International Journal of Botany Studies
ISSN: 2455-541X
Impact Factor: RJIF 5.12
www.botanyjournals.com
Volume 2; Issue 6; November 2017; Page No. 191-195

Diversity, population structure, and regeneration of tree species in Lalgarh forest range of West Bengal, India

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Abstract
The present study deals with the diversity, population structure and regeneration of tree species in lalgarh forest range of India for understanding the future stability of the forest. A total of 52 tree species of 45 genera and 23 families were recorded from study site. *Shorea robusta* emerged as the dominant and *Diospyros melanoxylon* was codominant tree species with their average density (366 no/ ha and 183.13 no/ha respectively) basal area (17.31 m^2/ha and 2.79 m^2/ha respectively) and IVI value (119.32 and 27.49 respectively). The size class distribution of tree of species showed a reverse 'J' shaped population curve with larger stem density and total basal area in lower girth classes. It was indicated a stable nature of forest stand. Although, maximum number of tree species represented 'fair' and 'poor' regeneration status. This could be due to low productivity and over exploitation of tree species by local community for multiple uses. It is a matter of concern. However, this study provides baseline information about present status and future stability on the tropical dry Lalgarh forest range.

Keywords: diversity, population structure, regeneration, conservation

1. Introduction
Forest has a great role in preserving environmental value. It offers better protection to the soil and water regimes. Tropical forests are most species diversity rich terrestrial ecosystems (WCMC, 1992) [25]. It contributes around 80% of world's total requirements of forest resources (Ambasht, 1988) [1]. These forests are now converted to most exploited and endangered ecosystems of Biosphere (Janzen, 1988; Gentry, 1992; Murphy and Lugo, 1986) [8, 4, 13]. Loss of tropical forest is affected most serious environmental and economic problems to all over the World (Hare, *et al*., 1997) [6].
The community composition and structure of a forest tree are very important tools for conservation purpose. Population (age) structure of a species is understood by its regeneration behavior (Saxena and Singh, 1984) [19]. Successful regeneration of a species depends upon an ability to initiate new seedlings and ability to survive and growth of seedlings and saplings (Good and Good, 1972) [5]. Representation of population structure as a percent of individuals by size classes is the only workable method to analyze the regeneration status of forest communities (Singh, *et al*., 1986) [23].
Indian continent is one of the seventeen mega-diversity centers of the World. The country is covered by 701673 sq. km. forest, which is 21.81% of the total geographical area of the country (India State of Forest Report, 2015). The Northern part of India is predominated by tropical forest. These regions are mainly the lateritic zone of West Bengal, comprising Midnapore, Jhargram, Bankura, Birbhum and Burdwan districts (Champion and Seth, 1968) [2]. Among them, the Jhargram district is very enriched by its fauna and flora diversity (Mukharjee, 1997) [12]. The phytosociological study in the district provided valuable information about the forest (Mallick, 2002) [10]. Now, most of the forests are become fragmented and lying in the undeveloped states. Extreme demographic pressure, overspreading urban sprawls and conversion of forestland to agricultural purpose by the tribal people are the main causes behind this. Presently about 40 angiosperm species of this district has become rare and are likely to attain the status of threatened (Mukharjee, 1997) [12].
The available information with reference to vegetation structure and composition of trees were very little. To stop the destruction and to conserve the habitat of the forest ecosystem, there was a necessity of huge study. So, the main objectives of present study were to find out diversity, population structure and regeneration of tree species in the entire forest range for the establishment and future stability.

2. Material and method
2.1 Study area
The Lalgarh forest range spread over an area of 7235.07 ha. It is located in some part of Binpur-I and Salboni block of Jhargram district, of West Bengal, India, within N-$22^0$53'-$22^0$68' longitude and E-$87^0$08'-$87^0$13' latitude. The area of the Lalgarh range is bounded on the North and West by the Goyaltore range and river Kangsabati, on the East by Pirakata range and on the South by Chandra range.

2.2 Data analysis
To determine the vegetation structure and regeneration of the forest, 40 quadrates for stems and 400 quadrates for seedlings were randomly placed in the study site. The quadrates size was 20 m X 20 m for the stem of the tree and 1m X 1m for seedlings. Vegetation data were quantitatively analyzed for basal area, relative frequency and relative density (Philips,

1959). The importance value indexes (IVI) of tree species were also analyzed. (Cottam and Curtis, 1956.; Mishra, 1968) [3, 11]. The species diversity and concentration of dominance in the community were calculated by Shanon-Wiener's index (Shanon and Wiener, 1963) and Simpson's index (Simpson, 1949) [22] respectively. The number (ind. /ha) of different species were noted as per following categories i.e. adult (>10 cm in dbh), sapling (3.3 to 10cm in dbh), and seedling (< 3.3 cm in dbh but > 15 cm high), throughout the entire forest. Regeneration status of the species was estimated based on following classes (Shankar, 2001) [20]:

a) 'good' - when seedling > sapling > adult
b) 'fair' – when seedling > sapling < adult
c) 'poor' – when species survives only in sapling stage but not as in seedling.
d) 'none' – when species are present only in adult stage.
e) 'new' – when species has only saplings and / or seedlings stage but no adults. The population structure of tree species was categorized by different dbh (cm) girth classes (Saxena *et al*, 1984) [19].

3. Results and discussion

3.1 Composition

The present study recorded 52 different tree species in Lalgarh forest range. These species belong to 45 genera of 23 families (Table-1). Fabaceae was most dominant family among them, representing 10 species, followed by Anacardiaceae and Combretaceae (5 species each), Apocynaceae and Rubiaceae (4 species each), Moraceae and Rutaceae (3 species each), Phyllanthaceae and Myrtaceae (2 species each) and remaining 14 are monospecific family. Some important family with the percentage of species is showed in figure-1. The most speciose genera were *Terminalia*, with 5 species. The similar Fabaceae dominance was also recorded from a tropical moist deciduous forest of the Eastern Ghats, India (Reddy *et al*., 2008). Vegetation is provided root strength by modifying the saturated soil water regime. As a result, forested slopes get more stability.

3.2 Species density

The density of a species refers to the area available as living space. The density of 52 tree species in the study site showed a wide variation, ranging from 366 to 1 no/ha. The average stand density (>3.3 cm in dbh) in the present study showed a greater value of 1336 stems/ha as compared to 568 stems/ha (ranges 527-665 stem/ha) was reported for Indian tropical forest (Reddy, *et al*., 2007) [17]. The dominant species was *Shorea robusta* covering 25.41% (366 no/ ha) and *Diospyros melanoxylon* was codominant species covering 12.73% (183 no/ha) of total site's density. Some species (*Ficus religiosa, Saraca asoca, Gardenia latifolia* etc.) have very lower density (1 no/ha). The density of the dominant species *Shorea robusta* is far below than previously recorded value (500, 1200 and 1133.33 no/ha) of three sites in Indian tropical forest (Joshi, 2012) [9].

The total basal area of the study site was 30.52 m^2 /hac., ranging from 17.31 to 0.01 m^2/ hac. The value of mean basal area falls within a range of 26.3- 43.1 m^2/ha. for *Shorea robusta* dominated tropical dry forest in India (Shankar, 2001, Reddy. *et al*., 2007) [17, 20]. The *Shorea robusta* had the largest basal area in the study site with about 56.71% (17.31 m^2/ha) of the total basal area followed by *Diospyros melanoxylon* 9.13% (2.79 m^2/hac), *Madhuca longifolia* 4.96% (1.51m^2/hac) and *Terminalia bellirica* 3.63% (1.11m^2/ha). Each species occupies only the area that can adequately meet its requirements. Thus greater density and basal area of a species mean its better stability on that site.

Shorea robusta was completely dominated among the 52 tree species by comprising highest IVI (119.32) compare to others (Table-1). The other subdominant species of the site have *Diospyros melanoxylon* (27.49), *Madhuca longifolia* (18.85), *Terminalia bellirica* (13.9), *Terminalia tomentosa* (13.67) and *Terminalia tomentosa* (10.67). The diversity dominance curve for 52 different tree species represents a log series model (Fig.-2). The higher IVI value of *Shorea robusta*, have a large gap between subdominant species which represent that the forest is very much disturbed. Similar types of occurrence were also reported from Western Odisha, India (Pradhan *et al*, 2017).

The calculated value of Shannon-Weiner index (H') and Simpson's Index in the study site were 2.65 and 0.18 respectively. The diversity value (H') falls within the range of 0.83-4.0 for Indian tropical forest (Singh *et al*., 1985, Visalakshi, 1995) [24]. The Simpson's Index value is lower than the reordered value for a tropical forest of India which is in a range of 0.21-0.92 (Visalakshi, 1995) [24].

3.3 Population structure

Population (age) structure of tree species in a forest can say its regeneration behavior. Population structure of 52 species showed a logarithmic plot against diameter classes in the entire study area (Fig. - 2).With the increase in class size, the number of the stem (no/ha) is decreasing rapidly at first and then more slowly. Although in lowest girth class (3.3-10 cm) it was nearly half than next girth class (10-20.8 cm). The representation of tree size in other girth classes (31.9 to >75.9 cm) is nearly similar in position. However, the total basal area (m^2/ha) in different girth classes is also decreased with increasing girth sizes. The diameter distribution of average density and basal area on different girth classes, have reverse 'J'- shaped curve. A similar pattern of distribution was also reported from a tropical dry deciduous forest of Malyagiri hill ranges, Eastern Ghat, India (Sahu *et al*, 2012) [18]. This type distribution of trees indicates an evolving or expanding population.

3.4 Regeneration

Regeneration is a key process for a species, to existence under varied environmental conditions. The successful regeneration of a forest species is characterized by the sufficient number of seedlings, saplings and adults. The present study recorded that among the 52 tree species, 4 species were under 'good' regeneration class, followed by 26 'fair', 4 'poor', 16 'none' and remaining 2 species appear to be 'new' class in the forest range (Table-1). So, the maximum species (50%) was under 'fair' status, including dominant (*Shorea robusta*) and codominant species (*Diospyros melanoxylon*). The second dominant regeneration class was 'none, by representing 30.77% species. The 'poor' and 'good' regeneration classes have 7.69% of species for each class. The absence of saplings

and or seedlings stage in the maximum number of species was due to low productivity, anthropogenic disturbance and less supportive microclimate conditions like germinability, the viability of seeds, predators, dispersing agents etc. 7.69% species were in 'good' regeneration class by getting all their micronutrient and environmental condition. However, a few percentages (3.85%) of species were recorded as 'new' class. These species may reach here through fruit dispersal by birds or animals. They should colonize by the availability of resources.

Table 1: List of tree species along with their family, phytosociological attributes and regeneration status recorded from Lalgarh forest range.

Sl. No.	Species	Family	Phytosociological attributes			Regeneration status			
			Density (No./ha)	Basal Area (m^2/ha)	IVI	Seedling (No./ha)	Sapling (No./ha)	Adult (No./ha)	status
1	*Shorea robusta Roth*	Dipterocarpaceae	366	17.31	119.32	16550	48	318	fair
2	*Diospyros melanoxylon Roxb.*	Ebenaceae	183	2.79	27.49	3550	21	162	fair
3	*Madhuca longifolia (J.Konig) J.F.Macbr.*	Sapotaceae	110	1.51	18.85	350	12	98	fair
4	*Terminalia bellirica (Gaertn.) Roxb.*	Combretaceae	62	1.11	13.9	2400	8	54	fair
5	*Holarrhena pubescens Wall.ex G. Don*	Apocynaceae	133	0.42	13.67	1500	76	57	good
6	*Terminalia tomentosa Willd.*	Combretaceae	47	0.95	10.67	150	8	39	fair
7	*Semecarpus anacardium L. f.*	Anacardiaceae	19	0.79	8.47	100	4	15	fair
8	*Lannea coromandelica (Houtt.) Merr.*	Anacardiaceae	39	0.63	7.89	0	2	37	poor
9	*Cleistanthus collinus (Roxb.) Benth. ex Hook.f.*	Phyllanthaceae	54	0.33	7.31	550	41	13	good
10	*Buchanania cochinchinensis (Lour.) M.R.Almeida*	Anacardiaceae	8	0.32	4.4	75	1	7	fair
11	*Syzygium cumini (L.) Skeels*	Myrtaceae	34	0.14	4.05	575	15	19	fair
12	*Strychnos nuxvomica L.*	Loganiaceae	33	0.31	3.89	50	4	29	fair
13	*Gmelina arborea Roxb.*	Lamiaceae	20	0.25	3.77	25	4	16	fair
14	*Terminalia chebula Retz.*	Combretaceae	33	0.16	3.75	0	15	18	poor
15	*Ziziphus oenoplia (L.) Mill*	Rhamnaceae	47	0.06	3.42	150	8	39	fair
16	*Terminalia arjuna(Roxb.) Wight & Arn.*	Combretaceae	31	0.26	3.01	50	2	29	fair
17	*Ficus benghalensis L.*	Moraceae	17	0.24	2.57	0	1	16	poor
18	*Mangifera indica L.*	Anacardiaceae	31	0.09	2.45	50	4	27	fair
19	*Streblus asper Lour.*	Moraceae	31	0.05	2.31	50	21	10	good
20	*Schleichera oleosa (Lour.) Merr.*	Sapindaceae	3	0.24	2.25	0	0	3	none
21	*Cassia fistula L.*	Fabaceae	3	0.11	2.19	150	1	2	fair
22	*Accacia aurifolia*	Fabaceae	2	0.12	2.15	50	2	0	new
23	*Pterocarpus marsupium Roxb.*	Fabaceae	3	0.15	1.95	100	0	3	fair
24	*Anacardium occidentale L.*	Anacardiaceae	4	0.23	1.93	0	0	4	none
25	*Tectona grandis L. f.*	Lamiaceae	7	0.35	1.79	150	1	6	fair
26	*Aegle marmelos (L) Correa.*	Rutaceae	2	0.21	1.78	0	0	2	none
27	*Butea monosperma (Lam.)Taub.*	Fabaceae	4	0.17	1.77	50	1	3	fair
28	*Careya arborea Roxb.*	Lecythidaceae	3	0.08	1.73	0	0	3	none
29	*Morinda pubescens Sm.*	Rubiaceae	16	0.03	1.54	0	0	16	none
30	*Albizia amara (Roxb.) Boiv.*	Fabaceae	16	0.02	1.48	100	4	12	fair
31	*Acacia catechu (L.F.) Willd*	Fabaceae	3	0.1	1.45	50	0	3	fair
32	*Trewia nudiflora L.*	Euphorbiaceae	16	0.05	1.24	0	0	16	none
33	*Oroxylum indicum (L.) Kurz.*	Bignoniaceae	1	0.15	1.21	0	0	1	none
34	*Millettia pinnata(L.) Panigrahi*	Fabaceae	16	0.04	1.19	150	2	14	fair
35	*Terminalia alata Wall.*	Combretaceae	1	0.13	1.16	0	0	1	none
36	*Annona squamosa L.*	Annonaceae	16	0.01	1.11	0	1	15	poor
37	*Randia dumetorum L.*	Rubiaceae	16	0.01	1.11	50	10	6	good
38	*Holoptelea integrifolia Planch.*	Ulmaceae	1	0.08	0.97	25	0	1	fair
39	*Adina cordifolia (Roxb.) Hook. f*	Fabaceae	1	0.06	0.91	0	0	1	none
40	*Tamarindus indica L.*	Fabaceae	1	0.04	0.87	150	0	1	fair
41	*Alstonia scolaris (L.) R. Br.*	Apocynaceae	1	0.04	0.84	50	0	1	fair
42	*Plumeria rubra L.*	Apocynaceae	1	0.03	0.82	25	0	1	fair
43	*Azadirachta indica A. Juss.*	Meliaceae	1	0.02	0.78	150	0	1	fair
44	*Schliechera trijuga Wild.*	Rubiaceae	1	0.09	0.66	0	0	1	none
45	*Ficus religiosa L.*	Moraceae	1	0.08	0.61	0	0	1	none
46	*Syzygium operculatum (Rox.) Nied*	Myrtaceae	1	0.04	0.5	0	0	1	none
47	*Carissa spinarum L.*	Apocynaceae	1	0.04	0.49	0	1	0	new
48	*Limonia acidissima Groff.*	Rutaceae	1	0.03	0.45	0	0	1	none
49	*Naringi crenulata (Roxb.) Nicolson*	Rutaceae	1	0.03	0.45	0	0	1	none
50	*Saraca asoca (Roxb.) Willd.*	Fabaceae	1	0.03	0.45	50	0	1	fair
51	*Gardenia latifolia Aiton*	Rubiaceae	1	0.02	0.44	0	0	1	none
52	*Glochidion ferdinandii (Mull.Arg.) F.M.Bailey*	Phyllanthaceae	1	0.02	0.42	0	0	1	none

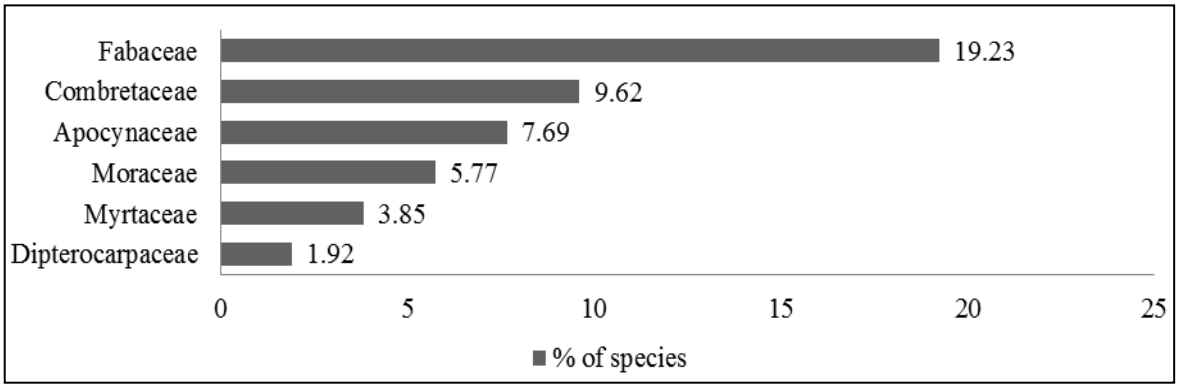

Fig 1: Some dominant family with their consisting percentage of tree species.

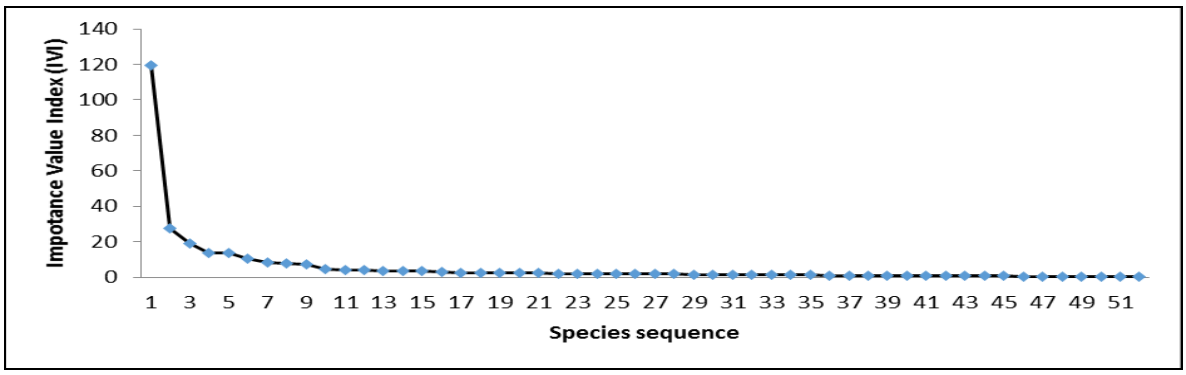

Fig 2: Species sequence curve/ diversity distribution curve of study site.

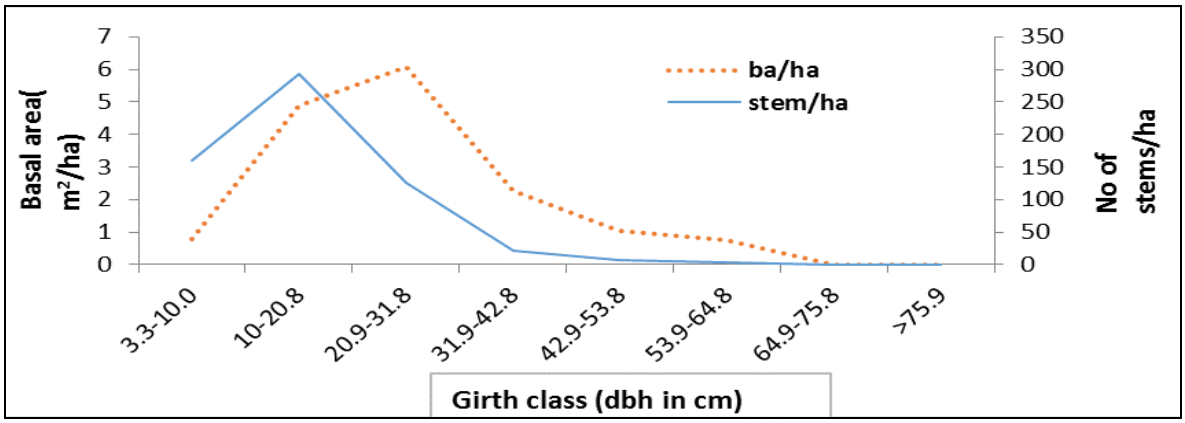

Fig 3: Diameter class contribution towards number of stems and basal area in Lalgarh forest range.

4. Conclusion

The presence of high species diversity, average stand density and basal area indicates that the forest is in a climax and stable condition. But from the regeneration study of all tree population, we were found that larger number of species were in 'fair' and 'none' regeneration status. The problem of anthropogenic pressure is the main causes behind this. It is exists by the regular collection of timber, fuel wood and medicinal plants. These should be checked practically and must be given highest priority for the habitat conservation of entire forest. The government is must be taken a step to stop the commercial logging in the forest range to conserve forest structure. Awareness to local communities about declining status of natural resources is also necessary.

5. Acknowledgements

The authors are sincerely thankful to the Midnapore Forest Department, for providing necessary information about the study site. The help received from the local tribal people involved during survey is duly acknowledged. Our deepest gratitude goes to Dr. N. Behera, Sambalpur University, India, for valuable suggestions and encouragements.

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