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Ecological studies on *Myristica* swamp forests of Uttara Kannada, Karnataka, India

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Abstract: Ecological studies on *Myristica* swamp forests in Uttara Kannada district of Karnataka state in India with reference to floristic composition, structure, diversity and edaphic factors were conducted. Transect method was employed by laying out sample plots in Kathalkane Reserve Forests of Western Ghats and enumeration of all trees ≥10 cm diameter at breast height was made. Sixty three species, including one unidentified species of trees and bamboos belonging to twenty six families with DBH >10 cm were recorded. The forest is of evergreen type dominanted by *Myristica fatua* var. *magnifica, Gymnacranthera farquhariana, Hopea ponga* and *Dipterocarpus indicus*. Myristicaceae dominated the swamps with maximum Importance Value Index of 102.63 represented mainly by *G. farquhariana* (57.83) and *M. fatua* var. *magnifica* (38.49). The forest floor is covered by knee roots. The physico-chemical properties of the soil of swamp were also determined. Endemism was fairly high, with 23 species endemic to the Western Ghats and ten species were rare and threatened. Soils were silty and sandy loam of acidic to neutral pH and moderate organic carbon levels. Soil nitrogen, phosphorous and potassium contents were in the ranges 0.64-1.26%, also slightly lower than other forest ecosystems of the region.

Resumen: Se realizaron estudios ecológicos de los bosques de pantano de *Myristica* en el distrito Uttara Kannada, estado Karnataka, India, en términos de su composición florística, estructura, diversidad y factores edáficos. Se utilizó el método de transecto por medio de la colocación de parcelas de muestreo en bosques de la Reserva Kathalkane de los Gates Occidentales y se enumeraron todos los árboles con diámetro a la altura del pecho ≥10 cm. Se registraron 63 especies, incluyendo una especie arbórea no determinada y bambúes, pertenecientes a 26 familias con DAP >10 cm. El bosque es de tipo perennifolio y está dominado por *Myristica fatua* var. *magnifica*, *Gymnacranthera farquhariana*, *Hopea ponga* y *Dipterocarpus indicus*. Las Myristicaceae fueron dominantes en los pantanos con un Índice de Valor de Importancia máximo de 102.63, correspondiente principalmente a *G. farquhariana* (57.83) y *M. fatua* var. *magnifica* (38.49). El piso del bosque está cubierto por neumatóforos. También se determinaron las propiedades fisicoquímicas del suelo de pantano. El endemismo fue bastante alto, con 23 especies endémicas de los Gates Occidentales, y 10 especies fueron raras y amenazadas. Los suelos fueron limosos y franco arenosos, de pH ácido a neutral y niveles moderados carbono orgánico. Los contenidos edáficos de nitrógeno, fósforo y potasio estuvieron en el intervalo de 0.64 a 1.26%, valores también ligeramente menores que en otros ecosistemas forestales de la región.

Resumo: Procederam-se a estudos ecológicos em florestas pantanosas em Uttara Kannada distrito de Karnataka no estado da Índia com referência à composição florística, estrutura, diversidade e factores edáficos. Empregou-se um método de transeptos dispondo as parcelas amostra nas florestas florestais de Kathalkane nos Gates Ocidentais e enumeração de todas as

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árvores com diâmetros à altura do peito ≥10 cm. Foram registadas sessenta e três espécies, incluindo uma espécie arbórea não identificada e bambus, pertencentes a vinte e seis famílias com DAP>10 cm. A floresta é do tipo sempreverde dominada pela *Myristica fatua* var. *magnifica, Gymnacranthera farquhariana, Hopea ponga* e *Dipterocarpus indicus.* Myristicaceae dominando o pântano com um valor do índice de importância de 102,63 representado principalmente pela *G. farquhariana* (57.83) e *M. fatua* var. *magnifica* (38.49). O solo florestal apresentava-se coberto por "raízes joelho". As propriedades físico-químicas do solo de pântano foi igualmente determinado. Os endemismos eram razoavelmente altos, com 23 espécies endémicas dos Gates Ocidentais e dez espécies eram raras e ameaçadas. Os solos eram limosos e areno-argilosos de pH ácido a neutro e com níveis de carbono orgânico moderados. Os teores de azoto do solo, fósforo e potássio situaram-se no intervalo 0,64-1,26% e eram ligeiramente mais baixos que os outros ecossistemas florestais da região.

Key words: Edaphic factors, floristic diversity, *Myristica* swamp, soil nutrients, vegetation.

Introduction

The Western Ghats (8º 20' - 20º 40' N and 73º -77º E) extending from Tapti in Gujarat to Kanniyakumari in Tamil Nadu, traversing through Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala along the west coast and forming a practically unbroken relief for about 1600 km, with the exception of the Palghat Gap, are a magnificent stretch of hill ranges, presenting rich and varied flora and fauna. Different types of vegetation occur here namely, scrub forests, grasslands at lower altitudes, moist and dry deciduous forests, tropical evergreen forests and montane grasslands and sholas. About 5000 species of the estimated 17000 species of the flowering plants of India are found in the Western Ghats (Nayar 1996). It is also one of the 25 'Hotspots of Biodiversity' identified in the world (Myers *et al*. 2000). A large proportion of the plants found here *viz*., 54 genera, and 1720 species and 135 infraspecific taxa are endemic (Shetty & Kaveriappa 1991). Nearly a third of the endemic taxa found here are rare or threatened and several are believed to be extinct or at serious risks of becoming extinct.

Swamps and marshes are physio - geographic features of low-lying areas resulting from hydrologic and geomorphic peculiarities (Taylor *et al*. 1990). They support characteristic vegetation types subjected to seasonal flooding. In the tropics, such vegetation occurs frequently amid natural forests and along the flood plains of major rivers. They form integral part of the wetland ecosystems, serving as habitats, nursery grounds and sources of food for many organisms (Brown *et al*. 1979).

In India, fresh water swamp forests (4C/FSI of Champion & Seth 1968) occur mainly in the valleys of the Western Ghats (Krishnamoorty 1960) and in the foot hills of Himalaya (Dakshini 1960; Ghildiyal & Srivatsava 1989). They are isolated, small woods, often few hectares in extent. Many swamp forests, however, face extinction due to anthropogenic factors, particularly conversion to wetland paddy fields (Krishnamoorty 1960) and arecanut and teak plantations.

The swamps remain completely inundated during a greater part of the year. According to Krishnamoorty (1960) the *Myristica* swamps of Travancore remain water-logged between June and January. Restricted gas exchange between rhizopshere and the aerial environment is a major problem in this context. It decreases oxygen concentration in the root zone, elevates carbon dioxide levels and increases root resistance to water uptake (Smith & Stachowiak 1988). Flooding also decreases the redox potential of the soil and other physical and chemical changes (Ponnamperuma 1984).

Methods

Study area

The study was conducted in Kathalkane (14° 15' 40" to 14° 15' 50" N latitude and 74° 45' 25" to 74° 45' 35" E longitude) situated at an elevation of

500-530 m in Gersoppa, about 45 km from Honnavar, in Uttara Kannada district of Karnataka state (Fig. 1).

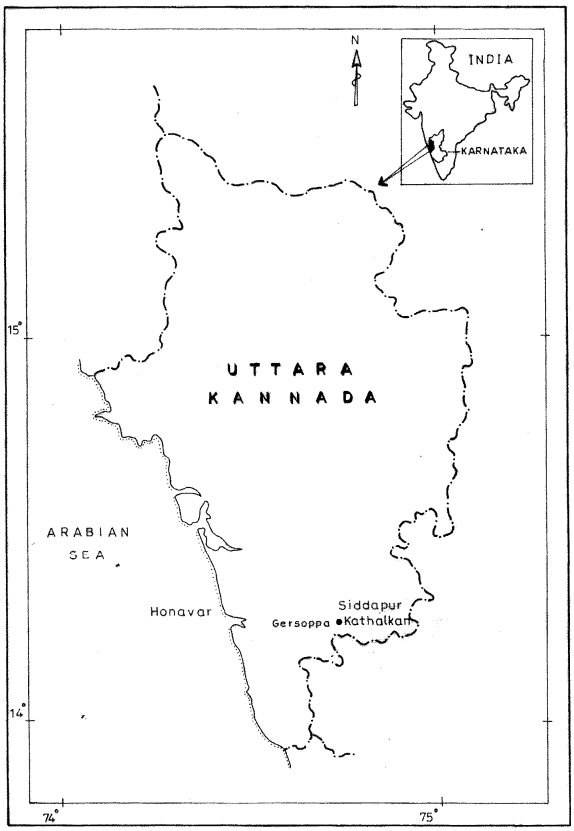

Fig. 1. Map showing the study location.

The maximum rainfall occurred between the end of May and the end of August and the average annual rainfall during last 10 years was 3705 mm. The monthly maximum temperature varied from 28.2 to 33.5ºC and the monthly minimum from 20.4 to 26.2ºC. The temperature increased steadily by the end of February and reaches the peak during April-May and began to decline by the end of May due to pre-monsoon showers. The temperature again increases during August-September and reaches its peak in December.

Vegetation sampling

After a detailed reconnaissance of the entire area and based on visual observations on physiological features and floristic composition in the area quadrats of size 10 m x 10 m were laid during dry period. The quadrats were established using bamboo stakes and outlined by colored nylon ropes. Height and girth at breast height (GBH) of all trees and shrubs $\geq$10 cm GBH were measured using a Suunto Clinometer and tape respectively (GBH values were subsequently converted to diameter at breast height, DBH). Additionally individuals <10 cm GBH were counted and recorded by species.

Floristic structure and diversity

Using the vegetation data, species-area relations and structural attributes such as diameter and height distribution of trees were computed. Phytosociological parameters such as relative frequency (rF), relative density (rD), relative dominance (rD) and Importance Value Index (IVI) were calculated as per Curtis & McIntosh (1950).

Simpson's floristic index [D] (Simpson 1949) was calculated as

$$D = 1 - \sum_{i-1}^{s} (ni/N)^2$$

where, ni = No. of individuals of the species 'i'
N = Total no. of individuals in the plot
s = No. of species in the plot
$D = 1 - (ni/N)^2 + (n_2/N)^2 + \ldots\ldots\ldots\ldots$

Shanon-Wiener indices (Shanon & Wiener 1963) were calculated as

(1) $H\ max = \log_2 S$

(2) $H' = 3.3219 (\log_{10} N - 1/N \sum_{i-1}^{s} (ni \log_{10} ni)$

(3) $E = H'/H\ max$

where, ni, n and s denote the same as in Simpson's index and 3.3219 corresponds to the conversion factor from $\log_2$ to $\log_2$.

Soil analysis

Soil samples from the fresh water swamp forest were collected during the survey , air dried and used for chemical analysis in the laboratory (Jackson 1958). The soil pH, electrical conductivity and soil temperature were measured by pH meter, conductivity meter and soil thermometer respectively in the field itself. The chemical constituents of soil like organic carbon and organic matter by Walkley-Black method; total nitrogen by micro-kjeldahl method; phosphorus by molybdate method using UV Spectrophotometer (Shimadzu 160 A); sodium and potassium by flame

photometer; calcium, copper, iron, magnesium, manganese and zinc by Atomic Absorption Spectrophotometer (AAS).

Results and discussion

Sixty-three species, including one unidentified species of trees and bamboos with DBH >10 cm were recorded (Table 1). Of these, 23 species were endemic to the Western Ghats of India and ten taxa were considered as rare and threatened. *Gymnacranthera farquhariana* represented by 103 individuals in the study area was the dominant species, followed by *Myristica fatua* var. *magnifica* (97 individuals), *Mastixia arborea* (63 individuals), *Pinanga dicksonii* (59 individuals) and *Hopea ponga* (51 individuals). Species whose number of individuals ranged between 20 and 50 were *Agrostistachys meeboldii*, *Lophopetalum wightianum*, *Pandanus unipapillatus* and *Dipterocarpus indicus*. Fifty-four species were represented by less than 20 individuals. Seedlings of the above plant species were also recorded in the quadarts. Trees whose height was >25 m include *Calophyllum apetalum*, *Dipterocarpus indicus*, *Gymnacranthera farquhariana*, *Mastixia arborea* and *Myristica fatua* var. *magnifica*.

Table 1. The phytosociological parameters of *Myristica* swamp forest at Kathalkane, Uttara Kannada.

Species	No. of individuals	Basal area (m^2)	Per cent frequency	Relative density	Relative dominance	Relative frequency	Importance Value Index
**Gymnacranthera farquhariana*	103	121.82	72	15.12	31.83	10.88	57.83
***Myristica fatua* var. *magnifica*	97	52.36	70	14.24	13.68	10.57	38.49
**Mastixia arborea*	62	21.68	54	9.1	5.67	8.16	22.93
**Pinanga dicksonii*	59	2.48	24	8.66	0.65	3.63	12.94
**Hopea ponga*	51	9.04	56	7.49	2.36	8.46	18.31
***Dipterocarpus indicus*	48	50.76	50	7.05	13.27	7.55	27.87
**Pandanus unipapillatus*	31	1.21	16	4.55	0.32	2.42	7.29
Lophopetalum wightinum	29	68.46	44	4.26	17.89	6.65	28.8
Agrostistachys meeboldii	24	1.98	22	3.52	0.52	3.32	7.36
***Myristica malabarica*	9	0.66	12	1.32	0.17	1.81	3.3
**Meiogyne pannosa*	9	0.4	12	1.32	0.1	1.81	3.23
Dimocarpus longan	9	3.54	12	1.32	0.92	1.81	4.05
Syzygium montanum	8	12.64	12	1.17	3.3	1.81	6.28
**Knema attenuata*	7	1.78	10	1.03	0.46	1.51	3
***Holigarna grahamii*	7	1.37	10	1.03	0.36	1.51	2.9
**Ochlandra travancorica*	6	0.05	4	0.88	0.01	0.6	1.49
Holigarna ferruginea	6	5.1	8	0.88	1.33	1.21	3.42
***Hydnocarpus pentandra*	6	1.48	4	0.88	0.39	0.6	1.87
Syzygium zeylanicum	5	0.1	2	0.73	0.03	0.3	1.06
S. cumini	5	0.94	8	0.73	0.25	1.21	2.19
**Litsea coriacea*	5	0.3	10	0.73	0.08	1.51	2.32
Mangifera indica	5	0.51	8	0.73	0.13	1.21	2.07
Elaeocarpus tuberculatus	4	1.43	8	0.59	0.37	1.21	2.17
**Litsea laevigata*	4	0.22	4	0.59	0.06	0.6	1.25
Casearia esculenta	4	0.18	8	0.59	0.05	1.21	1.85
***Garcinia indica*	4	0.3	6	0.59	0.08	0.91	1.58
**Euonymus indicus*	4	0.39	6	0.59	0.1	0.91	1.6
**Syzygium laetum*	3	0.62	6	0.44	0.16	0.91	1.51
***Calophyllum apetalum*	3	0.17	2	0.44	0.05	0.3	0.79
**Cyathea gigantea*	3	0.08	2	0.44	0.02	0.3	0.76
Calophyllum polyanthum	2	7.62	4	0.29	1.99	0.6	2.88

Contd...

Table 1. Continued

Species	No. of individuals	Basal area (m^2)	Per cent frequency	Relative density	Relative dominance	Relative frequency	Importance Value Index
**Actinodaphne malabaricum*	2	0.07	4	0.29	0.02	0.6	0.91
**Tabernaemontana heyneana*	2	0.25	4	0.29	0.07	0.6	0.96
***Diospyros paniculata*	2	0.38	2	0.29	0.1	0.3	0.69
**Polyalthia fragrans*	2	0.15	4	0.29	0.04	0.6	0.93
Chionanthus mala-elengi	2	0.18	4	0.29	0.05	0.6	0.94
Nothapegia racemosa	3	0.53	6	0.44	0.14	0.91	1.49
Persea macrantha	12	2.58	10	1.76	0.67	1.51	3.94
Olea dioica	2	0.25	4	0.29	0.07	0.6	0.96
Elaeocarpus serratus	2	0.32	4	0.29	0.08	0.6	0.97
Garcinia morella	2	0.07	4	0.29	0.02	0.6	0.91
Alstonia scholaris	2	0.87	4	0.29	0.23	0.6	1.12
Schefflera venulosa	2	0.06	2	0.29	0.02	0.3	0.61
**Arenga wightii*	2	1.93	2	0.29	0.51	0.3	1.1
**Memecylon malabaricum*	2	0.1	2	0.29	0.03	0.3	0.62
Leea indica	2	0.05	4	0.29	0.01	0.6	0.9
Combretum latifolia	2	0.15	4	0.29	0.04	0.6	0.93
***Artocarpus hirsutus*	1	0.07	2	0.15	0.02	0.3	0.47
**Litsea ghatica*	1	0.02	2	0.15	0.01	0.3	0.46
**Litsea deccanesis*	1	0.03	2	0.15	0.01	0.3	0.46
Memecylon terminale	1	0.06	2	0.15	0.02	0.3	0.47
***Vateria indica*	1	0.44	2	0.15	0.12	0.3	0.57
Garcinia spicata	1	0.07	2	0.15	0.02	0.3	0.47
Diospyros candolleana	1	0.16	2	0.15	0.04	0.3	0.49
Semecarpus anacardium	1	0.13	2	0.15	0.03	0.3	0.48
Sapindus emerginatus	1	0.05	2	0.15	0.01	0.3	0.46
**Glochidion ellipticum*	1	0.07	2	0.15	0.02	0.3	0.47
Caryota urens	1	0.33	2	0.15	0.09	0.3	0.54
Macaranga indica	1	0.28	2	0.15	0.07	0.3	0.52
Ficus hispida	1	0.05	2	0.15	0.01	0.3	0.46
Ficus tsjahela	1	3.14	2	0.15	0.01	0.3	0.46
**Canarium strictum*	1	0.03	2	0.15	0.01	0.3	0.46
Mallotus philippensis	1	0.1	2	0.15	0.03	0.3	0.48
Total	681	382.64					

*-Endemic
**-Rare and threatened

Climbers/lianes were represented by *Ancistrocladus heyneanus, Artabotrys zeylanicus, Bridelia scandens, Butea purpurea, Capparis zeylanica*, *Cayratia mollissima*, *Cissus discolor, Connarus wightii, Cyclea peltata, Diploclisia glaucescens*, *Gnetum ula, Grewia heterotricha, Hibiscus furcatus, Jasminum malabaricum, J. rottlerianum, Lettsonia elliptica, Moullava spicata*, *Piper logum*, *Piper trichostachyon*, *Pothos scandens, Rubia cordifolia*, *Smilax perfoliata, Tetrastigma gamblei* and *T. sulcatum*. Erect shrubs include *Atalantia racemosa*, *Breynia vitis-idea, Canthium angustifolium*, *Clerodendrum viscosum*, *Crotalaria retusa*, *Dichapetalum gelenioides*, *Gomphandra coriacea*, *Ixora coccinea, I. nigricans, I. polyantha*, *Glycosmis pentaphylla*, *Maesa indica*, *Maytenus rothiana*, *Memecylon malabathricum, M. terminale*, *Psychotria dalzellii*, *P. flavida* and *P. nigra*.

Herbs recorded include *Alpinia malaccensis, Aneilema versicolor*, *Boehmeria glomerulifera*, *Canscora decurrens*, *Centotheca lappacea*, *Costus speciosus*, *Desmodium triquetrum*, *Eclipta prostrata*, *Elephantopus scaber*, *Flemingia strobilifera*, *Lagenandra meeboldii*, *Lepianthes umbellata*, *Nelgirianthus heyneanus*, *Ophiorrhiza*

rugosa, *Polygonum barbatum*, *Strobilanthes calva, Triumfetta rhomboidea* and *Zingiber cernuum*; orchids like *Acampe* spp., *Bulbophylum* spp., *Cymbidium bicolor, Pholidota* spp. and *Vanda* sp., ferns such as *Adianthum* sp., *Blechnum orientale, Bolbitis subcrenata*, *Cyathea gigantea*, *Diplazium esculentum*, *Lygodium flexuosum*, *Microlepia spluncae* and *Pteris quadriaurita* and rattans like *Calamus lacciferus*, *C. pseudotenuis* and *C. thwaitesii* were observed.

The maximum IVI was scored by *G. farquhariana* (57.83) followed by *M. fatua* var. *magnifica* (38.49), *Dipterocarpus indicus* (27.87) and *Mastixia arborea* (22.93) (Table 1). A total of 26 families including a solitary pteridophytic family Cyatheaceae were represented in the ≥10 cm DBH category. Myristicaceae formed the dominant with Family Index Value (FIV) of 102.63 and it also accounted for 31.72% of the total stems present and 41.16% of the stand basal area at this site. Other important families included: Dipterocarpaceae (FIV= 46.85, Celastraceae (FIV= 30.4), Cornaceae (FIV= 22.93) and Arecaceae (FIV= 14.58) (Table 2). On the other hand, Varghese & Kumar (1997) in their study identified 16, 15 and 9 families in three sites of which six families registered an FIV >10. Shivaprasad *et al.* (2002) revealed in their studies on the structure of Pilarkan Reserve Forest and the dominant species was *Hopea parviflora* with IVI of 80.66 followed by *Diospyros buxifolia* (61.76) and *Artocarpus hirsutus* (26.92). They also found that Dipterocarpaceae emerged as dominant family with FIV of 109.8 followed by Ebenaceae (63.4), Moraceae (28.0) and Myiristicaeae (25.6). In another study on the structure of Charmady Reserve Forest of the Western Ghats of Karnataka Vasanthraj & Chandrashekar (2006) observed *Vateria indica* (61.0) with a greater IVI than other species. The FIV was maximum for Dipterocarpaceae (105.1) followed by Fabaceae (31.1), Myristicaceae (14.8) and Moraceae (14.1).

Gymnacranthera farquhariana, Myristica fatua var. *magnifica, Mastixia arborea, Pinanga dicksonii* and *Hopea ponga* were the commonest species represented by more than 50 individuals (≥ 10 cm DBH) in the fresh water swamp of Uttara Kannada, whereas *G. farquhariana, M. fatua* var. *magnifica, Lophopetalum wightianum* and *M. malabarica* were the predominant tree species at all sites in the fresh water swamp of south Kerala (Varghese & Kumar 1997). They have also found that these representative plants accounted more than 100 individuals as well as Importance Value Indices (IVI) >20. On the other hand, in the present study only *G. farquhariana* was represented by more than 100 individuals and *M. fatua* var. *magnifica* by 97 individuals, but there were five plant species (*G. farquhariana, M. fatua var. magnifica, Mastixia arborea, Dipterocarpus indicus* and *Lophopetalum wightianum)* with IVI >20.

In the present study in an area of 2000 m² a total of 681 individuals (≥10 cm DBH) belonging to 63 species were recorded. Varghese & Kumar (1997) in their study on fresh water swamp forests of southern Kerala, in a plot of 0.5 ha in Kulathupuzha, Anchal and Shendurney sites the number of individuals (≥10 cm DBH) were 891, 682 and 1012 respectively, belonging to 21, 21 and 14 species respectively and 1107, 891 and 1245 in the less than 10 cm DBH category.

Table 2. Family Importance Value (FIV) of *Myristica* swamp forest of Kathalkane.

Family	No. of species	FIV
Myristicaceae	4	102.63
Dipterocarpaceae	3	46.85
Celestraceae	2	30.4
Cornaceae	1	22.93
Arecaceae	3	14.58
Myrtaceae	4	10.96
Anacardiaceae	5	10.36
Lauraceae	6	9.34
Euphorbiaceae	4	8.83
Pandanaceae	1	7.29
Clusiaceae	5	6.63
Sapindaceae	2	4.51
Annonaceae	2	4.16
Flacourtiaceae	2	3.72
Elaeocarpaceae	2	3.14
Apocynaceae	2	2.08
Oleaceae	2	1.9
Gramineae	1	1.49
Moraceae	3	1.39
Ebenaceae	2	1.18
Melastomataceae	2	1.09
Combretaceae	1	0.93
Leeaceae	1	0.9
Cyatheaceae	1	0.76
Araliaceae	1	0.61
Burseraceae	1	0.46

Vasanthraj & Chandrashekar (2006) recorded 99 species belonging to 84 genera under 47 families, of which 67 tree species belonging to 37

Table 3. Comparison of floristic diversity indices (≥10 cm DBH) of the fresh water swamp forests of southern Kerala*(area : 5000 m²), Uttara Kannada of Karnataka** (area: 2000 m²) and Pilarkan (area 3000m²) as well as Charmady Reserve Forests of Western Ghats (area 5000m²) of Karnataka.***

Site	Number of species	Number of individuals	Simpson's index (D)	Shannon-Wiener indices		
				H'	H max	E^k
Kulathupuzha*	21	891	0.73	2.53	4.39	0.58
Anchal*	21	682	0.85	3.69	4.39	0.84
Shendurney*	14	1012	0.75	2.46	3.81	0.65
Kathalkane**	63	681	0.93	4.04	4.80	0.84
Pilarkan ***	27	883	0.81	3.25	4.85	0.67
Charmady ***	67	961	0.90	4.90	6.10	0.80

families in Charmady Reserve Forests of Western Ghats with ≥10 cm GBH in an area of 5000 m². They also found 37 endemic species in their investigation. The dominant vegetation type was *Hopea parviflora-Dipterocarpus indicus - Vateria indica*. At the higher elevation (2000 m a.s.l.) evergreen shola forests of Eravikulam, Jose *et al*. (1994) reported 942 stems (≥10 cm GBH) belonging to 53 species in a 0.5 ha plot. In the mid elevation (900 m a.s.l.) wet evergreen *Cullenia – Mesua – Palaquim* forest type of Attapadi, Pascal (1988) observed 303 individuals (≥10 cm GBH) belonging to 32 species, in 0.2 ha area. Similarly in the low elevation (425 m a.s.l.) *Dipterocarpus-Kingiodendron-Humboldtia* forest type of Kadamakal, Pascal (1988) recorded 460 stems (≥10 cm GBH) of 70 species in 0.16 ha. So it can be comparable to earlier reported values in the Western Ghats (Table 3).

The ground was covered by the looped knee roots and the dominant species according to Krishnamoorthy (1960) were *M. fatua* var. *magnifica* (very frequent), *Gymnacranthera canarica* (frequent), *M. malabarica*, *Lagerstroemia flos-reginae*, *Lophopetalum wightianum*, *Anthocephalus cadamba*, *Eugenia montana* and *Carallia integerrima*. In the present study *G. farquhariana* became the very frequent and *M. fatua* var. *magnifica* remained frequent one. Other common species include *Mastixia arborea, Pinanga dicksonii, Hopea ponga, Dipterocarpus indicus, Pandanus unipapillatus, Lophopetalum wightianum* and *Agrostistachys meeboldii*.

Height and DBH classes

Nearly three quarters of the individuals were within the range of 1-8 m height range and nearly half of the individuals were within the range of 4-8 m (Table 4). Only 15% of the individuals were in the height classes above 20 m. Similar results were reported by Shivaprasad *et al*. (2002) and Vasanthraj & Chandrashekar (2006). More than half of the individuals were in the DBH range of 20-60 cm (Table 5, Fig. 2). About 10% of individuals came under 10-20 cm and 60-100 cm DBH classes. There was sharp decrease in the number of individuals as girth class increased. In the one of the earlier reports, more than half of the individuals were in the DBH range of 10-20 cm and nearly one third were in the DBH range of 20-60 cm (Shivaprasad *et al*. 2002; Vasanthraj & Chandrashekar 2006). Thus the present study site is of regenerating type.

The floristic diversity - Simpson's diversity index in this study was 0.93, which was found to be slightly higher compared to earlier reports on other fresh water forest studies in the Western Ghats (Varghese & Kumar 1997). This higher value, however, indicates higher concentration of dominance in this forest compared to other forest ecosystems of the Western Ghats (Pascal 1988; Jose *et al*. 1994; Shivaprasad *et al*. 2002; Vasanthraj & Chandrashekar 2006). The lower floristic diversity observed in the other forest ecosystems were attributed to the factors such as adverse environmental condition - flooding and associated soil changes, and the consequent habitat specialization, which permit only few species to colonize the swamp area (Leigh *et al*. 1993).

Edaphic factors

The soil is dark reddish brown, silty clay loam, medium to weak granular in structure, moist very friable, slightly sticky and non-plastic, fine roots plenty, rapid permeability and clear, smooth boundary. The physico-chemical analysis of soil revealed that there was moderate pH as well as

nutrient contents (Table 6). In the earlier studies on fresh water swamps of Kerala, Varghese & Kumar (1997) reported that the clay content increased with depth and moderate acidic to neutral pH as well as lower nutrient contents was due to continuous water logging effect. Similar observation was also made by Ponnamperuma (1972, 1984). The total nitrogen and phosphorus, potassium and organic carbon contents lower in the soil than those of other forest ecosystems in the Western Ghats, which was supported by earlier reports (Jose *et al*. 1994; Varghese & Kumar 1997). High rainfall, the fluctuating water table and the characteristics of swamp may be responsible for the low nutrient levels, especially N and K (mobile elements, susceptible to leaching).

Table 4. Height classes and density of plants in the *Myristica* swamp forest.

Height classes	Range (m)	No. of individuals	Percentage
1	≥1-4	198	29.07
2	>4-8	276	40.52
3	>8-12	58	8.52
4	>12-16	27	3.96
5	>16-20	24	3.52
6	>20-24	3	0.44
7	>24-28	31	4.55
8	>28-32	28	4.11
9	>32-36	13	1.91
10	>36-40	18	2.64
11	>40-50	5	0.73

Table 5. DBH classes and density of plant species in the *Myristica* swamp forest.

DBH class	Range (cm)	No. of individuals	Percentage
1	>10-20	75	11.01
2	>20-60	394	57.86
3	>60-100	85	12.48
4	>100-140	55	8.08
5	>140-180	34	4.99
6	>180-220	16	2.35
7	>220	22	3.23

Conclusions

The swamp forest represents apparently stable vegetation with reasonably good regeneration potential. They are, however, characterized by a lower floristic diversity than other vegetation types of Western Ghats in terms of speciation, despite having comparable stem density. Other vegetation features include a pronounced canopy

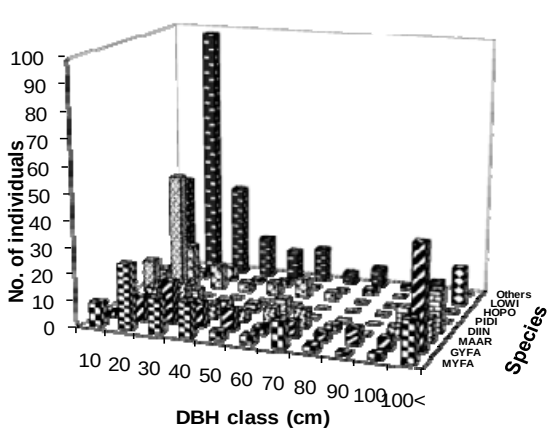

Fig. 2. Diameter distribution of some species in *Myristica* swamps (≥10 cm DBH). MYFA - *Myristica fatua* var. *magnifica,* GYFA - *Gymnacranthera farquhariana,* MAAR - *Mastixia arborea,* DIIN - *Dipterocarpus indicus,* PIDI - *Pinanga dicksonii,* HOPO - *Hopea ponga,* LOWI - *Lophopetalum wightianum*

Table 6. Physico-chemical properties of *Myristica* swamp forest soil at Kathalkane.

Moisture content (%)	35.08
Temperature (°C)	23.03
pH	5.83
EC (mmhos)	4
OM (%)	3.91
N (%)	0.61
P (%)	1.26
K (%)	0.64
Na (%)	0.353
Ca (%)	0.0613
Cu (%)	0.0033
Fe (%)	1.43
Mg (%)	0.168
Mn (%)	0.016
Zn (%)	0.0057
Sand (%)	89
Silt (%)	6
Clay (%)	5

with lofty trees which occupy the forest. The soil type with continuous water table led to the tolerant species especially Myristicaceae in the swamps having knee root system. The swamps are also characterized by lower amounts of major nutrients than in other types of ecosystems. There is an immediate conservation strategy required to conserve the swamps as well as swamp inhabiting threatened *Myristica fatua* var. *magnifica* populations from extinction.

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