

Tree species diversity, distribution and population structure in a tropical dry deciduous forest of Malyagiri hill ranges, Eastern Ghats, India

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Abstract: Tree species diversity, distribution and population structure of tropical forests of Eastern Ghats are poorly understood. We analyzed the structure of a tropical deciduous forest in Malyagiri hill ranges of Eastern Ghats, Odisha. The study was conducted by laying 60 quadrats, each 20 m x 20 m in size. In total, 1063 trees belonging to 57 species were recorded from 2.4 ha sampling area. Mean density was 443 trees ha⁻¹ and basal area was 13.73 m² ha⁻¹. The dominant tree species was *Shorea robusta* with an Importance Value Index (IVI) of 44.67. Other important species were *Terminalia alata* (IVI 31.98), *Madhuca indica* (17.3), *Anogeissus latifolia* (15.64) and *Diospyros melanoxylon* (13.41). Stem density and species richness decreased with increasing girth class of trees. The Shannon-Wiener index (H') was 3.38 and Simpson's index (C) 1.0 indicating high tree species diversity in the present tropical deciduous forest. Out of 57 species, five species were randomly and fifty two species contagiously distributed. Tree species diversity, distribution and population structure provide baseline information for conservation and management of the present forest.

Resumen: El entendimiento de la diversidad, la distribución y la estructura poblacional de las especies arbóreas de los bosques tropicales de los Gates Orientales es pobre. Nosotros analizamos la estructura de un bosque tropical caducifolio en las colinas de las serranías Malyagiri de los Gates Orientales, Odisha. Para realizar el estudio se establecieron 60 cuadros de 20 m x 20 m cada uno. En total se registraron 1063 árboles pertenecientes a 57 especies en un área muestreada de 2.4 ha. La densidad media fue 443 árboles ha⁻¹ y el área basal fue 13.73 m² ha⁻¹. La especie arbórea dominante fue *Shorea robusta*, con un Índice de Valor de Importancia (IVI) de 44.67. Otras especies importantes fueron *Terminalia alata* (IVI 31.98), *Madhuca indica* (17.3), *Anogeissus latifolia* (15.64) y *Diospyros melanoxylon* (13.41). La densidad de tallos y la riqueza de especies decrecieron conforme aumentó la clase perimétrica de los árboles. El índice de Shannon-Wiener (H') tuvo un valor de 3.38 y el índice de Simpson (C) de 1.0, lo que indica una diversidad alta de especies arbóreas en el bosque tropical caducifolio actual. De las 57 especies, cinco estuvieron distribuidas aleatoriamente y 52 tuvieron una distribución contagiosa. La diversidad, la distribución y la estructura poblacional de las especies arbóreas proporcionan información de línea base para la conservación y el manejo del bosque actual.

Resumo: A compreensão sobre a diversidade das espécies arbóreas, da distribuição e estrutura da população das florestas tropicais dos Ghats orientais é escassa. Analisou-se a estrutura da floresta tropical caducifolia em Malyagiri nas colinas onduladas dos Ghats orientais, Odisha. O estudo foi conduzido estabelecendo uma quadrícula com 60 quadrados de 20

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m x 20 m. No conjunto, e para a área de 2,4 ha amostrados, registaram-se 1063 árvores pertencentes a 57 espécies. A densidade média foi de 443 árvores ha⁻¹ sendo a área basal de 13,73 m² h⁻¹. A espécie dominante era a *Shorea robusta* com um valor do Índice de Importância (IVI) de 44,67. As outras espécies importantes eram a *Terminalia alata* (IVI 31,98), *Madhuca indica* (17,3), *Anogeissus latifolia* (15,64) e a *Diospyros melanoxylon* (13,41). A densidade de troncos e a riqueza específica decresceu com o aumento das classes de perímetro das árvores. O índice de Shannon-Wiener (H') foi de 3,38 sendo o índice de Simpson (C) de 1,0 indicando a elevada presença de diversidade específica arbórea na presente floresta tropical caducifolia. Das 57 espécies, cinco distribuem-se casualmente e cinquenta e duas distribuem-se com um padrão contagioso. A diversidade arbórea, a distribuição e a estrutura da população proporcionam a informação base para a conservação e gestão da floresta atual.

Key words: Diversity, distribution pattern, Eastern Ghats, Malyagiri hill ranges, population structure, tree species.

Tropical and subtropical forests harbour maximum diversity of plant species found on the earth (WCMC 1992). These forests are rich in medicinal and economically important plants. Over-exploitation has resulted in a rapid loss of tropical forests which is considered as one of the most serious environmental and economic problems all over the world (Hare *et al.* 1997). A study on tree species diversity, distribution pattern and population structure of tropical forests is ecologically significant besides its usefulness in forest management.

Malyagiri hill ranges harbour floristically important tropical deciduous forest of Eastern Ghats, India. The wide ranges of topographic and climatic conditions favour luxurious growth of vegetation in this hill range. Many of the plants have immense medicinal properties. Due to over-exploitation of medicinal plants, fuel wood collection, habitat destruction and grazing, plant diversity of Malyagiri hill ranges is declining at an alarming rate. This may lead to extinction of many valuable species. However, barring a few floristic and ethnobotanical studies (Brahmam & Saxena 1990; Patra & Choudhury 1989; Saxena & Dutta 1975; Saxena *et al.* 1991), no quantitative analysis of forest structure has been reported. Therefore, a detailed study was undertaken to analyze the diversity, distribution and population structure of tree species of Malyagiri hill ranges.

Malyagiri hill ranges, a part of Eastern Ghats of India lies between 21° 10' and 21° 42' N latitude and 85° 0' and 85° 25' E longitude. It is located in the Pallahara Sub-division of Angul district in Odisha. The whole area is characterized by undu-

lating hills interspersed with strips of valleys. The mountain range has one of the highest peaks in Odisha with an elevation of 1,187 m. There are as many as 4 perennial water-falls with dense forests in the northern part, which is known as "Nagira". These provide a congenial niche for the luxuriant growth of marshy plants. The area experiences three distinct seasons in a year, viz. summer, rainy and winter, and receives an average annual rainfall of 1421 mm (mean of the past 10 years). The highest temperature 43.9 °C is recorded in May and it drops to 14.6 °C in December. Most hill tops are covered with lateritic soil. The soils in valley are mainly red in colour and the texture ranges from clay to clay-loam.

Vegetation analysis was carried out during March 2007 to December 2009 by laying 60 quadrats for each element of vegetation. For all trees ≥ 15 cm girths at breast height (GBH) were sampled through 20 x 20 m quadrats, placed randomly, with sampling intensity of 0.001 % covering an area of 2.4 ha. Individuals with less than 15 cm GBH were considered as saplings. The shrubs were sampled through 5 x 5 m and herbs, climbers and saplings were sampled by laying 1 x 1 m quadrats, which are nested within the quadrats for trees. The height of trees was measured using a clinometer. Herbarium specimens were prepared and the species were identified with the help of regional floras (Gamble & Fischer 1915-1935; Saxena & Brahmam 1996). The specimens were deposited in the herbarium RRL-B at the Institute of Minerals and Materials Technology (CSIR), Bhubaneswar. The vegetation data were analyzed for 57 tree species. Abundance (A),

Table 1. Phytosociological characteristics of tree species in Malyagiri hill range, Eastern Ghats.

Name of the species	F (%)	D (ind. ha ⁻¹)	BA (m ² . ha ⁻¹)	IVI	Distribution
<i>Aegle marmelos</i> (L.) Corr.	16.7	8.8	0.12	5.17	C
<i>Albizia lebbek</i> (L.) Benth.	3.3	0.8	0.04	0.93	C
<i>Alstonia scholaris</i> (L.) R.Br.	3.3	0.8	0.01	0.73	C
<i>Anogeissus latifolia</i> (Roxb. ex DC.) Wall.ex Guill. & Perr.	50.0	12.5	0.01	15.64	Ra
<i>Bauhinia purpurea</i> L.	1.7	0.8	0.01	0.45	C
<i>Bombax ceiba</i> L.	3.3	1.3	0.01	0.72	C
<i>Bridelia retusa</i> (L.) Spreng.	1.7	0.3	0.01	0.26	C
<i>Buchanania lanzan</i> Spreng.	38.3	24.5	0.34	8.15	C
<i>Careya arborea</i> Roxb.	5.0	2.5	0.03	1.47	C
<i>Casearia graveolens</i> Dalz.	18.3	10.8	0.11	5.74	C
<i>Cassia fistula</i> L.	11.7	3.3	0.04	2.63	C
<i>Chloroxylon swietiana</i> DC.	15.0	6.5	0.07	4.01	C
<i>Cleistanthus collinus</i> (Roxb.) Benth. ex. Hook. f.	26.7	15.8	0.12	8.13	C
<i>Dalbergia paniculata</i> Roxb.	1.7	0.3	0.02	0.46	C
<i>Dalbergia sisoo</i> Roxb.	1.7	0.3	0.01	0.35	C
<i>Diospyros malabarica</i> (Desr.) Kostel.	20.0	14.0	0.49	6.24	C
<i>Diospyros melanoxylon</i> Roxb.	36.7	19.0	0.56	13.41	Ra
<i>Diospyros montana</i> Roxb.	8.3	4.5	0.16	3.36	C
<i>Erythrina variegata</i> L.	1.7	0.3	0.69	5.32	C
<i>Ficus benghalensis</i> L.	1.7	0.3	0.01	0.26	C
<i>Ficus semicordata</i> Buch.-Ham.ex J.E.Sm.	3.3	0.8	0.02	0.74	C
<i>Ficus mollis</i> . Vahl	16.7	7.0	0.11	4.61	C
<i>Gardenia latifolia</i> Ait.	8.3	5.8	0.13	3.38	C
<i>Glochidion velutinum</i> Wight	3.3	1.3	0.04	1.02	C
<i>Gmelina arborea</i> Roxb.	28.3	14.5	0.21	8.67	C
<i>Haldinia cordifolia</i> (Roxb.) Ridsd.	1.66	0.8	0.05	0.8	C
<i>Ixora pavetta</i> Andr.	10	5.0	0.03	2.67	C
<i>Lagerstroemia parviflora</i> Roxb.	13.3	7.0	0.30	5.58	C
<i>Lannea coromandelica</i> (Houtt.) Merr.	1.7	0.8	0.01	0.39	C
<i>Macaranga peltata</i> (Roxb.) Muell.-Arg.	31.7	17.8	1.23	17.3	C
<i>Madhuca indica</i> Gmel.	3.3	1.3	0.01	0.76	C
<i>Mangifera indica</i> L.	15.0	9.5	1.00	11.54	C
<i>Melastoma malabathricum</i> L.	35.0	18.3	0.26	10.75	Ra
<i>Mitragyna parvifolia</i> (Roxb.) Korth.	13.3	6.3	0.10	3.94	C
<i>Morinda pubescens</i> Sm.	1.7	0.3	0.01	0.27	C
<i>Murraya paniculata</i> (L.) Jack	13.3	6.5	0.06	3.71	C
<i>Nyctanthes arbor-tristis</i> L.	10.0	3.3	0.04	2.39	C
<i>Phyllanthus emblica</i> L.	5.0	2.5	0.04	1.6	C
<i>Polyalthia cerasoides</i> (Roxb.) Bedd.	8.3	4.5	0.04	2.42	C
<i>Protium serratum</i> (Wall. ex Colebr.) Engl.	1.7	0.3	0.03	0.46	C

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Table 1. Continued.

Name of the species	F (%)	D (ind. ha ⁻¹)	BA (m ² . ha ⁻¹)	IVI	Distribution
<i>Pterocarpus marsupium</i> Roxb.	15.0	7.0	0.09	4.25	C
<i>Pterospermum acerifolium</i> (L.) Willd.	13.3	5.3	0.09	3.63	C
<i>Pterospermum xylocarpum</i> (Gaertn.) Sant & Wagh	6.7	3.8	0.04	2	C
<i>Randia malabarica</i> Lam.	1.7	0.3	0.01	0.26	C
<i>Schleichera oleosa</i> (Lour.) Oken	10.0	10.8	0.32	6.17	C
<i>Semecarpus anacardium</i> L.f.	3.3	1.3	0.02	0.86	C
<i>Shorea robusta</i> Gaertn.f.	73.3	59.5	2.88	44.67	Ra
<i>Strychnos potatorum</i> L.f.	11.7	6.5	0.23	4.74	C
<i>Symplocos racemosa</i> Roxb.	11.7	8.3	0.05	3.84	C
<i>Syzygium cumini</i> (L.) Skeels	13.3	6.3	0.21	4.74	C
<i>Terminalia alata</i> Heyne ex Roth.	65.0	49.5	1.62	31.98	Ra
<i>Terminalia arjuna</i> (Roxb.ex DC.) Wight & Arn.	3.3	2.0	0.31	3.13	C
<i>Terminalia bellirica</i> (Gaertn.) Roxb.	5.0	1.5	0.07	1.5	C
<i>Terminalia chebula</i> Retz.	3.3	1.3	0.02	0.87	C
<i>Wendlandia tinctoria</i> (Roxb.) DC.	23.3	12.0	0.16	7.05	C
<i>Xylia xylocarpa</i> (Roxb.) Taub.	10.0	5.8	0.11	3.37	C
<i>Zizyphus xylocarpus</i> (Retz.) Willd.	5.0	32.5	0.01	1	C

F- Frequency; D - Density; BA - Basal Area; IVI - Importance Value Index; Ra - Random; C - Contiguous.

Frequency (F), Relative frequency (RF), Density (D), Relative density (RD), Basal area (BA), Relative basal area (RBA), Importance Value Index (IVI), Shannon-Wiener index (Shannon & Weaver 1963) and Simpson's index (Simpson 1949) were calculated following Misra (1968). IVI of each species was calculated by summing the RF, RD and RBA values following Curtis (1959). Abundance to Frequency ratio (A/F) of each species was calculated to study the dispersion pattern. The ranges of values for determining dispersion pattern were: regular (< 0.025), random (0.025 - 0.05) and contiguous (> 0.05) (Curtis & Cottam 1956). Population structure of tree species was analyzed across five girth classes.

The dominant forest type of Malyagiri hill ranges is tropical dry deciduous forest (Champion & Seth 1968). A total of 1063 trees belonging to 57 species were recorded from 60 sample plots. The dominant tree species in descending order of IVI are *Shorea robusta* (44.67), *Terminalia alata* (31.98), *Madhuca indica* (17.3), *Anogeissus latifolia* (15.64), *Diospyros melanoxylon* (13.41) (Table 1). The luxuriant growth of herbs, shrubs and climbers increased the density of the forest vegetation. Among the herbs, *Chromolaena odorata*

(L.) R. King & H. Robins., *Andrographis paniculata* (Burm.f.) Wall. ex Nees, *Elephantopus scaber* L., *Curculigo orchioides* Gaertn. were most common species. Important shrub species were *Combretum roxburghii* Spreng., *Holarrhena pubescence* (Buch.-Ham.) Wall. ex G. Don, *Woodfordia fruticosa* (L.) Kurtz, *Lantana camara* L., *Helicteres isora* L. and *Ixora pavetta* Andr. The dominant climbers were *Dioscorea bulbifera* L., *Smilax macrophylla* Roxb., *Ampelocissus latifolia* (Roxb.) Planch. and *Bauhinia vahlii* Wight & Arn.

Out of 57 species, five species were randomly distributed and fifty two species contagiously distributed. Odum (1971) stated that contagious distribution is the commonest pattern of plant distribution in nature. Kumar & Bhatt (2006) reported that most species follow contagious distribution pattern in the foot-hill forests of Garhwal Himalaya and Rao *et al.* (1990) had similar findings for tree species of a subtropical forest of north-east India. The Shannon-Wiener index (H') was 3.38 and Simpson's index was 1.0. These values indicate that the present tropical deciduous forest is a species diverse system. The diversity value (H') of 3.38 falls within the range of 0.83 - 4.1 reported by earlier workers for Sal forest (Rasingam

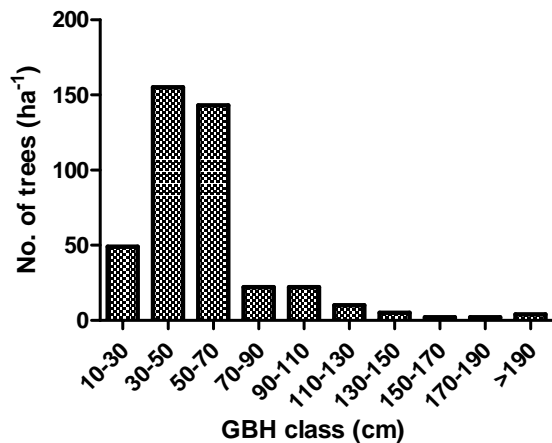


Fig. 1. Distribution of trees in different Girth classes in Malyagiri hill ranges, Eastern Ghats.

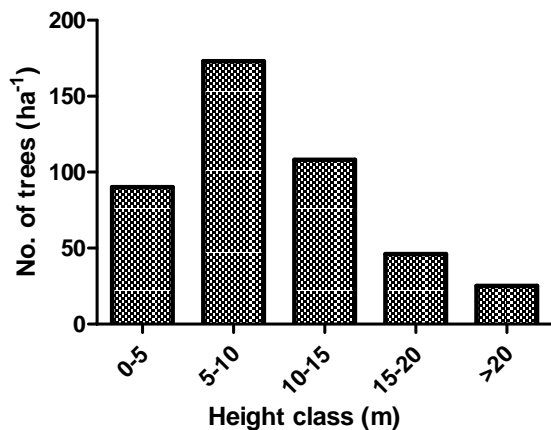


Fig. 2. Distribution of trees in different Height classes in Malyagiri hill ranges, Eastern Ghats.

& Parthasarathy 2009; Shukla 2009; Singh *et al.* 1985; Tripathi & Singh 2009; Visalakshi 1995).

The mean tree density of the forest was 443 ha⁻¹. The mean forest density is well within the range of 276 - 905 stems ha⁻¹ reported for trees ≥ 15 cm gbh in other tropical forests (Bhadra *et al.* 2010; Nirmal Kumar *et al.* 2010; Sahu *et al.* 2007). The value obtained for basal area in the present study is comparable to the Indian tropical forests (Visalakshi 1995). Stem density and species richness decreased beyond 30 - 50 cm gbh class. The distribution of the basal area across different gbh classes shows that the gbh class having 30 - 50 cm and 50 - 70 cm contributed to 34.9 % and 32.2 % of species richness respectively (Fig. 1). The highest

GBH recorded for *Ficus benghalensis* (458 cm) followed by *Mangifera indica* (378 cm), *Shorea robusta* (230 cm), *Madhuca indica* (215 cm) and *Schleichera oleosa* (210 cm).

The mean tree height was 10 m with a height range of 1 to 35 m. Tree distribution by height class intervals shows that 39.1 % of individuals were in the height class of 5 - 10 m, followed by 24.3 % in the height class of 10 - 15 m and 20.4 % in the height class of 0 - 5 m (Fig. 2). Only 5.73 % of individuals were in the height class of > 20 m. The tallest trees were *Shorea robusta* (35 m), *Mangifera indica* (33 m), *Terminalia bellirica* (32 m), *Syzygium cumini* (32 m) & *Diospyros malabarica* (27).

The reverse J-shaped GBH-density distribution of trees indicates an evolving or expanding population. The unsustainable collection of medicinal plants (bark of *Oroxylum indicum* and whole plant of *Gloriosa superba* and *Uraria picta*) needs to be checked to maintain the favourable population structure. Tree species diversity, distribution and population structure analyzed in this study should be useful to the conservation researchers and scientists and also to the forest managers for the effective management of the forest ecosystem.

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