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Diversity of over storey plant communities of tropical forest covers of Balasore district, Odisha, India

Abstract

The structure and function of a forest ecosystem is maintained by upper storey vegetation layer which principally consist of tree species. The tropical forest covers of Balasore, one of the coastal district of Odisha was analysed for structure, composition and diversity of upper storey vegetation layer (≥30cm circumference at breast height). A total of 94 tree species representing 77 genera and 38 families were recorded in this area. The average number of species per family was nearly equal to 2.5 and per genus was>1.2.The species diversity index and concentration dominance of the forest were 3.68 and 0.055, respectively. The Importance Value Index (IVI) of species ranged from 0.55 to 40.47. The estimated diversity indices indicated heterogeneity of the tropical forest covers of Balasore district in composition, structure and function. Thus rich over storey plant diversity with many of them as rare occurrence in the area supports the need of conservation for future use and sustenance.

Keywords: floristic composition, species diversity, concentration of dominance, IVI, conservation

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Introduction

Vegetation diversity assessment in tropical forests have mostly been concentrated on tree species than other plant life forms, because tree species diversity is an important aspect of forest ecosystem structure and fundamental to tropical forest biodiversity. Tropical forests, the major repository of biodiversity, are undergoing rapid fragmentation and degradation all over the world.[1] These covers 7% of the earth's land surface, but harbours more than half of the world's species[2] and are currently disappearing at an overall rate of 0.8 to 2% per year.[3] The declining of tropical forests in different parts of the world is most probably due to the activities of human kind.[4] Phytosociology is the study of the characteristics, classification, relationship and distribution of plant communities. It is useful to collect data on the quantitative change of each species studied and how their relationship with other species in the same community. Further, such studies serve as a pre-requisite for investigating the details of primary productivity of tropical ecosystems and can be used for environmental impact assessment studies in future with reference to understand the changes experienced in the past and continuing on into the future.

Most of the developed and developing countries have these basic studies and defined with the help of vegetation maps.[5] Presently as the tropical forests in most part of the world are under immense anthropogenic pressure require careful management intervention to maintain their overall biodiversity and sustainability.[6] The Indian subcontinent rich in biodiversity and as the 12mega-diversity centres of the world facing problem in disappearance of tropical forests at an alarming rate due to anthropogenic activities and invasion of invasive species.[7] During the period 2009 to 2011 net and gross deforestation rate in India was -0.03 and -0.43, respectively.[8] In Odisha, forest covers covering about 37.34% of the state's geographical area and about 7.66% of country's forest[9] having net and gross deforestation rate during 1935 to 2010 was -0.69 and -0.79, respectively.[8] Balasore, one of the coastal districts of Odisha located at 20° 48'to 21° 59' north latitude and 86° 16' to 87° 29' east longitude having a total forest area of 351 sq.km consisting of 23 sq.km of dense forest, 126 sq. km of moderate dense forest and 202sq. km of open forest.[10] A study mentioned that the gross deforestation rate of the district was found 0.69 with in a period of 31years from 1973 to 2004.[8] As per the State of Forest Report, Govt. of India from 2003 to 2007the comparative account of decrease in close forest cover including very dense and moderate dense forest of the district was 1.5sq. km per year. Thus accurate quantification of vegetation especially over storey vegetation layer is a prerequisite to provide information in formulating various action plans or management plans for their restoration. In these contexts vegetation analysis pertaining to Phytosociology and community structure of over storey vegetation layer in different forest covers of Odisha was made by various workers.[11–13] However, it remains as a neglected area with no such studies was made for the tropical forest covers of Balasore. Keeping paucity on quantitative information on over storey plant composition, diversity, and community characteristics the present study was designed to assess the species diversity, richness, abundance and distribution of over storey vegetation layer existing in the study area.

Materials and methods

Study area

The Phytosociological study of upper storey vegetation layer (tree) was carried out in Balasore district, Odisha. The district lies between 20° 48' to 21° 59' north latitude and 86° 16' to 87° 29' east longitude (Figure 1). The district is surrounded by Medinipur district of West Bengal in its northern side, Bay of Bengal in its east, Bhadrak district in its south and Mayurbhanj and Keonjhar districts on its western side. The climate of the district is mostly hot and humid. Annual mean temperature and precipitation of Balasore is 32°C and the average rain fall is 1583mm.[14] Relative humidity is generally high throughout the year and varying in the range of 50% to 90%. The district total geographical area is 3806sq km. Nearly 9.22% of the geographical area of the district is covered by forest which plays an important role in the economy of the district.

Phytosociological analysis

Upper storey vegetation layer of tropical forest covers of the district was analysed by quadrat method. A total of 42 quadrats of 20mx20m size were laid down at different aspects. The size and number of quadrats laid down during survey was ascertained as per species area curve[15] and running mean method.[16] All the tree species in quadrats were enumerated and identified following Saxena et al.[17] All the trees occurring inside the quadrat were recorded and measured for girth at breast height level (1.37m) from the ground. Quantitative data collected during field survey were subjected to analyze various phytosociological parameters following standard methods of calculations and formulae.[15,16,18–20] The frequency values obtained were grouped in frequency classes to study the homogeneous/heterogeneous nature of vegetation.[21] To assess the overall impact of a species Importance Value Index (IVI) was determined by adding relative frequency, relative density and relative basal area as per Cottam et al.[18]

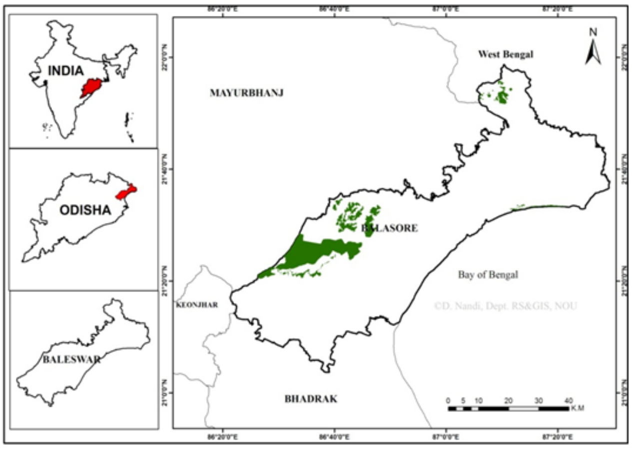

Figure 1 Location map of forest covers in Balasore district of Odisha.

Relative frequency (%): Relative frequency is the degree of dispersion of individual species in an area in relation to the number of all species occurred. It was determined following the equation as

$$Relative\ Frequency\ (\%) = (Frequency\ of\ the\ species / Frequency\ of\ all\ species) \times 100$$

Relative Density (%): Relative Density is the numerical strength of a species in respect to the total number of individual of all the species. It was calculated following the equation as:

$$Relative\ Density = (Density\ of\ the\ species / Density\ of\ all\ species) \times 100$$

Relative dominance (%): Dominance is the parameter which is determined by the value of basal area. For the comparative analysis relative dominance is determined. It is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.It was calculated as:

$$Relative\ dominance = (Basal\ area\ of\ the\ species / Basal\ area\ of\ all\ the\ species) \times 100$$

Importance value index: Importance Value Index is used to determine the overall impact of each species in the community structure. It was calculated by the addition of the percentage values of the relative frequency, relative density and relative dominance (Relative basal area).

$$IVI = Relative\ dominance\ (Relative\ basal\ area) + Relative\ density + Relative\ frequency.$$

Species diversity of upper storey vegetation layer was determined with the Shannon-Wiener diversity index.[22] Concentration of Dominance (CD) was calculated to evaluate the level of dominance of a species within a community and was expressed by Simpson's index.[23]

Shannon-wiener index (Shannon & Wiener, 1963): It is a measure of the average degree of 'uncertainty' in predicting to what species an individual chosen at random from a collection of S species and N individuals. It was estimated by using formula:

$$H' = -\sum_{i=1}^{s}\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)$$

Where, ni: Number of individuals belonging to the species

N: Total number of individuals in the sample

Dominance index (Simpson, 1949): It is a measure of dominance since it weighted towards the abundances of commonest species. It was estimated by using formula:

$$D = \sum_{i=1}^{s}\left(\frac{ni}{N}\right)^2 or Pi^2$$

Where "ni" and "N" are same to Shannon-Wiener index.

Results and discussion

Floristic composition

A total of 94 species belonging to 77 genera and 38 families were recorded from the study area. A majority of the families were represented by only one or two species (Table 1). The most common families were Euphorbiaceae (10species) and Rubiaceae (8species) followed by Combretaceae (5species), Caesalpiniaceae=Ebenaceae=Anacardiaceae=Apocynaceae=Verbenaceae=Oleaceae (4species each), Rutaceae=Barringtoniaceae (3 species each), etc. The number of species per genus was more than 1.2 and that per family was nearly equal to 2.5. The species richness of 94species over 16.8ha area of the district reflects a moderate level of diversity in forests of Eastern Ghats (Table 1). The results of the study compared well to other inventories conducted in tropical forests both in India and elsewhere. Murphy and Lugo[24] emphasized that average tree species richness of a dry tropical forest community ranges from 35 to 90. Condit[25] recorded 63 species from 50ha plot at Mudumalai Forest Reserve, India to 996 species in 52ha plot at Lambir, Malaysia. In a recent assessment of species richness in southern Eastern Ghats, Pragasan and Parthasarathy[26] recorded 272 species in 60ha sampled area.

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Table 1 Species composition, frequency (%), density (Plants/ ha), basal area (m^2/ha), A/F ratio, importance value index (IVI), species diversity (H') and concentration of dominance (Cd) of over storey vegetation layer in tropical forests of Balasore district

Name of the Species	Family	Density (Plants/ha)	Frequency (%)	Basal Area (m2/ha)	A/F	IVI	Species Diversity(H')	Concentration of Dominance (Cd)
Acacia leucophloea (Roxb.) Willd	Mimosaceae	2.38	9.52	0.009	0.049	1.13	0.019	0.000011
Acacia pennata (L.)Willd.	Mimosaceae	1.19	4.76	0.144	0.11	1.05	0.01	0.00003
Actinodaphne angustifolia (Bl.) Nees	Lauraceae	4.76	9.52	0.1	0.1	1.81	0.033	0.00004
Aegle marmelos (L.) Corr.	Rutaceae	2.38	9.52	0.096	0.049	1.43	0.019	0.000011
Alangium salvifolium (L.f.)Wang.	Alangiaceae	1.19	4.76	0.053	0.11	0.74	0.01	0.000003
Alstonia scholaris (L.) R. Br.	Apocynaceae	2.38	4.76	0.2	0.2	1.41	0.019	0.000011
Anogeissus latifolia (Roxb.ex.Dc.) Wall.exGuill. &Perr.	Combretaceae	9.52	33.33	0.233	0.02	4.82	0.057	0.0002
Anthocephalus chinensis (Lam.)A. Rich. ex Walp.	Rubiaceae	4.76	9.52	0.1	0.1	1.91	0.033	0.00004
Antidesma ghasembilla Gaertn.	Euphorbiaceae	1.19	4.76	0.03	0.1	0.66	0.01	0.000003
Aporusa octandra (Buch.-Ham.exD. Don)	Euphorbiaceae	1.19	4.76	0.007	0.1	0.57	0.011	0.000003
Barringtonia acutangula (L.) Gaertn.	Barringtoniaceae	1.19	4.76	0.13	0.1	1.02	0.011	0.000003
Bauhinia malabarica Roxb.	Caesalpiniaceae	1.19	4.76	0.174	0.1	1.16	0.011	0.000003
Bauhinia purpurea L.	Caesalpiniaceae	1.19	4.76	0.019	0.1	0.62	0.011	0.000003
Bauhinia semla Wunderl	Caesalpiniaceae	2.38	4.76	0.203	0.2	1.42	0.018	0.000011
Bombax ceiba L.	Bombacaceae	9.52	19.05	0.631	0.049	5.05	0.057	0.000171
Boswellia serrata Roxb.ex Colebr.	Burseracee	25	33.33	1.16	0.04	10.18	0.116	0.00118
Bridelia airy-shawii P.T.Li	Euphorbiaceae	3.571	14.29	0.23	0.03	2.45	0.026	0.000024
Buchanania lanzan Speng.	Anacardiaceae	22.62	28.57	0.375	0.049	6.73	0.107	0.000964
Canthium dicoccum (Gaertn.)Teijsm & Binnend.	Rubiaceae	3.57	9.52	0.041	0.07	1.4	0.026	0.000024
Careya arborea Roxb.	Barringtoniaceae	7.14	23.81	0.07	0.025	3.15	0.045	0.0001
Casearia graveolens Dalz	Flacourtiaceae	4.76	19.05	0.019	0.02	2.26	0.033	0.000043
Cassia fistula L.	Caesalpiniaceae	7.14	19.05	0.059	0.08	2.73	0.045	0.00001
Chionanthus macrophylla (Wall.ExG. Don)Bl.	Oleaceae	5.95	4.76	0.076	0.5	1.47	0.039	0.00007
Chionanthus mala- elengi (Dennst.) Green	Oleaceae	8.33	14.29	0.264	0.08	3.22	0.051	0.000131
Cleistanthus collinus (Roxb.) Benth. ex. Hook.f.	Euphorbiaceae	8.33	14.29	0.131	0.08	2.76	0.051	0.000131
Combretum roxburghii Spreng.	Combretaceae	1.19	4.76	0.001	0.11	0.56	0.01	0.000003
Croton roxburghii Balak	Euphorbiaceae	25	38.09	0.493	0.03	8.23	0.116	0.001177
Cycas circinalis L.	Cycadaceae	1.19	4.76	0.01	0.1	0.59	0.01	0.000003
Dalbergia lanceolaria L.f.	Moraceae	2.38	4.76	0.29	0.2	1.73	0.018	0.000011
Dalbergia latifolia Roxb.	Fabaceae	2.38	9.52	0.23	0.049	1.9	0.019	0.000011
Dalbergia volubilis Roxb.	Fabaceae	1.19	4.76	0.002	0.1	0.56	0.01	0.000003
Dillenia pentagyna Roxb.	Dilleniaceae	11.91	23.81	1.299	0.04	8.1	0.067	0.0003
Diospyros sylvatica Roxb.	Ebenaceae	4.76	14.29	0.037	0.049	1.94	0.033	0.000043
Diospyros malabarica (Desr.) Kostel	Ebenaceae	5.95	9.52	2.215	0.13	9.33	0.039	0.00007
Diospyros melanoxylon Roxb.	Ebenaceae	17.86	23.81	0.116	0.06	4.78	0.09	0.000601
Diospyros montana Roxb.	Ebenaceae	7.14	14.29	0.122	0.07	2.56	0.045	0.0001

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Table Continued..

Name of the Species	Family	Density (Plants/ha)	Frequency (%)	Basal Area (m2/ha)	A/F	IVI	Species Diversity(H')	Concentration of Dominance (Cd)
Erhetia laevis Roxb.	Ehretiaceae	1.19	4.761	0.001	0.1	0.56	0.011	0.000003
Fagerlindia fasciculate (Roxb.) Tirveng.	Rubiaceae	9.52	28.57	0.2	0.02	4.33	0.057	0.000171
Garuga pinnata Roxb.	Burseracee	1.19	4.76	0.014	0.1	0.59	0.01	0.000003
Glochidion lanceolarium (Roxb.) Dalz	Euphorbiaceae	16.66	19.05	0.196	0.09	4.51	0.086	0.000523
Grewia tilifolia Vahl.	Tiliaceae	1.19	4.76	0.011	0.1	0.59	0.01	0.000003
Haldinia cordifolia (Roxb.)Ridsd.	Rubiaceae	8.33	19.05	0.468	0.04	4.32	0.051	0.000131
Heterophragma roxburghii L.	Bignoniaceae	1.19	4.76	0.007	0.1	0.57	0.01	0.000003
Holarrhena pubescens (Buch-Ham.) Wall.ex G Don	Apocynaceae	19.05	57.14	0.285	0.01	8.23	0.095	0.000683
Holoptelia integrifolia (Roxb.)Planch.	Ulmaceae	1.19	4.76	0.016	0.1	0.6	0.01	0.000003
Ixora pavetta Andr.	Rubiaceae	2.38	4.76	0.011	0.21	0.75	0.019	0.000011
Ixora undulate Roxb.	Rubiaceae	2.38	9.52	0.048	0.049	1.26	0.019	0.000011
Kydia calycina Roxb.	Malvaceae	2.38	9.52	0.261	0.049	2.01	0.019	0.000011
Lagerstroemia paviflora Roxb.	Lythraceae	3.57	9.52	0.037	0.07	1.39	0.026	0.000024
Lannea coromandelica (Houtt.)Nerr.	Anacardiaceae	7.14	14.29	0.124	0.07	2.57	0.045	0.0001
Leea asiatica (L.) Ridsdale	Vitaceae	1.19	4.76	0.008	0.1	0.58	0.01	0.000003
Ligustrum gamblei Ramam.	Oleaceae	1.19	4.76	0.01	0.1	0.6	0.01	0.000003
Limonia crenulata Roxb.	Rutaceae	1.19	4.76	0.036	0.1	0.68	0.01	0.000003
Litsea glutinosa (Lour) Robins.	Lauraceae	1.19	4.7619	0.025	0.1	0.64	0.011	0.000003
Litsea monopetala (Roxb.) Pers.	Lauraceae	1.19	4.76	0.024	0.1	0.63	0.011	0.000003
Macaranga peltata (Roxb.)Muell.-Arg.	Euphorbiaceae	9.52	33.33	0.062	0.02	4.22	0.057	0.000171
Madhuca indica Gmel.	Sapotaceae	21.43	14.29	0.232	0.2	4.91	0.104	0.000865
Mallatous philippensis (Lam.) Muell.-Arg.	Euphorbiaceae	1.19	4.76	0.005	0.1	0.57	0.011	0.000003
Mangifera indica L.	Anacardiaceae	8.33	9.52	5.451	0.18	20.98	0.051	0.000131
Melia azadirachta L.	Meliaceae	1.19	4.76	0.045	0.1	0.71	0.01	0.000003
Meyna spinosa Roxb.ex Link.	Rubiaceae	1.19	4.76	0.011	0.1	0.588	0.011	0.000003
Miliusa velutina (Dunal) Hook.f.& Thoms.	Annonaceae	1.19	4.76	0.001	0.1	0.54	0.011	0.000003
Morinda pubescens Sm.	Rubiaceae	1.19	4.76	0.002	0.1	0.56	0.011	0.000003
Murraya paniculata (L.)Jack.	Rutaceae	2.38	4.76	0.009	0.21	0.74	0.019	0.000011
Nyctanthes arbor-tristis L.	Oleaceae	1.19	4.76	0.018	0.1	0.61	0.011	0.000003
Ochna squarrosa L.	Ochnaceae	1.19	4.76	0.006	0.1	0.57	0.01	0.000003
Oroxylum indicum (L.) Vent	Bignoniaceae	3.57	14.29	0.086	0.03	1.95	0.026	0.000024
Phyllanthus emblica L.	Euphorbiaceae	3.57	9.52	0.03	0.07	1.36	0.026	0.000024
Polyalthia suberosa L.	Annonaceae	1.19	4.76	0.021	0.1	0.62	0.01	0.000003
Pongamia pinnata (L.)Pierre	Fabaceae	19.05	19.05	1.721	0.1	10.17	0.095	0.000683
Premna calycina Haines	Verbenaceae	5.95	4.76	0.174	0.5	1.81	0.039	0.00007
Pterocarpus marsupium Roxb.	Fabaceae	13.09	23.81	0.231	0.04	4.53	0.072	0.000323
Pterospermum acerifolium (L.)Willd	Sterculiaceae	1.19	4.76	0.041	0.1	0.69	0.01	0.000003
Schleichera oleosa (Lour.) Oken	Sapindaceae	14.29	28.57	0.31	0.03	5.35	0.077	0.000384
Shorea robusta Gaertn.f	Dipterocarpaceae	134.523	66.66	4.753	0.06	40.47	0.312	0.034092
Soymida febrifuge (Roxb.)A. Juss.	Meliaceae	3.57	4.76	0.04	0.3	1.03	0.026	0.000024

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Table Continued..

Name of the Species	Family	Density (Plants/ha)	Frequency (%)	Basal Area (m2/ha)	A/F	IVI	Species Diversity(H')	Concentration of Dominance (Cd)
Spondias pinnata (L.f.)Kurz	Anacardiaceae	1.19	4.76	0.001	0.1	0.57	0.01	0.000003
Sterospermum colais (Buch.-Ham.ex Dillw.) Mabberley	Bignoniaceae	1.19	4.76	0.001	0.1	0.59	0.011	0.000003
Strychnos nox-vomica L.	Strychnaceae	2.38	4.76	0.041	0.21	0.86	0.019	0.000011
Syzygium cumini (L.)Skeels	Myrtaceae	13.09	42.86	0.491	0.01	6.97	0.072	0.000323
Syzygium cerasoides (Roxb.) Chatt. & Kanjilal f.	Myrtaceae	1.19	4.76	0.144	0.1	1.06	0.01	0.000003
Tectona grandis L.f.	Verbenaceae	3.57	4.76	0.028	0.3	0.97	0.026	0.000024
Terminalia alata Heyne.ex Roth	Combretaceae	70.24	61.91	1.496	0.03	19.87	0.225	0.009294
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	10.71	23.81	0.37	0.04	4.71	0.062	0.000216
Terminalia chebula Retz.	Combretaceae	3.57	9.52	0.063	0.07	1.48	0.026	0.000024
Trema orientalis (L.) Bl.	Ulmaceae	2.38	4.76	0.04	0.2	0.88	0.019	0.000011
Trewia nudiflora L.	Euphorbiaceae	4.76	9.52	0.245	0.11	2.28	0.033	0.00004
Vitex peduncularis Wall.ex Schauer	Lamiaceae	1.19	4.76	0.021	0.1	0.62	0.01	0.000003
Vitex pinnata L.	Verbenaceae	3.57	9.52	0.159	0.07	1.82	0.026	0.000024
Vitex trifolia L.	Verbenaceae	1.19	4.76	0.252	0.1	1.43	0.011	0.000003
Wendlandia tinctoria (Roxb.) DC	Rubiaceae	7.14	14.29	0.122	0.07	2.56	0.045	0.0001
Wrightia arborea (Dennst.)Mabb.	Apocynaceae	9.52	14.29	0.119	0.09	2.88	0.056	0.000171
Wrightia tinctoria (Roxb.) R.Br.	Apocynaceae	14.29	23.81	0.113	0.049	4.28	0.077	0.000384
Xantolis tomentosa (Roxb.)Rafin.	Sapotaceae	20.24	28.57	0.347	0.049	6.3	0.099	0.000772
		728.474		**28.453**		**300**	**3.681**	**0.055475**

Distribution pattern of species

Of the 94 tree species recoded in the study area most of the species exhibited contiguous distribution (70 species). Only few species exhibited random (17species) and regular (7species) distribution. Contiguous distribution was more pronounced by *Chionanthus macrophylla, Premna calycina, Soymida febrifuge, Tectona grandis, Ixora pavetta, Murraya paniculata, Strychnos nox-vomica, etc. Species showed regular distribution were Anogeissus latifolia, Macaranga peltata, Holarrhaena pubescens, Careya arborea, Fragerlindia fasciculate, Syzygium cumini and Casearia graveolens* (Table 1).

Raunkiaer's frequency class distribution

The over storey species had a wide range of occurrence in the study site ranging in frequency from 4.76 to 66.67 % and most of the species occurred only twice (Table 1). The distribution of the species into Raunkiaer's frequency classes showed that most of the species encountered were in class "A" followed by class "B" and equal in "C" and "D" (Figure 2). This indicates that most of the species had low frequency as would be expected in typical species-abundance distribution in tropical forests.[27] Raunkiaer[21] frequency distribution holds good for this forest cover also. However this forest had only four classes instead of five as described in the law. This was due to its higher heterogeneous nature and deviation from the normal frequency distribution as described by Raunkiaer.[21]

Stand structure

Structural parameters like density (plants/ha), basal area (m^2/ha) and frequency (%) of upper-storey vegetation layer of the study area is presented in Table 1**.** Species wise density of individuals having ≥30cm girth ranged from 2 to 134plants/ha and the total density of 729 plants/ha. Maximum density was recorded for *Shorea robusta (134) followed by Terminalia alata (70), Croton roxburghii (25), Boswellia serrata (25), Buchnania lanzan (22.62), Madhuca indica (21.43) and Xantolish tomentosa (20.24). The minimum density of less than equal to two was observed for many species like Aporusa octandra, Spondias pinnata, Miliusa velutina, Bauhinia purpurea, Sterospermum colais, Litsia monopetala, Vitex penducularis, Syzygium cerasoides,* etc. Rest of the species showed intermediate range of density per hectare

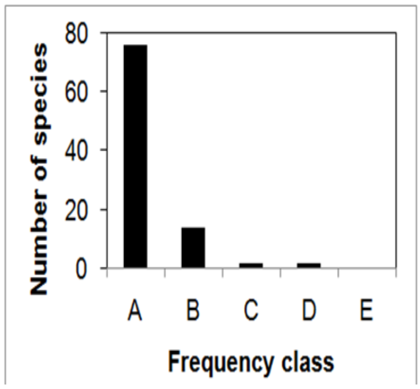

Figure 2 Raunkiaer's frequency class distribution of over storey vegetation layer of the study area.

The tree density of 729 individuals/ha recorded in the present investigation is lower as compared to densities reported from Saddle Peak of North Andaman Islands and Great Andaman Groups (946-1137trees/ha,[28]] and well comparable to tropical forests of

Kalkad, Western Ghats (575-855trees/ha,[29]), Similipal, Odisha,[30,31] Brazil (420-777trees/ha,[32]), seasonally deciduous forest of Central Brazil (734trees/ha,[33]), Semi deciduous forest of Piracicaba, Brazil (842trees/ha,[34]) and Costa Rica (617trees/ha,[35]). Basal area of upper storey vegetation in the study area ranged from 0.001-5.451m^2/ha, the highest for *Mangifera indica* and lowest for many species like *Ethetia laevis,* Sterospermum colais, *Spondias pinnata* and *Miliusa velutina* (Table 1). Basal areas for some important timber species such as *Shorea robusta*, *Tectona grandis* and *Dalbergia lanceolaria* were 4.753, 0.028 and 0.290 m^2/ha, respectively. The overall basal area estimated was 28.453m^2/ha. *Mangifera indica* contributed maximum of 19% to the total basal area followed by *Shorea robusta* (16.61%), *Diospyros malabarica* (7.72%) and *Pongamia pinnata* (6%). The total contribution that resulted from this associated combination of *Mangifera-Shorea-Diospyros-Pongamia* was 50%. The overall basal area estimated of upper storey vegetation layer is well within the reported range of various Indian tropical forests[36] and lower than the value reported from Monteverde of Costa Rica (62m^2/ha,[37]). High basal area is a characteristic feature of mature forest stand and serves as a reflection of high performance of the trees. It may also presuppose the development of an extensive root system used efficient nutrient absorption, growth suppressing of subordinate plants as they intercept much of the solar radiation that might otherwise reach the forest floor.

Ecological importance of species

Importance Value Index (IVI) is the measurement of relative contribution of a species to the entire community and suggesting the ability of a species to establish over an array of habitats. However, there is no single perfect way of assessing the relative contribution of a species. The abundance of a species can be represented by several measures such as relative density, relative frequency and Importance Value Index (IVI). Though frequency and density values are suitable for herbs and shrubs,[39] IVI is an important information for tree species. On the basis of IVI, *Shorea robusta* was found as the dominant species having IVI of 40.47 followed by *Mangifera indica* (20.98), *Terminalia alata* (19.87), *Boswellia serrata* (10.18), *Pongamia pinnata* (10.17), etc. *Miliusa velutina* had IVI of 0.054 was considered as the rare species of the study area (Table 1). All other tree species showed intermediate range of IVI. High IVI values exhibited by those species clearly indicate the ecological importance of corresponding species. Such measurement of over storey vegetation layer also helps in understanding the ecological significance of a species in its community/habitat. Higher is the IVI more ecological significance of the species in a particular ecosystem.[27] Furthermore, information of IVI would of prime importance in deciding the management options for specific host population of native wildlife that is facing the danger of local extinction due to heavy human pressure surrounding this forest cover.

Diversity measures

Species diversity and concentration of dominance of upper-storey vegetation layer of the study area is given in Table 1. Measurement of biodiversity of specific area (local scale) on the basis of species richness does not provide a complete understanding about the individuals of the species in an ecosystem as it suffers from the lack of evenness or equitability. Shannon Wiener's index of diversity is one of the popular measures of species diversity. It ranged from 0.01 to 0.312 across the study area with a total diversity value of 3.68. Maximum species diversity of 0.312 was experienced by *Shorea robsusta* while the minimum of 0.01 was experienced by many species of the study area indicating that over storey vegetation layer of Balasore was highly diverse. The species diversity is generally higher for tropical forests, which is reported as 5.06 and 5.40 for young and old stand, respectively.[39] For Indian forests the diversity index ranges between 0.83-4.1.[41] Higher species diversity index in tropical forests as reported by Knight[40] in comparison to the present investigation may be due to differences in the area sampled and lack of uniform plot dimensions. In contrast to species diversity the concentration of dominance of such vegetation layer ranged from 0.000003 to 0.03. Maximum value was experienced by *Shorea robusta* and minimum by many species (Table 1). The range of concentration of dominance estimated for over-storey vegetation layer of the district implies that most of the species are equitably distributed while very few species showed the degree of dominance.[42] The range of concentration of dominance estimated of the study area is less than those recorded in Nelliampathy (0.085;[43]) and tropical dry deciduous forests of Western India (0.08- 0.16;[44]) and indicates the absence of single species dominance.

Conclusion

Tropical forest covers of Balasore district supports a diverse plant community. The rich plant diversity is worthy for its conservation to check it from further reduction in species richness, rapid deforestation and forest fragmentation. The rare species of the area identified based on IVI must need proper attention to determine their conservation status and key functions. Further research on mapping of such species with respect to their concentrated distribution in some pockets of the study area and study of their key ecological and structural functions would help to identify locations for conservation actions.

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Conflict of interest

The author declares no conflict of interest.

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