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Comparative assessment of structure, composition and diversity of tree species of tropical moist deciduous forests in three forest ranges of Nayagarh Forest Division, Odisha, India

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ABSTRACT

Quantitative assessment of tree species diversity from representative sample plots of three forest ranges of Nayagarh Forest Division of Odisha, India was made. Sixty six (66) transects (1000 m X 5 m) were laid in Nayagarh (20 nos), Dasapalla (20 nos.) and Mahipur (26 nos.) forest ranges for enumeration of the tree species having ≥ 30 cm GBH. A total of 162 tree species belonging to 115 genera under 44 families were recorded. Maximum of 128 tree species from Nayagarh, 119 species from Mahipur and minimum of 89 species from Daspalla range were enumerated. *Shorea robusta, Buchanania lanzan, Lannea coromandelica, Terminalia alata* and *Cleistanthus collinus* were the predominant tree species of the study area. The families Rubiaceae, Euphorbiaceae, Fabaceae, Moraceae and Mimosaceae were found to contribute to maximum species richness, stand density and basal area. The stem density varied in the range of 466.54 stem ha^{-1} in Dasapalla range to 530.30 stem ha^{-1} in Nayagarh range. The stand basal area was maximum (31.62 m2 ha^{-1}) in Dasapalla range followed by Mahipur (17.13 m2 ha^{-1}) and Nayagarh (13.16 m2 ha^{-1}). However, highest value of Shannon-Weiner Index (3.61) was recorded for Nayagarh range and lowest (3.51) for Manipur forest range. The tree density and species richness decreased with increasing girth class. Highest number of species and maximum density was recorded for 30-60 cm girth class in all the three forest ranges.

1. Introduction

Though tropical forests occupy only 7% of the earth's land surface (Laurance, 1999; Dirzo and Raven, 2003), they harbour 60% of all known terrestrial species and provide significant local, regional and global human benefits by providing a range economic goods and ecosystem services (Gardner *et al*., 2009). Over the past century tropical forests have been suffering from exceptional rates of change as they are degraded or destroyed by human activities. The combined influence of persistently high rates of deforestation and forest degradation (FAO, 2006), over-harvesting, invasive species and global environmental change threatens to make tropical forests the epicentre of current and future extinctions (Bradshaw *et al*., 2009).

Trees form the major structural and functional basis of tropical forest ecosystems can serve as robust indicators of changes and stresses at the landscape level (Sahu *et al*., 2012). Plant diversity inventories in tropical forests have mostly been concentrated on tree species rather than other life forms, because they constitute an important aspect of forest ecosystems and fundamental to total tropical forest biodiversity (Rennolls and Laumonier, 2000). They provide resources and habitat structure for almost all other species and form the major biotic component in the forest ecosystem (Cannon *et al*., 1998).

In India, most of the quantitative plant biodiversity inventories of tropical forests made so far are from the

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forests of the Western Ghats (Sukumar *et al*., 1992; Ganesh *et al*., 1996; Pascal and Pelissier, 1996; Ghate *et al*., 1998; Parthasarathy, 1999; Parthasarathy and Karthikeyan, 1997; Ayyappan and Parthasarathy, 1999; Chittibabu & Parthasarathy, 2000; Jayakumar and Nair, 2013; Reddy *et al*., 2008a) and that of the Coromandal coast (Parthasarathy and Karthikeyan, 1997; Parthasarathy and Sethi, 1997). However, Eastern Ghat region, largely covering the states of Odisha, Andhra Pradesh and Tamilnadu is poorly studied except those of Kadavul and Parthasarathy (1999a), Kadavul and Parthasarathy (1999b) and Arul Pragasan & Parthasarathy (2010) in Tamilnadu; Naidu & Aniel Kumar (2015) and Reddy *et al*. (2008b) in Andhra Pradesh; Sahu *et al.,* (2007) and Panda *et al.,* (2013) in Odisha.

In order to fulfill the above gap and to generate baseline data on forest trees occurring in tropical moist deciduous forests of Odisha, a comparative assessment of tree species diversity from representative sample plots of three forest ranges of Nayagarh Forest Division of Odisha was made.

2. Materials and methods

2.1. Study sites

Nayagarh Forest Division of Odisha, India is a part of Eastern Ghats region and occupies an area of 3067.28 sq. kms (Fig.1.). The forests comprising of Reserved Forests, Proposed Reserved Forests, Degraded Protected Forests and Village Forests (RFs, PRFs, DPFs and VFs) cover an area of 1063.16 sq. kms, which is 34.66 % of the geographical area of the division. The forests of the district is predominated by mixed Sal Forest, Dry Peninsular Sal forest, Miscellaneous Forest, Northern tropical dry deciduous forest and South Indian Moist Mixed Deciduous forest. In the lower hills and plains the forest is dominated by Sal but as the altitude increases in upper hill slopes the miscellaneous species is found abundantly. The altitude varies in the range of 47m to 932 m above MSL.

The forests are well drained by a large number of rivers, rivulets, streams and nallahs. The most important river of this district is Mahanadi and major portion of drainage water from the forests flows into this river. A small portion of forests of the Southern part, South-West part, Western portion and South-West portion drain in to the Rushikulya River of Ganjam District.

Three prominent seasons are observed in this area (hot and dry summer, hot and humid rainy season and moderate winter season). The highest temperature in summer is around 39^0 to 44^0 C but at some places it is around 35^0C. The monsoon temperature is around 30^0 C with relative humidity varying in the range of 70% to 90%. The winter temperature

Fig. 1. Map showing location of study area

from December to February goes down to nearly 8^0 to 10^0 C. The mean annual rainfall is 1500 mm approximately out of which 80% is received during June-September. Most of the rainy days are distributed in monsoon season i.e. from 3rd week of June to 2nd week of September.

The rocks occupying the greater part of the study area include Khondalite, acid charnockite, garnetiferous granite gneiss, granulites, quartz and pegmatite veins, sandstones. Sub-recent and recent deposits of laterite, alluvium and soil overlie these successions. The soils occurring in the division are dominantly very deep, well drained, fine loamy in texture and are acidic in reaction. They are slightly eroded and have medium available water capacity. The soil types of such characteristics have been classified as Typic Haplustalfs with deep well drained and moderately eroded soil.

For the present study, a total of 66 transects (1000 m X 5 m) were laid in Nayagarh (20 nos), Dasapalla (20 nos.) and Mahipur (26 nos.) forest ranges of Nayagarh Forest Division for quantitative assessment of tree diversity. The geographical location of the sampling sites in these forest ranges are given in Table 1.

2.2. Field methods

The moist deciduous forest patches in three forest ranges of Nayagarh Forest Division viz. Nayagarh, Dasapalla and Mahipur were identified based on information available in recent Working Plan for Nayagarh Forest Division, interaction with forest officials, ground truthing and analysis of dominant species and their common associates as reported by Champion & Seth (1968) and ICFRE (2013). A total of 66 transects each measuring 0.5 ha (1000 m X 5 m) were laid in moist deciduous forest patches of Nayagarh (20 nos), Dasapalla (20 nos.) and Mahipur (26 nos.) forest ranges and all standing trees of ≥ 30 cm GBH (girth at breast

Table-1:
Geographical location of the sampling sites in Nayagarh Forest Division

Forest Range	Latitude	Longitude	Altitude
Dasapalla	20° 11.460' N-20° 25.076' N	84° 33.676' E- 85° 39.859' E	44-248 m
Mahipur	20° 07.158' N -20° 16.142' N	84° 49.450' E-85° 13.884'E	76-168 m
Nayagarh	19° 58.328'N-20° 14.431' N	84° 28.175'E-85° 14.355'E	58-279 m

height, *i.e.* 1.37 m above ground level) were enumerated. Data on number of individuals of each species, their GBH and height were measured. Associated shrubs, climbers and herbs were listed and field information on regeneration potential of trees was also noted. Plants were identified using regional floras (Haines, 1921-25, Mooney, 1950, Gamble and Fischer, 1915-1935 and Saxena and Brahmam, 1994-96) and by matching them with authentic herbarium specimens housed in different Indian Herbaria. The voucher specimens were housed in the Herbarium of Regional Plant Resource Centre (RPRC), Bhubaneswar, India.

2.3. Data analysis

The phytosociological characteristics of individual species and their 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 relative importance of any species in the community was assessed by determining the 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 of all species belonging to a botanical family. 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 ($Cd = \Sigma(n_i/N)^2$, and diversity as Shannon's Index ($H = -\Sigma(n_i/N) \log (n_i/N)$, 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 ($D = -\Sigma p_i^2 / \text{In } S$), 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 recorded from all the transects (0.5 ha each) of the particular Forest Range and the values were expressed per hectare basis for comparison. The girth (GBH) was converted into basal area (BA) as $BA = GBH^2/4\pi$.

3. Results

3.1. Floristic composition and species richness

A total number of 16063 individuals of tree species with ≥ 30 cm GBH were recorded from 33 ha of area sampled in Daspalla, Mahipur and Nayagarh forest ranges. They represent 162 species belonging to 115 genera under 44 families. The family Rubiaceae with 13 species was the most dominant taxon in terms of species content followed by Euphorbiaceae (11 species), Fabaceae and Moraceae (9 species each) and Mimosaceae (8 species) and 12 families were represented by single species only (Tab. 5). Of these, 89 species (4695 individuals) occur in Daspalla range, 119 species in Mahipur range (6065 individuals) and 128 species (5,303 individuals) were reported from Nayagarh range. Of the three, Nayagarh range was observed to be more species-rich. In terms of similarity in species occurrence, all the three ranges had an average similarity of 0.55 (55%), which implies that 55% of species are common to all the three studied ranges. Mahipur and Nayagarh forest ranges shared maximum similarity of 0.63 in terms of species presence and least (0.55) between Dasapalla and Nayagarh forest ranges. In general, though there is no correlation between species richness and stand density, highest number of species (128 species) and highest stand density (530.30 stems/ha) were observed in Nayagarh range. However, in 10 ha of sampled area in Daspalla forest range, lowest number (89 species) of tree species were recorded but the stand density (469.50 stems/ha) was higher than that of Mahipur range, where as many as 119 species were found to occur.

The values of diversity indices like Shannon-Weiner Index and Simpson Index varied greatly among the three forest ranges studied. Shannon's Index varied from 3.51-3.61, the highest value being for Nayagarh range and lowest for Mahipur range. Simpson Index ranged between 0.06 and 0.11 across the three study sites. The species accumulation curves for the three study sites were initially steep as the area of sample plots increased up to 4 ha but then the rise with increasing number of sampling plots was

much slower. However, the species area curve didn't reach an asymptote (Fig. 2).

3.2. Importance value index (IVI)

The IVI depicts the sociological structure of a species in its totality in the community. Tropical deciduous forests of Odisha state are dominated by the single species, *Shorea robusta* (Sal). This species scored highest IVI of 63.85 in Daspalla range, 93.84 in Mahipur range and 91.60 in Nayagarh range showing the dominance of the species in terms of density, basal area and frequency of occurrence. The top 10 species and their contribution to density, basal area and IVI in the three forest ranges of Nayagarh Forest Division are shown in (Table 3). (The variation in stand density, basal area and frequency of five dominant species namely, *Shorea robusta, Lannea coromandelica, Madhuca indica, Buchanania lanzan* and *Terminalia alata* occurring in all the three ranges are presented in (Table 3) for the purpose of comparison.)

3.3. Family composition

The total of 16,063 numbers of trees belonging to 162 species under 115 genera and 44 families were enumerated from representative sample plots located in Daspalla, Mahipur and Nayagarh forest ranges. In terms of tree density, Dipterocarpaceae with the lone species *Shorea robusta* and with 5,627 individuals dominated the tropical moist deciduous forests of Nayaharh district, followed by Anacardiaceae (1,687 stems) and Combretaceae (1,329 stems). Dipterocarpaceae, alone contributed to 35.03% of the tree population having Family Importance Value (FIV) of 80.16. The top 10 families comprised of 13,106 individuals contributed to 70.03% of total FIV. Twelve families were represented by single species with 5989 individuals and they accounted for 30.28% of total FIV, which includes the predominant species *Shorea robusta* (Dipterocarpaceae). Dipterocarpaceae scored the maximum FIV of 80.16, followed by Anacardiaceae (FIV=21.83), Combretaceae (FIV=20.21) and Euphorbiaceae (FIV=19.53). The FIV of Dipterocarpaceae although represented by single species. (FIV=80.16) is greater than the FIV of all speciose families such as Rubiaceae, Euphorbiaceae and Fabaceae (Table 5).

3.4 Stand Density, Basal Area and Girth Class distribution

A total of 4695, 6065 and 5303 trees were enumerated from the sample sites of Dasapalla (10 ha), Mahipur (13 ha) and Nayagarh (10 ha) forest ranges respectively. The stand density varied in the range of 530.30 stems ha^{-1} in Nayagarh forest range to 466.54 stems ha^{-1} in Mahipur forest range. In Daspalla range, maximum stand density of 219.700 stems/ha was observed under the lowest girth class of 30-60 cm but maximum stand basal area (10.529 m^2/ha) was recorded under the highest girth class of >150 cm. In case of Mahipur range, stand density and stand basal area went on decreasing with increasing girth classes. However, stand density showed a decreasing trend with increasing girth class in Nayagarh range but stand basal area went on decreasing till it attained a girth class of 120 cm and again increased with higher girth class of 121-150 cm and >150 cm. The total basal area showed variation in the range of 316 m^2 in Dasapalla range to 131.59 m^2 in Nayagarh range. Similarly, the stand basal area was recorded the highest (31.62 m^2/ha) for Dasapalla range followed by Mahipur (17.13 m^2/ha) and the lowest in Nayagah range (13.16 m^2/ha) (Table 4).

The terms of height class distribution of trees in all the three forest ranges, maximum percentage of standing trees were in the height range of 6.0 m-20.0 m. Individuals with less than 5 m height or more than 25 m height were quite few in number (Table 6).

Table 2
Key diversity attributes of forests in Nayagarh Forest Division, Odisha.

Description	Daspalla (10ha)	Mahipur (13ha)	Nayagarh (10ha)	Total for all sites (33ha)
Number of tree species	89	119	128	163
Number of individuals	4695	6065	5303	16063
Stand Density (Stems ha^{-1})	469.5	466.54	530.3	486.76
Total Basal area (m^2)	316.23	222.66	131.59	670.47
Stand Basal Area (m^2 ha-1)	31.62	17.13	13.16	20.32
Shannon-Weiner Index	3.54	3.51	3.61	3.68
Simpson Index	0.06	0.11	0.1	0.08
Evenness Index	0.79	0.73	0.74	0.72

Table 3
Density, basal area and IVI of the ten dominant species in three forest ranges of Nayagarh Division, Odisha

Daspalla Range				Mahipur Range				Nayagarh Range			
Species	Stand Basal area (m^2)	Stand Density	IVI	Species	Stand Basal area (m^2)	Stand Density	IVI	Species	Stand Basal area (m^2)	Stand Density	IVI
Shorea robusta	11.83	104	63.85	*Shorea robusta*	9.36	172.62	93.84	*Shorea robusta*	5.85	234.30	91.60
Cleistanthus collinus	1.07	38.2	15.36	*Terminalia alata*	0.78	26.46	12.83	*Terminalia alata*	0.49	25.80	11.38
Lannea coromandelica	1.74	24.7	14.59	*Buchanania lanzan*	0.39	21.77	9.11	*Buchanania lanzan*	0.41	26.20	10.73
Schleichera oleosa	1.59	16.5	12.37	*Diospyros melanoxylon*	0.41	15.38	8.12	*Diospyros melanoxylon*	0.55	9.70	8.64
Madhuca indica	1.45	20.7	12.15	*Cleistanthus collinus*	0.28	11.62	6.60	*Madhuca indica*	0.30	12.00	7.35
Protium serratum	1.40	20.8	12.02	*Dalbergia paniculata*	0.35	8.08	6.34	*Lannea coromandelica*	0.26	12.40	6.94
Buchanania lanzan	0.68	25.7	11.00	*Madhuca indica*	0.26	9.15	6.19	*Pterocarpus marsupium*	0.35	13.30	6.38
Desmodium oojeinensis	1.10	17.5	10.36	*Pterospermum xylocarpum*	0.33	10.38	6.09	*Semecarpus anacardium*	0.22	8.90	5.66
Terminalia alata	1.18	15.2	10.34	*Syzigium cumini*	0.32	9.62	6.00	*Terminalia chebula*	0.19	9.60	5.28
Anogeissus latifolia	1.05	11.3	8.21	*Lannea coromandelica*	0.23	8.46	5.98	*Careya arborea*	0.13	6.30	4.47
Total of above 10 species	23.07	294.6	170.24	Total of above 10 species	12.71	293.54	161.08	Total of above 10 species	8.74	358.50	158.43
Remaining 79 species	8.55	174.90	129.76	Remaining 109 species	4.42	173.00	138.92	Remaining 118 species	4.42	171.80	141.57
All species (89 species)	31.62	469.5	300.00	All species (119 species)	17.13	466.54	300.00	All species (128 species)	13.16	530.30	300.00

Table 4
Distribution of girth classes and their contribution to basal area and stand density in three forest ranges of Nayagarh Forest Division, Odisha.

	Girth Class									
Sites	30-60 cm		61-90 cm		91-120 cm		121-150 cm		>150	
	Stand Density (stems/ ha)	Stand Basal Area (m^2 /ha)	Stand Density (stems/ ha)	Stand Basal Area (m^2 /ha)	Stand Density (stems/ ha)	Stand Basal Area (m^2 /ha)	Stand Density (stems/ ha)	Stand Basal Area (m^2 /ha)	Stand Density (stems/ ha)	Stand Basal Area (m^2 /ha)
Dasapalla	219.700	3.331	92.5	4.220	6.490	6.247	5.460	7.816	37.800	10.529
Mahipur	300.000	0.437	97.000	0.421	47.077	0.355	20.077	0.284	8.462	2.154
Nayagargh	412.300	0.627	100.300	0.407	8.100	0.069	5.500	0.083	4.000	1.301

Table 5
Species content, number of individuals, contribution to basal area and FIV of the plant families in Nayagarh Forest Division, Odisha.

Sl No.	Family	No of Species	No of individuals	Basal area (m^2)	FIV
1	Rubiaceae	13	672	24.23	15.77
2	Euphorbiaceae	11	1303	31.30	19.53
3	Fabaceae	9	849	39.38	16.68
4	Moraceae	9	134	8.92	7.69
5	Mimosaceae	8	198	8.10	7.35
6	Combretaceae	7	1329	51.26	20.21
7	Meliaceae	7	168	3.86	5.92
8	Verbenaceae	7	62	1.54	4.91
9	Anacardiaceae	6	1687	51.27	21.83
10	Caesalpiniaceae	6	160	4.23	5.31
11	Ebenaceae	6	826	30.90	13.43
12	Rutaceae	6	150	3.02	5.06
13	Annonaceae	5	24	0.42	3.28
14	Bignoniaceae	5	126	4.62	4.54
15	Flacourtiaceae	5	159	3.38	4.56
16	Sterculiaceae	4	257	8.34	5.91
17	Apocynaceae	3	109	1.91	2.80
18	Burseraceae	3	317	17.94	6.49
19	Lythraceae	3	126	2.55	3.00
20	Oleaceae	3	47	0.71	2.24
21	Boraginaceae	2	8	0.18	1.30
22	Celastraceae	2	29	0.97	1.55
23	Dilleniaceae	2	93	5.79	2.67
24	Lauraceae	2	37	1.21	1.64
25	Loganiaceae	2	107	4.00	2.49
26	Malvaceae	2	34	1.04	1.59
27	Myrsinaceae	2	9	0.20	1.31
28	Myrtaceae	2	284	8.09	4.20
29	Sapindaceae	2	240	18.84	5.53
30	Sapotaceae	2	481	21.61	7.44
31	Tiliaceae	2	39	0.61	1.56
32	Ulmaceae	2	10	0.26	1.33
33	Acanthaceae	1	1	0.07	0.63
34	Alangiaceae	1	46	0.71	1.01
35	Arecaceae	1	18	0.60	0.81
36	Bombacaceae	1	49	2.73	1.32
37	Cochlospermaceae	1	1	0.01	0.62
38	Dipterocarpaceae	1	5627	298.49	80.16
39	Lecythidaceae	1	207	6.46	2.87
40	Leeaceae	1	4	0.08	0.65
41	Melastomataceae	1	2	0.04	0.63
42	Ochnaceae	1	29	0.55	0.88
43	Opilliceae	1	3	0.05	0.64
44	Rhamnaceae	1	2	0.03	0.63

Table 6
Height class-wise proportion of tree individuals in Nayagarh Forest Division, Odisha.

Height	Study sites			Individuals	% of Individuals
	Daspalla	Mahipur	Nayagarh		
≤ 5m	51	357	569	977	6.08
6-10m	640	1183	1353	3176	19.77
11-15m	1315	2118	1184	4617	28.74
16-20m	1119	1147	1320	3586	22.32
21-25m	675	735	788	2198	13.68
>25m	895	525	89	1509	9.39
Total	4695	6065	5303	16063	100

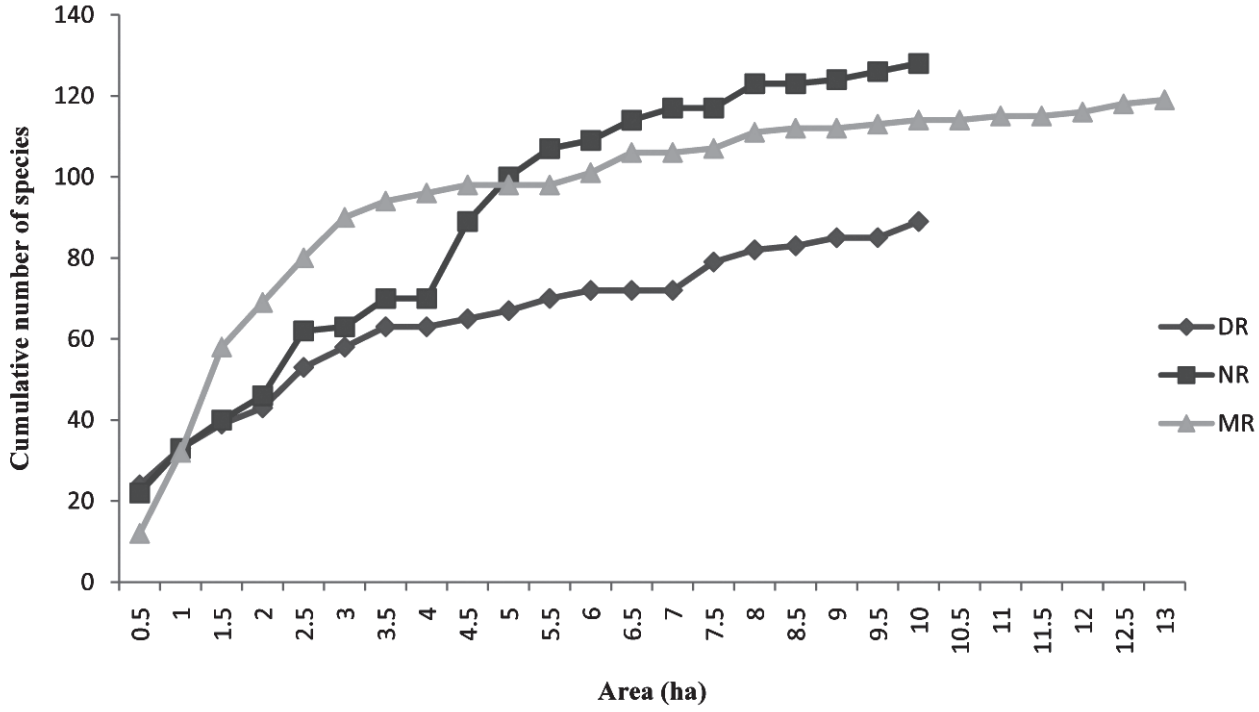

Fig. 2. Species accumulation curve for three different study sites in Nayagarh Forest Division, Odisha

4. Discussion

The predominant forest types of the Eastern Ghats of Odisha are tropical dry deciduous, tropical moist deciduous and semi-evergreen types (Champion and Seth, 1968) and are highly diversified and species rich. The density, abundance and distribution of individual species are measurable indicators of plant diversity (Wattenberg and Breckle, 1995). The species richness of 163 species over 33 ha sampled area in three forest ranges of Nayagarh Division reflects a moderate level of diversity 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 example, 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). In a recent assessment of species richness in southern Eastern Ghats, Arul Pragasan and Parthasarathy (2010) recorded 272 species in the 60 ha area sampled using similar sampling and data collection procedures.

The stand density of 469.50 stems/ ha now reported for Daspalla range, 466.54 for Mahipur range and 530.30 stems/ha remains within the range reported for other tropical forests of Indian subcontinent; 352 stems ha^{-1} in northern Eastern Ghats (Panda *et al*., 2013); 443 stems ha-1 in Malyagiri hills of Odisha (Sahu *et al*., 2012); 298 stems ha”1 at Mudumalai Forest Reserve, India and 689 stems

ha"1 at Sinharaja, Sri Lanka (Condit *et al*., 2000). Chittibabu and Parthasarathy (2000) reported tree density in the range of 266 trees ha"1 to 632 trees ha"1 from tropical evergreen forests of Koli Hills of Western Ghats of India and between 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 mean stand density of trees now reported for Nayagarh Forest Division (486.76 stems ha-1) is well within the reported range for tropical forests of India.

The species diversity depends on the adaptation of species which increases with the stability of community and Shannon's Index (H') is generally higher for tropical forests (Knight, 1975). In Indian forests, the value is reported to vary in the range of 0.83 to 4.0 (Singh *et al*., 1984). In the present study, Shannon's Index of diversity of tree species in all three sites varied between 3.54 to 3.61 which are within the reported range for the forests of Indian sub-continent (Gandhi and Sundarapandian, 2014; Ayyapan and Parthasarathy, 1999; Pandey, 2003; Panda *et al*., 2013). Comparison of diversity indices is very difficult because of the difference in the area sampled and lack of uniform plot dimensions. However, the index now determined is lower than the value reported for Northern Andhra Pradesh (Reddy *et al*., 2011), Niyamgiri hills, Odisha (Dash *et al*., 2009). The higher dominance index could be attributed to single-species dominance in the forest ecosystem.

In most of the studies relating to vegetation composition and site quality of forests, basal area acts as an important attribute (Mani and Parthasarathy, 2005; Parthasarathy and Karthikeyan, 1997; Srinivas and Parthasarathy, 2000). The basal area recorded in the present study ranged from 13.16 m^2 ha^{-1} in Nayagarh range to 31.62 m^2ha^{-1} in Daspalla range. These values are within the reported range for tropical deciduous forests in other parts of Eastern Ghats (Jha and Singh, 1990, Reddy and Prachi, 2008, Sahu *et al*., 2012 and Panda *et al*., 2013). However, the values of basal area determined in the present study are lower as compared to some other tropical forests of India (Kadavul and Parthasarathy 1999b; Reddy *et al*., 2008; Reddy *et al*., 2011; Parthasarathy and Karthikeyan, 1997; Parthasarathy *et al*., 1992; Prakasha *et al*., 2008).

The diameter distribution reflects the disturbance effect within the forests (Denslow, 1995; Hett and Loucks, 1976) and helpful in detecting trends in regeneration patterns (Poorter *et al*., 1996). The low basal area values in almost all the three ranges of the present study revealed the extent of forest disturbance with poor representation of trees in higher girth class. However, higher basal area under 121-150 cm and >150 cm girth class in Daspalla range is indicative of better forest regeneration following reduction in human interference. Tree density decreased with increasing size class of trees 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 (Khamyong *et al.,* 2004) and the present findings are in conformity with the above observation.

Quantitative floristic data from the present study will provide base-line information on distribution, richness and relative abundance of taxa for formulating management and conservation actions.

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