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Woody Plant Diversity of Tropical Dry Deciduous Forest of Ranchi, Jharkhand

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ABSTRACT

The study was conducted to determine the composition and diversity of three different growth stages of plant in tropical dry deciduous forest in Horhap under Mahilong Range, Ranchi during the year 2018-2019. The entire area was divided into two sites based upon the physiographic factors. The simple random sampling procedure was followed with quadrates of 10×10 m^2 for trees and saplings and 2×2 m^2 quadrates for seedlings were taken. A total of 1430–1810 stems ha^{-1} in trees, 1080–1240 stems ha^{-1} in saplings and 45500–56500 stems ha^{-1} in seedlings were encountered. The total basal area was varied between 35.97 to 48.01 m^2 ha^{-1} for trees, 4.67 to 5.42 m^2 ha^{-1} for saplings and 3.78– 3.88 m^2 ha^{-1} for seedlings. *Shorea robusta* showed highest value of IVI in tree sapling and seedling layers. Shannon index ranged from 2.43–2.97 for trees, 3.07–3.08 for saplings and 2.21–2.26 for seedlings. The concentration of dominance was 0.24–0.33 for trees, 0.19–0.21 for saplings and 0.37–0.4 for seedlings. Equitability ranged from 0.92–0.99 for trees, 1.0 for saplings and 0.84–0.86 for seedlings. Species richness ranged from 1.79–2.53 for trees, 2.11–2.43 for saplings and 1.19–1.21 for seedlings. However there is a need for ideal silvicultural operations and scientific approach-based management practice to retain the diversity ultimately a healthy forest ecosystem.

Keywords Floristic, Diversity, Tropical dry deciduous forest, Sal.

INTRODUCTION

Tropical dry deciduous forest spreads over maximum area of India i.e., 3,13,617 km^2, which is 40.86% of the total forest area (IFSR 2019). It is commonly known as monsoon forests as it shows falling and shedding of leaves during the autumn and cold winter season and re-grow new leaves in the next spring and monsoon season. "Deciduous" means "falling off at maturity", which is the typical characteristic feature of the forest. Tropical forest not only covers the largest area but also support high terrestrial species diversity (Kumar *et al.* 2006). Among the 16 groups of forest found in India (Champion and Seth 1968) mostly two

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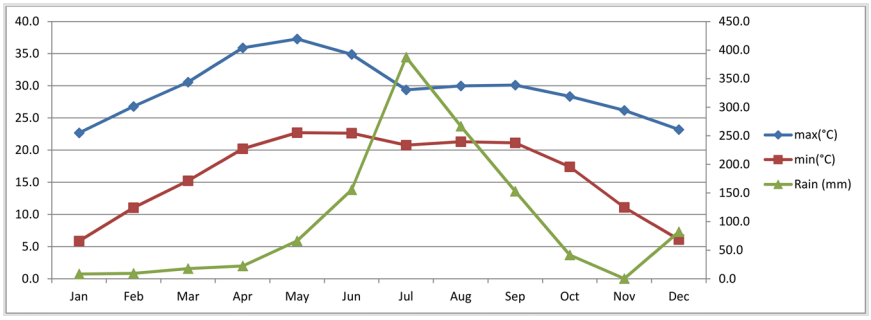

Fig.1. Ombrothermic diagram of tropical deciduous forest of Ranchi (Jan 2014- Jun 2019).

types of forest i.e., Tropical moist deciduous forest and Tropical dry deciduous forest, are dominated in Jharkhand (Mishra 2013).

Structural characteristics and floristic composition of forests are having paramount importance in assessing health of the forests (Prakasha *et al.* 2008). It reflects the interrelationship of various biotic and abiotic factors and make a complex ecosystem which characterized by exchange of energy and biomass. Forest stand structure is a key element in understanding forest ecosystems and also an important element of stand biodiversity (Ozcelik 2009). However, the disappearance of these forests at a rapid rate of 1-2% per year comes at a time, whenever our knowledge of their structure, composition, dynamics, diversity and taxonomy has not fully resolved (Hubbell *et al.*1999). The critical management reflects the change in forest structure resulting from succession and to differentiate between the various forest types (Cairns *et al.*

Table 1. Vegetational composition of tree layer.

Sl. No.	Species	Site I F (%)	D (stems ha^{-1})	BA (m^2 ha^{-1})	IVI	Site II F (%)	D (stems ha^{-1})	BA (m^2 ha^{-1})	IVI
1	*Lagerstroemia parviflora* Roxb.	20	40	0.66	7.28	60	180	3.23	36.57
2	*Diospyros melanoxylon* Roxb.	100	280	5.39	45.21	50	90	1.39	22.65
3	*Shorea robusta* Roth.	100	800	28.56	122.21	100	790	25.01	149.77
4	*Adina cordifolia* Roxb.	70	150	4.49	30.61	20	50	1.63	13.03
5	*Scheichera oliosa* (Lour.) Oken	20	20	0.27	5.38	40	90	1.43	20.27
6	*Mangifera indica* Linn.	20	50	1.31	9.20	-	-	-	-
7	*Millettia pinnata* (L.) Panigrahi	10	30	0.47	4.49	-	-	-	-
8	*Phyllanthus emblica* L.	20	50	0.51	7.53	-	-	-	-
9	*Terminalia catappa* L.	10	10	0.09	2.60	10	30	0.36	5.59
10	*Syzygium cumini* (Linn.) Skeels.	20	50	0.81	8.16	-	-	-	-
11	*Terminalia arjuna* Roxb.	20	40	0.51	6.97	-	-	-	-
12	*Bombax ceiba* L.	10	10	0.37	3.17	-	-	-	-
13	*Terminalia tomentosa* Roxb.	40	110	2.19	18.05	10	20	0.34	4.85
14	*Azadirachta indica* A. Juss	10	20	0.24	3.46	20	40	0.72	9.79
15	*Dillenia indica* L.	10	30	0.38	4.29	20	40	0.50	9.19
16	*Gmelina arborea* Linn.	10	20	0.26	3.49	-	-	-	-
17	*Bridelia retusa* LA Juss	10	10	0.10	2.60	-	-	-	-
18	*Madhuca indica* JF Gmel.	20	40	0.67	7.31	10	20	0.30	4.74
19	*Butea monosperma* (Lamk) Taub.	10	40	0.65	5.42	10	20	0.26	4.62
20	*Limonia acidissima* L.	10	10	0.08	2.57	30	40	0.39	11.37
21	*Streblus asper* Lour.	-	-	-	-	10	10	0.09	3.45
22	*Bauhinia variegate* (L.) Benth	-	-	-	-	10	10	0.33	4.11
	Total	**540**	**1810**	**48.01**	**300.00**	**400**	**1430**	**35.97**	**300**

F= Frequency, D=Density, BA= Basal area, IVI= Important value index.

Table 2. Vegetational composition of sapling layer.

Sl. No.	Species	Site I F (%)	Site I D (stems ha^{-1})	Site I BA (m^2 ha^{-1})	Site I IVI	Site II F (%)	Site II D (stems ha^{-1})	Site II BA (m^2 ha^{-1})	Site II IVI
1	*Diospyros melanoxylon* Roxb.	70	120	0.57	40.29	80	180	0.83	47.96
2	*Lagerstroemia parviflora* Roxb	20	110	0.26	20.69	50	80	0.42	25.57
3	*Adina cordifolia* Roxb.	50	80	0.21	24.19	20	20	0.12	8.46
4	*Shorea robusta* Roth.	90	450	2.20	110.66	80	460	2.11	94.30
5	*Syzygium cumini* (Linn.) Skeels.	20	30	0.16	11.11	-	-	-	-
6	*Millettia pinnata* (L.) Panigrahi	10	20	0.08	6.09	-	-	-	-
7	*Phyllanthus emblica* L.	20	50	0.20	13.78	10	30	0.05	5.68
8	*Terminalia catappa* L.	20	50	0.20	13.86	30	150	0.60	29.97
9	*Azadirachta indica* A. Juss	10	10	0.06	4.61	10	10	0.06	4.23
10	*Dillenia indica* L.	10	10	0.06	4.61	40	90	0.21	20.22
11	*Terminalia tomentosa* Roxb.	20	20	0.10	8.78	-	-	-	-
12	*Gmelina arborea* Linn.	10	10	0.06	4.61	-	-	-	-
13	*Bridelia retusa* (L.) A. Juss	10	20	0.12	6.78	-	-	-	-
14	*Butea monosperma* (Lamk) Taub	10	20	0.11	6.73	10	20	0.09	5.65
15	*Scheichera oliosa* (Lour.) Oken	10	20	0.04	5.25	20	40	0.22	11.78
16	*Madhuca indica* JF Gmel.	10	10	0.04	4.27	10	20	0.10	5.76
17	*Limonia acidissima* L.	10	20	0.11	6.60	30	50	0.22	14.91
18	*Wrightia antidysenterica* (L.) R.Br	10	30	0.09	7.10	10	30	0.09	6.43
19	*Bauhinia variegate* (L.) Benth	-	-	-	-	10	20	0.05	4.73
20	*Streblus asper* Lour.	-	-	-	-	20	30	0.17	10.12
21	*Aegle marmelos* (L.) Correa	-	-	-	-	10	10	0.06	4.23
	Total	**410**	**1080**	**4.67**	**300**	**440**	**1240**	**5.42**	**300**

F= Frequency, D=Density, BA= Basal area, IVI= Important value index.

2003). These forests are highly threatened by various human activities (Htun *et al*. 2011). Tree species diversity impacts on the forests by influencing the micro-climate, stand structure, species composition and geomorphology. The rapid inventory of tree species, that provides information on diversity, is an important tool to enhance our ability to focus on maximizes biodiversity conservation that results from deforestation and degradation (Baraloto *et al.* 2013). Information from the quantitative inventory will provide with a valuable reference of forest assessment and improve our knowledge by the identification of economically important, ecologically useful species as well as species of special concern, thus identifying conservation efforts for sustainability of forest biodiversity. Anthropogenic disturbances can change the successional pattern of stand, subsequently the diversity and biomass of the forest.

Land use pattern and disturbance dominions had a prolific effect on the abundance, distribution and diversity of vegetation in the area (Kyayesimira and Lejju 2015). The forest stands are subjected to various kinds of natural disturbances that emit a range of space for new species introduction (Jhariya and Yadav 2018). These factors causing great loss to the biodiversity and ultimately destructing the natural vegetation and habitat of the region. In the tropical domain, net annual loss of forest area from 2000 to 2010 was about 7 million hectares and net annual increase in agricultural land area was more than 6 million hectares (FAO 2016).

In tropical dry deciduous forest in central plateau region of India, a few quantitative phyto-diversity inventories (Kumar and Saikia 2020, Panda *et al.* 2020, Ekta *et al.* 2020) are available. The study thus focused on the structure and composition of woody plant diversity in dry tropical ecosystem of central plateau region in Ranchi.

MATERIALS AND METHODS

The study on was carried out at Horhap forest beat situated in Mahilong Forest Range under Ranchi East Forest Division, Jharkhand during the year 2018–

Table 3. Vegetational composition of seedling layer.

Sl. No.	Species	Site I F (%)	D (stems ha^{-1})	BA (m^2 ha^{-1})	IVI	Site II F (%)	D (stems ha^{-1})	BA (m^2 ha^{-1})	IVI
1	*Shorea robusta* Roth.	100	28000	1.70	134.01	100	32750	1.80	135.88
2	*Diospyros melanoxylon* Roxb.	70	5500	0.95	56.47	70	7000	0.56	48.44
3	*Adina cordifolia* Roxb.	10	1000	0.04	5.97	-	-	-	-
4	*Lagerstroemia parviflora* Roxb.	20	1250	0.04	9.49	10	5500	0.54	27.12
5	*Phyllanthus emblica* L.	40	2000	0.14	19.40	20	750	0.08	9.43
6	*Azadirachta indica* A. Juss	20	2000	0.24	16.15	10	750	0.08	6.38
7	*Scheichera oliosa* (Lour.) Oken	10	1000	0.09	7.42	30	2500	0.12	16.62
8	*Syzygium cumini* (Linn.) Skeels.	20	1000	0.03	8.74	-	-	-	-
9	*Mangifera indica* Linn.	10	750	0.11	7.48	-	-	-	-
10	*Alstonia scholaris* (L.) R. Br	10	1000	0.02	5.54	10	750	0.01	4.75
11	*Dillenia indica* L.	10	500	0.02	4.35	20	2000	0.06	11.33
12	*Bridelia retusa* (L.) A. Juss	10	500	0.09	6.41	-	-	-	-
13	*Wrightia antidysenterica* (L.) R. Br	10	500	0.26	10.68	-	-	-	-
14	*Limonia acidissima* L.	10	500	0.15	7.89	10	500	0.15	7.88
15	*Streblus asper* Lour. -	-	-	-	-	10	750	0.10	7.04
16	*Samanea saman* F. Muell	-	-	-	-	10	500	0.10	6.43
17	*Madhuca indica* JF Gmel.	-	-	-	-	10	1000	0.04	5.96
18	*Millettia pinnata* (L.) Panigrahi	-	-	-	-	10	500	0.05	5.15
19	*Butea monosperma* (Lamk) Taub	-	-	-	-	10	1250	0.09	7.59
	Total	**350**	**45500**	**3.88**	**300.00**	**330**	**56500**	**3.78**	**300**

F= Frequency, D=Density, BA= Basal Area, IVI= Important Value Index.

2019. The entire area is situated on hilly forest tract, which comes under Tropical Dry Deciduous Forest and spreads over an area of 651.544 ha (1610 acre). The area lies at an altitude of 629 m (2,064 ft) from mean sea level (msl). It lies between 23°18'10.072" N to 23°21'18.575" N latitude and 85°26'18.218" E to 85°29'1.539" E longitude. It experiences tropical climate, with hot summer from March to May, well distributed rainfall from June to September during southwest monsoon and winter in November to February. December and January are the coolest months, with 7°- 22°C mean daily temperature (Fig. 1). The annual rainfall is about 1210 mm (47.64 inches) and from June to September the rainfall is about 965 mm. The average humidity is about 63–84%. The soils of the district are mostly of the residual type depends upon the topographical factor.

The entire area as divided into two sites based upon the physiographic factors. The site I included human settlements, slopy and lateritic soil type, while the site II was on hilly track with swallow soil. The simple random sampling procedure was adopted for characterization of vegetation. The phyto-diversity analysis of the forest was carried out by randomly placing, a total of twenty quadrats of 10×10 m^2 (ten in each site) with 0.03% sampling intensity. In each quadrate, GBH (girth at breast height) of individual (≥ 30 cm girth) trees and saplings (individuals >10 cm - ≤ 30 cm girth) was measured. In center of each 10×10 m^2 quadrate, a 2×2 m^2 area was marked for enumeration of seedlings (individuals <10 cm girth). Stem girth of trees and saplings was measured at breast height (i.e., 1.37 m from the ground) and at collar region for seedlings.

The vegetational data was quantitatively analyzed for frequency, density, abundance (Curtis and

Table 4. Comparison of vegetational composition with other forests.

Location	Layers	Density (stems ha^{-1})	Basal area (m^2ha^{-1})	Source
Sal dominate tropical deciduous forest, CG	Tree	–33.5–46.8	0.31–0.35	Raj (2019)
	Sapling	–	–	
	Seedling	12250–14500	–	
Tropical moist deciduous forest, Ranchi	Tree	397	262.50	Kumar and Saikia (2020)
Central Himalayan	Tree	560-1100	27.24- 80.04	Arya *et al*. (2017)
	Sapling	50-110	--	
	Seedling	60-390	--	
Achanakmar- Amarkantak Biosphere Reserve	Tree	260–810	9.96- 41.60	Yadav (2016)
	Sapling	7500-35000	0.86- 5.07	
	Seedling	25000-92500	0.28-0.96	
Tropical forest, Odisha	Over story	728.474	28.453	Mishra *et al.* (2018)
Sal dominat forest, Central Himalayan	Tree	650	–	
	Sapling	36	–	
	Seedling	400	–	
Sal- Teak mixed forest, Central Himalayan	Tree	911		Kapkoti *et al.* (2016)
	Sapling	1303		
	Seedling	6656		
Tropical dry mixed deciduous forest, Myanmar	Tree	1061	27.52	Aye *et al.* (2014)
Southern tropical moist deciduous forests	Tree	132	23.32	Jayakumar and Nair (2013)
Subtropical dry deciduous forest	Tree	288	14.32	
Himalayan subtropical Pine forest	Tree	498	37.75	Sharma and Kant (2014)
Dry tropics	Tree	100-510	14.67-26.67	Pawar *et al.* (2014)
	Sapling	30-610	0.06-1.24	
	Seedling	7750-39500	--	
Tropical dry deciduous forest	Tree	1430-1810	35.97-48.01	Present Study
	Sapling	1080-1240	4.67- 5.42	
	Seedling	45500-56500	3.78- 3.88	

McIntosh 1950). An importance value index (IVI) was calculated as the sum total of relative frequency, relative density and relative basal area (Phillips 1959).

Plant diversity in both the sites was quantified by following diversity indices.

Shannon Index (H') = - $\sum$pi $\log^2$ pi (Shannon and Weaver 1963)

Concentration of dominance (Cd) = Σ (Ni / N)^2 (Simpson 1949)

Equitability (e) = H' / lnS. (Pielou 1966)
Species richness (d) = S^{-1} / lnN. (Margalef 1958)

Where, Pi = Proportion of total stand basal area represented by the ith species, H' = Shannon index, S = The number of species, Ni = The total basal cover of species i, N = Basal area of all species (m^2 ha^{-1}).

RESULTS

Tree layer

In the site I, a total of 1810 trees ha^{-1} representing 20 species and 15 families with basal area of 48.01 m^2 ha^{-1} were enumerated. Dipterocarpaceae represented the maximum (800) individuals followed by Ebenaceae (280), Rubiaceae (150) and Combretaceae (150). The density and basal area of individual tree species (Table 1) varied from 10 to 800 stems ha^{-1} and 0.08 to 28.56 m^2 ha^{-1}, respectively. *Shorea robusta* represented the highest density followed by *Diospyros melanoxylon* and *Adina cordifolia* respectively whereas *Limonia acidissima* had the lowest density followed by *Bridelia retusa*, *Bombax ceiba* and *Terminalia catappa*. *S. robusta* also showed the highest basal

Table 5. Comparison of diversity indices with other forests.

Location	Layers	H'	Cd	e	d	Sources
Sal dominating tropical deciduous forest	Tree	1.61-1.86	0.18-0.58	0.6-0.82	1.71-2.23	Raj (2019)
	Sapling	1.42-1.68	0.28-0.79	0.67-0.96	0.89-1.48	
	Seedling	1.46-1.75	0.21-0.62	0.48-0.71	1.2-1.67	
Sal forest in Kumaun region	Tree	0.313	0.894			Kapkoti *et al.* (2016)
	Sapling	0.871	0.674			
	Seedling	0.722	0.722			
Central Himalaya	Tree	0.93-2.18	0.1-0.44	0.49-0.87	0.16-0.54	Arya *et al.* (2017)
	Sapling	0.5-1.84	0.16-0.55	0.72-0.92	0.11-0.6	
	Seedling	0.2-2.02	0.13-0.54	0.18-0.97	0.12-0.92	
Tropical moist deciduous forests of Ranchi	Tree	2.25	0.32	0.49	10.28	Kumar and Saikia (2020)
Tropical Deciduous forest		1.09-2.3	0.25-0.65	0.49-1.2	5.0-12.1	Yadav (2016)
Southern tropical moist deciduous forests	Tree	2.79				Jayakumar and Nair (2013)
	Sapling	2.48				
	Seedling	2.62				
Tropical dry mixed deciduous forest, Myanmar	Tree	1.45-3.61	0.5-0.96	0.38-0.84		Aye *et al.* (2014)
Eastern ghats, odisha	Tree	1.29-2.19	0.62-0.87	0.68-0.92		Sahu *et al.* (2019)
Eastern ghats, Andhra Pradesh		3.76-3.96	0.96-0.97	0.6-0.78	10.0-11.2	Naidu and Kumar (2016)
Subtropical forest Siwaliks	Tree	3.38	0.96	0.84	16.46	Sharma and Kant (2014)
Dry tropics	Tree	2.32-2.83	0.2-0.24	1.13-1.29	1.08-1.91	Pawar *et al.* (2014)
	Sapling	0.91-2.65	0.18-0.55	1.06-1.31	0.29-1.29	
	Seedling	1.5-2.68	0.2-0.55	0.72-1.37	0.33-0.23	
Tropical deciduous forest	Tree	2.43-2.97	0.24-0.33	0.92-0.99	1.79-2.53	Present study
	Sapling	3.07-3.08	0.19-0.21	1.0	2.11-2.43	
	Seedling	2.21-2.26	0.37-0.40	0.84-0.86	1.19-1.21	

H'= Shannon index, Cd= Concentration of dominance, e=Equitability, d= Species richness.

area followed by *D. melanoxylon*, *A. cordifolia* and *T. tomentosa, L. acidissima* also showed the lowest basal area. *S. robusta* showed highest value of IVI (122.21) followed by *D. melanoxylon* (45.21) and *A. cordifolia* (30.61). Similarly *L. acidissima* showed lowest value of IVI (2.57) followed by *T. catappa* (2.60) and *B. retusa* (2.60).

In site II, a total of 1430 trees ha^{-1} representing 14 species and 12 families with basal area of 35.97 m^2 ha^{-1} were enumerated. Dipterocarpaceae represented the maximum (790) individuals followed by Lythraceae (180), Sapindaceae (90) and Ebenaceae (90). Basal area and density of individual tree species varied from 0.09 to 25.01 m^2 ha^{-1} and 10 to 790 stems ha^{-1}, respectively. *S. robusta* was the most densely populated tree followed by *Lagerstroemia parviflora* and *Scheichera oliosa* whereas *Bauhinia variegate* and *Streblus asper* showed the lowest density. *S. robusta* showed the maximum basal area followed by *L. parviflora*, *A. cordifolia*, *S. oliosa* and *D. melanoxylon*. In other hand, *S. asper* showed the lowest basal area. *S. robusta* showed highest IVI (149.77) followed by *L. parviflora* (36.57) and *D. melanoxylon* (22.65) whereas *S. asper* showed lowest IVI (3.45) followed by *B. variegate* (4.10) and *Butea monosperma* (4.62).

Sapling layer

In the site I, a total of 1080 saplings ha^{-1} representing 18 species and 15 families were enumerated with 4.67 m^2 ha^{-1} basal area. Dipterocarpaceae represented the highest 450 individuals followed by Ebenaceae (120), Lythraceae (110) and Rubiaceae (150). Basal area and density of individual saplings (Table 2) varied from 0.04 to 2.19 m^2 ha^{-1} and 10 to 450 stems ha^{-1}, respectively. *S. robusta* showed the highest sapling density followed by *D. melanoxylon* and *A. cordifolia* whereas the lowest density was found in *Madhuca indica, Gmelina arborea*, *Dillenia indica* and *Azadirachta indica*. Highest basal area was observed in *S. robusta* followed by *D. melanoxylon,*

A. cordifolia, *T. catappa* and *P. emblica* whereas the lowest basal area was observed in *M. indica*. Among the saplings, *S. robusta* showed highest IVI (110.66) followed by *D. melanoxylon* (40.29) and *A. cordifolia* (24.19). However, *M. indica* showed lowest IVI (4.27) followed by *G. arborea* (4.61) and *D. indica* (4.61).

In the site II, a total of 1240 saplings ha^{-1} representing 16 species and 13 families were enumerated with 5.42 m^2 ha^{-1} basal area. Dipterocarpaceae showed the maximum 460 individuals followed by Ebenaceae (180), Anacardiaceae (150) and Dilleniaceae (90). Basal area and density of individual species varied from 0.06 to 2.11 m^2 ha^{-1} and 10 to 460 stems ha^{-1}, respectively. *S. robusta* showed the highest sapling density followed by *D. melanoxylon* and *T. catappa* whereas the lowest density was recorded in *Aegle marmelos* and *Azadirachta indica*. Basal area followed the similar trend of sapling density. The maximum IVI (94.30) was recorded in *S. robusta* followed by *D. melanoxylon* (47.96) and *T. catappa* (29.97) whereas, the lowest IVI (4.23) was recorded in both *A. marmelos* and *A. indica* followed by *B. variegate* (4.73) and *M. indica* (5.76).

Seedling layer

In the site I, a total of 45500 seedlings ha^{-1} representing 14 species and 12 families were enumerated with basal area of 3.88 m^2 ha^{-1}. Dipterocarpaceae represented the maximum 28000 individuals followed by Ebenaceae (5500) and Phyllanthaceae (2500). Basal area and seedling density of individual species (Table 3) varied from 0.015 to 1.7 m^2 ha^{-1} and 500 to 28000 seedlings ha^{-1}, respectively. *S. robusta* showed the highest density followed by *D. melanoxylon* and *P. emblica* whereas, the lowest density was recorded in *L. acidissima, B. retusa*, *Wrightia antidysenterica* and *D. indica*. The basal area followed the similar trend that of seedling density. *S. robusta* showed highest IVI (134.01) followed by *D. melanoxylon* (56.47) and *P. emblica* (19.40) whereas the lowest IVI (4.35) was recorded in *D. indica* followed by *Alstonia scholaris* (5.54) and *A. cordifolia* (5.97).

In the site II, a total of 56500 seedlings ha^{-1} representing 14 species and 12 families were enumerated with basal area of 3.78 m^2 ha^{-1}. Dipterocarpaceae represented the maximum 32750 individuals followed by Ebenaceae (7000), Lythraceae (5500) and Sapindaceae (2500). Basal area and density of individual species varied from 0.01 to 1.8 m^2 ha^{-1} and 500 to 32750 stems ha^{-1}, respectively. *S. robusta* showed the highest seedling density followed by *D. melanoxylon* and *L. parviflora*, respectively. However the lowest density was recorded in *L. acidissima, Millettia pinnata* and *Samanea saman*. Highest basal area was observed in *S. robusta* followed by *D. melan*oxylon, *L. parviflora* and *L. acidissima* whereas *A. scholaris* showed the lowest basal area. Overall, *S. robusta* showed highest IVI (135.88) followed by *D. melanoxylon* (48.44) and *L. parviflora* (27.12) and *A. scholaris* showed lowest IVI (4.74) followed by *M. pinnata* (5.15) and *M. indica* (5.96).

Species diversity

Maximum diversity as found in saplings layer with Shannon index ranged from 3.07-3.08 followed by trees (2.43-2.97) and seedlings (2.21-2.26); this indicates a spindle shaped stand structure where the future seedling population was less diverse than the upcoming sapling population which had more diversity than present tree population. The concentration of dominance were found highest in seedlings layer (0.37- 0.4) followed by trees (0.24- 0.33) and saplings (0.19- 0.21). Highest equitability was found in sapling layer with equitability 1.0 followed by trees (0.92-0.99) and seedlings (0.84-0.86) that showed the plants were more evenaged in all the layers. The species richness was found highest in sapling layer (2.11-2.43) followed by trees (1.79-2.53) and seedlings (1.19-1.21) that indicated poor species richness and dominance of single species and also showed the post-succession nature of the forest.

DISCUSSION

The tree basal area is a key factor for determination of the growth of the strata. The tree basal area cover varied from 35.97 to 48.01 m^2 ha^{-1}, which provided similar results with Sal dominating tropical deciduous forest (Raj 2019) and other tropical forest (Mishra *et al*. 2018). The sapling and seedling basal area cover varied from 4.67 to 5.42 m^2 ha^{-1} and 3.78 to 3.88 m^2 ha^{-1}, which showed similar results as compared to

the areas under Achanakmar- Amarkantak biosphere reserve (Yadav 2016). The tree density in the present study varied from 1430 to 1810 ha^{-1}.The sapling and seedling density in the present study varied from 1080 to 1240 and 45500 to 56500 stems ha^{-1}, respectively which was higher than the dry tropics as reported by Pawar *et al*. (2014). The present study showed increasing density and decreasing basal area as compared to Kumar and Saikia (2020). The enhancement in stem density may be due to strong social security and enforcement of forest policies whereas the decline in basal area may be due to lack of silvicultural management, insect attack, extraction of dammar and small timbers. *S. robusta* is the most dominant species in all the three layers i.e. tree, sapling and seedling with highest IVI of 122.21-149.77, 94.3-110.66, 134.01-135.88 respectively; which supported with the IVI in Sal dominating forest of Ranchi as described by Kumar and Saikia (2020) and Raj (2019). The study area falls under Northern dry Sal bearing forests 5 B/ C1 type (Champion and Seth 1968) that may be one of the reasons for domination of *S. robusta* in this region. The vegetational composition of tropical dry deciduous forest of Ranchi was compared with other forest in Table 4.

The study clearly indicated that species viz. *B. variegate*, *G. arborea*, *T. catappa* and *T. tomentosa* were present in both tree and sapling layer whereas absence in the seedling layer. In other hand, *W. antidysenterica* was present in both sapling and seedling stage that indicated the suitability of site quality towards the species growth and establishment and species viz. *M. indica* was present in both tree and seedling stage that indicate poor regeneration and anthropogenic pressure in past few years. Similarly, species viz. *T. arjuna* and *B. ceiba* were present in tree layer that may be due to the poor regeneration and heavily grazing value, *A. marmelos* found in sapling layer and *A. scholaris* and *S. saman* were present in seedling layer that indicate recent introduction of species to the area via plantation and animal movement. All the diversity data were compared with the other forest areas are presented in the Table 5. The comparison indicates the higher diversity in the inferior species, high concentration dominance of the dominant species, more evenness among the dominant species and abundant species richness compare to other forest areas.

The tropical forest of this area witnesses the abundant natural regeneration of Sal and other species as reflected in the seedling layer but immense anthropogenic stress such as grazing and dammar tapping leads to decrease the plant number in the sapling layer. However, the social security acts as a positive factor to enhance the tree population. Moreover there is a need for ideal silvicultural operations and scientific approach-based management practice to retain the diversity ultimately a healthy forest ecosystem. Ecological restoration may provide better growth, especially in terms of basal area and overall plant growth.

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