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Structural and Floristic Diversity of Panchar Malai *Myristica* Swamp Forest of the Western Ghats, India

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Abstract: Ecological studies were carried out in lowland (altitude 142m). One hectare area in acritically endangered *Myristica* swamp ecosystem with reference to floristic diversity and structure. GBH (Girth at Breast Height) were measured for all the plants having a girth of ≥ 10 cm. Floristic survey of the swamps resulted in the documentation of 65 plant species belonging to 58 genera and 34 families of these 43 species belonging to 40 genera and 27 families including a common Gymnosperm belonged to plants with GBH ≥ 10 cm. Plants below 10cm GBH were representedby 23 species distributed in 18 genera and 7 families. There were 3 species of Pteridophytes. Of which 9 species are endemic to the Western Ghats. *Myristicamalabarica* Lam.,*Gymnacrantheracanarica* (King.)Warb., *Hydnocarpuspentandra* (Buch. – Ham) Oken. Are vulnerable species and *Artocarpushirsutus* Lam. isleast concerned species, *Humboltia brunonis* Wall.is rare and are threatened species. One fern, *Schizaeadigitata* is extremely rare and endangered. Myristicaceae is the dominant family found in the study area.The studied swamp forest contains 63.99 % of endemic tree species and 87.95 % evergreen trees. The stand basal area is 74.88 m^2ha^{-1}.The forest contains good number of lower girth class trees.

Keywords: *Myristica* swamp, Girth class, Important Value Index, Family Importance value, Western Ghats, Endemism, Evergreen forests.

Introduction

The Western Ghats is one of the 36 biodiversity hot spots(http://surl.li/ydgzfz)and India is one of the 12 mega diversity centres in the world (Chand *et al*.1992, Varghese &Menon 1999). The Western Ghats of India and Sri Lanka biodiversity hotspot is often regarded as one unit because of shared bio geographical history (Gunawardane*et al.,* 2007). It is a chain of mountain ranges stretching North – South along the western peninsular India for about 1600 Km covering 1, 60,000 km^2. In Karnataka, Western Ghats are known as Sahyadri mountain ranges (Prajapathi 2010).

The complex topography and the heavy rainfall have made certain areas inaccessible and have helped these regionsto retain its diversity. Nearly 63% of the tree species of the low and the medium elevation evergreen forests of the Western Ghats are endemic (Ramesh *et al*., 1991). These forests occur between

200-1500 meter elevation range and 2500-5000 mm rain fall range. The evergreen forest of the Western Ghats includes many fresh water swamps. *Myristica* swamps are one such unique fresh water swamps which occur in the evergreen forests of Western Ghats.

In the Western Ghats, *Myristica*swamp for the first time was reported by Krishna moorthy (1960) from Kulathupuzha region of the Western Ghats of Kerala.

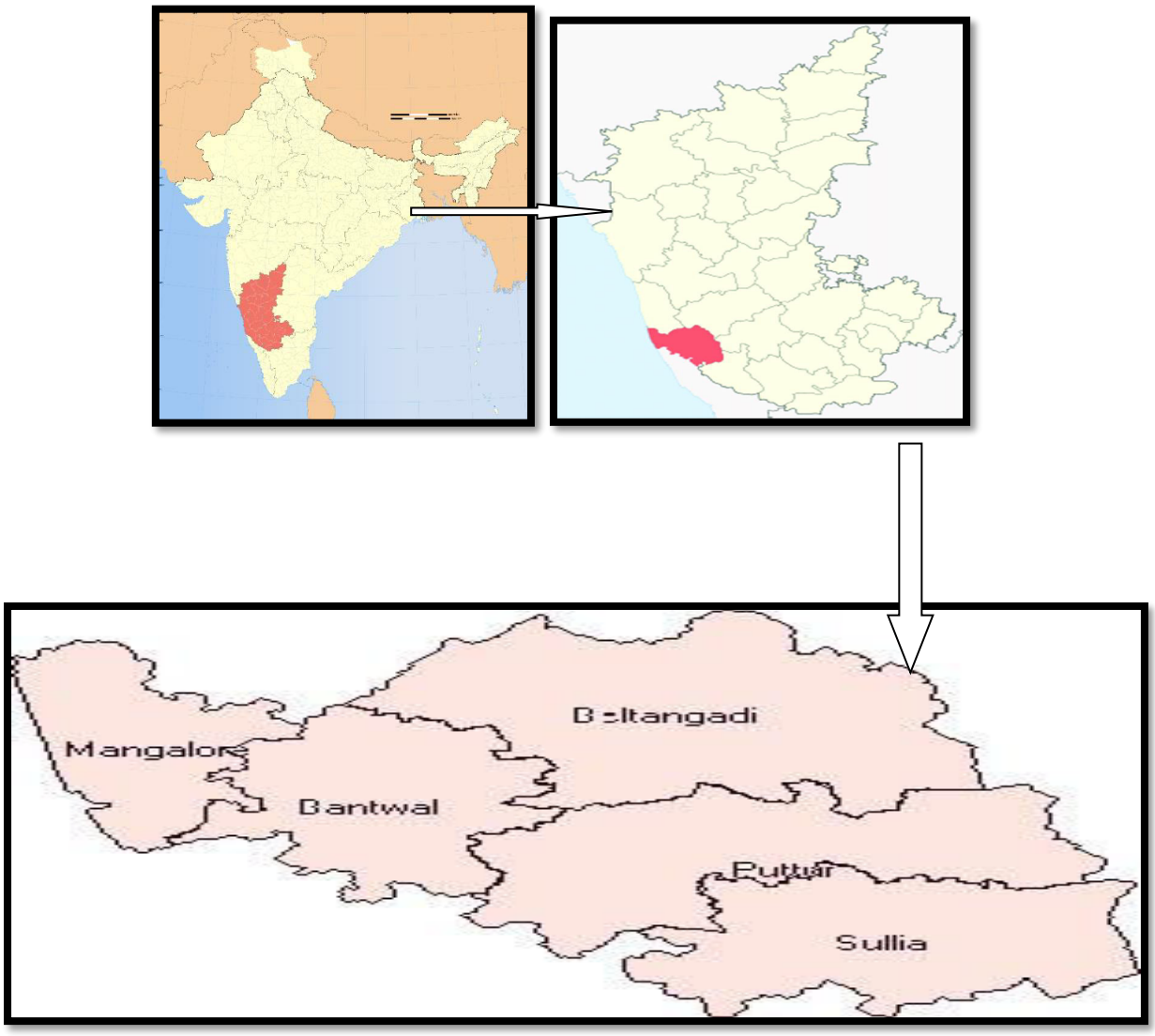
Myristica swamps are any patch of forest in the perennial swampy regions dominated either by *Gymnacrantheracanarica* (King) Warb. or*Myristicafatua*Houtt. var. *magnifica* (Bedd.) Sinclair. or both. Almost all *Myristica*swamps are situated along small streams or stream beginning areas, trees being distributed on both sides of these streams (Roby *et. al* 2007). Champion & Seth (1968) classified this as Tropical fresh water swamp forests (4C/FSI).

Special kinds of adaptations are required for the species which lives in these habitats. Usually,they have aerial adventitious roots called 'stilt roots' / 'knee roots' **(Figure 1.& 2)** that springs out from the main trunk providing additional support to the swamp trees in the soil. Myristica swamps are virtually living museums of ancient life and have high watershed value and are treasure house of many endangered species of flora and fauna (Chandran& Mesta 2005; Jose *et al.,* 2014).

These swamps are highly restricted in distribution and occurrence and are considered as a critically endangered ecosystem (Chandran*et al.*2005; Roby *et al.* 2014). Moreover, these are less understood in terms of their structure and floristics.

Figure 1 Figure2.
Knee roots of*Gymnacranthera canarica*King (Warb.)

Materials and Methods



Source: Google
Figure.3-Sampling site

The studied swamp is (altitude 142 m) situated in PancharMalai forest (13° 03' 22.1'' N and 075° 17' 47.9'' E)at an altitude of 142 m in BelthangadyTaluk of Dakshina Kannada district of Karnataka, India(Fig.3).Here the swamps are intermingled with deciduous forests. There is continuous water flow with heavy water flow during monsoon.

Sampling Methods

The swamp is spread over an area ofone hectare.Sampling was done with quadrats of 10X10 m. GBH (Girth at Breast Height) was measured for all the plants with a girth of ≥ 10 cm. Girth measurement was taken at 1.3m from the

ground. For multi- stemmed trees bole girth was measured separately and for trees having buttresses, measurements were made just above the buttresses. Plants below10 cm GBH were counted and recorded.

Herbarium specimens were prepared for all the plants. Identification was done using relevant floras like Flora of the Presidency of Madras (Gamble 1915-1936), Flora of Karnataka (Saldhana1996), Flora of South Kanara (Bhat 2014) and field key for the identification of the tree species of Western Ghats (Ramesh & Pascal 1987).

Data Analysis

The data were quantitatively analysed for basal area, relative density, relative frequency and relative dominance (Phillips, 1959).The Importance Value Index (IVI) for the tree species was determined as the sum of the relative density, relative dominance, relative frequency (Cottam& Curtis,1956).

$$\text{Basal Area} = \frac{(GBH)2}{4\pi}$$

$$\text{Density} = \frac{\text{Total No.of Individuals of the species in all the sampling units}}{\text{Total No.of sampling units studied}}$$

$$\text{Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}}$$

$$\text{Frequency} = \frac{\text{No.of sampling units in which species occured}}{\text{Total No.of sampling units studied}}$$

$$\text{Relative Density (rD)} = \frac{\text{Density of the species}}{\text{Total densities of all the species}} \times 100$$

$$\text{Relative Dominance (rd)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

$$\text{Relative Frequency (Rf)} = \frac{\text{Frequency of the species}}{\text{Sum of the frequency of all the species}} \times 100$$

Importance Value Index (IVI) = Relative Density (rD) + Relative Dominance (rd) + Relative frequency (Rf)

Family Importance Value

It is the sum of the importance value index of all the species of the family.

Percentage of Evergreenness

$$\% \text{ Evergreenness} = \frac{\text{No.of evergreen trees}}{\text{Total No.of trees}} \times 100$$

Percentage of Endemism

$$\% \text{ of Endemism} = \frac{\text{No.of Endemic trees}}{\text{Total No.of trees}} \times 100$$

Diversity Indices

1. Simpsons' Diversity Index, $D = 1 - \sum (ni / N)^2$

Where ni = total number of individuals of the species
N= total number of individuals in the plot

2. Shanon Wieners diversity $H' = \Sigma Pi (\ln Pi)$
Pi = the proportion of the species

3. Equitability Index = $\log_2 S$

$$E = \frac{H'}{H \max}$$

N/S ratio

It is the ratio indicating the number of individuals of each species to total number of species

Statistical Analysis

Statistical Analysis is done using R – Software,R Core Team (2018).

Soil Analysis

Sampling Methods

Soil samples were collected randomlyusing soil corer from the surface and depths of 0-10cm, 10 – 20 cm and 20 – 30 cms. The samples were mixed thoroughly, air dried and passed through a 2mm mesh sieve to remove the debris, stone and root particles etc.

The composite sample was used for detailed soil analysis.

Soil Analysis was carried out for the following parameters:

i) pH - using digital pH meter.
ii) Total Nitrogen by Kjeldahl Method (1883)
iii) Available phosphorus by Bray *et al.* (1945) Method
iv) Availability of Potassium by flame photometer
v) Organic carbon by Walkley and Black Method (1934)

Results

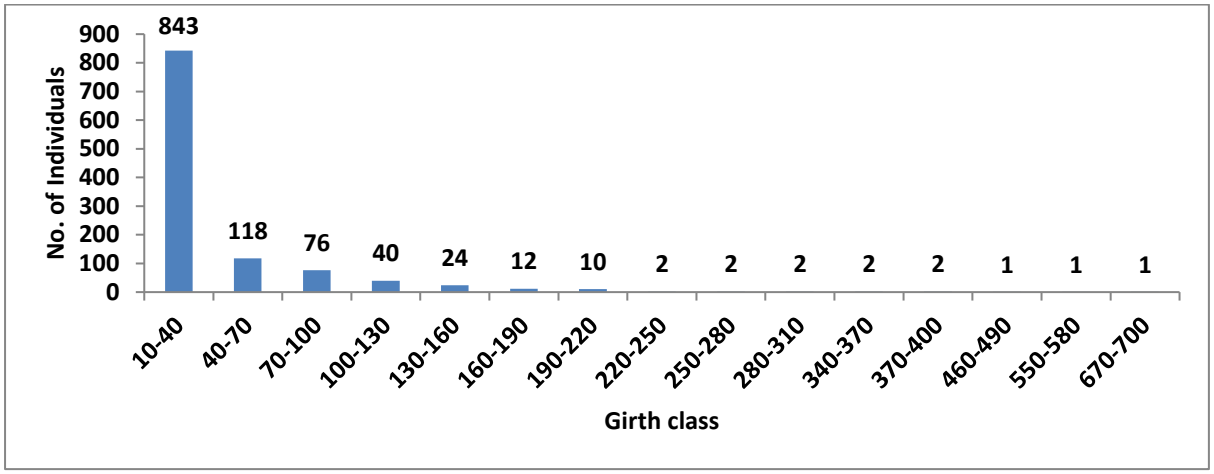


Figure4.Girth Class Distribution

Girth class distribution follows a reverse J- shaped curve. The lower girth classes are well represented. Girth Class 10-40 cm contribute 74 % of the total individuals. Individuals within the 100 cm GBH comprises of 91 % of the total individuals. GBH 100-220cm girth range has 7.5 % of total individuals. There are only 9 individuals with GBH > 300cm. These are larger trees. Girth classes from 460-700 cm range are represented by a single individual. The lower girth class also represents large number of species (Fig.4.) indicating a good regeneration of many species.

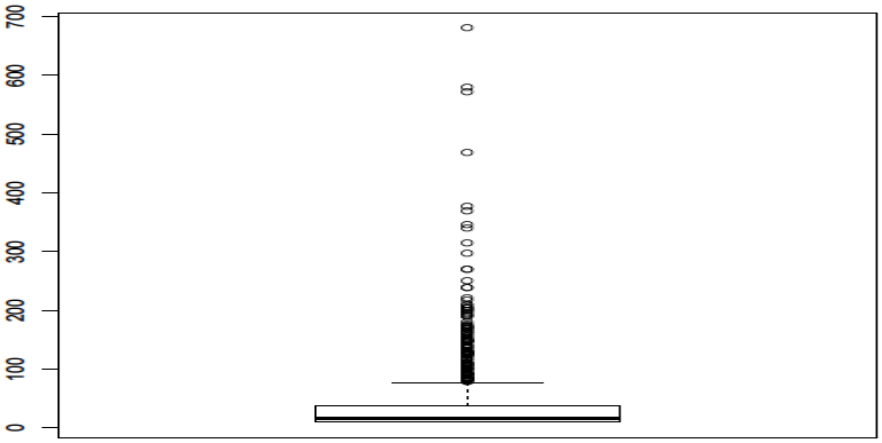


Figure 5.Box and Whisker Plot representation of Girth class of the trees

The figure(5) known as Box and Whiskers plot is used to represent the distribution of samples. The thick horizontal line represents the median of the distribution. The horizontal at the top of the box corresponds to the third quartile of the distribution. The horizontal line at the bottom of the distribution of the box

represents the first quartile of the distribution. The horizontal line outside the box at the top corresponds a value three times the third quartile. Similarly, the horizontal line outside the bottom of the box corresponds to the value which is one third of the first quartile. The dot outside the graph at the top corresponds to the values which are treated as outliers.

From the above graph of Pancharmalai*Myristica*swamp, which is skewed towards the left of the median (17.0) which indicates the concentration of the girth class below the median i.e. approximately 10-17 cms of girth at breast height (smaller range).Upper girth class trees distributed in a wider range. This method of representation is first of its kind in the girth class studies.

Density

A total of 1136 stems **(≥** 10 cm) were recorded with an average mean relative density of 2.27 ± 0.58 (Median = 0.60).Four families Myristicaceae (284 individuals ha $^{-1}$, 25 %), Dipterocarpaceae(215 individuals ha $^{-1}$, 18.92 %), Anacardiaceae(104 individuals ha $^{-1}$, 9.15 %) andCelastraceae(79 individuals ha $^{-1}$, 6.95 %) had the highest density altogether contributing 60 % of the stand density of this forest.

For species, the highest density was recorded by *Hopeaponga* (215 individuals ha $^{-1}$, 18.92 %)followed by *Gymnacrantheracanarica*stands second (128 individuals ha $^{-1}$, 11.26 %), *Knemaattenuata* (110 individuals ha $^{-1}$, 9.68 %) and *Holigarnaarnottiana* (100 individuals ha $^{-1}$, 8.8 %). 7 specieswere represented by singleindividuals. Table (1).

Basal area

The stand basal area of the forest was 74.88m^2 ha^1 with an average of 1.74 ± 0.61 (Median = 0.08). Maximum basal area was contributed by *Hopeaponga*(20.57 %), followed by*Lophopetalumwightianum*(18.6 %) and *Gymnacrantheracanarica*(17.91 %).

Importance Value Index (IVI)

Hopeaponga is found to be the dominant species in the swamp with 215 individuals contributing to the highest IVI of 48.8958; *Gymnacrantheracanarica*is the second dominant species with an IVI 38.62 with 128 individuals and *Lophopetalumwightianum*has an IVI of 30.24 with 63 individuals. Twelve species have IVI less than one and are represented by 1-3 individuals. Details of IVI of the species are given in **table (1).**

Table 1.Structural parameters of Panchar Male swamp forest.

Species	No. of Individual	Basal Area	Relative Density (Rd)	Relative Dominance (rd)	Relative Frequency (Rf)	IVI = Rd+rd+rF
Hopeaponga(Dennst.)Mabb.	50	15.416	18.487	21.638	8.772	48.896
Gymnacranthera canarica (King) Warb.	50	13.419	11.006	18.841	8.772	38.619
*Lophopetalumwightianum*Arn.	30	13.931	5.417	19.56	5.263	30.241
*Holigarnaarnottiana*Hook.f.	51	3.872	8.599	5.436	8.947	22.982
Knemaattenuata(Hook.f.&Thomson) Warb.	53	0.556	9.458	0.776	9.298	19.532
*Diospyrosebenum*Koenig.	40	1.033	8.513	1.45	7.018	16.980
*Sapinduslaurifolius*Vahl	1	11.464	0.086	16.097	0.175	16.358
*Myristicamalabarica*Lam.	40	1.779	3.955	2.499	7.018	13.472
*Ixorabrachiata*Roxb.	35	0.202	5.159	0.283	6.140	11.583
Leeaindica(Burm.f) Merr.	25	0.054	5.073	0.0751	4.386	9.534
Syzygiumhemisphericum (Wight.) Alston	23	1.585	3.267	2.226	4.035	9.528
Aporusacardiosperma(Gaertn.) Merr.	17	0.634	1.806	0.889	2.983	5.678
Perseamacrantha	7	2.379	0.859	3.34	1.228	5.428

(Nees) Kosterm.						
Actinodaphne wi ghtiana (Kuntze) Noltie	14	0.782	1.548	1.098	2.456	5.102
Loeseneriella arn ottiana (Wight) A.C. Sm.	16	0.142	1.376	0.199	2.807	4.382
*Ventilagomadera spatana*Gaertn.	4	5.521	0.429	7.752	0.702	8.884
*Gnetumula*Brong n.	14	0.023	1.204	0.032	2.456	3.692
Hydnocarpuspent andra(Buch-Ham) Oken	10	0.056	0.859	0.078	1.754	2.692
Pterospermumret iculatum Wight &Arn.	10	0.041	0.859	0.057	1.754	2.671
*Humboltiabrunon is*Wallich	3	0.075	1.806	0.105	0.526	2.437
Schleicheraoleos a(Lour.) Oken	8	0.029	0.946	0.041	1.404	2.390
*Ardissiasolanace a*Roxb.	7	0.0095	0.774	0.013	1.228	2.015
*Oleadioica*Roxb.	7	0.079	0.602	0.110	1.228	1.941
Careliya brachiate (Lour.) Merr.	3	0.809	0.258	1.136	0.526	1.920
*Cinnamomumver um*J.S.Presl	5	0.093	0.859	0.131	0.877	1.868
*Combretumlatifol ium*Blume	5	0.046	0.602	0.065	0.877	1.544
*Strychnoscolubri na*auct.non L.	5	0.043	0.429	0.060	0.877	1.368
Madhucanerifolia (Moon.) H.J.Lam	5	0.035	0.429	0.0491	0.877	1.356
*Terminaliapanicu lata*Roth.	4	0.099	0.344	0.139	0.702	1.185
*Mangiferaindica*L .	4	0.066	0.344	0.092	0.702	1.138

Calycopteris floribunda Lam.	4	0.016	0.344	0.022	0.702	1.068
Artocarpushirsutus Lam.	2	0.238	0.258	0.333	0.351	0.942
Holarrhenapubescens(Buch-Ham.) Wallich ex G.Don	3	0.020	0.344	0.029	0.526	0.899
Terminaliatomentosa Wight. &Arn.	3	0.063	0.258	0.089	0.526	0.873
*Psychotriadalzelli*iHook.f.	3	0.005	0.258	0.007	0.526	0.791
*Vitexaltissima*L.f.	2	0.006	0.172	0.008	0.351	0.531
Terminaliabellerica(Gaertner.)Roxb.	1	0.106	0.086	0.149	0.175	0.411
Haldinacordifoilia(Roxb.)Ridsid	1	0.079	0.086	0.112	0.175	0.373
Memecylonedule	1	0.079	0.086	0.11	0.175	0.372
Dalbergiahorrida (Dennst.) Mabb.	1	0.012	0.172	0.017	0.175	0.364
Garciniamorella(Gaertner.) Desr.	1	0.003	0.086	0.004	0.175	0.265
*Pterospermumdivercifolium*Blume	1	0.002	0.086	0.002	0.175	0.264
*Sterculiaguttata*Roxb.exG.Don	1	0.0008	0.086	0.001	0.175	0.263

Floristic Richness

A total of 65 species belonging to 58 genera and 34 families were recorded.

43 species belonging to 40 genera and 27 families including a common Gymnosperm belonged to plants with GBH ≥ 10 cm.

Plants below 10cm GBH had 23 species distributed in 18 genera and 7 families. There were 3 species of Pteridophytes.

Of these nine species are endemic to the Western Ghats. *Myristicamalabarica* Lam. and *Gymnacrantheracanarica* (King.)Warb.,*Hydnocarpuspentandra* (Buch. –

Ham) Oken.are vulnerable species and*Artocarpushirsutus* Lam. is categorised as least concerned species, *Humboltiabrunonis*Wall.is rare and are threatened species(IUCN2023).

Herbs and Shrubs

Psychotriaflavida Talbot.Dominated the ground vegetation is completely covered by this species. The second dominant component is the saplingsof*Hopeaponga.* In herb layer, *Piper nigrum* was the major component and also some of the Pteridophytes like, *Tectariapolymorpha, Bolbitis, Schizaeadigitata*and *Pteris* sp. were present.

Family Importance Value (FIV)

Myristicaceae is the most dominant family with highest importance value71.62followed by Dipterocarpaceae with the importance value48.8958. Families like Dipterocarpaceae, Ebenaceae, Vitaceae, Myrtaceae, Rhamnaceae, Phyllanthaceae, Gnetaceae, Achariaceae, Primulaceae, Oleaceae, Rhizophoraceae, Loganiaceae, Sapotaceae, Moraceae, ApocynaceaeClusiaceae, Melastomataceae, and Lamiaceae are represented by single individuals. Detailed family importance value is given in **Table (2).**

Table 2. Family Importance Value of Panchar Male swamp forest

Sl.No.	**Family**	**No. of Species**	**Family Importance Value (FIV)**
1.	Myristicaceae	3	71.62
2.	Dipterocarpaceae	1	48.89
3.	Celastraceae	2	34.62
4.	Anacardiaceae	2	24.12
5.	Sapindaceae	2	18.75
6.	Ebenaceae	1	16.98
7.	Rubiaceae	3	12.74
8.	Lauraceae	3	12.39
9.	Vitaceae	1	9.53
10.	Myrtaceae	1	9.53
11.	Rhamnaceae	1	8.88
12.	Combretaceae	5	5.74
13.	Phyllanthaceae	1	5.68
14.	Gnetaceae	1	3.69
15.	Malvaceae	3	3.19
16.	Fabaceae	2	2.80
17.	Achariaceae	1	2.69
18.	Primulaceae	1	2.02

19.	Oleaceae	1	1.94
20.	Rhizophoraceae	1	1.92
21.	Loganiaceae	1	1.37
22.	Sapotaceae	1	1.36
23.	Moraceae	1	0.94
24.	Apocynaceae	1	0.89
25.	Lamiaceae	1	0.53
26.	Melastomataceae	1	0.37
27.	Clusiaceae	1	0.27

Ecological Details

This is the largest *Myristica*swamp located in the study area. This swampcontains a large open area and a perennial stream. Water from this is diverted to nearby areca gardens. The swamp is also characterised by huge rocks.

The diversity indices suggest a fairly good diversity. Simpson's Index shows that out of every 100 pairs of trees taken at random 9 pairs are composed of the same species suggesting high diversity.

Shanon- Wiener's index of 2.85 suggests a moderate diversity in these forests. Equitability index of .75 shows a good dispersion of the species in these plots.

Table 3.

Table 3. Floristic Diversity of Panchar Male swamp forest

Evergreenness (%)	**Endemism (%)**	**N/S Ratio**	**Simpson's' Index**	**Shanon Index Value**	**Equitability Index (E)**
87.95	63.99	26.41	0.9131	2.85	0.7567

Soil Analysis

The soil is silty clay loam, sandy clay medium to weak granular in structure; moist very friable, slightly sticky and non-plastic, fine roots plenty, clear, smooth boundary. The soil is sandy in most areas but has alluvial sediments in and around. **Table 4.**

Table 4. Results of Soil Analysis of the swamp for pH, organic carbon, Available Nitrogen, Phosphorus Potassium, exchangeable Calcium and Magnesium

Sl. No.	Soil Sample	pH	Organic Carbon (%)	Available N(Kg/ha)	Available P(Kg/ha)	Available K (Kg/ha)	Exch. Ca (%)	Exch. Mg (%)
1.	Surface	5.20	0.76	213.16	4.08	12	0.005	0.010
2.	10cm depth	5.09	1.37	200.54	---	32	0.015	0.032
3.	20cm depth	5.02	1.03	200.74	----	32	0.014	0.032
4.	30cm depth	4.95	1.86	275.97	1.39	12	0.032	0.040

Discussion

Girth class distribution

Generally, girth class distribution pattern of tree species is used to assess the regeneration pattern and population structure (Sexena& Singh 1984 and Sarkar& Devi 2014). It is the most commonly used method for assessing the population structure (Tesfaye*et al.* 2010).

In the present studythe swamp forest shows the reverse- J shaped curve. 74 % of the total number of individuals fall on the lower girth class i.e. 10-40 cms range. There are only 9 individuals with GBH > 300cm. Girth classes from 460-700 cm range are represented by a single individual.Higher girth class trees are represented by the evergreen component s such as *Gymnacrantheracanarica, Lophopetalumwightianum*, *Perseamacrantha* and *Hopeaponga*. In majority of the forests, the girth class distribution of individuals follow a reverse J- shaped curve which is characteristic of many tropical forests (Richards, 1996). Such a distribution is indicative of the health of the forest and suggests to a good regeneration (Sathish*et al*., 2013) and it also depicts a more stable population (Maiwada, 2014). Similar trend has been reported in the *Myristica* swamps of Uttara Kannada district (Bhat&Kaveriapppa 2009) and in the*Myristica* swamps of Southern Kerala. (Varghese & Kumar 1997).

Density

Four families viz. Myristicaceae, Dipterocarpaceae, Anacardiaceae and Celastraceaehad the highest density altogether contributing 60 % of the stand density of this forest. In terms of number of individuals per hectare 1136 stems were recorded (≤10 cms GBH). In PancharMalai swamp forest the highest density

was recorded by *Hopeaponga*(215 individuals ha $^{-1}$, 18.92 %) *Gymnacrantheracanarica*stands second (128 individuals ha $^{-1}$, 11.26 %).Vargheese&Balasubramanyan (1999) reported thestand density in terms of number of individuals per hectare varies from 780 trees – 1520 trees depending on the pattern of distribution in wet evergreen forests of Agasthyamalai region in Kerala.

Basal area

In the low and mid elevation forests in the Western Ghats the basal area ranges from 36 to 94 m^2 ha^{-1} (Ayyappan&Parthasarathy 1999;Parthasarathy2001; Davidar*et al.*2007).In the present study the stand basal area recorded is74.88m^2 ha^1.This value is almost similar to the values obtained in Anchal range of *Myristica* swamps of Southern Kerala by Vargheese& Kumar (1997).

Importance Value Index (IVI)

Hopeaponga was found to be the dominant species in the swamp forest and second dominant species was *Gymnacrantheracanarica*.In all previous work, Varghese &Kumar (1997), Vargheese and Menon (1999), Bhat&Kaveriappa (2009) and Chandran*et al.* (2010), have reported *Gymnacrantheracanarica*as the dominant species in *Myristica* swamps.

Floristic Richness

A total of 65 species belonging to 58 genera and 34 families were recorded.43 species belonging to 40 genera and 27 families including a common Gymnosperm*Gnetumula*Brongn. belonged to plants with GBH ≥ 10 cm.

Nine species are endemic to the Western Ghats. Details and status of the speciesare given in table (2). The studied swamp also contains an extremely rare and endangered fern called
Schizaeadigitata(L.) Sw. Information on its occurrence and habitat is meagre. The genus *Schizaea*has 30 species usually found in warm tropical regions. (Mabberly, 1997). Most of the species of *Schizaea*have restricted distribution. Of these, *Schizaeadigitata*(L.) Sw. has a wider distribution extending from Madagascar to Polynesia (Holtum, 1959, 1968). In India, it is reported to be restricted to Khasia&Janthia hills of Meghalaya. In all these places this is reported to be rare. Madhusoodhanan&Sathish Kumar (1986) have reported small populations of this fern from the forests at Palode in the Southern Western Ghats.Rajgopal&Bhat(1998) reported this species to Karnataka from a single locality in Bantwal of Dakshina Kannada District. Another report was from the lowland evergreen forests in the foot hills of the evergreen forests of the Western Ghats in Karnataka (Shenoy&Krishnakumar 2009). The present report is a record of its new habitat in *Myristica*swamps of Dakshina Kannada District.

Psychotriaflavida Talbot.dominate the ground vegetation. Generally, swamps have an abundance of this species (Shetty*et al.* 2002).

Family Representation

Here the species are distributed in 27 families. The range of families represented in tropical forests varies from 16-58 (Campbell *et.al* 1992) and 44 families in the Eastern Ghats of Andhra Pradesh (Naidu & Kumar 2016).

In all the *Myristica* swamps, Myristicaceae is found to be dominant and families like Celastraceae, Dipterocarpaceae and Anacardiaceae are other dominant families. Family Dipterocarpaceae is generally well represented in the swamps with a preponderance of low altitude members and it is characteristically a lowland family and also found in mixed evergreen forests and forms a large proportion of first storey (Richards, 1952). In the same trend, families have been represented in Kulathpuza*Myristica*swamp (Roby *et al.,* 2018).

Evergreeness and Endemism

Percentage of Evergreeness and Endemismof the studied swamp forest isrespectively 87.95 and 63.99. On the whole, high level of endemism is exhibited in the swamps including flora and fauna.But in the present study endemism of swamp is little less when compared to theevergreeness of the forest. Similar result was recorded by Chandran*et.al* (2010)in the Kattalekan*Myristica* swamp forest of Uttara Kannada districtof Karnataka. Since *Myristica* swamps are the patches of evergreen forest many evergreen non endemic species like*Perseamacrantha*, *Lophopetalumwightianum*,*Caralliabrachiata, Aporusacardiosperma* are well represented in the swamp and also other evergreen endemics like *Artocarpushirsutus*, *Knemaattenuata*, *Myristicamalabarica*, *Hydnocarpuspentandra* are also represented and are added for the endemic status of the swamps but exclusive endemic of the *Myristica* swamps only *Gymnacrantheracanarica* is represented in the forest.*Myristica*swamps are dominated by the members of Myristicaceaeviz. *Myristicamalabarica*, *Knemaattenuata* and *Gymnacrantheracanarica.*

Diversity indices

Simpson's index of the study was 0.91.Simpson's index is easily interpreted in terms of probability (Pascal 1988). It is the probability of drawing without replacement two individuals of different species from a given collection (Casanovs&Judio, 2012, Wheater*et al.,* 2011). The observed Simpson's value in other swamp forests are0.93 (Bhat&Kaveriappa2009) in the Kattalekan swamp forest of Uttara Kannada district and in *Myristica* swamps of Southern Kerala was 0.73 - .85 (Varghese & Kumar, 1997).

Shannon index is more sensitive to the sample size and thus always underestimates the compartment diversity, and is always biased. It is the

statistical abstraction between two components such as species richness and evenness (Tripathi, 2006). Shanon index of the area is 2.85which suggests a moderate diversity in these forests.Similar ranges of values were reported in *Myristica* swamps of Southern Western Ghats of Kerala i.e.2.46 -3.69 (Vargheese& Kumar, 1997).

Equitability index (H' / H max) or evenness is the relative distribution as compared to the maximum dispersion taking into account the number of species present in the plot (Pascal, 1988).Generally, Equitability index value of swamp varies from 0.59 - 0.75. All these values of different swamps falls within the range of the other swamps except in Anchal*Myristica* swamp forest of Southern Kerala (0.84) (Varghese & Kumar 1997).

N /S ratio is the ratio indicating the number of individuals of each species to total number of species. N /S ratio of the studied area is 26.41.The higher N/Svalue indicates that the communities are relatively poor in species (Kanade*et.al*, 2008). Hence this swamp forestis having good diversity of species.

Soil Analysis

The soil is silty clay loam, sandy clay medium to weak granular in structure; moist very friable, slightly sticky and non-plastic, fine roots plenty, clear, smooth boundary.

The rocks in the forests are derived from laterite rock. Generally laterite soils having acidic pH.Water logged condition in swamp results in high leaching losses of nitrogen. This may be the reason for lower available nitrogen in swampsoils compared to soils from nearby forest area albeit the available N is far higher compared to crop lands (Vijayakumar and Vasudeva 2011).These microhabitat changes in the swamp may be more important in restricting the species composition. (pH of the soil ranges from 4.95– 5.2 indicating the acidic nature. This particular swamp has less of organic carbon. Organic carbon content of the soil varies from place to place (Nair *et.al* 2007). And exchangeable Ca^{++} and Mg^{++} are in traces similar result was obtained in the *Myristica*swamp of Kattalekan of Uttara Kannada district (Bhat&Kaveriappa 2009).

Anthropic disturbances to the ecosystems

Premature harvesting of the fruits of *Myristicamalabarica*and lopping the branches for fruit harvest of lower girth class trees of*Gymnacrantheracanarica*for house hold purposes pose great threat to these components of the swamp ecosystems and in the banks of the streams some areca nut trees were also planted which is a harmful activity to the ecosystem.

Conclusion

On the basis of the results obtained *Myristica* swamp of the studied area is well represented by Myristicaceae members and also by other swamp members. The

ecosystem is apparently stable with reasonably good regeneration. Since the ecosystem is critically endangered and fragile they need immediate conservation.

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References

1. Bhat, G. K. 2014. Flora of South Kanara (Dakshina Kannada and Udupi Districts), Madhuca, SrinivasaNagara, ChitpadyUdupi. Pp: 928.
2. Bhat, R. P. and Kaveriappa, K. M. 2009. Ecological Studies on*Myristica* swamp forests of Uttara Kannada, Karnataka, India. *Tropical Ecology*. 50: 329-337.
3. Bray, R. H. and Kurtz, L. T. 1945. Determination of total, organic and available phosphorus in soil. *Soil Science*. 59: 39-45.
4. Campbell, D. G., Stone, A. and Rosas, J. R. 1992. A comparison of the phytosociology and dynamics of three flood plain (Vazae) forests of known ages, Rio, Jurua, Western Brazilian Amazon. *Botanical Journal of the Linnean Society*. 108: 213-237.
5. Casanoves, F., Pla L., Di Rienzo, J. A. and Díaz, S. 2012. Diversity: A software package for the integrated analysis of functional diversity. *Methods in Ecology and Evolution.*2: 233–237.
6. Champion, H. G. and Seth, S. K. 1968. *A Revised Survey of the Forest Types of India*, Government of India (GoI), New Delhi. Pp. 404.
7. Chandran, M. D. S. and Divakar, M. 2005. *Myristica* Swamps, *Sahyadri E-News Issue* XIII, www.ces.iisc.ernet.in
8. Chandran, M. D. S., Rao, G. R., Gururaj, K.V. and Ramachandra, T. V. 2010. Ecology of Swampy Relic forests of Kathalekan from Central Western Ghats, India, Biodiversity, Bioremediation and Bioavailability, Global Science Book. Pp54 – 68.
9. Cottam, G. and Curtis, J.T. 1956. The use of different measurement in phytosociological sampling. *Ecology.*37:451-460
10. Gamble, J. S. 1935. Flora of the Presidency of Madras Vol. I, II & III. Adlard and Son, Limited London. Pp: 2017.
11. Gunavardene, N. R., Daniels, A. E. D., Gunatilleke, I. A. U. N., Gunatilleke, C. V. S., Karunakaran, P. V., Nayak, K. G., Prasad, S., Puyravaud, P., Ramesh, B. R., Subramanian, K. A. and Vasanthy, G. 2007. A Brief Overview of the Western Ghats- Sri Lanka Biodiversity Hotspot. *Current Science*. 93:1567-1572.
12. Holtum, R. E. 1959. Flora Malesiana series II Pteridophyta, part 1. N. V. Evren P. NoordhottGroingen, Netherlands. Pp.300
13. Holtum, R. E. 1968. A revised flora of Malaya, Vol. II Ferns of Malaya. Govt. printer Singapore

14. IUCN 2023. The IUCN Red List of Threatened Species. Version 2022-2. www.iucnredlist.org
15. Jose Joyce, Roby T.J. and Ramachandran K.K 2007.*Myristica* Swamps-a forgotten wetlandEcosystem Envis News Letter 3(1).
16. Jose, J., Ramachandran, K. K., Roby, T. J. and Nair, P. V. 2014. A Preliminary Checklist of Amphibians in and around the *Myristica*swamp forests of Kulathupuzha, South Western Ghats. *Journal of Entomology and Zoology Studies*. 2: 11-18.
17. Kanade, R., Tadwalkar, M., Kushalappa, C. And Patwardhan, A. 2008. Vegetation composition and woody species diversity at Chandoli National Park, northern Western Ghats, India.*Current Science.*95: 637-646.
18. Kjeldahl, J. Z. 1883. A new method for the determination of nitrogen in organic bodies. *Analytical Chemistry*. 22: 366.
19. Krishnamoorthy, K. 1960.*Myristica*swamps in the evergreen forests of Tranvancore. *Indian Forester*.86: 314–315.
20. Mabberly, D. J. 1987. The Plant Book Cambridge University Press, Cambridge. Pp: 858.
21. Madhusoodhanan, P.V. and Sathish, K. 1986. *Schizeadigitata* (L.) Sw. from South India. *Indian Journal of Botany*. 9: 144-146.
22. Maiwada, N. A. 2014. Girth class distribution analysis of some tree species in the parklands of North-Western Katsina State, Nigeria. *International Journal of Current Microbiology and Applied Sciences*. 3: 183-188.
23. Naidu, M. T. and Kumar, O. A. 2016. Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *Journal of Asia-Pacific Biodiversity*. 9: 328-334.
24. Pascal, J. P. 1988. Wet Evergreen Forests of the Western Ghats of India Ecology, Structure, Floristic composition and Succession, Institute Francais De Pondichery. Pp:345.
25. Pascal, J. P. And Ramesh, B. R. (1987). A field key to the identification of the evergreen forests of the Western Ghats (India).InstitutFrancais DE Pondichery- 23.Pp:236.
26. Prajapathi, 2010. Biodiversity of Karnataka at a glance, Government of Karnataka. Pp:96.
27. Rajagopal, P. K. and Bhat, K. G. 1998. Pteridophyte flora of Karnataka State. *Indian Fern Journal*.15:1-28.
28. Roby, T. J. and Vijaya, K. N. P. 2007. *Myristica*swamps prime habitat of the critically endangered tree *Syzygiumtravancoricum* Gamble, The proceedings of the XVIII Kerala Science Congress, Pp764-765.
29. Roby, T. J., Joyce, J. and Nair, V. P. 2014. Checklist of flora of *Myristica* swamps – A critically endangered fresh water ecosystem of Southern Western Ghats of Kerala, India. *Indian Forester*. 140: 608-616.

30. Roby, T. J., Joyce, J. and Nair, V. P. 2018. Phytosociological analysis of *Myristica*swamp forests of Kulathupuzha, Kerala, India. *Current Science*. 114: 25.
31. Richards, P. W. 1952. The tropical rain forest: an ecological study. 1st edition. Cambridge University Press, London. Pp: 450
32. Richards, P.W. 1996. The Tropical Rain Forest: An Ecological Study. 2ndedn. Cambridge University Press, Cambridge.
33. Saldhana, C.J.1996. Flora of Karnataka.Vol II. Oxford & IBH Publishers, New Delhi. Pp: 335.
34. Sathish, B. N., Viswanath, S., Kushalappa, C.G., Jagadish, M.R. and Ganeshaiah, K.N. 2013. Comparative assessment of floristic structure, diversity and regeneration status of tropical rain forests of Western Ghats of Karnataka, India. *Journal of Applied Natural Sciences*.5: 157-164.
35. Saxena, A. K. and Singh, J. S. 1984.Tree population structure of certain Himalayan forest associations and implications concerning their future composition.*Vegetation*.58: 61-69
36. Shenoy, H.S. and Krishnakumar, G. 2009.A note on the occurrence of *Schizaeadigitata* (L.)Sw. in a lowland evergreen forest of Dakshina Kannada in Karnataka.*Journal of Economic and Taxonomic Botany*.33: 54-56.
37. Shetty B.V., KaveriappaK.,M and GopalakrishnaBhat K.2002.Plant Resources of Wstern Ghats and Lowlands of Dakshina Kannada and UdupiDistricts.PilikulaNisargaDhama Society Moodushedde, Mangalore Pp264.
38. Tesfaye, G.,Teketay, D.Fetene, M. and Becc, E.2010. Regeneration of seven indigenous tree species, in a dry Afromontane forest, Southern Ethiopia.*Flora.*5:135-143.
39. Tripathi, O.P. 2006. Fragmentation and plant diversity status of major forest types in Meghalaya, North East India. *Indian Forester*. 132: 1598-1608.
40. Varghese, A.O. and Menonm, A.R. R. 1999.Ecological niches and amplitudes of rare, threatened and endemic trees of Peppara Wildlife Sanctuary.*Current Science*.76:1204-1208.
41. Varghese, V. and Kumar, M.B.1997. Ecological observations in the fresh water swamp forests of southern Kerala, India.*JournalofTropical Forest Science*.9: 299-314.
42. Walkley, A., and Black, I. A. 1934. An examination of the Degtjareff method for determining organic carbon in soils, Effect of variations in digestion conditions and of inorganic soil constituents.*SoilSciences*.63:251-263