The Bioscan 16(3):189-194, 2021
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

PHYTOSOCIOLOGICAL AND EDAPHIC ATTRIBUTES OF MYRISTICA SWAMP FOREST OF SHENDURNEY WILDLIFE SANCTUARY, KOLLAM, KERALA, INDIA

H . BILYAMINU*., K. VIDYASAGARAN AND S. GOPAKUMAR
Department of Natural Resources Management, Kerala Agricultural University,
Thrissur, Vellanikkara - 680 656
e-mail: bilyaminhalliru@gmail.com

KEYWORDS
Edaphic attributes
Knema attenuata
Myristica swamp
Myristicaceae

Received on :
27.11.2020

Accepted on :
08.07.2021

***Corresponding author**

ABSTRACT
Phytosociological and edaphic attributes studies were carried out in Myristica swamp forest of Shendurney Wildlife Sanctuary. In 2700 m^2 study area, 33 trees species $\geq$ 10 cm gbh were recorded out of which 14 species were endemic to Western Ghats. The study recorded a total of 309 individuals ($\geq$ 10 cm gbh) with a total basal area of 2392.59 m^2. The forest is dominated by Myristica magnifica, *Myristica dactyloides, Knema attenuata, Vateria indica, Hopea parviflora*, and *Gymnacranthera farquhariana*. Myristacaceae family was found to be the dominant one with the important value index of (149.01). Diversity indices such as Shannon–Weiner diversity index (H') (2.67), and Simpson index of diversity (0.99) were worked out. The edaphic study revealed that the soil is slightly acidic with the pH value (5.39 - 5.67) and with moderate organic carbon (1.33% - 0.46%). This study reported a relatively high number of endemic, endangered, critically endengered vulnerable species, emphasized the increased need for conservation of this important ecosystem.

INTRODUCTION

Myristica swamp is one of Western Ghats' unique ecosystems, a global megadiversity hotspot (Chandran and Mesta, 2001). The swamp is found in the low laying poorly drained areas. It is characterized by vegetation dominated by tree species belonging to Myristicaceae's family, mainly two species *viz*. Myristicafatua var.magnifica and Gymnacranthera farquhariana.Other Myristica fatua species found are Myristica malabarica and Knema attenuata. Moorthy (1960) was the first to report the Myristica swamps from the erstwhile Travancore region of southern Western Ghats. Further studies reported these swamps in the valleys of Shendurney, Kulathupuzha, and Anchal forest ranges in this region. Champion and Seth (1968) classified this unique vegetation as tropical freshwater swamp forests (4C/FS1) and emphasized the critical need for urgent conservation (Rodgers and Panwar, 1992). However, over the period of agricultural interference such as the shifting cultivation, plantation establishment, monocultural farming system as well as the commercial cropping system, *etc*., the swamp drastically reduced to patches in the Western Ghats region (Chandran and Mesta, 2001)

The science of phytosociology deals with plant communities' structure composition and development, and the relationship between them (Pott, 2011). Phytosociology can also be considered a system for classifying these communities, aiming to achieve an empirical coefficient model of vegetation using a plant taxa combination that characterizes vegetation units. For (Mishra *et al*., 2012), phytosociology is useful in describing each plant species' population dynamics that occur in a particular community and helps understand how they relate to other species in the same community. Several studies on floristic diversity, species composition, distribution pattern, and phytosociology of myristica swamp have been reported, such as that of myristica swamp of Southern Western Ghats (Vaghese and Menon, 1999), Swamp of Uttar Kannada district of Karnataka Western Ghats (Bhat and Kaveriappa, 2009), Northern Kerala (Sreejith *et al*., 2016), Myristica swamp forests of Kulathupuzha (Roby *et al*., 2018). Lack of regular monitoring of previously explored species is considered as the major challenge face in assessing threat status and ecological significance of endangered, rare, vulnerable and threatened species (Kumar and Bimal, 2016). Therefore, documenting and inventorying the plant communities' structural and composition is fundamental for biodiversity conservation and sustainable management of delicate ecosystems like myristica swamp forests (Swamy *et al*., 2010). The objective of this investigation was conceptualized to obtain information on ecological status base on density, frequency and important value index (IVI) and soil physicochemical properties within the swamp.

MATERIALS AND METHODS

Study Area

The investigation carried out the phytosociologicaal and edaphic study of Myristica swamp of Shendurney Wildlife

Sanctuary of Thenmala, Kollam district of Kerala state, India which is located between 8º44' and 9º14' N and longitudinal coordinates of 76º59' and 77º16' E longitude, with the notified area of 171Km^2 (Fig.1). The site receives rainfall during the dual (Southwest and Northeast) monsoon season. A higher percentage (75%) of the precipitation recorded at the southwest monsoon from May to the middle of September. The intensity of rainfall varies across the areas, but the annual rainfall is approximately 3200mm (KFD, 2012). Substantial temperature fluctuation is typical both seasonal and diurnal due to disparity in elevation, with the hottest months being March to May while the coldest is December and January**.** The temperature varies between 17º to 35ºC with maximum daytime temperature during the hottest month of the year recorded at about 39º C (KFD, 2012). The objective of this study was centred to obtain information on ecological status and soil physicochemical properties of within the swamp.

The ecological analysis was carried out following the standard method (Phillips, 1959; Mueller-Dombois, and Ellenberg, 1974). Relatively undisturbed patches of the myristica swamp were selected for the study. The size of the quadrats was determined based on the species-area curve method (Misra, 1968). Twelve sample plots (quadrats) of 15 × 15 m size were used and enumerated all the individuals trees 10cm, counted, and the GBH was measured (Reddy *et al.*, 2007). Individual trees with multiple stems near the ground were measured as a single individual while an individual with buttresses was measured up to 2 m above the buttresses. Soil samples were collected from the representative's plots (quadrats) at four different soil depths (0-10, 10-30, 30-60, 60-100 cm). The samples were taken to the laboratory in a polythene bag, air dried and then grounded using pestle and mortar and sieve through 2mm mesh size sieve. The powdered sample was kept for chemical analysis. Bulk density of the soil sample was determined following the method of (Gupta, 2004) and was evaluated by the formula:

$$\text{Bulk density} = \frac{\text{Dry weight of soil sample(g)}}{\text{volume occupied by the same soil sample (cm}^3\text{)}} \text{X100}$$

The pH and electrical conductivity (EC) of the soil samples were determined using a glass electrode digital pH meter and electric-conductivity meter with a soil and water ratio of 1:2 following (Gliessman, 2000). Organic carbon was determined following the Walkley-Black method (Walkey and Black, 1934). Estimation of cation exchange capacity was carried out using the Barium chloride method ($BaCl_2$), the exchangeable cation extracted by $BaCl_2$ was estimated using atomic absorption spectrophotometer for (Ca, Mg) and flame photometer for (Na, K) (Hendershot and Duquette, 1986).

Statistical Analysis

The soil physicochemical data obtained for all the attributes was subjected to statistical analysis using the analysis of variance (ANOVA). The correlation coefficient was analysis using SPSS statistical software respectively.

Important Value Index (IVI)

The data obtained were subjected to analysis to determine the Relative density, Relative dominance and Relative frequency. The Important value index was obtained following the method of Curtis, (1959) as the sum of the relative density (%), relative dominance (%) and relative frequency (%) of the species (Curtis, 1950).

Density (ni): The total number of individual specie A

Dominance (D): Sum of the total basal area at (1.37 m) for the individual of the same species

$$\text{Relative Density} = \frac{\text{Total number of individuals of the species}}{\text{Total number of individuals of all the species}} \text{X 100}$$

$$\text{Relative Frequency} = \frac{\text{Frequency value of an individuals of the species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal area of individual species}}{\text{Sum of total basal area of all the species}} \text{X100}$$

Species Richness

The richness of the species is the defined as the number of species in a quadrat. For this investigated the individual number of the species in a quadrat recorded throughout the sampling quadrats was used as the expression of the species richness. The species richness was successfully used in many studies as a measure of diversity (Magurran, 1988).

Shannon–Wiener diversity index

Shannon–Wiener diversity index was used to described the species diversity (Whitter, 1972)

Shannon–Wiener diversity index (H) = - ∑_(i = 1)^sln

Where, H = Shannon-Weiner index; S = the number of species; In = log basen

Simpson's floristic diversity Index (D): The Simpson index of dominance of the species was computed using the Simpson's Index (Simpson, 1949) as:

$$\text{simpson index(CD)} = \sum_{i=0}^{s} (pi)^2$$

Where, ni is the total number of individuals of species i , N = total number of all the individual of all the species; Pi = The proportion of the abundance of the ith species *i.e.*, (ni/N),

S = Number of the species in the plot i = 1.

RESULTS AND DISCUSSION

The result of this investigation is obtained following the intensive study carried out in undisturbed area of the myristica swamp forest of Shendurney wildlife sanctuary. This study recorded a total of 33 species, which are represented by 19 families. Out of the 33 species, 14 species are endemic to the Western Ghats. The dominant species is *Myristica fatua*, followed by *Myristica dactyloides*, *Knema attenuata*, and *Vateria indica* (Table 1). The taxonomic representation of the woody vegetation of Shendurney Wildlife Sanctuary is dominated by the species belonging to the Myriticaceae family with a maximum of (5) species followed by Anacardiaceae, Dipterocarpaceae, and Euphorbiaceae (3), Clusiacaeae, Ebenaceae, Rubiaceae and Rutaceae (2) (Table 2.). A similar observation was recorded by (Bhat and Kaveriappa, 2009) in Karnataka's myristica swamp and Northern Kerala (Sreejith *et al.*, 2016).

Table 1: The phytosociological parameters of Myristica Swamp forest of Shendurney Wildlife Sanctuary

Species	No. of individuals	Basal area (m2)	Frequency Percentage	Relative frequency	Relative density	Relative dominance	Importance Value Index
**Myristica magnifica*	65	180.71	100	10.26	21.04	7.55	38.85
Myristica dactyloides	60	816.04	100	10.26	19.42	34.11	63.78
**Knema attenuata*	35	128.95	83.33	8.55	11.33	5.39	25.26
**Vateria indica*	27	197.72	75	7.69	8.74	8.26	24.69
**Hopea Parviflora*	17	40.62	66.67	6.84	5.5	1.7	14.04
**Gymnacranthera farquhariana*	14	27.56	66.67	6.84	4.53	1.15	12.52
Lophopetalum wightianum	10	57.98	50	5.13	3.24	2.42	10.79
**Myristica malabarica*	10	46.49	33.33	3.42	3.24	1.94	8.6
**Holigarna arnottiana*	8	266.78	33.33	3.42	2.59	11.15	17.16
**Baccaurea courtallensis*	7	1.76	41.67	4.27	2.27	0.07	6.61
Mitrephora grandiflora	5	39.07	16.67	1.71	1.62	1.63	4.96
**Xanthophyllum arnottianum*	5	75.52	33.33	3.42	1.62	3.16	8.19
**Cinnamomum malabratum*	4	0.47	25	2.56	1.29	0.02	3.88
Haldina cordifolia	3	139.65	25	2.56	0.97	5.84	9.37
**Diospyros paniculata*	3	9.63	16.67	1.71	0.97	0.4	3.08
Garcinia gummi-gutta	3	7.76	16.67	1.71	0.97	0.32	3
Gomphandra coriacea	3	1.86	8.33	0.85	0.97	0.08	1.9
Mitragyna parviflora	3	35.66	8.33	0.85	0.97	1.49	3.32
Hopea malabarica	3	12.55	8.33	0.85	0.97	0.52	2.35
**Hydnocarpus pentandra*	2	31.93	16.67	1.71	0.65	1.33	3.69
Spatholobus parviflora	2	2.48	16.67	1.71	0.65	0.1	2.46
Mesua ferrea	2	22.21	16.67	1.71	0.65	0.93	3.29
Atalantia racemosa	2	2.76	8.33	0.85	0.65	0.12	1.62
Dysoxylum macrocarpum	2	25.13	16.67	1.71	0.65	1.05	3.41
**Kingiodendron pinnatum*	2	8.95	16.67	1.71	0.65	0.37	2.73
Diospyros foliosa	2	1.7	8.33	0.85	0.65	0.07	1.57
**Mastixia arborea*	2	7.7	16.67	1.71	0.65	0.32	2.68
Aporusa bourdillonii	2	52.23	8.33	0.85	0.65	2.18	3.68
Buchanania axillaris	2	46.66	8.33	0.85	0.65	1.95	3.45
Lagerstroemia flos-reginae	1	6.17	8.33	0.85	0.32	0.26	1.44
Lannea coromandelica	1	97.53	8.33	0.85	0.32	4.08	5.25
Aporusa cardiosperma	1	0.16	8.33	0.85	0.32	0.01	1.18
Melicope lunu-ankenda	1	0.2	8.33	0.85	0.32	0.01	1.19
Total	309	2392.59					

*Endemic to Western Ghats

Table 2: Family Important Value (FIV) of Myristica swamp forest of Shendurney Wildlife Sanctuary.

Family	No. of Species	FIV
Myristicaceae	5	149.01
Anacardiaceae	3	25.86
Dipterocarpaceae	3	41.08
Euphorbiaceae	3	11.48
Clusiaceae	2	6.29
Ebenaceae	2	4.66
Rubiaceae	2	12.69
Rutaceae	2	2.8
Annonaceae	1	4.96
Caesalpiniaceae	1	2.73
Celastraceae	1	10.79
Cornaceae	1	2.68
Fabaceae	1	2.46
Flacourtiaceae	1	3.69
Icacinaceae	1	1.9
Lauraceae	1	3.88
Lythraceae	1	1.44
Meliaceae	1	3.41
Xanthophyllaceae	1	8.19

The species important value index (IVI) of the myristica swamp of Shendurney Wildlife Sanctuary was represented in (Table 1). The maximum IVI was recorded for Myristica dactyloides (63.78), followed by *Myristica fatua* (38.85), *Knema attenuata* (25.26) and *Vateria indica* (24.69) (Table 1.). The family Myristicaceae has the maximum family important value index of (FIV = 149.01), followed by Dipterocarpaceae (FIV = 41.08%), Anacardiaceae (FIV = 25.86%), Rubiaceae (FIV = 12.69%), Euphobiaceae (FIV = 11.48%) and Celastraceae (FIV = 10.79%) (Table 2). A similar result was obtained by (Bhat and Kaveriappa, 2009) in the swamp of Uttara Kannada.

The maximum average value of GBH was observed for *Lannea coromandelica* (350 cm), followed by *Haldina cordifolia* (240 cm), *Aporosa bourdillonii* (180 cm) and (170 cm) for *Buchanania axillaris* while the lowest GBH value was recorded for *Cinnamomum malabratum*. The understory vegetation is dominated by *Syzygium travancoricum*, *Myrristica dactylodes, Knema attenuata, Myristica magnifica, Gymnacanthera farquhariana, Olea dioica*, and *Dysoxlum malabaricum*. The swamp is predominated by the presence of different types of climbers and lianas like *Myxospyrum smilacifolium, Stenochlaena palustris, Pothos scandens, Chilocarpus denudatus, Kunstleria keralensis, Calamus hookerianus, Bauhinia phoenicea, Ventilago bombaiensis,*

Table 3 : DBH Classes and density of plant species in Myristica swamp forest of Shendurney Wildlife Sanctuary

DBH Classes	Range (cm)	No. of Individual	Percentage
1	>10-20	62	20.06
2	>20-60	121	39.16
3	>60-100	51	16.5
4	>100-140	37	11.97
5	>140-180	15	4.85
6	>180-220	11	3.56
7	>220	12	3.88

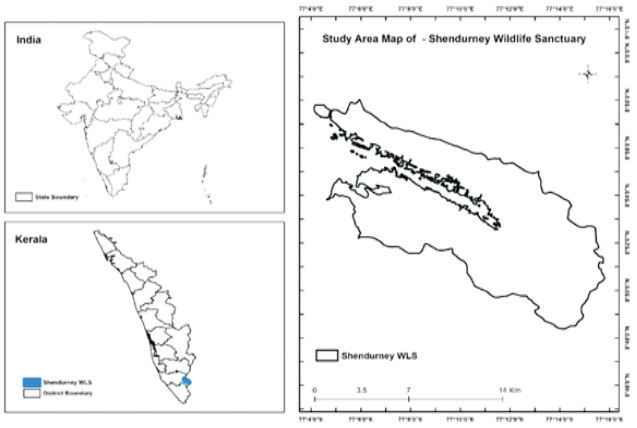

Figure 1: Map showing the study area

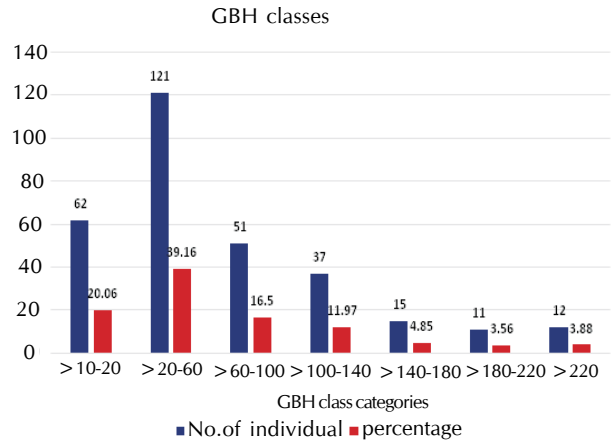

Figure 2: DBH class categories, Number of individual and percentage of tree species of Myristica swamp forest of Shendurney.

Chilocarpus denudatus, Entada rheedi and *Gnetum edule*.

Girth Class Distribution (GBH)

The girth class distribution is one of the characters of the stand structure and graphic representation of the different girth classes (Kumar and Bimal, 2016). This study recorded approximately 40 % of the individual species were within the DBH class range of (>20-60 cm), followed by 20 % (>10-20 cm) and 16 % (> 60-100 cm), while 4% were observed within the range of >220 cm GBH classes (Table 3.). A similar result was reported by (Shivaprasad *et al*., 2002; Bhat and Kaveriappa, 2009). However, the present study observed a subsequent decrease in species with increased GBH (Table 3 and Figure 2). Vasanthraraj and Chanraashekar (2006) recorded more than half of the species in the 10-20 cm GBH classes, while Shivaprasad *et al*. (2002) reported nearly one-third of species in the 20-60 cm GBH classes. Chandrashekara and Jayaraman (2002) recognized that the value of floristic diversity indices was comparatively less than evergreen and semi-evergreen indices. The freshwater swamp is a delicate forest ecosystem subject to compositional and structural changes due to biotic and abiotic factors.

Diversity Index

Depending on tree species composition in an ecological zone, the diversity indices varies significantly (Abdulrashid and Bilyaminu, 2020). The Shannon- Weiner diversity indices (2.67) obtained in the present study were higher compared with the 2.15 for (Varghese and Menon, 1999), 0.12-0.19 for (Chauhan *et al*., 2017), and lower than 3.69 for (Varghese and Kumar, 1997) and 3.23 for (Sreejith *et al*., 2016). In the present study, the Simpson index of diversity found is 0.99, which is greater than the 0.93 reported by (Bhat and Kaveriappa, 2009) in the swamp of Uttara Kannada. Dissimilar to the diversity of other evergreen forest ecosystems such as reported by (Giriraj *et al*., 2008) with the Shannon diversity indices value of 4.89, the diversity of myristica swamp forest is relatively low is due to the domination of few forest trees species belonging to the Myristicaceae family that are confined and adaptable throughout the year inundation in the area. The trees species can thrive due to their physiological and structural attributes such as adventitious roots (stilt roots) and seed germination strategy.

Soil Physicochemical Properties

The soil in the Myristica swamps of Shendurney wildlife sanctuary is slightly acidic (Table 4). The maximum pH value (5.67) was recorded for (10-30cm) depth in the sub-horizon, the lowest pH value (5.39) was observed in the uppermost horizon, which may be due to the presence of organic matter (Litter, twigs, animal waste, leaves). However, there is no significant difference between the pH at (0-10 cm), (30-60cm), and (60-100cm) depths level in the present study. Earlier studies by Bhat and Kaveriappa (2016) recorded a higher soil pH (5.83) for the myristica swamp of Uttara Kannada. The soil pH value showed no strong correlation with any of the soil properties and no specific trend with increasing depth. In this study, the maximum percentage of soil organic carbon 1.33% was recorded at 0-10cm depth which may be attributed to the greater accumulation of litter minerals in the upper layer (Tab.4), which is low compared to 1.98 % of 0-15cm depth in the evergreen forest but similar to 1.31% at 0-15 cm depth of semi-evergreen forest (Balagopalan and Jose, 1993). The percentage of organic carbon showed a decreasing trend with increasing depth similar decreasing trend was observed by (Jehangir *et al*., 2012, Gosain, 2016). The soil electrical conductivity (EC) is the relative measure of the total quantity of ions in the soil sample. The soil's EC value indicated a significant variation. The greater value (0.367 dSm1) was recorded for the upper layer (0-10cm) with no significant difference between the 10-30 cm and 30-60 cm depth but a significant difference

Table 4: Soil Physicochemical properties of Myristica Swamp forest of Shendurney Wildlife Sanctuary

Soil depths (cm)	Soil Physicochemical Parameters (Mean ± SD)					
	pH	Electrical conductivity(dS/m^{1})	Organic carbon (%)	Bulk density (g/cm^{3})	CEC (cmol (+)kg^{-1})	Base saturation (%)
0-10	5.39b±0.02	0.367a±0.01	1.33a±0.01	1.60b±0.06	4.54a±0.07	14.27a±0.26
30-Oct	5.67a±0.06	0.118bc±0.002	0.69b±0.01	1.58b±0.03	3.66c±0.03	13.83ab±0.17
30-60	5.40b±0.04	0.136b±0.01	0.63bc±0.03	1.82a±0.06	4.30b±0.035	12.95c±0.12
60-100	5.48b±0.05	0.102c±0.002	0.46c±0.03	1.87a±0.05	3.70c±0.047	13.44bc±0.80
CD	0.146	0.02	0.185	0.169	0.184	0.606

Table 5: Pearson's correlations coefficient between soil properties in Myristica Swamp forest

	CEC	SOC	pH	EC	BD	PBS
CEC	1					
OC	.753**	1				
pH	-.642*	-0.298	1			
EC	.788**	.953**	-0.436	1		
BD	-0.102	-0.492	-0.288	-0.462	1	
BS	0.084	.584*	0.096	.629*	-.725**	-

CEC: Cation Exchange Capacity; SOC: Soil Organic Carbon; pH; Soil Hydrogen Ion concentration; EC: Electrical Conductivity; BD: Bulk Density; PBS: Percentage Base Saturation.
** . Correlation is significant at the 0.01 level (2tailed); *. Correlation is significant at the 0.05 level (2tailed)

between the 30-60 and 60-100 cm depth. The value is higher than 0.19 dS/m, 0.08 dS/m and 0.08 dS/m at 0-15, 15-50 and 50-100 cm depth for evergreen forest and 0.11 dS/m, 0.06 dS/m and 0.05 dS/m for semi-evergreen respectively (Balagopalan and Jose, 1993). However, the EC of the soil decreases with an increase in depth. The electrical conductivity of soil is influenced by variation in sites, soil depth, and interaction. Digvijay *et al*. (2020) earlier reported the electrical conductivity of forest soil of *Cedrus deodara*.The study also observed a significant decreased in electrical conductivity with an increase in soil depth. This may be attributed to the leaching of soils nutrient from the surface soils. The soil bulk density value differed across the soil depths with a lower value (1.60 g/cm3) in the upper layer, with no significant difference between the first and second depth. This study showed and increasing trend in bulk density with increasing soil depth. Dar *et al*. (2015) reported similar increasing in bulk density in Gulmarg forest site. The substantial increase in bulk density with increasing depth could be attributed to decrease in organic matter and more compaction downward. Similar increase was also reported by (Mishra *et al*., 2017) in the also reported depth in the tropical semi-evergreen forest of Eastern Himalaya and (Guo *et al*., 2016) for native forest, mixed forest, and for a tea garden. The Pearson correlation coefficient between the physicochemical properties of soil in myristica swamp forest is presented in Table 5. The correlation matrix showed significant positive correlations between the soil percentage organic carbon and soil pH and soil organic carbon and electrical conductivity. The highest negative correlation was observed between the bulk density and soil percentage organic carbon.

ACKNOWLEDGMENT

We would like to greatly acknowledge the Shendurney Wildlife Sanctuary's management staff for their exceptional assistance, making this research possible. We also remain undoubtedly grateful to the Kerala forest department's authority for granting us full permission to carry out this research.

REFERENCES

Abdulrashid, I and Bilyaminu H. 2020. Diversity of Regenerating Tree Species in Response to Different Soil Chemical Properties in Parkland Area of Gwarzo Local Government, Kano State. *The Ecoscan* **15(4):**505-509

Balagopalan, M. and Jose A.I. 1993. A comparative study on the properties of soils in relation to the vegetational types. *J. Trop. Agric.* **31:** 167-173.

Bhat, P. R. and Kaveriappa, K. M. 2009. Ecological studies on myristica swamp forests of Uttara Kannada, Karnataka, India. Trop. *Ecology*. **50:**329.

Champion, H. G. and Seth, S. K. 1968. A revised survey of the forest types of India. Government of India.

Chandran, M. D. S. and Mesta, D. K. 2001. On the conservation of the Myristica swamps of the Western Ghats. Forest genetic resources: status, threats, and conservation strategies, pp.1-19.

Chandrashekara, U. M. Jayaraman, K. 2002. Stand structural diversity and dynamics in natural forests of Kerala (No. 232, pp. 10-11). KFRI Research Report.

Chauhan, D. S., Lal, P. and Singh, D. 2017. Composition, population structure and regeneration of Rhododendron arboreum Sm. temperate broad-leaved evergreen forest in Garhwal Himalaya, Uttarakhand, *India. J. Earth Sci. Clim. Change*. **8:**430.

Curtis, J. T. and McIntosh, R. P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*. **31:**434-455.

Dar, D. A., Pathak, B. and Fulekar, M. H. 2015. Assessment of soil organic carbon stock of temperate coniferous forests in Northern Kashmir. *Int. J. Environ*. **4:**161-178.

Digvijay, R., Gopal, R., Kumar, Y. and Ramola, G. C. 2020. Soil Chemical Properties of Cedrus deodara (Roxb) G. Don. Forest Soil in Garhwal Himalaya, *India. J. Tree Sci.* **39:** 42–51.

Giriraj, A. Murthy, M. S. R. and Ramesh, B. R. 2008. Vegetation composition, structure and patterns of diversity: a case study from the tropical wet evergreen forests of the Western Ghats, India. *Edinburgh J. Bot*. **65:**447.

Gliessman, R. S. 2000. Field and laboratory Investigations in Agro Ecology. New York: (Eric W. Engles, ed.) Lewis Publisher.

Gosain, B. G. 2016. An Assessment of C-stock and Soil physicochemical properties in standing dead trees of Pine (Pinus roxburghii Sargent) forests in a Mountain Watershed Kumaun Himalaya, India. *International J. Multidisciplinary Research and Development*. **3(4):** 279-286.

Guo, X., Meng, M., Zhang J. and Chen, H. Y. 2016. Vegetation change impacts on soil organic carbon chemical composition in subtropical forests. *Scientific reports*. **6:**29607.

Gupta, P.K. and Gupta, P. 1999. Soil, plant, water and fertilizer analysis. Agro Botanica.

Hendershot, W. H. and Duquette, M. 1986. A simple barium chloride method for determining cation exchange capacity and exchangeable cations. *Soil Sci. Soc. Am. J.* 50: 605-608

Jehangir, A., Yousuf, A.R., Reshi, Z. A., Tanveer, A. and Ahmad, A. 2012. Comparison of physical, chemical and microbial properties of soils in a clear-cut and adjacent intact forest in North Western Himalaya, India. *International J. Soil Science.* **7(3):**71.

Kerala Forest Department, 2012. Shendurney Wildlife Sanctuary Management Plant Accessed: July 2020.

Kumar, V. and Bimal, B. S. 2016. Biodiversity and phytosociological analysis of plants around the Chikhali Taluka, Navsari district, Gujarat, India. *The Ecoscan.* **10:**689-696.

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, New Jersey, 179.

Mishra, G., Das, P.K., Borah, R. and Dutta, A. 2017. Investigation of phytosociological parameters and physicochemical properties of soil in tropical semi-evergreen forests of Eastern Himalaya. *J. For. Res.* **28:** 513–520.

Misra, R. 1968. Ecology Workbook. Oxford and IBH Publishing Co., New Delhi, India. PP.244-245.

Mishra, N. K., Singh, R. and Ojha, S. 2012. Phytosociological perspectives of representative herbaceous genera of common occurrence belonging to family asteraceae in grassland ecosystem of anpara region in district sonebhadra (UP). *Indian J. Life Sci.* **2:**119-123.

Moorthy, K. K. 1960. Myristica swamps in the evergreen forests of Travancore. Indian For. **86:**314-5.

Mueller-Dombois, D. and Ellenberg, H. 1974. Aims and methods of vegetation ecology. Wiley.

Phillips E.A. 1959. Methods of vegetation study. Henry Holt, New York, p. 107.

Pott, R. 2011. Phytosociology: A modern geobotanical method. Plant Biosystems-An *International J. Dealing with all Aspects of Plant Biology*. **145(1):** 9-18.

Reddy, C.S., Pattanaik, C., Mohapatra, A, Biswa A.K. 2007. Phytosociological Observations on Tree Diversity of Tropical Forest of Similipal Biosphere Reserve, Orissa, India.Taiwania.**52:** 352-359.

Rodgers, W. A. and Panwar, H. S. 1992. Planning a wildlife protected area network for India: an exercise in applied biogeography. In 'Tropical ecosystem, ecology and management'. (Eds KP Singh, JS Singh) pp. 93–107. (Wiley Eastern Ltd: New Delhi).

Roby, T.J., Jose, J. and Nair, P.V. 2018. Phytosociological analysis of Myristica swamp forests of Kulathupuzha, Kerala, India. *Curr. Sci.* **114:** 1687.

Simpson, E. H. 1949. Measurement of diversity. Nature 163:688.

Shivaprasad, P. V., Vasanthraj, B. K. and Chandrashekar, K. R. 2002. Studies on the structure of Pilarkan Reserve Forest, I*ndia. J. Trop. For. Sci.* 71-81.

Sreejith, K. A., Chandrashekara, U. M., Nirmesh, T. K. and Sreekumar, V. B. 2016. Tree species composition and distribution pattern in a myristica swamp of northern Kerala, *India. Curr. World Environ.* **11:**743.

Swamy, S. L., Dutt, C.B.S., Murthy, M.S.R., Mishra, A. and Bargali, S.S. 2010. Floristics and dry matter dynamics of tropical wet evergreen forests of Western Ghats, *India. Curr. Scie*. **99:**353-364.

Varghese, V. and Kumar, B. M. 1997. Ecological observations in the fresh water swamp forests of southern Kerala, *India. J. Trop. For. Sci.* 299-314.

Varghese, A. O. and Menon, A. R. R. 1999. Floristic Composition, Dynamics and Diversity of Myristica Swamp Forests of Southern-Western Ghats, Kerala. Indian For. **125:**775-783.

Vasanthraj, B.K. and Chandrashekar, K. R.2006. Analysis of the structure of Charmady reserve forest. *Tropical Ecology*. **47(2):** pp.279-290.

Walkley, A. and Black, I. A. 1934. An examination of the detjareff method for determining soil organic matter and a proposed modification to the chronic acid titration method. *Soil Science.* **37:**29–38.

Whittaker, R. H. 1972. Evolution and measurement of species diversity. *Taxon*. **21:** 213-251.