Dec. 1934, Barnes 959, 972(K); *Tamilnadu:* Aliyar submergible area, Coimbatore dist., 350 m, 24 Nov. 1962.

Cryptocoryne retrospiralis (Roxb.) Kunth, Enum. Pl.3:12. 1841; Wight, Icon. Pl. Ind. Or.3:t. 772. 1844; Schott, Aroideae 8. 1853, Sun. Ariod. 2. 1856; Bonplandia 5: 222. 1857; Prodr. Syst. Ariod. 18.1860; Engler in Mon. Phan. 2: 625. 1879; in Engler, Pflanzenr. 4. 23F (73): 246. 1920; Hook.f., Fl. Brit. India 6: 493. 1893; Cooke, Pres. Bombay 2: 818. 1908; Rao Travancore 424. 1914; Haines, Bot. Bihar & Orissa 871. 1924; Blatter & McCann, J. Bombay Nat. Hist. Soc. 35: 17. 1931; Fischer in Gamble, F1. Pres. Madras 1575. 1931; Vartak, Enum P1. Gomantak 108. 1966; De Wit, Belmontia 13: 263. 1970; Nicolson in Sald. & Nicols., F1. Hassan Dist. 786. 1976; Rao & Razi, Syn. Fl. Mysore Dist 584.1981.

Type: Roxburgh's unpublished drawings (Lecto-1792 of *Ambrosinia retrospirale*)

Rhizome stout, ca. 1 cm thick. Leaves linear lanceolate, green, ca. 24.6 cm long. Petioles ca.11 cm, long, basally sheathed up to ca.6cm gradually widens into ca. 13.6 cm long and ca. 0.95 cm broad, lamina margins sometimes slightly wavy, midrib pronounced. Peduncle ca. 1.9 cm long. Spathe ca. 17.9 cm long, shorter than the leaves; kettle ca. 1.8 cm long and 0.65 cm wide, 2-3 times broader than the basal part of the upper tube, upper part purplish red inside, valvule white with purplish red spots, below the male portion constricted, densely purple dotted, with small white depressed translucent windows, upper tube ca. 11.0 cm long and 0.35 cm wide, white with red spots within, greyish blue on the outside, sometimes the margins not completely fused; limb ca. 4.8 cm long and ca. 0.55 cm wide at the base, smooth, about 5 times spirally twisted, without a collar, white with purlish red spots within, grayish blue on the outside. Spadix ca. 1.6 cm, long, consisting of ca. 0.33 cm, long female portion ca. 1.0 cm long, naked interstice 0.22 cm long, male portion with ca. 180 very small stamens, and a short ca. 0.05 cm long, flattened sterile appendix. Female fowers ca. 5, white; stigmas covered with small hairs and a depression in the middle; each pistil with ca.18 ovules; olfactory bodies ca. 6, situated just above the female flowers. The syncarp pear shaped, ca. 1.3 cm long and 0.8-1 cm wide.

Distribution: Peninsular India from Maharashtra state downwards to Kerala and Tamil Nadu, and in the North East in Bengal.

Specimens examined: Malappuram Dist: Parakkadavu river side, 6th April1976, *Sivadasan CU 13126* (CALI); *CU 21419* (CALI), Palaghat Dist. Thutha river side, 16th Feb. 1978, *Sivadasan, CU 21413* (CALI), Calicut Dist: Vaithiri river, 25th Jan. 1976, De Wit, Aquariumpl. 227. 1982: Mayo et al., Gen. Araceae 197. 1997. Kannur Dist: Chapparapadavu riverside, 10th Feb 2012 *Abdul Jaleel RAK 150* (SS college Herbarium, Karimbam); Kasaragod Dist: Cherupuzha river side 15th Feb 2012 *Abdul Jaleel RAK 160* (SS college Herbarium, Karimbam).

Cryptocoryne spiralis (Retz.) Fischer ex Wydler, Linnea 5: 1830; Blume, Rumphia1: 84,t. 36C; Kunth, enum. Pl. 3: 12. 1841.

Type: *Cryptocoryne spiralis* (Retz.) Fischer ex Wydler (*Arum spirale* Retzius)

(a). *Cryptocoryne spiralis* (Retz.) Fischer *ex* Wydler **var. *cognatoides*** (Blatter *et* McCann) Yadav, Patil *et* Bogner. Aqua Planta 18 (2): 62. 1993.

C. cognatoides blatter et McCann, J. Bombay Nat. Hist. Soc. 35:17,t. 2.1931. De Wit, Het Aquarium 31(2):31. 1960.

Type: Blatter-Herbarium, Bombay.

Rhizome ca. 0.8 cm thick, roots thick and contractile. Leaves ca. 30 cm long. Petioles ca. 30 cm long, 0.4 cm wide, basally sheathed up to ca. 8.5 cm, colour varies from green to purple. Lamina linear to narrow lanceolate, ca. 14.5 cm long and 3.0 cm wide, green, top acute; midrib very pronounced; leaf margins entire, rarely wavy. Peduncle ca. 1.2 cm long. Spathe ca. 28.0 cm kettle ca. 3.5 cm long and 1.0 cm, wide, thick walled, constricted just above the middle, white, purplish both on inside as well as outside towards the top opening to the kettle covered by a septum, leaving just a small, oval opening in the middle; upper tube absent, but sometimes the lower 1cm of the limb forms a tubular structure; limb ca. 22 cm, long, basally ca. 1cm, wide, margins toothed, basal part ca. 3.5 upright, apical part sometimes 1-2 times spirally twisted, reddish outside, yellowish in the upper part and reddish purple in the lower part within, rarely completely purple, with horizontal ridges at the base and smooth at top; collar absent. Spadix ca. 3.5 cm long; female portion ca. 0.5 cm long, with ca. 5 female flowers; style very short; each pistil with ca. 5 ovules; placentation sub basal to axile; olfactory bodies 5 to 10 situated just above the female flowers; sterile naked ca. 100 male flowers; sterile appendix very short, flattened.

Distribution: Endemic to South West India. Confined to Maharashtra State (Satara, Kolhapur and Sindhudurg-district) and North Kanara district of Karnataka State.

(b). *Cryptocoryne spiralis* (Retz.) Fischer *ex* Wydler var. *spiralis*

Type: Ind. Orient., Tranquebar, Koenig s.n., (Holo-BM; Iso-C).

Rhizome with contractile roots and very thin rootlets. Leaves ca. 30 cm long. Petioles ca. 14.0 cm long, basally sheathed up to 5.5cm, green or with purplish tinge. Lamina linear to narrowly lanceolate, ca. 15 cm long and 1.3 cm broad, green or rarely with purple markings, entire or rarely undulate. The leaves vary enormously, some plants have very short dark green leaves with undulate margins and purple petioles, others have long, slender light-green petioles, midrib pronounced, green, gradually disappears towards tip, Peduncle ca. 1.3 cm long. Spathe ca. 8.7 cm, long; kettle ca. 1.5 cm long and 0.85 cm wide, inner wall constricted in the middle or upper third, the upper half partly alveolate, with a septum covering the opening to the kettle, leaving just a small oval opening in the middle; upper tube absent; limb ca. 6.9 cm, long, basal ca. 0.78 cm, wide, narrowed to the top, 1-2 times spirally twisted, outside brownish green, purple-red within, horizontal lamellae all through within or at basal two third and apically smooth. Spadix ca. 1.6 cm long; female portion ca. 0.45 cm long, with 4-6 female flowers; style very short; stigma depressed in the centre: each pistil with 7- 9 ovules; placentation axile, olfactory bodies ca. 5, situated just above the female flowers; sterile naked interstice ca. 0.65 cm, long; male portion ca. 0.35 cm long, with ca. 75 male flowers; sterile appendix short, flattened. Syncarpium, elliptical, ca.1 cm long and 0.6 cm wide.

Distribution: South India towards Maharashtra and Bengal and in Bangladesh.

Specimens examined: Kozhikode Dist.: Kuttiadi bridge (Neemhattupaku), 24th Dec. 1984, *Sabu & Sivadasan, CU 36574* (CALI), Ramanattukara, 4th April1976, *Sivadasan, CU 13114*; Chorod,. 6th April 1978, *Sivadasan, CU 21416* (CALI); Malappuram Dist.: Tirur, *Sivadasan, CU 21435* (CALI); Parakkadavu river side, *Sivadasan, CU 13125* (CALI); Ramanattukara, Calicut Dist., 4th April 1976, *Sivadasan, CU 13113*. Kannur Dist: Madayippara 17th Feb. 2012, *Abdul Jaleel*, *RAK 162* (SS college Herbarium, Karimbam) ; Kodiyeri, Thalasserry 21 Feb. 2012, *Abdul Jaleel, RAK 165* (SS college Herbarium, Karimbam).

Cryptocoryne sivadasanii Bogner,

Type: Holotypus: India, Kerala, Malappuram Dist., stream-bed in Vallamthodu ,2.2.2004, *Sivadasan & Kiran Raj CU 21595* (CAL; Isotype: K, M, MH) Willdenowia 34: 195. 2004 .

Rhizomatous perennials, rhizome ca. 5 cm long and 0.5 cm diam., often with nodal ridges; roots ca. 2 mm diam. Leaves several, the submerged ones very long, the emerged ones short without normal blades; petiole ca. 18 cm long and 0.1 cm in diam., sheath ca. 8 cm long, leaf blade ca. 70 cm long and ca. 0.5 wide, linear, tip apiculate, margin entire, sometimes rarely undulate to wavy, olive to purplish green, midrib light green, not very pronounced. Peduncle ca. 2 cm long and 0.25 cm in diam. Spathe ca. 7 cm long; kettle ca. 2 cm long and 0.7 cm in dia., somewhat constricted below the male portion, white at base and purplish above inside; tube between kettle and limb ca. 2.5 cm long and 0.5 cm in diam., with purplish spots inside; limb ca. 2.5cm long and 1 cm broad at base, ovate, acuminate, tip spirally twisted and recurved, warty inside, its colour yellowish green to purplish, reddish brown, bluish green or cream, collar present at base of the limb, warts present on the limb above the collar. Spadix ca. 15-28 mm long, the basal female portion ca. 5 mm long, the naked slender interstice (axis of spadix) ca. 8 mm long, the male portion ellipsoid to globular, ca. 3 mm long and 2 mm in diam., with ca. 60 male flowers, the terminal, short elongate-conoid appendix ca. 1.25 mm long. Flap elliptic, ca. 3 mm long and 2 mm wide, whitish. Male flowers consisting of one stamen only, ca. 0.5 mm long and 0.3 mm wide with a conspicuous rim at the top and two bilocular thecae, each with a tubular horn, opening apically by a small pore. Female flowers ca. 3-4, ca. 4 mm high, connate in a whorl; stigma sessile, ca. 0.7 mm in dia., round, with slight depression in the centre, covered with short papillae; each ovary with ca.12 ovules; olfactory bodies usually 4, rarely to 6, obconoid with a rough and flat top, each ca. 0.3 mm long and 0.75 mm in diam., situated just above the female flowers and alternating with the stigmas. *Infructescence* ovoid, ca.18 mm long and 10 mm in dia., *Seeds* 5-8 per ovary, more or less ellipsoid, ca. 4 mm long and 1.5 mm wide, brownish; testa more or less smooth or finely punctate, not ribbed; embryo elongate, ca. 1.8 mm long and 0.4 mm dia., endosperm copious, white, ca. 0.4 mm thick.

Distribution: Endemic to Kerala and southwestern Karnataka. Only few localities are known, some near the Calicut University Campus in Malappuram District, Kerala State, and one in Padubidri between Mangalore and Udupi in the southern Kanara District, Karnataka State.

Specimens examined: Kerala State: *Malappuram Distr.*, Thenjhipalam, Vallamthodu, 23.10.1976, *Sivadasan CU 19160* (CALI); ibid., 14.3.1981, *Sivadasan CU 21480* (CALI); Malappuram Distr: Small stream 1 km south of Calicut University Campus, alt. c. 45 m, 22.12.1993, *C. D. K. Cook & M. Camenisch 5224* (Z); Malappuram Distr., small roadside stream, c. 6 km south of Calicut University Campus, alt. c. 20 m, 20.11.1993, *C. D. K. Cook & M. Camenisch 5222* (Z); *Kozhikode Distr.*, Ramanattukara, 3.12.1993, *C. D. K. Cook & M. Camenisch 5321* (Z).

Karnataka State: S Kanara Distr., Padubidri, 30.1.2004, *Sivadasan CU 21594* (CALI). Thenjhipalam, Vallamthodu, 25.02.2012, *Abdul Jaleel KAR 165*(SS college Herbarium, Karimbam).

LAGENANDRA Dalzell, in Hooker's J. Bot. Kew Gard. Misc. 4: 289. 1852.

Lagenandra keralensis Sivadasan et Jaleel, Bot. Bull. Acad. Sin. 42:153-157.

Type: India, Kerala, Ernakulam Dist., Boothathankettu near Kothamangalam, ca. 750 m. 15th Jun 1997. Bobby Thomas RIA 85 (Holotype: K, with inflorescence and infructescence; isotype: M, with inflorescence and infructescence: CAL, with inflorescence).

Rhizome ca. 4.5 cm long and 0.5 cm broad, pale to dark brown in colour; roots numerous. Cataphylls ca. 2 cm long and 0.5 cm broad at base, tapering towards the tip, base white, light purplish spotted on the upper half, thin membranous. Leaves ca. 7.5 cm long, lamina ca. 2.5 cm long and 2.4 cm broad, ovate acute-acuminate at apex, base auricles, usually light purplish. The entire surface bears unicellular hairs, more prominent and cosely arranged on the mid vein as well as the primary and secondary laterals. Leaf margin closely undulate; Petiole ca. 3.5 cm long and 0.5 cm across at apex, basally sheathing. Inflorescence ca. 6.5 cm long, peduncle 2.5 cm long and 0.1 cm dia., basal tube slightly broader than the limb, ca. 0.7 cm long and 0.6 cm diam, light purplish to pink in colour outside with small ridges extending up to half of limb, purplish within. Limb ca. 1.2 cm long and 0.5 cm across, curved towards one side with a narrow oblique opening ca. 0.8 cm long and 0.3 cm wide and with a basal, thin, arch like collar; the upper portion of the limb caudate. Inner flap of the opening with a few warty projections on its margin. Caudate tip tapering, erect or sub-erect, ca. 2.5 cm long, light purplish in colour. Spadix ca. 1 cm long , with pistillate portion at base to ca. 2 mm followed by a sterile naked interstice of ca. 4 mm, a staminate portion of 2 mm long. The pistillate portion comprises ca. 7 female flowers in a single whorl; each flower sessile, short flattened and conical or slightly laterally compressed, ca. 2 mm long and 1.5 mm broad, white in colour, warty at apical portion a wing-like extension on either sides below the stigmatic portion. Stigma obcordate, with two obconic basal lobes recurved to the adaxial side of the flower. Ovary unilocular with 4-8 orthotropous ovules surrounded by numerous placental trichomes. Olfactory bodies 5-8, clavate, or above the pistillate portion, each ca. 1 mm long, white in colour. Staminate portion ca. 2 mm long and 1.5 mm across, cream coloured. Male flowers ca. 90, spirally arranged, each with two tubular projections at apex through which pollengrains are liberated . Beyond the male zone, spadix is produced into a short fleshy sterile conical appendix, ca. 1 mm long and 0.5 mm diam. at base. Peduncle elongating during seed setting, and reaching to ca. 5 cm long. Infructescence with persistent basal tubular portion of the spathe, ca. 1.2 cm long and 0.8 cm diam. Berries fleshy with irregular rough surface; dehiscing by longitudinal splits from base upwards with recurved lobes. Seeds 4-8, each ellipsoid, ca. 6 mm long and 1.5 mm across with few longitudinal ridges.

Specimens examined: India, Kerala, Ernakulam Dist., Bhoothathankettu, 8 Jun 1997, *Pradeep RIA 82* (with inflorescence, CALI); 21 Jun 1997, *Bobby Thomas RIA 91a* (with inflorescence, CALI); 21 Mar 1999, *Abdul Jaleel RIA 329* (with inflorescence).

Lagenandra meeboldii (Engl.) Fischer in Gamble, Fl. Pres. Madras 1576. 1931; de Wit, Aquarienpfl. 230. 1971, Meded. Landbouwhogeschool 78-12: 29.1978.

Type : Karnataka state, Mysore, Agalhatti, 3500", Nov. 1908, Meeebold 9235(B).

Rhizome ca.1.25 cm diam., leaves with petiole ca. 15 cm long, basally sheathed to ca. 2.5 cm; lamina ca.10 cm long and 5 cm broad, usually ovate to oblong-acute or shortly acuminate, base rounded-cordate;

cataphylls abaxially 2-keeled, ca. 4 cm long, ca. 2 cm broad. Inflorescence greenish purple in colour; peduncle ca. 6 cm long; spathe ca. 8 cm long with tubular basal portion to ca. 2.2 cm long and 1.2 cm diam., upper expanded limb portion ca. 3.0 cm long. The tubular portion light purplish outside and dark purplish inside with slight longitudinal ridges. The dialated limb portion yellowish green outside with yellowish white, irregularly arranged dense patches of fimbriate lamellae; slender, greenish purple, ca. 5.5 cm long. Spadix ca. 3.5 cm long with a basal sub globose pistillate portion, followed by a slender interstice of ca. 1.1 cm long, a cylindric staminate portion, and terminating into a short appendix which is attached to the auricular flap. The pistillate portion globose, containing ca. 65 pistillate flowers, few clavate neuter flowers on the upper portion of the pistillate mass around the base of the interstice; each pistillate flower ca. 1.8 mm high and 1.4 mm diam., externally muricate on the upper portion; ovary unilocular with 3-8 basal orthotropous ovules surrounded by placental hairs; stigma sessile with a central pit. Staminate portion cylindrical or sub conical, composed of ca. 110 sessile staminate flowers; each flower ca. 0.5 mm high with two anther lobes, each anther lobe bears a short tubular projection at its apex through which the pollen grains are liberated; Spadix appendix short, conical, ca. 1.7 mm high with apical tapering projection. Infructescence globose with many fruits. Each fruit more or less fleshy capsule, fruit wall muricate mainly on the upper one-third; vestige of stigma is seen on the top of the fruit; each fruit contain usually 2-4 seeds; seeds elliptic.

Distribution: South India, Particularly in Karnataka and southwards.

Specimens examined: Palakkad dist., Karappara river, ,26.02.2012, *Abdul Jaleel KAR 167* (SS college Herbarium, Karimbam).

Lagenandra nairii Ramam. & Rajan, J. Bombay Nat. Hist. Soc. 80:613.1984.

Type: Kerala State, Trichur Dist., Athirappally water falls in Chalakkudi river, alt. 300 m, 17 Mar. 1982. Rajan 73052 (CAL)

Rhizome ca. 1.5 cm diam., leaves with hairy petiole ca. 15 cm long basally sheathed to ca. 3.5 cm; lamina broad, elliptic-oblong to ovate, with undulate margin, acute at aped , cordate at base, ca. 15 cm broad, densely hairy. Cataphylls abaxially 2-keeled Inflorescence with spathe ca.4.5 cm long, basal tube ca. 1.2 cm long and 1 cm diam, limb ca. 2 cm long ovate-oblong, oriented in more or less at right angles to the tube, ovate-oblong, tip acute or acuminate margin internally serrate, greenish purple in colour; a prominent collar present at the base of the limb; spathe hairy outside, irregularly hairy lammellate and light purplish within except the collar region; yellowish below the collar. Spadix about ca. 1.8 cm long with lower portion occupied by a mass of pistillate flowers followed by a slender interstice of ca. 0.8 cm long, a cylindrical mass of staminate flowers, and terminating into an elongate conical appendix of ca. 1.5 cm long. Pistillate portion contain ca.18 pistillate flowers arranged in more or less 2 rows; each flower ovate-truncate, ca. 2.0 mm high and1.0 mm diam., ovary unilocular with ca. 5 basal orthotropous ovules. Few neuter flowers present just at the base of the interstice. Staminate portion cylindrical, composed of ca. 70 staminate flowers, each flower ca. 0.4 mm high, 0.2 mm across with two anther lobes, each lobe bears a short tube at its apex through which the pollen grains are liberated. Infructescence with a receptacular base of the spathe containing ca. 18 truncate, conical tipped fruits; each fruit more or less a fleshy capsule, muricate mainly on the upper one-fourth region and with persistent portion. Seeds elliptic with longitudinal ridges.

Flowering and Fruiting: February-May

Distribution: Kerala state, Trichur dist., Athirapally waterfalls in Chalakkudi river.

Lagenandra ovata (L.) Thwaites, Enum. Pl. Zeyl. 334. 1864; Engler, Pflanzenr, IV 23F (73): 228. 1920, Pro parte, excl., Fischer in Gamble, Fl. Pres. Madras 3: 1576. 1931; Nicols. In Sald. & Nicols.,Fl. Hassan Dist. 787. 1976; *Karin pola* Rheede, Hort. Malab. 11.45, t. 23. 1692.

Type: Kerala, Illustration of Karin-pola (t. 23) published by van Rheede in Hortus Malabaricus (Vol. 11, 1962) . (vide de Wit, Meded. Landbou-whogeschool 78-13: 5. 1978)

Rhizome ca. 4 cm.; leaves with petiole of ca. 55 cm, basally sheathing to ca. 10 cm; lamina ca. 35cm long and 10 cm broad, ovate-oblong, acute, margin entire, base acute-cordate. Cataphylls long, abaxially 2-keeled. Inflorescence large, dark purplish in colour; peduncle ca. 22 cm long; spathe ca. 18 cm long with basal tubular portion ca. 4.5 cm long and 2 cm diam., and upper limb portion with a lower swollen warty part about ca. 6 cm long and 5 cm broad which gradually tapers into a twisted thick warty tail of ca. 7 cm long. The inner surface of the limb portion is with irregular horizontal lamellations. At the junction of the basal tube and the upper limb a thick spongy mass of tissue forming a convex partition between the two with a narrow apical opening and an inner auricular flap is present. Spadix ca. 4 cm long with basal sub globose pistillate portion followed by a slender interstice of ca. 2 cm long, a cylindrical staminate portion and terminating into a short appendix. The pistillate flowers ca. 110, arranged in close spirals, ca. 8 nueter flowers are seen just above the pistillate flower, ca. 3 mm high and 2 mm diam., with muricate projections all over, mostly on the upper three-fourths; ovary unilocular with one basal orthotropous ovule surrounded by many placental hairs; stigma sessile, sub globose with a central small pit. Staminate portion composed of ca. 180 staminate flowers; each flower sessile, ca. 0.5 mm high with two anther lobes, each bearing a short tubular projection at its apex through which pollen grains are liberated. The spadix appendix ca. 1.8 mm high conoid. Infructescence globose with many fruits, each fruit is more or less a fleshly capsule, wall is muricate on upper one-fourth region; persistent stigmatic area is seen as a small cap like projection on the top of the fruit; seed single, ovoid-elliptic with longitudinal furrows .

Flowering and Fruiting: September-February.

Specimens examined: Trivandrum Dist., Nedumangad, 28.02.2012, *Abdul Jaleel KAR 169* (SS college Herbarium, Karimbam).

Lagenandra toxicaria Dalzell, Hooker's J. Bot. Kew Gard. Misc. 4: 289. 1952; Schott, syn. Aroid. Aroid. 3. 1856, Prodr. Syst. Aroid. 19. 1860; Engler in DC., Monogr. Phan. 2: 621. 1979; Hooker, Fl. Brit. India 6: 495. 1893, *pro parte,* excl. *L. ovata*; de wit, Meded. Landbouwhogeschool 78-13: 12.1978.

(a). *Lagenandra toxicaria* var. *barnesii* Fischer, Bull. Misc. Inf. 1938(3): 126.

Type: Nilgiri-Wynad, near Nadgani, 3000 ft., June 1937, Barnes, 1523 (K).

Rhizome ca. 4.0 cm diam., leaves with petiole ca. 45 cm long 0.5-1.0 cm diam., basally sheathing to ca. 8.0 cm; lamina oblong, acuminate, ca. 35 cm long and 12 cm broad, with pinnately parallel venation. Cataphylls abaxially 2-keeled. Inflorescence with a short peduncle ca. 2 cm long; spathe light pinkish or greenish pink in colour, ca. 14 cm long outer surface smooth, basal tube of the spathe ca. 2 cm long and 1.2 cm diam.; limb long ovate, ca. 3 cm long and 1.5 cm diam., gradually tapering into a long caudate tip of about 6 cm long; limb twisted and bent downward at maturity, dark purplish within and bearing closely packed irregular fimbriations. The spadix ca. 1.8 cm long with basal globose pistillate portion followed by a slender barren interstice of ca. 3 mm long , a conical or sub globose staminate portion, and terminating in a short conical appendix with small projection. The pistillate flowers are in close spirals. About 6-10 neuter flowers are seen around the base of the interstice just above the pistillate zone. Pistillate flowers are about ca. 75, more or less truncate, each ca. 2mm high and 1 mm diam., externally muricate on the upper half; ovary unilocular with 4-7 basal orthotropous ovules and thin placental hairs; stigma sessile, hexagonal with a central raised portion. Staminate flowers ca. 175-200, each flowers sessile and ca. 0.5 mm high with two anther lobes, each anther lobe bear a short tubular projection at its apex. The spadix appendix is flat conical with an apical tapering projection. Infurctescence sub globose with many fruits. Fruit more or less a fleshy capsule, with elliptic, longitudinally ridged seeds.

Flowering and Fruiting: February-May.

Distribution: South West India.

Specimens examined: Kozhikode Dist., Thusharagiri, 30.02.2012, *Abdul Jaleel KAR 170* (SS college Herbarium, Karimbam).

(b). *Lagenandra toxicaria* var. *toxicaria* Dalzell

Type: Bombay (no date), Daizall s.n. (K).

Rhizome ca. 2.5 cm diam.; leaves with a long petiole of ca. 20 cm long and 2 cm diam., with basal sheathing to ca. 4 cm. Cataphylls abaxially 2 keeled, ca. 8 cm long and 1.5 cm broad. Lamina broad, ovate-oblong, acute, base acute-cordate, ca. 25 cm long and 7 cm broad. Roots to ca. 30 cm long. Inflorescence with spathe ca.10 cm long having a basal tubular portion ca. 2 cm long and 1.5 cm diam., and an upper limb portion with lower expanded ovate portion of ca. 2.5 cm long which abruptly narrows to form a slender tail ca. 6 cm long. The tubular portion is light purplish outside, dark purplish within, expanded limb greenish purple outside, dark purple with irregularly arranged fimbriations on the inner side. Spadix ca. 1.5 cm long with a basal pistillate portion followed by a slender interstice of ca. 0.3 cm long, a cylindrical staminate portion, and terminating into a short conical appendix. The pistillate portion consists of spirally arranged closely packed pistillate flowers ca. 50 in number, few neuter flowers are just above the pistillate zone. Each pistillate flower ca. 1.5 mm high and 1.4 mm diam., externally muricated on the upper three-fourths; ovary unilocular with 4-8 basal orthotropous ovules surrounded by thin placental hairs; stigma sessile; flat, haxagonal, more or less covering the top of the ovary and with a central pit. Staminate portion more or less conical, with ca. 100 staminate flowers , each flower sessile, ca. 0.4 mm with two another lobes, each lobe bears a short tubular projection at its apex through which the pollen grains are liberated out. Infructescence more or less globose with many fruits; each fruit a capsule; fruit wall muricated mainly on the upper three-fourths; seeds elliptic with longitudinal ridges.

Flowering and Fruiting: December-March.

Distribution: South India.

Specimens examined: Kannur Dist., Taliparamba, Muyyam, 02.03.2012, *Abdul Jaleel KAR 172* (SS college Herbarium, Karimbam).

Taxonomic analysis

In Peninsular India, the genera *Cryptocoryne* and *Lagenandra* are equal in number, five genera and one variety each. The species of *Cryptocoryne* are viz. *C. cognata* Schott, *C. consobrina* Schott, *C. retrospiralis* (Roxb.) Kunth, *C. sivadasanii* Bogner and *C. spiralis* (Retz.) Fischer *ex* Wydler and one variety viz. *C. spiralis* var. *cognatoides* (Blatter *et* McCann*)* Yadav, Patil *et* Bogner. *C. cognata* is restricted to Maharashtra and Goa; *C. consobrina* is restricted to Kerala, Tamilnadu and Karnataka; *C. retrospiralis* is widely distributed in Kerala, Tamilnadu, west Bengal and Northern states; *C. spiralis* var. *spiralis* is widely distributed in Kerala, Tamilnadu, Karnataka, Maharashtra and west Bengal; *C. spiralis* var. *cognata* is restricted to Karnataka and Maharashtra; and *C. sivadasanii* is restricted to Kerala and Karnataka.The species of *Lagenandra* are, viz. *L. keralensis* Sivad. *et* Jaleel, *L. meeboldii* (Engl.) C. E. C. Fisch., *L. nairii* K. Ramamurthy *et* R. Rajan, *L. ovata* (L.) Thwaites, and *L.*

toxicaria Dalzell, and one variety, viz. *L. toxicaria* var. *barnesii* C. E. C. Fisch. *L.toxicaria* and *L.meeboldii* are restricted to South west India; *L.ovata* is restricted to Southern part of Kerala; *L. keralensis* and *L. nairii* are restricted to Central part of Kerala.

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References

1. **Bogner, J. 2004.** *Cryptocoryne sivadasanii* (Araceae), a new species from India. *Willdenowia* 34: 195-201.
2. **De Wit, H.C.D. 1978.** Revisie van het genus *Lagenandra* Dalzell (Araceae). Meded. Landbouwhogeschool 78: 5-14.
3. **Engler, A. 1920.** Araceae-Aroideae und Araceae-Pistioideae. *In* A. Engler (ed.), Das Pflanzenreich 73(IV-23F): 1-274.
4. **Mayo, S. J., J. Bogner & P.C. Boyce. 1997.** *The genera of Araceae*. Royal Botanic gardens, Kew, England.
5. **Schott, H.W.1860.** Prodromus systematis Aroidearum. Typis Congegations Mechitharistica, Wien, pp.602.
6. **Sivadasan, M., V. Abdul Jaleel & Bobby Thomas. 2009.** *Lagenandra keralensis* (Araceae), a remarkable new species from India. Bot. Bull. Acad. Sin. 42:153-157.

Study of Polymorphism in different species of the genus *Polypleurum* belonging to the family Podostemaceae

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Abstract

The state of Kerala encompasses 80% of the Podostemaceae members of our country. Most of the 44 rivers in Kerala originate in Western Ghats and they are rich in Podostemaceae. This rheophytic family is unique due to their peculiar morphology and habitat of the members and are incapable of growing in still water. Plant body is not differentiated into root and stem, but "thallus-like", herbaceous and attached to rocks by means of haptera. The intraspecific variations among the members of the family Podostemaceae are very peculiar and most members show polymorphism, particularly the genus *Polypleurum*. Plant body of *Polypleurum* is ribbon-shaped, free-floating or completely creeping with marginal flowers. Four species are reported from Kerala; *P. stylosum, P. prostratum, P. minor* and *P. discifome*.

Key words: *Polypleurum,* Podostemaceae, polymorphism

Introduction

Podostemaceae is the largest family of submerged flowering plants community known as 'River weed family' due to their peculiar morphology and habitat of the members. In their simplicity of structure, they resemble Algae and Bryophytes. The family comprises 48 genera and about 270 spp. (Grubert, 1975, 1991; Cook 1990; Mohan Ram and Sehgal, 1992; Philbrick and Novelo, 1993, 1995). *Maurera fluvitalis* collected from French Guiana by Aublet (1775) is the first recognized member of the family (Willis, 1902 b).

Indian Podostemaceae have been reported from Himalayas, Arunachal Pradesh, Meghalaya, Assam, Orissa, Madhya Pradesh, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Cook, 1996). The Western Ghats run primarily North South for a length of 1600 km from the Tapti river to Kanyakumari, thus forming a continuous chain along the Eastern side of Kerala State. In Kerala the Western Ghats have an average height of 950 metre, with the highest elevations reaching 2600 metre. The presence of W. Ghats combined with the North East and South West monsoons provide a subtropical climate and seasonally flooded mountainous rivers – ideal conditions for Podostemaceae. Most of the 44 rivers in Kerala originates in W. Ghats and they are rich in Podostemaceae. According to Mathew and Satheesh (1997), the state of Kerala encompasses 80 percentage of the Podostemaceae of our country. Nileena (2001) collected 10 genera and 17 species including 3 new species from Kerala rivers.

Podostemaceae is a very interesting group of aquatic angiosperms with unlimited scope for investigation. Many of the members of this family such as *Polypleurum stylosum* show the phenomenon of polymorphism. The degree of polymorphism is so high that Nileena (2003) had proposed two new species for *Polypleurum: P. prostratum* and *P. disciforme*. The present study deals with the thorough investigation of morphology of four different species of *Polypleurum* collected from different localities with special reference to the phenomenon of polymorphism.

Material and methods

Members of Podostemaceae exist near the sources of rivers and small streams which appear during the monsoon seasons. The sites of collections were often in remote forest areas and high ranges, which could be reached only by jeep. The plants were in bloom during December to January. The rivers particularly near the sources started drying after January. During March and May, due to intense sunlight and hot weather, the plants became exposed and gradually they dried up. No collections could be made between June and August as the river sources were flooded during this period.

The collected materials were preserved in 15 % for formaldehyde for morphological study. These were examined under a Carlseize Binocular dissection microscope for studying morphological features. Occasionally a compound microscope was also used.

Details of specimens used for the study

1. **P. stylosum:** Collected from following localities
   Thommenkuthu, Mulappurum, Valara, Pooyamkutty, Kannanpara, Urulanthanny, Blavana (Idukki district).
   Teekoy, Adukkam, Eelakkayam (Kottayam district).
   Thirunelli – Kabbani River (Wayanad district)
   Silent valley – Kunthipuzha (Palakkad district)
   Kulathupuzha – (Kollam district).
2. **P. prostratum:** Collected from following localities
   Churuli, Karimban, Cheruthoni, Panamkootty, Vellathooval, Kuthungal, Mangathotty, Vimalacity – Vellathooval, Urulanthanny (Idukki district)
   Mangalagiri – Teekoy (Kottayam district)
   Mukkadavu – (Kollam district)
   Elanthukadavu – (Calicut district)
3. **P. minor:** Collected from following localities
   Pullampara – (Calicut district)
   Melukavu, Teekoy (Kottayam district)
   Karimanal, Pambla, Pakuthipalam, Churuli, Vellathooval, Vimalacity, Muttukadu (Idukki district)
   Perumthenaruvi - (Pathanamthitta district)
   Palaruvi – Thenmala – (Kollam district)
4. **P. disciforme :** Collected from following localities
   Kurumkayam – (Calicut district)
   Pooyamkutty, Kuthungal – Panniyar (Idukki district)

Observations

The members of the genus *Polypleurum* are rheophytic, herbaceous, submerged plants attached to rocks by haptera. Plant body is ribbon-shaped or disc-shaped, free-floating or completely creeping. Vegetative shoots marginal submarginal, later transformed into floriferous shoots.

Key to the species collected from Kerala rivers

Thallus ribbon shaped, thick, upto 30 cm long, attached by haptera at the base only, other portions free-floating, spathella funnel shaped and symmetric.. ***P. stylosum***

Thallus ribbon shaped, thick, less than 10 cm long, attached by haptera at the base as well as at other points of contact with the substratum and grows parallel to the substratum, spathella funnel shaped, symmetric rarely asymmetric .... ***P. prostratum***

Thallus ribbon shaped, thick or thin up to 5 cm long, attached by haptera present all along the underside of the thallus, completely creeping, spathella funnel-shaped, symmetric or asymmetric .... ***P. minor***

Thallus disc-shaped, thick, 5-7mm diameter, attached by haptera at the centre of the underside of the disc-shaped thallus, spathella funnel-shaped, symmetric or asymmetric .... ***P. disciforme***

1. *Polypleurum stylosum* (Wight) J.B. Hall.

Thallus (plant body) ribbon shaped, thick, brown-coloured, upto 30cm long and 5-10mm broad, attached to rocks by haptera at the only, while other portions are free-floating (Fig. 1); vegetative and floral shoots marginal, flowers present towards the older parts of the thallus.

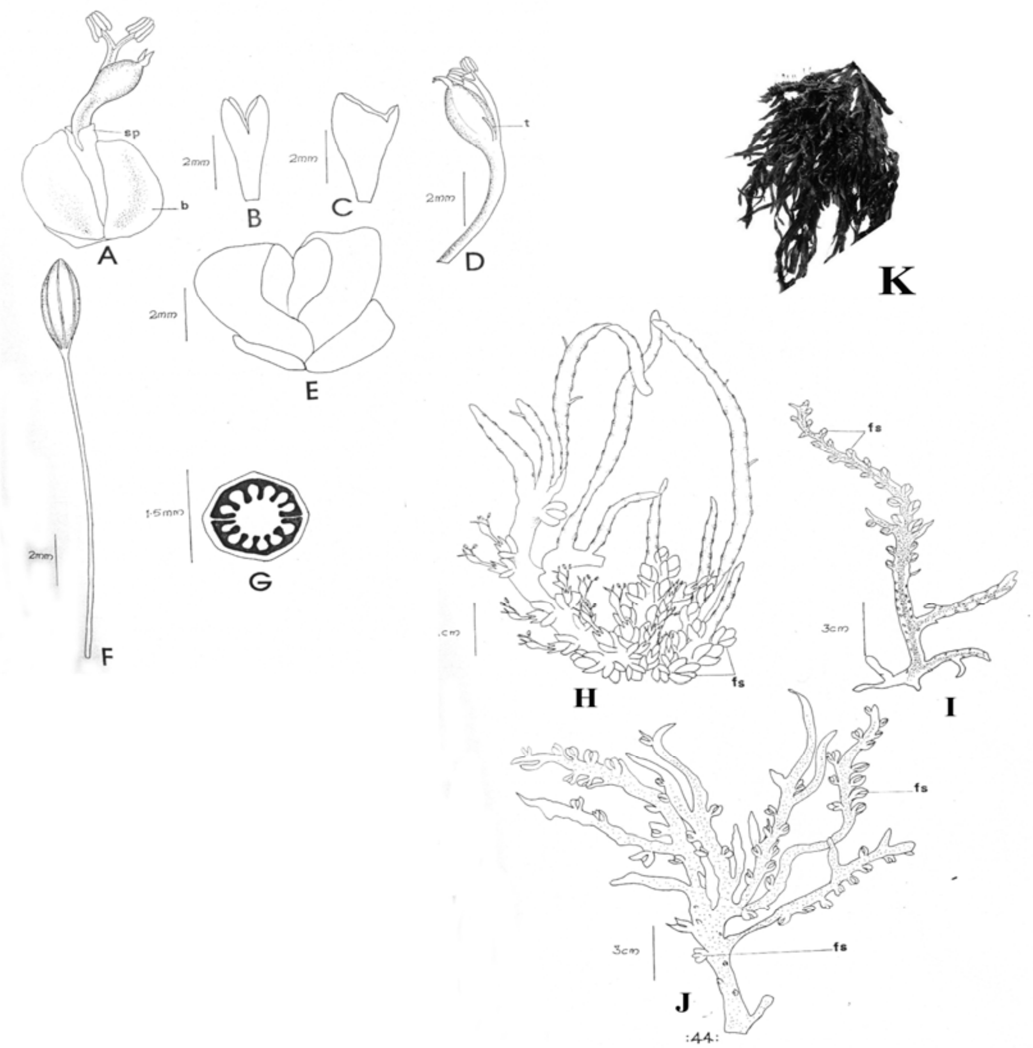

Fig. 1: A: Flower with Spathella and bracts; **B**: Funnel shaped spathella; **C**: Two lobed Spathella;
D: Flower after removal of spathella; **E**: 2 pairs of bracts; **F**: Fruit; **G**: Ovary C.S.;
H: Thallus showing floral shoots crowding towards the base; **I**: Thallus with floral shoots towards the tip;
J: Floral shoots distributed more or less equally all along the thallus;
K: Photograph showing habit of *P. stylosum*

Table 1: Intra specific comparison of *Polypleurum stylosum* collected from different localities

Character	Cheeyappara	Pooyamkutty	Thommenkuthu	Eelakkayam
Thallus	Up to 7 cm long and 5-6 mm broad	Up to 10 cm long and 3-5 mm broad	Up to 15 cm long and 2-6 mm broad	Up to 30 cm long, more than 1 cm broad
Position of the vegetative and floral shoots	Arranged towards the base of the thallus	Arranged towards the base only	Equally distributed on the thallus	Equally distributed on the thallus
Bracts	4-6	2-4	2-4	2-3
Spathella	Up to 7.5 mm long, 3 or more lobed	Up to 4-5 mm long, 7-8 lobed	Up to 4 mm long, 3 lobed	Up to 4-5 mm long, 2 lobed, one lobe again forked
Tepals	Up to 2 mm long, shorter than the ovary	1.5-2 mm long, shorter than the ovary	Up to 0.75 mm long, shorter than the ovary	2-2.2 mm long, equal to the ovary
Androecium	3-5 mm long shorter than the gynoecium	3-3.5 mm long shorter or equal to the gynoecium	3-3.5 mm long, equal to the gynoecium	3-4 mm long, longer than the gynoecium
Ovary	Up to 4 mm long	2-3 mm long	2.5-3.5 mm long	2.5 – mm long
Stigma	Up to 2 mm long, lobes equal, sometimes one of the lobes forked	0.75-1.25 mm long, lobes equal one lobe forked	0.75 – 1 mm long, lobes unequal	0.75 – 1.25 mm long, lobes unequal
Fruit	----	Capsule 2.5 -3 mm long; stalk 5.5mm- 1.2 cm long	Capsule 3-3. 5 mm long, stalk 7mm- 2cm long.	3 mm long; stalk 1.25 cm-2.8cm long

2. *Polypleurum prostratum* Mathew et Nileena

Thallus ribbon shaped, brown to green colored, 2-7 cm long, attached to the substratum by haptera at the base as well as at other points of contact with the substratum. Vegetative shoots later transformed into floral shoots which are marginal or sub marginal (Fig. 2).

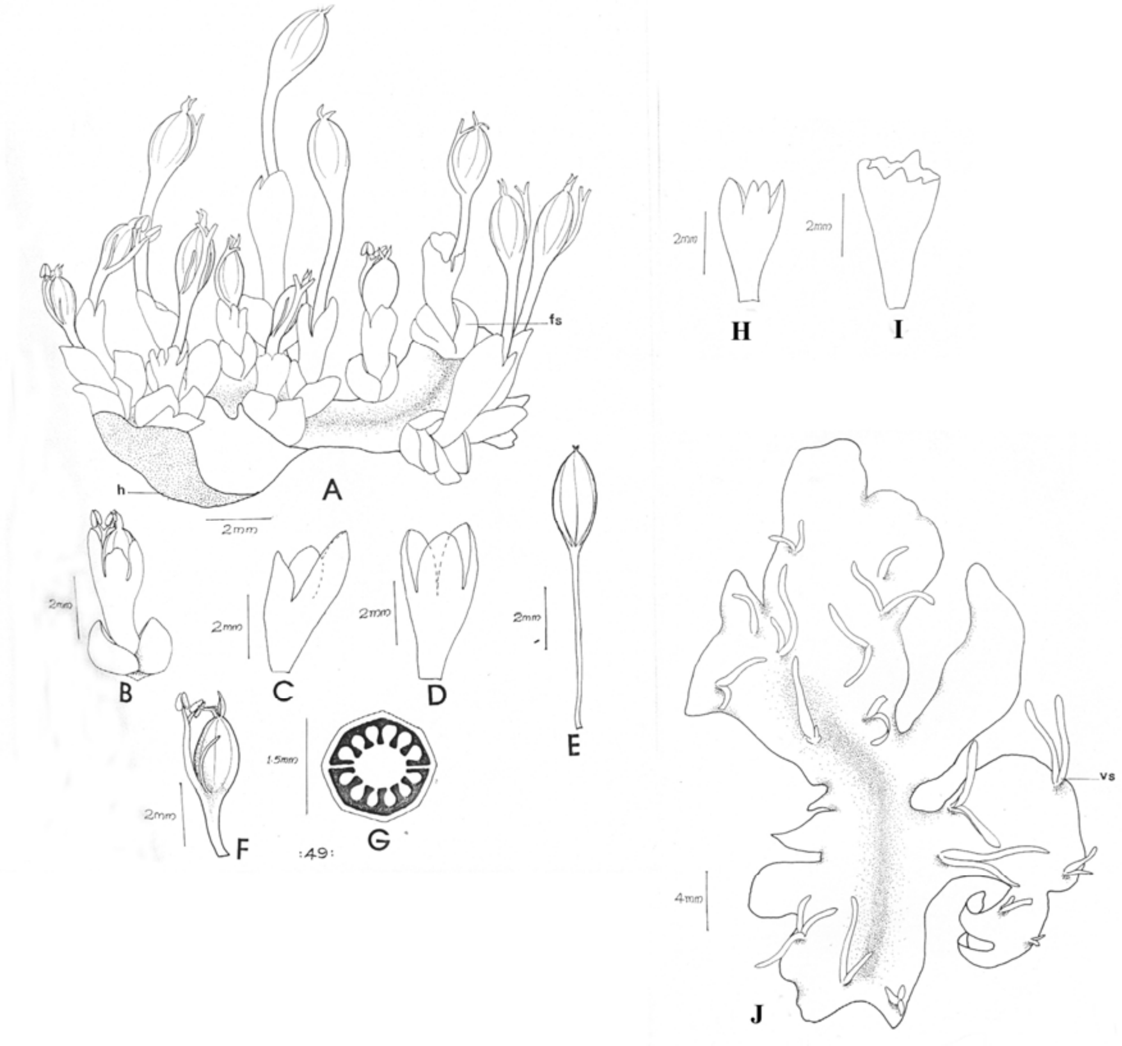

Fig. 2: A: Thallus with flowers; **B**: Young flower with bracts; **C**: Asymmetrical spathella; **D**: Symmetrical spathella; **E**: Fruit; **F**: Flower after removal of spathella; **G**: Ovary C.S.; **H**: 3 lobed spathella; **I**: Spathella without distinct lobes; **J**: Thallus in vegetative stage; **fs**: floral shoot, **h**: haptera, **f**: filament, **t**: tepal, **sp**: spethalla, **vs**: vegetative shoot

Table 2: Intra specific Comparison of *Polypleurum prostratum* collected from different localities

Character	Churuli	Chemmannar	Vellathooval	Panakootty	Teekoy	Mukkadavu	Nelliyampathy
Thallus	2.5-3 cm long, 5-8 mm broad, attached at the base as well as at the points of contact	2-3.5 cm long, 5-8 mm broad attached at the base only	Up to 2 cm long, 3-5 mm broad attached at the base only	2-2.5 cm long, 5 mm-1 cm broad attached at the base only	2-2.5 cm long, 4mm-1.1cm broad, attached at the base only	Up to 3 cm long, 2-4 mm broad attached at the base only	3-7 cm long, 4.8 mm broad attached at the base only
Position of the vegetative and floral shoots	Marginal to sub marginal	Marginal to sub marginal	Marginal to sub marginal	Sub marginal	Marginal to sub marginal	Marginal to sub marginal	Sub marginal
Bracts	2-4, Symmetric	2, Symmetric	2-4, Symmetric	2, rarely 3, Symmetric	2, Asymmetric	2-3, Symmetric or asymmetric	2-3, slightly asymmetric
Spathella	Symmetric, up to 4 mm long , 3-lobed	Symmetric, up to 5 mm long , 5-lobed	Symmetric, sometimes asymmetric, 4 - 4.5 mm long, 3-lobed	Asymmetric, 4-5 mm long , 2-lobed, sometime 4 lobed	Symmetric, 3 - 3.5 mm long , 2-lobed or irregularly many lobed	Symmetric, 4.5-5.5 mm long , 3-lobed	Symmetric, 4 -5 mm long, 3-lobed, sometimes one lobe forked, rarely with numerous small lobes
Tepals	Up to 1.25 mm long, equal to the ovary	Up to 2 mm long, shorter than the ovary	1.25 - 1.5 mm long, shorter than the ovary	1.25-2 mm long, shorter than the ovary	Up to 1.25 mm long, equal to the ovary	1.75 - 2 mm long, shorter than the ovary	2-2.5 mm long, equal to the ovary
Androecium	Up to 2 mm long, shorter than the gynoecium	Up to 3 mm long, longer than the gynoecium	2.25 - 3 mm long, equal to the gynoecium	3.5 - 4 mm long, equal to the gynoecium	1.75 - 2 mm long, shorter than the gynoecium	3.5-4 mm long, longer than the gynoecium	3.5- 4 mm long, longer than the gynoecium
Ovary	1.25 mm long	2.5 – 3 mm long	1.5-2mm long	2-3 mm long	2-3.5 mm long	2-2.5 mm long	2-2.5 mm long
Stigma	Obcuneate, up to 0.5mm long, lobes equal	Ovate, up to 0.5 mm long, lobes unequal	Obcuneate, up to 0.5-0.75 mm long, lobes unequal	Obcuneate, up to 0.25-0.5mm long, lobes equal	Obcuneate, up to 1-1.5 mm long, lobes unequal	Obcuneate, up to 0.75-1 mm long, lobes sub equal	Obcuneate, up to 0.5-0.75 mm long, lobes sub equal
Fruit	Capsule 2-2.5 mm long; stalk 4-8 mm long	Capsule up to 3 mm long; stalk 5 mm -1.2 cm long	Capsule 2-4 mm long; stalk 5mm -1.2 cm long	Capsule 2.5 -3 mm long; stalk 7.25 mm -1.7 cm long	Capsule 2-4 mm long; stalk 5-10 mm long	Capsule 2.5-4 mm long; stalk 1.25-2.6 cm long	-----

3. ***Polypleurum minor*** (Wedd.) Nagendran, Arekal *et* Subramanyam comb. nov.

Thallus ribbon shaped thick, 2-5 cm long, completely creeping, attached to rocks by haptera all along the underside of the thallus (Fig. 3). Vegetative and floral shoots marginal or sub marginal.

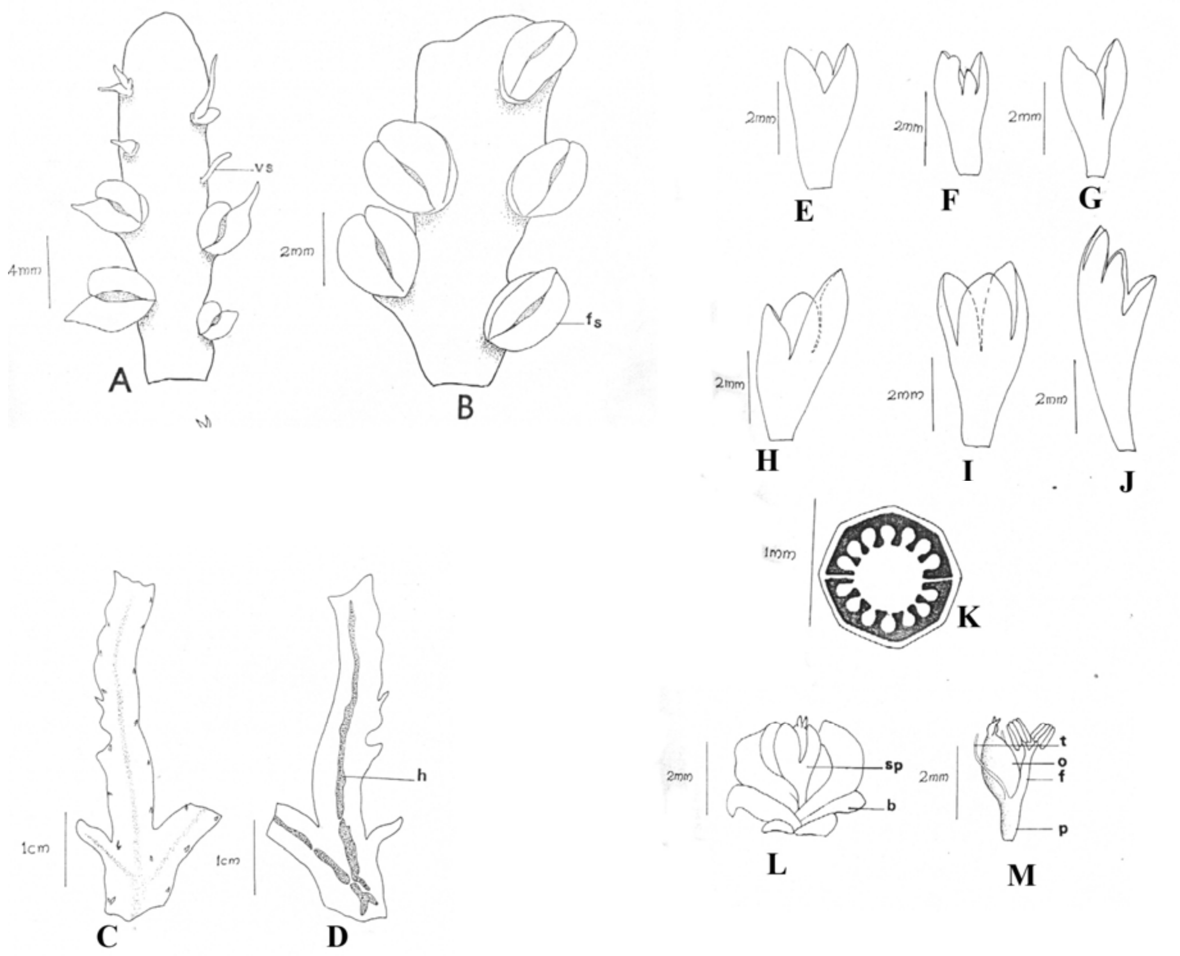

Fig. 3: A: Young thallus; **B**: Thallus showing floral shoots; **C**: Young thallus (upper side); **D**: Young thallus showing haptera along the underside; **E**: Funnel shaped spathella with three unequal lobes; **F**: Funnel shaped spathella with three irregular unequal lobes; **G**: Spathella with two lobes; **H:** Asymmetrical spathella; **I**: Symmetrical spathella; **J**: Asymmetrical spathella with 5 lobes; **K**: Ovary C.S.; **L**: Young flower covered by spathella and bracts; **M**: Flower after removal of spathella; **fs**: floral shoot, **b**: bract, **h**: haptera, **sp**: spethalla, **o**: ovary, **s**: stigma, **t**: tepal, **f**: filament, **vs**: vegetative shoot

Table 3: Intra specific comparison of *Polypleurum minor* collected from different localities

Character	Pullampara	Muttukadu	Vellathuval	Pakuthipalam	Pambla	Karimban	Churuli	Perum thenaruvi
Thallus	Up to 2 cm long, 3 mm broad, thick	2-2.6 cm long, 2.6 mm broad, thick	Up to 2 cm long, 3 mm broad, thick	2-3 cm long, 2-2 mm broad, thin	Up to 1 cm long, 2- 2.5 mm broad, thin	Up to 3 cm long, 2-10 mm broad, thick or thin	Up to 2 cm long, 3.5 mm broad, thick	Up to 5 cm long, 2-8 mm broad, thin
Position of the vegetative and floral shoots	Marginal	Marginal to sub marginal	Marginal to sub marginal	Marginal to sub marginal	Marginal	Marginal	Marginal	Marginal
Bracts	2-4, symmetric	2-3, asymmetric	2, symmetric	2-3 symmetric with persistent leaf tips	2, symmetric	2-3, symmetric	2-4, sometimes 3 symmetric	2-3, rarely 5 symmetric
Spathella	Symmetric, up to 3.6 mm long irregular, many lobed	Asymmetric 3.5-6 mm long, 5 lobed	Symmetric or asymmetric, 4-5 mm long, 3 lobed	Symmetric 2 lobed, sometimes 4, 4-4.5 mm long	Symmetric 3.5-4 mm long, 2 lobed, one of them again forked	Symmetric 3-3.5 mm long, 2 or 3 lobed	Symmetric 3-4 mm long, 2 lobed, 1 lobe again forked	Symmetric & asymmetric 3-4.5 mm long, 2 lobed
Tepals	Up to 1.5 mm long shorter than the ovary	1.5-1.75 mm long equal to the ovary	2-3 mm long, shorter/equal to the ovary	1.5-1.75 mm long, shorter than the ovary	1-1.5 mm long, shorter than the ovary	Broad, 1.5-1.7 mm long, shorter than the ovary	1.5-1.75 mm long equal to the ovary	2-2.5 mm long longer than the ovary
Androeciu m	2.5-3 mm long, longer than the gynoecium	2.5-3 mm long, longer than the gynoecium	3-3.5 mm long, equal to the gynoecium	3.5-4 mm long, equal to the gynoecium	2.5-3 mm long, equal to the gynoecium	2.75-3 mm long, shorter than the gynoecium	2.5-3 mm long, longer than the gynoecium	2.5-3 mm long, longer than the gynoecium
Ovary	Up to 1.75 mm long, smooth	Up to 2.25 mm long, ribbed	2.25-3 mm long, ribbed	2-3 mm long, ribbed	2-2.25 mm long, ribbed	2-3 mm long, ribbed	1.75-2 mm long, ribbed	1.75-2.25 mm long, ribbed
Stigma	0.5 mm long, lobes unequal	0.5-0.75 mm long, lobes equal/ unequal	0.5-0.75 mm long, lobes unequal	0.25-0.5 mm long, lobes equal	0.5-0.75 mm long, lobes unequal	Up to 0.75 mm long, lobes unequal	0.5-0.75 mm long, lobes unequal	0.5-0.75 mm long, lobes equal
Fruit	----	Capsule 2.5-3 mm long, stalk 1.5-2.7 cm long	Capsule 2.5-3.25 mm long, stalk 5-6 mm long	Capsule 2.5-3 mm long, stalk 2.5-7.5 mm long	Capsule 2.25-2.75 mm long, stalk 5mm-1 cm long	Capsule 2-2.5 mm long, stalk 3.5-4 mm long	----	Capsule 1.75-2.5 mm long, stalk 2.25-8 mm long

4. *Polypleurum disciforme* Mathew *et* Nileena

Thallus usually disc shaped 5-7 mm in diameter (Fig. 4), rarely ribbon shaped, 2-2.5 cm long, attached to substratum by haptera at the centre of the underside of the disc shaped thallus, in others by haptera at the points of contact only.

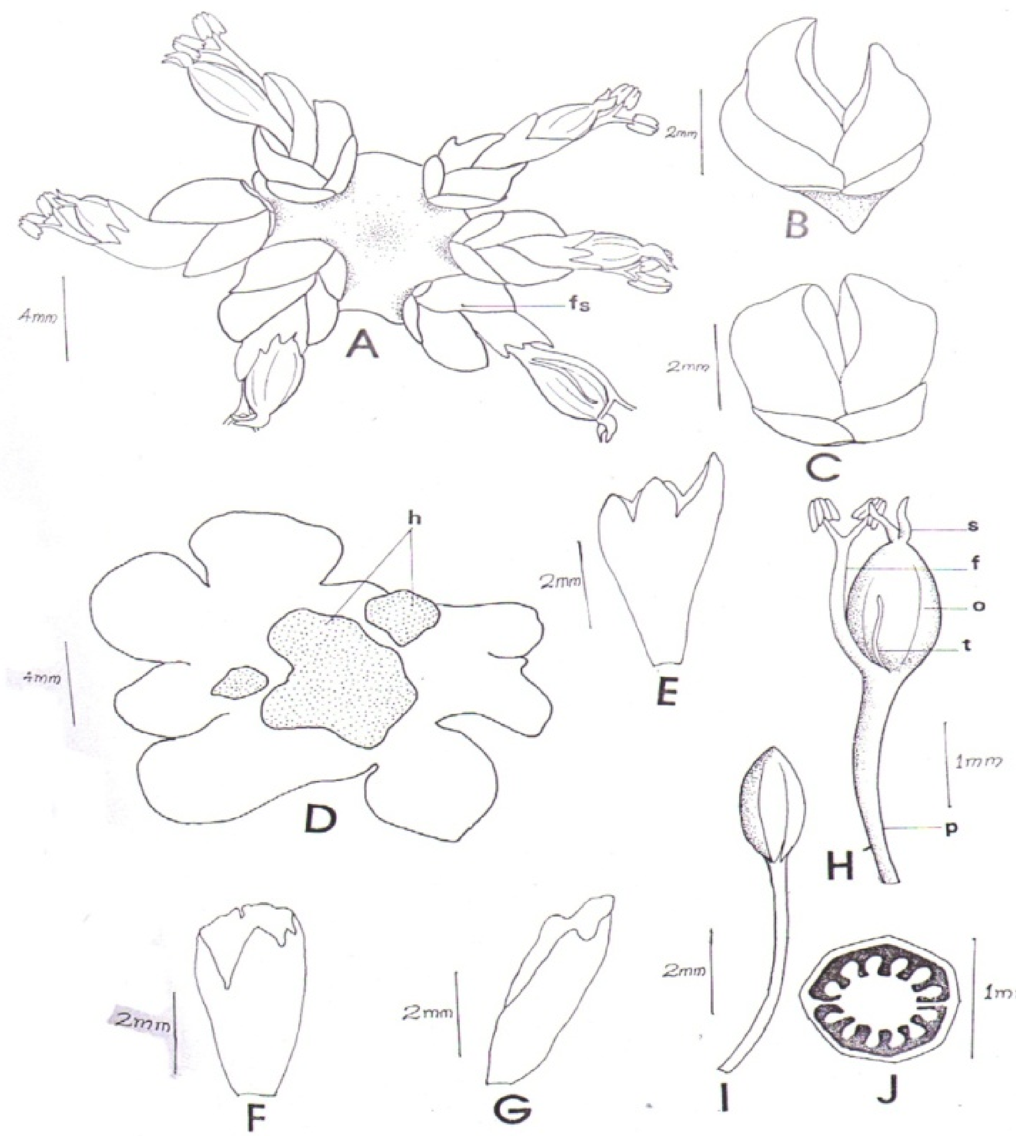

Fig. 4: A: Typical disc shaped thallus with floral shoots; **B**: Asymmetric bracts; **C**: Symmetric bracts; **D**: Lower side of the thallus showing haptera; **E**: Asymmetric spathella with 4 lobes; **F**: Symmetric spathella with vague lobing; **G**: Spathella showing tendency for boat –shape; **H**: Mature flower after the removal of spathella; **I**: Fruit; **J**: Ovary C.S.; **f**: Filament, **fs**: floral shoot, **h**: haptera, **o**:ovary, **p**: pedicel, **s**: stigma, **t**: tepal

Table 4: Intra specific comparison of *Polypleurum disciforme* collected from different localities

Characters	Kuthungal(Panniyar)	Pooyamkutty	Kurunkayam
Thallus	Disc shaped 2-6 mm diameter, attached at the center of the underside of the thallus	Disc shaped, 3.5-4 mm diameter, attached at the center of the underside of the thallus or ribbon shaped, up to 2 cm long, 2-3 mm broad, attached at the base only	Disc shaped 5-10 mm diameter, attached at the center of the underside of the thallus or ribbon shaped up to 2.5 cm long, 3-5 mm broad, attached all along the underside of the thallus
Position of the vegetative and floral shoots	Marginal	Marginal – sub marginal	Marginal
Bracts	2, symmetric	2-4, asymmetric	2/sometimes 3, symmetric
Spathella	Symmetric/asymmetric, 2-3 lobed	Symmetric, sometimes tendency to become boat shaped, 2 lobed one lob again forked	Symmetric, 4-5 mm long, 2 lobed
Tepals	1.5-2 mm long, shorter than the ovary	1.5-1.75 mm long, shorter than the ovary	1.75-2.25 mm long, equal to the ovary
Androecium	3-4 mm long, equal to the gynoecium	Up to 4 mm long, equal to the gynoecium	3-3.5 mm long, longer than the gynoecium
Ovary	2-3 mm long	2.5-3 mm long	1.5-2.5 mm long
Stigma	0.5-1 mm long, lobes equal	Up to 1 mm long, lobes equal	Up to 1 mm long, lobes equal
Fruit	Capsule 2.5-3.5 mm long, stalk 5 mm-1 cm long	Capsule 2.5-3 mm long, stalk 5.5 mm-1.2 cm long	Capsule up to 2.5 mm long, stalk 7.5 mm-1.3 cm long

Discussion and Conclusions

According to Willis (1902a), *Dicraea* (*Polypleurum*) species are variable and polymorphic and much detailed study is needed to determine the specific limits. By using very broad distinctions, he considered 5 species. These are: *Dicraea elongata* Tul., *D. dichotoma* Tul., *D. minor* Wedd., *D. wallichii* Tul. and *D. stylosa* Wight. Hall (1971) described *Polypleurum submersum* in addition to *P. dichotomum*, *P. elongatum* and *P. stylosum*. Cusset (1992) described the following species of *Polypleurum*: *P. munnarense, P. filifolium, P. schmidtianum*, *P. elongatum, P. stylosum, P. wallichii* and *P. minor* from South India.

According to Dr. Rolf Rutoshauser (in a personal communication, letter dated March 28, 1993) the best criterion to distinguish *P. stylosum* and *P. wallichii* are still their distribution area: *P. stylosum* in South India and Ceylon, *P. wallichii* sensu lato(including *P. minor*, *P. agharkarii*) in North East India and Burma. However Raveendran and Mathew (1994) collected *P. wallichii* from South India. The author is of the opinion that along with *P. stylosum* and *P. wallichii*, *P. minor* is also available in the rivers of Kerala, although she could not personally collect *P. wallichii*, *P. elongatum* and *P. dichotomum*. They may occur in some remote river sites or perhaps these two species might have disappeared completely.

Polyplerum stylosum was collected from four different localities. There are some morphological variations in the plants of different localities. These are: size of the thallus, distribution of floral shoots, number of bracts, lobing of spathella and forked or unforked nature of stigma lobes (Ref. Table 1, Fig 1A-K). These variations are due to the phenomenon of polymorphism.

Polypleurum prostratum was collected from 7 different localities. The specimen differ in the following characters: attachment of the thallus to the substratum, position of secondary shoots, shape of the bracts, shape and number of lobes of the spathella, length of the tepals, length of the stamens, equal or unequal nature of stigma lobes and length of fruit stalk (Ref. Table .2, Fig 2 A-K).

P. minor was collected from 8 localities and they show slight morphological variations. The variations are the following: size of the thallus, position of floral shoots, number and shape of the bracts, shape of the spathella and number of the lobes of the spathalla, length of tepals, length of stamens, smooth or ribbed ovary, equal or unequal stigma lobes, length of fruit stalk (Ref. Table 3, Fig. 3 A-N). These variations are due to the phenomenon of polymorphism.

P. disciforme was collected from 3 different localities. The plants vary slightly in their morphological features. The thalli are generally disc shaped, sometimes ribbon shaped. The position of floral shoots may be marginal or sub marginal, bracts symmetric or asymmetric, spathella symmetric or asymmetric, the attachment is by haptera at the centre of the underside of the disc shaped thallus while only at the points of contact in ribbon shaped thallus. This species also show some degree of polymorphism.

The genus *Polypleurum* shows high degree of polymorphism. Based on morphological variations, mainly in the vegetative characters, the author has proposed two new species (Nileena 2003). These are: *P. prostratum* and *P.disciforme*. From the above intra specific comparative study of different species of *Polypleurum*, the author conclude that all the above species exhibit some degree of polymorphism. However the variations are not enough to consider them as separate varieties or types.

References

1. **Aublet., 1775.** Hist. des Pl. de la Guiana fanc., 1: 582.
2. **Cook, C.D.K., 1990.** *Family Podostemaceae in Aquatic Plant Book*, p. 171-19,1 SPB Academic Publishing Co. The Hague, The Netherland.
3. **Cusset, C., 1992.** Contribution a l etude des Podostemaceae: 12 Les genres asiatiques, *Bull. Mus. Natl. Hist. Nat.*, Paris 4^{e}, Ser. 14, sect.B, Adansonia, n^{0} 1: 13-54.
4. **Grubert, M., 1975.** Okologie extreme adaptierter Blutenpflanzen tropischer Wasserfalle. *Biologie in Unsere*. Zeit, 5:18-25.
5. **Grubert, M., 1991.** Ecologia fanerogamas de saltos tropicales adaptadas en ferma extrema. *Natura* (Caracas), 91: 54-61.
6. **Hall, J.B., 1971.** “New Podostemaceae from Ghana with notes on related species”, *Kew Bull.*, 26(1), p. 125-136
7. **Mathew, C.J & Satheesh, V.K., 1997.** Taxonomy and distribution of the Podostemaceae in Kerala, India, *Aquat. Bot.,* 57: 243-274.
8. **Mathew, C.J., Nileena, C.B., & Jager Zurn, I., 2003.** Morphology and Ecology of Two New Species of *Polypleurum* (Podostemaceae) from Kerala, India, i., 237(3): 209-217.
9. **Mohan Ram, H.Y. & Sehgal, A., 1992**. Podostemaceae – the strange family of aquatic angiosperms, *Palaeobotanist*; 41: 192-197.
10. **Nileena, C.B., 2001.** *Detailed Studies on the Genera and Species of the Family Podostemaceae with Particular Reference to the Phenomenon of Polymorphism*, Ph.D Thesis submitted to M.G. Uvty., Kottayam.
11. **Philbrick, C.T., & Novelo, R.A., 1993.** A fascinating family of aquatic flowering plants. *Aquaphyte*, 13: 1-7
12. **Philbrick, C.T., & Novelo, R.A., 1995**. New World Podostemaceae: Ecological and evolutionary enigmas; *Brittonia*, 47: 210-222
13. **Raveendran, T.P. & Mathew, P., 1994.** *Polypleurum wallichii* (R.Br.ex. Griff.) Warm, (Podostemaceae) a new plant record for South India, *Rheedea*, 4(2): 106-108.
14. **Willis, J.C., 1902 a.** Studies in the morphology and ecology of the Podostemaceae of India and Ceylon; *Ann. R. Bot. Gard., Peradeniya*, 1: 181-250.
15. **Willis, J.C., 1902 b.** A revision of the Podostemaceae of India and Ceylon; *Ann. R. Bot. Gard., Perdeniya*, 1: 267-465, tab. 4-38.

Curative climbers of Thadagai hills of Anamalais

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Abstract

The present study was conducted in Thadagai hills of Anamalais, Western Ghats to explore the diversity of climbers. The study is primarily based on field surveys conducted throughout the hills, where dwellers, especially Pulaiyer community provided information on plant species used as medicine. A total of 55 medicinally important climbers belonging to 45 genera and 20 families were identified to be used by ethnic people to cure various ailments such as diabetes, fever, rheumatism, cough etc. It is evident from the study that the ethnic people still values traditional medicines as a way of meeting their medicinal needs.

Key words: Traditional medicine, ethnic people, climber, ailments.

Introduction

Climbers are plants that germinate on the floor of the forest and grow, at least for part of their life, or when the forest closes up around them, by winding around, leaning on, or anchoring or adhering to other to attain great stature plants (Jongkind and Hawthorne, 2005; Swaine *et al*., 2005). They occur in many plant families with only a few families such as *Dioscoreaceae, Cucurbitaceae* and *Convolvulaceae* consisting completely of climbing plants.

Climbers occur in all woody ecosystems of the world, although a high abundance is considered to be characteristic of tropical and subtropical forests (Bongers *et al*., 2005). Specifically, in tropical rain forest, they comprise about 25-30% of species diversity (Schnitzer and Bongers, 2002). They are an abundant and diverse life-form in most tropical forests and their presence is often a key physiognomic feature differentiating tropical from temperate forests (Reddy & Parthasarathy, 2003;, Schnitzer & Bongers, 2002; Nabe-Nielsen, 2001; Perez-Salicrup *et al.,* 2001). Climbers contribute substantially to the floristic, structural and functional diversity of tropical forests (Benavides *et al.* 2005), where they can compete with other vegetation. They can also have positive effects on forests, providing valuable food resources, habitat, and connections among tree canopies that are used as pathways by arboreal animals (Emmons & Gentry 1987, Ødegaard 2000).

Lianas, the woody vines are an important, but understudied growth-form, common to most forests throughout the world, particularly in the tropics (Schnitzer and Bongers 2002). The past few decades have brought increasing awareness of the importance of lianas to species diversity (Gentry and Dodson 1987; Schnitzer and Carson 2001; Burnham 2002). They constitute 25 % of the woody stem density and species diversity in tropical forests (Gentry 1991). They are often a large component of the canopy in tropical forests, often one-third or more of the entire leaf area, though only a small component of the basal area and biomass (Schnitzer and Bongers 2002).

Through the present study which was conducted in Thadagai hills of Anamalais, Western Ghats, we could explore the diversity of climbers and their uses in traditional medicines by ethnic people (Pulaiyer community).

Study area

The Anaimalai Hills is a range of mountains in the Western Ghats in Tamil Nadu and Kerala states of South India. These hills are located between 10°13' and 10°31' N latitude. and 76°52' and 77°23' E longitude. They form a southern portion of the Western Ghats. Anaimalai Hills are south of where the Western Ghats are broken by the Palghat Gap, which in turn is south of the Nilgiri Hills. They border the state of Kerala on the Southwest and the Cardamom Hills to the southeast. To the east are the Palni Hills. The study area Thadagai Hills are seen in the foothills of Anamalai hills (humid; 680 m above msl; moist semi-evergreen forest).

Materials and Methods

The present study was carried out through intensive and extensive field visit during September 2011-August 2012 to collect information on traditional uses of climbers used in the preparation of crude herbal drugs by the tribal people living in the Thadagai Hills of Anaimalai Hills. The data were documented through interviews, discussion and field observations with folk practitioners and knowledgeable people of the study area using standard methods adopted by Jain and Goel (1995). During the field survey, the plants have been collected in their flowering and fruiting stages as far as possible and identified using the local floras. The voucher specimens are deposited in the Herbarium of Department of Botany, Kongunadu Arts and Science College, Coimbatore, Tamil nadu.

Results and Discussion

The present study resulted in the documentation of curative properties of 55 climbers belonging to 45 genera and distributed over 21 families. The plants are tabulated with correct botanical names followed by family, parts used and their medicinal uses (Table 1). *Asclepiadaceae, Convolvulaceae* and *Fabaceae* (8 species each) are most dominant families, followed by *Cucurbitaceae* (5 species), *Menispermaceae* and *Aristolochiaceae* (3 species each) and *Apocynaceae*, *Capparidaceae, Sapindaceae* and *Liliaceae* (2 species). Rest of the families are represented by single species only.

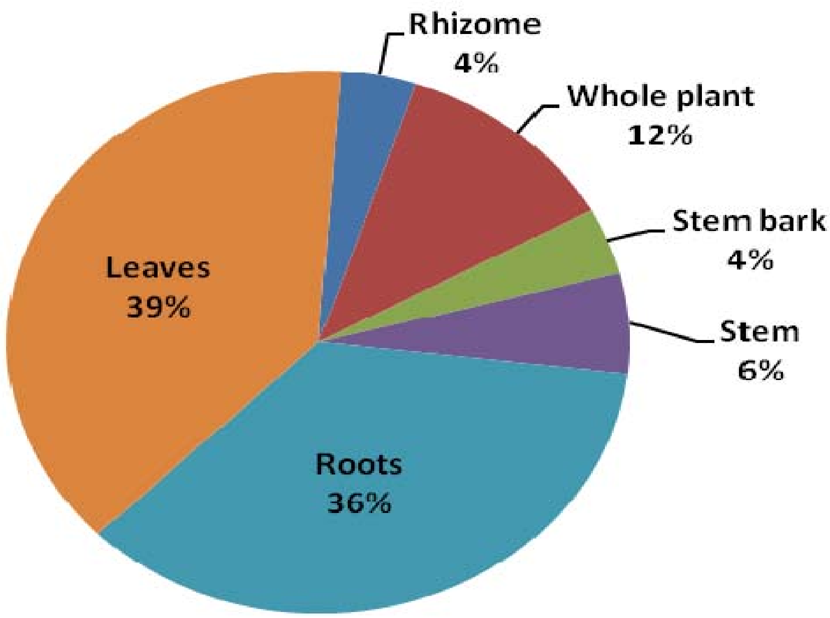
Table 1: List of Curative Climbers of Thadagai hills

Sl. No	Botanical Name	Useful Part	Medicinal uses
1	*Abrus precatorius* L. (Fabaceae)	Seeds	Seeds are administered to nervous disorders
2	*Acacia torta* Craib. (Mimosaceae)	Stem bark	Stem bark decoction is taken for cough
3	Aganosma cymosa G. Don (Apocynaceae)	Whole part	Whole plant is used as anthelmintic
4	*Argyreia elliptica* (Roth)Choicy (Convolvulaceae)	Fresh leaves	Eye injuries
5	*Aristolochia bracteolata* Lam. (Aristolochiaceae)	Whole part	Snake bite
6	*Asparagus asiaticus* L (Liliaceae)	Leaves	Tender leaf is applied topically on swellings
7	*Bauhinia va*hlii Wight & Arn. (Fabaceae)	Leaves	Leaf extract is taken orally to cure dysentery.
8	*Capparis sepiaria* L. (Capparidaceae)	Leaves	To cure skin diseases
9	*Capparis zeylanica* L. (Capparidaceae)	Roots	Root paste is applied to snakebite

Sl. No	Botanical Name	Useful Part	Medicinal uses
10	*Cardiospermum canescens* Wall. (Sapindaceae)	Leaves	Joint pain.
11	*Cardiospermum halicabum* L. (Sapindaceae)	Leaves	Body pain
12	*Ceropegia juncea* Roxb. (Asclepiadaceae)	Whole part	Stomach ulcer
13	*Cissampelos pareira* L. (Menispermaceae)	Leaves	Cure fever
14	*Cissus quadrangularis* L. (Vitaceae)	Stem	Swellings
15	*Cocculus hirsutus* (L.) Diels (Cucurbitaceae)	Roots	Snake bite
16	*Cucumis trigonus* Roxb. (Cucurbitaceae)	Fruit	Stomach pain
17	*Dioscorea oppositifolia* L. (Dioscoreaceae)	Tuber	Fertility
18	*Diplocyclos palmatus* L. (Cucurbitaceae)	Whole part	Cough
19	*Gloriosa superba* L. (Liliaceae)	Whole part	Piles
20	*Grewia heterotricha* Mast. (Tilaceae)	Stem bark	Cough
21	*Gymnema sylvestre* (Retz.) R. Br. ex Schult. (Asclepiadaceae)	Leaves	Diabetes
22	*Hemidesmus indicus* R. Br. (Asclepiadaceae)	Roots	Snake bite
23	*Ichnocarpus frutescens* (L.) R. Br. (Apocynaceae)	Roots	Diabetes
24	*Ipomoea eriocarpa* R.Br. (Convovulaceae)	Leaves	Rheumatism
25	*Ipomoea staphylia* L. (Convolvulaceae)	Leaves	Stomach ulcer
26	*Jasminum azoricum* L. (Oleaceae)	Leaves	Fever
27	*Parsonsia alboflavescens* L. (Convovulaceae)	Roots	Snake bite
28	*Passiflora foetida* L. (Passifloraceae)	Leaves	Headache
29	*Sarcostemma intermedium* L. (Asclepiadaceae)	Stem bark	Rheumatism
30	*Tylophora indica* L. (Asclepiadaceae)	Whole part	Piles

The most commonly used medicinal climbers are *Abrus precatorius* L., *Aristolochia bracteolata* Lam., *Cocculus hirsutus* L., *Diplocyclos palmatus* L. and *Tylophora indica* L., which play an important role in the primary healthcare system of tribal community of Pulaiyers in Thadagai hills. They are using these plants to cure diseases related to skin, cough, fever, headache, rheumatism etc. It is evident from the study that, different plant parts of climbers were used as medicines.

Figure 2: Different parts used for different ailments



Conclusion

Medicinal plants play a major role in the medical and healthcare needs of tribal people. This preliminary study focused on documenting most of the curative climbers used by the Pulaiyer community in Thadagai hills, the Western Ghats of Tamil Nadu to facilitate conservation efforts. However, destruction of habitat through deforestation and over exploitation for commercial purposes and changes in cultural altitude threatens to constrain many of these species into extinction.

References

1. **Benavides, A. M., Alvaro, J., Duque, M., Duivenvoorden, G., Vasco, A., & Callejas, R. 2005**. A first qantitative census of vascular epiphytes in rain forests of Colombian Amazonia. *Biodiversity and Conservation, 4*, 739-758.
2. **Bongers, F., M.P.E. Parren, M.D. Swaine and D. Traoré, 2005.** Forest Climbing Plants of West Africa: Introduction. In: Forest Climbing Plants of West Africa: Diversity, Ecology and Management Bongers, F., M.P.E. Parren and D. Traoré (Eds.). CAB International, Wallingford, Oxfordshire, UK., pp: 5-18.
3. **Burnham, R. J. 2002.** Dominance, diversity and istribution of lianas in Yasuni. Ecuador: Who is on op Journal of Tropical Ecology 18: 845-864.

4. **Daniel, R. J. R 1997.** Taxonomic Uncertainties and Conservation Assessment of the Western Ghats**,** *Current Science***,** 73(2), 169-170.
5. **Emmons, L. H., & Gentry, A. H. 1983.** Tropical forest structure and the distribution of gliding and prehensiletailed vertebrates. *American Nature, 121*, 513-524.
6. **Gadgil, M, 1996.** Western Ghats : A Lifescape, Journal of the Indian Institute of Sciences, 76, 495-504
7. **Gentry, A. H. 1991**. The distribution and evaluation ofclimbing plants; p. 3-49 *In* F.E. Putz and H. A.Mooney (ed.), The Biology of vines. Cambridge,Cambridge University Press.
8. **Gentry, A. H. and C. Dodson. 1987.** Contribution of on-trees to species richness of a tropical rain forest.Biotropica 19: 149-155.
9. **Jongkind, C.C.H. and W.D. Hawthorne, 2005.** A Botanical Synopsis of the Lianes and Other Forest Climbers. In: Forest Climbing Plants of West Africa: Diversity, Ecology and Management, Bongers, F., M.P.E. Parren and D. Traoré (Eds.). CAB International, Wallingford, Oxfordshire, UK., pp: 19-39.
10. **Nabe-Nielsen, J. 2001.** Diversity and distribution of lianas in a neotropical rainforest, Yasuni National Park, Ecuador. *Journal of Tropical Ecology, 17*, 1-19.
11. **Ødegaard F. 2000.** The relative importance of trees versus lianas as hosts for phytophagous etles (Coleoptera)in tropical forests. *Journal of Biogeography, 27*, 283-296.
12. **Perez-Salicrup, D. R., Sork, L. V., & Putz, F. E. 2001.** Lianas and trees in a liana forest of mazonian Bolia. *Biotropica, 33*, 34-47.
13. **Reddy, M. S. & Parthasarathy, N. 2003.** Liana diversity and distribution in four tropical dry evergreen forest onthe Coromanded coast of South India. *Biodiversity and Conservation, 12*, 1609-1627.
14. **Schnitzer, S. A. & Bongers, F. 2002.** The ecology of lianas and their roles in forests. *Trends in Ecology and Evolution, 17*, 223-230.
15. **Schnitzer, S. A. and F. Bongers. 2002.** The ecology of ianas and their role in forests. Trends in Ecology andEvolution 17: 223-230.
16. **Schnitzer, S. A. and W. P. Carson. 2001.** Tree fall gapsand the maintenance of species diversity in a tropicalforest. Ecology 82: 913-919.
17. **Schnitzer, S.A. and F. Bongers, 2002.** The ecology of lianas and their role in forests. TREE, 17: 223-230.
18. **Swaine, M.D., W.D. Hawthorne, F. Bongers and M. Toldedo Aceves. 2005.** Climbing Plants in Ghanaian Forests. In: Forest Climbing Plants of West Africa: Diversity, Ecology and Management, Bongers, F., M.P.E. Parren and D. Traoré (Eds.). CAB International, Wallingford, Oxfordshire, UK., pp: 93-107.

Notes on *Belosynapsis kewensis* Hassk., an endemic and endangered Commelinaceae from India

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Abstract

The morphology, taxonomy, conservation status and phytogeographical significance of *Belosynapsis kewensis* Hassk., an endemic and endangered Commelinaceae from southern Western Ghats is discussed. Coloured plates depicting the habit and floral details are provided for easy identification.

Key words: Commelinaceae, southern Western Ghats, endangered, endemic, conservation.

Introduction

Belosynapsis Hassk. is a genus of epiphytic or lithophytic herbs represented by six species in the world (Govaerts, 2013), *viz*. *Belosynapsis ciliata* (Blume) R.S. Rao, *B. epiphytica* (Blatt.) C.E.C. Fisch., *B. kewensis* Hassk., *B. moluccana* (Roxb.) C.E.C. Fisch., *B. vivipara* (Dalzell) C.E.C. Fisch. and *B. kawakamii* (Hayata) C.I. Peng & Y.J. Chen. The genus is distributed in tropical and subtropical Asia to south west Pacific. Karthikeyan *et al.* (1989) has reported 3 species from India. Among them, *B. kewensis* Hassk. is an endangered species, known only from one or two localities in the southern Western Ghats.

Belasynopsis kewensis is described for the first time by Hasskarl (1871) from a plant cultivated at Kew, probably from southern India. Later Hooker (1875) described another species and genus named *Erythrotis beddomei* based on a collection by Beddome from Myhendra mountains, southern Travancore, cultivated at Kew, and is definitely conspecific to *Belosynapsis*. It is probable that, Hooker might have described his new genus and species based on the same collection from which Hasskarl (l.c.) had described *Belosynapsis*, though he hasn't given any details on the collector and location.

Later, Clarke (1881) combined both *Belosynapsis* and *Erythrotis* under the genus *Cyanotis* in his treatment of *Commelinaceae* in *Monographiae Phanerogamarum*. Kuntze (1891) combined all these species under the genus *Tonningia*, and named as *T. kewensis* (C.B. Clarke) Kuntze.

Complete Synonymy

Belosynapsis kewensis Hassk., Flora 54: 259. 1871; C.E.C. Fisch. in Gamble, Fl. Madras 9: 1551. 1931; Kammathy in Nayar & Sastry, Red Data book of Indian Plants 120. 1987. **Type**: Not cited by Hasskarl, described from a plant cultivated in Kew. *Cyanotis kewensis* C.B. Clarke in A.L.P.P. de Candolle & A.C.P.de Candolle, Monogr. Phan. Gen. 3: 243. 1881, nom. superfl.; in Hook.f., Fl. Brit. India 6: 388. 1892. *Tonningia kewensis* (C.B. Clarke) Kuntze, Revis. Pl. 2: 722. 1891. *Erythrotis beddomei* Hook.f., Bot. Mag. 101: t. 6150. 1875. *Cyanotis beddomei* (Hook.f.) Erhardt, Götz & Seybold, Grosse Zander 2: 1825. 2008. (Figs. 1 & 2).

Prostrate herbs with reddish brown hairs all over. Roots fibrous. Stems and branches 7.5–30 cm long, somewhat fleshy, rooting at the nodes, densely hairy, hairs turning brown on drying. Leaves radical and cauline, rather fleshy, densely villous and ciliate; radical rosulate, elliptic, acuminate at apex, narrowed at base, 3.75–5.5 × 1.25–1.8 cm; cauline distichous, ovate or ovate-lanceolate, acute or acuminate at apex, usually cordately auriculate at base on one side, 1.25–5 × 0.6–1.8 cm, often bright red beneath, especially on the apical part;

sheaths short, densely villous. Flowers 4–8, racemed in pairs on a densely hairy peduncle, shortly pedicelled; bract short, elliptic–oblong or lanceolate, 8.5–9.3 × 1.8–2.3 mm, hairy, acuminate at apex, margins ciliate; sepals 3, fused at base, 3.5–4.6 × 1.8–2 mm, with long rufous hairs from bulbous bases outside, glabrous within, margins ciliate; petals 3, free, ovate-elliptic, 3.4–3.6 × 1.9–2.1 mm, acute at apex, basally narrowing, glabrous, margins entire, rose/pink, whitish basally. Stamens 3; filaments 4–5 mm long, with a subapical swelling, bearded with blue moniliform hairs; anthers yellow, elliptic-oblong, 0.5–0.7 × 0.4–0.65 mm, deshising through a longitudinal slit; pollen yellow. Ovary obovate-oblong, c. 0.8 × 0.6–0.8 mm, villous, base narrowing, truncate distally; style narrow, filiform, 4–5 mm long, blunt at apex, white to hyaline, glabrous. Capsule 1 or 2 per cyme, 3-loculed, oblong, 3–3.5 × 2–2.5 mm, distally villous, hairs with bulbous base; locules 2-seeded; seeds obscurely pitted.

Flowering & Fruiting: September to January

Habitat & Ecology: Grows on wet, moss covered, dripping rocks and rock crevices and also on bark of trees.

Specimens examined: Tamil Nadu, Kanyakumari District, Myhendra hills, 03.1928., *Beddome s.n.* (Kew, image !); Wayanad District, Gurukula Botanical Sanctuary, cultivated (originally brought from Kothayar?), 08.11. 2012, *Santhosh Nampy* & *Manudev 134101* (CALI).

Phytogeography and Distribution

This species is endemic to southern Western Ghats. It was first collected by Beddome from Myhendra Hills and later by Kammathy in 1963 from Shiveli falls, in Kanyakumari District, Tamil Nadu. This species grows either as epiphyte on the bark of trees or on dripping, mossy rocks. It can be best grown as an ornamental and suited for hanging pots with its attractive foliage and bluish to purple flowers.

Status and strategies for Conservation

B. kewensis Hassk has been assessed as endangered (Kammathy in Nayar & Sastry, 1987). Earlier, this species was under cultivation in the Royal Botanic Gardens at Kew and Edinburgh. Kammathy had introduced a few plants in the experimental garden of Botanical Survey of India, Pune in 1963 but couldn't maintain in living condition for long due to prolonged dry spells after monsoon season. The species now grows in Gurukula Botanical Sanctuary, Wayanad and also at Calicut University Botanical garden. The plant usually survives in moist, shady conditions.

Following strategies are recommended for the conservation of *B. kewensis*.

- *In situ* conservation in its natural habitats.
- Introduction in other ecologically suitable habitats in other forest areas.
- *Ex situ* conservation in botanic gardens.
- Popularizing it as an ornamental plant.

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References

1. **Clarke, C.B. 1881**. Commelinaceae. In: A.L.P. & C. de Candolle (Ed.) *Monographiae Phanerogamarum* Vol. **3**. G. Masson, Paris. pp. 113 – 324.

2. **Govaerts, R. 2013.** World Checklist of Commelinaceae. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; http://apps.kew.org/wcsp/ - accessed 5 March 2013.
3. **Hasskarl, C. 1871.** Commelinaceae *Flora* 54: 259.
4. **Hooker, J.D. 1892.** *Flora of British India*. Vol. **6**. L. Reev & Co. Ltd., London.
5. **Hooker, J.D. 1875.** *Erythrotis beddomei* Hook.f. *Bot. Mag*. 101: t. 6150
6. **Karthikeyan, S., Jain, S.K., Nayar, M.P. & M. Sanjappa 1989**. *Florae Indicae Enumeratio: Monocotyledonae.* Botanical Survey of India. Kolkata. pp. 24 – 26
7. **Kuntze, O. 1891.** Revisio Generum Plantarum, A. Felix, Leipzig. 2: 722.

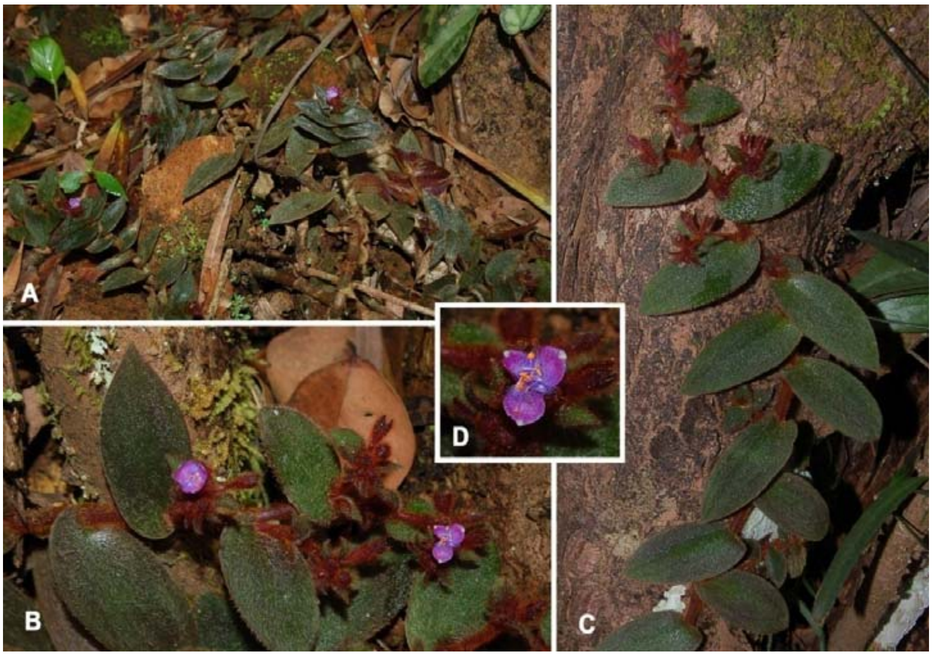

Fig. 1. *Belasynopsis kewensis* Hassk. **A-C.** Habit; **D.** Flower.

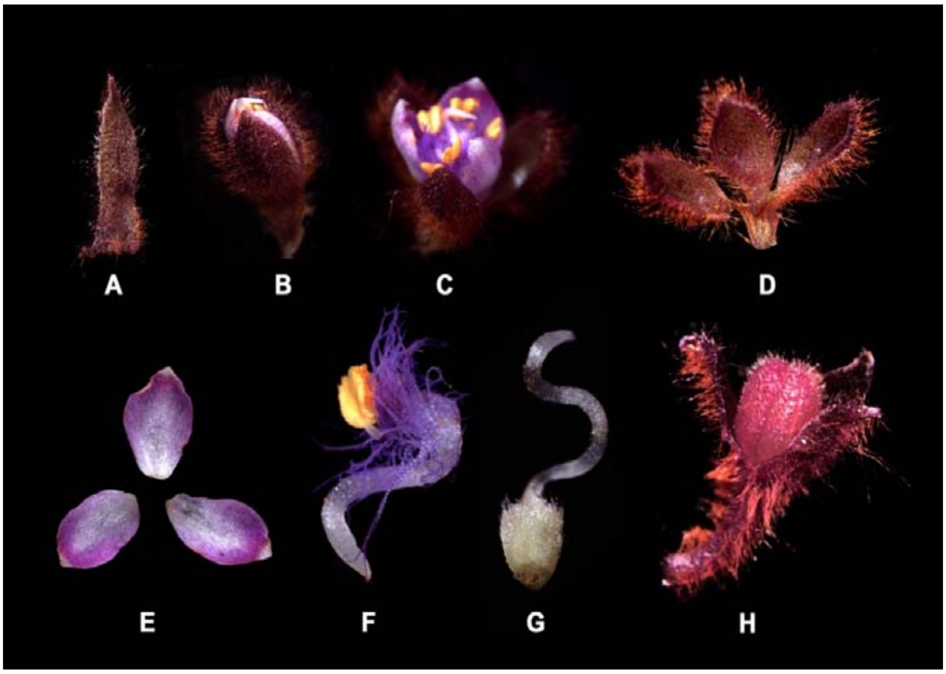

Fig. 2. *B. kewensis* Hassk. **A.** Bract; **B.** Flower bud; **C.** Flower; **D**. Calyx;
E. Petals; **F.** Stamen; **G.** Pistil; **H.** Capsule

Need for conserving the dwindling population of *Terminalia travancorensis* Wt. & Arn., an endemic tree in the Western Ghats

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Introduction

Tropical forests assume unusual significance for conservation since they are the most threatened ecosystems. Terminalia L., a tree genus of the family Combretaceae, is an important component of moist tropical forests and is known to comprise six species in the Kerala part of the Western Ghats. Among them, *Terminalia travancorensis* Wt. & Arn., a large tree endemic to the Western Ghats, occurs in low-level evergreen forests. It has been included in the 80 RET species under the heading 'Endemic Medicinal trees in Kerala' by For-RET (Lakshmi et al., 2012). Occurrence of the species is very low and reported from Thiruvananthapuram, Kollam, Idukki, Thrissur, Palakkad and Wayanad (Sasidharan, 2004). Demand for timber, raw materials for traditional medicine and its role in maintenance of the ecosystem(s); make the species a very important tree resource deserving enhancement. However, no detailed report is available on the status of the species.

In this context, the present study was undertaken to examine its demographic details. Objective of the study was to analyse density and distribution patterns of *T. travancorensis* in tree phase as well as natural regeneration in forest tracts of Kerala. Such a study is important to understand the factors responsible for either sparse or dense distribution.

Key words: *Terminalia travancorensis*, endemic, conservation, Western Ghats

Materials and methods

The study was carried out in five Forest Circles of Kerala extending from South to North (8.2-12.8ºN & 74.3-77.4ºE). It has a tropical, warm, humid monsoonal climate. There are two main monsoons, the South-West monsoon starts in early June and extends until November. The North-East monsoon is relatively dry with occasional rains and lasts from December to February. The summer season is from March to May. The average annual rainfall is 3000 mm (range 2200-3600 mm) spread over 120 days. Mean annual atmospheric temperature is 27ºC (range - 20-42 ºC). Annual relative humidity ranged between 64% (February-March) and 93% (June-July).

Enumeration was carried out in seven Divisions of Southern Circle, five Divisions of Central Circle, six Divisions of Northern Circle, eight Divisions of High Range Circle and seven Divisions of Olavakkode Circle, representing all the Ranges in each Forest Division. Temporary plots were established to study regeneration of *T. travancorensis*, and structural status of mature trees of the species and associate species. A total of 218 plots (51.7 ha) of varied size (5 x 500 to 5 x 1000 m belt transect) were enumerated.

Height and girth at breast height of mature trees and associate species were measured from the belt transect. Regeneration of *T. travancorensis* was analyzed from sub-plots of 5 x 100 m along the belt transects and from the point center plots around 10 m radius of mature trees. Regeneration of the species was classified into 3 girth classes, viz., <3 cm (seedlings), 3-10 cm (saplings) and >10 cm (poles) (Menon 2010). Phenological observation was carried out simultaneously. The data were subjected to phytosociological analysis using the software 'InventNTFP' developed by KFRI.

Results and Discussion

A total of 259 tree species including *T. travancorensis* were enumerated from the study sites. *T. travancorensis,* in the present study, was recorded only from limited number of localities (2% of the total study area) in Kerala as reported by others (Sasidharan, 2004). Overall density (trees per ha), frequency, basal area (m^2) and importance value index (IVI) of the species was 0.46, 0.023, 13.08, 0.996, respectively. In general, contribution of *T. travancorensis* was minimal with respect to tree density, basl area and IVI (0.16, 0.55 and 0.33%) to the total tree population. They were recorded from the low elevated evergreen forests in Vazhachal Division of Central Circle, Nenmara Division and Parambikkulam Wildlife Division of Olavakkode Circle and Idukki Wildlife Division of Higrange Circle. Major associate species were *Aglaia malabarica* Sasidh., *Chukrasia tabularis* A. Juss., *Cullenia exarillata* Robyns, *Dysoxylum malabaricum* Bedd. *ex* Hiern in Hook. f., *Hopea parviflora* Bedd., *Knema attenuata* (Hook. f. & Thoms.) Warb., *Myristica malabarica* Lam., *Palaquium ellipticum* (Dalz.) Baill., *Schleichera oleosa* (Lour.) Oken, etc. Study sites had high species richness (Margalef's Index - 26.93) and diversity (Shannon's Index - 3.71). Figure 1 depicts the distribution status of *T. travancorensis* in each the Forest Circle.

Divisionwise analysis showed that in the Olavakkode Forest Circle, *T. travancorensis* was found only from Nenmara and Parambikulam Wildlife Divisions with a density, frequency, basal area and IVI 1.02/ha, 0.064, 8.15 m^2 and 2.604 respecvively. Its contribution to density and basal area of other tree community was 0.51 and 1.66%. Similarly, contribution to IVI of other tree community was 0.87%. In the Central Circle, out of 39 plots (9.4 ha) enumerated *T. travancorensis* was reported only from a single plot in the Vazhachal Division with tree density 0.41/ha, frequency 0.026, basal area 3.48 m^2 and IVI 1.240. Contribution of density, basal area and IVI of the species to the total of tree population was 0.20, 0.89, 0.41, respectively. Similarly, in the Highrange Circle occurance of *T. travancorensis* was reported only from 2% of the study plots (out of 59 plots - 13 ha). Its density, frequency, basal area and IVI was 0.06/ha, 0.018, 1.44 m^2, 0.525, respectively. Contribution of the species to the total tree population was with 0.03% density, 0.38% basal area and 0.17% IVI.

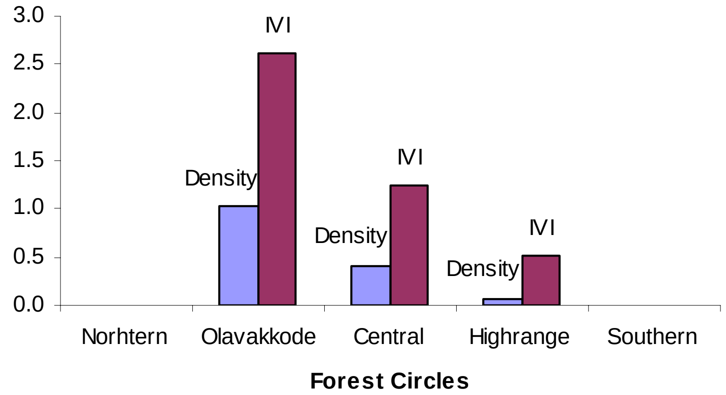

Fig. 1. Density and IVI of *T. travancorensis* in the study sites of Forest Circles

Regeneration of *T. travancorensis*

Only a single pole of *T. travancorensis* was recorded from the study sites in Parambikulam Wildlife Division. Regeneration is important as it addresses mainstream biodiversity concerns and quantitative assessment of regeneration of tree species in a forest helps to predict future status of concern (Bhadra and Dhal, 2010). Within a primary forest, occurrence of a species in any particular spot is determined by the regeneration of that species, and it is governed by the presence of mature trees, dispersal mechanism, flowering and fruiting behaviour (Menon, 2010). Overall regeneration of *T. travancorensis* from the study sites in Kerala was 0.019/ha. According to Bhadra and Dhal (2010), density values of regeneration are considered as regeneration potential of the species.

According to Khumbongmayum *et al.* (2006), regeneration is said to be good if the proportion is seedlings > saplings > adults, regeneration is fair if seedlings > or ≤ saplings > adults and regeneration is poor if the species survives only in sapling stage (saplings may be <, > or = adults). They stated that the future community structure and regeneration status of a species could be predicted from the relative proportion of seedlings and saplings in the total populations of various species in the forest. The present study indicated that regeneration of *T. travancorensis* was negligible. Kunhikannan *et al.* (2003) stated that absence of seedlings and saplings indicate a projected local extinction of the species. According to Khumbongmayum *et al.* (2006), presence of species that represented only by adults without any seedlings and saplings may be due to poor seed set, germination and poor establishment of seedlings in the forest. Reddy and Ugle (2008) mentioned that reduced regeneration may be a threat to the species and the population structure will be unstable and regeneration potential will be negligible if the species is represented only by adults in any forest.

Variations in the population structure of regeneration may be attributed to differences in their habitat and prevailing microenvironmental factors. Earlier study stated that open canopy might favour germination and seedling establishment by increased incidence of solar radiation on the forest floor and consequent increase in surface temperature, and reduced competition from the canopy layer (Srinivas, 1992). According to Adam and El Tayeb (2008), lack of natural regeneration ultimately affects the regular distribution of diameter classes, and consequently the performance of the tree in its ecological and production functions. The present study showed that regeneration of the species is favoured only under <40% canopy cover. Reduced amount of light that reaches the forest floor is responsible for the decline of tree seedlings (Sharma and Raghubanshi, 2006). Sapkota and Oden (2009) reported that relative seedling density of *Terminalia alata* increases with increase in gap areas. Since *T. travancorensis* is an evergreen species, negligible occurrence of its regeneration might be due to thick litter accumulation and closed canopy, which reduce seed germination. However, regeneration of *T. travancorensis* in the present study was not in par with their mature trees.

Phenology

Trees of *T. travancorensis* were leafless during January. Similar event was reported in Troup's Silviculture of Indian Trees (FRI, 1984). Trees were in flush (young leaves) between February and March. Flowering commenced from May and continued upto January. Fruiting was from September to June. The various phenological events are triggered by rainfall, availability of water, temperature, photoperiods, duration of dry spell and change in daylength. Timing of recurring biological events provides a background for seed collection and help to understand the regeneration process of the species. Information on phenological events is useful in evolving proper management strategy as well as better understanding of natural regeneration potential.

Seed germination

Pre-sowing treatments on seeds of *T. travancorensis* enhanced germination and maximum (35%) germination was obtained when the seeds were subjected to weathering treatment (wetting and drying for seven days); very low germination (3%) was found in the split treatment (Table 1). ANOVA showed significant ($P = 0.01$) treatment effect on germination. The study revealed that weathering is the best pre-treatment to get a better seed germination. Seeds without pre-treatment (T_0) showed little change in the germination percentage after 68 days of sowing. However, seeds subjected to weathering treatment (T_1) continued to germinate even upto 101 days after sowing. In teak also weathering is an effective pre-treatment for enhancing seed germination (Omalsree *et al.*, 2010).

Table 1: Mean germination percent of different treatments in *T. travancorensis*

Sl. No	Treatment code	Treatment	Germination %
1	T_0	Control	25.75 ± 4.50
2	T_1	Weathering	34.50 ± 7.05
3	T_2	De-pulped & weathering	12.50 ± 3.32
4	T_3	De-pulped & Split	2.67 ± 1.31

Vegetative propagation

Juvenile shoots from the branches of mature trees showed negative response to the rooting hormones. Shoots from the established seedlings of *T. travancorensis* responded to rooting hormones. The response of rooting to different hormone concentrations is given in Table 2. Maximum rooting was found in the auxin combination IBA+Kinetin 6000 ppm. Lowest rooting was observed in control indicating the need for hormonal treatment for enhanced rooting. Similarly, maximum root length was also in IBA+Kinetin 6000 ppm followed by IBA+Kinetin 8000 ppm and IBA+Kinetin 7000 ppm. The result was statistically analyzed using ANOVA, which showed significant difference ($P = 0.05$) between treatments.

Table 2: Rooting response of single nodded cuttings of *T. travancorensis*

Treatment code	Treatment	Rooting %
T_0	Control	37.50
T_1	IBA+Kinetin 5000 ppm	64.75
T_2	IBA+Kinetin 6000 ppm	70.83
T_3	IBA+Kinetin 7000 ppm	53.85
T_4	IBA+Kinetin 8000 ppm	62.48

The study revealed that natural regeneration of the species in the original habitat is very meager probably due to the impact of microclimate without much canopy gap. For conserving such important species, artificial regeneration is one of the effecticve tools to sustain the population.

Conclusions

The study concluded that occurrence of *T. travancorensis* was minimal and limited to a few localities and their regeneration was negligible. Regeneration of the species is not in par with their mature trees. In order to regenerate the species artificially, weathering is one of the best pre-treatments for enhancing seed germination. In addition to the seed germination, artificial regeneration could be possible through vegetative propagation by juvenile shoots from the established seedlings of the species using an auxin combination - IBA+Kinetin 6000 ppm, as rooting hormone. For conserving the diminishing *T. travancorensis*, restoration of the species *in situ* through the artificial regeneration is an effective tool.

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References

1. **Adam, A.A. and El Tayeb, A.M. 2008.** A comparative study of natural regeneration of *B. papyrifera* and other tree species in Jebel Marra Darfur; Sudan. *Research Journal of Agriculture and Biological Science* 4:94-102.
2. **Bhadra, A. and Dhal, N.K. 2010.** Tree seedling diversity in the protected natural forest of Gandhamardan hill ranges. *The Bioscan* 2:451-459.
3. **FRI, 1984.** *Troup's Silviculture of Indian Trees*. The Controller of Publications, Govt. of India, New Delhi Vol. V; 68-149.
4. **Khumbongmayum, A.D., Khan, M.L. and Tripathi, R.S. 2006**. Biodiversity conservation in sacred groves of Manipur, northeast India: population structure and regeneration status of woody species. *Biodiversity and Conservation* 15:2439-2456.
5. **Kunhikannan, C., Dogra, R.K., Venkatasubramanian, N., Sivalingam, R., Kumar, N.P. & Thomas, S. 2003**. Population structure and regeneration status of some threatened medicinal plants in Silent Valley medicinal plant conservation area (MPCA). Pp. 24-27. *In*: Kallaracka, J., Swarupanandan, K and Sharma, J.K. (eds.) *Proceedings of Workshop on Conservation and Research Needs of the Rare, Endangered and Threatened (RET) Tree Species in Kerala Part of the Western Ghats*, Thiruvananthapuram, 14 February 2003.
6. **Lakshmi, M.1, Bindu, R. Nair and Chandrasekhara Pillai, P. K. 2012.** Pharmacognostic evaluation and phytochemical analysis of bark and leaves of *Terminalia travancorensis* Wight & Arn. (Combretaceae). *Journal of Pharmacy Research* 5(4): 1988-1991.
7. **Menon, A.R.R. 2010.** Impact of selection felling on tropical forest ecosystem with special reference to forest regeneration. *Annals of Forestry* 18:15-38.
8. **Omalsree, M. Jiji, A.H. and Subin, S. 2010.** Standardization of weathering treatment in teak seeds (*Tectona grandis* Linn. f.). *In* Proceedings of 22nd Kerala Science Congress, 28-31January 2010, KFRI, Peechi, pp. 599-600.
9. **Reddy, C.S. & Ugle, P. 2008.** Survival threat to the flora of Mudumalai Wildlife Sanctuary, India: An assessment based on Regeneration status. *Nature and Science* 6:42-54.
10. **Sapkota, I.P. & Oden, P.C. 2009.** Gap characteristics and their effects on regeneration, dominance and early growth of woody species. *Journal of Plant Ecology* 2:21-29.
11. **Sasidharan, N. 2004.** Biodiversity documentation for Kerala- Flowering Plants, part 6: Kerala Forest Research Institute. 44p.
12. **Sharma, G.P. & Raghubanshi, A.S. 2006.** Tree population structure, regeneration and expected future composition at different levels of *Lantana camara* L. invasion in the Vindhyan tropical dry deciduous forest of India. *Lyonia* 11:27-39.
13. **Srinivas, C. 1992.** *Plant biomass, net primary productivity and nutrient cycling in Oak Quercus serrata Thumb. Forests of Manipur*. Ph.D. Thesis, Manipur University, Manipur, India.
14. **Tripathi, R.S. & Khan, M.L. 1990.** Effects of seed weight and microsite characteristics on germination and seedlings fitness in two species of *Quercus* in a subtropical wet hill forest. *Oikos* 57:289-296.

Taxonomic studies of the genus *Litsea* Lam. (Lauraceae) in Kerala

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Abstract

The genus *Litsea* Lam. belongs to the family Lauraceae occurring in Kerala has been revised here. A total of 21 taxa were recognized till date from Kerala.

Key words: *Litsea,* Lauraceae, Kerala, taxonomy

Introduction

The genus *Litsea* Lam., which comprises approximately 400 species, is the largest genus in the tribe *Laureae* of the family *Lauraceae*. It is a dioecious genus of evergreen or deciduous trees or shrubs, respectively. The genus is widely distributed in tropical and subtropical Asia, Australia, New Zealand, North America, and subtropical South America (Li and Christophel, 2000; Mabberley, 2008). There are about 21 *Litsea* species recorded in Kerala, of which 15 taxa are identified as endemic to Western Ghats, one is endemic to South India and two belong to Peninsular India. *Litsea beddomei* Hook. f., *L. mysorensis* Gamble, *L. nigrescens* Gamble and *L. travancorica* Gamble are assessed as endangered by IUCN (Sasidharan, 2004). Morphological data were collected from personal observation of live plants, herbarium specimens and the available literature. In addition, taxa within certain species complexes are difficult to distinguish from one another because few characters distinguish them (Li et al., 2004). *L. nigrescens* Gamble could not be relocated after Gamble from its type locality. Herbarium specimens were collected during the field surveys (2008-2012) and herbaria prepared. Flowers and fruits were kept in FAA for future reference. The voucher specimens are housed at the herbarium of Centre for Medicinal Plants Research, Arya Vaidya Sala, Kottakkal.

The endemic species of *Litsea* are confined to 10 states of India. The highest number of endemic species (15) is recorded from Kerala followed by Tamil Nadu (12). The states of Karnataka, Maharashtra and Arunachal Pradesh have 7, 5 and 3 endemic species, respectively (Plate 1 & 2).

Materials and methods

Botanical surveys were conducted to study the genus *Litsea* Lam. in the Western Ghats of Kerala from 2008 to 2012. A thorough exhaustive literature survey and study of herbarium specimens preserved at the Central National Herbarium, Botanical Survey of India, Howrah in West Bengal (CAL) and Coimbatore in Tamil Nadu (MH) and those of research institutes and colleges housing good collections of Lauraceae members such as TBGT, KFRI, CALI, FRLH, herbarium of Centre for Ecological Studies, Bengaluru. Herbarium specimens of different species with a minimum of three samples per species were prepared based on standard herbarium techniques (Jain and Rao, 1977) and (Bridson and Forman, 1991). Digital images of type specimens were obtained from the Royal Botanic Gardens, Kew (K) to confirm the identity of the species. The status of the relevant species included in IUCN Red List of Threatened Species has been given following IUCN (2010), IUCN Red List of Threatened Species, Version 2013. <http://www.iucnredlist.org/>.

Enumeration

1. ***Litsea beddomei*** Hook. f., Fl. Brit. India 5: 177. 1886.
Small trees. Leaves linear - oblong or lanceolate, to 15 x 3.5 cm, obtuse, glabrous above, white-glaucous beneath when dry. Berries ca. 1.2 cm long, oblong.
Distribution: Endemic to the Western Ghats of Kerala and Tamil Nadu. *Status*: Endangered.
Habitat: Evergreen forests. *Flowering* & *Fruiting*: September - November.
Specimens examined: P. S. Udayan & A. J. Robi, 05844 collected from Periya, Wayand district, Kerala, at an altitude of 800-1300 m on 07.04.2009

2. ***Litsea bourdillonii*** Gamble, Bull. Misc. Inform. Kew 1925.
Small trees. Leaves: lamina obovate or obovate-oblong, to 21 x 12 cm, base cuneate or acute, apex obtusely acute. Flowers in umbellules, sessile or subsessile, in axillary or lateral clusters of 2-5. Berries ca. 1. 5 mm long, oblong.
Distribution: Endemic to the Southern Western Ghats.
Habitat: Evergreen forests. *Flowering* & *Fruiting*: December – May.
Specimens examined: P. S. Udayan & A. J. Robi, 05766 collected from Ummikuppankudi, Idukki district, Kerala, at an altitude of 800-1100 m on 17.03.2009

3. ***Litsea coriacea*** (Heyne ex Meisner) Hook. f., Fl. Brit. India 5: 166. 1886.
Medium sized trees. Leaves elliptic-lanceolate or elliptic-ovate, to 17.5 x 7.5 cm, base acute or cuneate, apex acute or acuminate, glabrous above, minutely puberulous beneath. Flowers in 4-flowered axillary, subsessile, crowded umbels. Berries 1.2 cm long, ovoid.
Distribution: Endemic to Peninsular India.
Flowering & *Fruiting*: December – January. *Habitat*: Semi-evergreen forests and sacred groves.
Specimens examined: P. S. Udayan & A. J. Robi, 05548 collected from Siruvani, Palakkad district, Kerala, at an altitude of 550-750 m on 14.01.2010

4. ***Litsea deccanensis*** Gamble, Fl. Pres. Madras 1235 (864). 1925.
Small trees. Leaves crowded at the end of branchlets, elliptic, obovate or elliptic-oblong, to 24 x 9 cm, base acute or round, apex acute or acuminate, glabrous above except on veins, glossy, finely tomentose and yellowish-white beneath. Flowers pale yellow, in axillary, pedunculate, solitary or in many flowered umbellate heads. Berries, 1.5 cm, globose.
Distribution: South India and Sri Lanka
Specimens examined: P. S. Udayan & A. J. Robi, 04988 collected from Calicut University, Malapuram district, Kerala, at an altitude of 80-150 m on 31.03.2008.

5. ***Litsea floribunda*** (Blume) Gamble, Fl. Pres. Madras 1238(867). 1925.
Medium sized trees. Leaves elliptic-oblong or ovate oblong, to 28 x 10 cm, base acute, apex acute or acuminate, rusty tomentose beneath. Flowers in axillary racemose umbellules. Berries 1.8 cm, oblong.
Distribution: Endemic to the Western Ghats.
Habitat: Semi-evergreen to Shola forests.
Flowering & *Fruiting*: December - April.

Specimens examined: P. S. Udayan & A. J. Robi, 06892 collected from Nelliyampathy, Palakkad district, Kerala, at an altitude of 850-950 m on 05.06.2010.

6. ***Litsea ghatica*** Saldanha, Fl. Karnataka 1: 67. 1984.

Large shrubs. Leaves, subverticillate, obovate, 20 x 9 cm, apex abruptly acute or obtuse, tapering to subacute or rounded base, glabrous except nerves above, more or less softly tomentose beneath. Flowers in solitary umbels. Berries, 1.5 cm, globose.

Distribution: Endemic to the Western Ghats of Karnataka and Kerala.

Habitat: Evergreen forests. *Flowering* & *Fruiting*: September - February.

Specimens examined: P. S. Udayan & A. J. Robi, 05817 collected from Pakshipathalam,Waynad district, Kerala, at an altitude of 950-1110 m on 26.03.2009

Note: The present collection from Waynad district of Kerala extends its distribution further towards southern Western Ghats.

7. ***Litsea glabrata*** (Wall. ex Nees) Hook. f., Fl. Brit. India 5: 174. 1886.

Small trees. Leaves linear-oblong or elliptic-lanceolate, 18 x 5 cm, base acute or cuneate, apex acute. Flowers in axillary racemes of 2-6 cm long. Berry, bright-red, 1 cm, ovoid.

Distribution: Southern Western Ghats

Habitat: Semi-evergreen forests. *Flowering* & *Fruiting*: September - May.

Specimens examined: P. S. Udayan & A. J. Robi, 06831 collected from Kallar,Idukki district, Kerala, at an altitude of 650-800 m on 02.09.2010

8. ***Litsea glutinosa*** (Lour.) Robins., Philipp. J. Sci. 6: 321. 1911.

Small trees. Leaves pilose when young; elliptic-oblong or obovate, to 23 x 10 cm, base acute, apex acute, obtuse or acuminate, glabrous above, grey-pubescent beneath. Flowers yellow, in many flowered umbels. Berry, depressed globose, 6 mm, purple.

Distribution: Indo-Malesia and China

Habitat: Moist deciduous and semi-evergreen forests. *Flowering* & *Fruiting*: April - May.

Specimens examined: P. S. Udayan & A. J. Robi, 06851 collected from Chelakara, Thrissur district, Kerala, at an altitude of 150-200 m on 10.02.2008

9. ***Litsea keralana*** Kosterm. in Ceylon J. Sci., Biol. Sci. 12: 138. 1977.

Large trees. Leaves elliptic-oblong or obovate, 25 x 14 cm, base slightly acute, obtuse or truncate, apex obtuse, glabrous above and roughly fulvous-pubescent beneath. Flowers yellowish, in axillary, lateral or cauliflorus umbellules 10-20 together. Berry ellipsoid-obtuse, 1.5 cm, reddish-brown.

Distribution: Endemic to the Western Ghats.

Habitat: Semi-evergreen - evergreen forests. *Flowering* & *Fruiting*: September - October.

Specimens examined: A. J. Robi, 01820 collected from Kulamav, Idukki district, Kerala, at an altitude of 750 - 900 m on 04.04.2011

10. ***Litsea laevigata*** (Nees) Gamble, Fl. Pres. Madras 1236 (865). 1925.

Small trees. Leaves oblong-lanceolate or elliptic-lanceolate, base slightly obliquely acute or obtuse, apex acuminate or acute, glabrous above and puberulent beneath. Flowers yellowish, 10-12 in axillary or lateral subsessile umbellules. Berry, 1.5 cm long, ellipsoid, glabrous, yellow.

Distribution: Endemic to the Southern Western Ghats.

Habitat: Semi-evergreen forests. *Flowering* & *Fruiting*: March - April.

Specimens examined: P. S. Udayan & A. J. Robi, 05681 collected from Pandipath, Trivandrum district, Kerala, at an altitude of 900 – 1100 m on 14.02.2009

11. ***Litsea myristicaefolia*** (Wall. ex Nees) Hook.f., Fl. Brit. India 5: 172. 1886.

Small trees. Leaves elliptic-oblong or lanceolate, to 12 × 4.5 cm, base attenuate, apex acute or acuminate. Flowers yellowish, in globose umbellules clustered in axillary and subterminal racemes. Berry globose, 1 cm.

Distribution: Indo-Malesia

Habitat: Shola forests. *Flowering* & *Fruiting*: May - August.

Specimens examined: P. S. Udayan & A. J. Robi, 06042 collected from Kurisumala, Trivandrum district, Kerala, at an altitude of 950 – 1000 m on 20.05.2009

12. ***Litsea mysorensis*** Gamble, Bull. Misc. Inform. Kew 1925: 130. 1925.

Small trees. Leaves linear-lanceolate or elliptic-oblong, base acute, apex acute or acuminate, margin entire, glabrous, chartaceous. Flowers yellowish, in subsessile umbellules. Berry globose, 0.8 cm.

Distribution: Endemic to the Western Ghats of Kerala, Karnataka and Tamil Nadu.

Habitat: Evergreen forests. *Flowering* & *Fruiting*: July - September. Status: Endangered.

Ecology: Rare in evergreen and mixed forests of Western Ghats at elevations from 900-1200 m.

Specimens examined: P. S. Udayan & A. J. Robi, 05846 collected from Periya, Waynad district, Kerala, at an altitude of 900 – 1200 m on 04.04.2010

13. ***Litsea nigrescens*** Gamble, Fl. Pres. Madras 1236(865). 1925.

Moderate sized trees. Leaves elliptic or oblong, base cuneate, apex obtusely acute or acuminate, black when dry. Flowers in umbels, arranged in racemes; fruits not known.

Distribution: Endemic to Kerala and Tamil Nadu.

Habitat: Evergreen forests of the Western Ghats at altitude 600-1200 m. *Flowering*: April - June. *Status*: Endangered.

Specimens examined: *Bourdillon 998* Trivandrum, Kerala, (CAL).

Note: This plant is not recollected yet after type collection

14. ***Litsea oleoides*** (Meisner) Hook. f., Fl. Brit. India 5: 175. 1886.

Large trees. Leaves elliptic-oblong or elliptic-lanceolate, to 17 x 7.5 cm, base acute, apex acute or obtuse, reddish-brown beneath when dry. Flowers yellowish, in axillary racemes. Berry 2-2.5 cm across, red with white spots.

Distribution: Endemic to Kerala and Tamil Nadu.

Habitat: Evergreen forests. *Flowering* & *Fruiting*: August - June.

Specimens examined: P. S. Udayan & A. J. Robi, 06790 collected from Pambadushola, Idukki district, Kerala, at an altitude of 800 – 1200 m on 05.05.2010

15. ***Litsea quinqueflora*** (Dennst.) Suresh in Nicolson et al., Interpr. Hort. Malab. 158. 1988.

Small trees; branchlets densely tomentose. Leaves, obovate, to 20 x 9 cm, obtuse at apex, acute to the base.

Flowers in umbellules 10-20 mm across; bracts orbicular, densely tomentose outside. Berry, globose, 1.5 cm.
Distribution: Endemic to the Southern Western Ghats.
Habitat: Evergreen and moist deciduous forests. *Flowering* & *Fruiting*: April - May.
Specimens examined: P. S. Udayan & A. J. Robi, 05459 collected from Eravikulam, Idukki district, Kerala, at an altitude of 1000 – 1200 m on 22.01.2009

16. ***Litsea stocksii*** (Meisner) Hook. f. var. ***glabrescens*** (Meisner) Hook. f., Fl. Brit. India 5. 176. 1886.
Small trees. Leaves elliptic-oblong or elliptic-lanceolate, base acute, apex acute or obtuse, reddish-brown beneath when dry. Flowers yellowish, in umbellules, in axillary racemes up to 6 cm. Berry oblong, 2-2.5 cm across, red with white spots.
Distribution: Endemic to the Peninsular India.
Habitat: Evergreen forests. *Flowering* & *Fruiting*: December - February.
Specimens examined: P. S. Udayan & A. J. Robi, 05459 collected from Pandipath, Trivandrum district, Kerala, at an altitude of 1000 – 1100 m on 04.12.2008

17. ***Litsea stocksii*** (Meisner) Hook. f., Fl. Brit. India 5: 176. 1886, var. ***stocksii***
Medium trees. Leaves elliptic to obovate, acute, reddish beneath, glabrous. Flowers in racemes, umbellules few. Drupes obovoid, 12 x 8 mm, reddish brown, smooth.
Distribution: Endemic to Maharashtra, Karnataka, Kerala and Tamil Nadu.
Habitat: Moist deciduous, semi-evergreen and evergreen forests. *Flowering* & *Fruiting*: August - March.
Specimens examined: P. S. Udayan & A. J. Robi, 05444 collected from Kakkayam, Kozhikode district, Kerala, at an altitude of 900 – 1300 m on 20.01.2009

18. ***Litsea travancorica*** Gamble, Bull. Misc. Inform. Kew 1925: 132. 1925.
Medium sized trees. Leaves opposite, elliptic-oblong to ovate-oblong, to 20 x 7.5 cm, base obtuse or acute, apex acuminate, fulvous-pubescent. Flowers yellowish, in axillary crowded sessile umbellules. Berries ellipsoid, 1 cm long.
Distribution: Endemic the Southern Western Ghats of Kerala.
Habitat: Evergreen forests. *Flowering* & *Fruiting*: February - April. *Status:* Endangered.
Specimens examined: P. S. Udayan & A. J. Robi, 06552 collected from Kattalapara, Kollam district, Kerala, at an altitude of 900 – 1200 m on 22.01.2010

19. ***Litsea venulosa*** (Meisner) Hook.f., Fl. Brit. India 5: 161. 1886. *Litsea beei* N.Mohanan & E.S.S.Kumar, Nordic J. Bot. 23: 611. 2005, *syn nov*.
Shrubs. Leaves elliptic-oblong to 12 x 5 cm, obtusely caudate-acuminate, base obtuse, glaucous below. Flowers in umbels, solitary or 4-5 flowered. Berries, 6-10 mm in diameter, globose.
Distribution: Endemic to Kerala and Tamil Nadu.
Habitat: Evergreen and semi-evergreen forests. *Flowering* & *Fruiting*: June - February.
of Western Ghats at elevations 700-1400 m.
Specimens examined: P. S. Udayan & A. J. Robi, 04857 collected from Athirumala, Trivandrum district, Kerala, at an altitude of 700 – 1400 m on 22.01.2010

20. ***Litsea wightiana*** (Nees) Hook. f. var. ***tomentosa*** (Meisner) Gamble, Fl. Pres. Madras 1238(866). 1925.
Large trees. Leaves elliptic-oblong to oblong-lanceolate, to 15 x 6 cm, base acute or rarely obtuse, apex obtuse, glabrous above, rusty brown pubescent beneath. Flowers 4-6, in umbels. Berries ellipsoid, 8-12 mm long.
Distribution: Endemic to Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu.
Habitat: Evergreen and semi-evergreen forests. *Flowering* & *Fruiting*: August - July.
Specimens examined: P. S. Udayan & A. J. Robi, 05691 collected from Poochappara, Palakkad district, Kerala, at an altitude of 1000 – 1800 m on 07.03.2009

21. ***Litsea wightiana*** (Nees) Hook. f. in Benth. & Hook. f., Gen. Pl. 3: 162. 1880,p.p, var. ***wightiana***
Medium sized trees. Leaves obovate or oblong, apex obtuse, acute, cuneate at base, reddish brown beneath, tomentose, often recurved, glabrous above, rusty brown pubescent beneath. Flowers in axillary racemose umbellules, the whole inflorescence brown pubescent. Berry ovoid, 1 cm long.
Distribution: Endemic to the Southern Western Ghats.
Habitat: Evergreen forests. *Flowering* & *Fruiting*: August- October.
Specimens examined: P. S. Udayan & A. J. Robi, 04918 collected from Kakkayam, Kozhikode district, Kerala, at an altitude of 850 – 1000 m on 26.03.2008

Results and discussion

There are about 21 species of *Litsea* recorded from Kerala, of which 15 taxa were identified as endemic to Western Ghats, one is endemic to South India and two belongs to Peninsular India. *Litsea beddomei* Hook. f., *L. mysorensis* Gamble, *L. nigrescens* Gamble and *L. travancorica* Gamble are assessed as Endangered by IUCN.

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References

1. **IUCN, 2010.** IUCN Red List of Threatened Species. http://www.iucnredlist.org/. IUCN, Gland, Switzerland. Retrieved on 21 September 2010.
2. **Li , J. and D. C. Christophel. 2000.** Systematic relationships within the *Litsea* complex (Lauraceae): A cladistic analysis based on morphological and leaf cuticle data. *Australian Systematic Botany* 13 : 1 – 13 .
3. **Li , J., D. C. Christophel , T. G. Conran , and H. W. Li. 2004.** Phylogenetic relationships within the 'core' Laureae (*Litsea* complex, Lauraceae) inferred from sequences of the chloroplast gene *mat* K and nuclear ribosomal DNA ITS regions. *Plant Systematics and Evolution* 246 : 19 – 34 .
4. **Mabberley, D. J. 2008.** The Plant Book: A portable dictionary of plants, their classification and uses. Third Edition. Cambridge University Press, Cambridge, pp. 496.
5. **Sasidharan, N. 2004.** Biodiversity documentation for Kerala, Part 6: flowering plants. KFRI, Peechi.
6. <**http://www.iucnredlist.org/**>.

A. *Litsea beddomei* Hook. f., B. *Litsea bourdillonii* Gamble, C. *Litsea coriacea* (Heyne ex Meisner)Hook.f., D. *Litsea deccanensis* Gamble, E. *Litsea floribunda* (Blume)Gamble, F. *Litsea ghatica* Saldanha, G. *Litsea glabrata* (Wall. ex Nees)Hook. f., H. *Litsea glutinosa* (Lour.)Robins., I. *Litsea keralana* Kosterm., J. *Litsea laevigata* (Nees)Gamble

A. *Litsea myristicaefolia* (Wall. ex Nees)Hook. f., B. *Litsea mysorensis* Gamble, C. *Litsea oleoides* (Meisner)Hook.f., D. *Litsea quinqueflora* (Dennst.)Suresh, E. *Litsea stocksii* (Meisner)Hook. f. var. *glabrescens* (Meisner)Hook.f., F. *Litsea stocksii* (Meisner)Hook. f. var.*stocksii*, G&H. *Litsea travancorica* Gamble, I. *Litsea venulosa* (Meisner)Hook.f., J. *Litsea wightiana* (Nees)Hook.f. var. *tomentosa* (Meisner)Gamble, K. *Litsea wightiana* (Nees)Hook.f. var. *wightiana*

Landscape analysis of Parambikulam Tiger Reserve in the Western Ghats of India, using Remote Sensing and GIS

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Abstract

Land use planning and necessary supporting data are crucial to protected areas of the Western Ghats that are usually under severe climatic, environmental and demographic strains. Approaches and methods to map the variability of natural resources are important tools to properly guide spatial planning. Many geographic information systems are being developed that store topographic information as the primary data for analysing ecological problems. The use of GIS for collecting, storing, and processing the spatial database was useful to interpret and determine the Landscape of the area. A geospatial approach was used for the analysis of terrain features such as altitude, slope, aspect, drainage, contour and land cover of the Parambikulam Tiger Reserve of Kerala in the Western Ghats of India. Digital elevation models, Satellite imageries and Survey of India topo sheets are the primary data used in the analysis of topography and also to study the distribution of vegetation on different terrains. Digital image processing of IRS P6 LISS III imagery of the year 2005 showed that the area is covered by 7 major land cover classes such as Evergreen forest, Semi evergreen forest, Moist Deciduous forest, Teak plantation, Open forest, Dense Scrub forest and Reservoir. The slopes derived from the Digital Elevation Model range from 0-63^0. The area in general has a slope towards the west. In contrast to other mountainous regions in the Western Ghats the ridges here run west-east. The southern slopes of these ridges are steeper than the northern slopes. The altitude in the study area ranges from 84m to 1527m. The general topography of the reserve can be concluded as mountainous. The terrain is most undulating with a valley in the basin. Majority of the study area (60%) lies between the altitudinal ranges 400-800m and supports natural vegetation. The Evergreen forests are confined to the higher altitudes and the medium altitude supports Moist Deciduous forest and Teak Plantation. Results indicate the distribution of major landforms and dominant land cover, and provide a synoptic inventory of natural resources.

Key words: Parambikulam Tiger Reserve, Kerala, Western Ghats, land scape analysis, remote sensing, GIS

Introduction

One of the most rapidly growing applications of remotely sensed data is the derivation of landscape pattern metrics for the assessment of land cover condition and landscape change dynamics (Betts et al., 2003; Santiago et al., 2007). Satellite remotely sensed data has significant potential use in analysis and evaluation on Landscape Pattern. Relying on the recent advances in satellite remote sensing and geographic information system (GIS) techniques, (Jianping et al., 2007) this paper aims to probe into the analysis and evaluation on landscape pattern of Parambikulam Tiger Reserve. Terrain parameters such as elevation, slope etc. are often required as input in a large number of applications such as preparation of development and conservation plan for natural resources, watershed management, modeling of soil loss, runoff and site suitability analysis etc. Conventionally these parameters are obtained through field measurement/survey or from existing topographic maps depending on the purpose and level of information required. The above mentioned terrain parameters can be extracted from DEM (Digital Elevation Model). Satellite data and DTM (Digital Terrain Model) are the most acceptable and cost effective way to understanding geomorphologic features of landscape.

Study area

The area selected is of Parambikulam Tiger Reserve (PKTR) which lies between the longitudes 76˚ 30′ and 76˚ 55′ East and latitudes 10˚ 15′ and 10˚ 35′ North (Fig. 1). The Tiger Reserve is situated in Palakkad and Thrissur districts in the state of Kerala and the drainage basin is Chalakkudi River. Parambikulam Tiger Reserve has an area of 643.662 km^2. The Tiger Reserve is located in the immediate south of Palakkad gap, exhibits undulating terrain interspersed with dry or moist valleys. Tropical Evergreen Forests, Moist Deciduous Forests and Teak Plantation Forests are the prominent biogeographic Biomes. The altitude ranges from 84m to 1527m.

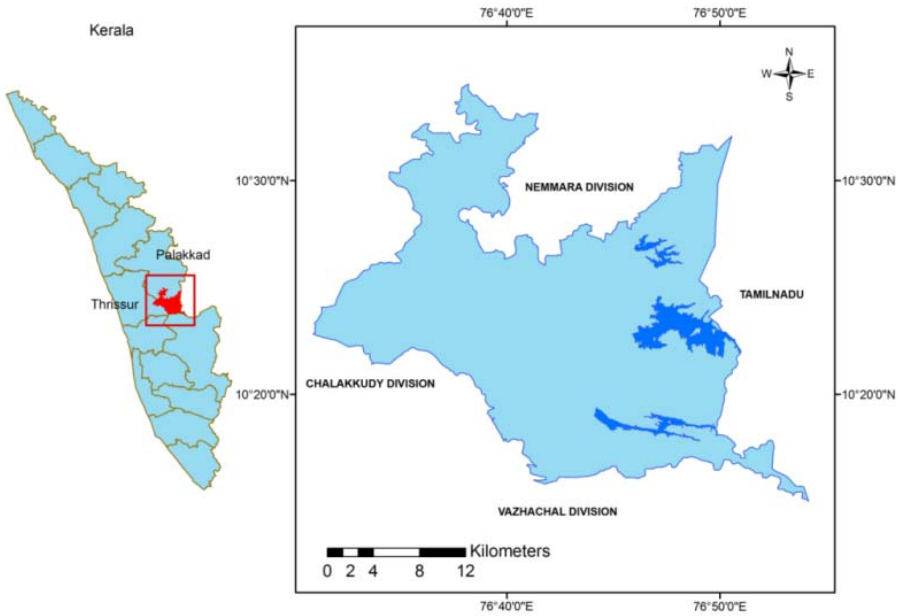

Fig. 1: Map of the study area

Materials and methods

Geospatial approach was used for the analysis of terrain features such as altitude, slope, and land cover of the Parambikulam Tiger Reserve of Kerala in the Western Ghats of India. Digital elevation models, Satellite imageries and SOI topoheets are the primary data used in the analysis of topography and also to study the distribution of vegetation on different terrains. The The topographic information such as elevation (m), slope (degrees) and aspect were derived from SRTM (Shuttle Radar Topo Mission) data using Arc Gis and Global Mapper. Areas under different elevation range and slope classes were demarcated and their respective percentage was calculated. The land cover coming under each elevation and slope classes was also find out.

Digital interpretation of satellite imageries are implemented to prepare landcover map. The cloud free satellite data of IRS-P6 LISS III covering the Parambikulam Tiger Reserve were acquired from NRSC, Hyderabad. The satellite data was rectified with reference to (1:50,000 scale) SOI topographical maps using geometrical rectification tools of ERDAS Imagine. Supervised classification technique was used to prepare the land use land cover map from the IRS P6 LISS III data.

Elevation of the study area was classified in 5 zones *i.e.* very low (84-400m), low (400-600m) medium (600-800m), high (800-1000m) and very high (1000-1498m). These elevation zones were determined based on the topographic variations, variability in the forest species and forest structure. The area is composed of the plateau (higher elevation), slopes and lower plains. Area and percentage of forest cover in different altitudinal zones was calculated by overlying the elevation map with the land cover map using appropriate tools in GIS softwares.

Forest cover in different slope categories was carried out using SRTM –DEM. The data was analysed in GIS format to determine the forest cover in different slope classes. The slope map generated from the 90m DEM has three different slope classes *viz.* Class 1 with 0-15º (Gentle) slopes, Class 2 with 15-30º (Steep) slopes, Class 3 having 30-63º(Very steep) slopes. Areas under different slope classes were demarcated and their respective percentages were calculated. The area status of landcover types in different slope categories was also find out.

Results & Discussion

Vegetation Mapping

Vegetation map was prepared from IRS P6 LISS III satellite imagery of the year 2005procured from National Remote Sensing Centre (NRSC), in digital format. The bands of 2 in blue, 3 in green and 4 in red were used for FCC creation and digital image processing. Supervised classification technique was used for the digital image processing to know the status of land use/land cover (LULC). Altogether, seven land cover classes have been identified *viz.*, evergreen forest, semi evergreen forest and moist deciduous forest, teak plantation, forest blank and open forest (Fig.3). The seven land cover classes, area statistics and percentage of area are given in Table.1 and Fig.2. Among the forest types, Evergreen forest covers 34%, Semi evergreen forest 12%, Moist deciduous forest 18%, Teak plantation 13%, Forest blank 9%, Open forest 11%, Reservoir 4%. The area is predominantly covered by Evergreen forest which is approximately 34% (217 km^2) of the total area.

Table 1: Area statistics of the major land cover types in PKTR

(derived from IRS P6 LISS III data of the year 2005)

Sl. No.	Land cover type	Area (km^2)	% of Area
1	Evergreen	217	34
2	Semi Evergreen	76	12
3	Moist deciduous	118	18
4	Teak Plantation	81	13
5	Reservoir	24	4
6	Forest blank	55	9
7	Open forest	72	11
	Total	**643**	**100**

Vegetation is a vital component of the ecosystem, which indicates the effects of changing environmental conditions in an obvious and easily measurable manner. The PKTR has a wide spectrum of forest types ranging from wet evergreen to dry deciduous within an area of 643.7 km^2. The distribution of land cover was according to the prevailing climatic and topographic gradients in the area. The western and southern parts of the higher elevation zones of the area, where rainfall is higher showed moister types of vegetation, while northern part were predominantly covered with deciduous types of vegetation.

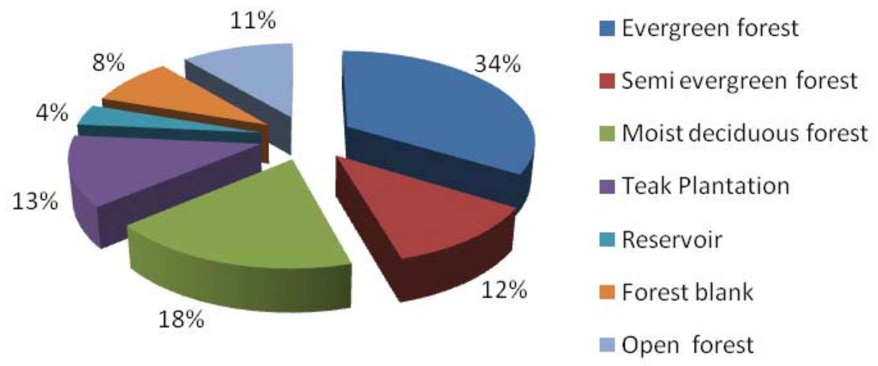

Fig. 3: Land cover map of PKTR derived from IRS P6 LISS III satellite image of the year 2005

Forest cover in different altitudinal zones

Forest cover in different altitudinal zones was analysed using Digital Elevation Model. The data was analysed in GIS format to determine the forest cover in different altitudinal zones. For the analysis, the zones have been taken as 84-400m, 400-600m, 600-800m, 800-1000m and 1000-1498m (Fig. 4). Overall, 80% of the forest area is coming under the altitudinal range 400-1000m and the least representation of the forest area (4%) falls within the altitudinal range 84-400m.The medium to high elevation range (600-1000m) supports evergreen habitat whereas the low to medium elevation range (400-800m) is characterized by the other land cover types such as Semi evergreen forest, Moist deciduous forest, Teak plantation, Forest blank and Open forest. The medium elevation area where the rainfall is higher showed moist types of vegetation, while lower parts were predominantly covered with deciduous type of vegetation.

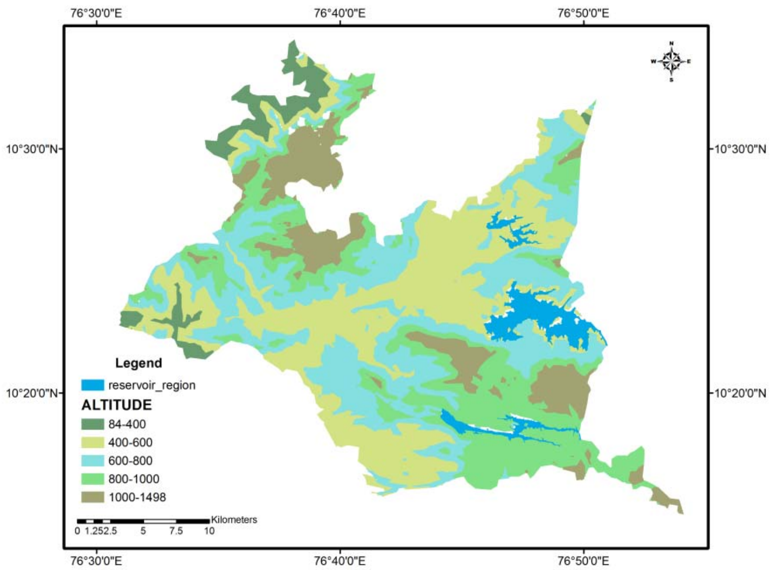

Fig. 4: Map showing the area coming under different altitudinal range

Around 70% of the evergreen forests are coming under the altitudinal range 600-1000m. No evergreen forests are reported from the altitudinal range 84-400m. Here the percentage contribution of EG forest increases with increase in altitude up to 1000m and decreased after 1000m. Around 65% of the Semi evergreen forest lies under the altitudinal belt 400-800m. Least representation of the Semi evergreen forest was in very low (84-

400m) and very high (1000-1498m) altitudinal belt. 80% of the moist deciduous forests are seen in 400-800m. Above 800m, the representation of moist deciduous forests is very less. 90% of the Teak plantations are in the 400-800m altitudinal belt, of which 65% is in 400-600m. Around 60% of the forest blank and open forests are in the 400-800m altitudinal belt (Fig. 5).

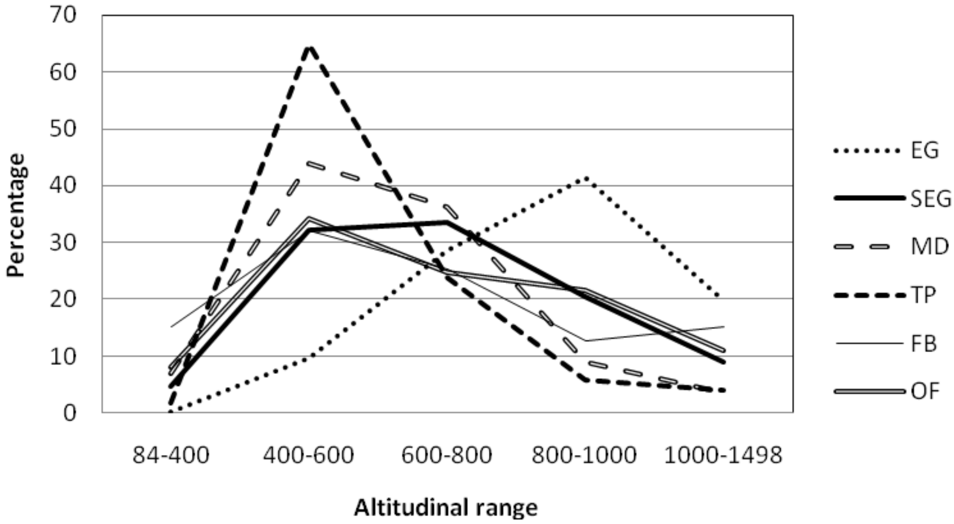

Fig. 5: Graph showing the forest cover in different altitudinal zones

Forest cover in different slope categories

Forest cover in different slope categories was carried out using SRTM - DEM. The data was analysed in GIS format to determine the forest cover in different slope classes. The slope map generated from the 90 m DEM has three different slope classes *viz.* Class 1 with 0-15° (Gentle slopes), Class 2 with 15-30° (Steep slopes), Class 3 having 30-63°(Very steep) slopes (Fig. 6).

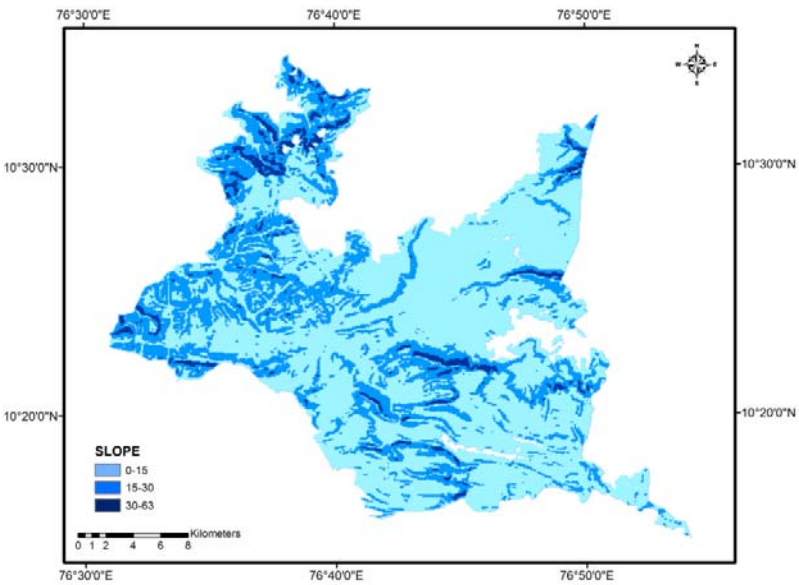

Fig. 6: Map showing the area coming under different slope classes

The slopes derived from the Digital Elevation Model (DEM) range from 0-63°. Areas of land cover types under different slope classes were demarcated and their respective percentages were calculated. Around 66%

of the forest cover is coming under the gentle slope category 0-15° and 30% of the land cover is coming in 15-30°. Very steep (30-63°) slope supports only less area of vegetation. The major extent of the study area falls within the gentle slope (0-15°) and supports tropical evergreen forests (Table. 2 and Fig.7). The slopes in the mountainous areas support wet evergreen forest, whereas mountain tops are characterized by extensive stretches of grasslands.

Table 2: Area and percentage contribution of land cover types in various slope categories

Slope (in degrees)	EG		SEG		MD		TP		FB		OF		Total	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
0-15	150	70	44	59	81	70	67	83	25	47	36	52	404	66
15-30	59	28	30	40	32	27	12	14	23	44	29	41	184	30
30-63	5	2	2	2	3	2	2	3	5	9	5	7	21	3
Total	**214**		**75**		**116**		**81**		**53**		**70**		**609**	

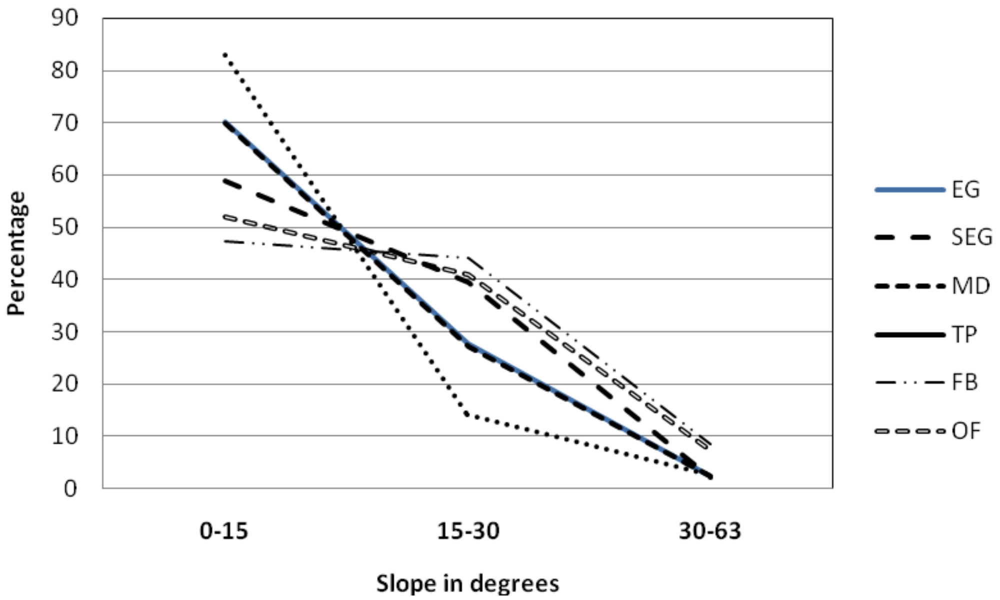

Fig. 7: Graph showing the forest cover in different slope categories

The slope category above 30 degree showed least area compared to all classes. All the major forest types were represented in 0-15 degree and 15-30 degree slope classes above which, land cover areas are least represented.

Conclusions

Spatial analysis of distribution of major landforms and dominant land cover provide a synoptic inventory of natural resources. With Remote Sensing and GIS technology, this paper analyzes and investigates the landscape level analysis, hoping that it will have a detailed view on the landscape pattern in Parambikulam Tiger Reserve and provide some new methods and ideas for the landscape protection.

References

1. **Betts, M.G., Franklin, S.E., Taylor, R.G. 2003.** Interpretation of landscape pattern and habitat change for local indicator species using satellite imagery and geographic information system data in New Brunswick, Canada. Canadian Journal of Forest Research 33 (10): 1821-1831.
2. **LI Jianping, GAO Feng and Zhang Bai. 2007.** Dynamic Change of Landscape Pattern at Jilin Province from 1980 to 2000, Geo-spatial Information Science 10(2): 128-132.
3. **Santiago Saura, Sandra Castro. 2007.** Scaling functions for landscape pattern metrics derived from remotely sensed data: Are their subpixel estimates really accurate? ISPRS Journal of Photogrammetry & Remote Sensing 62: 201-216.

Phylogenetic relevance of species diversity and endemism of the genus *Leucas* (Lamiaceae) in the Western Ghats

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Abstract

The genus *Leucas* R.Br. with ca 104 species are distributed mainly on dry or disturbed ground in the tropical to southern Africa and the tropical and subtropical parts of Asia and Australasia. Species found in Afro-Arabia shows marked differences with Asian species in morphological characters and only four species are common in two regions. A revisionary study attempted by the author recognized ca 104 species of which, 42 are found in Asia and in India. The morphology based phylogenetic studies pointed out a monophyletic nature to Asian species and the recent molecular based phylogenetic works have supported this. Based on these studies, it is proposed to consider Asian monophyletic group as *Leucas* s.str and the polyphyletic Afro-Arabian groups in another generic name together with allied genera. Further studies on Asian monophyletic groups revealed high endemism and species diversity in the Western Ghats, which is much higher than any region. This in turn pointed out the significance of the southern Western Ghats in the origin of this genus. Occurrence of very closely related species, their variant forms and polymorphic nature together with the presence of certain key character of African species in some of the narrow endemic species in this area signifies the phylogenetic relevance of Western Ghat diversity in the evolution of this genus.

Key words: *Leucas*, Lamiaceae, phylogeny, diversity, endemism

Introduction

The genus *Leucas* R. Br. is one of the largest genera of subfamily Lamioideae with ca. 104 species distributed mainly on dry or disturbed ground in the tropical to southern Africa and the tropical and subtropical parts of Asia and Australasia. (Harley et al, 2004). Some of the species are valuable medicinal herbs, used extensively in the traditional systems of medicine in India due to its antiseptic and microbicidal properties (Sunojkumar & Mathew, 2009) The African-Arabian and Indian species of *Leucas* have been treated in separate monograph by Sebald (1980) and by Mukerjee (1940). Very recently, Singh (2001) published a herbarium based study on Indian specimens as part of Flora of India work. In all these works, the focus has been on species diversity in part of the global distributional ranges, with the only representatives from other geographic groups being the 4 species as widespread taxa; probably introduced. All these studies were strictly based on morphological similarities and differences and analysed the diversity in the two major centres of diversity: tropical Africa and Asia. The highest species richness is found in the northern part of East Africa and the second area of species richness is in Indian sub-continent, more specifically in southern India. These studies also pointed out a clear morphologocal distinction between species in these two regions, but less is known regarding their relationships. Singh (2001) even suggested that the Asian and African species have evolved and developed independently. In the cladistic analysis of gross morphology and anatomy, Ryding (1998) found that Asian species form a monophyletic group within the 'paraphyletic' *Leucas*. According to him *Leucas* originated in north east tropical Africa including Socotra and later, Asia and eastern to southern Africa seems to have become the centre of evolution.

Leucas **s.str.**

Based on a detailed molecular phylogenetic study using sequence data from four chloroplast regions on African and Asian species, the monophyletic nature of Asian taxa were stressed by Scheen *et al* (2009). Considering the support for this hypothesis, they discussed splitting of *Leucas* sl into two genera: Asian taxa as *Leucas* s.str and the paraphyletic Afro-Arabian groups into a separate group and warrants further study to delineate its generic boundary. Since the genus *Leucas s.str.* is confined to Asia, studies on Asian diversity is much relevant, and analysis of south Indian diversity is further important due to high density and diversity of the species. In this context, a phytogeographic analysis was conducted on *Leucas* s.str. to understand the nature of diversity and endemism in order to trace the significance for Western Ghat diversity in the origin and evolution of the genus. This is discussed in the following sections and the need for further study on Asian diversity is stressed.

Methodology

Herbarium based survey of species distribution in India were analysed followed by field visits to the different parts of south India for a period of five years focusing on all phytogeographical regions. Special attention was given to three phytogeographical regions from Kalinadi to Coorg (WG2), in Nilghiris (WG3), the Anamalais Palnis and Cardamom hills (WG4) of the Southern Western Ghats (Subramanyam & Nayar (1974). Multiple trips were conducted to different centres of origin (Nayar, 1996) and potential diversity rich areas in different seasons to study the species diversity in natural conditions. Specimens were properly identified by cross examination with type specimens and protologues. Hundreds of herbarium specimens deposited in all major herbaria in India were visited to document information about locality, date of collection and ecological pecularities. The available information was plotted against the major photogeographical regions to identify species richness and endemism. Relevant information from published works and reports were also consulted.

Phytogeographical analysis of diversity and endemism

Almost 42 species of *Leucas* were reported from Asia and all these are found in India; the highest diversity is reported in the Southern Peninsula. Analysis of Asian diversity (*Leucas* s.str) shows that 27 species amount to 64% are found in the Southern Western Ghats region. Of these 12 are endemic to here which represent 28.5% of all *Leucas* s.str species reported so far. Western Ghat diversity is not uniform every where; region 3 shows highest diversity and about 6 species are found only in this region. Endemism and diversity in the Southern Western Ghats is depicted in tables 1 and 2 respectively.

Phylogenetic relevance

The biogeographically abrupt demarcation between Asian and Afro-Arabian species led Singh (2001) to state that the Asian and African species of *Leucas* have evolved and developed independently. In both analysis (Ryding, 1998 & Scheen et al, 2007) dealing with the phylogeny of *Leucas,* Asian taxa represent a monophyletic group and their sister group consisting of African species as well as related genera. Asian species of *Leucas* (*Leucas* s.str) can be distinguished from the rest by the unique combination of three morphological characters: absence of glands on ovaries and nutlets, anterior corolla lip longer than posterior corolla lip, and dorsal side of calyx exceeding or equalling the ventral sides (Ryding, 1998). Although a few of the African taxa are similar in one of these characters, they do not combine all three states (Ryding, 1998).

Since Asian *Leucas* are considered as separate genus under this name (Scheen et al, 2007), presence of high diversity and endemism in the southern Western Ghat region indicate two points that are very relevant to its origin: (1) due to high species diversity, endemism and presence of infraspecific variant form, the southern Western Ghat region may represent the centre of origin of *Leucas* s.str (2) presence of characters like glands on ovary and nutlets in some of the southern Western Ghat endemic taxa (*L. beddomei*) may represent a connecting link between the diversity in two regions. Hence, diversity in the southern Western Ghats indirectly indicates great relevance with regard to the origin and diversification of this genus. These are some of the hypothesis originated in the analysis. However, a molecular phylogenetic and biogeographic study is required to test these hypothesis.

Acknowledgements

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References

1. **Harley, R.M., Atkins, S., Budantsey, A.L., Cantino, P.D., Conn, B.J., Grayer, R., Harley, M.M., Kok, R.De., Krestovskaja, T., Morales, R., Paton, A.J., Ryding, O. & Upson, T. 2004.** Labiatae. *In*: Kadereit, J.W. (Ed.) The families and Genera of Vascular Plants. Springer, Germany.
2. **Mukerjee, S.K. 1940.** A revision of Lamiaceae of Indian Empire. Rec. Bot. Surv. Ind. 14(1): 37- 56.
3. **Nayar, M . P. 1996.** Hot spots of endemic plants of India, Nepal and Bhutan. Tropical Botanical Garden and Research Institute, Palode, Thiruvananthapuram.
4. **Ryding, O. 1998.** Phylogeny of the *Leucas* Group (Lamiaceae) Syst. Bot. 23(2): 235-247.
5. **Sebald, O. 1980.** Die Guttung Leucas R.Bre. (Labiatae) in Afrika und auf der Arabischen Halbinsel. Stuttgarter Beitrage zur Naturkunde, Serie A 341: 1-200.
6. **Scheen, A-C., & Albert, V.A. 2007.** Nomenclatural and taxonomic changes within the *Leucas* clade (Lamioideae: *Lamiaceae*) Systematics and Geography of Plants 77:229-238.
7. **Scheen, A-C., & Albert, V.A. 2009.** Molecular Phylogenetics of the *Leucas* Group (Lamioideae; Lamiaceae) Systematic Botany 34(1): 173-181.
8. **Singh, V. 2001.** Monograph on Indian *Leucas* R.Br. (Dronapushpi) Lamiaceae. Scientific Publishers, Jodhpur, India.
9. **Subramanyam, K. & Nayar, M. P. 1974.** Vegetation and phytogeography of Western Ghats. In: Mani, M. S. (ed) Ecology & Biogeography of India, p.p. 178-196.
10. **Sunojkumar, P. & Mathew, P. 2009.** South Indian *Leucas*: a Taxonomic monograph. CRIKSC, Calicut.

Table 1: Endemic taxa found in the Southern Peninsular India and their distribution

No	Name of the taxa	Section	Altitude (m)	Phyto. region	Distribution
1	*L. anandaraoana*	Ortholeucas	MSL	EG2	Mannar Biosphere Res.
2	*L. beddomei*	Lanceaefolia	±1770	WG3	Wayanad
3	*L. ciliata* var. *angustifolia*	Astrodon	±1200	WG3	Silent valley
4	*L. ciliata* var. *oblongifolia*	Astrodon	1200-1800	WG4	Idukki
5	*L. ciliata* var. *sericostoma*	Astrodon	1200-1800	WG4	Idukki
6	*L. decemdentata* var. *sebastiana*	Ortholeucas	900-1300	EG1	Visakapatanam
7	*L. eriostoma*	Lanceaefolia	1200-1600	WG2,3	Canara to Wayanad
8	*L. eriostoma* var. *lanata*	Lanceaefolia	±1400	EG2	Bababudan
9	*L. helianthimifolia*	Helianthimifolia	1200-1900	WG3,4	Nilgiri, Idukki
10	*L. hirta*	Astrodon	±1300	WG2,3,4	Idukki, Nilgiris
11	*L. lamiifolia*	Astrodon	1000-1500	WG3,4	Nilgiri, Idukki
12	*L. lanceaefolia*	Lanceaefolia	1500-2600	WG3,4	Nilgiris, Idukki
13	*L.lavandulifolia* var. *lavandulifolia*	Plagiostoma	±1800	WG3	Nilgiris
14	*L. mukerjiana*	Ortholeucas	±1300	EG1	Visakapatanam
15	*L. marrubioides var. pulneyensis*	Ortholeucas	900-1300		
16	*L. nepetaefolia*	Ortholeucas	±1000	EG2	Nellore, Cuddapah
17	*L. prostrate*	Astrodon	1400-1920	EG2 WG3	Nilgiris, Yercaud,
18	*L. pubescens*	Ortholeucas	1400-1600	WG4	Idukki
19	*L. rosmarinifolia*	Helianthimifolia	2200-2500	WG3	Nilgiris
20	*L. sebaldiana*	Astrodon	1394	WG3	Wyanad
21	*L. sivadasaniana*	Lanceaefolia	1200-1400	WG2	Kudachadri hills
22	*L. suffruticosa*	Helianthimifolia	2100-2550	WG3	Nilgiris
23	*L. wightiana*	Plagiostoma	MSL-	EG2	Tirunelveli Kanyakumari

(**Note**: **WG2** – Western Ghats from river Kaliei to Coorg; **WG3** – Nilgiri; **WG4** – the Anamalai, Palni and Cardamom hills. **EG1** – Eastern Ghat from the east to the Godavari-Krishna gap; **EG2** – the southern Eastern Ghat up to Kanyakumari. Altitudes in metres)

Table 2: Distribution of *Leucas* R.Br. species in South India (excluding endemic taxa)

No	Name of the species	Section	Distribution (World)	Distribution in South India
1	*L. angularis*	Ortholeucas	SI, SL	WG 2, 3, 4
2	*L. aspera*	Plagiostoma	SI, SL, NE, PH, SEA, CA	WG 2, 3, 4; EG 1, 2 & D
3	*L. biflora*	Ortholeucas	SI, IN, SL, BA	WG 2, 3 4; EG 1, 2 & D
4	*L. cephalotes*	Plagiostoma	SI, SL, IN, CA, SEA	EG 1, 2 & D
5	*L. chinensis*	Ortholeucas	SI, C	WG 3, 4
6	*L. ciliata* var. *ciliate*	Astrodon	SI, IN, NE, BH, C, TH	WG 2, 3, 4 & EG 1, 2
7	*L. ciliata* var. *vestita.*	Astrodon	SI, IN, NE, BH, C, TH	WG 2, 3, 4 & EG 1, 2

No	*Name of the species*	Section	Distribution (World)	Distribution in South India
8	*L. decemdentata* var. *decemdentata*	Ortholeucas	SI, IN, SL, CA, SEA	EG 1, 2 & D
9	*L. diffusa*	Plagiostoma	SI, IN*	EG 1, & 2 ; D
10	*L. lavandulifolia* var. *lavandulifolia*	Plagiostoma	SI, IN, SL, SEA, CA	WG 2, 3 4; EG 1, 2 & D
11	*L. lanata* var. *lanata* .	Ortholeucas	SI, IN, CA, SEA	EG 1, 2 & D
12	*L. lanata* var. *candida*	Ortholeucas	SI, IN*	WG3 & EG1,2
13	*L. marrubioides*	Ortholeucas	SI, SL, MA	WG 2, 3, 4; EG 1, 2 3 & D
14	*L. martinicensis*	Plagiostoma	SI, Asia, Arabia, Africa, America	WG 2, 3, 4; EG 1, 2 & D
15	*L montana*	Ortholeucas	SI, IN*	WG 2, 3; EG 1, 2 & D
16	*L. nutans*	Plagiostoma	SI, IN, PA, MY	EG 1, 2 & D
17	*L. stelligera*	Astrodon	SI, IN, SL	WG 2, 3 &D
18	*L. stricta*.	Plagiostoma	SI, IN, MY	WG 2, 3, 4; EG 1, 2 & D
19	*L. urticifolia*	Hemistoma	SI, Asia, Arabia, Africa	WG 2, 3, 4; EG 1, 2 & D
20	*L. zeylanica*.	Plagiostoma	SI, IN, SL, SEA, CA	WG 2, 3, 4; EG 1, 2 & D

(**Note**: ***** = Indian endemic; **BA** = Bangladesh, **C** = China, **CA** = Central Asian countries, **IN** = India, **MY** = Myanmar, **NE** = Nepal, **PA** = Pakistan, **PH** = Philippines, **SEA** = South East Asian countries, **SI** = South India, **SL** = Sri Lanka, Note: **WG2** – Western Ghats from river Kaliei to Coorg; **WG3** – Nilgiri; **WG4** –the Anamalai, Palni and Cardamom hills. **EG1** – Eastern Ghat from the east to the Godavari-Krishna gap; **EG2** – the southern Eastern Ghat up to Kanyakumari. **D** = Deccan Division)

An approach to landscape level conservation plan in Western Ghats: a case study from Muthikulam High Value Biodiversity Area

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Abstract

Systematic conservation planning and management of biodiversity depends on the information on the spatial distribution of biological resources. Western Ghat biodiversity hopspot holds one of the world's endangered forests and in Kerala, nearly two third of the available biodiversity is found outside the protected areas. This paper deals with the conservation planning of Muthikulam High Value Biodiversity Area in the Southern Western Ghats of Kerala, India. By exploring the biodiversity significance and landuse pattern with Geographical Information System (GIS) analysis, we suggest the management zones to mainstream strategies with different functional sectors in the forest region for the conservation and sustainable utilization of the existing 'High Value Biodiversity Area'.

Key words: Muthikulam forests, Southern Western Ghats, Landuse, GIS, Biodiversity, Management Zones

Introduction

Tropical forests are the Earth's biologically richest ecosystems and play vital roles in regional hydrology, carbon storage and the global climate (Butler and Laurance, 2008). The global biodiversity is at a crisis and diminishing at unprecedented rates (Myers, 1980). The main reasons for the wide range of decline in biodiversity are habitat alterations, increased rates of species invasions, over-exploitation of the resources and other human-caused impacts (Kinnaird *et al.*, 2003). The information on spatial distribution of resources is one of the most crucial part of the systematic conservation planning and management of biodiversity (Margules & Pressey, 2000). The information on the conservation aspects such as distribution, abundance and habitat quality (Baillie *et al.*, 2004) is important to identify threats, which enables to derive a management strategy. Hence maintaining and restoring biodiversity in forests promote their resilience and is an 'insurance policy' and safeguard against expected climate change impacts. The Western Ghats, a biodiversity hotspot holds one of the world's most endangered forests (Puyravaud *et al.*, 2010).

In the state of Kerala, nearly two third of the available biodiversity is found outside the protected areas. The territorial forests or the "*Working Divisions*" concentrate mainly at the extraction of commercially important timber and other non timber forest produces. The utilization of the resources are largely done with unscientific approaches, which more often results in over exploitation and loss of forest resources. The lack of baseline data on the biodiversity richness and the non-availability of the forest quality information are mainly attributed for this problem. To implement conservation activities at working Divisions, we developed a regional conservation plan in Muthikulam High Value Biodiversity Area. The present land use pattern, biodiversity significance, management zones, and conservation strategies to be implemented and sustainable utilization the available resources are discussed in this paper.

Study area

Muthikulam High Value Biodiversity Area (HVBA) is located in Mannarkad Forest Division, which borders the North -western portion of the Western Ghats on the northern side of Palakkad gap in Mannarkad Taluk of Palakkad District. The tract dealt with lies within the north latitude of 10° 14′ and east longitudes between 76 ° 47′ and 76 ° 16′. Muthikulam HVBA consists of undulating hills and valleys well clothed with vegetation except for the large grassy area around Muthikulam to the south east and the mass of high hills to the south viz., Elival range. It is a plateau with elevation varying from 610 m at exit of Siruvani to 2,065 m, the highest peak northwest of Elivalmalai (Figs. 1 & 2). Muthikulam situated at an elevation above 1000 m enjoys salubrious climate with average temperatures not exceeding 22.6^0 C. The average annual daily temperature for the past 30 years is 19.6^0 C (Fig. 3) and area receives a heavy annual rainfall with total rainfall amounts to 4731mm. Average rainfall for the past 30 years is provided in Fig. 4 and It is evident that June, July and August provide maximum rainfall.

Fig. 1: Siruvani Reservoir

Fig. 2: Grassland Savannah

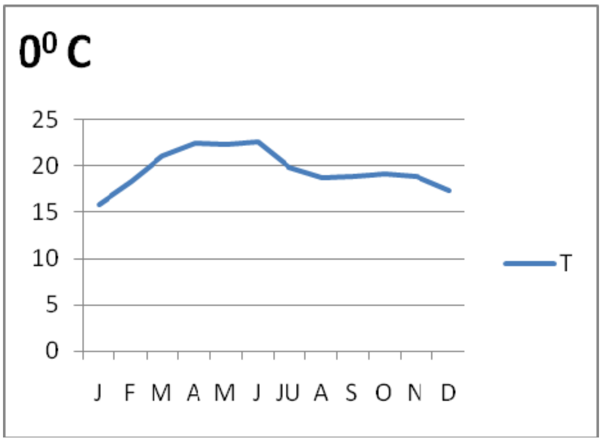


Fig. 3: Average temperature in Muthikulam

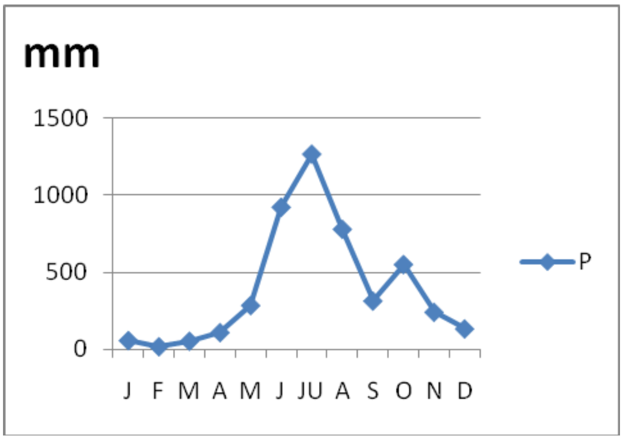


Fig. 4: Average rainfall in Muthikulam

Materials and Methods

A base map of the Muthikulam High Value Biodiversity Area (HVBA) was made in the GIS platform depicting the administrative boundaries. The Survey of India Topographic (SOI) Sheets at the scale of 1: 25,000, 58 B9, and 58 A 12 (four each sheets respectively) were used to delineate the boundaries of Muthikulam HVBA. The topographic maps were scanned at a resolution of 300 dpi in a flatbed scanner and geo referenced with the raster processing software Erdas. Then the individual sheets were digitized in the GIS software ArcGIS. Various categories of forest type information available in the toposheets were digitized and the biodiversity information obtained through fieldwork and collected through secondary means were plotted to identify the biodiversity rich areas. The management oriented forest map of South India proposed by Pascal (1993) was followed for the forest type classification scheme. The forest type map of Nilgiris landscape at the scale of 1:100,000 published by Prabhakar and Pascal (1996) and the Forest Map of South India – Coimbatore-Trichur Sheet with a scale of 1: 250,000 (De Franceschi *et al.*, 2002) were used to combine the forest type/landuse map of the region. The Spatial Analyst tool of ArcGIS was used to calculate the area of different forest types.

The field study was conducted between the years 2009 and 2010. Field trips were arranged to explore and enumerate the richness of the flora and fauna of the Muthikulam – Siruvani forests. An earlier study of the Kerala Forest Research Institute (Basha, 1987) was used to finalize the plant species richness in the region. Rapid surveys were organized to visit and confirm the species presence in the reported localities. A SWOT (Strength-Weakness-Opportunities-Threat) analysis was done with all the available information. The management zones were delineated based on the biodiversity richness, landuse pattern, spatial distribution of the biological resources, the conservation threats deduced from the SWOT analysis.

Results and Discussion

Land use pattern

The total extent of the forest coming under the Muthikulam High Value Biodiversity Area is 110.44 km^2 which include both the natural forests and cultivated land (Table 1). Out of the total 110.44 km^2 area, 25.0165 km^2 area belongs to low elevation (below 750m) evergreen and semi-evergreen forests whereas an area of 61.45671 km^2 includes medium elevation (750-1400m) evergreen, semi-evergreen forests, moist deciduous and dense thickets (Map 1). The high elevation (1400-1800m) consists of *Schefflera* spp- *Litsea* spp- *Syzygium* spp. type composition with an area covering about 11.14 km^2. The Shola forests occupy about 6.781 km^2 area and cultivated land includes 1.644 km^2 area. The overall pattern shows that more than 90 percent of the area belongs to evergreen and semi-evergreen forests at different elevation ranges from medium to high which are the repository of high value biodiversity of both flora and fauna. Approximately 11% of the area is under different forms of degraded vegetation types from secondary moist deciduous to scattered shrub.

Biodiversity values

Phytogeographically, the vegetation structure of Muthikulam hills shows more affinities to that of tropical Asia and Sri Lanka, thereby suggesting the existence of land connections in the past. The rate of endemism is comparatively high with most species distributed throughout the Western Ghats. The comparison of floristic diversity of Silent Valley, Muthikulam and Nelliampathy forests indicates (Basha, 1987) that the flora of these areas is of very high Simpson's index above 0.87 with Silent valley (0.94) and Muthikulam (0.93). The main species association in Muthikulam forests is *Myristica – Mesua – Aglaia* and these three species constitute 50% of the tree species. The floristic survey shows 488 species of flowering plants, including 387 dicotyledonous, 101 monocotyledonous, of which 99 are endemic to the Peninsular India. The most dominant families are Orchidaceae (22 sps.), Poaceae (22 sps.), Rubiaceae (22 sps.), Euphorbiaceae (21), Fabaceae (17 sps.), Lauraceae (17) and Piperaceae (14 sps.) and the dominant genera are *Piper* (9 sps.), *Impatiens* (7), *Ficus* (6 sps.), *Syzigium* (5 sps.) and *Oberonia* (4 sps.). Many of the important species to the Western Ghats such as *Vateria macrocarpa*, *Holigarna arnottiana, Palaquium ellipticum, Cullenia exarillata, Myristica dactyloides, Mesua ferrea, Calophyllum elatum, Hopea ponga, Aglaia eleagnidea, Cinnamomum macrocarpum, Dysoxylum malabaricum* and *Diospyros bourdillonii* are found in this region (Plate 1). Matching the floral wealth, the faunal wealth in Muthikulam HVBA also is endowed with fantastic diversity. The diversity in wildlife is tremendous- be it in case of mammals (23 spp.), amphibians (21 spp.), birds (48 spp.), reptiles (52 spp.) and butterflies (ca. 84 spp.).

Major threats

Muthikulam HVBA forms connectivity between forests north of the Palakkad gap and Silent Valley. However, the major land use changes, selective felling, encroachments, fire and forest degradation are a major threat to the connectivity between Attappadi Block VI and Silent Valley forests. Annual fires are common in evergreen, semi-evergreen, deciduous forests and plantations. These forests adobes the habitats of many rare endangered flora and fauna. The populations of rare and endemics (e.g. *Vateria macrocarpa*) are restricted to small isolated pockets and the selective logging process in the past, caused reduction in population size of these plants in this area.

Conservation zones and conservation implications

Two zones have been delineated in Muthikulam for the purpose of implementing the Biodiversity Conservation Plan with the High Value Biodiversity Conservation zone (77.7 km^2), and Ecorestoration zone (32.74 km^2) (Map 2).

1. ***High Value Biodiversity Conservation Zone*** (77.70 km^2)

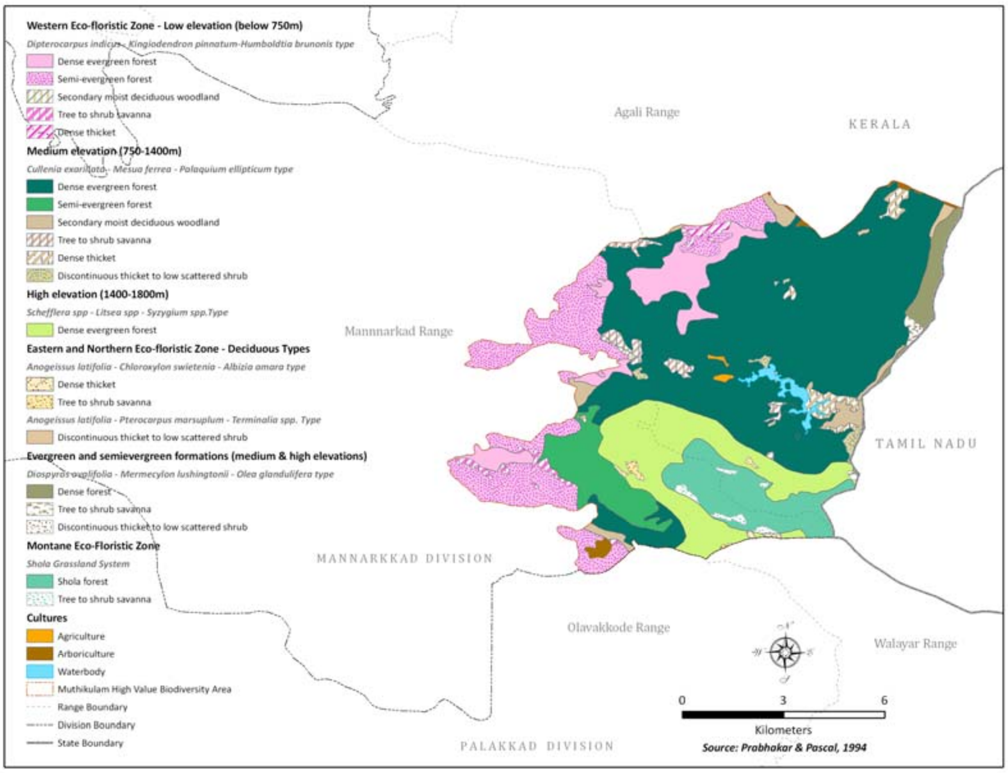
The High Value Biodiversity Conservation Zone is subdivided in to Conservation Zone I (59.27 km^2) mainly constituting medium elevation (750 - 1400m) dense evergreen and semi evergreen forests and Conservation Zone II (18.43 km^2) constituting High elevation dense evergreen and shola forests (1400 - 1800m). This has been done as high elevation forests require special attention and separate treatment. The natural patches in Karimala, Vellingirimala and Elival mala provide more or less continuous forest cover with different types of forests viz., Dense evergreen, Semi-evergreen with *Cullenia exarillata* – *Mesua ferrea* – *Palaqium ellipticum* type vegetation structure. The conservation zones are to be managed primarily for their conservation values and the activities that endanger these values need be avoided/ restricted. All these areas are important in terms of floral diversity, specific habitats of fauna and for the dispersal of animals towards eastern and northern directions.

2. ***Eco-restoration Zone*** (32.74 km^2)

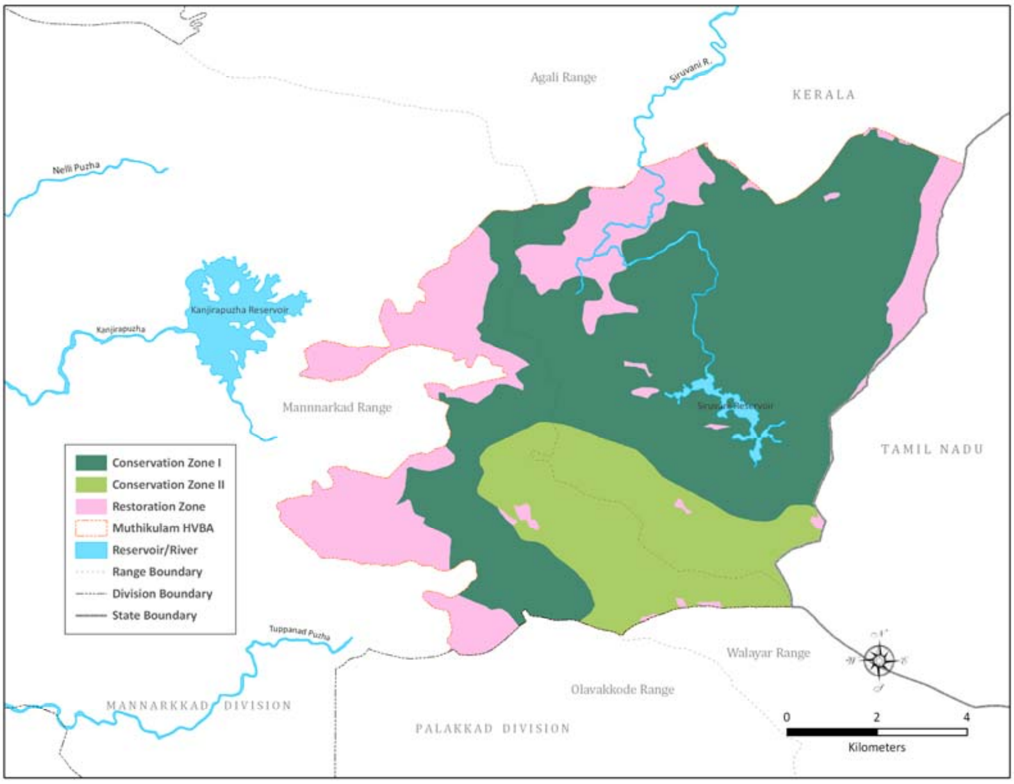
This zone will include areas where degraded natural forests, agriculture and arboriculture are available but at elevations below 750m. There are six plantations of eucalypts, covering an area of 92.5 ha are understocked and belong to the failed category. These are located in grassland area and it is possible to bring back the area to natural conditions with the native species.

Table 1. Landuse of Muthikulam High Value Biodiversity Area

Type	Area (km^2)	Species composition
Western–Eco-floristic Zone- Low elevation (below 750m)		
1. Dense evergreen forest	6.217	*Dipterocarpus indicus -Kingiodendron - Humboldtia brunonis* type
2. Semi-evergreen forest	14.72	
3. Secondary moist deciduous woodland	0.1144	
4. Tree to shrub savanna	3.6112	
5. Dense thicket	0.3539	
Medium elevation (750-1400m)		
1. Dense evergreen forest	49.45	*Cullenia exarillata – Mesua ferrea-Palaquium ellipticum* type
2. Semi-evergreen forest	5.958	
3. Secondary moist deciduous woodland	2.394	
4. Tree to shrub savanna	1.676	
5. Dense thicket	1.50091	
6. Discontinuous thicket to low scattered shrub	0.4778	
High elevation (1400-1800m)		
1. Dense evergreen forest	11.14	*Schefflera* spp- *Litsea* spp- *Syzygium* spp. type
Eastern and Northern Eco-floristic Zone- Deciduous Types		
1. Dense thicket	0.08380	*Anogeissus latifolia –Chloroxylon swietenia- Albizia amara* type
2. Tree to shrub savanna	0.2711	
Anogeissus latifolia –Pterocarpus marsupium		
1. Discontinuous thicket to low scattered shrub	0.2459	*Terminalia* spp. type
Evergreen and semi evergreen formations (medium & high elevations)		
1. Dense forest	1.941	*Diospyros ovalifolia –Memecylon lushingtonii – Olea glandulifera* type
2. Tree to shrub savanna	0.2514	
3. Discontinuous thicket to low scattered shrub	0.06719	
Montane Eco- Floristic Zone		
1. Shola forest	6.781	Shola Grassland System
2. Tree to shrub savanna	0.5032	
Cultivated land		
1. Agriculture	1.157	
2. Arboriculture	0.4872	
3. Water body (Siruvani Reservoir)	0.738	
TOTAL	**110. 44**	



Map 1. Landuse of Muthikulam High Value Biodiversity Area



Map 2. Management zones in Muthikulam High Value Biodiversity Area

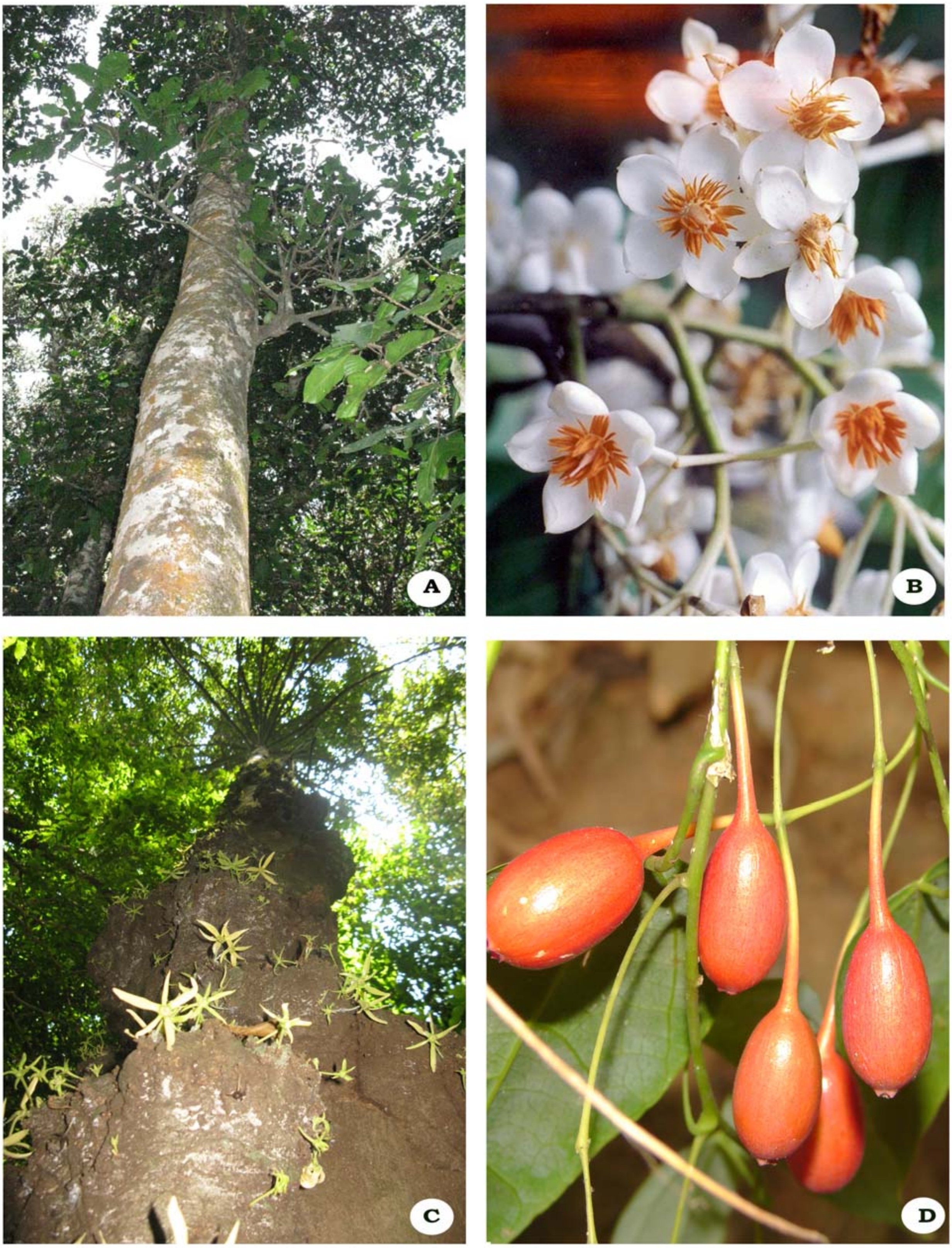


Plate 1: *Vateria macrocarpa* Gupta. **A.** Habit, **B.** Flower,
C. *Polyalthia coffeoides* (Thw. ex Hook. f. & Thoms.) Hook. f. & Thoms. **D.** *Erythropalum scandens* Blume

Conclusions

The study had identified two major zones for the long term conservation of the Muthikulam High Value Biodiversity Area viz., High Value Biodiversity Conservation Zone and Ecorestoration Zone. The High Value Biodiversity Conservation Zone has two sub zones I and II. The first zone I have around 60 km^2 of medium elevation *Cullenia* dominant forests which is the prime food species of the endangered lion-tailed macaque. A proper conservation of this zone would make the habitat more suitable for this primate species when compared to other areas. For example, the Silent Valley National Park has only 30 km^2 of *Cullenia* dominant forests and still supports a viable population of the lion-tailed macaques. The conservation zone II perhaps is the only contiguous habitat of high elevation evergreen forests (Pascal, 1988) in the whole Western Ghats. By restoring the failed plantations in the area will nourish the plant species diversity and its persistence. To summarize the biodiversity conservation concerns in Muthikulam HVBA, the various production sectors identified for mainstreaming are

a. The forestry operations in the failed plantation areas especially the six plantations of eucalypts, raised between 1962 and 1987 covering an area of 92.5 ha can be phased out slowly to convert them into natural forests.
b. Conservation and widening of distribution of threatened and endemic species like *Vateria macrocarpa*.
c. Monitoring the wildlife especially populations of Lion-tailed Macaque, Nilgiri Tahr, Tiger, etc., with scientific monitoring protocols
d. Ensuring sustainable collection of Non Timber Forest Produce like *Balanophora fungosa* ssp. *indica*, *Canarium strictum, Myristica beddomei, Curcuma zeodaria, Hydnocarpus pentandra*, *Garcinia gummi-gutta, Curcuma sp., Piper sp., Momordica dioica*, *Pittosporum neelgherrense, Coscinium fenestratum* etc.
e. Ensuring the availability of species of tubers/ leafy vegetables most frequently used by tribals, in their settlements.
f. Identify, map and document the existing and potential corridor for elephants and other larger mammals to restore the connectivity between Muthikulam HVBA and Silent Valley. Detailed studies on ecological, socio-economic, landuse pattern, etc. and assess the status of the corridors.
g. Weeds like *Mikania*, *Lantana* and *Chromolaena* which are widespread in grasslands in Keralamedu and Singappara areas also posing high threat to natural populations of bryophytes, ferns and Balsams. These invasive species should be removed by uprooting during monsoon in phased manner but continuously for three years, then alternate year, wherever needed.

References

1. **Baillie, J.E.M., Hilton-Taylor, C. and Stuart, S.N. 2004.** *IUCN Red List of Threatened Species. A global species assessment*. IUCN, Gland, Switzerland and Cambridge, UK.
2. **Basha, C. 1987.** Studies on the ecology of evergreen forests of Kerala with special references to Silent Valley and Attappady. PhD Thesis. University of Kerala.
3. **Butler, R. A., and Laurance, W.F. 2008.** New strategies for conserving tropical forests. *Trends in Ecology and Evolution*, 23, 469–472.
4. **De Franceschi, D., Ramesh, B.R. and Pascal, J.P. 2002.** *Forest Map of South India. Coimbatore - Thrissur*. Institut Français de Pondicherry, Pondicherry, India.
5. **Kinnaird, M.F., Sanderson, E.W., O'Brien, T.G., Wibisono, H.T. and Woolmer, G. 2003.** Deforestation trends in a tropical landscape and implications for endangered large mammals. *Conservation Biology*, 17, 245-257.

6. **Margules, C.R. and Pressey, R.L. 2000.** Systematic conservation planning. *Nature*, 405, 243-253.
7. **Myers, N. 1980.** *Conversion of Tropical Moist Forests*. National Academy of Science, Washington, DC, USA.
8. **Pascal J.-P. 1993.** Management Oriented Forest Map of South India: Thematic derivations. *Vegetatio*, 109, 47-61.
9. **Pascal, J.P. 1988.** *Wet evergreen forests of the Western Ghats of India: Ecology, Structure, Floristic Composition and Succession*. Institut Français de Pondicherry, Pondicherry, India.
10. **Prabhakar, R. and Pascal, J.P. 1996.** *Nilgiri Biosphere Reserve Area. Vegetation and land use. Map 1:100,000*. Centre for Ecological Sciences, Indian Institute of Science and Institut Français de Pondicherry, Pondicherry.
11. **Puyravaud J.P., Davidar, P. and Laurance, W.F. 2010**. Cryptic loss of India's native forests. *Science*, 329, 32.

Fern Flora of Mahe, U.T. of Puducherry, India

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Abstract

Mahe, Union Territory of Puducherry, is situated on West Coast of the Indian Peninsula between 11° 42′ and 11° 43′ N latitude and 75° 31′ and 75° 33′ E longitude, just between Badagara and Thalassery of Kannur district in Kerala State. This former small French Town, covering an area of 9 sq. km. is a part of biodiversity rich Western Ghats holding a heavy population. An attempt has been made to document the pteridophyte flora of Mahe. The present study revealed the occurrence of 24 taxa belonging to 12 families and 19 genera. Of these 15 are terrestrial, 6 are aquatics or semi-aquatics, 3 are epiphytes. Species of *Pteris*, *Selaginella* and *Lygodium* are found to be common. Species of *Adiantum, Lindsaea*, *Pteris* and *Selaginella* occur only on slopes and their habitat is under threat. *Athyrium hoheneckeranum, Lygodium microphyllum* and *Pityrogramma calomelanos* var. *aureoflava* are found to be rare. The pteridophytes are very important in the ecological point of view and hence need to be documented. The destruction of habitats and population explosion are major threats to the species diversity and these need to be conserved at sites.

Key words: Fern, Mahe, threats

Diversity of Bryophytes in Silent Valley National Park, Kerala

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Abstract

The Silent Valley National Park, also known as *Sairandhri vanam,* located in the Nilgiri Hills of Palakkad District in Kerala state, is one of the most popular protected areas in India. The National Park spreads over an area of 91 km^2 and forms the major part of the Nilgiri International Biosphere Reserve. The great diversity in ecological factors and high range of altitudinal variation supports the very rich and diverse vegetation of the area. It belongs to the Indo-Malayan eco-region (Olson *et al.,* 2001) with the major vegetation types including North Western Ghats montane rain forests (IM0135) (Tropical wet evergreen forests), North Western Ghats moist deciduous forests (IM0134) (Tropical Moist deciduous forests (300-800 m)), South Western Ghats montane rain forests (IM0151) (Subtropical montane forest (1400-1868) and Grass lands. These grasslands of the higher altitudes are seen over the crest of the Silent Valley National Park and at the Poochipara area.

Based on the recent explorations, an account of the diversity of the bryophytes of Silent Valley is presented. It includes 78 taxa comprised of 65 mosses and 13 liverworts. Of these seven species were new records of occurrence for Peninsular India and four species were new records for Kerala.

Key words: Bryophytes, diversity, Silent valley

Botanical diversity of the genus *Plectranthus* in theWestern Ghats, Tamil Nadu

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Abstract

The Western Ghats is biologically rich and biogeographically unique - a veritable treasure house of biodiversity. The range starts near the border of Gujarat and Maharashtra, south of the Tapti river, and runs approximately 1,600 km through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanniyakumari, at the southern tip of India. The Western Ghats contain more than 30% of all plant, fish, herpeto-fauna, bird, and mammal species found in India. Many species are endemic. The Western Ghats include a diversity of ecosystems ranging from tropical wet evergreen forests to montane grasslands containing numerous medicinal plants and important genetic resources such as the wild relatives of grains, fruit and spices. They also include the unique shola ecosystem which consists of montane grasslands interspersed with evergreen forest patches. All over the world 350 species are present in the Genus *Plectranthus* and it belongs to Lamiaceae (Mint Family). The following species *of Plectranthus* such as *P. bournea, P. caninus, P. malabaricus, P. amboinicus, P. urticifolius, P. walkeri, P. bishopianus, P. deccanicus, P. vettiveroides* are found in the hilly regions in Tirunelveli, Kanniyakumari, Palani, Kodaikanal, Coimbatore and Nilgiri parts of the Western Ghats in Tamilnadu. Among them, *P. bourneae, P. urticifolius, P. bishopianus, P. deccanicus* and *P. vettiveroides* are endemic to Tamil Nadu

Key words: *Plectranthus,* Diversity, Western Ghats, Tamil Nadu

Introduction

Tamil Nadu covers an area of 130,058 sq. km. and is the eleventh largest state in India. It is home to many natural resources, hill stations, beach resorts, multi-religious pilgrimage sites and eight UNESCO World Heritage Sites. The western, southern and the north-western parts are hilly and rich in vegetation. It is bound by the Eastern Ghats in the north, the Nilgiri, the Anamalai hills and Palakkad on the west, by the way of Bengal in the East, the Gulf of Mannar, the Palk Strait in the South East, and by the Indian Ocean in the South. The climate of the state ranges from dry sub-humid to semi arid. The normal annual rainfall of the state is about 945mm (37.2 in) of which 48% is through the North East Monsoon and 32% through the South West Monsoon. There are about 2000 species of wildlife that are native to Tamil Nadu. Indian Angiosperm diversity comprises 17,672 species with Tamil Nadu leading all states in the country, with 5640 species accounting for 1/3 of the total flora of India. This includes 1559 species of Medicinal plants, 533 endemic species, 260 species of wild relatives of cultivated plants and 230 red listed species. Common plant species include the state tree: Palmyra Palm, Eucalyptus, Rubber, Cinchona, Clumping Bamboos (*Bambusa arundinacea*), Common teak, *Anogeissus latifolia,* Indian Laurel, Grewia, and blooming trees like Indian labumusum, Ardisia, and Solanaceae. Rare and unique plant life includes *Combretum ovalifolium*, Ebony (*Diospyros nilagrica*), *Habenaria rariflora* (Orchid), Alsophila, *Impatiens elegans*, *Ranunculus reniformis*, and Royal fern.

Nomenclature of *Plectranthus* L.

Plectranthus amboinicus (Lour) Spreng has commonly been referred to as *Coleus amboinicus*, and *Coleus aromaticus* Benth. *Plectranthus barbatus* Andr. Synonyms include *Plectranthus forskohlii* Wild., *Coleus barbatus* Benth. and *Coleus forskohlii* Wild Briq. *Plectranthus caninus* has been called *Coleus spicatus* Benth. Synonyms of *Plectranthus coleoides* is *Plectranthus wightii* Benth. *Plectranthus deccanicus* is referred to as *Plectranthus fruticosus* (Benth) Wight. and *Coleus fruticosus* Benth. Synonyms of *Plectranthus japonicas* var. *japonicas* is *Scutellaria japonica* Burm., *Plectranthus coetsa* Buch., *Plectranthus menthioides* Benth, and *Rabdosia japonica* Burm. *Plectranthus japonicas* var. *macreai* (Benth) has commonly been referred to as *Plectranthus macreai* Benth, and *Plectranthus coetsa* var. *macreai* Buch-Ham. *Plectranthus malabaricus* (Benth) is called *Coleus malabaricus* Benth. Synonyms of *Plectranthus mollis* Spreng is *Ocimum molle* Ait and *Plectranthus incanus* Link. Those of *Plectranthus nigrescens* Benth are *Rabdosia nigrrescens* (Benth). *Plectranthus nilgherricus* Benth is called *Rabdosia nilgherricus* (Benth). Synonyms of *Plectranthus rivularis* Wight. is *Rabdosia rivularis* (Wight). *Plectranthus rotundifolius* Spreng synonyms include *Germanea rotundifolia* Prior. *Coleus parviflorus* Benth. and *Coleus rotundifolius* (Prior). Synonyms of *Plectranthus scuttellaroides* (L) are *Ocimum scuttellaroides*, *Coleus scuttellaroides* (L) and *Coleus blumei* Benth. *Plectranthus vettiveroides* (Jacob) referred to as *Coleus vettiveroides* Jacob. *Plectranthus walkeri* (Arn) include synonyms of *Rabdosia walkeri* (Arn). Synonyms of *Plectranthus wightii* Benth. are *Plectranthus pulneyensis* Hook., *Plectranthus nepeteafolius* Benth. and *Rabdosia wightii* (Benth).

Methodology

The present study was carried out by frequent field surveys encompassing different parts of the Western Ghats in Tamil Nadu during different seasons. The methodology adopted by previous workers was followed. All the species cited as medicinal plants were collected from the field at reproductive stage, with the help of informants in duplicate. A field sheet was recorded with collector's name, vernacular name, local name and ecological parameters. The herbarium samples were dried, processed, identified taxonomically and the names were confirmed with the help of standard flora (Flora of the Presidency of Madras by J. S. Gamble and Flora of Tamil Nadu by A. N. Henry and N. C. Nair).

Results and Discussion

In the present attempt, total number of 21 species with 2 varieties were recorded such as, **1**. *P. amboinicus* is a fleshy shrub, strongly aromatic; cultivated and found in wild condition. It's mostly collected from Attakatti, Naduvattam, Kodaikanal. **2**. *P. barbatus* is a perennial herb, often cultivated in gardens and economically important species. **3**. *P. bishopianus & P. deccanicus* are large erect, slightly fleshy under shrubs, it is collected from Pillar rocks in Kodaikanal. **4**. *P. bourneae* is a large succulent under shrub growing on rocks in the hills of Tirunelveli district. **5**. *P. caninus* is perennial fleshy herb, mostly found in arid places on rocky ground among bushes of Nedungundru, Attakati of Coimbatore district. **6**. *P. coleiodes* is a natural succulent herb and mostly available in Naduvattam, Devala of Nilgiri district. **7**. *P. japonicus* var. *japonicus*, *P. rivularis*, *P. japonicus* var. *macraei*, and *P. malabaricus* are tall herbs in nature and its present in the various regions like Kunnacombai, Devala, upper tiger shoals of Nilgiri district . **8**. *P. mollis, P. nigrescens, P. nilgherricus* are having the nature of slender erect herb available from the various regions of the district of Nilgiri. **9**. *P. rotundifolius* is a soft and fleshy, prostrate or ascending with tuberous roots; sometimes cultivated for its edible tubers in nature are also present. It is used by tribals in Tirunelveli district. **10**. *P. scutellarioides* is a herb with erect slender stem, cultivated in gardens. **11**. *P. stocksii, P. urticifolius, P. vettiveroides*, these are having the nature of small and small slender herb and its available in the regions of Kanyakumari district. *P. walkeri, P. wightii* is having tall herb nature and these species available in various places in the district Tirunelveli. All the plant species studied have been arranged along with their Binomial, Species citation, vernacular name and distribution.

Conclusions

There is always a search for rich ethnobotanical knowledge for ethnobotanical studies of medicinal plants. The present study has placed on records the local uses of medicinally important plants especially the genus *Plectranthus* that were used by local people and tribals in and around the parts of Western Ghats in Tamil Nadu. This study envisages the ethnomedicinal values of *Plectranthus* species spreading the study area. The local informants and field survey taken in this research accounted the habit and distribution of *Plectranthus* species and its diversity in the Western Ghats of Tamil Nadu.

References

1. **Gamble J.S. & Fischer C.E.C. 1959.** *The flora of the Presidency of Madras*, Reprinted Edition, Vol. I-III, (Botanical Survey of India, Calcutta).
2. **Henry A.N, Kumari G.R. & Chitra V. 1987.** *Flora of Tamil Nadu*, Series I, Vol.III, (Botanical Survey of India, Southern Circle, Coimbatore).
3. **Jain S.K. & Goel A.K. 1995.** *A Manual of Ethnobotany,* (ed.) S K Jain, (Scientific Publishers, Jodhpur, 142 pp.
4. **Mathew K.M. 1991.** *An excursion flora of Tamil Nadu, India,* (Oxford and IBH Publishing Co. Ltd., New Delhi).
5. **Nair N.C. & Henry A.N. 1983.** *Flora of Tamil Nadu*, Series I, Vol. I,II and III, (Botanical Survey of India, Southern Circle, Coimbatore).
6. Biodiversity, Tamil Nadu Dept. of Forests. Forests.tn.nic.in. Retrieved 2012-09-10.
7. Geography of India by Joel Anderson. Southasiaoutreach.wisc.edu. Retrieved 2012-09-10.
8. Gross State Domestic Product (GSDP) at constant prices (as on 15-03-12) – All-India GDP – Data book for DCH; 10 April 2012 - Page 105.
9. Press Information Bureau English Release. Pib.nic.in. Retrieved 2012-09-10.
10. UNESCO World Heritage List. Whu.unesco.org. Retrieved 2012-09-10.
11. United Nations, System of Organizations. Unsystem.org. Retrieved 2012-09-10.

Assessment of Drosophila diversity during post monsoon season in Brahmagiri Wildlife Sanctuary, Western Ghats

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Abstract

Post monsoon studies were conducted to analyze the altitudinal variation in a population of *Drosophila* (Diptera: *Drosophilidae*) in Brahmagiri Wildlife Sanctuary belonging to the Western Ghats of Coorg district, Karnataka State, India. A total of 4636 *Drosophila* flies belonging to 8 species of 3 subgenera were collected at altitudes of 800 m, 900 m, 1000 m. The subgenus *Sophophora* was predominant with 5 different species, subgenus *Drosophila* with 2 different species and the subgenus *Scaptodrosophila was* least represented with only a single species. The population density varied in above three altitudes and highest density was found at 800m, then the density reduced at 900m (380 flies) and again the density increased at 1000m. This shows that *Drosophila* community is affected by elevation. The diversity of the *Drosophila* community was also assessed by applying the Simpson and Berger-Parker indices. At 800m the Simpson Index was low at 0.37 and the Berger-Parker index was high at 0.47 at 900 m. The distributional pattern of a species or related group of species was uneven in space and time. *D. kikkawai, D. takahashii, D. immigrans*, and *D.nigra* were found in all the three altitudes suggesting that these species are dominant in this region.

Key words: *Drosophila*, Brahmagiri, Western Ghats

Introduction

The organisms such as bacteria, nematode worm, zebra fish, house mouse, and *drosophila* are extensively used as model organisms in research, of all *Drosophila* has been used since Morgan's time from almost a century. It is being employed in studies ranging from basic to advanced molecular aspects in research. The family *Drosophilidae* is one of the richest families in the order *Dipthera*. In this family, 3500 species have been described from various ecosystems throughout the world (Balchi 1998), of which most genera are concentrated in the Tropical regions. The pattern of eco-distribution, biodiversity (Guru Prasad *et al* 2009,) clinal and altitudinal variations (Guru Prasad and Hegde, 2006) have been well studied using *drosophila*. Compared to other parts of the world, the *Drosophila* taxonomic studies in India are poorly concentrated as it involves the hardships during work and lack of opportunities in the field. But recently very few attempts have been made to collect *Drosophila* from a few parts of India (Guruprasad et al 2011). Brahmagiri wildlife sanctuary in the Western Ghats of Coorg district is one such place where collection studies of *Drosophila* has not been made. This sanctuary derives its name from the highest point, the Brahmagiri peak. This peak is 1067 meters in height. The sanctuary has an altitude, varying up to 1527m. The average temperature varies from 10^0 C during winter to 35^0C during summer and average rainfall in the region is 2500mm- 6000mm (Jun-Oct). The forests are mainly evergreen and semi evergreen in nature, shola vegetation is dominant in higher altitudes of the sanctuary. Further, in the lower regions of the sanctuary, deciduous forests are seen, which is an abode for rich faunal diversity of *Drosophilidae*. Therefore, the present study has been undertaken in this sanctuary to understand the biodiversity of *Drosophila* in relation to microhabitat variations.

Materials and methods

In the present study, *Drosophila* collections were made during the post monsoon period, October to December in the Brahmagiri wildlife sanctuary in the Western Ghats of Coorg district to record the biodiversity of *Drosophila* fauna. The collections were made using sweeping and bottle trapping methods in three different places, with an altitude of 1000m, 900m and 800m (above sea level).

In net sweeping methods, various rotting fruits, such as, *Vitis vinifera* (Grape), *Musa paradisiaca* (Banana), *Solanum lycopersicum* (Tomato), *Manilkara zapota (*Sapodilla*), Citrus sinensis* (Orange*), Pyrus malus* (Apple), *Carica papaya* (Papaya), *Citrus aurantium* (Lime), *Ananas comusus* (Pine apple), were mixed and spread under shaded areas to attract flies. After a day of spreading, the flies were collected by sweeping using fine net. The flies were then transferred to the bottles containing wheat cream–agar medium and brought to laboratory for identification. Bottle trapping method was also followed for collection; in this technique, culturing bottles containing smashed banana sprayed with live yeast were tied to twigs of bushes under shaded areas. The following day, bottles with attracted flies were collected by plugging the bottles and later transferring to culture bottles containing wheat cream-agar medium and brought to the laboratory for identification. The males were studied as such but the individual females, which could not be identified, were subjected to isofemale line establishment. The progeny obtained from such single isofemale lines were used for species identification. Uniformity was maintained in using the techniques and in the number of baits used in the collection sites.

The sanctuary is rich in floral diversity. Vegetation at the collected sites include *Acacia catechu*, *Albizia amara, Alstonia scholaris, Artocarpus, Bauhinia sp., Bombax, Caryota urens, Calophyllum, Careya arborea, Cinnamomum sp., Coffea arabica, , Eucalyptus grandis, Ficus benghalensis, Garcinia gummi-gutta*, *Gymnema sylvestre, Hibiscus sp., Lantana camara, Litsea sp., Mesua ferrea, Pongamia glabra, Vitex negundo, Holarrhena* and *Strobilanthes*.

The abundance, richness and diversity relationship of flies collected were assessed by Simpson (D), Shannon-Wiener (H) and Berger-Parker (1/d) indices (Mateus et al 2006). The Simpson index (D) that measures the probability that two individuals randomly selected from a sample that belong to the same species, was calculated using the formula,

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species and N = the total number of organisms of all population.

Shannon-Wiener measures the value of species as a function of their frequency in the community. Shannon was calculated using the formula,

$$H = -\sum p_i \ln (p_i)$$

Here p_i is the proportion of total number of species made up of the ith species.

Berger- Parker index (1/d) which shows the relative abundance was calculated using the formula,

$$1/d = \frac{N}{N_{Max}}$$

Where, N = Number of individuals of all species and N max = Number of individuals in the most common species.

Results and Discussion

The number of flies at three different altitudes of Brahmagiri wildlife sanctuary collected during the post monsoon season is shown in Table 1. At 800 m, the number of flies collected was highest with 2919 flies comprising 8 different species. At 900 m a total of 380 flies belonging to 6 different species were recorded. In contrast to this at 1000 m a total of 1337 flies of only 5 different species were collected. *D. kikkawai, D. takahashii, D. immigrans* and *D.nigra* species were seen as common species in all altitudes.

The collection data of *Drosophila* (figure 1) at different altitudes of Brahmagiri Wildlife Sanctuary shows that highest *Drosophila* density is in the lowest altitude of 800m, after which the density of *Drosophila* drastically falls at 900 m. Following this at 1000m again the *Drosophila* density increased to 1337 flies. This shows that *Drosophila* community is affected by elevation. Studies by Guruprasad et al (2011) in Chamundi hill and Wakahama (1962) have also reported the influence of elevation on the distribution of *Drosophila* flies. They have found that density of *Drosophila* decreased with increase in elevation. Greater density of *Drosophila* flies in the lowest altitude found in the present study could be due to the increased floral diversity. The sanctuary is rich in*, Manilkara zapota* , *Citrus sinensis* , *Musca paradisiaca, Garcinia gummi-gutta*, *Cinnamomum sp.*, *Hibiscus sp.* and at this altitude most of the *Coffea arabica* and *Coffea robusta* estates are found. This floral diversity is seen decreasing with increasing altitude.

The value of Simpson, Shannon-Weiner and Berger-Parker indices that indicate the abundance, richness and diversity of *Drosophila* flies in different altitudes of the hill are shown in Table 1. At the lowest altitude of 800 m, Simpson = 0.79; Shannon-weiner=1.79 and Berger-Parker = 0.37; at 900 m Simpson = 0.69; Shannon-weiner=1.38 and Berger-Parker = 0.47. At the higher altitude of 1000m, Simpson = 0.79; Shannon-weiner =1.79 and Berger-Parker = 0.37

In the Simpson index (D) 0 represents infinite diversity and 1, no diversity, i.e, the greater the value of D, lower is the diversity but the reverse is true in case of Berger-Parker and Shannon-Wiener indices (Ludwig and Reynold, 1988; Mateus *et al* 2006). Applying these indices to understand the measures of biodiversity of flies at different altitudes demonstrates that the lower altitude of 800 m has a higher value (D) and lower value of 1/d indicating more biodiversity compared to the higher altitude of 900 m and 1000m (Table 1).

The density or richness of species also depends on the number of biotic and abiotic factors encountered in the seasons. Dobzansky and Pavan (1950) showed that rainfall appears to have a greater influence on the abundance of *Drosophila* than temperature. For building larger communities of *Drosophila*, monsoon is a suitable season and population density declines from the middle of post monsoon due to the prevalence of cold and dry weather (Guruprasad *et al* 2011). So the observed lower densities of *Drosophila* in the present study can be attributed to the post monsoon climatic conditions. In addition, climatic variables such as humidity, rainfall, temperature and incidence of sun light among others are the determining factors in the occurrence of *Drosophila* species. These studies suggest that the changes in the natural environment caused by the alteration of seasons would result in the change in relative frequency of different species from season to season.

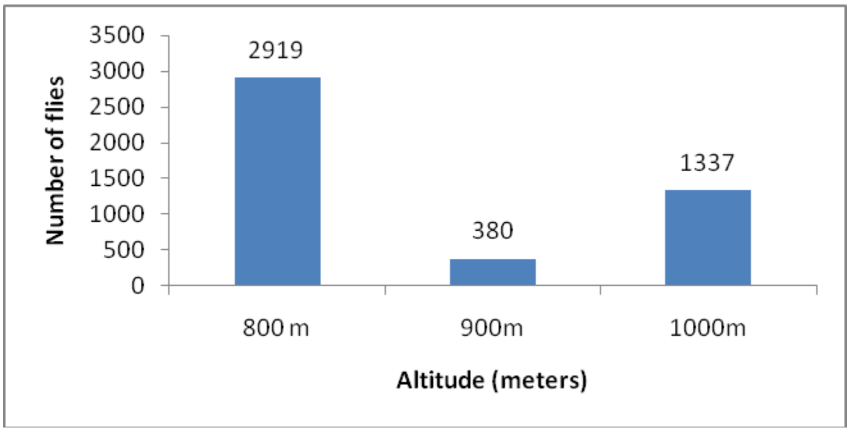

Fig. 1: Altitudinal variation of *Drosophila* population at different altitudes of Brahmagiri Wildlife Sanctuary

Table 1. The *Drosophila* species and their numbers collected from the Brahmagiri Wildlife Sanctuary from Oct-Dec 2012.

No.	Species	800 m	900 m	1000 m	Total
Subgenus *Sophophora*					
1	*D. ananassae*	304	03	00	307
2	*D. bipectinata*	81	00	11	92
3	*D. kikkawai*	368	60	609	1037
4	*D. malerkotliana*	372	00	00	372
5	*D. takahashii*	133	177	458	768
	Total	**1258**	**240**	**1078**	**2576**
Subgenus *Drosophila*					
6	*D. immigrans*	113	28	89	230
7	*D. nasuta*	1067	91	00	1158
	Total	**1180**	**119**	**89**	**1388**
Subgenus *Scaptodrosophila*					
8	*D. nigra*	481	21	170	672
	Total	**481**	**21**	**170**	**672**
	Grand Total	**2919**	**380**	**1337**	**4636**
Simpson index		1.79	1.38	1.21	
Shannon-Wiener		1.79	1.38	1.21	
Berger –Parker index		0.37	0.47	0.46	
Mean temperature in ^{0}C		18.33	19	19.66	

References

1. **Bachli G. 1998.** Family *Drosophilae*. In; L. Papp & B. Darvas (eds), contributions to a manual of palearctic Diptera. III. Higher Brachteera. Science Herald.
2. **Dobzhansky T.H., Pavan C. 1950.** Local and seasonal variations in relative frequencies of species of *Drosophila*. Brazilian Journal of Animal *Ecology*. 19: 1-14.
3. **Guruprasad B.R., Hegde S.N. 2006.** Altitudinal and seasonal flucatuation of *Drosophila* fauna of Chamundi hill*. Drosophila*. inform. Serv., 89: 10-11*.*
4. **Guruprasad B.R., Hegde S.N., Krishna M.S. 2009.** Seasonal and altitudinal changes in population density of 20 species of *Drosophila* in Chamundi hill. J. Insect. Sci., 10: 129-139
5. **Guruprasad B.R., Hegde S.N., Krishna M.S. 2010.** Seasonal and altitudinal changes in population density of 20 species of *Drosophila* in Chamundi hill. *Journal of Insect Science* 10:123 available online: insectscience.org/10.123.
6. **Hegde S.N., Vasudev V. and Krishna M.S. 2001.** Biodiversity of *Drosophila* of South India. In Wildlife Biodiversity Conservation (eds) Hosetti BB and Venkateshwarulu M Vol. 1; 55-71.
7. **Ludwig J.A., Reynolds J.F. 1988**. Statistical ecology: 337p. A primer on methods and computing. John Wiley and Sons.
8. **Mateus R.P., Buschini M.L.T., Sene F.M. 2006.** The *Drosophila* community in xerophytic vegetations of the upper Parana- Paraguay River Basin. *Brazlian Journal of Biology*. 66(2B): 719-729.
9. **Wakahama K.L. 1962.** Studies on the seasonal variation of population structure in *Drosophila,* I. Seasonal activity of *Drosophilid,* flies observed on Mt. Dakesan. Annot. Zoological Japan. 35:234-242.

Invasive Plant Species in Manjeri Municipality Area

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Abstract

Invasive species of plants, animals and microorganisms are considered as one of the biggest threats to Biodiversity all over the world. Invasive species of plants are highly problematic in introduced areas where they destroy other plants by smothering, allelopathy or competition. This aggressive behavior of invasives is attributed to successful association with symbiotic microbes and lack of pathogens or pests. Five invasive species of plants have been reported in Kerala. These are: *Mikania scandens, Chromolaena odorata, Lantana camara, Mimosa diplotricha* and *Wedelia trilobata*. A roving survey has been conducted in Manjeri, Narukara and Payyanad villages of Manjeri municipality area to analyse the occurrence and distribution of invasive species. Six species are observed in these areas. Among these six species, *Chromolaena odorata, Lantana camara* and *Mimosa diplotricha* are observed in all the three villages. *Mikania scandens, Wedelia trilobata* and *Ipomoea cairica* are found in Manjeri village only. The latter three are found in dry as well as wet areas. Faster colonization of wet areas by these species has also been observed.

Key words: Invasive plants, Manjeri, threats

Introduction

Invasive species are the biggest threat to Biodiversity next to habitat destruction. In introduces areas, they are highly problematic, destroying other plants by smothering, allelopathy or competition. Kerala's Biodiversity faces a severe threat from 89 invasive species (Kerala Biodiversity Board, 2012). Nine present very high risk, displacing and destroying a large number of native plants including medicinal plants and reduces availability of fodder, causing environmental and economic loss. Alien species like *Lantana camara* attract a large number of pollinating insects, which reduce pollination in native species. Invasive species are considered as a serious constraint to conservation and sustainable use of biodiversity, with significant undesirable impacts on goods and services provided by ecosystems (Raghubanshi et.al., 2005).

Among the 89 species, 9 are highly problematic. These are: *Acacia mearnsii* (Black wattle), *Antigonon leptopus* (Mountain rose), *Arundo donax* (Giant reed), *Chromolaena odorata* (Siam weed), *Ipomoea cairica* (Railway creeper), *Mikania micrantha* (American vally), *Mimosa diplotricha* var. *diplotricha* (Anathottavadi), *Prosopis juliflora* (Sali), *Wedelia trilobata* (Singapore daisy).

Study Area

The study was conducted in Manjeri Municipality of Malappuram district, which was formed in 1969 with an area of 3550 sq. km. The capital is Malappuram. It has a population of 4,110,956 as per the 2011 census report. There are 6 taluks (*Ernad, Nilambur, Tirur, Ponnani, Perinthalmanna* & *Tirurangadi*), 135 villages and 100 Grama Panchayaths and 5 Municipalities in the district. The Manjeri Municipality was formed on 1st April 1978. It is situated in the Ernad taluk and has an area of 53.06 sq. km with a population of 83,704 (2001 census). There are three villages in the Municipality (*Manjeri, Payyanad* and *Narukara*) and 50 wards. The NSS College Campus falls under College Kunnu - Ward 15 (Figs. 1).

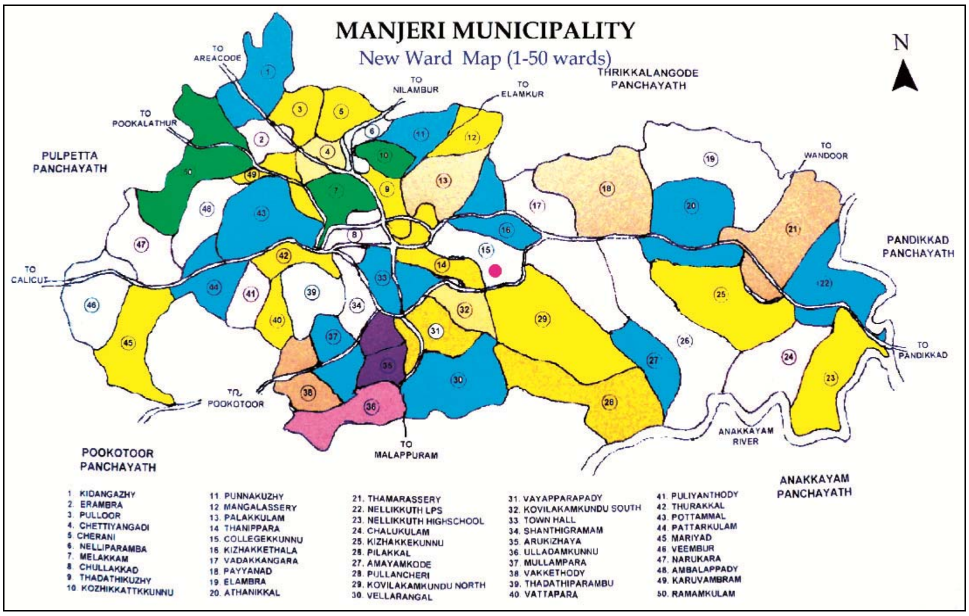

Fig. 1. Manjeri Municipality – New Ward Map

Results and Discussion

Six species of invasives have been observed in Manjeri municipality area. These are: *Chromolaena odorata, Lantana camara, Mimosa diplotricha* var. *diplotricha, Mikania micrantha, Wedelia trilobata* and *Ipomoea cairica*. List of species and their distribution are presented in Table 1.

Table 1. Distribution of Invasive species in different villages.

Sl. No.	Species	Manjeri	Narukara	Payyanad
1	*Chromolaena odorata*	+	+	+
2	*Lantana camara*	+	+	+
3	*Mimosa diplotricha* var. *diplotricha*	+	+	+
4	*Mikania micrantha*	+	-	-
5	*Wedelia trilobata*	+	-	-
6	*Ipomoea cairica*	+	-	-

Among the six species, *Chromolaena odorata, Lantana camara and Mimosa diplotricha* var. *diplotricha* are found in all the three villages. The other three species are found only in Manjeri Municipality. All the six species are found in Manjeri, the thickly populated village, which indicates the role of human beings in spreading invasive species.

Among the six species five are listed among the highly problematic species (Sudhi, 2012). In the light of these findings in a preliminary study, further investigations are required to understand environmental risks and management strategies for avoiding such risks.

Acknowledgements

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References

1. **Raghubanshi, A S, Rai, L C, Gaur, J P and Singh, J S.2005.** Invasive alien species and biodiversity in India. Current Science, 88 (4): 2005.
2. **Sudhi, K S. 2012.** 89 invasive plant species present a threat to Kerala's biodiversity. The Hindu Science and Technology, Kochi, May 30, 2012.

Analysis of Angiosperm Diversity and Endemism in the Tropical Montane (Shola) Forests of Kerala State, South India

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Abstract

A detailed floristic expedition was carried out for more about a decade in various Tropical Montane (Shola) forest regions of Kerala State, South India, for analyzing the plant diversity, endemism and the conservational importance of Sholas. The study areas comprised major shola forest regions of Idukki High ranges in Kerala such as Mannavan Shola (the largest shola forest of the state), Pambadam Shola, Pullaradi Shola, Idivara Shola, Sholas of Eravikulam National Park, Vellari Mala Shola of Wayand etc. A total of 669 angiosperm and 93 pteridophyte taxa were collected from the study areas, which indicated the high diversity prevailing in these regions. The collection of pteridophytes, comprised 27.6% of the total pteridophyte flora of the state (337 species). Among the 669 angiosperm taxa collected, 246 (36.8%) were endemics, out of which more than 30 % of the plants were endemic to Western Ghat regions only and about 6 % were endemic to South India. These figures substantiated the general view that sholas are megacentres of endemism.

About seven plants, which were considered as '*possibly extinct*', could also be rediscovered. This include *Actinodaphne bourneae* Gamble, *Arisaema attenuatum* Barnes & C.E.C. Fisch., *Arisaema psittacus* Barnes, *Impatiens anaimudica* C.E.C. Fisch., *Impatiens platyadena* C.E.C. Fisch., *Pimpinella pulneyensis* Gamble and *Symplocos monantha* Wight. About 70 plants, including 15 pteridophytes could also be located for the first time from the state. Thorough explorations in the area may lead to the discovery of more new taxa, since many of the regions remain still unexplored due to inaccessibility and hostile environments. In short, the sholas which are floristically unique in all respects, have to be protected and explored thoroughly to elucidate the floral diversity and status of the endemics, before they get extinct due to degradation, depletion or conversion of natural vegetation.

Key words: Shola, Tropical montane, diversity, endemism, conservation

Introduction

'Sholas' are *`Tropical Montane Forests'* situated in the higher mountain tracts of the Western Ghats, above 1500 m. They are the continuation of the *`Tropical Wet Evergreen Forests'* in the higher altitudes (Champion, 1935, 1936; Champion & Seth, 1968; Meher-Homji, 1984). 'Sholas' are very characteristic vegetation. They are generally found restricted to the sheltered valleys, glens, hollows and depressions owing to their fastidiousness as regards to soil moisture. The trees are stunted, profusely branched, without a straight bole and with an umbrella shaped canopy. The crooked branches are densely covered with epiphytic mosses, ferns, lichens and orchids. The species are basically of a tropical stock. But, temperate species dominate in the forest ecotones. They have often been referred to as living fossils, because of their inability to expand, due to the nature of the climatic conditions in the area (Vishnu-Mittre & Gupta, 1965).

In the state of Kerala, typical shola forests are distributed along the crest of the Western Ghats, where the altitude goes beyond 1500 m. Eravikulam (located in the High ranges of Idukki district), Devarmala (Pathanamthitta), Agasthyamala (Thiruvananthapuram), Sispara Ghat (Palakkad), New Amarambalam reserve forest (Malappuram), Vellarimala sholas (Kozhikode) and Brahmagiri hills (Wayanad) are some of the prominent regions. Some of these regions are actually extensions of the forest types of Tamilnadu state, from the Nilgiris, Pulneys or Anamalai hills. However, it is to be noted that majority of shola forests are distributed in the 'High ranges' of Idukki district and even the largest shola forest of the state, namely Mannavan Shola (presently under Anamudi Shola National Park), is located in this region (Balasubramaniam & Kumar, 1999; Kumar, 2004). In total, the area under shola-grassland vegetation in Kerala is estimated to be approximately 70 km^2 (CESS, 1984).

Very few studies have been conducted in the shola forests of Kerala, perhaps due to their remote occurrance and unfavourable climates. A comparable floristic account of the shola forests of Kerala is due to the pioneering studies of Sebastine and Vivekananthan (1967) and Shetty & Vivekananthan (1968, 1970. 1971, 1972, 1973a, 1973b, 1975 and 1991). Rice (1984), Jose *et al.* (1994), Karunakaran (1997), Karunakaran *et al.* (1997) etc have added further documentation on the plant wealth and ecology of the region. But since most of these studies were concentrated mainly on the ecological aspects, botany of the region remained scanty. Later, Swarupanandan *et al.* (1998, 2000) conducted some studies on the floristic and ecological aspects of a few sholas of the High Ranges of Idukki district, which was later, broadened to other areas of the state by Kumar (2004) as a continuation of the research project. In the mean time, research activities on various aspects on the shola forests of the state were initiated. These works were later compiled into the form of a book by Nair *et al.* (2001).

Materials and methods

Regular field trips were organized to Mannavan Shola, Idlimottai Sholas, Pullaradi Shola, Pambadam Shola and Eravikulam National Park for collecting plant specimens. A few trips were carried out to Silent Valley (Palakkad) and Vellarimala (Kozhikode) regions also. Collections were brought to the field stations and herbaria prepared as per standard procedure (Fosberg and Sachet, 1965; Bridson and Forman, 1991). Flowers and fruits of almost all specimens or even the whole plants (if small) were preserved either in *Formalin Aceto Alcohol* (FAA) or *Kew mixture* (9 parts of 70 % Ethyl alcohol, ½ part of 40% Formaldehyde and ½ part of Conc. Acetic acid) for further microscopical studies. Large fruits were dried and poisoned separately to keep the shape unchanged. All the herbarium specimens are deposited in *Kerala Forest Research Institute Herbarium* (KFRI), Peechi.

The specimens were critically studied and identifications were made initially with the help of the *Flora of the Presidency of Madras* (Gamble, 1915-1936), *Flora of British India* (Hooker, 1872-1897), Fyson's *Flora of the Nilgiri and Pulney Hill-tops* (1915-1921), *Flora of South Indian Hill Stations* (1932), *Flora of Palni Hills* (Matthew, 1999) etc. Illustrations of the species available in Wight's, *Icones Plantarum Indiae Orientalis* (1838-1853), both the works of Fyson (1915-21; 1932) and those in *Illustrations on the Flora of Palni Hills* (Matthew, 1996) and the *Supplement to Illustrations on the Flora of the Palni Hills* (Matthew, 1998) were referred for identification. Available monographs and revisions were also consulted. Several literature on phytogeographical studies and the internet cites of IPNI (www.ipni.org) were also referred to get the world distribution of each species. Specimens were also taken to the *Madras Herbarium* (MH) at Coimbatore and the *Calicut University Herbarium* (CALI) for verification and confirmation. Those, which needed further confirmation, were referred to experts in the concerned groups in India and abroad. Apart from those collected during the study period, specimens collected earlier from the study area by others and available at MH, CALI and KFRI were also referred to for the present study.

Since Pteridophytes form a major part of the flora of shola forests, systematic collection of the pteridophytes was also done. Most of the plants, except a few large ones and tree ferns, were collected in full including the rhizomes by uprooting them. Identification of the specimens was done mainly using pertinent literature such as Beddome (1863-1864, 1865-70, 1876, 1883 and 1892), Manickam (1986, 1989, 1995), Manickam and Ninan (1984), Manickam and Irudayaraj (1992), Nayar and Geevarghese (1993), Hameed *et al.* (2003), various monographs, M. Phil. and Ph. D. dissertations and hundreds of other publications on pteridophytes. Doubtful specimens were sent to experts and got confirmed.

Publications such as Chatterjee (1940), Joseph (1977), Henry *et al* (1979), Jain & Sasthry (1984), Ahmedullah & Nayar (1987), Nayar (1996, 1997), Nayar & Sasthry (1987, 1988, 1990), Sastry & Sharma (1991), Nayar & Geevarghese (1993) etc, were referred to learn the distributional and endemic aspects of the species.

Results and Discussion

a. Floristic analysis

During this study, 669 taxa (661 species and 8 infraspecific taxa) of flowering plants belonging to 369 genera under 110 families could be collected. Dicotyledons were represented by 536 taxa (529 species and 7 infraspecific taxa) belonging to 295 genera under 94 families. Monocotyledons were represented by 133 taxa (132 species and 1 variety) in 74 genera under 16 families. Among the total of 669 taxa, there were 14 subspecies and 41 varieties. In the case of pteridophytes, there were 93 taxa (92 species) belonging to 48 genera under 25 families. In total there were 3 varieties also (Kishore, 2004; Kishore & Sasidharan, 2012) (See Table 1).

Table 1: Preliminary information regarding the floristic analysis

No	Plant Groups	Family	Genera	Taxa	Species	Sub- Species	Variety
A	**Angiosperms**	**110**	**369**	**669**	**661**	**14**	**41**
1.	Dicots	94	295	536	529	14	37
2.	Monocots	16	74	133	132	0	4
B	**Pteridophytes**	**25**	**48**	**93**	**92**	**0**	**3**
Total		**135**	**417**	**762**	**753**	**14**	**44**

Among the dicots, *Asteraceae* with 50 taxa belonging to 29 genera is the largest family. It is followed by *Fabaceae* (42/22), *Rubiaceae* (36/17), *Acanthaceae* (26/7), *Lamiaceae* (24/10) etc. Among the monocots, *Orchidaceae* with 37 taxa under 20 families is the largest family. It is followed by *Poaceae* (35/26), *Cyperaceae* (19/8), *Commelinaceae* (9/3), *Araceae* (7/1), *Juncaceae* (5/1) etc. When the South Indian flora is considered, *Fabaceae* holds the prime position in dominance followed by *Poaceae* and *Rubiaceae* (Gamble, 1915). But in this study, these families held the second, fifth and fourth positions respectively, while *Asteraceae*, which holds the seventh position in South Indian, flora stands first here.

When the tree species alone are considered, *Lauraceae* with 23 taxa under 9 genera is the largest. It is followed by *Rubiaceae* (15/7), *Euphorbiaceae* (10/7), *Symplocaceae* (10/1), *Myrtaceae* (9/4), *Myrsinaceae* (7/4), etc. The relative dominance of these families, which constitute the tree flora, is the case prevailing in all shola regions. But the undergrowth flora shows a different picture as indicated by the earlier figures. In this study, only the shola vegetation was given much importance. The dominance figures would have changed if the grassland vegetation was also given equal importance.

Among the pteridophytes, *Aspleniaceae* with 12 taxa under 1 genus is the largest. It is followed by *Polypodiaceae* (8/5), *Dryopteridaceae* (9/3), *Lycopodiaceae* (8/3), *Thelypteridaceae* (7/5), *Athyriaceae* (6/4) etc.

It was understood that many of these species were ethnobotanically important and several such information were unknown to the scientific world also (Kumar *et al.*, 1999, 2000; Kumar & Sasidharan, 2002).

b. Distribution of the species

It is understood from the figures that more than 30 percent of the plants are restricted to Western Ghats (Table 2). About 16 percent of plants are common to South India and Srilanka. Indo-Malesian species constitute about 8 percentage. About 3 percentage of plants are of Southeast Asian distribution. Out of the total number of 669 angiosperm taxa, 32 (4.8 %) are exotics.

Table 2: Pattern and percentage of geographical distribution of Angiosperm taxa

No	Distribution	Dicots	Monocots	Total	Percentage
1.	South India	31	7	**38**	5.68
2.	Western Ghats	43	5	**48**	7.18
3.	Southern Western Ghats	131	28	**159**	23.77
4.	Western Ghats & Srilanka	5	0	**5**	0.75
5.	South India & Srilanka	78	34	**112**	16.74
6.	Kerala	1	0	**1**	0.15
7.	India	10	1	**11**	1.64
8.	Indo-Malesia	48	7	**55**	8.22
9.	India & Himalayas	5	1	**6**	0.90
10.	South East Asia	15	3	**18**	2.69
11.	Exotic	32	0	**32**	4.78
12.	Others	129	46	**175**	26.16
13.	Unidentified taxa	8	1	**9**	1.35
	TOTAL	**536**	**133**	**669**	**100**

Some of these are introduced ornamentals escaped from the gardens or mere weeds (*Acanthospermum hispidum, Ageratina adenophora, Ageratum houstonianum, Calceolaria gracilis, Desmodium uncinatum, Erigeron karvinskianus, Galinsoga parviflora, Gamochaeata coarctata, Lantana camara, Oenothera laciniata, Parthenium hysterophorus, Chenopodium ambrosioides* etc). The introduction of exotic fodder grasses by the State Livestock Development Board has resulted in the influx of the seeds of several other herbaceous plants also, which have now naturalised in the wild. Some introduced and widely cultivated trees have also entered into sholas (*Acacia dealbata, A. mearnsii, A. dealbata, Eucalyptus globulus, E. grandis, Grevillea robusta* etc). Several introduced vegetables such as *Cyphomandra betacea, Lycopersicon lycopersicum, Passiflora edulis, P. ligularis, P. mollissima,* etc. are also now seen growing in low altitude shola regions. The role of birds, animals and man in the dispersal of the seeds of these species is noteworthy.

c. Endemism

In India, there are about 5725 endemic taxa of angiosperms, which represent 33.5 % of Indian flora (17,000 species). They are located in mainly the 'hotspots' (Nayar, 1996). 'Anamalai-High Ranges' where most part of this study is concentrated is one among these hotspots. Ahmedullah & Nayar (1987) have reported that there are 1,923 taxa of flowering plants endemic to Peninsular India. Out of the estimated 4,800 species of flowering plants in Kerala, 1272 (22.6 % of Indian endemics) are endemic to the Southern Western Ghats (Nayar, 1996). These endemic flora belong to a paleotropic one, a part of the peninsular Indian endemic flora of Gondwanaland origin.

Kerala is the natural habitat of about 120 taxa of *paleoendemic* angiosperms belonging to 75 genera and 40 families. This number excludes *neoendemic* species and also those endemic taxa of Western Ghats/Peninsular India, which also occur in Kerala. Together with the Western Ghats/ Peninsular Indian endemics and Kerala endemics, endemism of the flora of our state is very high.

The importance of shola forests in this regard which are considered, as the megacentres of endemism becomes evident (Basha & Nair, 1991; Nair & Basha, 1995). This is evidenced from the present study also. Out of the total 669 angiosperm taxa, 246 (36.8 %) are endemics. This ratio is very high, when compared with the scenario of the country (only 33.5 %). Out of this, 206 taxa (30.7 %) belong to dicots, while monocots constitute only 40 taxa (5.97 %). Among the pteridophytes, out of the 93 taxa, only 6 taxa (6.5 %) are found to be endemic. This indicates that pteridophytes often have a wide range of (cosmopolitan) distribution (Table 3).

Table 3: Categorisation of the taxa into various distributional/conservational statuses

No	Plant groups	Total Taxa	Endemics	Rare	Endangered /Threatened	Possibly extinct
A	**Angiosperms**	**669**	**246**	**111**	**20**	**7**
1.	Dicots	536	206	78	15	5
2.	Monocots	133	40	33	5	2
B	**Pteridophytes**	**93**	**6**	**34**	**8**	**0**
	Total	**762**	**252**	**145**	**28**	**7**

A list of the Peninsular Indian endemic genera (6 nos.) reported from the shola forests is given as Table 4. This includes *Campbellia, Diplocentrum, Helicanthes, Nilgirianthus, Phlebophyllum* and *Vanasushava*. Among these, *Nilgirianthus* and *Phlebophyllum* are now treated under *Strobilanthes*. Genera such as *Arisaema, Hedyotis, Impatiens, Strobilanthes, Ophiorrhiza* and *Vernonia* are represented by more than 3 endemic species in Kerala, many of which are reported from the shola forests only.

Table 4: List of the Endemic genera* and the species reported from the sholas

No	Name of the genera	Family	Name of the species	Present nomenclature
1.	*Campbellia* Wight	Orobanchaceae	*C. cytinoides* Wight	*Christisonia neilgherrica* Gardner
2.	*Diplocentrum* Lindl.	Orchidaceae	*D. recurvum* Lindl.	(no change)
3.	*Helicanthes* Danser	Loranthaceae	*H. elastica* (Desr.) Danser	(no change)
4.	*Nilgirianthus* Bremek. #	Acanthaceae	*N. foliosus* (Wight) Bremek.	*Strobilanthes foliosus* T. Anders.
		Acanthaceae	*N. neilgherrensis* (Bedd.) Bremek.	*Strobilanthes neilgherrensis* Bedd.
		Acanthaceae	*N. papillosus* (T. Anders.) Bremek.	*Strobilanthes papillosus* T. Anders.
		Acanthaceae	*N. perrottetianus* (Nees) Bremek.	*Strobilanthes perrottetianus* Nees
		Acanthaceae	*N. urceolaris* (Gamble) Bremek.	*Strobilanthes urceolaris* Gamble
		Acanthaceae	*N. wightianus* (Nees) Bremek.	*Strobilanthes wightianus* Nees
5.	*Phlebophyllum* Nees #	Acanthaceae	*P. kunthianum* Nees	*Strobilanthes kunthianus* (Nees) T. Anders. *ex* Benth.
6.	*Vanasushava* Mukh. & Constance	Apiaceae	*V. pedata* (Wight) Mukh. & Constance	(no change)

(* Ref.: Ahmedullah & Nayar, 1997; # now treated under *Strobilanthes*)

Among the dicots, majority of the South Indian endemics (6 taxa) belong the family *Lamiaceae,* while *Asteraceae* (7 taxa) and *Rubiaceae* (21 taxa) have the highest number taxa as Western Ghats and Southern Western Ghats endemics. Out of the total number of 23 *Impatiens* reported, 18 (73 %) are endemics (14 species are Southern Western Ghats endemics and 4 are Western Ghats endemics). Similarly, out of the total number of 19 *Strobilanthes* reported, 16 (84 %) are endemics (15 are Southern Western Ghats endemics and one is Western Ghat endemic).

Among the *Rubiaceae,* all the species of *Hedyotis* (4), *Lasianthus* (5) and *Psychotria* (3) are S. W. Ghat endemics. Same is the case with all the species of *Actinodaphne* (3) and *Cinnamomum* (6) of *Lauraceae*. In the case of monocots, out of the 37 *Orchidaceae* members, 13 (35 %) are S. W. Ghats endemics and 5 are South Indian endemics. Among the 7 *Arisaema* (*Araceae*) collected, 5 are S. W. Ghats endemics and one is W. Ghats endemic.

Among the pteridophytes, *Elaphoglossum, Psuedocyclosorus, Sphaeropteris* (earlier name *Cyathea*) and *Gleichenia* coming under *Lomariopsidaceae, Thelypteridaceae, Cyatheaceae* and *Gleicheniaceae* are the four genera, which have representation of endemic taxa.

d. Plants under different threat categories

Joseph (1977), Henry *et al* (1979), Jain & Sastry (1984), Ahmedullah & Nayar (1987) and Nayar & Sastry (1987, 1988, 1990) have well documented the rare and threatened plants of South India. Nayar (1997) listed out 1272 endemic taxa in Kerala and 460 of them are placed under threat categories. Since sholas are centers of endemism, with more than one third (39.3 %) of the taxa being endemic as evidenced from the present study, chances of local extinction of species is far great. The habitat destruction and other anthropological activities have speeded up this process. So the figures of rare and threatened plants as documented in the above works are always not dependable, since majority of these works are based on secondary data or those based on the earlier herbarium collections. Thorough field investigation studies are necessary to validate many of this information.

It is a fact that a lot of other species, which are not reported in the works cited earlier, are found locally in very rare and threatened conditions. Since sholas are facing several threats, documentation of such information deserves attention in the conservation point of view. Because many of such locally endangered taxa may face extinction, if proper conservational measures are not taken up.

e. Rediscovery of plants categorized as '*Possibly extinct*'

During the study seven species of angiosperms (all dicots), earlier documented as '*Possibly extinct*' could be rediscovered (Kumar & Sasidharan, 2010; Kumar, 2012). *Actinodaphne bourneae* could not be collected during this century and was considered extinct (Nayar, 1997). This species could be collected from the Anamudi slope of Eravikulam National Park (Table 5).

Table 5: 'Possibly extinct'* plants rediscovered during the study

No.	Name of the species	Habit	Family	References
1.	*Actinodaphne bourneae* Gamble	Tree	Lauraceae	Nayar, 1997
2.	*Arisaema attenuatum* Barnes & C.E.C. Fisch.	Herb	Araceae	Shetty & Vivekananthan, 1991; Nair & Basha, 1995
3.	*Arisaema psittacus* Barnes	Herb	Araceae	Shetty & Vivekananthan, 1991; Nair & Basha, 1995

4.	*Impatiens anaimudica* C.E.C. Fisch.	Herb	Balsaminaceae	Nayar & Sastry, 1988
5.	*Impatiens platyadena* C.E.C. Fisch.	Herb	Balsaminaceae	Ahmedullah & Nayar, 1987; Hajra *et al.,* 1997
6.	*Pimpinella pulneyensis* Gamble	Herb	Apiaceae	Nayar, 1997; Matthew, 1999
7.	*Symplocos monantha* Wight	Tree	Symplocaceae	Nayar, 1997

Arisaema attenuatum and *A. psittacus* were treated as *'possibly extinct'* by Shetty & Vivekananthan (1991). *A. attenuatum* could be collected from the Chengalar dam region at Mannavan Shola and also from the Umayamala valleys (MPCA plots) at Eravikulam. This species is occasionally found in the shola borders or scrublands. *A. psittacus* is a threatened, narrow endemic species which could not be relocated after the type collection by Barnes in 1937 from Chunduvurrai & Mannavan Shola. It was so considered extinct in its natural habitat. However the species was recently rediscovered from the same localities by Nair *et al.* (1997). I could collect the species from both these locations and also from another locality named Pambadam Shola, which is situated nearby.

Impatiens anaimudica was considered as *'possibly extinct'* by Nayar & Sastry (1988), since it was not collected after the type collection by Barnes (1933) from Anamudi. I could collected this species during October 1996 from the Umayamala ranges of Eravikulam. Biju (2001) also relocated this species from Anamudi. *Impatiens platyadena* was considered as '*possibly extinct*' by Ahmedullah & Nayar (1987) and Hajra *et al* (1997). It was Barnes who made the type collection from the Nyamakkad gap of Idukki District during 1933 and after that it could not be collected. The species was collected from the Nilagiri teri region of Eravikulam. *Pimpinella pulneyensis* was so far reported from it's type locality (Palni hills) only and was considered '*possibly extinct*' (Nayar, 1997; Matthew, 1999). Present collection from Idlimottai region of Mannavan Shola thus forms both a rediscovery and extension of distribution of the species to Kerala. *Symplocos monantha* was also considered extinct by Nayar (1997) since it could not be relocated after the type collection, which was made from the Shevagherry Hills of Tamil Nadu by Robert Wight, until it was reported from Periyar Tiger Reserve recently (Sasidharan, 1998). Present collection from the Idlimottai regions of Mannavan Shola extends the distribution of the species.

f. <u>New records</u>

About 70 plants were reported for the first time from Kerala as a result of this study (Kumar, 1997; Kumar *et al.* 1997; Rajesh & Kumar, 2003; Kumar & Sasidharan, 2010; Kumar, 2012). This include 55 angiosperms and 15 pteridophytes. These figures form about 8.2 % of the total angiosperms collected (669 taxa) and 16 % of the total pteridophytes collected (93 taxa), which is a substantially high figure. Among these, three are rediscoveries of plants considered as '*possibly extinct*' (*Actinodaphne bourneae, Pimpinella pulneyensis* and *Symplocos monantha*), while one is a new record to the country (*Oenothera laciniata* – Onagraceae)(See Kumar, 2012).

g. <u>Diversity of Pteridophytes</u>

The total number of 93 pteridophytes collected from the shola regions of Kerala forms 28.1 % of the total pteridophyte flora of the state (331 species: Easa, 2003). The significance of this figure becomes clear when we compare the area of shola forests with that of Kerala as a whole. We have earlier seen that Shola forests occupy only about 70 sq. km area, while Kerala as a whole occupy 38,863 sq. km of land, with about 9400 sq. km area under forests (Nair, 1997). It is quite interesting to see that shola forests which form only less than one percentage (0.7 %) of the total forested land of Kerala (0.2 % of the whole area of the State), is supporting 28.1 % of the pteridophytes of the state. The present figure also forms 54 % of the total collections made from the Malabar region by Nayar & Geevarghese (1993).

Very rare and interesting tree ferns, which are considered as '*fossil plants*', are found to grow only in the shola forests, where they are facing several threats of destruction (Kumar, 1999). The need for conserving the shola forests, which acts as a refugium of pteridophyte diversity, becomes evident here.

Conclusions

From the study it is becoming clear that sholas are one of the most diverse ecosystems in the Western Ghats, which is considered as one of the 'hottest' of the hotspots of biodiversity. The total of 669 angiosperm taxa collected from a small area certainly indicates the high diversity prevailing in these regions. The 93 taxa of pteridophytes which contribute about 28.1 % of the total flora of the state, collected from such a small area also signifies the high pteridophyte diversity of the region. Out of the total of 669 angiosperm taxa collected, 246 (36.8 %) belong to endemics. These figures substantiates the general view that sholas as megacentres of endemism. Perhaps the unique altitudinal and climatic factors, which favour diverse microclimatic situations, might be leading to the high endemic concentration and diversity in these regions.

A number of plants belonging to various threat categories could be located during this study. About 70 plants including 15 pteridophytes could be reported for the first time from Kerala. Seven plants, which were considered as 'possibly extinct', could also be rediscovered. Thorough explorations in the area may lead to the discovery of more new taxa, since many of the regions remain still unexplored due to inaccessibility and hostile environments.

Therefore in short, the sholas, which are floristically unique in all respects, have to be protected and explored thoroughly to elucidate the floral diversity and status of the endemics, before they get extinct due to degradation, depletion or conversion of natural vegetation.

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References

1. **Ahmedullah, M. and M. P. Nayar. 1987.** *Endemic Plants of the Indian Region*, Vol. 1 (Peninsular India), Botanical Survey of India, Calcutta.
2. **Balasubramaniam, K. and K. K. Kumar. 1999.** The Riddle of the Shola. *Evergreen* 42: 1-5, News letter of Kerala Forest Research Institute, Peechi.

3. **Basha, S. C. and K. K. N. Nair. 1991.** Endemic angiosperms of the Western Ghats of India with special reference to Kerala: a review. In: C. K. Karunakaran *et al.* (eds.) *Proc. Symp. Rare, Endangered and Endemic Plants of the Western Ghats.* Kerala Forest Dept., Trivandrum. pp. 276-290.
4. **Beddome, R. H. 1863-1864.** *The Ferns of Southern India*. Gantz Bros., Madras. (Reprint ed., 1970). Today and Tomorrow's Printers & Publishers, New Delhi.
5. **Beddome, R. H. 1865-1870.** *The Ferns of British India*. Vol. 1 & 2. Gantz Bros., Madras. (Reprint ed., 1973). Oxford & IBH Publishing Co., New Delhi.
6. **Beddome, R. H. 1869-1874.** *The Flora Sylvatica for Southern India*. Gantz Bros., Madras.
7. **Beddome, R. H. 1876.** *Supplement to the Ferns of Southern India and British India.* Gantz Bros., Madras.
8. **Beddome, R. H. 1883.** *A Handbook to the Ferns of British India, Ceylon and Malay Peninsula*. Thacker Spink & Co., Calcutta. (Reprint ed., 1976). Today and Tomorrow's Printers & Publishers, New Delhi.
9. **Beddome, R. H. 1892.** *Supplement to the Ferns of British India, Ceylon and Malay Peninsula*. Thacker Spink & Co., Calcutta. (Reprint ed., 1976). Today and Tomorrow's Printers & Publishers, New Delhi.
10. **Beddome, R.H. 1868-1874.** *Icones Plantarum Indiae Orientalis*. Gantz Bros., Madras.
11. **Biju, S. D. 2001.** Relocation *of Impatiens anaimudica* C. E. C. Fischer (Balsaminaceae) and the taxonomic status of *I. konalrensis* Chandrab. *et al.* Rheedea 11 (2): 109-113.
12. **Bridson, D. M. and L. Forman. 1991.** *The Herbarium Handbook*. Royal Botanic Gardens, Kew.
13. **CESS (Centre for Earth Science Studies), 1984**. *Resource Atlas of Kerala.* Govt. of India and CESS, Trivandrum.
14. **Champion, H. G. 1935.** A preliminary survey of the forest types of India and Burma. *Indian For. Rec*. (N. S.) 1(1): 1-286.
15. **Champion, H. G. 1936.** Forest types of India and Burma. *Indian For. Rec.* (N. S.), *Silvicult*. 1:1.
16. **Champion, H. G. and S. K. Seth. 1968.** *A revised survey of the forest types of India*. Govt. of India Press, Nasik.
17. **Chatterjjee, D. 1940.** Studies on the endemic flora of India and Burma. *J. Asiat. Soc. Bengal* 5: 19-67.
18. **Easa, P. S. 2003.** *Biodiversity documentation for Kerala, Part 5: Pteridophytes*. KFRI Handbook No. 17, Kerala Forest Research Institute, Peechi, Kerala, 94p.
19. **Fischer, C. E. C. 1921**. A survey of the flora of Anamalai Hills, in the Coimbatore District, Madras Presidency. *Rec. Bot. Surv. India*. 9:1-128.
20. **Fosberg, F. R. and M.M. Sachet. 1965.** *Manual of Tropical Herbaria*. Reg. Veg. 39. Utrecht
21. **Fyson, P. F. 1915-1921.** *Flora of the Nilgiri and Pulney Hill tops*, Vols. 1-3, Govt. Press, Madras.
22. **Fyson, P. F. 1932.** *The Flora of South Indian Hill Stations*, Vols. 1 and 2, Govt. Press, Madras.
23. **Gamble, J. S. and C. E. C. Fischer. 1915-1936.** *Flora of the Presidency of Madras*, Parts 1-11, London.
24. **Hameed, C. A., K. P. Rajesh and P. V. Madhusoodanan. 2003.** *Filmy ferns of South India.* Penta Book Publishers & Distributors, Calicut. 260 p.
25. **Henry, A. N., K. Vivekananthan and N. C. Nair. 1979.** Rare and threatened flowering plants of South India. *J. Bombay Nat. Hist. Soc.* 75: 684-697.
26. **Hooker, J. D. 1872-1897.** *The Flora of British India*, Vol. I-VII, Reeve & Co., London.
27. **Jain, S. K. and R. R. Rao. 1977.** *A Handbook of Field and Herbarium methods*. Today and Tomorrow's Printers and Publishers, New Delhi.
28. **Jain, S. K. and A. R. K. Sastry, 1984.** *The Indian Plant Red Data Book*. Botanical Survey of India, Calcutta.
29. **Jose, S., A. Sreepathy, B. Kumar and V. K. Venugopal. 1994.** Structural, floristic and edaphic attributes of the grassland-shola forests of Eravikulam in Peninsular India. *For. Ecol. Manage*. 65(2-3): 279-291.

30. **Joseph, J. 1977.** Floristic Studies in India-with Special Reference to Southern Circle of Botanical Survey of India. *Bull. Bot. Surv. India* 19: 109-111.

31. **Karunakaran, P. V. 1997.** *Ecological Studies on the Grasslands of Eravikulam National Park, Kerala.* Doctoral thesis, Saurashtra University.

32. **Karunakaran, P. V., G. S. Rawat and V. K. Unniyal. 1997.** *Ecology and conservation of the grasslands of Eravikulam National Park, Western Ghats*. Research Report, Wildlife Institute of India, Chandrabeni, Dehra Dun, 164 p.

33. **Kumar, K.K. 2004.** *Taxonomic and Ecological Studies on the Shola forests of Kerala,* Doctoral Thesis, University of Calicut

34. **Kumar, K.K. and N. Sasidharan. 2010.** New records of some little known plants from the Shola forests of Kerala State. *Scientia*, 6(1): 99-117, Dept. of Zoology, Mercy College, Palakkad, Kerala.

35. **Kishore Kumar. K. and N. Sasidharan. 2012.** Floristic checklist and Analysis of Angiosperm diversity in the Tropical Montane (Shola) Forests of Kerala State, South India. *Journal of Eco. & Tax. Bot.*, Jodhpur, India, 36(4): 712-735.

36. **Kumar, K.K. 2012.** Rediscovery of seven '*Possibly extinct'* plants from the Shola Forests of Kerala State. *Scientia*, 8(1): 87-94, Dept. of Zoology, Mercy College, Palakkad, Kerala

37. **Kumar, K. K. and N. Sasidharan, 2002.** Ethnomedicines: a case study from the shola forests of Kerala, India. In: Singh *et al* (ed.) *Recent Progress in Medicinal Plants*, 1: 201-214, *Ethnomedicine and Pharmacognosy*, Sci Tech Publ. LLC, Texas, USA, 399 p.

38. **Kumar, K. K., N. Sasidharan, and K. Swarupanandan. 1999.** Ethnobotanical studies on the hill tribes in the shola forests of High ranges, Kerala. *J. Econ. Tax. Bot.* 23(2): 451-466.

39. **Kumar, K. K., N. Sasidharan and K. Swarupanandan. 2000.** Ethnobotanical studies on the hill tribes in the shola forests of High ranges, Kerala. In: J. K. Maheswari (ed.) *Ethnobotany and medicinal plants of Indian subcontinent*, Advance Books, Jaipur.

40. **Manickam, V. S. 1986.** *Fern flora of the Palni Hills (South India).* Today and Tomorrow's Printers & Publishers, New Delhi.

41. **Manickam, V. S. 1989.** Ferns of the Western Ghats (South India). In: K. H. Shing & K. U. Kramer (ed.). *Proc. Intern. Symp. Systematic Pteridology*, Beijing, China, pp. 181-192.

42. **Manickam, V. S. 1995.** Rare and endangered ferns of the Western Ghats of South India. *Fern Gaz.* 15: 1-10.

43. **Manickam, V. S. and C. A. Ninan. 1984.** *Ecological Studies on the Fern Flora of Palni Hills (S. India).* Today and Tomorrow's Printers & Publishers, New Delhi.

44. **Manickam, V. S. and V. Irudayaraj. 1992.** *Pteridophyte flora of the Western Ghats (South India).* B. I. Publications Pvt. Ltd., New Delhi.

45. **Matthew, K. M. 1996.** *Illustrations on the Flora of Palni Hills*, *South India*, The Rapinat Herbarium, Tiruchirappalli.

46. **Matthew, K. M. 1998. Matthew, K. M. 1996.** *Supplement to the Illustrations on the Flora of Palni Hills*, *South India*, The Rapinat Herbarium, Tiruchirappalli.

47. **Matthew, K. M. 1999.** *The Flora of Palni Hills,* Vol. 1-3, The Rapinat Herbarium, Tiruchirappalli.

48. **Meher-Homji, V. M. 1984.** A new classification of the biogeographic zones of India. *Indian J. Bot.* 7(2): 224-233.

49. **Nair, K. K. N and S. C. Basha. 1995.** Centres in Kerala rich in endemic angiosperms as potential sites for biodiversity preservation. *J. Econ. Tax. Bot.* 19(3): 719-733.

50. **Nair, K. K. N., S. K. Khanduri and K. Balasubramanyan. 2001.** *Shola Forests of Kerala: Environment and Biodiversity*, Kerala Forest Dept. & Kerala Forest Res. Inst., 453 p.
51. **Nair, K. Narayanan, R. Jayakumar and R. Prathapachandran. 1997.** Rediscovery *Arisaema psittacus* (Araceae), a little known endemic and threatened species. *Rheedea* 7(2): 101-106.
52. **Nayar, B. K. and K. K. Geevarghese. 1993.** *Fern Flora of Malabar*. Indus Publishing Co., New Delhi.
53. **Nayar, M. P. 1996.** *Hotspots of Endemic Plants of India, Nepal and Bhutan*, Tropical Botanic Gardens Research Institute, Thiruvananthapuram, pp. 1-252.
54. **Nayar, M. P. 1997.** Biodiversity challenges in Kerala and Science of Conservation Biology. In: P. Pushpangadan and K. S. S. Nair (eds.) *Biodiversity and Tropical Forests: The Kerala scenario*. STEC, Kerala, pp 7-80.
55. **Nayar, M. P. and A. R. K. Sastry. 1987, 1988, 1990.** *Red Data Book of Indian Flowering Plants,* Vol. 1-3. Botanical Survey of India, Calcutta.
56. **Rajesh, K. P. and K. K. Kumar. 2004.** *Taeniophyllum alwisii* Lindl. (Orchidaceae) - new record for Kerala. *J. Econ. Tax. Bot.* 28(1): 101-103.
57. **Rice, C. G. 1984.** *The behaviour and ecology of Nilgiri tahr (Hemitragus hylocrius* Ogilby, 1938). Doctoral Thesis. Texas and A. M. University
58. **Sasidharan, N. 1998.** *Studies on the flora of Periyar Tiger Reserve.* KFRI Res. Report No. 150, Kerala Forest Research Institute, Peechi, 558 p.
59. **Sastry, A. R. K. and B. D. Sharma. 1991.** The significance of the Western Ghats in plant conservation. In: C. K. Karunkaran (ed.) *The proceedings of the symposium on Rare, Endangered and Endemic plants of the Western Ghats.* Kerala Forest Dept., Trivandrum.
60. **Sebastine, K. M. and K. Vivekananthan. 1967.** A contribution to the flora of Devicolam, Kottayam District, Kerala. *Bull. Bot. Surv. India* 9(4): 163-185.
61. **Shetty, B. V. and K. Vivekananthan. 1968.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala I: A new variety of *Leucas vestita* Benth. *Bull. Bot. Surv. India* 10(2): 237.
62. **Shetty, B. V. and K. Vivekananthan. 1969.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala II: A new species of *Hedyotis* Linn. *Bull. Bot. Surv. India* 11: 447-449.
63. **Shetty, B. V. and K. Vivekananthan. 1970.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala III: A new species of *Vernonia* Schreb. *Bull. Bot. Surv. India* 12(1-4): 266-267.
64. **Shetty, B. V. and K. Vivekananthan. 1971.** Studies on the vascular flora of Anaimudi and surrounding regions, Kottayam District, Kerala. *Bull. Bot. Surv. India* 13: 16-42.
65. **Shetty, B. V. and K. Vivekananthan. 1972.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala IV: Notes on some rare species. *Bull. Bot. Surv. India* 14: 19-23.
66. **Shetty, B. V. and K. Vivekananthan. 1973a.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala V: A new variety of *Pogostemon travancoricus* Bedd. *Bull. Bot. Surv. India* 15(1-2): 155-157.
67. **Shetty, B. V. and K. Vivekananthan. 1973b.** Notes on some interesting grasses from Southern India. *Bull. Bot. Surv.* 15(3-4): 276-278.
68. **Shetty, B. V. and K. Vivekananthan. 1975.** New and little known taxa from Anaimudi and surrounding regions, Devikolam, Kerala VI: An un-described species of *Oberonia* Lindl. *Bull. Bot. Surv. India* 17: 157-159.
69. **Shetty, B. V. and K. Vivekananthan. 1991.** The endemic and endangered plants of the High Range, Idukki district, Kerala. In: C. K. Karunakaran *et al.* (ed.) *Proc. Symp. Rare Endangered and Endemic plants of Western Ghats*.

70. **Swarupanandan, K., N. Sasidharan, K. C. Chacko and S. C. Basha. 1998.** *Studies of the Shola Forests of Kerala*. KFRI Research Report No. 158, Kerala Forest Research Institute, Peechi.
71. **Swarupanandan, K., N. Sasidharan, K. C. Chacko and S. C. Basha. 2000.** Floristic and ecological studies of the Sholas of Idukki District. In: K. K. N. Nair *et al.* (eds.) *Shola Forests of Kerala: Environment and Biodiversity*, Kerala Forest Dept. & Kerala Forest Res. Inst., pp. 259-286.
72. **Vishnu-Mittre and H. P. Gupta 1965.** A living fossil plant community in South Indian Hills. *Curr. Sci.* 37(23): 671-672.
73. **Wight, R. 1838-1853.** *Icones Plantarum Indiae Orientalis,* 6 Vols., Madras.
74. **Wight, R. 1840.** *Illustrations of Indian Botany*. Glasgow'
75. **www.ipni.org**

Influence of geographical peculiarity in the distribution pattern of Marine Fungi along the Kerala Coast

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Abstract

Marine fungi constitute a vital link in coastal ecosystem particularly in biogeochemical cycles. During a marine mycological survey along the west coast of India, a total of 111 marine fungi comprising 84 Ascomycetes, 3 Basidiomycetes and 24 Mitosporic fungi were encountered. Maximum fungal species were recorded along the Kerala coast (106) followed by Goa (47), Maharashtra (45), Mahe (36), Karnataka (35) Kanyakumari (31) and Gujarat (16). Great majority of fungal species recorded along Kerala might be due to the fact that the westward fast flowing 41 rivers of Kerala carry along with them huge amount of debris from the fauna and flora rich Western Ghats, whose biodegradation takes place comparatively at a faster rate than other coastal regions of India and makes the Kerala coast a fertility rich zone.

Keywords: Biodegradation, Coastal wetlands, Fertility, Marine fungi

Introduction

Marine fungi are not taxonomically but an ecologically and physiologically defined group (Kohlmeyer & Kohlmeyer, 1979). Approximately 530 taxa of filamentous fungi are recognized as obligate or facultative marine fungi that are able to grow and reproduce in saline or brackish water environment (Jones et al., 2009). They are the important intermediaries of energy flow from detritus to higher tropic levels in the marine ecosystem (Hyde & Lee, 1995). Studies on marine fungi were initiated at the temperate parts of the world. Subsequently tropical locations were the centers of interest to understand the abundance and diversity. The distribution of marine fungi is influenced by a number of factors either individually or synergistically. These factors include temperature, salinity, tidal amplitude, p^H, dissolved organic nutrients, seasonality, nature of the host, availability of the substrata, ecological niches, position of intertidal region, nature of floor etc ((Kohlmeyer & Kohlmeyer, 1979).

Some of the relevant works on marine fungi from India are Raghukumar, 1978; Borse, 1988; Chinnaraj, 1992; Prasannarai & Sridhar, 2001; Sarma & Vittal, 2000, 2004; Maria & Sridhar, 2002, 2003,2004; Raveendran & Manimohan, 2007; Gayatri & Raveendran, 2009a, 2010, 2011, 2012 etc. During the marine mycological survey along west coast of India certain interesting marine fungi were isolated. The present paper deals with the distribution of marine fungi along west coast of India.

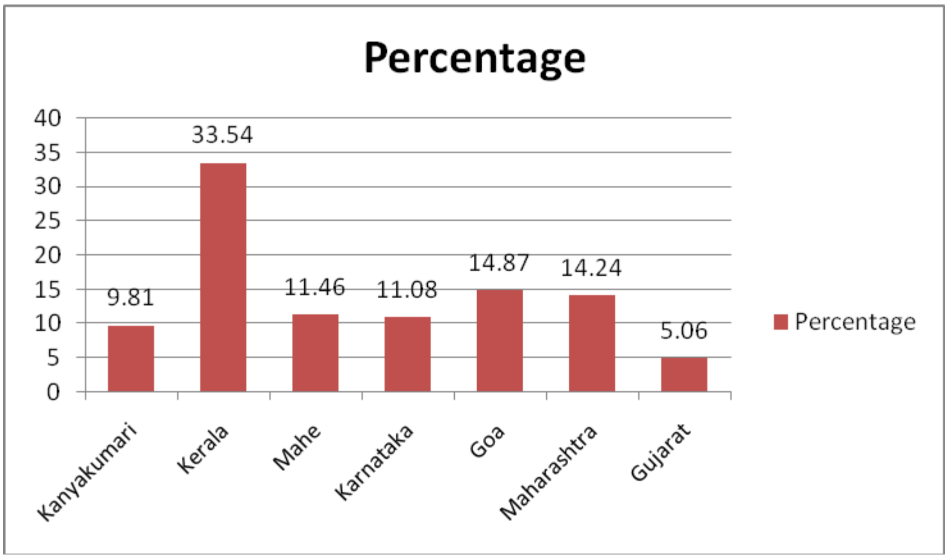
Materials and Methods

Woody substrates were collected from the coastal wetlands of Kanyakumari, Kerala (Kannur, Kozhikode, Cochin, Vizhijam), Mahe, Karnataka (Mangalore), Goa (Pajim), Maharashtra (Ratnagiri) and Gujarat (Surat) during July 2007 – September 2010. After thorough washing, they were observed under stereomicroscope for fungal fructifications and incubated in polythene bags at room temperature. Periodical isolation of marine fungi from these wood samples was carried out for five months. Identifications of marine fungi were done using taxonomic keys by Kohlmeyer & Kohlmeyer, 1979; Kohlmeyer & Volkmann Kohlmeyer, 1991; Hyde & Sarma, 2004 and Raveendran & Manimohan 2007.

Results and Discussion

The 4054 fungal isolates obtained from the west coast of India yielded 111 species belonging to 65 genera of higher marine fungi representing 84 Ascomycotina, 3 Basdiomycotina and 24 Deuteromycotina. *Torpedospora radiata*, *Clavatospora bulbosa* and *Periconia prolifica* were common to all the locations along west coast of India. Highest percentage of marine fungal species was obtained from Kerala (33.54%) and least from Gujarat (5.06%) (Fig. 1).

Fig. 1: Percentage of marine fungi obtained along the west coast of India



Kerala supported the maximum number of marine fungi along the west coast of India *i.e* 106 followed by Goa (47) (Table. 1). This might be due to the fact that the 41 west-flowing rivers of Kerala are originating from the bio- diversity rich Western Ghats. The distance between the mountain on the east and the sea on the west being very short, almost all rivers in Kerala are short in length and tidal in their lower reaches. They are estimated to discharge 7000 million cubic meters of water annually in to the estuarine tracts (Azis & Nair, 1987).

Table No. 1: Details of marine fungi isolated along west coast of India

No.	Locations	No. of marine fungi isolated
1.	Kanyakumari	31
2.	Kerala	106
3.	Mahe	36
4.	Karnataka	35
5.	Goa	47
6.	Maharashtra	45
7.	Gujarat	16

An outstanding feature of the Kerala coast is the presence of a large number of perennial/ temporary estuaries popularly known as the backwater (Kayals). These water bodies which exist in different sizes and shapes have their bed levels at about 1.5 to 1.8m below the mean sea level and remain separated from the sea by a narrow strip of land (Velupillai, 1940). These water bodies are connected by canals offering an important artery for navigation from one end of the state to the other. The entire estuarine system along the Kerala coast is exposed to tides from the sea and hence water is brackish almost throughout the year (Azis & Nair, 1987).

During and after the heavy down pour months of monsoon these rivers carry with them innumerable different varieties of dead-remains of plants and animals which are harboured at different coastal water bodies (such as brackish, backwater, estuaries and inshore waters) comparatively higher than the other states of India. Thus trapped organic matters are degraded by microorganisms especially marine fungi (Gayatri & Raveendran, 2009b). The biodegradation of these organic matters takes place comparatively at a faster rate than other coastal regions of India and makes Kerala coast a fertility rich zone.

The present study clearly supports that Kerala coastal ecosystems are ideal places for the growth and reproduction of marine mycoflora. However, the interaction of these marine fungi with the coastal habitats and supply of essential nutrients to the detrivores is not clearly known (Gayatri & Raveendran, 2012).The southern part of Western Ghats is comparatively rich in biological diversity than the northern part. According to Hawksworth (2001), fungus: plants species ratio is 6:1. Hence, it is possible that the nearness of the Western Ghats to the coastal zone of Kerala might be one of the reasons behind the rich marine fungal diversity along the Kerala coast.

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References

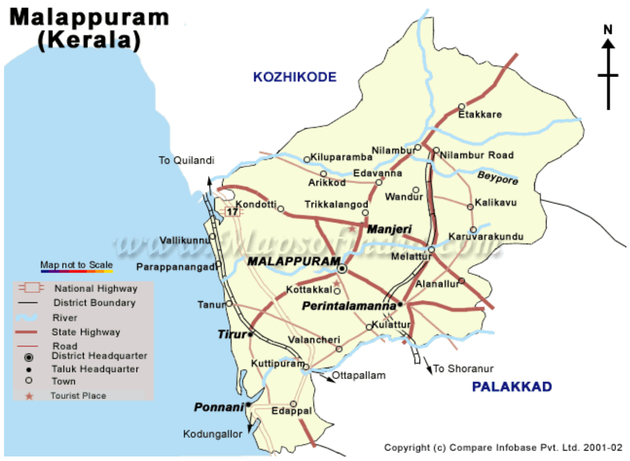
1. **Azis, A.P.K. & Nair, B.N. 1987.** The estuarine scenario of Kerala with reference to the status of aquaculture development. In: The Proceedings of the National Seminar on Estuarine Management (Ed: Balakrishnan Nair, N) Tvm. pp:532-543.
2. **Borse, B.D. 1988.** Frequency of occurrence of marine fungi from Maharashtra coast, India. *Indian J. Mar. Sci.*, 17: 165-167.
3. **Chinnaraj, J. 1992.** Higher marine fungi of Lakshadweep Islands and a note on *Quintaria lignatilies*. *Crypto gamie Mycol.*, 13:312-319.
4. **Gayatri, R. Nambiar & Raveendran, K. 2009a.** Marine mycoflora in backwater ecosystem of Kerala (India). *J. Envt. Biol.*, 30: 30-32.
5. **Gayatri, R. Nambiar & Raveendran, K. 2009b.** Diversity of marine fungi in Kerala water bodies –A divine gift. In: A Compendium of the selected papers of the National Seminar on Land Use Planning for Biodiversity Conservation (Ed: Jose Issac) KSLUB, Tvm. pp: 103-107.
6. **Gayatri. R. Nambiar & Raveendran, K. 2010.** Ecobiodiversity of marine mycoflora of Gulf of Mannar Biosphere Reserve (India), *Ecol, Envt. & Cons.,* 15:739-743.
7. **Gayatri R. Nambiar & Raveendran K., 2011.** *Arenariomyces triseptatus* and *Halosphaeria appendiculata:* Two new record of marine fungi from India. *Geobios* 1:17-19.

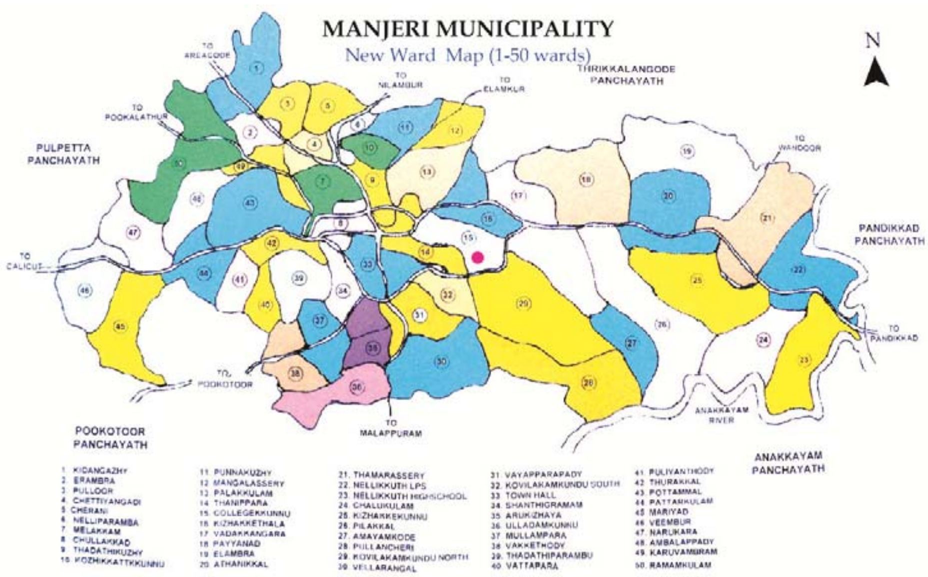
8. **Gayatri R. Nambiar & Raveendran K., 2012.** Floristic expolaration of marine mycoflora of Kerala coastal wetlands (India). In:Biodiversity, Biotechnology and Climatic Change (Eds: Tuwar, A and Shaik, M) Sonai, MS. pp:113-117.
9. **Hawksworth, D.L. 2001.** The magnitude of fungal diversity: the 1.5 million species estimated revisited. *Mycol. Res*. 105: 1422-1432.
10. **Hyde, K.D. & Lee, S.V. 1995.** Ecology of mangrove fungi and their role in nutrient cycling: What gaps occur in our knowledge? *Hydrobiol*., 295:107-118.
11. **Hyde, K.D. & Sarma, V. V. 2000.** Pictorial keys to higher marine fungi. In: *Marine Mycology* – A *Practical Approach* (Eds., Hyde, K.D. and Pointing, S.D.) Fungal Diversity Press, Hong Kong. pp. 205-270.
12. **Jones, E.B.G., Sakayaroj, J., Suetrong, S., Somrithipol, S. & Pang, K.L. 2009.** Classification of Marine Ascomycota, anamorphic taxa and Basidiomycota, *Fungal Diversity*, 35:1-187.
13. **Kohlmeyer, J & Kohlmeyer, E. 1979.** *Marine mycology- The Higher fungi* Academic Press, New York, US.
14. **Kohlmeyer J. & Volkmann-Kohlmeyer, B.1991.** Illustrated key to the filamentous higher marine fungi. *Bot. Mari*., 34: 1 – 61.
15. **Maria, G.L. & Sridhar, K. R. 2002.** Richness and diversity of filamentous fungi on woody litter of mangroves along the west coast of India, *Curr. Sci*., 83: 1573 - 1580.
16. **Maria, G.L. & Sridhar, K.R. 2003.** Diversity of filamentous fungi on woody litter of five mangrove plant species from the south west coast of India. *Fungal Diversity*. 14: 109- 126.
17. **Maria, G.L. & Sridhar, K.R. 2004.** Fungal colonization of immersed wood in mangroves of the southwest coast of India. *Can. J. Bot.,* 82: 1409-1418.
18. **Prasannarai, K. & Sridhar, K.R. 2001.** Diversity and abundance of higher marine fungi on woody substrates along the west coast of India. *Curr. Sci.,* 81: 304-311.
19. **Raghukumar, S. 1978.** Marine lignicolous fungi from India. *Kavaka,* 1:73-85.
20. **Raveendran, K. & Manimohan, P. 2007.** *Marine fungi of Kerala – A Preliminary Floristic and Ecological Study* (Malabar Natural Historical Society, Calicut, Kerala, India).pp 1-270.
21. **Sarma, V.V. & Vittal, B.P.R. 2000.** Biodiversity of marine mangrove fungi on different substrata of *Rhizophora apiculata* and *Avicennia* sp from Godavari and Krishna deltas, east coast of India. *Fungal Diversity*, 5: 23-41.
22. **Sarma, V.V. & Vittal, B.P.R., 2004.** Manglicolous fungi recorded from Godavari and Krishna deltas, A. P., east coast of India along with a dichotomous key and notes on some taxa. *Kavaka.* 32:65-111.
23. **Vellupillai, T.K. 1940.** *The Travancore State Manual* . Vol. 1. Kerala Govt. Press.

about manjeri & malappuram

The **Malappuram district** was formed in 1969 with an area of 3550 sq. km. The capital is at Malappuram. It has a population of 41,10,956 as per the 2011 census report with 19,61,014 males and 21,49,942 females. There are 6 taluks (*Ernad, Nilambur, Tirur, Ponnani, Perinthalmanna* & *Tirurangadi*), 135 villages, 100 Grama Panchayaths and 5 Municipalities in the district. There are five water sheds in the district, viz; *Bharathapuzha, Chaliyar, Kadalundi, Kanjiramukku* and *Tirur*. The college and Manjeri municipality regions come under the *Chaliyar* water shed. Regarding the Lithological peculiarities there are around eight different types of rock formations in the district such as *Biotite- Hornblende Gneiss, Hornblende Gneiss, Pink granite Gneiss, Charnokite, Foliated Granite, Laterite, Pebble bed,* and *Coastal sand & alluvium*. At Manjeri basically *Charnokite* rocks with a few laterite are found. Similarly, there are around thirteen land forms in Malappuram district, but in Manjeri only Lower latitude plateau and Valley plateau are found.

The **Manjeri Municipality** was formed on 1st April 1978. It is situated in the Ernad taluk and has an area of 53.06 sq. km with a population of 97,112 (2011 census). There are three villages in the Municipality (*Manjeri, Payyanad* and *Narukara*) and 50 wards. The NSS College Campus falls under ward 15 (College Kunnu).





about the college

The college is located in the **College Kunnu Ward** (Ward -15) of the Manjeri Municipality. The area lies in 11^0 07′ 10′′ North latitude and 76^0 07′ 71′′ East longitude. The altitude is about 138 m above msl. The terrain is laterite rocky. The characteristically hilly and undulating land is having an expanse of nearly 60 acres. The vegetation is a degraded moist-deciduous one. It was a barren hill at the time of inception of the college. Now the area plentiful trees planted by the nature clubs and other student community during the last three decades. There is a cashew plantation on the south-eastern side of the campus.

The vegetation is mainly secondary. Species *like Olea dioica, Aporosa cardiosperma, Mallotus phillipensis, Strychnos nux-vomica, Syzygium cumini, Ficus amplissima, F. tsjahela, F. mysoorensis, F. benghalensis, F. religiosa, Pongamia glabra, Tectona grandis, Mangifera indica, Peltophorum ferrugineum, Holigarna arnottiana*, *Briedelia retusa*, *Anacardium occidentale, Altsonia scholaris, Terminalia catappa, T. paniculata, T. cuneata, T. arjuna, Delonix regia, Alstonia scholaris* etc. represent the major tree species. Some scrub vegetation is also growing well in the area. The presence of tree species attracted in recent years a good troupe of *Bonnet Macaques* in the campus, besides several bird species including a few migrants like *Golden Oriole, Paradise Flycatcher, Green Pigeon* etc. A good number of butterfly species were found loitering in the habitat from September through February months visiting flowering plants.

There is a small pond on eastern slope of the land separated from the main college campus by private holding in between. It is the main water source of the college and is protected by laterite stone boundary on all sides. There are rubber plantations on the north-eastern slope and a cashew plantation on the south-eastern side. There are moderately wooded lands on the eastern and southern boundaries of the campus which are private holdings. The All India Radio – Manjeri FM station is situated on the south-eastern boundary of the campus.






programme schedule

VENUE: COLLEGE AUDITORIUM

THURSDAY, 14th FEBRUARY 2013

Registration: 09.00 am – 09.30 am

INAUGURAL SESSION: 09.30 am – 10.45 am

Prayer : Students

Welcome address
Dr. Balakrishnan Panayanthatta
Assistant Professor & Head,
Department of Botany, NSS College, Manjeri

Presidential Address
Dr. Vijayakumar T.N.
Principal, NSS College, Manjeri

Inaugural address
Prof. Sobindran. T.
Indira Priyadarshini National Vriksha Mitra Award winner;
Former HOD of Economics Dept.,
Zamorin's Guruvayurappan College, Calicut.

Release of Abstract
Dr. Prakash Kumar R.
Managing Director, Malabar Botanical Garden, Kozhikode;
Joint Director & Head, Science and Technology
Promotion Division, KSCSTE, Trivandrum.

Keynote address
Dr. Sankar S.
Former Scientist, Kerala Forest Research Institute, Peechi.

Felicitations
Sri. Sethumadhavan Nair P.K.
Chairman, College Development Committee
Dr. Sreekanthan K.N.
Convenor, IQAC
Sri. Ameer Suhail V.
College Union Chairman

Vote of Thanks
Dr. Kishore Kumar K.
(Convenor), Assistant Professor in Botany

Tea break: 10.45 am – 11.00 am

VENUE: COLLEGE AUDITORIUM

THURSDAY, 14th FEBRUARY 2013

ACADEMIC SESSIONS:

SESSION 1 11.00 am – 11.45 am
Invited Lecture

Origin & Biogeography of Western Ghats
Sri. Radhakrishnan C.
Former Addl. Director, Zoological Survey of India (ZSI),
Western Ghats Regional Centre, Kozhikode, Kerala

SESSION 2 11.50am – 12.35 pm
Invited Lecture

Vegetation types and Phytogeography of Western Ghats
Dr. Karunakaran P.V.
Principal Scientist, Salim Ali Centre for Ornithology & Natural History (SACON), Coimbatore, Tamil Nadu

Lunch break: 12.45 pm – 01.15 pm

SESSION 3 01.15 pm – 02.00pm
Invited Lecture

Higher Plant Diversity of Western Ghats
Dr. Sasidharan N.
Dr. B.P. Pal fellow; Former Scientist,
Kerala Forest Research Institute (KFRI), Peechi.

SESSION 4 02.00 pm – 02.45 pm
Invited Lecture

Conservation of the Western Ghats: WGEEP Report and the issues
Dr. Vijayan V.S.
Former Chairman, Kerala State Biodiversity Board;
Former Director, SACON, Coimbatore;
Member, Madhav Gadgil Committee

Tea break: 2.45 pm – 03.00 pm

SESSION 5 03.30 pm – 4.30 pm
Paper presentations
By registered participants

programme schedule

FRIDAY, 15th FEBRUARY 2013

ACADEMIC SESSIONS:

SESSION 1 09.30 am – 10.15 am
Invited Lecture

Invertebrate Diversity of Western Ghats
Dr. Rajmohana K.
Scientist, Zoological Survey of India (ZSI),
Western Ghats Regional Centre, Kozhikode, Kerala

SESSION 2 10. 15 am – 11.00 am
Invited Lecture

Vertebrate Diversity of Western Ghats
Dr. Mohammed Jafer Palot
Assistant Zoologist, Zoological Survey of India (ZSI),
Western Ghats Regional Centre, Kozhikode, Kerala

Tea break: 11.00 am - 11.15 am

SESSION 3 11. 15 am – 11.50 am
Invited Lecture

Bryophyte diversity of Western Ghats
Dr. Manju C. Nair
Assistant Professor, Department of Botany,
The Zamorin's Guruvayurappan College, Calicut

SESSION 4 11.50 am – 12.30 pm
Invited Lecture

Pteridophyte Diversity of Western Ghats
Prof. (Dr.) Madhusoodanan P.V.
Emeritus Scientist, Malabar Botanical Garden, Kozhikode,
Former HOD, Department of Botany, University of Calicut

Lunch break: 12.30 pm – 01.15 pm

SESSION 5 1.15 pm – 1.45 pm
Invited Lecture

Tribal Diversity of the Western Ghats and Conservation of Traditional Knowledge System
Dr. Bindu S.
Director, KIRTADS, Kozhikode

SESSION 6 01.45 pm – 04.00 pm

Paper presentations
By registered participants

programme schedule

SATURDAY, 16th FEBRUARY 2013

ACADEMIC SESSION 09.30 am – 10.15 am

Paper presentations
By registered participants

Tea break: 10.15 am – 10.30 am

VALEDICTORY SESSION 10.30 am – 11.30 am

Welcome address
Dr. Balakrishnan Panayanthatta
Assistant Professor & Head, Department of Botany

Presidential address
Dr. Vijayakumar T.N.
Principal, NSS College, Manjeri

Guest of honours
Prof. Prasad M.K.
Former Pro-Vice-Chancellor, University of Calicut;
Former President, Kerala Sasthra Sahitya Parishath;
Member of the Board of the Millennium Ecosystem Assessment

Prof. Pappootty K.
Former HOD of Physics, Govt. College, Madappally,
Former President, Kerala Sasthra Sahitya Parishath;
Former Director, Institute of Encyclopaedia Publications;
Editor, Eureka Science Fortnightly of KSSP.

Vote of thanks
Dr. Kishore Kumar K.
(Convenor), Assistant Professor in Botany

National Anthem

FIELD TRIP
To Nilambur parts of Western Ghats
11.30 am – 05.30 pm

- **Connolly's Teak Plantations**
- **KFRI Teak Museum**
- **Nedumkayam**

photo album