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Phytosociological Observations on Tree Diversity of Tropical Forest of Similipal Biosphere Reserve, Orissa, India

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ABSTRACT: The present study deals with the quantitative floristic inventory of three tropical forest types in Similipal Biosphere Reserve in Eastern Ghats of Orissa, India. Three forest types were distinct in field and differed in dominance, composition, diversity and structure. The study resulted in documentation of a total 549 species of flowering plants. Altogether, 4819 stems of ≥30 cm gbh belonging to 185 tree species were enumerated and analysed. Tree stand density varied from 527 to 665 ha^{-1} with average basal area of 43.51 m^2ha^{-1}. Shannon–Wiener index (H') ranges from 4.3 to 5.46. Similarity index revealed that only 25% of floristic composition of semi-evergreen forest was similar with moist deciduous forest. Analysis of population density of tree species across girth class interval showed that around 48.9% of individuals belong to 30-60 cm gbh. The present study can serve as baseline information for phytodiversity characterisation of tropical forests in the Similipal Biosphere Reserve in particular and Eastern Ghats of Orissa in general.

KEY WORDS: Tropical forest, semi-evergreen, deciduous, species composition, eastern Ghats, similipal biosphere reserve, Orissa.

INTRODUCTION

Tropical forests are highly diverse due to species interaction and niche variation, which is a result of favorable climatic (Ojo and Ola-Adams, 1996) and edaphic conditions. Understanding of vegetation composition, diversity of species and their habitats, and comparison with similar other habitats, may become a tool to estimate the level of adaptation to the environment and their ecological significance. Over the decades, forests in the Peninsular India were destructed at an alarming rate, which was largely addressed by environmental and economic problems in many tropical and subtropical countries, although the data on structure and functional dynamics of these forests (Parthasarathy and Sethi, 1997) are scarce.

Information on floristic composition, diversity and phytomass are absolutely essential in understanding the forest ecosystem dynamics (Gentry, 1990; Hartshorn, 1990). In peninsular India, quantitative phytodiversity inventories are available from the forests of the Western Ghats, whereas study on Eastern Ghats is lacking. Eastern Ghats are a long chain of broken hills and elevated plateaus, running along the Indian east coast and passes through the states of Orissa, Andhra Pradesh, Tamil Nadu and two districts of Karnataka state. The wide range of topography, varied climate favours luxurious growth of vegetation and forest with number of invaluable medicinal plant species (Rawat, 1997). It remain as a neglected area with very few attempts made for such studies in Eastern Ghats of Tamil Nadu (Kadavul and Parthasarathy, 1999a & b; Chittiibabu and Parthasarathy, 2000; Jayakumar et al., 2002; Natarajan et al., 2004). These kinds of studies are poorly explored in the State of Orissa, which covers a 46% of forest area in Eastern Ghats (Anonymous, 2006). Hence, the present study was undertaken to determine the structure and floristic composition of tree diversity in three tropical forest types of Similipal Biosphere Reserve (SBR), Eastern Ghats of Orissa, India.

MATERIALS AND METHODS

Study area

The Eastern Ghats are located along the Peninsular India extending over 1750 km with average width of about 100 km and covering the area

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under 11° 30′ to 22° 34′ North latitude and 77° 22′ to 87° 29′ East longitude. The Eastern Ghats are delimited in the north by Similipal hills of Orissa state. The middle section extends from river Krishna (Andhra Pradesh) to near about Chennai city (Tamil Nadu) and includes the Nallamalais, Nigidi, Seshachalam and Veligonda hills. The last section runs in south-southwest direction meeting the Western Ghats in the Nilgiris (Reddy et al., 2006). SBR is the only biosphere reserve of Eastern Ghats, situated in Mayurbhanj district of Orissa, India (Fig. 1). It situated between 21° 28' to 22° 08' N latitude and 86° 03' to 86° 37' E longitude. It has been declared as a wildlife sanctuary comprising a forest area of 2,200 sq. km during 1979. Similipal was declared as a biosphere reserve by Government of India on 22nd June 1994 due to its rich biodiversity and natural heritage. The hills, with their innumerable crests and valleys, interspersed with countless streams and rivers exhibit a great degree of topographic variation, ranging from 200 to 1166 m above sea level. Geological formation of the region consists of sub-metamorphic sandstones and quartzite haematites (Girach et al., 1999). There are 1076 plants recorded from the area including 60 species of ferns, 92 species of orchids and two gymnosperms (Saxena and Brahmam, 1989; Misra, 2004).

Field sampling

Phytosociological data were collected in the three forest types based on stratified random sampling method during October 2005 to February 2006. The size and number of quadrats needed were determined using the species area curve (Misra, 1968). Sample plot (quadrat) size of 20 x 20 m were placed and systematically surveyed for all trees ≥30 cm diameter of breast height (dbh - above 130 cm from the ground). In addition to the trees, data on shrubs (5 x 5 m), herbs, climbers and saplings (1 x 1 m) were collected. Thus, data were obtained from a total of 212 sample plots (total sampled area = 8.48 ha). Of the three forest types in the SBR, moist deciduous forest is the most common followed by dry deciduous and semi-evergreen forest. The species were identified with the help of the Flora of Presidency of Madras (Gamble and Fischer, 1915-1935) and Flora of Orissa (Saxena and Brahmam, 1996).

Data analysis

The vegetation 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 frequency, relative density and relative dominance (Cottam and Curtis, 1956). Some of the formulas are given below.

Basal area (m^2) = area occupied at breast height (1.3 m) = [pi* $(dbh/2)^2$].

Relative density = (Density of the species/Total density of all species) x 100.

Relative frequency = (Frequency of the species /Total frequency of all species) x 100.

Relative dominance = (Basal area of the species/Total basal area for all species) x 100.

Importance Value Index (IVI) = Sum of relative density + relative frequency + relative dominance.

Species diversity of each forest type was determined (Shannon and Weiner, 1963).

$$H' = -\sum [(ni/N)\log 2(ni/N)]$$

where *ni* is the total number of individuals of species *i* and *N* is the total number of individuals of all species in that vegetation type.

Similarity (Sorenson's index of similarity) between three forest types was determined (Sorenson, 1948).

Concentration of dominance was also measured (Simpson, 1949).

$$C = -\mathrm{S}\ (ni/N)$$

where *ni* and *N* are the same as those for the Shannon–Weaver information function.

RESULTS

Forest floristics

The study resulted in documentation of a total 549 species of flowering plants. A total of 4819 stems of ≥ 30 cm gbh belonging to 185 tree species were recorded within three forest types, representing 132 genera under 55 families (Table 1). Mean stem density was 568 trees ha^{-1} (range 527–665) and mean basal area was 43.1 m^2 ha^{-1}. Forest type-wise tree species richness was 100 for semi-evergreen, 121 for moist deciduous and 76 for dry deciduous with major differences between the plots. Semi-evergreen forests are more diverse at spatial scale than their counterparts. Within the three forest types, the most abundant families were Rubiaceae and Euphorbiaceae, representing 21 and 15 tree species respectively. An obvious variation in representation of tree species and the proportion of dominant species in the forest types can directly be attributed to rainfall distribution and favourable topographic conditions.

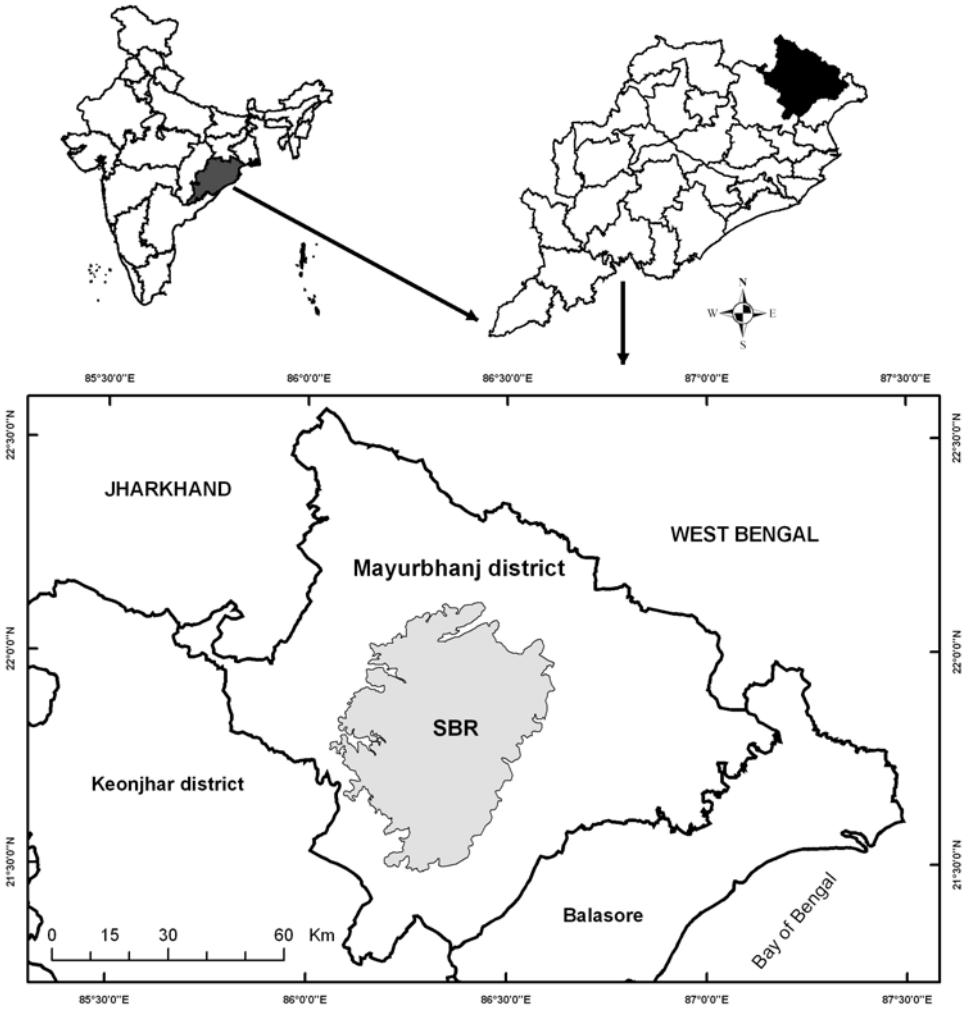

Fig. 1. Location map of the study area.

In semi-evergreen forest, moisture indicating species are prevalent, i.e. *Michelia champaca, Syzygium operculatum, Dillenia pentagyna, Syzygium cumini* and *Litsea glutinosa* (Table 2). Whereas in moist deciduous forest, species composition comprise a mixture of both moist and dry elements, indicating transitional type. In moist deciduous forest, *Shorea robusta, Terminalia alata, Anogeissus latifolia, Haldinia cordifolia* and *Protium serratum* are predominant species and occupy 61% of composition. In dry deciduous forest, *Shorea robusta, Terminalia alata, Buchanania lanzan, Madhuca indica* and *Diospyros melanoxylon* are predominant (Table 2). The semi-evergreen forest is represented by 53% of individuals of top ten species, where as in case of moist deciduous forest and dry deciduous forest the proportions are 71% and 77% respectively. A large group of species (34%) are represented by ≤ 2 individuals.

Forest structure

Basal area was ranging from 26.30 m^2 (dry deciduous) to 52.82 m^2 (semi-evergreen) (Table1). The distribution of the basal area across the forest types, using gbh interval classes, reveals the dominance of small stemmed individuals in the plots (Table 3). The mean diameter of top 10 dominant tree species covers 66% of ground cover. It means minority of species dominate the majority of the available resources. *Michelia champaca, Mangifera indica* and *Shorea robusta* represents highest girth of 600 cm, 455 cm and 430 cm respectively.

The mean tree height is 17.5 m with a height ranging from 1 to 35 m. Tree distribution by height intervals shows that around 22.6% of individuals are in the height of 15-20 m, where as 4% of individuals are in the height class of > 30 m (Table 4). The tallest individual trees were *Michelia champaca* (35 m) and *Syzygium operculatum* (34 m) in semi-evergreen

Table 1. Consolidated average details of species inventory in Similipal Biosphere Reserve.

Description	Semi-evergreen	Moist Deciduous	Dry Deciduous	Total
No. of sample points (20 x 20 m)	36	125	51	212
Area sampled (ha)	1.44	5.00	2.04	8.48
No. of tree species	100	121	76	185
No. of tree genera	86	91	62	132
No of tree families	43	42	33	55
No. of shrub species	27	36	20	52
No. of herb species	102	186	87	245
No. of climber species	34	50	19	67
Total species (incl. trees)	263	393	202	549
Density (stems/ha^{-1})	665	557	527	568
Species diversity index (H')	5.46	4.56	4.3	5
Simpson index (C)	0.96	0.81	0.82	0.90
Basal area (m^2/ha^{-1})	52.82	42.08	26.30	43.51
Similarity Index				
Site 1	---	25	21	
Site2		---	32	
Site3			---	

Table 2. Importance Value Index (IVI) of the ten most important species in different forest types of SBR.

Plant species	Relative Density	Relative Frequency	Relative Dominance	IVI
		Semi-evergreen		
Michelia champaca	9.4	5.2	20.9	35.5
Syzygium operculatum	8.3	4.5	9.7	22.5
Dillenia pentagyna	6.2	5.7	7.4	19.2
Syzygium cumini	7.4	4.1	5.5	17.0
Litsea glutinosa	4.2	4.3	3.6	12.1
Protium serratum	4.7	3.6	3.5	11.9
Shorea robusta	3.2	2.7	5.5	11.4
Schleichera oleosa	4.0	2.9	3.0	9.9
Cedrela toona	3.3	2.7	3.1	9.1
Mangifera indica	3.1	2.9	3.0	9.1
		Moist deciduous		
Shorea robusta	41.8	11.2	47.8	100.8
Terminalia alata	10.8	9.7	9.6	30.1
Anogeissus latifolia	3.2	4.2	3.5	10.9
Haldinia cordifolia	2.6	4.1	3.6	10.4
Protium serratum	2.9	3.4	3.0	9.3
Pterocarpus marsupium	1.9	3.3	2.7	8.0
Terminalia chebula	2.3	3.7	1.8	7.8
Buchanania lanzan	2.2	3.2	1.2	6.5
Xylia xylocarpa	1.5	1.4	3.3	6.3
Dillenia pentagyna	1.7	2.4	1.9	6.0
		Dry deciduous		
Shorea robusta	40.1	11.9	38.8	90.9
Terminalia alata	8.9	8.9	8.5	26.3
Buchanania lanzan	8.0	8.1	4.6	20.6
Madhuca indica	4.6	5.8	9.9	20.3
Diospyros melanoxylon	3.8	5.6	4.7	14.0
Schleichera oleosa	2.2	4.1	7.4	13.7
Croton oblongifolius	2.9	4.6	2.6	10.0
Cleistanthus collinus	2.9	4.1	1.8	8.7
Anogeissus latifolia	2.3	2.8	2.8	7.9
Careya arborea	2.0	4.1	0.9	7.0

forest and *Shorea robusta* (35 m) and *Terminalia chebula* (32 m) in moist deciduous forest. In dry deciduous forest, *Schleichera oleosa* and *Shorea robusta* recorded highest (30 m) in height. Tree species in dry deciduous forests show tendency towards shorter stature (40% of individuals are with less than 10 m height) than trees in semi-evergreen (18%) and moist deciduous forest (33%). The basal area and vertical structure of a forest is difficult to summarise as these relies heavily upon the climate and prevailing edaphic conditions. Tree heights are heavily influenced by the abundance of saplings, richness of nutrients and anthropogenic pressure.

Table 3. Population density of tree species (≥ 30 cm gbh) in three sites across girth class intervals.

GBH class	Semi-evergreen		Moist deciduous		Dry deciduous		Total			
	Species	Individuals	Species	Individuals	Species	Individuals	Total species	% of species	Individuals	% of individuals
30-60	80	350	104	1364	58	644	150	81.1	2358	48.9
60-90	51	199	61	544	38	240	93	50.3	983	20.4
90-120	37	109	37	310	19	88	82	44.3	507	10.5
120-150	34	136	38	278	10	51	57	30.8	465	9.6
150-180	24	64	21	130	12	30	48	25.9	224	4.6
180-210	20	47	17	96	11	22	25	13.5	165	3.4
210-240	11	20	9	22	5	8	20	10.8	50	1.0
240-270	9	15	5	11	3	3	19	10.3	29	0.6
>270	7	14	5	22	2	2	8	4.3	38	0.8
Total	100	954	121	2777	76	1088	185	100	4819	100

Table 4. Height class wise proportion of tree individuals in three forest types.

Height Class	Semi-evergreen		Moist deciduous		Dry deciduous		Grand Total		
	Species	Individuals	Species	Individuals	Species	Individuals	Total Species	Individuals	% of individuals
<5m	31	45	65	341	38	171	92	557	11.6
5-10	52	131	76	575	45	260	117	966	20.0
10-15	53	160	73	486	37	282	103	928	19.3
15-20	61	264	63	588	29	236	99	1088	22.6
20-25	43	229	48	506	15	98	75	833	17.3
25-30	22	67	24	163	11	26	39	256	5.3
>30	22	61	16	119	5	11	33	191	4.0
Total	100	957	121	2778	76	1084	185	4819	100

DISCUSSION

The predominant forest types of the Eastern Ghats of Orissa are tropical moist deciduous, tropical dry deciduous and semi-evergreen (Champion and Seth, 1968). Of the 549 species of flowering plants, herbs and trees contribute 245 (44.6%) and 185 (33.7%) species respectively (Table 1). The presence of 185 tree species in 212 sample plots (8.48 ha area) infers high variability in the tropical forests of SBR.

The mean stand density of 568 stems ha^{-1} and range of 527-665 stems ha^{-1} in the tropical forests of study area is well within the range of 276 - 905 stems ha^{-1} reported in the tropics (Ghate et al., 1998; Sundarapandian and Swamy, 1997; Murali et al., 1996). This range of stand density in the present study is higher when compared to study at Shervarayan hills, Kalrayan hills and Coromandel coast of Eastern Ghats. (Parthasarathy and Sethi, 1997; Kadavul and Parthasarathy, 1999a; Kadavul and Parthasarathy, 1999b) and lower from other study sites like Courtallam reserve forest, Sengaltheri and Kakachi RF of Western Ghats. (Ganesh et al., 1996; Parthasarathy and Karthikeyan, 1997a; Parthasarathy, 2001). The densities reported in other tropical sites across the world are also shows similar trend as in Costa Rica - 448 to 617 ha^{-1} (Heaney and Proctor, 1990); Brazil - 420 to 777 ha^{-1} (Campbell et al., 1992) and Malaysia 250 to 500 ha^{-1} (Primack and Hall, 1992). The most obvious variation in tree species and the proportion of dominant species in the three forest types can directly be attributed to altitudinal and rainfall distribution. Semi-evergreen and moist deciduous forests are distributed in high rainfall and high altitude (400 to 1000 m) areas, while dry deciduous forests were found in low altitude (< 400 m) areas.

Species rarity (those represented by ≤ 2 individuals) of 34% obtained in the present study area is higher as compared to Kuzhanthaikuppam and Thirumanikkuzhi (26% and 31% respectively) dry evergreen forest sites on the Coromandel coast (Parthasarathy and Karthikeyan, 1997b) and lower than that of (43%) Vellimalai, in the Kalrayan hills of Eastern Ghats (Kadavul and Parthasarathy, 1999b). This value is also lower than that of other tropical forests, 50% in West Java (Meijer, 1959), 55.4% in New Guinea (Paijmans, 1970), 59% in Jengka forest reserve, and Malaysia (Ho et al., 1987).

The overall expanding population structure indicates that study area represents typical mature stands with good regeneration. This is in conformity with that of three tropical dry evergreen forests on the Coromandel coast, India (Parthasarathy and Sethi, 1997; Parthasarathy and Karthikeyan, 1997b; Kadavul and Parthasarathy, 1999), and other forest inventories such as from Malaysia (Poore, 1968; Ho et al., 1987), Costa Rica (Lieberman et al., 1985; Nadkarni et al., 1995) and Brazilian Amazon (Swaine et al., 1987; Campbell et al., 1992).

Current study identified Rubiaceae (21 species) and Euphorbiaceae (15 species) are the families with highest number of tree species. Similar such predominance was recorded from Shervarayan hills (Kadavul and Parthasarathy, 1999a). Martin and Aber (1997) reported Leguminosae as the most abundant family in neo-tropical forests.

Girth class frequency showed J-shaped population structure of trees exhibited in all the three study sites are in conformity with many other forest stands in Eastern and Western Ghats such as Shervarayan hills (Kadavul and Parathasarthy, 1999a); Kalrayan hills (Kadavul and Parthasarathy, 1999b); Kakachi (Ganesh et al., 1996); Uppangala (Pascal and Pelissier, 1996); Mylodai-Courtallum resreve forest (Parthasarathy and Karthikeyan, 1997a).

CONCLUSION

Presence of high species richness and diversity, mean stand density and species rarity indicates the uniqueness and potentiality of SBR for conservation of ecosystem in its totality. The problem of forest fire, grazing, fuel wood extraction, medicinal plants collection is observed in periphery of study sites which should be checked practically and must be given highest priority for habitat conservation. The immediate attention on people's participation is most essential for effective conservation. The present study will serve as a primary input towards phytodiversity characterization of Similipal Biosphere Reserve in particular and Eastern Ghats of Orissa in general.

Hence, it may be concluded that some of the areas in Eastern Ghats are still rich in tree species diversity, even after disturbances in terms of fire, grazing, extraction of economic/medicinal species and invasion of exotic species.

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印度奧里薩邦 Similipal 生物圈保護區熱帶森林樹種多樣性探討

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摘　　要

本研究量化印度奧里薩邦東高止的 Similipal 生物圈保護區三處熱帶森林的量化植物相調查，該三處森林的優勢種、物種組成、歧異度及結構均有所不同。調查結果共記載 549 種顯花植物，其中胸高直徑 ≥30 cm 的樹木計有 4819 株，隸屬於 185 樹種。森林中的樹木密度每公頃為 527 to 665 株，平均底面積為 43.51 m^2，Shannon–Wiener 歧異度指數為 4.3 至 5.46。相似度指數的計算顯示本半常綠林之物種組成僅有 25%與濕潤落葉林相似，族群結構的分析結果呈現出 48.9%植株的胸高直徑介於 30-60 cm。本研究的成果將可提供基礎資料，以了解奧里薩邦地區（特別是 Similipal 生物圈保護區）的植物多樣性。

關鍵詞：熱帶森林、半常綠林、落葉林、物種組成、東高止地區、Similipal 生物圈保護區、奧里薩邦。

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