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Plant diversity in tropical deciduous forests of Eastern Ghats, India: A landscape level assessment

Pratap Chandra Panda[1]*, Ajay Kumar Mahapatra[1], Pradosh Kumar Acharya[1] and Akhil Kumar Debata[2]

[1]Taxonomy and Conservation Division, Regional Plant Resource Centre, Nayapalli, Bhubaneswar 751 015, Odisha, India.
[2]Central Rice Research Institute, Cuttack 753 006, Odisha, India.

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A landscape level plant diversity and population inventory was made in northern portion of eastern Ghat region of India comprising mostly dry deciduous and moist deciduous forests. A total of 444 transects of 0.5 ha (5 × 1000 m) area each was used for enumerating trees. Diversity and density of herbs, shrubs, lianas and regeneration of tree species were assessed from 5 x 5 m size plots within transects. A total of 882 species belonging to 532 genera and 129 families were recorded comprising of 263 tree species, 78 species of shrubs, 138 species of climbers/twinners and 403 species of herbs. *Shorea robusta, Lannea coromandelica, Madhuca india* and *Diospyros melanoxylon* were the predominant tree species where members of Euphorbiaceae, Rubiaceae, Fabaceae and Combretaceae contributed to maximum species richness, stand density and basal area. The stand density ranged from 268 to 655 stems ha^{-1} while basal area varied from 6.65 to 22. 28 m^2 ha^{-1}. The tree density and species richness decreased with increasing girth class; highest number of species and maximum density was recorded for 30 to 60 cm girth class. Shannon-Weiner Index and Simpson Index varied in the range of 1.85-2.05 and 0.013-0.018, respectively. Regeneration of many tree species was observed to be poor.

Key words: Plant diversity, population structure, Eastern Ghat, India.

INTRODUCTION

Tropical forests are regarded as world's most diversity rich ecosystem (Sanders, 2006; Sayer and Whitmore, 1991). It represents a common heritage with livelihood portfolios shared by a great majority of people especially in developing countries. In spite of their contribution to poverty alleviation and food security, and resilience against climate change, forests are still hardly integrated to address the national development challenges (Nkem et al., 2007). These resources however are getting eroded not due to rural consumption in underdeveloped economy, but also now driven by industrial growth and globalisation (Butler and Lawrence, 2008). Huge areas of diverse tropical forest are lost or degraded every year with dramatic consequences for biodiversity. Deforestation and fragmentation, over-exploitation, invasive species and climate change are the main drivers of tropical forest biodiversity loss (Gardner et al., 2009; Morris, 2010; Anonymous, 2013). The relative impacts of these threats vary among the world's major tropical forest regions (Corlett and Primack, 2008). Tropical forest destruction is likely to continue in the future, causing an extinction crisis among tropical forest species (Bradshaw et al., 2009). Though in recent time the rate has declined, the net forest loss in many humid tropics as Indonesia, Brazil, is still alarming (FAO, 2010). In India, the native forests is claimed to be reducing at a rate of 3.5%

*Corresponding author. E-mail: pcpanda2001@yahoo.co.in. Tel. 91-9439831495.

annually (Puyravaud and Davidar, 2010) notwithstanding a total forest cover increase, on account of reforestation. The disappearance of tropical forests comes at a time when our knowledge and understanding of their structure and dynamics is inadequate (Hubell and Foster, 1992) which is crucial for its sustainable use and conservation (Barthlott et al., 2007). Although permanent conversion of forest land in countries like India has slowed down in the last one decade on account of strict environmental regulations (Anonymous, 2009), selective removal of trees from managed forests by way of logging and illegal felling has affected the structure and growth of Indian forests essential to maintain a balanced population and resulting diversity in Indian forests (Sukumar et al., 1992).

Sustainable management and conservation of natural forests requires holistic understanding of the ecosystem structure and functions with the interacting biotic and abiotic elements (Hubbell and Foster, 1983; Ashton et al., 2004). Reliable data on temporal and spatial composition in species, its vulnerability, and response to climatic changes specific to ecosystem and forest types are crucial in designing conservation strategy to prevent degradation of natural resources. Observations made on India's tropical forests have emphasized the impact of disturbance especially on regeneration of tree species (Uma Shankar, 2001; Murali, 1996) making it imperative to look into different major forest types, particularly of dry forests of eastern part of the country where slash burn agriculture and NTFP extraction by rural and tribal folks are most intense which creates long term impact on forest composition and regeneration.

Worldwide, much of the studies focussed on tree communities of humid forests of tropics (Richards, 1996) whereas tropical deciduous forests and dry forests have received much less attention (Bullock et al., 1995; Shackleton et al., 2007) despite their widespread occurrence in inter-tropical belt. In India, most of the vegetation studies have so far been located in humid Western Ghats (Reddy et al., 2008; Parthasarathy et al., 1992; Sukumar et al., 1992; Ganesh et al., 1996) or in tropical wet evergreen forests (Chandrashekara and Ramakrishnan, 1994; Parthasarthy and Kartikeyan, 1997) whereas landscape level inventory on vegetation structure, regeneration status in dry eastern Ghat forests are lacking (Kadavul and Parthasarathy, 2000; Natrajan et al., 2004). Vegetation analysis of the eastern Ghat vegetation spread across Indian state as Odisha, Andhra Pradesh and particularly population profiling of plant diversity in Sal (*Shorea robusta*) dominated forests is lacking (Pandey and Shukla, 2003), even though dry deciduous forests constitutes 65% of India's 71 m. ha forests.

The present study aimed to full fill the gap by generating baseline data on native flora of tropical forest ecosystem in the north eastern Ghat region in Odisha; ecologically a least explored deciduous forest zone in India. Since macro scale studies are rare (Duran et al., 2006), we made a landscape based approach covering large sample area to capture diversity and forest composition over northern part of eastern Ghat region. It is in contrast to most phytosociological studies which tend to analyse few plots in a specific forest block or compare few sites in different forest areas measuring 1 to 50 ha selected on chosen parameters like forest types, plant groups, level of disturbance and protection, regeneration potential, etc. (Reddy et al., 2007; Nath et al., 2005; Chittibabu and Parthasarathy, 2000; Padalia et al., 2004; Kadavul and Parthasarathy, 1999; Shrestha et al., 2000; Pandey and Shukla, 2003). In order to achieve the objectives, the studies covered (i) inventory and description of the plant species, (ii) tree population structure, (iii) regeneration status of the tree species and (iv) pattern of secondary succession across 10 districts coming under eastern Ghat region. The observations have been analysed to provide a robust baseline data for forest management for aiding management decisions.

MATERIALS AND METHODS

Study site

The Eastern Ghats located along the peninsular India extends over 1750 km between 77° 22' to 85° 20' E longitude and 9° 95' to 20° 74' N latitude. There are a series of discontinuous low hill ranges running in northeast-southwest direction parallel to the coast of the Bay of Bengal between river Mahanadi in north and Vagai in south. The Ghat passes through the states of Odisha, Andhra Pradesh, Tamil Nadu and portion of Karnataka covering an area of 75,000 km^2. The vegetation and flora of Eastern Ghat region is quite rich and diverse; the forests represented by evergreen, semi-evergreen, moist deciduous, dry deciduous to dry evergreen forests having several subsidiary and seral types. The region has rich floristic diversity where more than 3,200 species of angiosperms are reported constituting about 16% of flowering plants of India as recorded in Flora of Odisha (Saxena and Brahmam, 1994); Flora of Andhra Pradesh (Pullaiah and Karuppusamy, 2008) and Flora of Tamil Nadu (Nair and Henry, 1983). The region is phyto-geographically interesting as considered to be a migratory route for plants of Himalayas to the Southern Peninsula and vice versa. Interestingly, some Western Ghat elements are also observed in Eastern Ghats.

Our study was confined to the northern portion of Eastern Ghats located in Odisha state. The area lies between 19°62' and 20°74' N latitude (Figure 1a and b) and covers most parts of the districts of Khandamal, Kalahandi, Ganjam, Nayagarh, Boudh and few hilly areas of Rayagada, Khurda, Bolangir, Cuttack and Angul districts.

Climate, soil and geology

The north Eastern Ghat region experiences three prominent reasons (summer, rainy and winter) in a year. Summer extends from March to June, rainy season is from July to September and has a short and pleasant winter during December-January. The maximum temperature in summer varies from 40 to 46.3 °C and winter temperature are in the range of 4.4 to 13.2°C amongst different districts. Relative humidity is relatively high in coastal districts and can be as high as 85% in Cuttack to 51% in the hinterland Kalahandi. Average annual rain fall during the period showed variation in the range of 1308 (Kalahandi) to 1888 mm

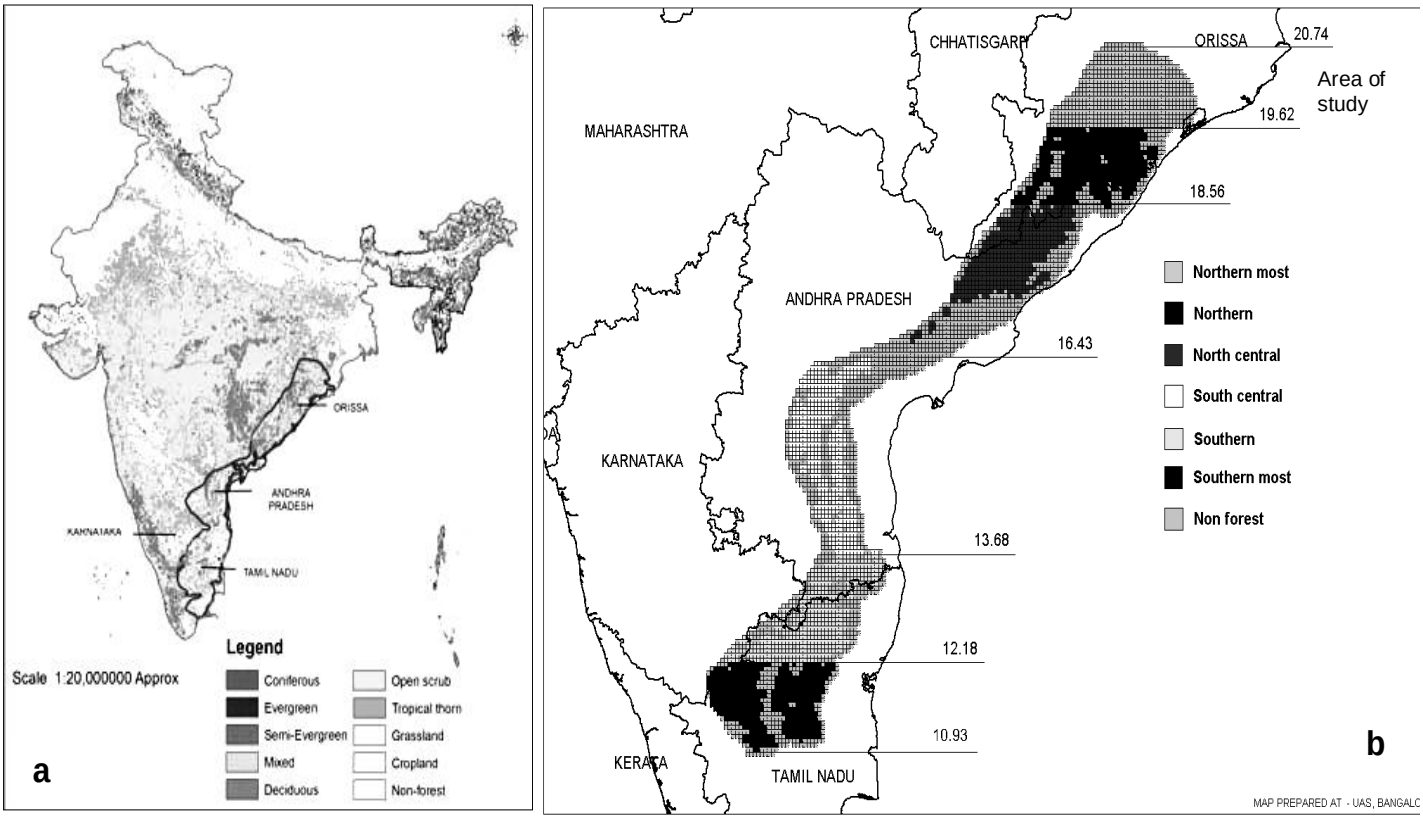

Figure 1. Map of India showing location of (a) Eastern Ghat and (b) the area of study.

(Cuttack).

The rocks occupying the greater part of the study area belong to the Eastern ghat group which are Archaean formations comprising Khodalites, charnockites and granite gneisses forming the basement to the younger groups such as the Gondwanas, laterite and recent alluvium. The region has four major types of soils viz inseptisols, alfisols, entisols and vertisols. Lateritic soil is found in Ganjam, Koraput and part of Khurda districts and brown forest soil is frequently observed in Phulbani and Boudh districts. Black soil is frequent in Kalahandi, Bolangir, Angul and Balugaon area of Khurda district.

Field methods

The northern Eastern Ghats comprising 10 districts of Odisha state was divided into smaller grids of 6.25 × 6.25 km on a topographical map of 1:50,000 scale. A total of 444 grids were laid randomly over 10 districts viz. Boudh, Kandhamal, Khurda, Rayagada, Nayagarh, Ganjam, Kalahandi and portion of Angul, Bolangir, and Cuttack covering forests of dry deciduous, moist deciduous, a few patches of semi-evergreen type. Within each grid, a belt transects of 0.5 ha (5m×1 km) strip was used and all standing trees ≥30cm girth at breast height (gbh) were enumerated. All total of 222 ha. were inventorised. This inventory protocol was designed as a multi-institutional effort of National Bioresource Development Board, Department of Biotechnology, Government of India to quantify plant resources of India. Understorey plant diversity and tree regeneration was investigated in quadrats of 5x5 m size and seedlings/ saplings of trees, shrubs and climbers/ lianas were also enumerated. Phenology, life form and fruiting conditions of plants were recorded. Within each transect of 1000 X 5 m, quantitative data in respect of herb species was collected from two numbers of small sample plots each measuring 1m X 1 m Regional floras such as Haines (1921-25), Gamble and Fischer (1915-1935); Saxena and Brahmam (1994-1996); Mooney (1950) were used for identifying plants, and voucher specimens were housed in the herbarium of Regional Plant Resource Centre (RPRC), Bhubaneswar. Trained research workers and surveyors supervised by authors conducted the field works during September, 2005 to August 2010.

Data analysis

Phytosociological characteristics of plant communities like; a) Frequency (percent of all transects in which a species was present), b) density (ratio of total number of trees to total number of transects) and c) abundance (ratio of total number of trees to total number of transects of occurrence) were recorded. The floristic structure was examined by Importance Value Index (IVI) following Curtis and Mcintosh (1950); where the relative values of frequency, density and basal cover for a species was derived as the value expressed in terms of percentage of the sum of the values for all the species in the plant community (Mueller-Dombois and Ellenberg, 1974); Family Importance Value (FIV) was taken as the sum of relative density, relative diversity, and relative basal cover. The relative diversity of a family was evaluated as the number of species within the family expressed as percentage of total number of species within all the families represented in the community (Mori et al., 1983). The dominance was determined by Simpson's index ($Cd = \sum(n_i/N)^2$, and diversity as Shannon's Index ($H = -\sum(n_i/N) \log$

Table 1. Taxonomic composition and habit-wise plant diversity in northern Eastern Ghats of India.

Parameter	Diversity	Bauda (22 ha)	Kandhamal (88 ha)	Khurda (5.5 ha)	Raygada (9.5 ha)	Nayagarh (30.5 ha)	Ganjam (31 ha)	Kalahandi (32.5 ha)	Other 3 districts (3.0 ha)	Total number Of species (222 ha)
Taxonomic composition	Number of families	95	112	80	77	88	94	101	67	129
	Number of genera	367	447	274	243	283	363	346	171	532
	Number of species	569	717	379	334	425	543	513	223	882
Life-forms	Trees	187	231	199	150	165	193	179	107	263
	Shrubs	44	63	24	18	36	51	44	17	78
	Climbers	92	109	38	41	60	83	68	27	138
	Herbs	246	314	118	125	164	216	222	72	403
	Total of each district	569	717	379	334	425	543	513	223	882

(n_i/N), where n_i = importance value index of species i, N= sum of importance value index for the community. Evenness was calculated by Pielou's index ($D= -\sum p_i^2 / \ln S$), where *S* is the species richness of the community (Magurran, 1988). Species similarity among different regions was computed using Jaccard's Coefficient of Similarity (Jaccard, 1908). The density and basal area in respect of species were calculated on the basis of data from all 444 transects (0.5 ha each) and the values were expressed per hectare basis for comparison. The girth (GBH) was converted into basal area (BA) as $BA= GBH^2/4\pi$.

RESULTS

Species richness and diversity

The landscape-level plant diversity assessment done in 10 districts of Odisha sampled over an area of 222 ha, revealed 882 plant species belonging to 532 genera and 129 families. This constitutes more than 1/3rd of the indigenous species reported to occur in the state of Odisha and forms about 25.2% of the estimated 3,500 species of higher plants of Eastern Ghat region of India. While only 2 species of gymnosperms and 11 species of pteridophytes were collected from the area, the rest 869 species belong to angiosperms. This includes 263 species of trees, 78 species of shrubs, 138 species of climbers/ twinners and 403 herbaceous taxa (Table 1). Fabaceae (Papilionoideae) with 91 species was the most dominant family in terms of species content followed by Poaceae (82 species), Euphorbiaceae (42 species), Rubiaceae (41 species), Asteraceae (33 species) and Acanthaceae (30 species). 57 families are represented by single species only.

Kandhmal district representing central upland is the richest in terms of species diversity, where 717 plant species (81.29%) of a total of 882 species was recorded. Similarly, 569 species in Boudh 543 in Ganjam, 513 in Kalahandi, and 425 species in Nayagarh were reported. Some 121 species (13.72%) were common to all the districts studied. On a landscape level, tree species richness ranged from 107 species in Cuttack-Angul-Bolangir district to 215 species in Kandhamal. Tree diversity in the upperstorey (≥30 cm gbh) was highest in Kandhamal district followed by Khurda (189 species), Boudh (166 species), Ganjam (193 species) and Kalahandi (180 species). Interestingly, 199 tree species were observed in 5.5 ha area in Khurda district, compared to Boudh, Ganjam and Kalahandi districts where sampled areas were much higher. On the other hand, lesser number of shrubs, climbers and herb species were found in Khurda and Rayagada compared to other districts.

Analysis of Jaccard coefficient of similarity showed that all the districts have an average similarity of 0.508 in terms of species presence. Kandhamal and Ganjam districts shared maximum similarity of 0.643 followed by Boudh and Kandhamal (0.604). In other words, more than 50% of species are common to all districts in the northen Eastern Ghat region. However, least similarity (0.404) was observed between Raygada and Khurda districts (Figure 2).

In general, although no correlation was seen between tree stand density and species richness, but in case of Raygada district, lowest species richness (150 species) and highest stand density (655 trees/ha) was recorded. In contrast, in Kandhamal species diversity (231 species), was the highest but with a low stand density (314 trees/ ha). The diversity indices such as Shannon and Simpson indices were 1.99 and 0.015, respectively for the whole 222 ha area studied (Table 2). The values of the two diversity indices varied greatly across the studied districts while Shannon's Index varied from 1.85-2.05, Simpson Index ranged between 0.013 and 0.018. Both

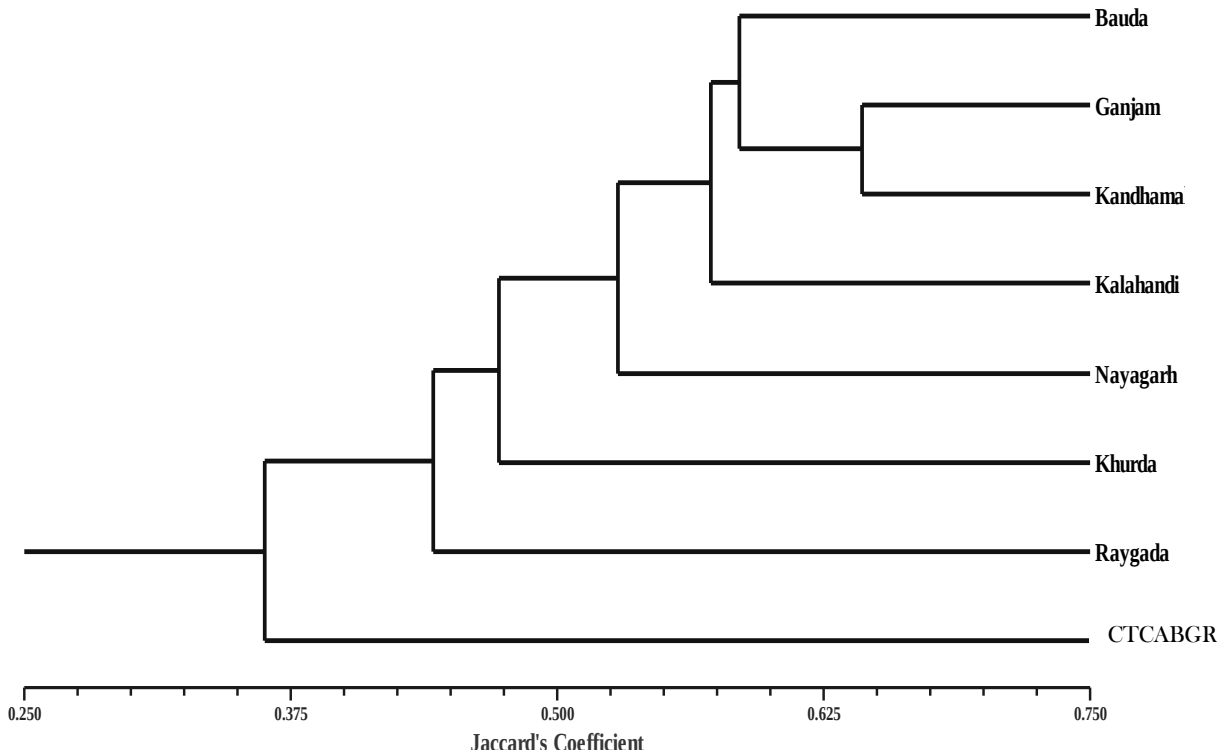

Figure 2. Dendrogram showing similarity of species among major districts.

Table 2. Key Diversity attributes of forests in northern Eastern Ghats.

Parameter	Bauda (22 ha)	Kandhamal (88 ha)	Khurda (5.5 ha)	Raygada (9.5 ha)	Nayagarh (30.5 ha)	Ganjam (31 ha)	Kalahandi (32.5 ha)	Other 3 districts (3.0 ha)	Total area (222 ha)
Species Richness (number of species)	166	215	189	137	158	193	180	107	256
Number of individuals	6808	27647	3069	6227	8184	9675	15802	944	78356
Stand Density (Number of stems ha^{-1})	309.45	314.17	558.0	655.47	268.33	312.10	486.22	314.67	352.95
Total basal area (m^2)	196.79	818.04	81.00	212.60	203.14	354.43	466.58	34.83	2367.40
Stand basal area (m^2 ha^{-1})	8.94	9.28	14.73	22.28	6.65	11.41	14.30	12.82	10.47
Shannon-Weiner Index	1.93	1.93	2.05	1.94	1.91	1.97	1.96	1.85	1.99
Simpson Index	0.016	0.018	0.013	0.015	0.018	0.016	0.014	0.017	0.015
Evenness Index	0.869	0.982	0.987	0.985	0.982	0.984	0.986	0.983	0.985

Shannon diversity index and Simpson Index revealed, Khurda forests to be the most biodiversity rich region as compared to other areas.

Species-area curve

Species-area curves for the seven major districts were initially steep up to 8.5 -10 ha, followed by gradual species accumulation and flattening till the sampling area reached 20 ha (Figure 3). The curve was quite steep for Khurda and Raygada districts where area of sampling was very small. In Boudh, Nayagarh, Ganjam, Kalahandi and Kandhamal districts, the species-area curve reached an asymptote between 21st and 32nd hectares of sampled area. The rate of climb of curve for Kandhamal district was moderate. In all districts except for Nayagarh, about 50% of the total species were captured with in 6-7 ha of

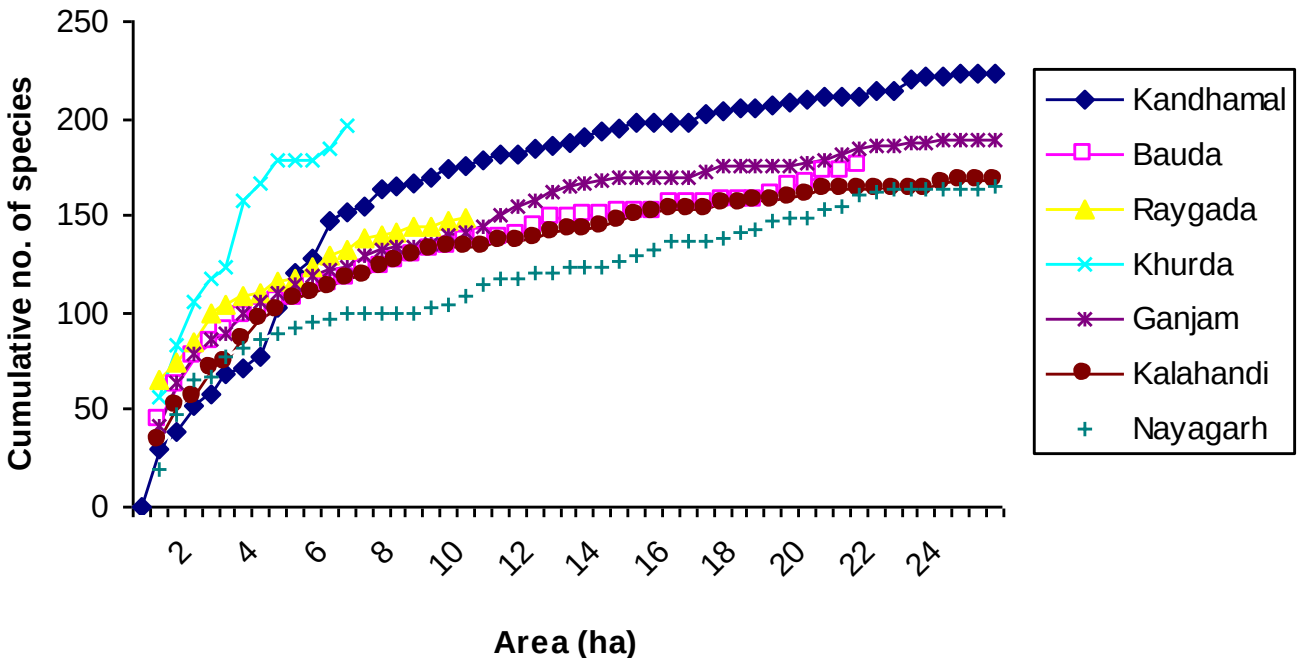

Figure 3. Species-Area curve up to 50 sample plots of forests in northern Eastern Ghats of India.

area sampled while in all other districts crossed the 100 species landmark in 3-4 ha area, Khurda captured this much of species in just 1.5 ha of sample area. The species-area relationship have been studied for Coromandal coast of India (Venkateswaran and Parthasarathy, 2003), Bhadra Wildlife Sanctuary in Karnataka, India (Krishnamurthy et al., 2010) and Boudh district of Odisha, India (Sahu et al., 2007) but with less number of tree species.

Species abundance and rarity

The abundance of species in the tree layer varied considerably across eight regions and ranged from merely one individual for species like *Albizia amara* and *Bambusa arundinacea* to 4840 stumps for *Shorea robusta* (Table 3). Based on abundance, tree species were grouped into five categories *viz.* very rare (1-2 individual), rare (3-20 individuals), common (21-100 individuals), dominant (101-500 individuals) and predominant (>501 individuals) for the entire 222 ha area following Pragasan and Parthasarathy (2010). Overall, 12 species were found to be very rare, 64 species were listed rare, 66 species as common, 62 species as dominant and 52 species as predominant (Table 4). The predominant species contributed 74.68% (58,517 individuals) of forest composition in northern Eastern Ghats. The major species are *Shorea robusta, Lannea coromandelica, Madhuca indica, Diospyros melanoxylon, Terminalia alata, Anogeissus latifolia, Buchanania lanzan, Cleistanthus collinus, Cassia fistula, Syzigium cumini, Bridelia retusa* in a wider distribution across the Eastern Ghat. Of the enumerated tree species, 12 species (4.69%) was categorised as 'very rare', that is *Albizia amara*, *Antidesma brunuis, Heterophragma roxburghii, Acacia polyacantha,* etc. 64 species were classified as 'rare', viz., *Aglaia lawii, Alphonsea maderaspatana, Acronychia pedunculata, Michelia champaca, Xylosma longifolium, Drypetes assamica, Dimorphocalyx glabellus, Lasiococca comberi* and *Siphonodon celastrineus* (Table 5).

Shrubs of most common occurrence are *Woodfordia fruticosa, Helicteres isora, Phoenix acaulis, Clerodendrum viscosum, Cipadessa baccifera* and *Pavetta crassicaulis* whereas, *Solanum anguivi, Coffea benghalensis, Clausena excavata, Flemingia macrophylla* and *Eugenia rothii* are of rare occurrence. Similarly, amongst climbers and lianas, *Bauhinia vahlii, Combretum roxburghii, Celastrus paniculata, Olax psittacorum, Smilax zeylanica, Millettia extensa* and *Acacia pennata* are the predominat species while *Rhynchosia minima, Piper trioicum, Holostemma annulare, Canavalia ensiformis* and *Calamus latifolius* were observed to be 'very rare'.

Understorey herbaceous flora are represented by mainly *Andrographis paniculata, Vernonia cinerea, Elephantopus scaber, Curculigo orchioides, Panicum notatum, Desmodium gangeticum* and *Knoxia sumatrensis* The populating and distribution of herbaceous taxa like *Zeuxine statuematica, Trichuriella monsonii, Thalictrum foliolosum, Striga angustifolia, Sopubia delphinifolia* and *Smithia sensitiva* are critically low as each of them is represented by single plant only.

Table 3. Dominant tree species and their contribution to density, frequency, basal area and IVI of forests in north Eastern Ghats of India.

Species	Family	No. of individuals	Relative frequency	Relative density	Relative dominance	Basal area (m^2)	IVI
Shorea robusta Gaertn.	Dioterocarpaceae	4840	2.211	6.177	8.969	208.484	17.36
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	1856	2.089	2.369	2.302	53.503	6.76
Madhuca indica Gmel.	Sapotaceae	1798	2.061	2.295	2.363	54.942	6.72
Diospyros melanoxylon Roxb.	Ebenaceae	1767	2.034	2.255	2.392	55.602	6.68
Terminalia alata Heyne exRoth,	Combretaceae	1603	1.784	2.046	2.187	50.568	6.02
Anogeissus latifolia (Roxb. ex DC.) Wall.	Combretaceae	1584	1.784	2.022	2.156	50.125	5.96
Buchanania lanzan Spreng.	Anacardiaceae	1550	1.989	1.978	1.897	44.084	5.86
Schleichera oleosa (Lour.)Oken.	Sapindaceae	1489	1.795	1.900	2.159	50.190	5.85
Bridelia retusa (L.) Spreng.	Euphorbiaceae	1518	1.723	1.937	2.101	0.045	5.76
Syzygium cumini (L.)Skeels	Myrtaceae	1523	1.567	1.944	2.204	51.227	5.71
Semecarpus anacardium L.	Sabiaceae	1490	1.739	1.902	1.961	45.584	5.60
Cleistanthus collinus (Roxb.) Benth.	Euphorbiaceae	1546	1.789	1.973	1.802	41.895	5.56
Cassia fistula L.	Caesalpiniaceae	1534	1.861	1.958	1.735	40.342	5.55
Protium serratum (Wall.ex Colebr.) Engl.	Burseraceae	1438	1.634	1.835	1.786	41.520	5.25
Pterocarpus marsupium Roxb.	Fabaceae	1341	1.656	1.711	1.787	41.544	5.15
Mallotus philippensis (Lam.) Muell.	Euphorbiaceae	1364	1.539	1.741	1.737	40.370	5.02
Lagerstroemia parvifolia Roxb.	Lythraceae	1259	1.617	1.607	1.649	38.334	4.87
Phyllanthus emblica L.	Euphorbiaceae	1217	1.767	1.553	1.500	34.860	4.82
Diospyros montana Roxb.	Ebenaceae	1277	1.600	1.630	1.468	34.135	4.70
Holarrhena pubescens (Buch.-Ham.) Wall.	Apocynaceae	1249	1.584	1.594	1.362	31.672	4.54
Mitragyna parvifolia (Roxb.) Korth.	Rubiaceae	1101	1.400	1.405	1.445	33.588	4.25
Careya arborea Roxb.	Baringtoniaceae	1112	1.506	1.419	1.315	30.558	4.24
Casearia elliptica Willd.	Flacourtiaceae	1310	1.673	1.672	0.833	39.997	4.18
Haldina cordifolia (Roxb.) Ridsd.	Rubiaceae	1075	1.372	1.372	1.249	29.034	3.99
Aegle marmelos(L.) Corr.	Rutaceae	1073	1.389	1.369	1.186	27.555	3.94
Terminalia chebula Retz.	Combretaceae	1060	1.289	1.353	1.294	30.073	3.94
Gardenia latifolia Ait.	Rubiaceae	962	1.417	1.228	1.094	25.436	3.74
Albizia odoratissma (L.f.) Benth.	Mimosaceae	948	1.067	1.210	1.325	30.792	3.60
Dalbergia paniculata Roxb.	Fabaceae	943	1.239	1.203	1.118	25.994	3.56
Bauhinia purpurea L.	Caesalpiniaceae	899	1.128	1.147	1.139	26.466	3.41
Desmodium oojeinensis (Roxb.) Ohashi,	Fabaceae	845	1.228	1.078	1.033	24.019	3.34
Butea monosperma (Lam.) Taub.	Fabaceae	916	1.156	1.169	0.996	23.163	3.32
Terminalia bellirica (Gaertn.) Roxb	Combretaceae	789	1.178	1.007	1.057	24.569	3.24
Guazuma ulmifolia Lam.	Sterculiaceae	809	1.078	1.032	1.003	23.310	3.11
Stereospermum colais (Buch.-Ham.ex Dillw.) Mabberley	Bignoniaceae	824	1.039	1.052	0.989	22.995	3.08

Table 3 Contd.

Albizia lebbeck (L.) Benth.	Mimosaceae	770	1.067	0.983	1.024	23.812	3.07
Diospyros sylvatica Roxb.	Ebenaceae	772	1.034	0.985	0.989	22.998	3.01
Dalbergia latifolia Roxb.	Fabaceae	805	0.928	1.027	1.048	24.367	3.00
Antidesma ghaesembilla Gaertn.	Euphorbiaceae	708	0.945	0.904	0.770	18.046	2.62
Grewia tilifolia Vahl,	Tiliaceae	645	1.006	0.823	0.782	18.174	2.61
Chloroxylon swietiana DC.	Rutaceae	665	0.872	0.849	0.844	19.612	2.56
Mangifera indica L.	Anacardiaceae	589	0.900	0.752	0.819	19.031	2.47
Bombax ceiba L.	Bombacaceae	597	0.989	0.762	0.719	16.715	2.47
Ficus benghalensis L.	Moraceae	427	0.811	0.545	1.038	24.131	2.39
Ehretia laevis Roxb.	Ehretiaceae	617	0.750	0.787	0.789	18.351	2.33
Xylia xylocarpa (Roxb.)Taub.	Mimosaceae	639	0.683	0.816	0.813	18.905	2.31
Morinda citrifolia L.	Rubiaceae	558	0.828	0.712	0.677	15.749	2.22
Kydia calycina Roxb.	Malvaceae	588	0.811	0.750	0.651	15.133	2.21
Gmelina arborea Roxb.	Verbenaceae	541	0.895	0.690	0.608	14.137	2.19
Ixora pavetta Andr.	Rubiaceae	543	0.967	0.693	0.532	12.361	2.19
Total of 1-50 species		57373	68.467	73.221	74.698	1708.10	216.39
Remaining 206 species		20983	31.533	26.779	25.302	659.30	83.61
All species (256 species)		78356	100	100	100	2367.40	300

Table 4. Distribution and abundance and rarity of species in northern Eastern Ghat.

Category based on number of individuals	Number of species				
	Tree	**Shrub**	**Climber**	**Herb**	**Total**
Predominant (>51individuals)	137	20	31	97	285
Dominant (26-50 individuals)	33	8	23	47	111
Common (11-25 individuals)	40	14	25	68	147
Rare (2-10 individuals)	51	34	52	159	296
Very rare (1 individual)	2	2	7	32	43
Total	263	78	138	403	882

Table 5. List of rare and very rare species in northern Eastern Ghat.

Tree	Shrub	Climber	Herb
Albizia amara	*Croton tiglium*	*Rhynchosia minima*	*Trichuriella monsonii*
Antidesma brunuis	*Solanum anguivi*	*Piper trioicum*	*Striga angustifolia*
Gardenia resinifera	*Flemingia macrophylla*	*Mukia maderaspatna*	*Sopubia delphinifolia*
Heterophragma roxburghii	*Eugenia rothii*	*Holostemma annulare*	*Peristylus goodyroides*
Aglaia lawii	*Dracaena terniflora*	*Canavalia ensiformis*	*Pelatantheria insectifera*
Alphonsea maderaspatana	*Coffea benghalensis*	*Calamus latifolius*	*Liparis paradoxa*
Michelia champaca	*Abelmoschus manihot ssp. tetraphyllus*	*Tylophora tenuis*	*Habenaria plantaginea*
Siphonodon celastrineus	*Toddalia aculeata*	*Tetrastigma lanceolaria*	*Habenaria furcifera*
Xylosma longifolium	*Dodonoea viscosa*	*Jasminum articulatum*	*Exacum pedunculatum*
Drypetes assamica	*Capparis brevispina*	*Heterostemma tanjorense*	*Dendrobium aphyllum*

Importance value index

Tropical deciduous forests of Odisha state is dominated by the single species, *Shorea robusta* (Sal). This species scored highest IVI of 17.36 (6% of total IVI for all species), followed by *Lannea coromandelica* (6.76), *Madhuca indica* (6.72), *Diospyros melanoxylon* (6.68), *Terminalia alata* (6.02) and *Anogeissus latifolia* (5.96). 18 species that is *Albizia amara*, *Antidesma brunuis*, *Gardenia resinifera*, *Acacia polyacantha*, *Aglaia lawii*, *Michelia champaca* scored a very low IVI of 0.01. In a range of 256 species, the IVI of 20 dominant species contributed to 41.11% of the total IVI values in northern Eastern Ghat region of India (Table 3).

The IVI of 20 dominant tree species contributed to 44.63, 44.47, 42.94, 41.96, 39.91, 37.99 and 37.34% of total IVI values for districts of Kandhamal, Nayagarh, Boudh, Ganjam, Kalahandi, Rayagada and Khurda respectively. *Shorea robusta* had the highest value of IVI in all districts, except Angul and Bolangir, where maximum IVI values were recorded for *Lannea coromandelica* and *Mallotus philippensis* ,respectively.

Family composition

Euphorbiaceae and Moraceae were found to be most diverse families with 24 species each, followed by Rubiaceae (23 species), Mimosaceae, Verbenaceae (12 species each) and Meliaceae (11 species). In terms of tree density, Euphorbiaceae with 7738 stems also dominated the deciduous forests of northern Eastern Ghats, followed by Rubiaceae (6626 stems; 8.46%), Fabaceae (5801 stems; 7.40%), Combretaceae (5535 stems; 7.06%). Dipterocarpaceae, though represented by only one species (*Shorea robusta),* alone contributed to 6.18% of the tree population having FIV of 15.33. The top 10 families with an abundance of 48,152 individuals (61.45% of tree composition), contributed to 57.26% of total family importance value. 20 families are represented by single species, with an abundance of 8109 individuals and accounted for 10.36% of total FIV, which includes the predominant species *Shorea robusta* (Dipterocarpaceae) with 4840 individuals. Euphorbiaceae scored the maximum FIV of 28.58, followed by Rubiaceae (FIV=24.95), Fabaceae (18.01), Combretaceae (17.20) and Anacardiaceae (15.99).

The FIV of Dipterocarpaceae although represented by single species. (FIV=15.53) is greater than the FIV of families such as Moraceae, Mimosaceae, Verbenaceae and Meliaceae that are more species rich (24, 12, 12 and 11 species respectively). Similarly, Ebenaceae having seven species and with a tree population of 4064 had a higher FIV of (13.10), compared to more speciose families such as Mimosaceae (12 species, FIV=12.09), Verbenaceae (12 species, FIV=9.62), Meliaceae (11 species, FIV=8.52)
and Rutaceae (9 species, FIV=7.99). Two families namely, Euphorbiaceae and Rubiaceae contributed to the maximum diversity and density and FIV.

Stand Density and basal area

A total of 78,356 trees were counted from the sampled area of 222 hectare. The mean tree density on a landscape level was 352 stems ha^{-1}. Stand density was 268 stems ha^{-1} in Nayagarh to as high as 655 stems ha^{-1} in Rayagada (Table 2), which differed significantly amongst eight districts. Lowest stand density and lowest basal area were recorded for Nayagarh district. The total basal area for the 222 ha area inventoried was 2324.34 m^2. Kandhamal district contributed to the maximum basal area of 806.38 m^2, followed by Kalahandi (455.84 m^2), Ganjam (345.45 m^2) and the minimum is from Cuttack district (6.91 m^2). Considering the variation in sample sizes, differing basal area amongst district was evident. Overall, the mean stand basal area for the north Eastern Ghat was 10.47 m^2 ha^{-1} and it ranged from 6.65 m^2 ha^{-1} in Nayagarh to a 22.28 m^2 ha^{-1}in Rayagada (Table 2).

In terms of basal area, members of Euphorbiaceae contributed to maximum basal area (221.39 m^2) followed

Table 6. Specie richness, density and basal area for different tree girth classes in northern Eastern Ghats

Girth class (cm)	Species richness	Density (Number of stems ha^{-1})	% contribution to density	Basal area (m^2 ha^{-1})	% contribution to Basal Area
30-60	253	256.14	72.57	3.891	36.88
61-90	231	74.36	21.07	3.274	31.03
91-120	166	11.91	3.37	1.007	9.54
121-150	142	6.17	1.75	0.904	8.57
≥ 150	114	4.37	1.24	1.475	13.98

by Dipterocarpaceae (208.55 m^2), Rubiaceae (181.15 m^2), Combretaceae (172.12 m^2) and Fabaceae (165.35 m^2) respectively. While 24 species of Euphorbiaceae covers 221.39 m^2 area, Dipterocarpaceae was represented by only one species that is *Shorea robusta* (Sal) which occupies 208.55 m^2, which signifies the predominance of Sal in the deciduous forests of northern Eastern Ghat region of India.

Relationship of species diversity and tree density to girth class

Species richness decreased with increasing girth class in the study region (Table 6). Out of enumerated 256 tree species, species richness was highest (253 species) in the lowest girth class (30-60 cm) followed by 231 species in the GBH range of 61-90 cm, to 142 for GBH class of 121-150 cm (Table 6). Overall, 98.30% of all tree species recorded from northern Eastern Ghats were represented by individuals belonging to the lowest girth class category (30-60 cm). Maximum species (70 species) under the girth class of ≥ 150 DBH were found in Kandhamal District

In the deciduous forests of the region, tree density decreased with increasing girth. Maximum density of trees per unit area (256 stems ha^{-1}) was observed in the girth class of 30-60 cm, that contributes 72.57% of the tree population (Table 8). On land-scape level, the average stand density taken together becomes 74 ha^{-1} under 61-90 cm girth class which constitutes 21.07% of forest tree composition. The stand density under this girth class varies from 218 (stems ha^{-1}) in Ganjam to 441 in Khurda. In case of the girth class of 60-90 cm, highest (236) and lowest (37) tree densities were recorded for Rayagada and Nayagarh district respectively. Only 970 number of trees having GBH of 150 and above were enumerated that constitutes a mere 1.24% of tree composition. Nayagarh forests exhibited lowest stand density (2.43 stems/ha) against the highest value of 7.19 for Ganjam forests.

In eastern Ghat forests of Odisha, trees in two lowest girth classes (30-60 and 61-90 cm) contributed to the bulk of tree basal area that is 1590.63 m^2 (67.91%). In general, a total basal area of 863.80 m^2 was occupied by plants in 30-60 cm girth class and 726.83 m^2 (31.03%) by trees of 61-90 cm GBH (Table 7). The lower girth class (30- cm GBH) scores a maximum stand basal area in all districts except Rayagada where maximum basal area was recorded from trees of 60-90 cm GBH class category. The basal area contributed by trees of 91-120 cm GBH class was more than the basal area of trees of the next higher class (121-150 cm) in Boudh, Khurda, Rayagada and Kalahandi. In general, the average stand basal area of trees having GBH of ≥ 150 cm was much higher than basal area occupied by trees of the two preceding girth classes (121-150 cm and ≥ 150 cm GBH) in spite of their lower population size.

Regeneration

Among the 10 districts of northern Eastern Ghat, Khurda forests showed adequate regeneration potential having most seedlings and saplings (9273/ha), Nayagarh being the poorest of all (6301 ha^{-1}). Regeneration of trees in Boudh (8955/ha) and Ganjam (8016) districts were also considerably high compared to other areas under study. The regeneration status of *Shorea robusta, Lannea coromandelica, Madhuca indica, Diospyros melanoxylon, Terminalia alata* etc. on forest floor is appreciable. *Shorea robusta* with 52.25 seedlings/ ha and 108.11 saplings/ ha topped the list followed by *Lannea coromandelica* (18.02 seedlings/ ha and 18.92 saplings/ ha). The regeneration condition of 20 dominant tree species is shown in Table 8.

In northern Eastern Ghat, the density of adult plants is disproportionately low compared to seedlings and saplings. In case of *Shorea robusta*, the predominant forest species of the region, density (stems/ha) of mature individuals is 21.80 but number of seedlings and saplings are 55.86 and 105.41 ha^{-1}, respectively. Among 172 tree species for which regeneration data could be collected, the seedlings and saplings population were high for *Ziziphus xylopyrus, Shorea robusta, Benkara malabarica, Ixora pavetta, Catunaregam spinosa, Protium seratum, Cleistanthus collinus, Holarrhena pubescens,* and moderate for *Careya arborea, Butea monosperma, Dalbergia lanceolaria, Kydia calycina, Azadirachta indica, Pterocarpus marsupium* and *Albizia odoratissma.* On the

Table 7. Distribution of girth classes and their contribution to basal area in northern Eastern Ghat.

District	Girth Class									
	30-60 cm		61-90 cm		91-120 cm		121-150 cm		≥ 150 cm	
	Density (Stems ha^{-1})	Basal area (m^2 ha^{-1})	Density (Stems ha^{-1})	Basal area (m^2 ha^{-1})	Density (Stems ha^{-1})	Basal area (m^2 ha^{-1})	Density (Stems ha^{-1})	Basal area (m^2 ha^{-1})	Density (Stems ha^{-1})	Basal area (m^2 ha^{-1})
Bauda	227.18	3.43	63.27	2.77	10.27	0.80	5.18	0.74	3.55	1.07
Kandhamal	235.84	3.57	60.42	2.66	08.30	0.67	5.75	0.84	3.85	1.42
Khurda	441.82	6.66	88.00	3.82	14.55	1.22	7.27	1.05	6.36	1.91
Raygada	362.95	5.81	236.53	10.44	44.74	3.28	6.00	0.89	5.26	1.47
Nayagarh	220.20	3.22	37.11	1.60	4.92	0.41	3.67	0.54	2.43	0.91
Ganjam	218.23	3.34	65.45	2.90	11.32	0.87	9.90	1.48	7.19	2.55
Kalahandi	340.43	5.24	115.08	5.08	19.97	1.51	6.18	0.90	4.55	1.29
Other 3 districts	229.33	3.42	55.67	2.61	11.00	0.81	11.00	1.62	7.67	2.74

other hand, regeneration level of valuable tree species of the region like *Boswellia serrata, Albizia chinensis, Memecylon umbellatum, Melia dubia, Miliusa tomentosa* and *Baccaurea ramiflora* is extremely low. Complete absence of seedlings on forest floor and occurrence of a few saplings was observed in case of species such as *Strychnos nux-vomica, Miliusa tomentosa*, *Ficus* spp., *Cordia dicotoma, Ardisia solanacea, Albizia chinensis,* etc. Similarly, no saplings could be spotted for *Toona ciliata, Persea macrantha*, *Cleistanthus patulus*, *Alphonsea madraspatna* and some species of *Ficus*.

In most of species, seedlings population was found to be less than that of saplings; a reverse trend was noticed in the case of species as *Premna latifolia* var. *mucronata, Diospyros sylvatica, Radermachera xylocarpa, Murraya paniculata, Desmodium oojeinensis,* and few other taxa. Interestingly, seedlings and saplings ratio is in balance for 24 species including *Phyllanthus emblica, Soymida febrifuga, Streblus asper, Sterculia urens, Vitex leucoxylon* and *Mitragyna parvifolia.*

DISCUSSION

The density, abundance and distribution of individual species are measurable indicators of plant diversity (Wattenberg and Breckle, 1995). The species richness of 256 species over 222 ha sampled area reflects a moderate diversity status in forests of northern Eastern Ghats. The result of the study compared well with other large-scale inventories conducted in tropical forests both in India and elsewhere. For instance, 63 species were recorded for 50 ha plot at Mudumalai Forest Reserve, India, to 996 species in 52 ha at Lambir, Malaysia (Condit et al., 2000). Tropical forests of the world is highly diverse; the density, and richness varying widely between dry and humid zone. For instance, species richness can be as low as 20 species ha^{-1} in flooded Varzea forest of Rio Xingu, Brazil (Campbell et al., 1992) to 307 species ha^{-1} in Amazonian Ecuador (Valencia et al., 1994). Compared on a large scale inventory, the mean stand density of northern Eastern Ghats (352 stems ha^{-1}) remains within the range reported for other tropical forests of Indian subcontinent; 298 stems ha^{-1} at Mudumalai Forest Reserve, India to 689 stems ha^{-1}at Sinharaja, Sri Lanka (Condit et al., 2000). In a recent assessment of species richness in southern Eastern Ghats, Pragasan and Parthasarathy (2010) recorded 272 species in the 60 ha area sampled using similar sampling and data collection procedures. Chittibabu and Parthasarathy (2000) reported tree density in the range of 266 trees per ha. to 632 trees ha^{-1} from tropical evergreen forests of Koli Hills of Western Ghats of India. The Kalrayan hills of Eastern Ghats stocked a range of 640 to 986 trees ha^{1} (Kadavul and Parthasarathy, 1999a) and 270 to 673 trees ha^{1} in the Anamalais (Ayyappan and Parthasarathy, 1999). Density of trees (30 cm gbh and above) in tropical forests ranges between 245 and 859 (Ashton 1964; Campbell et al., 1992; Richards, 1996) with intermediate values of 448 to 617 stems ha^{1} in Costa Rica (Heaney and Proctor, 1990) and 639 to 713 stems ha^{1} in Central Amazonia (Ferreira and Prance, 1998). The tree density in deciduous forests on Eastern Ghat reported in the present work is modest com-

Table 8. Regeneration status of top 20 species of forests in northern Eastern Ghats of India

Tree species	Seedlings ha^{1}	Saplings ha^{1}
Shorea robusta	52.252	108.108
Lannea coromandelica	18.018	18.919
Madhuca indica	12.162	15.766
Diospyros melanoxylon	14.865	30.631
Terminalia alata	13.514	25.225
Anogeissus latifolia	15.315	18.018
Buchanania lanzan	18.919	20.721
Schleichera oleosa	12.162	16.667
Bridelia retusa	11.712	22.523
Syzygium cumini	18.468	24.775
Semecarpus anacardium	15.766	22.973
Cleistanthus collinus	24.324	36.937
Cassia fistula	7.658	18.919
Protium serratum	33.333	36.036
Pterocarpus marsupium	5.856	11.712
Mallotus philippensis	21.171	33.333
Lagerstroemia parvifolia	3.604	4.054
Phyllanthus emblica	17.568	17.568
Diospyros montana	11.261	17.568
Holarrhena pubescens	23.423	29.279

pared to other tropical forest zones. Species diversity is generated by species interaction such as competition and niche diversification (Pianka, 1966; Bada, 1984), which are both greatly manifested in the tropics due to high humidity and temperature (Ojo and Ola-Adams, 1996). Similarly, tree density depends on efficacy of seed dispersal, survival and establishment and also on the levels of resource extraction by humans (Kadavul and Parthasarathy, 1998). The intermediate level of tree density and species richness observed in the present work may be attributed to the combination of all these factors.

Shannon's Index varied from 1.85-2.05 which are with in the reported range (0.83 to 4.1) for the forests of Indian sub-continent (Jha and Singh, 1990; Ayyapan and Parthasarathy, 1999; Pandey, 2000). Overall, the mean stand basal area for the north Eastern Ghat was 10.47 m^2 ha^{-1}; and it ranged from 6.65 m^2 ha^{-1} to 22.28 m^2 ha^{-1}. In southern Eastern Ghat, Pragasan and Parthasarathy (2010) reported the basal area to be 16.9 m^2 ha^{-1} for a 60 ha forest area in tropical dry evergreen forests. The stand density and basal area for the six sites assessed by them ranged from 290 to 527 stems ha^{-1} and from 5.6 to 24.4 m^2 ha^{-1} respectively. The average stand density of 352 stems $ha^{-1}$and basal area of 10.47 m^2 ha^{-1} reported in the present inventory, though less than the above values, is justifiable taking in to consideration the dry deciduous nature of the forests of northern Eastern Ghat. Our study also brought to fore the limitation of data accuracy on biodiversity as small scale plot level assessment tend to present inflated figure about species richness and density per hectare. For instance, Sahu et al. (2007) recorded mean stand density of 591 stems ha^{-1} and basal area of 25.59 m^2 ha^{-1} for 4 ha plots with trees ≥ 10 cm GBH in Buadh district of Odisha. This could be true for the specific site but does not reveal true composition of deciduous forests of the region. Species abundance is considered to be dependent and directly related to species richness (Condit et al., 1998; Denslow, 1995; Hayek and Buzas, 1997; Preston, 1962). In the present study, species richness positively correlated to stand density in Nayagarh, Boudh, Ganjam and Kandhamal forests, but not in the other four districts. It is most likely on account of dominance of species such as *Shorea robusta, Lannea coromandelica,Diospyros melanoxylon, Buchanania lanzan* etc. in these sites.

The most abundant species are often used to describe forest composition and categorise forest types (Valencia et al., 2004). In northern Eastern Ghats, 52 predominant species (species with >500 individuals) such as *Shorea robusta, Lannea coromandelica, Madhuca indica, Diospyros melanoxylon, Terminalia alata, Anogeissus latifolia, Buchanania lanzan,* etc., contributed 74.68% (58,517 individuals) of the total abundance and Euphorbiaceae , Moraceae (represented by 24 species each) and Rubiaceae (23 species) were observed to be most diverse families. Interestingly, similar findings were reported in studies of Ayyappan and Parthasarathy (1999) where Euphorbiaceae (18 species) was most dominant family in the evergreen forests in Anamalais of Indian Western Ghats. A recent large-scale inventory of southern Eastern Ghats (Pragasan and Parthasarathy, 2010) established Euphorbiaceae as the most diverse family followed by Rubiaceae and Moraceae. Rasingam and Parthasarathy (2009) reported Euphorbiaceae (17species), Moraceae (12) and Rubiaceae (11) as the dominant families in tropical low land forests of Little Andaman island, India. It is therefore obvious that across various tropical forests a greater similarity is evident at the family level.

Base-line data on distribution, richness, and relative abundance of taxa is useful for ecosystem ecology, phylogenetic assessment, and essential for monitoring biodiversity (Blackmore, 1996; Humphries et al., 1995; Magurran, 1988; May, 1988; Raven and Wilson, 1992). Species richness in particular is an important ecological indicator to prioritise habitat conservation (Coscaron et al., 2009). However, the rarity of species is high which underlines the attention for conservation.

Tree diversity in tropical forests of northern Eastern Ghats is seen to be at moderate level. The mean stand basal area 10.47 m^2 ha^{-1} as seen for northern Eastern Ghat region is lower than the pan-tropical average of 32 m^2 ha^{-1} (Dawkins, 1959), and other Eastern Ghats (Kadavul and Parthasarathy, 1999b) areas including tropical forests of other region as Malaysia (Poore, 1968),

Brazilian Amazon (Campbell et al., 1986, 1992); Costa Rica (Lieberman and Lieberman, 1987). Basal area act as an important attributes of vegetation composition and site quality of forest vegetation (Mani and Parthasarathy, 2005; Parthasarathy and Karthikeyan, 1997; Srinivas and Parthasarathy, 2000; Williams-Linera, 1990). Our effort was therefore to estimate the basal area and exploring its relationship to tree density and girth classes of trees. In the present study, the basal area of tree species varied greatly across the eight study areas (from 6.65 in Nayagarh to 22.28 m^2 ha^{-1} in Rayagada), revealing that the forest stand structure is considerably poor in Nayagarh district. The mean basal area of northern Eastern Ghats (10.47 m^2 ha^{-1}) is in the median range compared to other Indian tropical forests (1.3 m^2 ha^{-1} at Vindhyan hills (Sagar et al., 2003) to 98.6 m^2 ha^{-1} at Namdapha National Park, North east India (Nath et al*.,* 2005).

Diameter distributions reflect the disturbance effect within forests (Denslow, 1995; Hett and Loucks, 1976) and are helpful in detecting trends in regeneration patterns (Poorter et al., 1996). The low basal area values of site Nayagarh reveals the extent of forest disturbance with poor representation of trees in higher girth. Tree density distribution across different girth classes indicates how well the growing forest is utilizing site resources. A few small-to-medium sized trees per hectare may imply that land is not being fully utilized by the tree crop (Hitimana et al., 2004). Distribution curves that drop exponentially with increasing GBH are characteristic for many sites in India is also corroborated by our results (Khamyong et al*.,* 2004).

In nature, adult individuals constitute the reproductive pool, but species diversity and abundance is maintained through regeneration of component species. In an undisturbed mature forest, a significant relationship is expected between adult individual's population to seedlings and saplings population. The picture in northern Eastern Ghat is atypical as the adult populations are disproportionately less to seedlings and saplings. High seedlings and saplings to adult ratio as observed indicates forest to be young, regenerating after logging. Massive seed production, high seedling establishment, but poor rate of progression of saplings to adult stage can also lead to such situation.

We view higher saplings to seedlings ratio could be due to complex interaction of climatic, edaphic factors, the most potent being recurrent ground fire in Sal dominated dry deciduous forests; and forest grazing of livestock-typical feature of the study area. Low seedling density for most of the species compared to number of saplings in Odisha tropical forests is a matter of concern and points towards poor seed germination and survival on forest floor. As a substantial area of forest in Odisha has been degraded by human interference, mining and other commercial activities a proper conservation strategy targeting individual species has to be developed, so that the species does not become extinct. The information contained in this paper will provide a sound base for forest manager to prioritise management actions for conserving the biodiversity in northern Eastern Ghat of India.

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