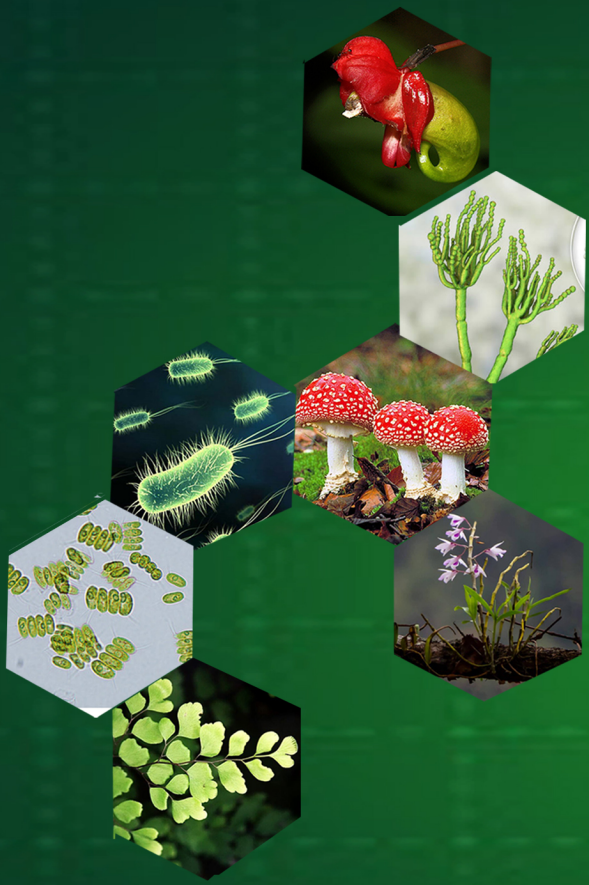
Proceedings of the National Seminar
Species The Passion 7



St. Thomas College (Autonomous), Thrissur

Proceedings of the National Seminar

"Species The Passion 7"

Editor–in–Chief

Dr. Anto P.V.
Assistant Professor
Convenor – "Species the Passion 7"

Editors

Ms. Afsana Khan
Ms. Keerthana Nandakumar
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Ms. Reshma Ashok

Organized by

Research and Post-Graduate Department of Botany
St. Thomas College (Autonomous), Thrissur

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FOREWORD

The Research and Post-Graduate Department of Botany has organized a National Seminar "Species The Passion 7" on the 9th of March 2022 at Menachery Hall, St. Thomas College (Autonomous), Thrissur. "Species The Passion", an annual event that has been organized for the last seven years, is an academic platform for young researchers and senior researchers alike, for telling stories of new species discoveries. Creating knowledge and disseminating it through the scientific community is the aim of this event. This seminar series with invited lectures from eminent researchers and its new findings along with the presentation is helpful to gather the knowledge among the future generations of science.

I have great pleasure in presenting the proceedings of "Species The Passion 7" to the scientific community. The seminar proceedings compile invited lectures and original articles of paper presentations. I acknowledge St. Thomas College (Autonomous),Thrissur for the support and facilities. I appreciate all the authors for sharing their original research articles with all and I express my sincere gratitude to all well-wishers who made the effort to make this event a great success. I hope everyone will utilize this opportunity to grow with science.

Dr. Anto P.V

(Assistant Professor)

Convenor & Editor–in–Chief

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Syzygium travancoricum Gamble, an endangered endemic species of Southern Western Ghats

Smitha P.S.[1] and Anto P.V.[2]

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Abstract

The genus *Syzygium* (Myrtaceae) is the largest genus of flowering plants across the world, comprising 1200-1800 species. The greatest diversity occurs in Australia and Southeast Asia. In India, the genus *Syzygium* consists of 102 species, among which 44 species are endemics. The Southern Western Ghats have the greatest diversity of species and endemism, which accounts to 54 species, among which 28 species are endemic. *Syzygium travancoricum* Gamble locally known as '*Poriyal*', '*Vathamkollimaram*', '*Kulirmavu*' or '*Kollignaval*', is one such endemic, endangered indigenous tree species found confined to the Southern Western Ghats, India. Due to its limited population size, this tree species is designated as "Critically Endangered" on the Red List of Threatened Species (IUCN 2010, 2013). The species has a unique habitat preference and hence they are only found in humid rainfed areas, such as myristica swamps and river banks of evergreen, semi-evergreen forests and a few sacred groves located in the districts of Thiruvananthapuram, Kollam, Thrissur, Kannur, Wayanad and Karnataka district of Uttara Kannada. A total of 465 individuals are recorded so far from the Southern Western Ghats, among which a maximum number of individuals are reported from Kalasamala Biodiversity Heritage site, in the Kalasamala hillocks, Thrissur. The species is reported to have immense medicinal potential and is a rich source of essential oil. However, the plant population is facing severe threats due to habitat destruction, poor seed germination potential, inferior germplasm, high rate of outbreeding, habitat specificity and climate change. An in-depth investigation on the core features pertaining to the distribution, habitat, morphology, phenology and significance of the species is pivotal for designing and

implementing the conservation strategies. Hence the present study attempts to summarize the biodiversity and distribution, phenology, species association, ecological significance, conservation strategies and bioprospecting of *S. travancoricum* Gamble.

Key Words: *Syzygium travancoricum*, Biodiversity, Myristica swamp, Endangered, Endemic

Introduction

The Western Ghats, which influence the ecology and biogeography of Peninsular India, have more than 3500 flowering plants of which about 1500 are endemics (Gopalan and Henry, 2000). Most of the endemic flora of Western Ghats are rare, facing threat from species extinction. As Volga *et al.* (2013) reported, the endemic plants of Western Ghats are on the verge of extinction because, more than a thousand species have highly uneven and scattered populations. The chances of survival of endemic trees at Western Ghats are very low at present, though small patches are available at remote pockets. These rare and endemic trees deserve special conservation strategies due to their restricted distribution.

The genus *Syzygium* (Myrtaceae) is native to the tropics, particularly to Australia and tropical America (Raju *et al.*, 2014). It has a universal, although very irregular, distribution in tropical and subtropical areas. It is recorded from many countries including Australia, South Africa, South America, and South-East Asia (Chantaranothai and Parnell, 1994). Hyland (1983) reported that *Syzygium* are extensively distributed, in Africa, mainland Asia, Malaysia, New Zealand, the western Pacific, and Australia. According to Raju *et al.* (2014) and Shareef *et al.* (2014), the genus contains about 1,100 species, and has a native range that spreads from Africa and Madagascar through southern Asia and tothe east through the Pacific. According to Parnell *et al.* (2007), the *Syzygium* genus encompasses more than 1200 species scattered mostly in the tropics from Africa to the West Pacific with a major concentration in Malaysia. The most interesting fact about the genus is that many of the species coming under the genus are very poorly known to the world and a lot of them have not been taxonomically described yet.

In India, the Western Ghats has the highest concentration of the genus (Govaerts *et al.*, 2008), of which 44 taxa are endemic. Latest taxonomic investigations about the genus revealed that 39 taxa occur in the Western Ghats of Kerala (Nair and Mohanan,

1981; Nayar *et al.*, 2006), among which, 17 are endemic to Western Ghats. However, a very recent taxonomic enumeration of the genus revealed that 43 taxa in Kerala state alone, including four exotics. (Nayar *et al.* 2006; Shareef *et al.*, 2012). The Southern Western Ghats have the greatest diversity of species and endemism, in the genus *Syzygium* which accounts to 54 species, among which 28 species are endemic. Most of the species of this genus are seen in the evergreen forests of Kerala, some of them are in the shola forests and some species like *S. travancoricum* are seen in the sacred groves (Thomas *et al.*, 2014). Just like the other parts of the world, a wide range of new *Syzygium* species are identified day by day in the Western Ghats also. Some of the recent additions to the checklist are *S. sasidharani* (Sujanapal *et al.*, 2013), *S. munnarensis* (Shareef *et al.*,2014), *S. dhaneshiana* (Narayanan *et al.*, 2014) and *S. sahyadricum* (Sujanapal *et al.*, 2014). An extensive collection of *Syzygium* species is there in the Western Ghats which are yet to be identified by the taxonomists.

Syzygium travancoricum (Gamble) also known as Kulavetti or Vathamkolli is a critically endangered endemic tree species belonging to the family Myrtaceae. It is endemic to the South Western Ghats, India. According to IUCN Red list 2010, 2012 and 2013, only 200 trees are found in Western Ghats (Roby *et al.*; 2013). A repository of *S. travancoricum* is located at Kalasamala, Thrissur district which has been considered as one among the five biodiversity heritage sites in Kerala. Habitat destruction due to human activity is the major threat to *S. travancoricum*. Traditionally this species has been used for curing diabetes and arthritis by local people. The species is also well known for its astringent, hypoglycemic, bactericidal, antifungal and neuro-psychopharmacological effects. It is also a source of essential oil. Despite its medicinal potential, there is a dearth of literature regarding the characterization of *S. travancoricum*. Moreover, an exhaustive study about the species may overcome the taxonomic disputes existing between *S. travancoricum* and its related species as well.

Biodiversity and distribution

Syzygium travancoricum was first discovered in the swampy lowlands of Travancore. It is present in the evergreen, semi-evergreen forests and a few scared groves in Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha and Thrissur districts (Sasidharan, 2006). The species has also been reported from freshwater Myristica swamps of Southern Kerala and Uttar Kannada district of

Karnataka. Myristica swamps of Kulathupuzha region is located in Southern Kerala between the geo co-ordinates 8.75° to 9.0° N and 76.75° to 77.25° E. The swamps are scattered in three forest ranges namely Kulathupuzha, Anchal forest ranges, and Shendurney Wildlife Sanctuary. *S. travancoricum* are mostly found in Myristica swamps, other swampy areas and river banks of Southern Kerala. Thiruvananthapuram and Punalur Forest Division showed maximum potential area of Myristica swamps (Fig. 1). Other than Myristica swamps, many populations were also identified in a few sacred groves of Thrissur and Kannur districts. A total of 465 trees have been recorded in Kerala among which a remarkable proportion occurs in Kalassamala sacred grove, Thrissur, followed by Thiruvananthapuram, Kollam and Kannur districts. In the state of Karnataka a total of 36 trees have been reported, of which 35 trees occur in the Myristica swamps of Siddhapur taluk and a single tree occurs in Ankola taluk.

Morphology

S. travancoricum is a medium to large evergreen tree of about 25 m height, with a greyish-brown bark surface which is longitudinally fissured and peeling off in thin irregular flakes (Fig.2.) The leaves are simple, opposite and estipulate with thepetiole having a length of 10-20 mm long. The lamina is glabrous, ovate or ovate-oblongwith a narrow base. The apex of the leaf is acuminate, obtuse, and the margin is entire. The leaves have lateral nerves in 10-20 pairs, parallel but very irregularly looped near the margin forming indistinct intra-marginal nerves. The leaves also have a characteristic odour. Flowers of the species are bisexual, white, mostly in axillary cymose or corymbose inflorescence. The petals are white, and the stamens numerous and free. The ovary is inferior of 2-celled with many ovules. Fruit is a berry, oblong-obtuse on both sides having a deep violet colour with juicy pericarp and single seed.

Phenology

Syzygium travancoricum, being an evergreen species, the leaf shedding and flushing processes could not be identified clearly and separately. Leaf fall and flushing continued throughout the year. The habit of large-scale leaf shedding was evolved as a mechanism to overcome adverse conditions. In the case of deciduous species, the process is strictly followed because they have to reduce transpiration during summer months. Gopakumar (1995) and Saju (2000) have also reported leaf fall during the arid months or just after the rainfall in many deciduous tree species. *S. travancoricum* is not

only an evergreen tree but a species growing in waterlogged conditions or near water bodies. So, the species is least affected by the unavailability of sufficient water. Therefore, *S. travancoricum* does not follow the pattern of leaf shedding as in other deciduous trees and that is reason for the delayed start of leaf shedding in January followed by flushing in mid-February.

The flowering time was also found to be different among the trees in different populations.The flowering in tropical tree species is generally influenced by moisture stress and many tropical trees have been reported to flower after the dry season (Saju, 2000). In evergreen species there occurs a synchronization of flowering with dry season as trees are said to flower during stress period (Richards,1952). In *S. travancoricum*, the flowering was observed in the beginning of April and may extend until the end of May.

Variations were found with respect to the flowering phenology of *S. travancoricum.* The same species occurring at different populations showed changes in the pattern of phenological events. Troup and Bor (2009) reported that the seasonal patterns of flowering and fruiting can be different in the same species if the species is standing in different populations. Also, Thakur (2013) stated that there were variations in the phenological events of *Artocarpus hirsutus* growing in two different altitudinal zones. The observed species of *S. travancoricum* also showed variations in flowering patterns between the different populations. Rathke and Lacey (1985) had correlated a number of abiotic factors with flowering time like seasonal availability of conditions favourable for pollen transfer, availability of pollinators, competitive effects on seed set. The above-mentioned reason might have contributed for variations in the flowering period. The factors related to the site, such as temperature and rainfall also can impact the phenology of a species (Clelan*det al.*, 2006). Sarvas (1962), found that, temperature is the most important parameter which determine the late or early occurrence of a phenological event. In the presentstudy also, change in temperature can be a reason for the variation in flowering phenology. Variability with respect to the fruiting response was also found between the populations of the species. In majority of evergreen species, fruit ripening is observed close to the onset of rainy season in order to enhance dispersal, escape predation, and avoid pathogen infection (Prasad and Raveendran, 2012). In *S. travancoricum*, flowering was followed by fruiting and continued till the end of June.

Species Association

The species which are growing in association with the *Syzygium travancoricum* trees at both of the populations were subjected to detailed examination. In the population at Kalasamala, the *S. travancoricum* was found associated with many members of Myristicaceae such as *Myristica fatua, Gymnacranthera farquhariana, Myristica malabarica*.

Population Threats

A major threat faced by *S. travancoricum* trees is habitat loss as most of the swampy wetland habitats are widely drained and converted into paddy fields (Faisal *et al.*, 2014). Another threat the tree as reported by the IUCN is the very poor natural regeneration of the seeds. Other threats like inferior germplasm, high rate of outbreeding and habitat specificity, are other factors which accounts for shrinking population.

Ecological significance

Ramesh *et al.* (1991) considered Myristica swamps as unique areas at the ecosystem level and pointed out that though species poor, most species found in and around the swamps are endemics. *S. travancoricum* is a tree species having a unique habitat preference which only occurs in rain fed areas such as sacred groves, myristica swamps and river sides. *S. travancoricum* is not only an evergreen tree but a species growing in waterlogged conditions or near water bodies. So, the species is least affected by the unavailability of sufficient water. These habitats are of much ecological significance as they represent the natural conservatories of water. Hence conservation strategies to protect *S. travancoricum* would definitely help to restore such fragile ecosystems in the Southern Western Ghats.

Bioprospecting

S. travancoricum is rich in essential oil which makes it a promising candidate for pharmaceutical industries. Moreover, the plant has been reported to have antidiabetic, antimicrobial and anti-inflammatory potential. Hence there is wide scope for futuristic research in natural drug discovery to treat several ailments.

Conservation Strategies

S. travancoricum is an important tree species that helps to restore the ecosystem through its specially designed root system capable of resisting floods and recharge the aquifers as well. Hence urgent measures to conserve this ecologically important plant species is a need of the hour. Both *in vivo* and *in vitro* methods of conservation are effective for expanding the population size. In situ conservation of *S. travancoricum* can be practiced using cuttings, layering and seedling propagation. Rapid multiplication through shoot buds and axillary buds are also effective strategies for large scale propagation and restoration of this plant species.

Conclusion

Syzygium travancoricum (Gamble) is a critically endangered tree endemic to the South Western Ghats, India. According to IUCN Red list 2010, 2012, and 2013, only less than 500 trees are reported from Southern Western Ghats. The species has a unique habitat preference and hence they are only found in humid rainfed areas, such as *myristica swamps* and river banks of evergreen, semi-evergreen forests and a few sacred groves located in the districts of Thiruvananthapuram, Kollam, Thrissur, Kannur, Wayanad and Karnataka district of Uttara Kannada. The species is reported to have immense medicinal potential and is a rich source of essential oil which demands future research on its bioprospecting. However, the plant population is facing severe threats due to habitat destruction, poor seed germination potential, inferior germplasm, high rate of outbreeding, habitat specificity and climate change. Hence an in-depth investigation pertaining to the distribution, habitat, morphology, phenology and significance of the species is pivotal for designing and implementing the conservation strategies and thereby restoring these pristine ecological niches.

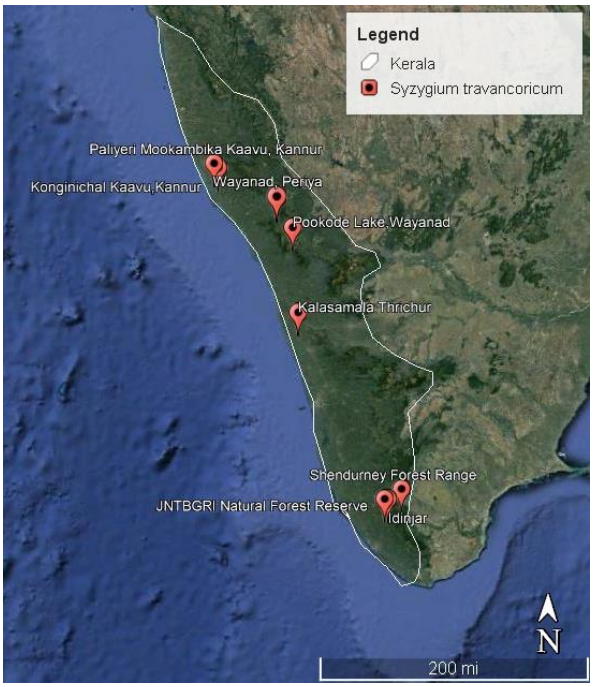

Fig.1. Distribution Map of *S. travancoricum* in Kerala

Fig. 2. Habit

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Diversity of the genus *Nostoc* (Cyanobacterium) from the forests of Palakkad District,Kerala

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Abstract

Cyanobacteria are oxygen producing prokaryotic organisms and are one of the important nitrogen fixators. This study is focused on the diversity of cyanobacteria in the forest regions of Palakkad District. Palakkad District lies alongside Thrissur and Malappuram Districts of Kerala and shares a border with the state of Tamil Nadu. Study area consists of a wide diversity of forests, hill stations, Ghats, reservoirs and other water bodies. Survey was conducted during 2018 to 2020 and a total of 32 cyanobacterial species were reported. Among them seven species were coming under the genus *Nostoc*. The identified cyanobacteria include members from *Microcystis*, *Chroococcus*, *Gloeocapsa*, *Gloeothece*, *Aphanocapsa*, *Aphanothece*, *Lyngbya*, *Nostoc*, *Calothrix*, *Rivularia*, *Scytonema*, *Tolypothrix* and *Westiellopsis*.

Key words: Heterocystous, Unicellular, Non-heterocystous, *Nostoc*

Introduction

Cyanobacteria are photosynthetic prokaryotic organisms commonly found in wet habitats. They are considered as the connecting link between prokaryotes and eukaryotes and are capable of fixing atmospheric nitrogen. Cyanobacteria are small, unicellular forms or filamentous often seen as colonies. The exact time of appearance of cyanobacteria on earth is still not clear. However, as per the current evidences, it is believed that their present diversity has been achieved more than 3.5 billion years ago. Mainly they occur in 3 different forms; unicellular, unbranched filamentous and branched filamentous. Unbranched filamentous are of two types, non heterocystous

and heterocystous. Branched filamentous forms are also of two types, false branched filamentous and true branched filamentous. Among the cyanobacteria, genus *Nostoc* is considered as the most relevant in availability, economic importance and mass multiplication. Cyanobacterial diversity is considered as an indicator of the strength of an ecosystem. High diversity of cyanobacteria illustrate the richness of that environment.

Materials and Methods

STUDY AREA

Palakkad, known as the "Rice bowl of Kerala", is the largest District of Kerala. Palakkad is bordered on the North-West by Malappuram District, South-West by Thrissur District and North-East and East by Nilgiri and Coimbatore Districts of Tamil Nadu respectively. Palakkad District covers a total area of 4480 km^2, out of which 1360 km^2 is occupied by forest. Hilly, highland and Ghats regions provide wide range of diversity to this District. These forests are mainly rain forest, evergreen forest, shola forest and semi deciduous forest. More than 10 major dams are situated in Palakkad District. Palakkad is one of the least explored area on cyanobacterial diversity.

SAMPLING

With permission from the forest authorities, samples were collected from forest regions including hill stations, Ghats, dam sites, etc. Samples were collected during the period of 2018-2020. Sites were chosen on the basis of the visual appearance of cyanobacterial mass on these areas. Samples were collected from soil, rock, bark of trees and also from water bodies and streams (Fig 1: A-F).

COLLECTION METHODS

Specimens were collected in collection bottles using scalpels, needle and spatula. Each specimen was provided with a voucher number. Collected samples were cleaned using distilled water, cultured in BG-11 medium (Rippka *et al.,* 1979) and deposited in germplasm collection of cyanobacteria at Department of Botany, University of Calicut. The collected specimens were examined using Leica DM 1000 compound microscope and microphotographs of each were taken. Photographed specimens were identified by using standard taxonomic manuals of Komarek & Anagnostidis (2008), Desikachary (1959) and Anand (1989).

Result and Discussion

A total of seven species belonging to the genera of *Nostoc* were collected from the forest regions of Palakkad District, Kerala. A brief description and characteristic features of each specimen is presented and they are shown in figure 1.

TAXONOMIC ENUMERATION

Order: **Nostocales**

Family: **Nostocaceae**

1. ***Nostoc calcicola*** Brebisson ex Bornet et Flahault

Colonies irregular, flat, gelatinous, dirt olive green to brownish green colour, rarely yellowish green; filaments long, flexuous, irregularly curved; cells barrel shaped, isodiametric or almost spherical, green, pale green or blue green colour, 2.5-4 µm wide, 2.5-4.5 µm long; heterocysts spherical, terminal or intercalary, slightly larger than vegetative cells, 4-6 µm diameter; sheath usually absent; granular content greenish, occasionally prominent.

Habitat: Epilithic, *Locality:* Nelliyampathy. (Fig 1: G)

2. ***Nostoc spongiaeforme*** Agardh ex Bornet et Flahault

Colonies large, initially spherical, later irregular, gelatinous, inside mucilaginous, forms mat like structures; trichomes long, flexuous, loosely entangled, constricted at the cross walls; cells barrel shaped or cylindrical, very rarely isodiametric; brownish green colour, 4-6 µm wide, 5-12.5 µm long; heterocysts oval or elongated, terminal and intercalary, larger than vegetative cells, olive green colour, 5-7.5 µm wide, 8-14 µm long; sheaths not observed; brownish granular content, sometimes prominent; aerotopes occasionally present.

Habitat: Epilithic and epiphytic, *Locality:* Siruvani. (Fig 1: I)

3. ***Nostoc paludosum*** Kutzing ex Bornet et Flahault

Blue green or brownish green colour, long, densely entangled; cells spherical or barrel shaped, sometimes isodiametric, in some parts of trichome cells become cylindrical, 4-6.5 µm wide, 5-8 µm long; apical cells cylindrical and rounded; heterocysts spherical or barrel shaped, sometimes slightly elongated, always slightly larger than vegetative cells, terminal and intercalary in position, 4-9 µm diameter; sheaths

occasionally present, thin, hyaline, colourless, unlamellate; granular contents fine, may or may not prominent; aerotopes sometimes present.

Habitat: Epilithic and epactiphytic, *Locality:* Nelliyampathy. (Fig 1: H)

***4. Nostoc punctiforme* (Kutz) Hariot.**

Cells loosely arranged and cell constriction prominent. Heterocyst intercalary and larger thanvegetative cells. Heterocyst spherical to hemispherical. Trichome 3.4-3.6 µm long and 2.2-2.5 µm broad. Heterocyst 4.4-4.6 µm long and 3.75-3.87 µm broad.

Habitat: Epilithic, *Locality:* Nelliyampathy (Fig 1: J)

5. Nostoc pruniforme Agardh ex Bornet et Flahault

Colonies spherical, oval or ovoid, inside mucilage is soft, olive green or brownish green colour; trichomes long variously curved, aggregated, blue green colour; cells spherical or compressed barrel shaped, occasionally isodiametric, 4-6 µm wide, 4-7 µm long, blue green colour; heterocysts spherical, larger than vegetative cells, terminal or intercalary, 6-9.5 µm diameter; sheaths thin to thick, brownish yellow colour, irregularly lamellated; granules present, not prominent.

Habitat: Epipelic and epilithic, *Locality:* Seetharkund. (Fig 1: K)

6. Nostoc commune Vaucher ex Bornet et Flahault

Colonies macroscopic, gelatinous, ball like structures, olive green, golden yellow, yellowish brown or dark brown colour, periderm firm; filaments flexuous, densely entangled, variously coloured; cells spherical or shortly barrel shaped, pale green or olive green colour, 3-7 µm long, 4-6 µm wide; heterocysts almost spherical, terminal or intercalary, rarely few in rows, 5-9 µm diameter; sheath firm, hyaline, colourless to yellowish brown colour, sometimes slightly or highly lamellated, occasionally constricted; granular contents fine, sometimes prominent.

Habitat: Edaphic and epactiphytic, *Locality:* Parambikulam. (Fig 1: L)

7. Nostoc carneum Agardh ex Bornet et Flahault

Colonies spherical lobate or irregularly clustering, gelatinous, attached to substrates, sometimes submersed, later floating free, olive green, greyish blue green, or brownish colour; filaments long, flexuous, irregularly curved, freely entangled; trichomes

constricted at the cross walls; cells almost isodiametric, usually barrel shaped, rarely spherical or cylindrical, 5-6.5 µm wide, 6-8.5 µm long, brownish green colour; heterocysts barrel shaped, 7-10 µm diameter, yellowish colour; sheaths unclear, colourless; granules present, occasionally prominent.
Habitat: Epilithic, *Locality:* Silent valley. (Fig 1: M)

Forest regions of Palakkad District are very rich in cyanobacterial diversity. Due to forest permission issues, we were not able to explore the core forest areas. But with limited aspects, 30 species of cyanobacteria from 6 families were recorded. Only a single exploration work has been reported from forest regions of Palakkad District. Manu *et al.,* (2016) reported 15 species of cyanobacteria coming under 4 families from Nelliyampathy Ghats, Pothundi dam and nearby areas. Since these microscopic organisms are highly promising, the need of more cyanobacterial explorations from forest regions of Palakkad District is essential. There are more cyanobacterial taxa waiting for their discovery and with no doubt, we will get many newer members to cyanobacterial community.

Conclusion

The present study aims to provide an authentic data of cyanobacterial diversity from forest regions of Plakkad District. By selecting least studied area, we report a total of 32 species among which 18 species of cyanobacteria are newly reported from forest regions of Palakkad District. Unicellular cyanobacteria show more representation with respect to unbranched filamentous type and branched filamentous type. But, wide range of diversity observed in the genus *Nostoc*.

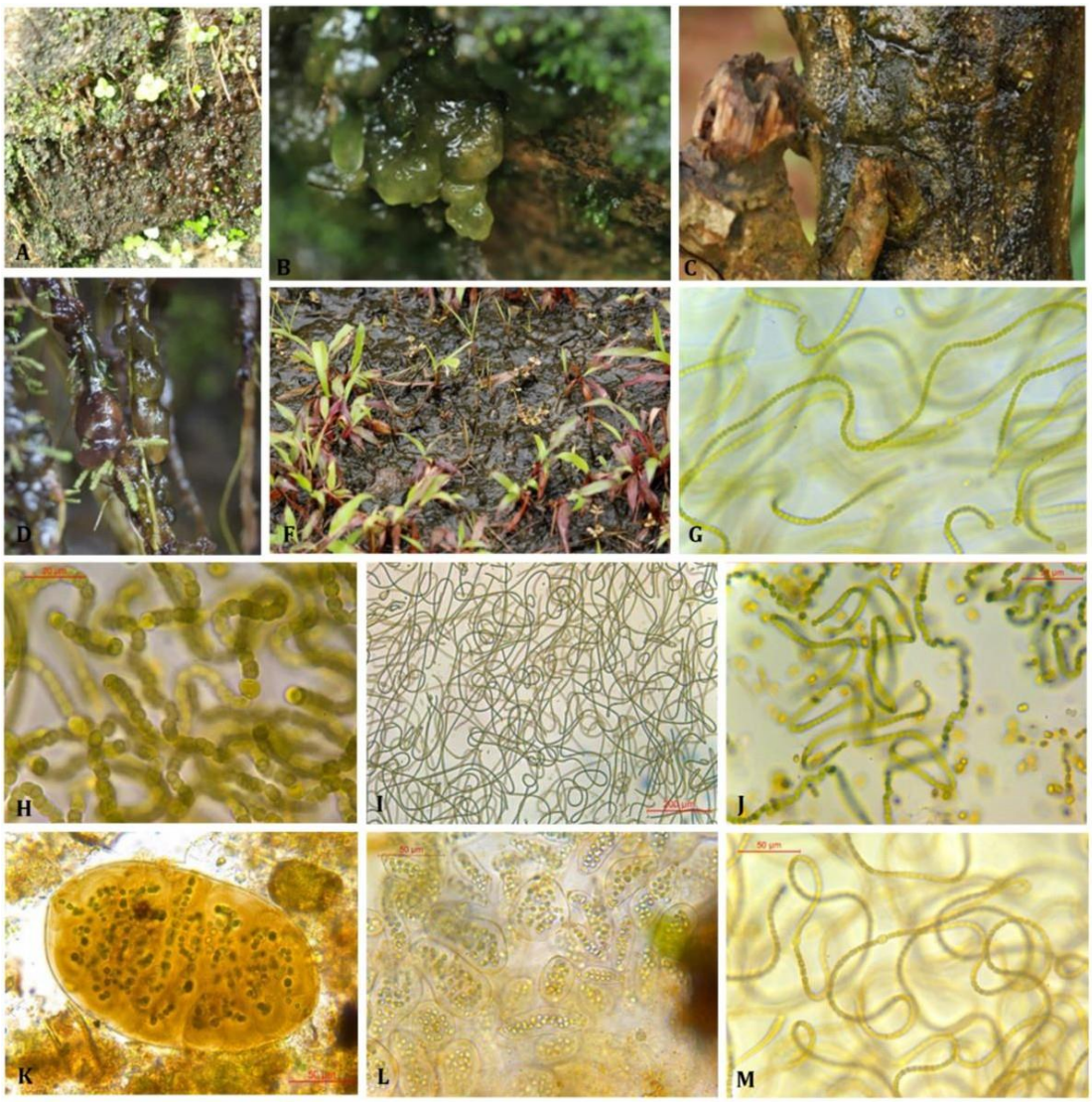

FIG. 1: A-F. Habitat **G.** *Nostoc calicicola* **H.** *N. paludosum* **I.** *N. spongiaeforme* **J.** *N. punctiforme* **K.** *N. pruniforme* **L.** *N. commune* **M.** *N. carneum*

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The genus *Oryza* and its cultivated species

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Among the cereals cultivated in the world, rice is known as the cereal of Asia since it provides the carbohydrate part of the diet of the majority of Asiatic people. As a result, rice has been grown and nurtured in almost all parts of Asia and the crop has become an integral part of the life, livelihood, culture and civilization of the people inhabiting this part of the world. Indians consume rice almost everywhere in the country and the crop has got conserved, diversified and improved through their activities from time to time.

Rice is the most important cereal staple food in the world, with more than half ofthe world's population eating it (Zhou *et al.*, 2002; Malik *et al.*, 2008; Zhu *et al.*, 2010; Surekha *et al.*, 2016). Rice, along with wheat and maize, is considered one of the world'sthree major food crops (Singh, 2018). Around 90% of the world's rice is produced and consumed in Asia, with the remaining 5% produced and consumed in America, 3% in Africa, and 1% each in Europe and Oceania (IRRI, 2006; Paranthaman *et al.*, 2009; Areum *et al.*, 2015). It supplies 35-60% of the nutritional calories consumed by approximately 3 billion individuals (Confalonieri and Bocchi, 2005; Fageria, 2007; Wang *et al.*, 2016). Rice is a self-pollinated (Oka, 1988), monocot semi-aquatic plant (Gupta and Guhey, 2011) largely cultivated in most of the tropical, subtropical and mediterranean regions having characteristically warm and humid climatic conditions (Singh, 2018).

Taxonomy of rice

Rice belongs to the Kingdom Plantae, Subkingdom Tracheobionta, Superdivision Spermatophyta, Division Magnoliophyta, Class Lilliopsida, Subclass Commelinidae, Order Cyperales, Family Poaceae, Subfamily Oryzoideae, Tribe Oryzeae, and Genus *Oryza* L. There are 25 recognised species in the genus *Oryza*, 23 of which are wild and weedy, and two of which are cultivated. The two farmed species are Asian rice (*Oryza sativa* L., 2n=24=AA) and African rice (*Oryza glaberrima*

Steud., 2n=24=AA). Asian rice is grown in practically all of the world's rice-growing regions, including Asia, North and South America, Europe, the Middle Eastern and Africa, while African rice is grown in western tropical Africa (Morishima, 1984; Vaughan 1994; Linares, 2002; Brar andKhush, 2003; Singh *et al.*, 2018; Ansari *et al.*, 2015).

Table 1. Characteristic differences between Asian and African cultivated rice (Roschevicz, 1931; Chatterjee, 1948; Sampath, 1962; Tateoka, 1963a; Nayar, 1973).

Traits	*O. sativa*	*O. glaberrima*
Habit	Annual, but can be perennated	Annual
Seedling vigour	Normal	High
Tillering capacity	Normal	High
Lodging	Less	More
Drought resistance	Normal	High
Flood resistance	Low	High
Ligule length (mm)	14-45	6-13
Spikelet morphology	Rough with short thorny hairs	Small tubercles on surface, generally glabrous
Primary branches	12.2–12.6	11.0–12.2
Secondary branches	37.5–41.0	15.2–24.0
Grain shattering	Less	Easy
Yield potential	Higher	Lower
Grain weight/panicle (g)	250	75-150

According to Vaughan and Morishima (2003), because they generally lack distinct distinguishing morphological traits, there is substantial disagreement in the literature over the exact name of the species most closely related to *Oryza sativa*. For the *Oryza* species, more than a hundred names have been proposed, including nineteen for *O. sativa* alone (Oka, 1988; Lu, 2004). According to Hutchinson (1934), the tribe Oryzeae is classified into two sections namely, Oryzinae and Zizaninae. The

section Oryzinae has three genera namely *Oryza*, *Leersia* and *Hygrorphiza* and the section Zizaninae has four genera namely, *Zizania*, *Zizaniopsis*, *Hydrochola* and *Luziola*. Bentham and Hooker (1883) described and recognized 25 species of the genus *Oryza* distributed in the tropical regions of which about 14 were reported from India. Nayar (1973) studied the cytogenetics of rice and described 26 species under the genus *Oryza* with conclusive comment that the actual number of species may be less. Duistermat (1987) and Chang (1988) have provided revised taxonomic keys for the identification of 22 species and 10 species have been kept under doubtful validity and uncertain nomenclature. The 22 species are *Oryza sativa*, *O. nivara*, *O. grandiglumis, O. meridionalis O. longistaminata, O. rufipogon, O. glaberrima, O. glumaepatula, O. barthii, O. australiensis, O. latifolia, O. alta, O. eichingeri, O. minuta, O. officinalis, O. punctata, O. granulata, O. meyeriana, O. redleyi, O. longiglumis, O. schiechieri and O. brachyantha* (Duistermat, 1987; Chang, 1988). Tateoka in the most comprehensive taxonomic survey of the genus *Oryza*, described species complexes within the genus. According to him, it is unwise to create confusion by changing the taxonomic treatmentwhich is generally adopted (Tateoka, 1962a; Tateoka, 1962b; Tateoka, 1963b; Tateoka, 1965a; Tateoka 1965b). The major contributions to *Oryza* taxonomy from 1960 to 1994as listed by Vaughan (1994) is given in Table 2.

Table 2. Major contributions to *Oryza* taxonomy since 1960

Reference	Contribution
Tateoka (1963b)	A series of papers on the taxonomy of the genus *Oryza* was published. He stated that *O. perennis* is a name of uncertain application because the type specimen was lost and should not be used. Tateoka considered *O. rufipogon* to be the valid name for this species.
Launert (1965)	Removed *O. perrieri, O. angustifolia* and *O. tisseranti* from the genus and placed them in the genus *Leersia*.
Sharma and Shastry	*O. nivara* was described as a new species and *O.*

(1965)	*rufipogon* was redescribed.
Clayton (1968)	Defined the right species names for the closely related African wild rices: *O. barthii* for the annual relative of *O. glaberrima* and *O. longistaminata* for the rhizomatous perennial relative.
Ng *et al.* (1981)	Described a new species from Australia, *O. meridionalis.*
Vaughan (1990)	Clarified the species of the *O. officinalis* complex in Sri Lanka, describing a new species, *O. rhizomatis.*

For cultivated and wild rice in Asia, Vaughan recommended a new nomenclature. It is *O. sativa sensu lato* subspp. *indica* and *japonica*, and *O. rufipogon sensu lato* subspp. *nivara* (annual) and *rufipogon* (perennial). All the authors, who have revised the genus *Oryza* taxonomically or discussed the validity of its taxa/ species, have been unanimous in retaining the species identities of both the African and Asian cultivated rices (Sharma, 2003).

Species complexes

According to Vaughan (1994), the species of the genus *Oryza* are divided into four complexes. They are the following: 1. Sativa complex 2. Officinalis complex 3. Ridleyi complex 4. Meyeriana complex. The Sativa complex (AA genome and diploid) comprises the cultivated species *O. sativa* and *O. glaberrima* and their wild ancestors that are perennial and rhizomatous like *O. longistaminata*, *O. barthii*, *O. rufipogon*, etc. The basic chromosome number of the genus is 12. The species are either diploid with 2n=24 chromosomes or tetraploid with 2n=48 chromosomes. The Sativa complex species represent the primary gene pool of rice due to their cross ability and ease of gene transfer. The Officinalis complex species make up the secondary gene pool. The technique of embryo rescue can be accomplished to create crosses between *O. sativa* and the species of Officinalis complex. The Ridleyi and Meyeriana complexes, as well as *O. schlechteri* (unclassified), make up the tertiary genepool. Between main gene pool

groups, hybridization, homologous chromosome pairing, and gene transfer are conceivable, but with secondary and tertiary groups, it is more challenging.

In 2003, Vaughan *et al.* have made certain modifications in the above classification and suggested four complexes as follows: 1. Sativa complex (AA; 2n:24); 2. Officinalis complex (BB, CC, EE, BBCC, CCDD; 2n: 24 or 48); 3. Ridleyi complex (HHJJ; 2n: 48); 4. Granulata complex (GG; 2n: 24). *Oryza schlechteri* (genome unknown; 2n: 48) and *Oryza brachyantha* (FF; 2n: 24) have been put separately.

The Sativa complex includes the two cultivated species, *O. sati*va L. and *O. glaberrima* Steud. *O. rufipogon* is thought to be the ancestor of *O.* sativa, while *O. barthii* is thought to be the progenitor of *O. glaberrima* (Chang, 1976; Oka,1988). In the instance of the genus, nine different genomes (A, B, C, D, E, F, G, H and J) and and one unexplained genome have been reported based on genome analysis depending on chromosome pairing behaviour and degree of sexual compatibility. (Khush, 2000; Vaughan *et al.*, 2003; Brar and Khush, 2003). Table 3 shows the species complexes of the genus *Oryza*, as well as their geographical distribution, as proposed by Brar and Khush (2003).

Table 3. Species complexes of the genus *Oryza* and their geographical distribution.

Species complex	Chromosome Number (2n)	Genome	Geographical distribution
I. Sativa complex			
1. *O. sativa* L.	24	AA	Cosmopolitan
2. *O. nivara* Sharma *et* Shastry	24	AA	South & Southeast Asia
3. *O. rufipogon* Griff.	24	AA	South & Southeast Asia, South China
4. *O. meridionalis* Ng.	24	AA	Tropical Australia
5. *O. glumaepetula* Steud.	24	AA	Tropical

			America
6. *O. glaberrima* Steud.	24	AA	Tropical West Africa
7. *O. barthii* A. Chev. *et* Roehr.	24	AA	West Africa
8. *O. longistaminata* A. Chev. *et* Roehr.	24	AA	Tropical Africa
II. Officinalis complex/ Latifolia complex			
9. *O. punctata* Kotschy ex Steud.	24	BB	East Africa
10. *O. rhizomatis* Vaughan	24	CC	Sri Lanka
11. *O. minuta* J.S. Pesl. ex C.B. Presl.	48	BBCC	Philippines, New Guinea
12. *O. malamphuzaensis* Krishn. *et* Chandr.	48	BBCC	Kerala, Tamil Nadu
13. *O. officinalis* Wall. ex Watt	24	CC	South & Southeast Asia
14. *O. eichingeri* A. Peter	24	CC	East Africa, Sri Lanka
15. *O. latifolia* Desv.	48	CCDD	Central & South America
16. *O. alta* Swallen	48	CCDD	Central & South America
17. *O. grandiglumis* (Doell) Prod.	48	CCDD	South America
18. *O. australiensis* Domin.	24	EE	Northern Australia
19. *O. schweinfurthiana* Prod.	48	BBCC	Tropical Africa
III. Meyeriana complex			
20. *O. granulate* Neeset Arn. ex Watt	24	GG	South & Southeast Asia

21. *O. meyeriana* (Zoll. *et* Mor. ex Steud.) Baill.	24	GG	Southeast Asia
IV. Ridleyi complex			
22. *O. longiglumis* Jansen	48	HHJJ	Indonesia, New Guinea
23. *O. ridleyi* Hook. f.	48	HHJJ	Southeast Asia
V. Unclassified (belonging to no complex)			
24. *O. brachyantha* A. Chev. *et* Roehr.	24	FF	West & Central Africa
25. *O. schlechteri* Pilger	48	HHKK	Indonesia, New Guinea

Oryza glaberrima (2n=24=AA genome), the annual cultivated rice grown in West Africa grows in both upland and lowland ecologies and has many useful traits like resistance to blast diseases, weed competitiveness, drought tolerance, etc. (Singh, 1997;Ram *et al.*, 2010). Monogenic dominant resistance gene for grassy stunt virus has been reported from *O. nivara* (2n=24=AA genome) (Khush and Ling, 1974). In India, *O. rufipogon* (2n=24=AA genome) has been utilized to transfer salinity tolerance to high yielding varieties. Rice varieties having tolerance to coastal salinity have been released or coastal wetland areas in Eastern India (Shobha *et al.*, 2011). *O. longistaminata* (2n=24=AA genome), a perennial, tall, wild rhizomatous rice from tropical Africa has been the source of resistance to many bacterial leaf blight virulent pathotypes (Devadath,1983). It carries a dominant Xa21 resistance gene, a gene for bacterial blight (BB) resistance which was transferred to *O. sativa* cv IR64 at International Rice Research Institute (IRRI) through repeated backcrossing (Khush, 1977; Khush and Virmani, 1985).

O. minuta (2n=48=BBCC genome) distributed in Philippines and Papua Guinea has the smallest grain size. Two brown plant hopper resistant genes, Bph20 and Bph21 resistant to brown plant hopper have been reported from this species (Rahman *et al.*, 2009). Monosomic alien addition lines have been developed in *O. australiensis* (2n=24=EE genome) to transfer desirable genes to *O. sativa* (Multani *et al.*, 1994). Studies on *Zizania palustris* L. (2n=30), a genus related to *Oryza*, called as wild rice in North America has revealed a genome map with 15 haploid chromosomes

representing the 12 chromosomes of *Oryza*, with duplication of chromosomes 1, 4 and 9 (Hass *et al.*,2003).

Varietal groups of *Oryza sativa*

Cultivated forms of rice arose out of some wild species resembling the wild species *O. perennis*. Many scientists believe that rice (2n=24) is a balanced secondary polyploid with a basic chromosome number 5. This number got duplicated and two additional chromosomes were added (10+2). This plant on duplication gave rise to the progenitor of rice with 2n=24. From India, rice moved to China where probably for the first time it was domesticated. It moved northward to Japan via Korea. From India, rice also moved to Africa and America with the help of Arabian countries (Chaudhary, 1982).During the process of domestication and over time, *O. sativa* first separated into two ecogenetic or varietal groups: indica and japonica, as a result of centuries of selection by man and nature for desired quality and adaptation to new niches. There are some physical, physiological, and genetic distinctions between the two groups. Later, the *javanica* group was added to this group. *Japonica* and *Javanica* were later referred to as temperate and tropical *japonicas* (Chang, 1985; Takahashi, 1984). *Japonica* is cultivated in North China, Korea and Japan. *Indica* is cultivated worldwide and *javanica* in Indonesia (Chaudhary, 1982).

When chromosome pairing behaviour, F1 sterility, and F2 segregation pattern are compared to indica-javanica and javanica-japonica crosses, studies demonstrate that the indica-japonica pair is the least compatible. The genetic differences between *indica* and *japonica* have been explained through genic (Oka, 1953; Oka, 1974) and chromosomal (Henderson *et al.*, 1959; Sampath, 1962) models. The F1 hybrid between a *japonica* cultivar and an *indica* cultivar is often partially sterile. However, this sterility "neither imposes direct adverse consequences nor acts as a barrier to orderly achievement of the breeding objectives" (Jennings, 1966). Low temperatures are one of the most significant constraints on agricultural productivity (Mc Donald, 1979; Mc Donald, 1994). Japonica cultivars are primarily planted in temperate climates and can germinate and thrive at lower temperatures than indica cultivars grown in tropical and sub-tropical climates. All cultivars produce sterile pollen when the temperature drops below 18°C at night during pollen production. (Mc Donald, 1994). Differentiation of *O. sativa* into three forms has been the result of changes in leaf shape and size, grain shape and other plant morphological characters adapting to different ecological

conditions. The characteristic features of the three groups are given in Table 4. (Chaudhary, 1982).

Table 4. Characteristic features of the three varietal groups (subspecies) of *O. sativa*

Characteristics	Subspecies		
	Indica	*Japonica*	*Javanica*
Tillering	High	Low	Low
Height	Tall	Medium	Tall
Lodging	Easily	Not easily	Not easily
Photoperiod	Sensitive	Non-sensitive	Non-sensitive
Cold temperature	Sensitive	Tolerant	Tolerant
Grain shattering	Easily	Not easily	Not easily
Grain type	Long to medium	Short and round	Large and bold
Grain texture	Non-sticky	Sticky	Intermediate

Hence, rice is one of the world's most significant grain crops. It is widely cultivated and acclimatized in most of the tropical, subtropical and Mediterranean regions, having characteristically warm and humid conditions. Since 1960s, the production of rice in the world increased considerably due to green revolution leading to successfully solving the global food crisis (Nanda and Agrawal, 2006). However, the globe is currently experiencing a probable food shortage due to rising population and the impact of climate change on crop productivity. To meet world food demand, it is anticipated that global rice output will need to expand by 116 million tonnes by 2035 (Yamano *et al.*, 2016). It is expected that scientific advancements, innovative technologies and improvised management practices will increase the yield potential thereby helping to meet the increasing food demands. Besides scientific management, crop improvement is an essential tool to address different environmental changes and increase yield potential. In the case of rice, the innumerable landraces and cultivars distributed throughout the tropics and its wild relatives constitute the rich genetic diversity of the crop.

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Addressing the Limitations of Niche Modelling for Species Distribution Prediction with Reference to the Western Ghats

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Abstract

Ecological Niche modelling has a prime importance in prediction of niche suitability of a species. The study addresses the limitations of Species Distribution Modelling (SDM) using a modified methodology (MSDM) and experimented here with four threatened species of the Western Ghats. The authentic distribution records and bioclimatic variable gives an accurate Maxent-based prediction to the potential habitat of the species. SDM is facing a greater challenge hence it not considering the factors of the Eltonian niche. The incorporation of species associates, altitude and terrain features helps to consider the factors of the Eltonian niche which probably lack in the Species Distribution Modelling (SDM). The study with the support of detailed works affirms here the MSDM is more efficient and suitable for prediction of potential locations for species in the Western Ghats compared to the normal SDM. The coalescence of habitat degradation factors based on vegetation and land use spatial information imparts more precision into the suitability of projected areas. Here, we tested this with the habitat prediction of four threatened species *Cryptocarya anamalayana* Gamble, *Diospyros crumenata* Thwaites, *Prioria pinnata* (Roxb. ex DC.) Breteler, *Orophea erythrocarpa* Bedd. which occupies a unique and narrow niche in the forest of the Western Ghats. This approach can be used for the prediction of potential habitat of threatened species for conservation and ecorestoration.

Keywords: Eltonian niche, Bioclimate, Maxent, Niche profile, Conservation, Ecorestoration.

Introduction

Species Distribution Modelling (SDM) has been considered as an effective tool for prediction of potential areas of species in conservation planning and recently in ecorestoration. The conservation assessments reveal nearly 361 tree species which are globally threatened with a threat level of 13.8 % in India (BGCI, 2022). A total of 332 species are threatened in the Western Ghats, in which 55 of them are Critically Endangered (CR) (Bawa *et al.*, 2007). Most of the insitu conservation programs lack proper species selection, propagation techniques and occasionally result as mono species planting without considering the habitat suitability. This intensify decrease in species diversity, invasion of a species into the niches of other species and degradation of ecosystems (Bachan and Devika, 2022). Therefore, a well-defined species conservation planning is required for conservation and restoration of the natural habitat of a species. Pearson and Dawson (2003) emphasized the concept of bioclimate envelope and pointed out this factor can be only considered as a key characteristic for species distribution.

The advancement of ecological concepts such as niche and its applications using statistical and computational techniques highly supports ecological studies, understanding the species heterogeneity and often to predict the spatial distribution of species. Even though we have only limited data for a particular species, the model-based predictions help to overcome those database limitations by predicting heterogeneity in species distribution. The prescence or absence records and now a days prescence only records of species occurrence are commonly used in different species distribution models (Naimi, 2015). The different kinds of models which are using prescence only records include Bioclim (Busby, 1991), Domain (Carpenter *et al.*, 1993), Mahalanobis (Farber and Kadmon, 2003), Maxent (Phillips *et al.*, 2006) and Maxlike (Royle *et al.*, 2012). Maxent based Niche modelling technique have been used most commonly. It is a simple and effective tool for habitat prediction based on the distribution records which have been used before (Peterson *et al.*, 2011). This method significantly contributes to protected area prediction, climate change, species invasion,

animal and plant distribution (Miller, 2010). Hence, this approach generates an overpass between the conservation biology and ecological restoration.

The concept of habitat is closely related to the niche of a species which were popularized by Hutchinson in 1957. The term 'niche' can be defined as the physical and functional space occupied by an organism. According to the Grinnellian niche only the environmental factors, especially climatic, constitute the niche of a species (Grinnell, 1971). But later the Eltonian niche concept disclosed the species composition and its interactions have a fundamental role in constituting the niche of a particular species (Elton, 1927). The Eltonian niche was considered as the baseline knowledge for understanding species intricacy and interactions. Therefore, the species occurrence is highly influenced by the bioclimatic factors, associated species composition and other intrageneric and intragroup interactions (Devika and Bachan, 2021). The WorldClim database provides 19 different combinations of variables for predicting the bioclimate that are used in SDM and other ecological modelling techniques. Here the bioclimatic suitability is well addressed in this Maxent-based Niche Modelling.

Limitations of Niche modelling

Earliest efforts in species distribution prediction brought out simple envelope method describing species in relation with environment (Box, 1981), later with a non linear species environmental relationship (Elith and Graham, 2009). These wide range use of species distribution prediction is facing a great challenge in this complex nature. The recent studies (Woodward and Beerling, 1997; Lawton, 2000) debated the validity of bioclimatic concept and they indicated the factors determining species distribution. According to Pearson and Dawson (2003), the great complexity of nature cannot be confined into a single bioclimatic factor hence need to focus the range of spatial scale in habitat prediction. Some of the other studies such as (Naimi, 2015; Lissovsky and Dudov, 2021; Bachan and Devika, 2022) brought up the limitations of species distribution modelling.

The SDM has been widely used as a tool for predicting the suitable habitat of a species but it is not enough for proper niche modelling since it only considers the factors of the Grinnellian niche. A combination of GIS Software and environmental layers can be considered as an improved technique of Niche modelling for larger geographic area (Rotenberry *et al.*, 2006). It is essential to consider the factors of Eltonian niche for

defining the habitat of a species, therefore factors like species associates, altitude, terrain features, and landuse need to be considered which are not being covered in the present SDM techniques (Devika and Bachan, 2021). Therefore, to overcome the limitations of SDM we integrated these factors using the QGIS platform for better predictions. The incorporation of vegetation types along with the environmental layers such as elevation, precipitation, slope aspect, temperature, soil type, landuse were suggested to regional niche models (Rotenberry *et al.*, 2006). This standardized methodology can have a greater importance in the conservation of threatened plants. A combined methodology using Niche modelling and Niche profiling has been developed for conservation planning and ecorestoration (Bachan and Devika, 2021). In this study we tried to use the potential of Niche modelling in conservation planning and ecorestoration but at the same time we tried to address the limitations of Niche modelling.

Methodology

Taxonomic publications and herbariums were reviewed for authentic distribution records. Field works were conducted for more populations, specimens were collected from newly recorded subpopulations and herbariums were prepared based on the standardized method (Fosberg and Sachet, 1965; Bridson and Forman, 1991). Some of the distribution records were recorded from floras and virtual herbarium specimens. The ecological niche modelling uses distribution records of the species in correlation with the bioclimatic parameters to predict the suitable geolocations. Here we used Maxent-based Niche modelling, Version. 3.4.1 (Philips *et al.*, 2006). The QGIS mapping platform was used to extract bioclimatic data for the targeted species. Generated outputs were run in the Maxent program for the bioclimatic prediction of potential habitat of the species. This has been considered an experiment to standardize method for endemic and threatened tree species in the Western Ghats region. The prediction outputs were further analyzed with standardized vegetation, terrain and land use factors for the Western Ghats in the QGIS environment as suggested by Bachan and Devika, (2021) to cover the limitations of Niche modelling. The species compositions were also profiled for some species for more precise niche prediction and suitability.

Results and Discussion

i. Scrutiny of taxonomic collection and distribution records

Taxonomic identity of the species and its critical review is an essential part of the species prediction modelling since the taxonomic collection records provide basic and essential information on distribution patterns. Various kinds of species occurrence data were analyzed for the four selected species (*Cryptocarya anamalayana* Gamble, *Diospyros crumenata* Thwaites, *Prioria pinnata* (Roxb. ex DC.) Breteler, *Orophea erythrocarpa* Bedd.) including herbarium specimens, human observations, checklists and so on. The study recommend use of preserved specimen records at least 80% of the data keeping human observations, checklist, revision works or population study with proper taxonomic scrutiny for the remaining 20%. A critical review to understand the taxonomic identity, range and habitat ecology of the species is necessary since many of the herbarium specimens lack exact location details (Fig. 1 & 2).

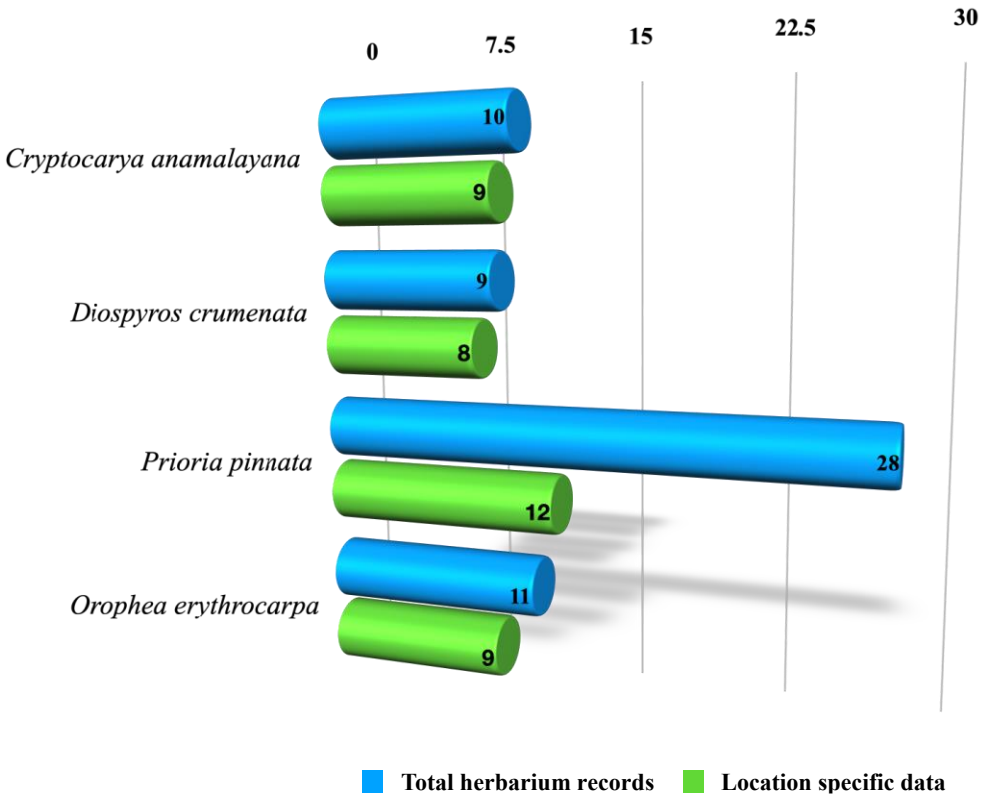


Fig. 1. Location specific herbariums data of four species

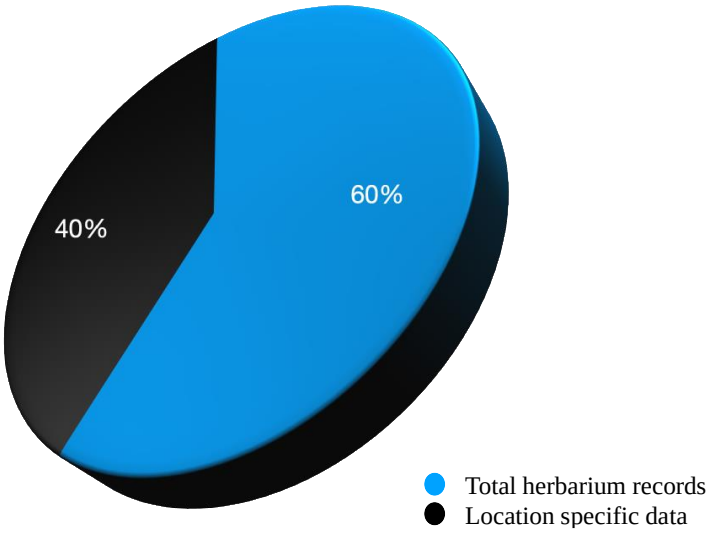


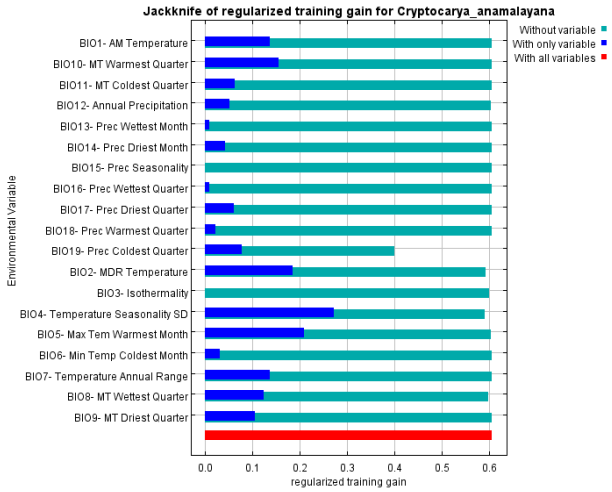
Fig. 2. Percentage contributed to the location specific data in herbarium records

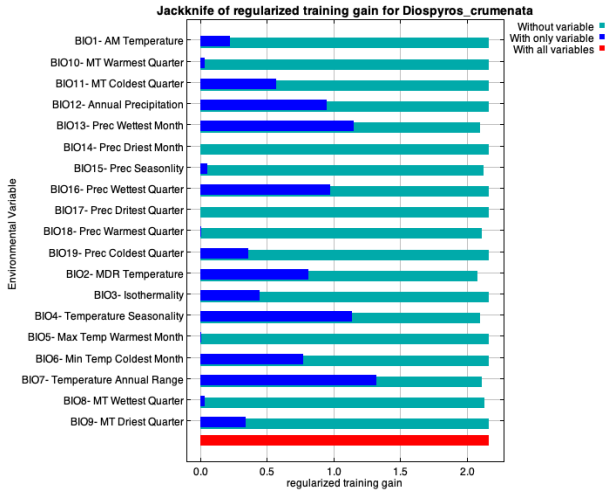
The virtual herbarium facilities of different herbaria especially of the Kew and International Plant Name Index (IPNI) were useful in fine tuning the taxonomic identity. A critical review of taxonomic revision works and similar published papers of the taxon were critical especially when the species has several synonyms.

ii. Bioclimatic variables defining the niche

The bioclimatic prediction includes 19 different variables among which each taxon shows differences in bioclimatic correlation in relation with vegetation type and brought out a narrow range of bioclimatic variables that determine the niches of the species within the given vegetation type (Fig. 3). All the four species *Cryptocarya anamalayana* Gamble, *Diospyros crumenata* Thwaites, *Prioria pinnata* (Roxb. ex DC.) Breteler, *Orophea erythrocarpa* Bedd. discussed here comes within the tropical moist evergreen forest in the Western Ghats. The bioclimatic prediction further delineates suitability of these species within the vegetation types. For example, the *Cryptocarya anamalayana* showed a narrow niche between the medium elevation evergreen and wet evergreen forest formations (Bachan and Devika, 2022). Hence the predicted suitable bioclimatic niches for the species were highly restricted. The *Diospyros crumenata* is basically a low elevation evergreen species with very restricted distribution. Niche modelling reveals a niche of the *Diospyros crumenata* within a very rare niche of low elevation evergreen having more wet evergreen bioclimatic parameters (Devika and Bachan, 2021). This kind of niche is scares within a low elevation area inferring the

rarity of species. *Prioria pinnata* is a low to medium elevation species, the Niche modelling indicated a narrow range in between low elevation and medium elevation seen continuously across the Southern and Central Western Ghats. A shift of the suitable bioclimate to a little higher elevation indicate the transition from the Southern Western Ghats to central part. Whereas, *Orophea erythrocarpa* shows affinity towards moist deciduous and evergreen bioclimatic niches.





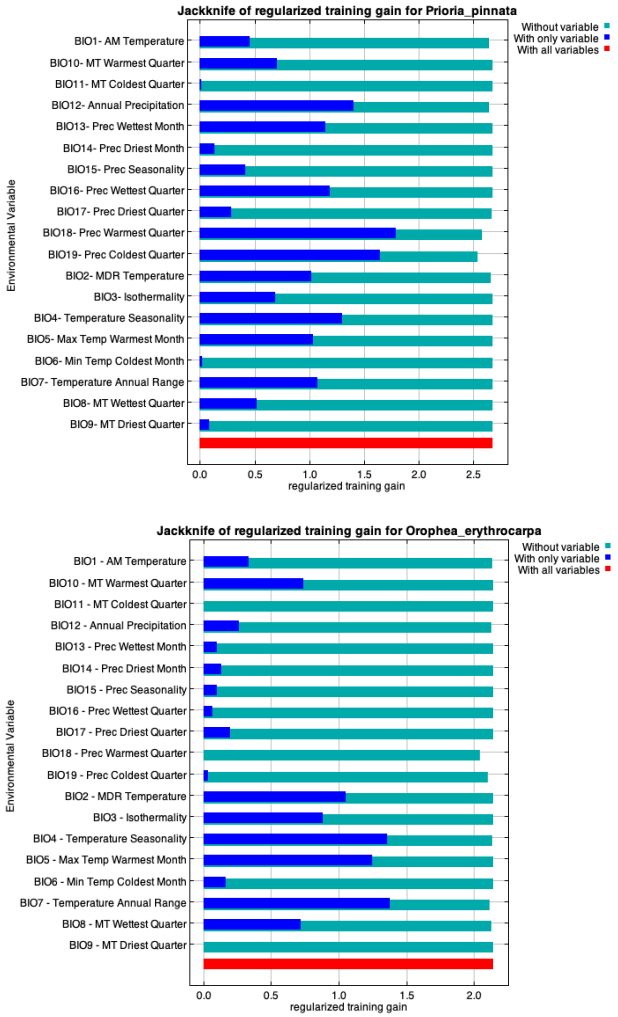


Fig. 3. The Jackknife test using different bioclimatic variables for the species

iii. Addressing the Limitations of Niche Modelling

The SDM was criticized for only considering environmental factors. Bachan and Devika (2022) demonstrated that the Maxent-based model considers 19 bioclimatic parameters which are more than a mere environmental variable such as temperature, light and precipitation. These factors vary across the globe along with latitude and altitude also with topographic and orographic features. Whereas the bioclimatic parameters show heterogeneity within given topographic regime or landscape and could not be completely explained with differential permutation combination of environmental factors. The species exist as populations with the surrounding community within a given environmental condition or factors decided by the Grinnellian niche habitat. Here we hypothesized that the overall species interaction with

a given environmental and topographic regime influence and modify the environment and hence influence the bioclimate. Hence, the bioclimatic prediction which is also a reflection of species interaction within a given environmental realm. Here we affirms that the bioclimatic prediction model accommodates very well the factors of the Eltonian niche and to some extent the factors of Grinnellian niche or the factors of species interaction with our detailed studies on *Cryptocarya anamalayana* (Bachan and Devika, 2022), *Diospyros crumenata* and *Prioria pinnata* (Devika and Bachan, 2021). A comparative account of the four species *Cryptocarya anamalayana, Diospyros crumenata, Prioria pinnata, Orophea erythrocarpa* here provided with further evidence of delineation of niches specific to the species according to the bioclimate (Fig. 5). A modified methodology was suggested (Bachan and Devika, 2021) to accommodate the factors of the Grinnellian niche using bioclimatic prediction in combination with elucidation of species association and its three-dimensional modelling as Niche profiling. This was successfully experimented in detail for *Cryptocarya anamalayana* (Bachan and Devika, 2022) and succeeded in fine tuning species prediction areas while incorporating terrain and landuse factors. A detailed study on the other three species (Devika and Bachan, 2021) provided similar conclusions. A comparison of prediction location based on the Maxent based Niche modelling and the modified methodology further fine-tuned to yield better result for the four species (Fig. 4.).

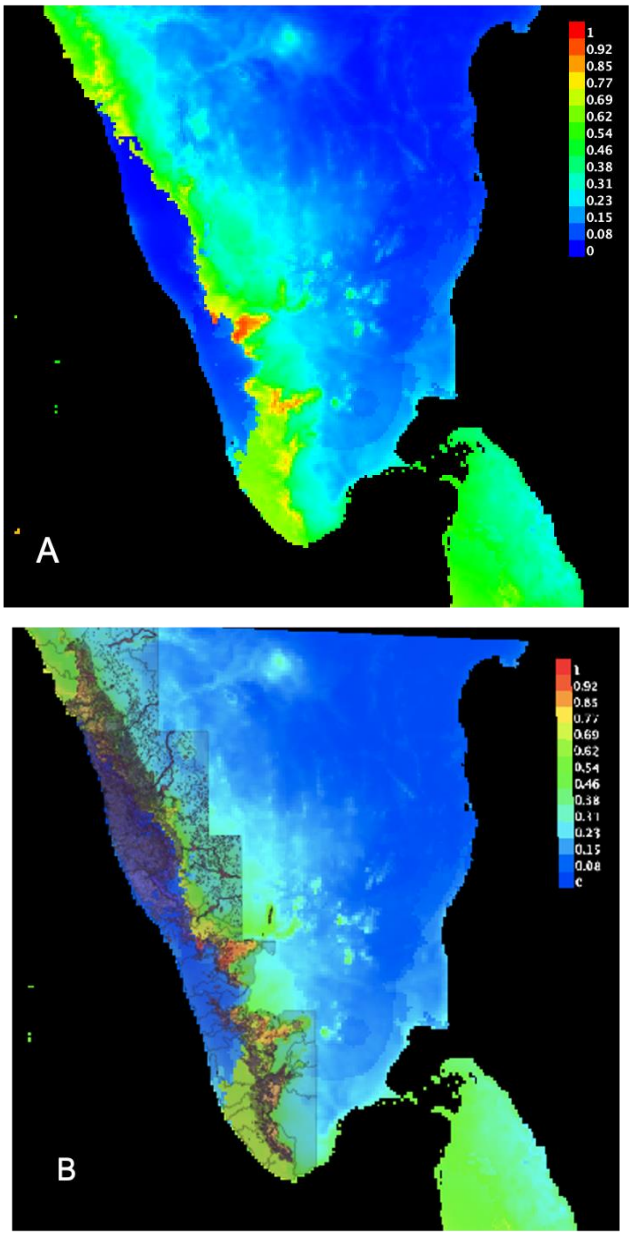


Fig. 4. (A). Map showing the predicted habitat suitability of *Cryptocarya anamalyana* Gamble (Maxent based SDM) (B). Predicted map of *Cryptocarya anamalyana* Gamble incorporated with the vegetation factors and terrain features (Maxent based Modified SDM).

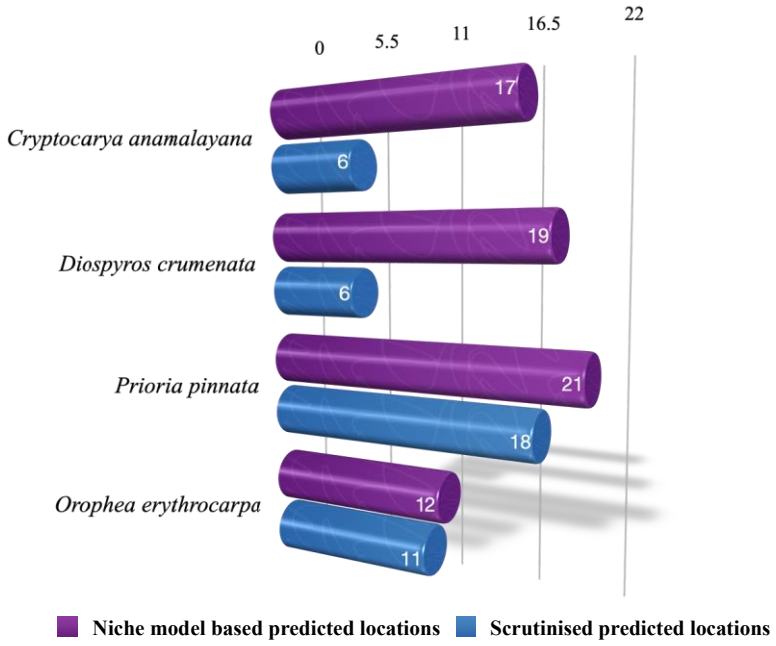


Fig. 5. Comparison of predicted SDM with Modified SDM (MSDM)

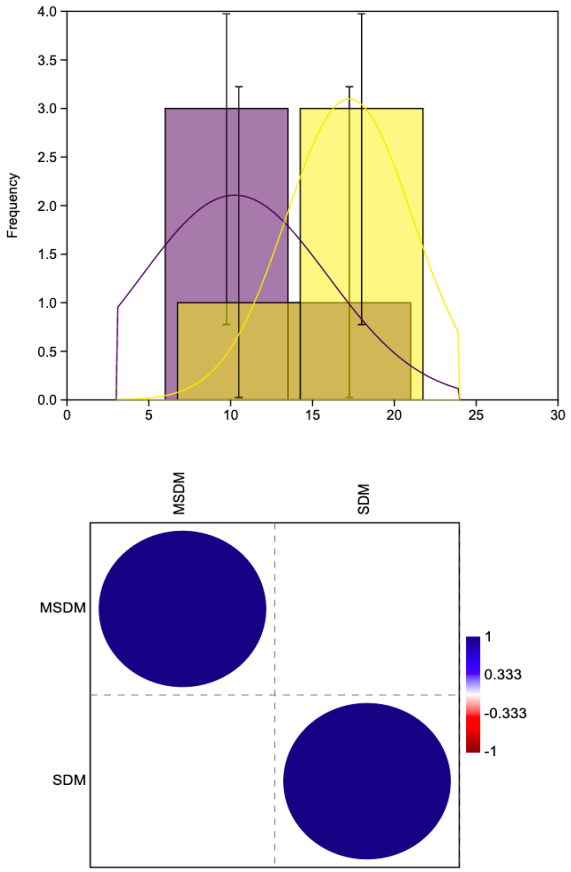


Fig. 6. (A). Histogram showing correlation within. (B). Correlation and P value between SDM and MSDM.

The correlation coefficient value of 7.8 indicated high correlation within both SDM and MSDM (Fig. 6. A), the correlation and high P value indicated significant variation between the SDM and MSDM (Fig. 6. B) proving the hypothesis that the modified SDM has more efficiency.

Conclusion

The Maxent based species distribution modelling (SDM) is commonly used in prediction of potential habitat of a species and has been criticized for its limitation restricting to the environmental factors of Grinnellian niche. The study addresses the limitations of the SDM using a modified methodology (MSDM) and experimented here with four threatened species of the Western Ghats. The study recommends use of scrutinized taxonomic specimen records for data validation for species distribution limiting other record to 20%. The study with the support of detailed works (Devika and Bachan, 2021; Bachan and Devika, 2022) affirms here the MSDM is more efficient and suitable for prediction of potential locations for species in the Western Ghats compared to the normal SDM. Using the SDM, predicted suitable habitat locations (Fig. 5) for *Cryptocarya anamalayana* (17), *Diospyros crumenata* (19), *Prioria pinnata* (21), *Orophea erythrocarpa* (12). While applying the modified methodology of SDM, the predicted location is further sharpened (Fig. 5) to forest areas such as in the case of *Cryptocarya anamalayana* (6), *Diospyros crumenata* (6), *Prioria pinnata* (18), *Orophea erythrocarpa* (11). This difference has been statistically proved (Fig. 6) to be significant during the study. This approach provides a better understanding of the percentage contribution of bioclimatic factors and also the topographic and vegetation factors, the factors of species assemblage. This again can be used for prediction of potential habitat of threatened species for conservation and ecorestoration.

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Taxonomy and Diversity of the Lesser-Known Varieties of *Ficus virens* (Moraceae) from The Western Ghats

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Abstract

The genus *Ficus* (Moraceae) which comprises around 115 taxa distributed in India is a dominant genus among the angiosperms. A comprehensive revision of the genus *Ficus* L., from the Western Ghats, recorded 36 taxa of *Ficus*. Encountered two interesting specimens were identified as varieties of *Ficus virens*. *Ficus virens* Aiton is one of the most common and widely distributed species of *Ficus* in the world. Which shows great complexity in the morphological characters and hence more complex in the taxa. Whereas the *Ficus virens* var *matthewii*, is a new record for Kerala and *Ficus virens* var *dispersa*, a new report to India. These two varieties of *Ficus virens* showed significant differences from the common variety *Ficus virens* var *virens.* A detailed taxonomic description of all the three varieties along with an identification key and images are provided here.

Keywords: Distributional record, *Ficus virens, Urostigma,* Western Ghats.

Introduction

The genus *Ficus* L., (Moraceae) is a highly diversified genera with respect to the habit pattern and life forms. The genus is mainly distributed in the tropical and sub-tropical regions of the world (Chaudhary *et al.,* 2012; Mohapatra *et al.,* 2020). The presence of the specialised inflorescence - hypanthodium, minute flowers and morphological complexities make the genera problematic. The global revision of the genus by E. J. H. Corner since 1930, reduced the number of species to ca. 750. The first detailed work on the genus from India was carried out by G. King (1887) and recorded 113 species and 47 infraspecific taxa of *Ficus.* The genus remained unnoticed except few regional works. BSI initiated a revisionary work on the genera and reported 115

taxa of *Ficus* from India (Chaudhary *et al.*, 2012). According to the current status, the Western Ghats region has a diversity of 36 taxa of *Ficus.*

The genus is divided into six sub genera, within which the subgenus *Urostigma* is the most abundant member (Berg and Corner, 2005). *Ficus virens* belonging to the subgenus *Urostigma* is one of the most widespread species in the genus *Ficus* (Berg, 2004; Chantarasuwan *et al.*, 2013). It is a morphologically highly variable species. Revisionary studies on the subgenus *Urostigma* established two new varieties of *Ficus virens* (Chantarasuwan *et al.*, 2013).

As part of the a comprehensive revision of *Ficus* of Western Ghats, field explorations in the Wayanad and Idukki districts of Kerala led to the collection of two interesting specimens. On detailed study, literature review and herbarium reference, the specimens were identified as *Ficus virens* var *matthewii* and *Ficus virens* var *dispersa. Ficus virens* var *matthewii* was a new distributional record to the state of Kerala (Nair *et al.*, 2021 a) and *Ficus virens* var *dispersa* was a new report to India (Nair *et al.*, 2021 b). Thus, three varieties of *Ficus virens* are distributed in the Western Ghats. This article provides a detailed description along with identification key and images to the lesser-known varieties of *Ficus virens* from the Western Ghats.

Materials and Methods

Field explorations were conducted for the collection of the specimens. The collected samples were studied in detail for the morphological and floral characters. The floral imaging of the samples was done using a digital microscope. The observed morphological and floral characters were enumerated in a data sheet. The samples were identified using relevant literatures (Corner, 1965; Berg, 2004 and Chantarasuwan *et al.*, 2013) and the identification was confirmed with reference to the type specimens of the taxa deposited in National Herbarium Nederland (L).

Result

The revision of the genus *Ficus* of Western Ghats region enumerated the presence of 36 taxa of *Ficus* from the region. No members belonging to the subgenus *Ficus* was observed from the study area. The subgenera wise diversity of the genus is shown in Fig 1. The most dominant subgenus was the *Urostigma,* similar to the global

diversity. This subgenus mainly included the epiphytic and hemi epiphytic species of the genus.

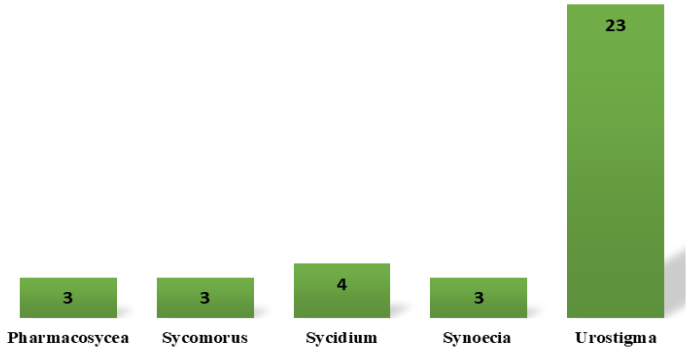


Fig 1. Subgenera wise diversity of *Ficus* in Western Ghats

Three varieties of *Ficus virens* were observed from the Western Ghats region. Two varieties *Ficus virens* var *matthewii* and *Ficus virens* var *dispersa* were not previously reported from the study area. These taxa showed substantial variations in their morphological and floral characters.

Systematic Treatment

***Ficus virens* Aiton var. *dispersa* Chantaras.** Syst. Bot. 38(3): 681. 2013; Nair *et al.*, Biodiv. Res. Conserv. 63: 41-47. 2021.

Type: Papua New Guinea. New Britain: West Nakanai, Rapuri village near Cape Hoskins, probably 5 Aug 1954, A. Floyd NGF 6457 (Holotype: L; isotype: K).

Description: Tree up to 15 m height, without aerial roots; bark smooth lenticellate, brown coloured; young twigs terete, brown, glabrous; inter node 0.4–1.2 cm. Stipules ovate, margins entire, 0.4–0.8 cm, apex acute, base truncate, glabrous, pale green–brown. Leaves alternate, spiral, margins entire, ovate–lanceolate, 5.9–11.8 × 3.6–5.8 cm, acumen 0.6–1.2 cm, apex cuspidate, base rounded–obtuse–cuneate, glabrous, pale red when young, green on maturity, subcoriaceous, brochidodromous venation, lateral veins 7–9 pairs; petiole terete, 2.6–4.8 cm, glabrous, pale green. Receptacles axillary, solitary or in pairs, monoecious; peduncle 0.3–0.4 cm, glabrous, pale green; basal bracts present. Syconium 0.7–1.1 cm across, globose, glabrous, pale green to purple coloured with spots; ostiole 0.1–0.2 cm in diameter. Male flowers abundant around ostiole and few dispersed, 1.2 mm long, sessile, tepals, 4, free, 0.75 mm long, linear, glabrous, pale red coloured. Female flowers at the base, 4 mm long, pedicellate, tepals 3, free, 2 mm

long, linear, stigma bifid, ovary 1 mm long, obovoid, glabrous, pale brown coloured. Gall flowers scattered, 2 mm long, tepals 3, fused, 1.5 mm long, linear, stigma short, ovary 1 mm long, obovoid, glabrous, pale brown coloured.

Etymology: The dispersed arrangement of male flowers within the receptacle might have named the variety "*dispersa*".
Habitat: Semi evergreen and deciduous forest.
Fruiting and Flowering: December–February.
Distribution: This variety is reported so far from Malaysia, Indonesia, Papua New Guinea and East Australia.

***Ficus virens* Aiton var. *matthewii* Chantaras., Syst. Bot. 38(3): 683. 2013; Nair *et al.*, Species. 22(69): 21-28. 2021.**

Type: India, Tamil Nadu (Madras), Dist. Dindigul, Anna, Pachalur, below village, 1 Nov 1987, K. M. Matthew RHT 50937 (holotype: L; isotypes: RHT, SHC)

Description: Tree up to 35 m height, without aerial roots; bark smooth lenticellate, brown coloured; young twigs terete, pale brown, glabrous; inter node 0.6–4.0 cm. Stipules triangular – widely triangular, margins entire, 0.7–1.5 x 0.6–1.2 cm, apex acute, base truncate, hairy, tomentose, pale brown. Leaves alternate, lanceolate -elliptic - lance ovate - ovate, margins entire, 5.8–20.5 x 3.1–7.2 cm, acumen 0.4–0.9 cm, apex acute – acuminate - obtuse, base attenuate – cuneate – obtuse – rounded - truncate, glabrous, green on abaxial, dark green on adaxial, subcoriaceous, brochidodromous venation, lateral veins 10–12 pairs; petiole terete, 1.5–11.2 cm, glabrous, pale green. Receptacles axillary or below the leaves, clustered, monoecious; peduncle 0.2–0.3 cm, glabrous, pale green; basal bracts present. Syconium 0.4–2.2 cm across, obovoid, glabrous, pale green to purple coloured; ostiole 0.3–0.4 cm in diameter. Male flowers few near the ostiole, 1.0–1.1mm long, pedicel short or sessile, tepals, 3–4, fused, 1 mm, linear, glabrous, pale brown coloured. Female flowers at the base, 3 mm long, sessile, tepals 3, fused, 1.5 mm, linear, stigma 0.4 mm, ovary 2 mm, obovoid, glabrous, pale brown coloured. Gall flowers 2.5 mm, tepals 4, fused, 2 mm, linear, stigma 0.2 mm, ovary 1 mm, obovoid, glabrous, pale brown.

Etymology: The variety is named *'matthewii'* in honour of the contributions by Dr. K M Matthew, who collected the specimen for the first time in 1987.

Habitat: In evergreen forests.

Flowering and fruiting: October – December.

Distribution: South India and Sri Lanka.

***Ficus virens* Aiton var *virens*., Corner, Gard. Bull. Singapore 21: 9. 1965; Chew, Fl. Australia 3: 35. 1989; Sasidh. & Sivar., Bio. Docu. Kerala part 6: 442. 2004; Chantaras., Syst. Bot. 38(3): 680. 2013.**

Description: Tree up to 30 m height, without aerial roots; bark smooth lenticellate, brown coloured; young twigs terete, pale brown, glabrous; inter node 0.4–3.8 cm. Stipules triangular, margins entire, 0.25–1.5 x 0.2–0.4 cm, apex narrowly acute, base truncate, glabrous, pale brown. Leaves alternate, ovate-elliptic- lanceolate-obovate, margins entire, 5.2–18.5 x 2.5–8.5 cm, acumen 0.4–1.0 cm, apex acute, base rounded to truncate, glabrous, green on abaxial, dark green on adaxial, subcoriaceous, brochidodromous venation, lateral veins 8–12 pairs; petiole terete, 1.6–6.1 cm, glabrous, pale green. Receptacles axillary or below the leaves, clustered, monoecious; peduncle 0.2–0.3 cm, glabrous, pale green; basal bracts present. Syconium 1.0–1.6 cm across, sub globose, glabrous or minutely puberulous, pale green to purple coloured; ostiole 0.2–0.4 cm in diameter. Male flowers near the ostiole, 1.0–1.5mm long, pedicel short or sessile, tepals, 3–4, fused, 0.75 mm, linear, glabrous, pale brown coloured. Female flowers at the base, 2 mm long, sessile or short pedicellate, tepals 3, fused, 0.75 mm, linear, stigma 0.25 mm, ovary 1 mm, obovoid, glabrous, pale brown coloured. Gall flowers 2.0 mm, pedicel short or sessile, tepals 4, fused, 0.75 mm, linear, stigma short, ovary 1 mm, obovoid, glabrous, pale brown.

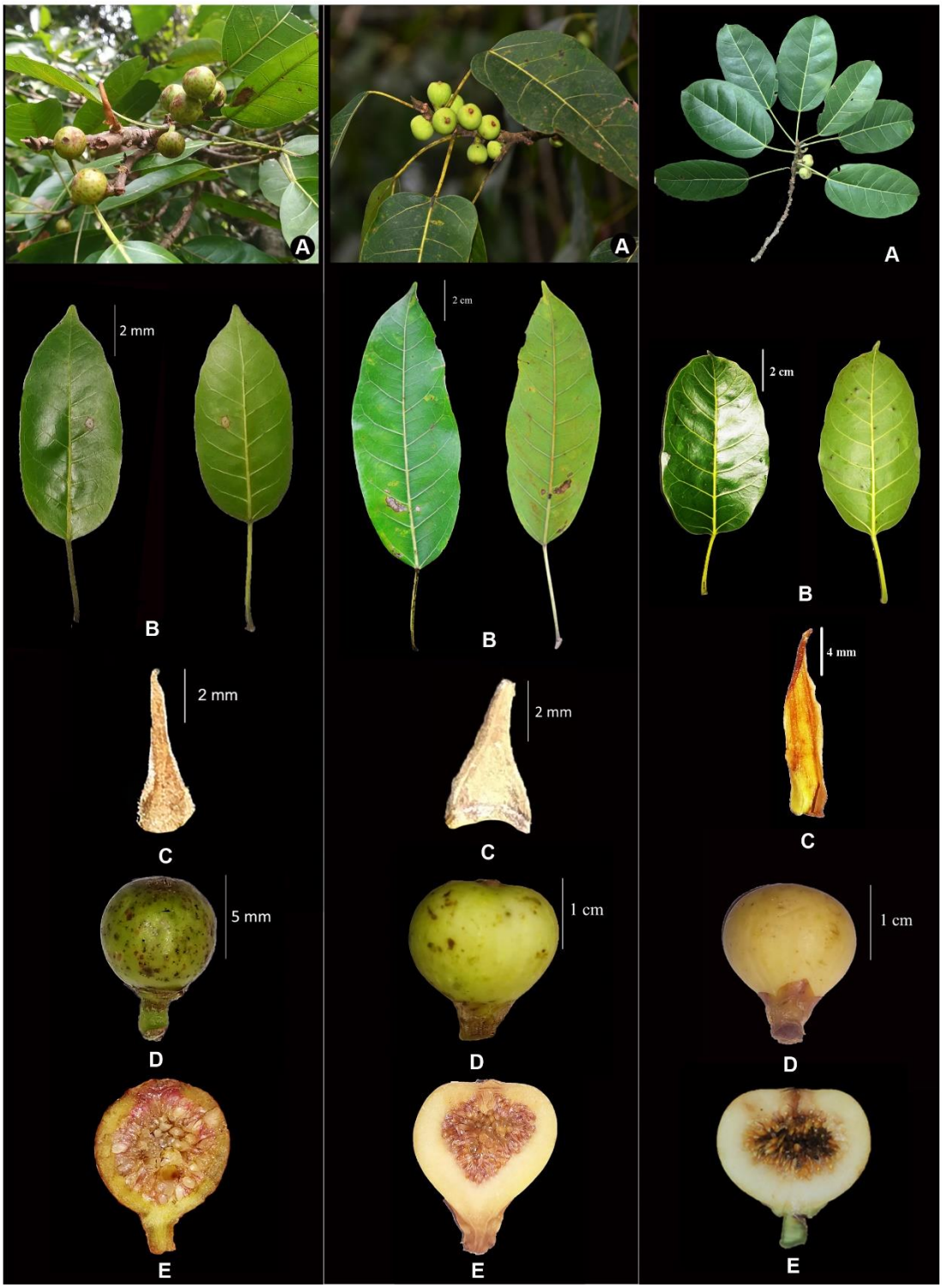
Etymology: The variety might have named *'virens'* due to the green and reddish colour of the young leaves.

Habitat: In evergreen and deciduous forests.

Flowering and fruiting: November – June.

Distribution: In the tropical and sub-tropical regions.

Diversity: The three varieties of *Ficus virens* shows considerable range of variations in their characters. Table 1 shows the variations in the characters of the three variety of *Ficus virens.* Figure 2 shows the images of the three varieties, *Ficus virens* var *dispersa, Ficus virens* var *matthewii* and *Ficus virens* var *virens.*



Ficus virens* var *dispersa ***Ficus virens* var *matthewii*** ***Ficus virens* var *virens***

Figure 2. **A.** Fruiting branch; **B.** Leaf abaxial and adaxial side; **C.** Stipule; **D.** Syconium; **E.** Syconium L S.

Character	***Ficus virens* var *dispersa***	***Ficus virens* var *matthewii***	***Ficus virens* var *virens***
Habit	Tree up to 15 m	Tree up to 35 m	Tree up to 30 m
Stipule size	0.4–0.8 cm	0.7–1.5 cm	0.25–1.5 cm
Petiole Size	2.6–4.8 cm	1.5–11.2 cm	1.6–6.1 cm
Leaf shape	Ovate - lanceolate	lanceolate -elliptic - lance ovate - ovate	ovate to elliptic to lanceolate to obovate
Leaf size	5.9–11.8 x 3.6 –5.8 cm	5.8–20.5 x 3.1–7.2 cm	5.2–18.5 x 2.5 – 8.5 cm
No of lateral veins	7–9	10–12	8–12
Peduncle size	3–4 mm	2–3 mm	2–3 mm
Syconium size	0.7–1.1 cm when fresh	0.4–2.2 cm when fresh	0.4–1.5 cm when dry
Syconium shape	Globose	Obovoid	Sub globose
Indumentum of syconium	Glabrous	Glabrous	Glabrous or minutely puberulous
Ostiole size	1.5–2.5 mm	3–4 mm	2–4 mm
Position of male flowers	abundant around the ostiole and a few dispersed	Few near ostiole	Near ostiole or dispersed
No of tepals	4	3–4	3–4
Nature of female flowers	Pedicellate	Sessile	Sessile or short pedicellate

Table 1: Character variations in varieties of *Ficus virens* Aiton.

Key to varieties of *Ficus virens*

1a. Small tree up to 15 m tall, stipules less than 1.0 cm long, lateral veins less than 10 pairs, peduncle 3–4 mm long, syconium globose …….. ***F. virens*** **var. *dispersa.***

1b. Large tree above 25 m tall, stipules more than 1.0 cm long, lateral veins up to 10 pairs, peduncle 2–3 mm long, syconium obovoid or sub-globose ……..…….. **2.**

2a. Petiole above 10 cm long, syconium obovoid in shape, indumentum glabrous, male flowers few, near the ostiole …… ***F. virens*** **var. *matthewii.***

2b. Petiole below 10 cm long, syconium sub-globose in shape, indumentum glabrous or minutely puberulous, male flowers near the ostiole and dispersed …… ***F. virens*** **var. *virens.***

Species examined: *F. virens* var *dispersa.* Papua New Guinea. West Nakanai, Rapuri village near Cape Hoskins, 05-08-1954, A. Floyd NGF 6457 (Holotype L; Isotype K). ***F. virens* var *matthewii***: Tamil Nadu, (Madras): Dindigul, Pachalur, 01-11-1987, Matthew RHT 50937 (L). ***F. virens*** **Aiton:** Tamil Nadu, Coimbatore, Girimalami, 18-03-1931, K. Cherian Jacob, 421(MH); Kerala, Kollam, Vilakkumaram, Shenduruny WLS, 09-12-1993, Sasidharan, 10687; Idukki, 1101 m, 16-05-1994, N. Sasidharan & Jomy Augustine, 13740 (KFRI); Thiruvananthapuram, Peringammala, 19-06-1984, N. Mohanan, 174 (TBGT); Wayanad, Vythiri, 900 m, 15-05-2000, Rathesh Narayanan, 2547 (CALI).

Conclusion

A total of 36 taxa of *Ficus* were recorded from the Western Ghats, among them *Ficus virens* var *matthewii* and *Ficus virens* var *dispersa* were two lesser known taxa and were reported as new records for India and Kerala respectively. They showed significant variations in the floral and morphological characters.

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TAXONOMY AND DISTRIBUTION OF GENUS *HYDANOCARPUS* GAERTN. (FLACOURTIACEAE) IN KERALA

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Abstract

Hydnocarpus is a small genus consists of six species India Viz *alpina* Wight. , *H. kurzii (*King) Warb. , *H. macrocarpa* (Bedd) Warb. , *H. pendulus* Manilal. *H. longipedunculatus* Robi, Sasi & Jose. *and H. pentandra* (Buch-Ham)Oken. of which all species are occur in Kerala. Out of these 6 species 4 species Endemic to Western Ghats and two species only known from their type locality. Taxonomic identity of *H. pendulus* Manilal was also discussed and due to its striking morphological difference from *H. alpina* Wight reinstate it as separate species.

Key Words: *Hydnocarpus,* India, Western Ghats, Kerala, *Hydnocarpus pendulus* Manilal, Reinstate

Introduction

Flacourtiaceae is a small arborascent tropical family comprising of about 1300 species and 84 genera mostly in tropical and subtropical regions, some extending into the temperate zone (van Steenis, 1958; Mabberley, 1997). In some recent works, all the members of Flacourtiaceae are transferred to other families, and Flacourtiaceae is proposed as a synonym of Salicaceae. Some workers considered two genera viz *Hydnocarpus* and *Gynocardia* are belongs to Achariaceae and remaining all others to Salicaceae.

Hydnocarpus is an arborascent genera consist of 40 species predominantly distributed in Indo-Malesian region. (Van Steenis, 1958; Mabberley, 1997). The genus

is major component of deciduous, semi evergreen and evergreen forests. The members of the genus is distributed from sea level up to 2000m or even more. *Hydnocarpus* is an important constituent in many traditional and folklore medicinal practice especially for the cure of leprosy and skin diseases. The seeds of *H. kurzii*. (King) Warb. Yield chalimoorga oil, a cyclo pentanyl fatty acid used for the treatment of leprosy. There are six species of *Hydnocarpus* in India viz., *H. alpina* Wight. , *H. kurzii* (King) Warb., *H. macrocarpa* (Bedd) Warb., *H. pendulus* Manilal., *H. longipedunculatus* Robi, Sasi & Jose. And *Hydnocarpus pentandra* (Buch-Ham) Oken. and all are present in Kerala. Based on the number of Petal, Sepal and Stamen Genus *Hydnocarpus* consist of 4 sections Taraktogenos, Hydnocarpus, Kerrandrias and Asteriastigma.

Methodology

Taxonomic description and notes on distribution made based on relevant literature and field collection. Morphological variations were recorded.

Result

Genus *Hydnocarpus* Gaerten. Consist of 6 species in India of which all are present in Kerala a provisional field identification Key were provided here for easy identification of Indian species.

KEY TO THE SPECIES IN KERALA

1. **Sepals 4 or multiples of 4 ……section Taraktogenos**

1.1. Sepals 4, veins irregularly branched …….. *H. kurzii*

1.2. Sepals12, veins seldom branched …….. *H. macrocarpa*

2. Sepals 5 or multiples of 5 …… section Hydnocarpus

2.1. Fruits are beaked and angled

2.1.1. Young leaves coriaceous, drooping ……. *H. pendulus*

2.1.2. Young leaves chartaceous, straight ……. *H. longipedunculatus*

2.2. Fruits are rounded without beak and angle

2.2.1. Peduncle 2 – 4 cm, Fruit smooth ……..... *H. alpina*

2.2.2. Peduncle 0.5-2 cm, fruits wrinkled …… *H. pentandrus*

***Hydnocarpus alpina* Wight.**

Trees to 15-18 m; bark brown to greyish-brown smooth. Young leaves copper red. Leaves alternate simple erect or drooping, ovate or elliptic, 6-22 x 4-11cm, apex acute .base oblique, or round , coriaceous; lateral nerves 5-12 pairs Flowers unisexual 15-20 mm across, greenish white or yellowish-white, axillary fascicles or solitary; pedicel 1. 5- 3cm long, Sepals 5, 6-8 mm long, ovate-oblong, puberulous, Petals 5, 1-1.5 cm long, oblong, glabrous. Stamens exerted 5-15.; ovary monocarpellary, tomentose, stigmas 5 free, Fruit is a berry, densely dark brown, tomentose.

Distribution: South India and Sri Lanka

Ecology: Dstributed in the evergreen and semi-evergreen and shola forests and sacred grooves of all districts in Kerala at an altitude of 100-2000 m. Swaroopanandhan reported from Shola forest.

***Hydnocarpus longipedunculatus* Robi, Sasi & Jose.**

Trees, to 10-12m height; Leaves alternate, 9–25 × 3–8 cm, oblong, chartaceous, glabrous, petiole 2-5 mm long, Inflorescence axillary pseudo-cymes consists of 1-7 flowers. Flowers greenish-white, peduncle slender 1 –6 cm long, puberulous; pedicel slender, 2–5 cm long, straight, puberulous. Sepals 5, ca. 8-10 × 4-5 mm elliptic or ovate, fused at base, obtuse or acute at apex, incurved, brownish green, puberulous. Petals 5, ca. 12-17 × 4-5 mm, lanceolate, greenish white, smooth, , acute or obtuse at apex, margins hardly incurved. Stamens 5, filaments ca. 4-7 mm long, glabrous creamy white erect. Female flowers creamy-white peduncle, pedicel, sepal, petal similar to male flower. . Ovary hairy; ovules many; style 3-4 mm long, stigma five-lobed. Fruit ovoid or ovoid-oblong, apex beaked, pentangular, may or may not sustain until maturity.

Distribution: Species recently described by Robi, Sasidharan, Jose from Kulamav. Found in evergreen and semi evergreen forest at an altitude of 800 meters. Species show affinity with *H. alpina* Wight but can easily distinguished from *H. alpina* in its pentangular beaked fruits and long peduncle. It is also similar to *H. pendulus* in its pentangular beaked fruit but can differentiated by their long pedicel, larger leaves.

***Hydnocarpus kurzii* (King) Warb.**

Medium sized trees, leaves simple, alternate, oblanceolate orr eliptic or eliptic-lanceolate, base cuneate, oblique; acute or acuminate at apex; bifarious, 7-15 x 4 5cm, margin entire ,flabrous; petiole 5-10 mm, grooved above, glossy. Flowers, unisexual, greenish or creamy white, 7-8 mm in diameter, sepal, petels are similar in male and female flowers. Sepal 4-8 x 2-3mm, broadly ovate, hairy along the margin. Petals 5 creamy white10 x 4mm long, imbricate. Stamens many, filament 5 mm, glaberous. Ovary rounded or ovoid, sessile, densely pubescent. Seeds many, angular

Distribution: Reported from the semi evergreen forest of Thenmala, Kollam district at an altitude of 300 meters

***Hydnocarpus macrocarpa* (Bedd) Warb.**

Evergreen trees, 15- 20 m tall. Leaves simple, alternate, petiole 10-25 mm, puberulous when young and glossy at maturity; lamina 10-32 x 4.5-15 cm, hardly oblong, acute or rounded at baseand, apex acute acuminate, glossy, chartaceous or coriaceous; lateral nerves 6-10 pairs, , prominent. Flowers polygamous, greenish white in axillary cyme or cauliflorous; sepals 4, 10-12 x 3-5imbricate; petals tetramerous, 12-16, greenish-white with 3-lobed scales; stamens many; ovary monocarpellary, sessile. Fruits a berry, 10-20 cm across, globose, woody, dark brown; seeds many, angular.

Distribution: Species endemic Southern Western Ghats distributed in the evergreen forests of Thiruvananthapuram, Kollam, Idukki and Thrissur, Malappuram, Calicut districts of Kerala at an altitude of about 400 – 1000 meters altitude

***Hydnocarpus pendulus* Manilal.**

Trees, to 10-15m height; Leaves alternate, 5–15 × 3–5 cm, oblanceolate, coriaceous, glabrous, young leaves cooper red and drooping. Petiole 4-10 mm long, Inflorescence axillary pseudo-cymes consists of 1-5 flowers. Flowers greenish-white or creamy white, peduncle slender 1 –3 cm long, slightly pubescent; pedicel slender, 3–5 cm long, slightly hairy. Sepals brownish green 5, ca. 7-10 × 4-5 mm, incurved elliptic or ovate, fused at base, obtuse or acute at apex, puberulous. Petals 5, ca. 12-17 × 4-5 mm, greenish white, lanceolate, glaberous, acute or obtuse at apex, margins strongly incurved. Stamens 5, filaments, erect ca. 5-7 mm long, hairless creamy white. Female flowers creamy-white peduncle, pedicel, sepal, petal similar to those of male flower.

Ovary pubescent; ovules many; style 4-5 mm long, stigma five-lobed. Fruit ovoid or ovoid-oblong, pentangular, beaked at apex may or may not sustain until maturity.

Taxonomic notes: Sasidharan treated the species as a synonym of *H.alpina* Wight but the species can easily distinguished by their long pedicel, peduncle and pentangular beaked fruit. Because of these marked differences the species reinstate as individual species. Species show close affinity with *H. longipedunculatus* but can easily distinguished by their coriaceous copper red young leaves, short peduncle.

***Hydnocarpus pentandra* (Buch-Ham) Oken.**

Medium sized trees 10 -15 m high, Leaves simple, alternate, 7-17 x 3-7 cm, elliptic-oblong or elliptic-lanceolate, base acute or truncate, apex acute or acuminate, margin entire or crenate, coriaceous, smooth; Flowers polygamous, 7-10 mm across, greenish-yellow or creamy white, solitary or pseudo cymes or in small fascicle. Sepals 5, strongly ovate, puberulous. Petals 5, hardly ovate, creamy-yellow or greenish yellow with minute white hairs. Stamens 5-15; filaments smooth or hairy at the base, subulate; ovary globose, pubescent, monocarpellary; stigma sessile and bilobbed. Fruit a berry, globose, surface uneven; seeds many, angular.

Distribution: Distributed throughout the state in the deciduous, moist deciduous, evergreen forests and plains at an altitude of sea level to 1800 meters. *H. pentandra* is the most widely distributed species

Discussion

In India genus consists of two section namely Taraktogenos and Hydnocarpus. Section Taraktogenos characterized by tetramerous flowers consist of two species *H. macrocarpa* and *H.kurzii*. section Hydnocarpus carries pentamerous flower consists of 4 species namely *Hydnaocarpus pentandrus*, *H. alpine*, *H.pendulus* and *H. longipedunculatus*

Genus *Hydnocarpus* Gaertn is a small genus consist of 6 species in India all are reported in Kerala. Among the species *Hydnaocarpus pentandrus* is most common and used in various indigenous system of medicine. Species widely distributed in sacred groves in plane, deciduous, semi evergreen and evergreen forest. The next common species *H. alpina* was described by Wight based on his collection from Montane forest later the species reported from evergreen, semi evergreen, deciduous even planes.

Hydncarpus kurzii is a north east species is distributed in semievergreen forest of Thenmala. Remaining 3 species are namely *H. macrocarpa*, *H. pendulus* and *H. longipedunculatus* are highly endemic found in evergreen forest at an altitude of 500-1000mtr.

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Phytoplankton assessment of Heart Lake, Western Ghats, Kerala

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Introduction

Despite of the known benefits of algae, freshwater algal studies are very limited. Even in biodiversity hotspots like Western Ghats, where algal wealth is expected not as much exploration of algae is conducted. Assessment of algae is important as it correlates to the natureof waterbody and divulge its algal diversity. So, we decided to ascertain algae in Heart Lake residing on Chembra Peak. The Lake is pristine and has very fewer human interventions.

Materials and Methods

Study site

Heart Lake (Figure 1) is situated in Chembra peak of Wayanad with elevation of 2100m. Chembra peak is the highest peak in Wayanad hills and one of the highest peaks in Western Ghats.

Figure 1: Heart Lake

Methodology

Systematic random sampling methods were adopted for collecting the water samples from the Heart Lake seasonally for June 2019-June 2020. Collected water sample is kept for settling and algal analysis is done. Collections were preserved in 4% formalin for further study.

Photomicrographs of various taxa are taken with the help of MICAPS digital camera attached to Labomed LX 400 microscope and are transferred to the computer for further analysis. Identification was done using standard literatures.

Results

Forty-two taxa of algae were identified representing four classes of algae (Table1). Class Chlorophyceae represents more species (21) followed by Bacillariophyceae (14). Class Euglenophyceae represents six species and Dinophyceae by one species.

	Algae	Class
1	*Monoraphidium contortum* (Thuret) Komárková-Legnerová	Chlorophyceae
2	*Golenkiniopsis minutissima* (M.O.P.Iyengar & M.S.Balakrishnan) R.Starr	Chlorophyceae
3	*Schroederia indica* Philipose	Chlorophyceae
4	*Scenedesmus quadricauda* (Turpin) Brébisson	Chlorophyceae
5	*Scenedesmus acuminatus* (Lagerheim) Chodat	Chlorophyceae
6	*Pediastrum tetras* (Ehrenberg) Ralfs	Chlorophyceae
7	*Pediastrum duplex* Meyen	Chlorophyceae
8	*Ankistrodesmus falcatus* (Corda) Ralfs	Chlorophyceae
9	*Tetrastrum heteracanthum (Nordstedt) Chodat*	Chlorophyceae
10	*Mucidosphaerium pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz	Chlorophyceae
11	*Oocystis sp*	Chlorophyceae
12	*Staurastrum tetracerum* Ralfs ex Ralfs	Chlorophyceae
13	*Staurastrum crenulatum* (Nägeli) Delponte	Chlorophyceae
14	*Cosmarium margaritatum* (P.Lundell) J.Roy & Bisset	Chlorophyceae

15	*Cosmarium cucurbita* Brébisson ex Ralfs	Chlorophyceae
16	*Cosmarium cucurbitinum* var. *truncatum* Willi Krieger	Chlorophyceae
17	*Cosmarium speciosum* P.Lundell	Chlorophyceae
18	*Cosmarium decoratum* West & G.S.West	Chlorophyceae
19	*Cosmarium trilobulatum* Reinsch	Chlorophyceae
20	*Euastrum neosinuosum O.V.Anissimova & Guiry*	Chlorophyceae
21	*Euastrum luetkemuelleri* F.Ducellier	Chlorophyceae
22	*Pinnularia panhalgarhensis* H.P.Gandhi	Bacillariophyceae
23	*Navicula pupula* Kützing	Bacillariophyceae
24	*Navicula cryptocephala* Kützing	Bacillariophyceae
25	*Surirella tenera* W.Gregory	Bacillariophyceae
26	*Synedra ulna* (Nitzsch) Ehrenberg	Bacillariophyceae
27	*Synedra acus* Kützing	Bacillariophyceae
28	*Cymbella pusilla* Grunow	Bacillariophyceae
29	*Frustulia saxonica* Rabenhorst	Bacillariophyceae
30	*Fragilaria sp*	Bacillariophyceae
31	*Neidium sp*	Bacillariophyceae
32	*Eunotia sp*	Bacillariophyceae
33	*Stauroneis phoenicenteron* (Nitzsch) Ehrenberg	Bacillariophyceae
34	*Cymbella pseudocuspidata* H.P.Gandhi	Bacillariophyceae
35	*Surirella subsalsa* W.Smith	Bacillariophyceae
36	*Trachelomonas volvocinopsis* Svirenko	Euglenophyceae
37	*Trachelomonas lacustris* Drezepolski	Euglenophyceae
38	*Euglena proxima* P.A.Dangeard	Euglenophyceae
39	*Euglena acus* (O.F.Müller) Ehrenberg	Euglenophyceae
40	*Monomorphina splendens* (Pochmann) T.G.Popova	Euglenophyceae
41	*Phacus* sp	Euglenophyceae
42	*Peridinium* sp	Dinophyceae

Table 1: Checklist of algae

Out of twenty algal genera listed by Palmer (Palmer, 1969), six genera were present in the lake. Palmer's pollution index of algal genera for Heart Lake was calculated as 18 which indicates organic pollution (Table 2).

Algal genera	Index value
Ankistrodesmus	2
Euglena	5
Navicula	3
Scenedesmus	4
Synedra	2
Phacus	2
TOTAL	18

Table 2: Palmer's algal pollution index value for Heart Lake

Trophic status of the lake can be determined by relative numbers of Chlorococcales and Desmidiaceae species through Chlorophycean quotient (Brook, 1965).

$$\text{Chlorophycean quotient} = \frac{\text{Chlorococcales}}{\text{Desmidiaceae}}$$

A total of 11 Chlorococcales and 10 Desmidaceae species is identified resulting Chlorophycean quotient of 1.1. The value indicates slight eutrophy in the lake as the value is greater than 1.

Conclusion

Hidden algal flora of Heart Lake is revealed by the study. Expected algal diversity is obtained. The calculated Palmer pollution Index shows moderate rate of organic pollution in Lake. The lake is found to be slight eutrophic as per Chlorophycean quotient. As human interventions are very limited in the Lake, the reason might be natural causes like flood, drought, weathering ofrocks or climate change in the area.

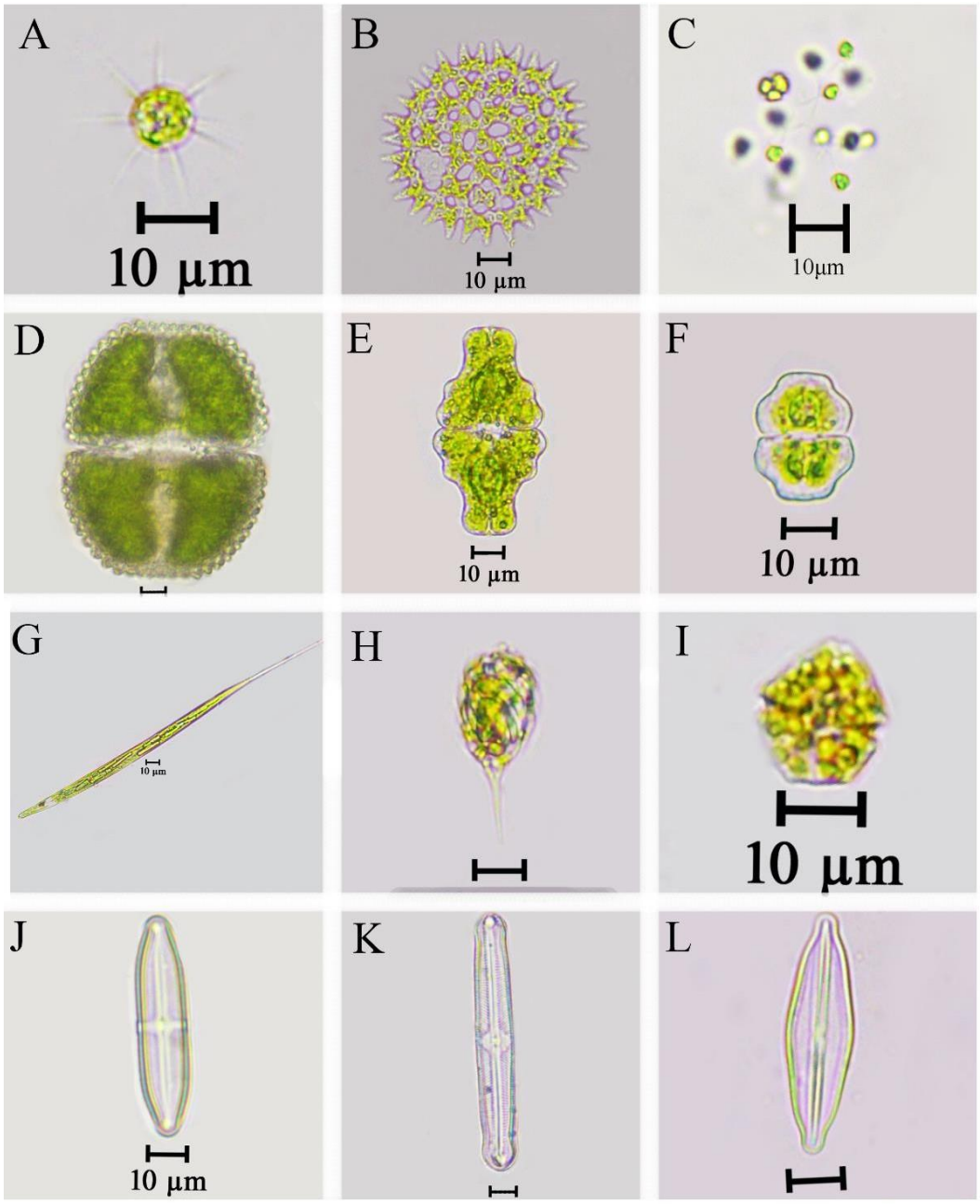

PLATE 1: A) *Golenkiniopsis minutissima* (M.O.P.Iyengar & M.S.Balakrishnan) R.Starr B) *Pediastrum duplex* Meyen C) *Mucidosphaerium pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz D) *Cosmarium decoratum* West & G.S.West E) *Euastrum neosinuosum O.V.Anissimova & Guiry* F) *Cosmarium trilobulatum* Reinsch G)*Euglena acus* (O.F.Müller) Ehrenberg H) *Monomorphina splendens* (Pochmann)T.G.Popova I) *Peridinium* sp J) *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg K) *Pinnularia panhalgarhensis* H.P.Gandhi L) *Frustulia saxonica* Rabenhorst

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Taxonomy and Distribution of Euglenoids in Kalpathy River, Palakkad

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Abstract

The present investigation aims to assess the taxonomy and distribution of euglenoids in Kalpathy River, tributary of Bharathapuzha River. During the algal study, a notable diversity of Euglenoids were observed. 22 taxa were identified belonging to 5 genera *Euglena, Phacus, Lepocinclis, Trachelomonas* and *Strombomonas* during the year 2018-2019. The heterogeneity and diversity of phytoplankton observed in this study shows the river to be eutrophic. This is the first documented report on the diversity of euglenoids from Kalpathy River.

Introduction

Photoautotrophic euglenophytes are cosmopolitan and mostly unicellular and free-swimming forms. They usually seen in rich with organic substances during the summer months when the water temperature is raised and the light levels are high. Euglenophytes are microscopic forms of eukaryotic organization usually with two flagella for locomotion, an undifferentiated cell wall and chloroplasts. These green euglenoids in a freshwater environment are usually pollution tolerant and their abundance and diversity indicates the quality status of the water. The present study on these bioindicators may serve as a baseline data for further quality monitoring approaches in Kalpathy River, Palakkad district.

Materials & Methods

Study area

The River Bharathapuzha is a major west flowing and second longest river in Kerala. Kalpathy River, one of the tributary of Bharathapuzha originates from

Anamalai hills and flows through Thathamangalam and Chittur areas of Palakkad District. The river Kalpathy is named after the Kalpathi Siva temple in Palakkad town. The average rainfall in the river basin is 1828 mm. Many areas of this river exploited to dumping yard of wastes from surroundings. People from the nearby used for washing and bathing. This area was highly affected by flood.

Figure 1. Sampling sites from Kalpathy River, Palakkad

Methodology

The phytoplankton diversity and environmental characteristics were analysed during the year 2018-2019. The samples were transferred into 1000ml capacity properly labelled plastic containers and immediately preserved with 4% formalin solution. Each sample concentrated to 10ml volume in the laboratory by centrifugation and this were used for slide mount for microscopic examination. Identification of phytoplankton organisms was done by reference to standard literatures like Philipose 1967, 1984, 1988: Prescott 1982; Wolowski 1998 etc.

Results & Discussion

Genus	Number of taxa
Euglena	9
Phacus	4
Lepocinclis	2
Trachelomonas	4
Strombomonas	3
Total	**22**

Division : **Euglenophyta**
Class : **Euglenophyceae**
Order : **Euglenales**
Family : **Euglenaceae**

Genus: ***EUGLENA*** Ehrenberg

1. *Euglena acus* Ehr.
Philipose, 1984. p.564, fig. 1f
Cell length - 83µm, breadth - 20µm. Cells elongate, spindle shaped, produced posteriorly into a long, fine tapering point, narrowed and truncate at the anterior end.

2. *Euglena agilis* Carter
Wolowski,1998. p.27, fig. 78
Cell length - 30µm, breadth - 13µm. Cells short, fusiform, chloroplast many with pyrenoids.

3. *Euglena acus* Ehrenberg var. ***acus*** (Starmach)
Wolowski,1998. p.13, fig. 9
Cell length - 125µm, breadth - 10µm. Cells long, fusiform, narrow at the anterior end, tapering towards posterior.

4. *Euglena anabaena* Mainx var. ***anabaena***

Wolowski,1998. p.28, fig. 88

Cell length - 30µm, breadth - 19µm. Cells wide, fusiform, narrowing towards the anterior end.

5. *Euglena deses* fo. ***deses*** (Pringsheim)

Wolowski,1998. p.38, fig.125

Cell length - 68µm, breadth - 12µm. Cells oblong cylindrical, flattened with many chloroplasts, band shaped, narrow projection at posterior end.

6. *Euglena deses* fo. ***intermedia*** Klebs

Wolowski,1998. p.39, fig.130

Cell length - 102µm**,** breadth - 12µm. Cells cylindrical, truncate at the anterior end.

7. *Euglena deses* fo. ***klebsii*** (Lemmermann) Popova

Wolowski,1998. p.38, fig.128

Cell length - 61µm, breadth - 10µm. Cells longitudinally cylindrical, flattened with many chloroplasts.

8. *Euglena ettlii* Wolowski

Wolowski,1998. p.26, fig.72

Cell length - 41µm, breadth - 10µm. Cells wide fusiform, tapering towards anterior end, posterior end with short tail.

9. *Euglena oxyuris* Schmarda fo. ***Oxyuris*** Popova

Wolowski,1998. p.15, fig. 21

Cell length - 125µm, breadth - 25µm. Cells slightly twisted, rounded at anterior end, posterior with short tail.

Genus: ***PHACUS*** Dujardin

10. *Phacus curvicauda* Swirenko

Prescott, 1982. p. 399, pl. 87, fig. 14

Cell length - 27µm, breadth - 23µm. Cells ovoid, anterior end broadly rounded, chloroplast numerous.

11. ***Phacus orbicularis*** fo. ***communis*** Popova

Wolowski,1998. p.76, fig. 260

Cell length - 47µm, breadth - 28µm. Cells wide, oval with posterior caudus.

12. ***Phacus orbicularis*** Hubner fo. ***orbicularis***

Wolowski,1998. p.76, fig. 260

Cell length - 62µm**,** breadth - 35µm. Cells wide, oval with long curved posterior caudus.

13. ***Phacus pseudoswirenkoi*** Prescott

Prescott, 1982. P. 402, pl. 85, fig. 26

Cell length - 45µm, breadth - 27µm. Cells with posterior caudus short, sharp and curved, anterior end broadly rounded with large circular disc.

Genus: ***LEPOCINCLIS*** Perty

14. ***Lepocinclis fusiformis*** **(**Carter) Lemm. Emend. Conrad

Philipose, 1984. p.512, fig. 7a

Cell length - 44µm, breadth - 27µm. Cells broadly ovoid, obtuse ends, posterior end with a short caudus.

15. ***Lepocinclis ovum*** (Ehr.) Minikiewic var. ***ovum*** Starmach

Wolowski,1998. p.66, fig. 210

Cell length - 37µm, breadth - 23µm. Cells broadly ovoid, end broadly rounded, posterior end with caudus.

Genus: ***TRACHELOMONAS*** Ehrenberg

16. ***Trachelomonas abrupta*** (Swir.) Deflandre

Prescott, 1982. p. 410, pl. 83, fig. 18

Cell length - 27µm, Cell breadth - 15µm. Cell broadly oval, wall coarsely punctate, truncate at the anterior end.

17. ***Trachelomonas armata*** (Ehr.) Stein.

Prescott, 1982. p. 410, pl. 83, fig. 32

Cell length - 25µm, Cell breadth - 35µm. Cell broadly ovate and flagellum aperture in a collar.

18. ***Trachelomonas armata*** (Ehr.) Stein. var. ***longispina*** (Playf.) Defl.

Prescott, 1982. p. 411, pl. 83, fig. 27

Cell length - 40µm, breadth - 29µm. Cell obovate, reddish brown, with collar, posterior end short spines.

19. ***Trachelomonas hispida*** (Perty) Stein emend. Defl.

M T Philipose, 1988. p.344, fig. 8a

Cell length - 15µm**,** breadth - 24µm. Cell ellipsoid, covered with short spines, very much depressed collar with few spines, reddish brown.

Genus: ***STROMBOMONAS*** Deflandre

20. ***Strombomonas fluviatilis*** (Lemm.) Defl.

Islam and Irfanullah, 2005a. pl. 3, fig. 44

Cell length - 43µm, breadth - 25µm. Cell with tail, lorica light brown colour.

21. ***Strombomonas girardiana*** (Playf.) Defl.

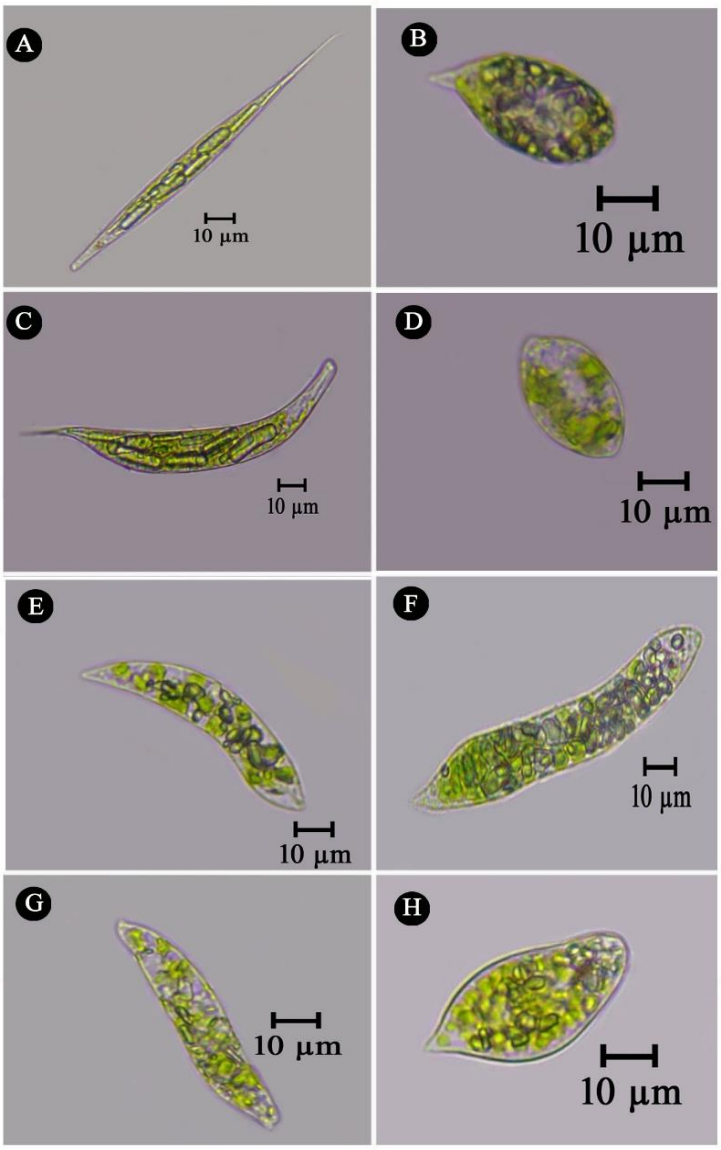
Philipose, 1988. p.379, fig. 53

Cell length - 42µm, breadth - 23µm. Cell light brown colour, tail short.

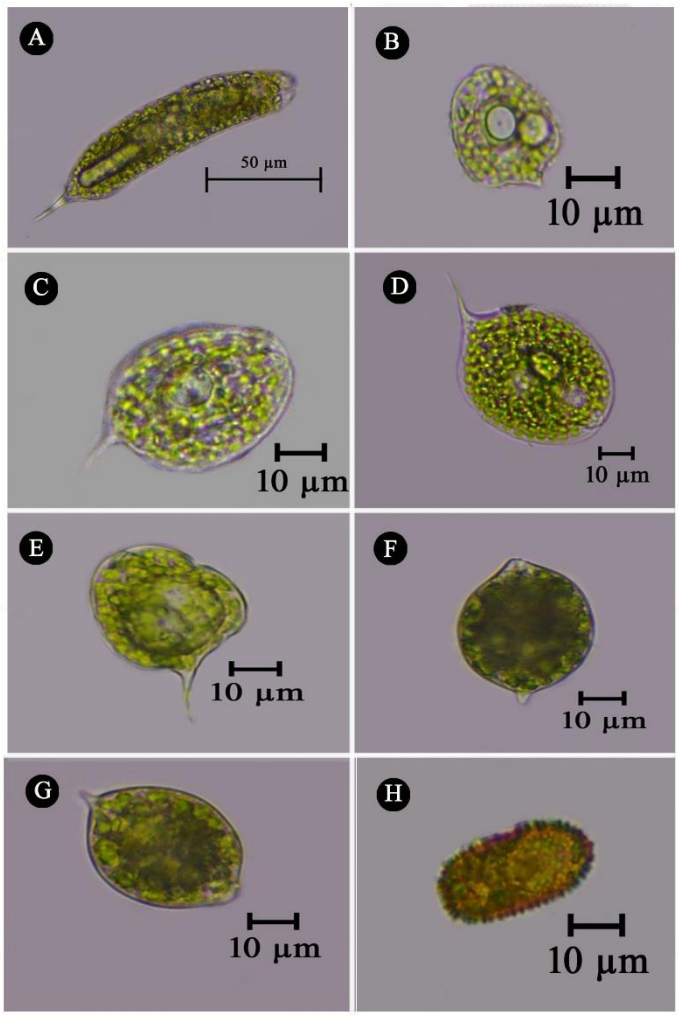
22. ***Strombomonas gibberosa*** (Playf.) Defl.

Philipose, 1988. p.385, fig. 62b

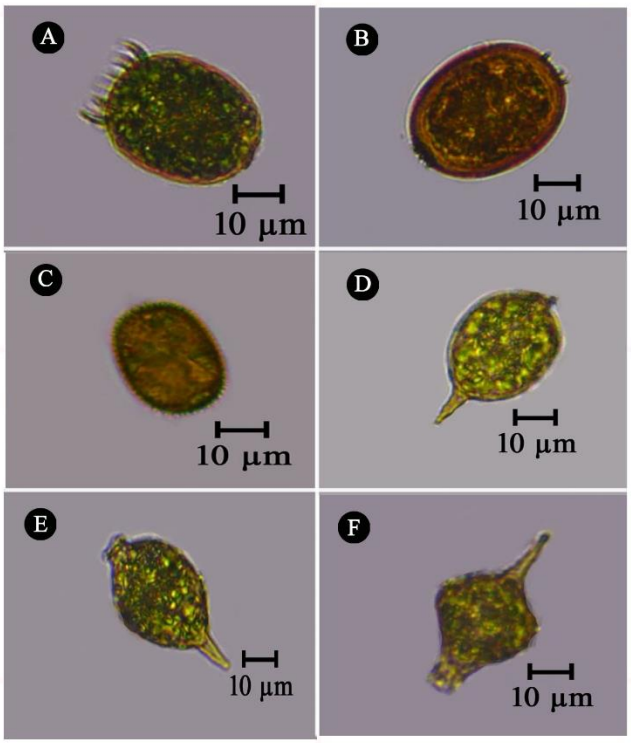
Cell length - 48µm, breadth - 25µm. Cell rhomboid with median angular, lorica light brown colour.



A. *Euglena acus* Ehr. **B.** *Euglena agilis* Carter **C.** *Euglena acus* Ehrenberg *var. acus* **D.** *Euglena anabaena* Mainx *var. anabaena* **E.** *Euglena deses fo. deses* **F.** *Euglena deses fo. intermedia* Kleb **G.** *Euglena deses fo. klebsii* Popova **H.** *Euglena ettlii* Wolowski



A. *Euglena oxyuris* Schmarda fo. *Oxyuris* Popova **B.** *Phacus curvicauda* Swirenko **C.** *Phacus orbicularis* fo. *communis* Popova **D.** *Phacus orbicularis* Hubner fo. *orbicularis* **E.** *Phacus pseudoswirenkoi* Prescott **F.** *Lepocinclis fusiformis* (Carter) Lemm. **G.** *Lepocinclis ovum* (Ehr.) Minikiewic var. *ovum* Starmach **H.** *Trachelomonas abrupta* (Swir.) Deflandre



A. *Trachelomonas armata* (Ehr.) Stein **B.** *Trachelomonas armata* (Ehr.) Stein var. *longispina* (Playf.) Defl. **C.** *Trache hispida* (Perty) Stein emend. Defl. **D.** *Strombomonas fluviat* (Lemm.) Defl. **E.** *Strombomonas girardiana* (Playf.) Defl. **F.** *Strombomonas gibberosa (Playf.) Defl.*

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Floral biology and phenology of *Impatiens violacea* (Balsamnaceae), an endemic balsam of Western Ghats

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Abstract

One of the endemic species of Western Ghats – *Impatiens violacea,* is collected from the type locality. Its floral biology and phenology is studied and presented here.

Key words: Endemic species, *Impatiens violacea,* Western Ghats

Introduction

Balsams or "jewel weeds" are the plants bearing beautiful flowers comprising the family Balsaminaceae. The genus *Impatiens* includes about 1000 species mainly located in the tropical and subtropical regions of the old world as well as in the Northern temperate regions (Gogoi *et al.* 2020). In India, the genus is represented by more than 210 taxa, among this, more than 106 species of *Impatiens* are endemic to the Western Ghats, and nearly 90 taxa are endangered.

Epiphytic species of the genus *Impatiens* are very attractive and strictly endemic to different parts of Western Ghats. *Impatiens violacea* is one of the epiphytic species endemic to Pettimudy, Munnar, Idukki, Kerala. Authors collected this species, during the floristic exploration conducted in this region. Floral biology and phenology of this species is studied and presented here.

Materials and method

The study area includes pettimudi, near Munnar located in the Idukki district of Kerala. This region is famous for its luscious green vegetation and huge number of endemic species. Fresh specimens of *Impatiens violacea* was collected from this region.

Specimens are labeled and kept in sealed polythene covers. Photographs of habit are taken using digital camera. Phenology of the species is recorded during the field survey.

Results and discussion

Impatiens violacea M.Kumar & Sequiera

Following are the morphological and floral characters of *Impatiens violacea*

Epiphytic on trees, stoloniferous herbs, upto 12 cm high; stem 0.5-2 cm diameter, monoliform, branched, stout, fleshy, rough, with persistent leaf scare, purple coloured; leaves 3-4x2-3 cm, crowded at apex, alternate, ovate to elliptic, apex acute, margins crenated, bristles present on each crenules, bristles dark violet coloured, 4-5 pairs of nerves, green with violet tinge on adaxial side, light green abaxialy, glabrous; petioles upto 3.5 cm long, channeled, 1-3 pairs of glands at the base, light green with purple tinge; Inflorescence axillary, 3-5 flowers in a cluster, peduncle 2.5-3 cm long, green, glabrous; pedicel 3-3.5 cm, teret, violet, glabrous; bracteolate 5 mm long, green; flowers upto 2 cm long, lateral sepals 7 x 2 mm, thick, elliptic, tip acute, green except at base, base violet, glabrous; lower sepal spured, spur 1.5 x 0.8 cm, saccate, wrinkled, tip curved, blue coloured, glabrous; standared petal 6.9 x 6 mm, orbicular, keeled, thick nerves present, light green, glabrous; keel 6.9 x 1.1 mm dark green; wing petal inserted into spur, bilobed, basal lobe 5.3 x 4.6 mm, wrinkled, thick, light green, glabrous, distal lobe 9.5x6 mm, wrinkled, margin curved inward, light green; androecium syngenicious, filament 4.9 mm long, light yellow, anthers five, yellow; ovary 4.8 mm long, elliptic, light green, slightly pubescent.

Phenology of *Impatiens violacea* – the plants begin to appear on the onset of monsoon season that is June. Plants become fully matured by July end. Flowers start appearing from August onwards. Flowers remain intact for about three weeks. Fruits are produced from September onwards. After ripping seeds are dispersed by forceful bursting of fruit. Flowering and fruting continue till November.

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Genus *Ophioglossum* fromThrissur District, Kerala

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Abstract

The Adders toungue fern *Ophioglossum* is a Eusporangiate fern belonging to family Ophioglossacea. Thrissur district of Kerala was not well explored yet for *Ophioglossum* genus. So, a taxonomic investigation for *Ophioglossum* in Thrissur district results in the collection of four *Ophioglossum* species namely*, O. costatum O. gramineum, O. lusitanicum and O. raphaelianum.*Their morphological description and photographs are given in the paper.

Keywords: *Ophioglossum*, Thrissur, Kerala

Introduction

The family Ophioglossaceae was discovered by Bauhin (1620) and Linnaeus (1753) confirmed the generic status of Ophioglossum in his "Species plantarum". The *Ophioglossum* genus is not well studied in Kerala, especially in Thrissur District due to its smaller size, distribution in the pocketed areas and its occurance only during the rainy season. The plant body is small having a small underground rhizome, tropophyll and a fertile spike. During this study we could collect four *Ophioglossum* species namely*, O. costatum O. gramineum, O. lusitanicum and O. raphaelianum*.

Methodology

Fresh *Ophioglossum* plants were collected from different localities of Thrissur district (Fig.1). Photographs from the field were taken using Canon 01 camera and Canon ixus 115 H5 camera. Morphological characters of Rhizome, Trophophore, Trophophyll, Strobilus were studied and Photographs were taken using LABOMED CCD stereomicroscope and Leica S8AP0 microscope.

Results

***Ophioglossum costatum* R.Br.** Prod. Fl. Nov. Holl. 163 (1810). Panigrahi & Dixit, Proc. Nat. Inst. Sci. India 35: 249 (1969); Frazer Jenkins Taxo. Rev. Three Hund. Ind. Pterido. 19 (2007).

Ophioglossum brevipe Bedd., Ferns. Southern India 23. t. 72 (1863).

Ophioglossum bulbosum Bedd. Ferns. Brit. India Supl. t. 28, (1876). (Fig. 2)

Plants 23- 25cm high, rhizome hemi spherical, corm like, rhizoids 1 cm-5.5 cm long, tropophyll dark green, glabrous, 6-8 cm long, 1.5-2 cm wide, lanceolate-elliptic, base cuneate, margine entire, acute or obtuse apex, fertile strobilus 8-12 cm long, 32-39 sporangia, alternate.

Disttribution: Kallampara,1°00'0.0" N, 1°00'0.0"E , Cheruchakkichola, 10.7002° N, 76.1993°E.

***Ophioglossum gramineum* Willd.** Nov. Act. Acad. Erfurt. 2: 18. t. f. 1 (1802); Beddome, Handb. Suppl. Ferns Brit. India 108. 1892; Balakrishnan *et al.*, Bull. Bot. Surv. India 2: 337 (1960)

Ophioglossum clietrichiae Prantl, Ber. Deut. Bot. Ges. 1: 352 (1883).

Ophioglossum dietrichiae Prantl, Ber. Deut. Bot. Ges. 1: 352 (1883).

Ophioglossum gregarium Christ, Nova Guinea Bot. 8: 164 (1909). (Fig. 3)

Plants green, grass like, 3-6 cm high, growing together with gramminae members; rhizome cylindrical, tuberous, two-four tropophylls, narrowed, linear, acicular, glabrous, acute at the apex, peduncle 1.2–3.5 cm long, strobilus up to 1 cm long, 9-10 sporangia per spike, alternate.

Distribution: Kallampara**,**1° 00' 0.0" N, 1° 00' 0.0" E**,** Pazhiyottumuri10.6836° N, 76.1421° E

Ophioglossum lusitanicum Linn. sp. Pl., 2: 1063, 1753; Clausen, Mem. Torry Bot. Club, 19 (2): 159, 1938; Mahable, Bull. Bot. Surv. India, 4: 71, 1962.

O. vulgatum var. *lusitanicum* (L).Hook. f (Fig. 4)

Plants 2-3 cm high, dark green; rhizome small, brown, tuberous; one- two trophophyll; trophophylls small, green, glabrous, lanceolate- elliptic, apex acute; strobilus short, 5-6 sporangia with a small pointed tip, alternate.

Distribution: Kallampara,1° 00' 0.0" N, 1° 00' 0.0" E, Vattayi, 10.6011° N, 76.2647° E, Peruvanmala, 10°37′20.86″N,76°8′6.5″E

O. raphaelianum Anto**,** Afs.Khan, F. Francis & I. Antony (Fig. 5)

Plants 2-5 cm high; rhizome subglobose, 0.2-0.6 cm long; tropophylls olivaceous-bluish green, subterranean, orbicular, minute, strobilus small with a sterile pointed apex; sporangia 6-7, opposite.

Distribution: Peruvanmala10°37′20.86″N**,** 76°8′6.5″E

Discussion

During this study we could collect four *Ophioglossum* species, *O. costatum O. gramineum, O. lusitanicum and O. raphaelianum* from different localities of Thrissur District. Among these O. *costatum* is the larger species, which is up to 25 cm high, and could be easily identified from the field by its large elliptic-lanceolate tropophylls (leaves) with central yellowish margins (costa) and corm like rhizome. Rests of the three species are smaller and they sizes up to 6 cm. Among these *O.gramineum* is distinguished by its erect needle like tropophylls, *O. lusitanicum* is distinguished by lanceolate-ovate tropophylls and *O. raphaelianum* is distinguished by its subterranean, olivaceous or bluish green coloured orbicular tropophylls.

Conclusion

Thrissur district of Kerala was not explored well for *Ophioglossum* genus. During our study we could collect four species from different localities. They are *O. costatum O. gramineum, O. lusitanicum and O. raphaelianum*

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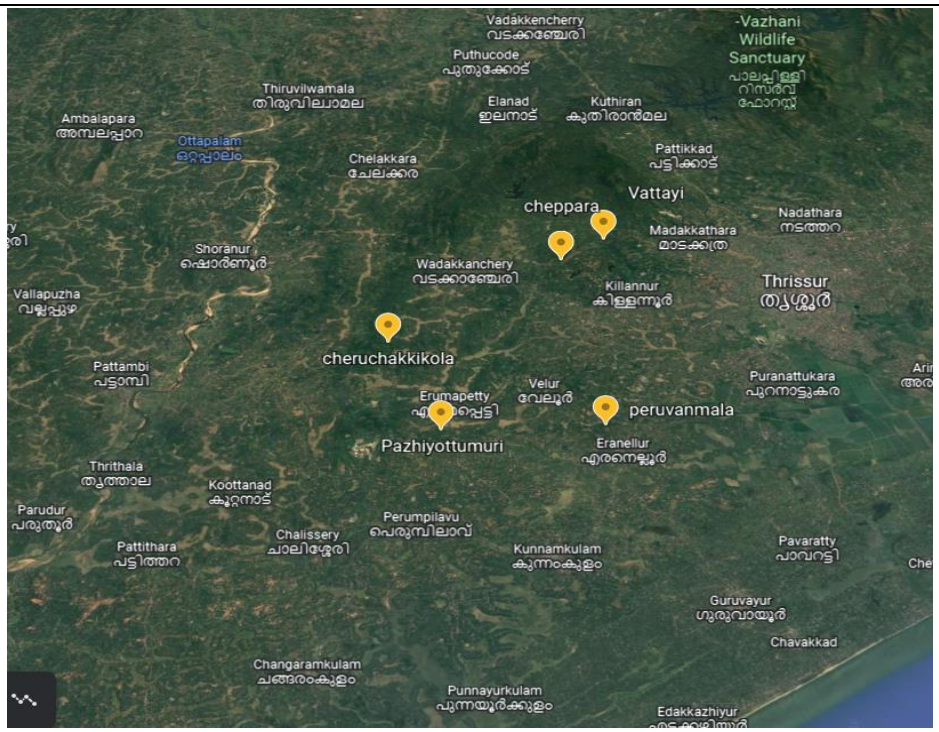

Fig.1. Geographical location of *Ophioglossum* plants in Thrissur District

Fig. 2. *O. costatum*

Fig. 3. *O. gramineum*

Fig. 4. *O. lusitanicum*

Fig. 5. *O. raphaelianum*

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Spatio-Temporal Variation of NDVI (Normalized Difference of Vegetation Index) of Thrissur District, Kerala

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Abstract

According to UN most of the urbanization will take place in developing countries. The rapid growth of global urbanization leads to land cover changes and affects the vegetation coverage, the surface albedo, the surface roughness and changes the urban environment and the near ground climate. The present study was mainly focused on to access the change of vegetation cover of Thrissur district, Kerala by using temporal change of NDVI as a parameter. The analysis did with the help of Landsat Thematic Mapper (TM) and OLI/TIRS remote sensing image data from 1992, 2002, 2013 and 2021. The result shows that, the area having the value of NDVI from 0.4-0.6 (moderate vegetation) decreases from 1992 to 2013 but shows narrow increase from 2013 to 2021. But the area of dense vegetation increases from 1992 (27.48%) to 2021 (67.18%). The area of sparse vegetation (0.2-0.4) decreases during the year 2021 when compared with the image of 1992. The discontinuous variation of temporal change of vegetation cover may be the impact of climate change or urban expansion.

Introduction

Urban area is expanding because of the migration of people from rural to urban area. By 2050 about 60% of the world population will reside in urban area (United Nations 2011). According to UN most of the migration will happen in developing countries. Most of the expansions cause transformation of non-urban area to urban area (Yanan *et al.* 2011; Yue *et al.* 2013). Urban area expansion cause serious changes in the land use and land cover pattern of earth surface like uncontrolled building constructions and other economic activities. These all changes cause serious environmental issues like change of land surface temperature (LST).

The understanding of how environmental changes affect the vegetation is very important for the predictions of effect of global warming, habitat degradation due to biodiversity loss (Pettorelli *et al.*, 2005). Normalized Difference Vegetation Index (NDVI) is perhaps the most popular metric used for the above purpose (Robinson *et al.*, 2017). NDVI is calculated by using NIR (Near Infra-Red) band and R (Red) band of the satellite image.

Present study is using remote sensing and Geographic Information system to access and analyze the data. Now remote sensing using satellite image is widely used for the estimation of land use land cover change, land surface temperature and urban heat island (Asgarian *et al.* 2015; j *et al.* 2015; Mohan and Kandya 2015; Rotem-Mindali *et al.* 2015; Xu *et al.* 2013; Deng and Wu 2012; Ma *et al.* 2010;) by temporal analysis (Mass 1999; Li and Yang 2004; Salman 2004; Yuan *et al.* 2005; Mallick *et al.* 2013; Mathew *et al.* 2016;). The satellite image of Landsat 5 (1992 & 2002) and Landsat 8 (2013 & 2018) was used for the study.

Thrissur, the central district of Kerala, India was selected for the study. The district has diverse natural ecosystem like kole wet lands, Mangroves, Forest etc. The city comprises 7 municipalities and small towns. According to UN most of the urbanizations is happening in small cities. Present study aims to analyze the temporal change of NDVI as a parameter to analyze the impact of human activity on natural habitat of an area with small cities.

Study Area:

Thrissur is the central district of Kerala and situated in southwestern part of India. It includes 10% population of Kerala. The latitude and longitude of the district is 10°10’30’’N to 10°47’30’’N and 75°58’00’’E to 76°53’30’’E respectively and has an area of 3032 sq. km. The district has an average summer temperature range from 22.5°C to 33°C while winter temperature ranges from 20°C to 29°C.

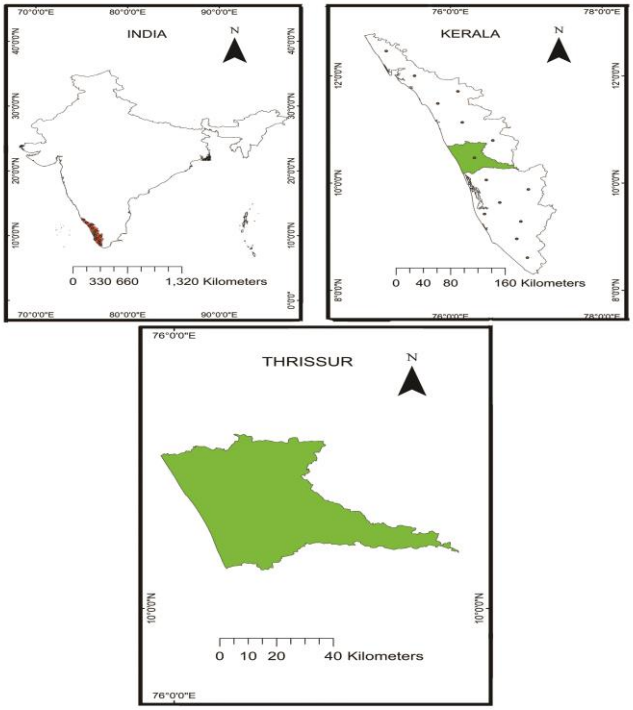


Fig:1 Location and sampling site of study area: http://div-gis.org/gdata

Data Source:

The satellite images downloaded from the Earth Explorer website of United States Geological Survey (USGS) were used in the study. The images of Landsat 5 (1991), Landsat 7(2001) and Landsat 8 OLI/TIRS (2013 & 2018) were used for spatiotemporal analysis and have a 30m spatial resolution.

satellite	Raw	Path	Date Of Accusation	Band Used	Sensor	Resolution
Landsat 5	144	53	31/12/1992	3 and 4	TM	30
Landsat 7	144	53	03/12/2002	3 and 4	ETM+	30
Landsat 8	144	53	07/11/2013	4 and 5	OLI/TIRS	30
Landsat 8	144	53	31/12/2021	4 and 5	OLI/TIRS	30

Table: 1, Shows satellite data

Methodology:

The landsat 5 and landsat 7 images were radiometrically corrected with the following equation (Landsat 7 Level-1 Data Format Control Book):

DN to At Sensor Radiance:

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{QCALMAX - QCALMIN}\right) * (QCAL - QCALMIN) + LMIN_\lambda$$

QCAL = Quantized calibrated pixel value in DN

LMINλ = Spectral radiance scaled of QCALMIN in (Watts/ (m² * sr * µm))

LMAXC = Spectral radiance scaled of QCALMAX in (Watts/ (m² * sr * µm))

QCALMIN = Minimum quantized calibrated pixel value of the image

QCALMAX = Maximum quantized calibrated pixel value of the image

Radiance to Top of Atmospheric Reflectance:

$$\rho p = \frac{\pi * L_{\lambda * \mathrm{d}^2}}{ESUN\lambda * \cos\theta s}$$

π= Mathematical constant (3.14159)

$L\lambda$ = Spectral radiance (at the sensor's aperture)

d = Earth-Sun distance

ESUNλ= Mean solar exo-atmospheric irradiance

Cosθs = Solar zenith angle (degrees)

The landsat 8 image was radiometrically corrected with the following equation (Landsat 8 Level-1 Data Format Control Book):

OLI and TIRS at Sensor Spectral Radiance:

$$L\lambda = ML * Qcal + AL$$

Lλ = Spectral radiance of unit W/ (m2 * sr * µm)

ML = Radiance multiplicative scaling factor

AL = Radiance additive scaling factor

Qcal = Level 1 pixel value

Radiance to Top of Atmospheric Reflectance:

$$\rho\lambda' = M\rho * Qcal + A\rho$$

ρλ' = TOA Planetary Spectral Reflectance, without correction for solar angle.

Mρ = Reflectance multiplicative scaling factor

Aρ = Reflectance additive scaling factor

Qcal = Level 1 pixel value

Note that ρλ' is not true TOA Reflectance, so it does not contain a correction for the solar elevation angle. And can correct to solar angle by using the following equation

$$P\lambda = \frac{P\lambda'}{\text{Cos}(\theta_{SZ})} \quad = \quad \frac{P\lambda'}{Sin\theta_{SE}}$$

ρλ = TOA planetary reflectance

θSE = Local sun elevation angle

θSZ = Solar zenith angle; θSZ = 90° - θSE

NDVI is calculated using the reflectance ratio of Red-Infrared region.

$$\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}$$

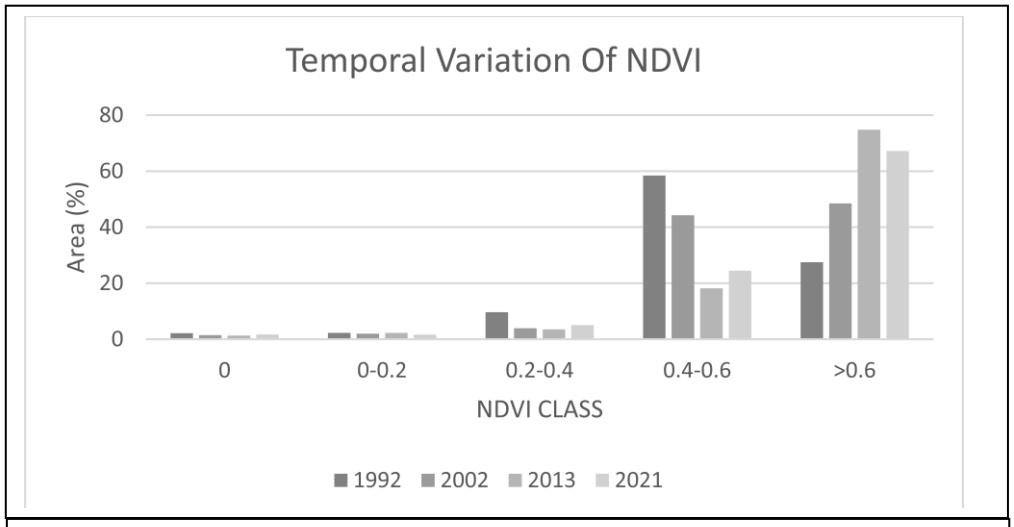
In the above equation NIR and RED represents the Near Infrared and Red light respectively which are reflected and captured by the satellite sensors. The reflectance of RED and NIR is used because the green leaves of healthy vegetation absorb the blue and red wavelengths of the electromagnetic spectrum for photosynthesis and reflect NIR region due to internal-leaf scattering. NDVI value varies with total vegetation cover from -1 to 1. In the present study the value of NDVI is divided into 4 classes, negative values of NDVI (<0) correspond to water and manmade surfaces, Values 0-0.2 generally correspond to barren areas, sand, or snow. The value between 0.2-0.4 was classified as sparse vegetation cover and the area having value between 0.4-0.6 was classified as moderate vegetation. The value of NDVI above 0.6 was considered as dense vegetation.

Result and Discussion

The lowest value for NDVI for the year 1992, 2002, 2013 and 2021 was near to -0.76,-0.32,-0.50 and -0.85 respectively and the highest value for the years was near to 0.81, 0.81, 0.85, and 0.86 respectively.

NDVI CLASSES	NDVI CLASS FEATURE	1992	2002	2013	2021
<0	Other LULC (eg: Water bodies)	2.15	1.45	1.31	1.68
0-0.2	Barren land	2.27	1.96	2.25	1.62
0.2-0.4	Sparse Vegetation	9.67	3.92	3.5	5.08
0.4-0.6	Moderate Vegetation	58.44	44.22	18.15	24.45
>0.6	Dense vegetation	27.48	48.46	74.8	67.18

Table: 2, Shows temporal variation of NDVI



Graph showing temporal variation of NDVI

The area having NDVI below 0 was 2.15% of total area in 1992, which changed to 1.45% in 2002 and 1.13% in 2013 and finally 1.68% in 2021. The area under 0-0.2 class was 2.27% in 1992, 1.96% in 2002, 2.25% in 2013 and 1.62% in 2021. In the case of third class (0.2-0.4) of NDVI, total area during 1992 was 9.67%, during 2002, 2013 and 2021 it was 3.92%, 3.5% and 5.08% respectively. The area having NDVI value between 0.4- 0.6 for 1992, 2002, 2013 and 2021 was 58.44%, 44.22%, 44.22% and

24.45% respectively. The area having NDVI value above 0.6 was 27.48% in 1992 but after 27 year, the area of dense vegetation increased to 67.18%.

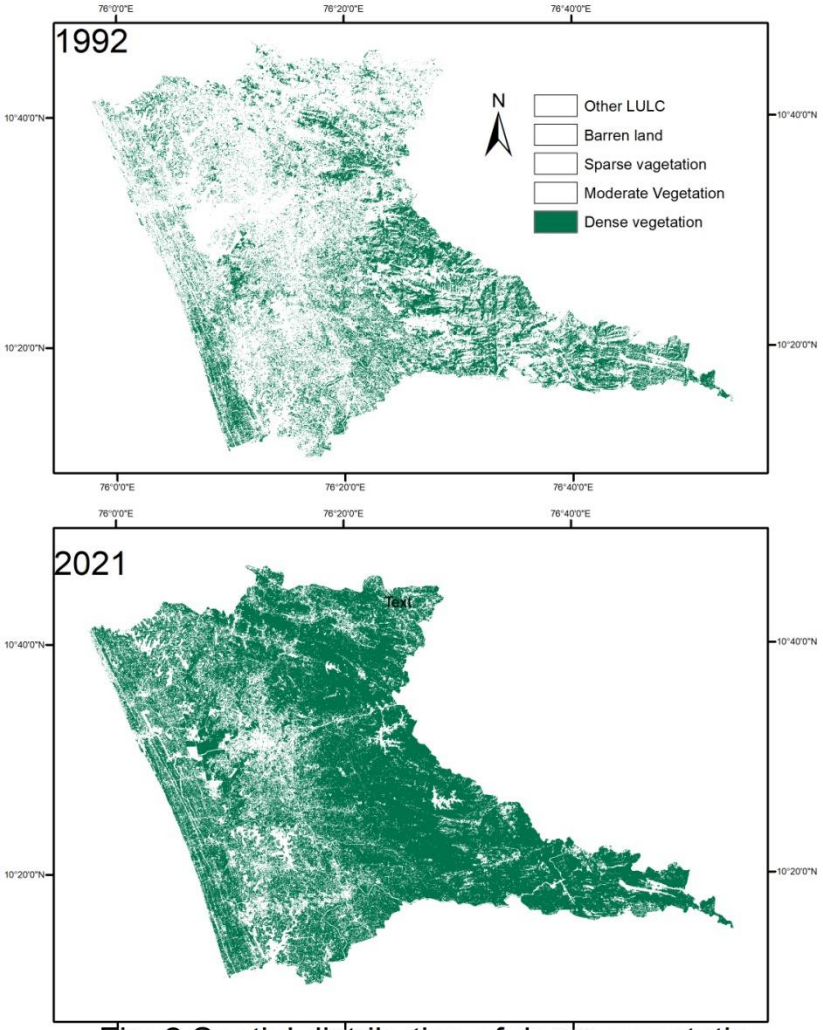


Fig: 2 Spatial distribution of dense vegetation during 1992 and 2021

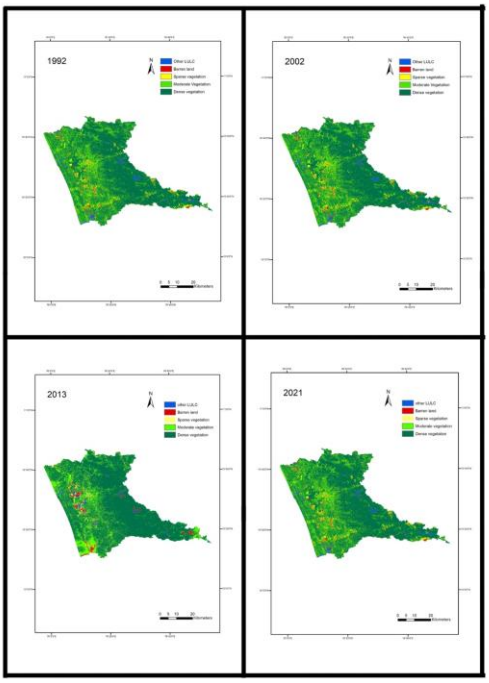


Fig 3: Showing temporal variation of NDVI

Conclusion:

The temporal variation of NDVI shows a drastic change of vegetation cover over Thrissur district. The area having the NDVI value between 0.4-0.6 (moderate vegetation) was 58.44% of study area in 1992 and decreased to 24.45% in 2021. The area having the NDVI value for dense vegetation was 27.48 % in 1992 and 67.18% in 2021. The result shows an increase in the area having dense vegetation and decrease the area with moderate vegetation during 27 years from 1992-2021. The temporal variation of NDVI can reveal where vegetation is thriving and where it is under stress, as well as changes in vegetation due to human activities such as deforestation, natural disturbances such as wild fires, or changes in plants' phonological stage (NASA USGS). Further studies are required to understand the factors driving the change of type of land cover to decisively draw a firm conclusion.

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A Preliminary study on Soil Fungi of Iringole Sacred Grove

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Abstract

In the present study, the soil samples were collected from four different sites in three seasons from the Iringole Sacred Grove located in Perumbavoor of Ernakulam District, Kerala. Soil samples were subject for the isolation of soil mycoflora. A total of 54, 45 and 26 species of fungi were isolated from Monsoon, winter and summer seasons respectively. And they belong to the following genera: *Aspergillus, Fusarium, Penicillium, Trichoderma, Mucor, Colletotrichum, Absidia, Fusarium, Moniliales, Geotrichum, Cephalosporium* and *Scopulariopsis.* Penicillium is the most dominating species followed by *Aspergillus and Trichoderma.* The fungal flora shows differences in each season and in each site in all the three seasons. Hence, we can conclude that each site in the sacred grove is different and hence conservation is necessary to save the diversity.

Key Words: Fungi, Sacred Groves, Iringolekavu, Mycology

Introduction

Fungi are the eukaryotic organisms that include microorganisms such as molds and yeast, but more familiar are mushrooms. Fungi are important component of the soil micro- biota, constitutes major portion of soil biomass than bacteria (Ainsworth and Bisby, 1995). A variety of ecosystem functions, vital in maintaining ecosystem stability is performed by soil mycoflora (Schlesinger, 1997). Still soil fungal diversity and their relationship between soil and plants remain unclear (Bridge and Spooner, 2001). Even though one third of the fungal diversity of globe exists in India, very few attempts have

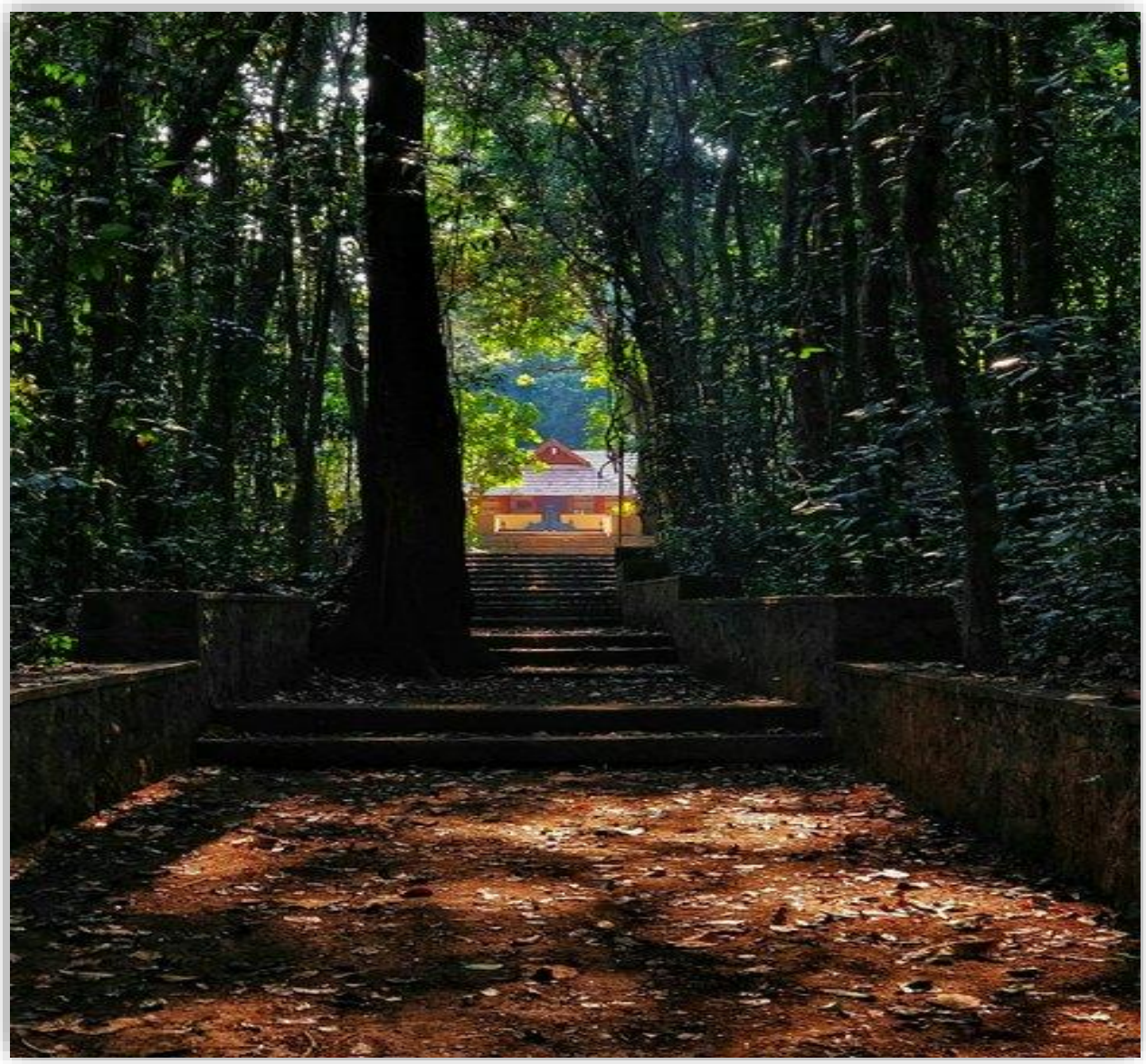
been made to study the fungal flora systematically. Vast tracts in India still remain unexplored for fungal diversity. In the present study we have planned to explore soil fungi from Iringole sacred Grove in Kerala.

Sacred groves have existed in Kerala as patches of densely vegetated areas. They are set aside on religious grounds and are distinct and unique in their biodiversity. Even though several studies are carried out in Sacred Groves about flora and fauna including macro fungi, micro fungi still remain uncovered. Iringole Sacred Grove is such a miniature forest with a very rich flora and fauna which includes valuable herbs; medicinal plants, monkeys, squirrel and mynah, located in Perumbavoor, Ernakulam District, Kerala where soil fungal studies are not yet carried out. Hence, soil micro-fungal study in Iringole Sacred Grove helps to contribute a lot to the fungal world. Also, it helps to study the fungi in its natural habitat. Iringole Sacred Grove is an undisturbed grove and hence it may be rich in fungal diversity andthere are possible chances to get new species of fungi.

Methodology

1. Study Area

Iringole Sacred Grove, one of the largest sacred groves, lies at $10^0$10" North latitude and $76^0$30" East latitude with hot and humid climate. The total area of the Sacred Grove is about 20.234 hectares and was the only grove of more than five hectares in the southern districts (Ramachandran and Mohanan, 1991). In the central part of the Grove, is located the ruling deity, *Iringole Kavil Amma*, who is considered as *Vana Durga*. The vegetation type of the Grove was reported as West Coast Tropical Evergreen type. Now the vegetation has changed to semi-evergreen type (Shanthakumar *et al.*, 2010). Iringole Sacred Grove is associated with two fresh water ponds. Total number of angiosperm species recorded in this sacred grove is about 185 species (Chandrasekhara, 2011). Total number of angiosperm species recorded in this sacred grove is about 185 species (Chandrasekhara, 2011).



2. Soil Sampling: Soil samples were collected from four sites during Monsoon, winter and summer Seasons from the Sacred Grove. The samples were collected aseptically from 0 to 10cm depth, kept in polythene-bags and carried to the laboratory for further studies.

3. **Isolation of Fungi:** Isolation of fungi was done using dilution plate method.

4. **Taxonomic Descriptions and Identification:** Both microscopic and cultural characters of each fungal isolates were recorded, in addition to details of collections, viz. date and place of collection, name of collector and accession number. The mycological features of fungi were noted. The Morphology based identification of

sporulating fungi was done using standard taxonomic keys and monographs (Barnet, 1960; Charles and Kenneth, 1945; Kenneth *et al.,* 1949).

Results and Discussion

In the Monsoon Season a total of 54 species belonging to 10 genera were isolated from 4 soil samples of which Zygomycetes – *Absidia,* Ascomycetes– *Colletotrichum, Scopulariopsis,* Hyphomycetes – *Aspergillus, Fusarium, Penicillium, Trichoderma,* Deuteromycetes – *Moniliales,* Saccharomycetes – *Geotrichum* were the major sporulating species. And Non-Sporulating fungi were also present. In that, the most dominating class is Hyphomycetes with *Penicillium, Aspergillus.*

In the Winter season a total of 45 species belonging to 7 genera were isolated from 4 soil samples of which Zygomycetes – *Mucor,* Ascomycetes–*Colletotrichum, Scopulariopsis* and Hyphomycetes – *Aspergillus, Fusarium, Penicillium, Trichoderma* were the major sporulating species. In that again Hyphomycetes is the dominating one with highest number of *Penicillium.*

And in the Summer season, a total of 26 species belonging to 4 genera from 4 soil samples were isolated of which Ascomycetes– *Cephalosporium,* Hyphomycetes – *Aspergillus, Fusarium, Penicillium* were the major sporulating species. Hyphomycetes dominates with highest number of *Aspergillus.*

The results obtained from the present work results are similar to Waksman (1916), Manoharachary (1977), Domsch *et al.,* (1980), Mangamma *et al.,*(1996). The dominating genera obtained in our study are *Penicillium* and followed by *Aspergillus* (Morrow, 1932; Warcup, 1950; Chou and Stephen, 1967 and Hasenekoglu (1985)). Hasenekoglu (1985) reported that *Penicillium* was the most common in terms of species and intensity in his research. *Aspergillus* and *Penicillium* were dominant in foreststsoil. Sarvanakumar and Kaviyarasan (2010) reported 76 taxa from montane wet temperate forest of Tamil Nadu, among these *Penicillium* and *Aspergillus* were dominated in both South West and North East monsoon. Asan (2004) reported that species belonging to the genera *Aspergillus* and *Penicillium* exist in greater numbers and more frequently than the other species in Turkey soil. But the present work is contradictory to the results of Rane and Gandhe (2006). Rane and Gandhe (2006) reported that *Aspergillus* was the dominant genus from the Madhudevi and Pal forest. Kambale and Patil (2009)

isolated 33 species of fungi, among them the most common genera were *Trichoderma, Aspergillus, Penicillium* and *Fusarium* and their result is correlating with the current results because these 4 genera were dominating in our results too.

In the present work Hyphomycetes dominates in the soil and represents 4 genera. This result is contradictory to the results of Danial *et al.,* (2010). He reported that most of the genera detected belonged to the Ascomycetes with a fewer belonging to class Deuteromycetes. But our result correlates with Siddiqui (2012). He reported that among 46 species, 39 species are Deuteromycetes and 2 species are Ascomycetes.

Summary and Conclusion

In the present study, soil fungi of Iringole Sacred Grove, the soil samples were collected from four different sites in three Seasons. Soil samples were subjected for the isolation of soil mycoflora. A total of 54, 45 and 26 species of fungi were isolated from Monsoon, winter and summer seasons respectively. And they belong to the following genera: *Aspergillus, Fusarium, Penicillium, Trichoderma, Mucor, Colletotrichum, Absidia, Fusarium, Moniliales, Geotrichum, Cephalosporium* and *Scopulariopsis.* The present study reveals that *Penicillium* sp. is dominating followed by *Aspergillus* and *Trichoderma.* The fungal flora shows differences in each season and in each site in all the 3 seasons. Hence, we can conclude that each site in the sacred grove is different and hence conservation is necessary to save the diversity.

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Ecological studies of Genus *Baccaurea* (Phyllanthaceae) in India

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Abstract

The genus *Baccaurea* was established by Loureiro in 1790 is belonging to the family Phyllanthaceae. The generic name *Baccaurea* is a Latin derived "bacca-aurea" referring to the golden yellow colour of the fruits. The genus comprises 173 species, extensively distributed from Indo-Malaysia to the West Pacific. Of these, only 4 species are native to Indian Subcontinent and only 2 species *viz B. courtallensis* and *B.ramiflora* are found in India. *B. courtallensis* is a medium-sized tree, endemic to South Western Ghats. It is usually seen in evergreen and semi-evergreen forests from South Canara southwards and adjoining western parts of Tamil Nadu to 914 m. *B .ramiflora* grows north eastern Himalayas in the primary or secondary evergreen forests, often on slopes, at elevations from 100 – 1,300 meters. The tree in mainly seen as second storey in forest. The distributions of both species are geographically disjunct due to Deccan plateau and Gangetic plain. Besides geographical isolation, the reproductive features and pollinating agents are probably responsible for species divergence and endemism of these species.

Keywords: *Baccaurea courtallensis, Baccaurea ramiflora,* Geographical isolation, Endemism.

Introduction

The genus *Baccaurea* was established by Loureiro in 1790 is belonging to the family Phyllanthaceae. The generic name *Baccaurea* has originated in two ways. One is Latin derived "bacca-aurea" referring to the golden yellow colour of the fruits and the other is based on fruit characteristic (*bacca* – Italian word that means berry, a simple

fruit that produced from single ovary) (Sofiyanti *et al.* 2022). The members of Genus *Baccaurea* are small trees, dioecious with male and female with flowers on separate plants. The most attractive feature of the genus is cauliflory (Inflorescence on the main trunk.). Inflorescences are borne as racemes forming clusters and globose fruits with sour-sweety arillode surrounded by leathery rind (Sivadasam *et al.* 2020). A total of 173 species has been published out of which 53 are accepted and 87 are synonyms (GBIF, POWO, www.theplantlist.org). The members of *Baccaurea* are distributed in southeast Asia, India Bhutan, Cambodia, Laos, Myanmar, Nepal, China, Vietnam; Pacific islands, China, New Guinea, Thailand, Malaysia, Indonesia (Sofiyanti, 2022).

Relation between environmental factors and evolution can be plainly explained by comparing distributions of closely related taxa which are ecologically similar but geographically separate. Most likely characters including geographical extent and tolerance of climate extremes are shared by related taxa at least in times past (Qian & Ricklefs, 2004).Understanding the ecology, biotic and abiotic factors and species response to the environment can provide an answer for species distribution (Gaston, 2003). Objective of the study is to assess the geographical (area and altitude) and climate (temperature and precipitation) distributions among *B.courtallensis* and *B.ramiflora.* (Salient features and botanical description are summarized in table 1 and 2 respectively).

Abiotic Factors

Climate plays an important role in determining plant distributions and diversity (Brown, 1995; O'Brien, 1998; Pearson and Dawson, 2003). Climatic condition includes temperature, rainfall and relative humidity. *B.courtallensis* grows in annual temperature of 28-30^{0}C, annual rainfall 1500-5000mm and relative humidity of 77% whereas *B.ramiflora* needs annual temperature of 28-30^{0}C, annual rainfall 2100-3000 mm and relative humidity of 65%-89%. Altitude range from 250-1500m above MSL is suitable for *B.courtallensis* and it is upto 900m for *B.ramiflora.* Both the plants prefer Tropical Evergreen and Semi-evergreen forest habitat. For example in evergreen and semi evergreen forests of Chimmoni forest, *B.courtallensis* show highest stand density (210) with associated species *Diospyros canarica, Hopea parviflora, polyalthia fragrans* etc (Vidyasagaran *et al.*, 2003). Similarly density of B.ramiflora in tropical semi-evergreen forest of Hollongapar Gibbon Wildlife Sanctuary, Assam, species density was

estimated with associated species *Camellia chinensis, Castanopsis indica, Dipterocarpus macrocarpus* etc (Bhuyan *et al.* 2002) (Table 3). Topography is a key factor strongly influencing the distribution of vegetation and plant species (Merriam, 1890; Whittaker, 1960; Coblentz and Riitters, 2004). Topography indirectly affects plant distributions by regulating other environmental factors such as soil conditions, hydrology, wind, temperature and fog frequency, as well as forest structure and dynamics (Svenning, 2001). Both species, *B.courtallensis* and *B.ramiflora* grow in hilly terrain.

Biotic Factors

Biotic interactions are significant element in composition and functioning of communities and thereby influence species distributions and diversity (Thomson, 2005).Vegetation structure and species interaction are included in biotic factors. The structure and composition of a community determines its microclimate and the surrounding vegetation (canopy) decides the light availability. *B. courtallensis* is a second storey tree species in an evergreen forest (Mohan 2009) but *B.ramifolra* is included in C-stratum or lower canopy in lowland tropical rainforest in North-east India (Deb and Sundriyal, 2011). Light gradients strongly influence species distributions in tropical forests as far as competition for light and shade tolerances are considered as growth factors (Carson and Schnitzer, 2008). Apart from vegetation structure, community functioning can be strongly affected by plant–plant interactions (Grace and Tilman, 1990; Bengtsson *et al.*, 1994), plant–animal interactions (Herrera and Pellmyr, 2002), as well as plant–pathogen interactions (Bradley *et al.*, 2008). At local scales plant–plant interactions affect species distributions by competition for resources (plant–plant interactions; Case *et al.*, 2005; Stoll and Bergius, 2005) and the plant- animal interaction by pollinators and frugivores.

Dispersal

The chance of a species being distributed in a given place is determined by mode of dispersal, occurrence and abundance of dispersers, and dispersal barriers. Due to physical barriers for dispersal, species often do not occur everywhere where the environment is suitable (Svenning and Skov, 2004; Gaston, 2009; Paul *et al.*, 2009). Animal being important seed dispersal agents in tropical regions, and their foraging

behavior may have strong influence on plant distribution (Jordano, 2000). As *baccaurea spp*. are predominantly animal dispersed (Mohan, 2009), frugivory and dispersal by vertebrates play a significant role. Natural propagation of both *B.courtallensis* and *B.ramiflora* are by recalcitrant seeds and hence moisture content of the seed and relative humidity of the habitat are the determinant elements for seed germination and seedling establishment. *B.courtallensis* seed with 50% moisture show highest germination percentage and (Yogesh *et al.*, 2016). Seeds of *B.ramiflora* show notable moisture loss and reduced lifespan as relative humidity declines (Wen and Cai, 2014). Time-limited expansion from place of origin or refugia (Svenning and Skov 2004, Paul *et al.* 2009) is also a delimiting factor in seed dispersal.

Future Prospects

Integration of phylogeny analysis of species is an innovation area in spatial ecology (Eiserhardt *et al.* 2011). Testing the significance of evolutionary rates for diversity patterns (Mittelbach *et al.*, 2007) relies on phylogenetic information. The genetic analysis to find the evolutionary relationship has been poorly documented in genus *Baccaurea*. At present a good number of scientific research is going on environment-based distribution prediction models and over predict probable distribution (Blach-Overgaard *et al.*, 2009, 2010) without considering spatial constrains (Blach-Overgaard *et al.*, 2010). A potential issue for the search of ecological data is the bias of existing studies towards certain regions or ecosystems. Comprehensive studies are obviously needed for better understanding of species ecology at global level. The morphological diversity of *B.ramiflora* was studied by Gurung *et al.*, (2018). But the reason behind the morphological variation and relation with ecosystems are still not known. The centre of origin of genus *baccaurea* is in the Malayan region and only a two species are distributed in India. In between Malaysia and India there is physical barrier of Bay of Bengal and between north-east India (distribution of *B.ramiflora*) and south Western Ghats (distribution of *B. courtallensis*) there is Deccan plateau and Gangetic plain. This leads to geographical disjunction. A thorough investigation in the area of phytogeography and ecology is needed for unveiling the reason behind this odd distribution pattern.

Table 1. Salient Features of *B.courtallensis* and *B.ramiflora*

	B.courtallensis	*B.ramiflora*
Scientific Name	*Baccaurea courtallensis* Muell. Arg	*Baccaurea ramiflora* Lour
Synonym	*Pierardia courtallensis* Wight, *P. macrostachya* (Wight& Arn.) Hook f. *Baccaurea macrostachya* Wight & Arn.	*Baccaurea sapida* Muell. Arg, *B. wrayi* King ex Hook. F.
Common Name	Kolikukke (Kannada), Mootalpazham, Mootikaippan, Moottithuri (Malalyalam), Maraootipazham (Tamil).	Latkan, Burmesegrape, Kusum, Leteku
Specimen Examined	1. India, Annamallay, Wight, R., 2675, 12/1851 2. India,s.coll, 12/1851	India, Assam, S.coll ,8071, 1836
Flowering and fruiting	December- June	December - July
Distributed areas in India	Western Ghats regions of Kerala, Tamil Nadu, Karnataka	Bihar, Arunachal Pradesh, Meghalaya, Assam, Nagaland, Tripura, Odisha, Manipur, Mizoram
Wild/Cultivated	Wild	Wild and cultivated
Local importance	Aril is edible Rind used for making pickles	Leaves and barks yields green dye and are used in dying Fruit is edible
Traditional ethnomedical properties	diarrhea, diabetes, dysentery, and mouth cancer, skin infections, stomach ulcers inducing fertility in men and women	Rheumatoid arthritis, injuries, stomach ulcer, stomach ache and colic, constipation.

Table 2. Botanical description of *B.courtallensis* and *B.ramiflora*

	B.courtallensis	*B.ramiflora*
Habit	Trees 15-18 m	Trees upto 25 m
Leaves	Leaves 10-18 x 1.5-8 cm, simple, alternate, often clustered towards the tip of branchlets, cuneate to attenuate base with acuminate apex	8 - 34 x 3 - 10 cm, cuneate-obovate to elliptic-obovate or elliptic to oblongelliptic, acute to obtuse at base
Inflorescence	Raceme in clusters, crimson red	fascicled, 4 - 12 cm long; Yellow
Male Flower	4-6 tepals, ovate to obovate,	4-6 tepals
Stamen	6-8, basifixed, longitudinal slits.	stamens 4 - 8
Female flower	5-6 tepals, lanceolate, sparsely puberulous	4-6 tepals
Ovary	3- Locular Subglobose, tomentose	3-locular, sericeous or velutinous, subglobose or ovoid
Stigma	3, flabellate	3, discoid or flabellate
Fruit	Abovoid - globose Crimson red with tomentose hairs Sour- sweet	globose, broadly ovoid or ellipsoid, Sweetish sour
Seed	1-2 no.	3 no.

Table 3. Biotic and Abiotic factors of *B.courtallensis* and *B.ramiflora*

	B.courtallensis	*B.ramiflora*
Rainfall	1500-5000mm.	2100-3000
Temperature	28-30^{0}C	26-30^{0}C
RelativeHumidity	77%	65%-89%
Topography	Hilly terrain	Hilly terrain
Altitude	250-1200 m	900 m
Soil	Hill soil and Forest soil	Brown Forest Soil
Habitat	Tropical wet Evergreen, Semi-evergreen forests	Tropical Evergreen, Semi-evergreen forests
Propagation	Seeds	Seeds, Stem cutting
Associated species	*Diospyros canarica, Hopea parviflora, Polyalthia fragrans*	*Camellia chinensis, Castanopsis indica, Dipterocarpus macrocarpus*

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Distribution and morphology of two species of *Parthenocissus* from Kerala

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Abstract

Distribution and morphology of two major species of *Parthenocissus* are studied and described here

Keywords: *Parthenocissus semicordata var. roylei*, *Parthenocissus renukae*, Kerala

Introduction

Parthenocissus is one of the genus belongs to the family Vitaceae. Members of the family are mainly located in tropical and temperate regions of eastern Asia and North America but are mainly centred in Asia (Trias Blasi *et al.*, 2017). Around 15 species identified worldwide among them five species reported from India.

Members of the genus are mainly lianas, woody and hermaphroditic. The key characteristics of the genus include branched tendril and tendril with attaching pads. *Parthenocissus semicordata var.roylei* and *Parthenocissus renukae* are the two major members of *Parthenocissus* from Kerala. Their distribution and morphology is described here.

Materials and methods

Parthenocissus semicordata var.roylei and *Parthenocissus renukae* are collected from various parts of Kerala. Field photograph was taken with a DSLR Camera and morphological observations were made using a Leica stereo microscope attached to a digital camera.

Results and discussion

Parthenocissus semicordata var. *roylei* (King ex R.Parker) Nazim. & Qaiser

Large climber; stem lenticellate. Leaves 3-foliolate; leaflets to 17 x 10 cm, ovate, acuminate, rounded at base, coriaceous, spinous serrate, 9-nerved; lateral leaflets

oblique at base; petiolule 0.5-1 cm long; rachis to 11 cm long. Cymes 9 cm across, terminal, peduncled. Flowers bisexual, pedicellate, densely packed; calyx cupular, 5-teethed; petals 4 mm long, oblong; stamens 5, filaments straight; disc obscure; ovary obovoid, truncate, 2-celled; stigma capitate on short style. Fruit a berry; seed 1.
Phenology: September-January
Distribution: Idukki, Palakkad, Kollam, Pathanamthitta

***Parthenocissus renukae* Anto & Pradeep**

Woody climber, 50 m height, stems and branches nodose, lenticelled. Young branches and tendrils, brownish -rose, soft hairy. Tendrils leaf-opposed, 8- branched, tips of tendrils modified to attaching pads. Leaf blades deeply cordate bristle serrate, leathery, and ferruginous when young, 5- ribbed, acuminate, 9–18 × 9–18 cm, lateral veins 3–5 pairs. Petiole up to 8 cm long, reddish-brown at tips-; stipules oblong hairy, 2 at base, internodes 11 cm long. Inflorescence leaf-opposed, short, branched, hairy, umbellate. Flowers drooping, regular, 4-5-merous, disc yellow, prominent, pedicellate-; pedicels 0.5 cm long; calyx cupulate; 4 or 5 sublobed below the disc, 0.12 cm. Petals 4 or 5, 2.5 × 2mm, hairy, cauducous, reddish, tip yellowish red, hooded tip 0.25 cm long, soft yellowish-red inside. Hairs drooping tomentous, T-shaped, one side flat. Stamens 4 or 5, 2.5mm long, antipetalous; anthers 0.8 × 0.8 mm, dithecous, yellowish, attached to the base of the disc; filaments subulate, 2mm long Disc yellowish, 4 or 5 lobed, densely pubescent with soft white hairs. Ovary ovoid, sunk in the disc; style short, 0.8 mm long, thick, stigma, capitate.
Phenology: April–May
Distribution: Thrissur, Palakkad

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