

## Population structure and regeneration status of selected tree species in eight tropical dry deciduous forests of West Bengal, India

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### Abstract

Present study analyzed the population structure and regeneration status of nine selected tree species in eight tropical dry deciduous forest of in the lateritic zone of West Bengal. All the selected species were not recorded from the eight sites. Highest number of species was recorded at Ballavpur (8) and lowest at Garh Joypur (1). The overall structure of the eight forests comprises of 15.82% seedlings, 59.35% saplings and 24.82% adult trees. The highest percentage (61.02%) of trees within a site was found at Garh Joypur forest and the lowest (10.78%) at Ganpur forest. Seedling, sapling and tree densities of different species differed significantly with sites. Regeneration was better at the Ganpur forest with its high density of seedlings (3290/ ha) and saplings (15900/ha). The forests were dominated by small sized trees in all the eight sites and exhibited reverse J shaped diameter density distribution.

**Keywords:** Diameter class, dry deciduous forest, Friedman test, regeneration status, seedlings, saplings

### Introduction

Tropical forests are regarded as world's most diversity rich ecosystem (Sanders, 2006) <sup>[1]</sup>. They cover even less than 10% of the total land area and harbour nearly 50-90% of the known terrestrial plant and animal species (Seppala *et al* 2009, FAO 2010) <sup>[2, 3]</sup>, provide most of the forest ecosystem services (MEA 2005) <sup>[4]</sup>. The structure, composition and functioning of these dry forests undergo changes with the length of wet period, amount of rainfall, latitude, longitude and altitude (Uma Shankar 2001) <sup>[5]</sup>. Waeber *et al.* (2012) <sup>[6]</sup> stated that up to 60% of Indian forests are comprised of dry forests and 38.2% are tropical dry deciduous forests (Anonymous 2009; Blackie *et al.* 2014) <sup>[7, 8]</sup>. Tropical dry deciduous forests are rich in economically important species. Dry deciduous forests are known to provide high potential timber revenue (Mahapatra and Tewari, 2005) <sup>[9]</sup> and provide many goods and ecosystem services (Li *et al.* 2003; Wang 2003; Armentaras *et al.* 2009) <sup>[10, 11, 12]</sup>, although they are exposed to a range of threats, mainly from human disturbances (Yosi *et al.* 2011; Baithalu *et al.* 2013) <sup>[13, 14]</sup>. Due to increasing anthropogenic and deforestation activities tropical forest cover has been decreasing globally (Lewis 2006; Kobayashi 2007; Eraldo *et al.* 2010; Chow *et al.* 2013) <sup>[15, 16, 17, 18]</sup>. Campbell *et al.* (2017) <sup>[19]</sup> found that disturbances directly cause loss of tree cover and subsequently affect other life forms, reducing overall forest species diversity.

Regeneration is the process by which trees and forests survive over time. Knowledge of the ecological requirements at seed and seedling stages may be useful for structuring the conservation and restoration processes. Extensive field-based knowledge at species and community levels are also needed (Khurana and Singh, 2001) <sup>[20]</sup>. Successful natural regeneration is an important step toward achieving long term forest stability (Saikia and Khan 2013; Malik and Bhat 2016) <sup>[21, 22]</sup>. The knowledge of seed germination and seedling establishment is also required for

the success of efforts on augmentation, introduction, and re-introduction of species populations in restoration efforts (Khurana and Singh, 2001) <sup>[20]</sup>.

In India the natural regeneration of tree species have been evaluated in the Vindhyan dry tropical forest of Sonbhadra district in Uttar Pradesh (Sagar and Singh, 2006) <sup>[23]</sup>, tropical dry deciduous forest of Eastern Ghats (Sahu *et al.*, 2012) <sup>[24]</sup>, tropical wet evergreen forest of Arunachal Pradesh (Bhuyan *et al.*, 2003) <sup>[25]</sup>, sub-tropical forest of Alaknanda Valley, Garhwal Himalaya (Ballabha *et. al.*, 2013) <sup>[26]</sup>, the forest of Kumayun Himalayas (Saxena and Singh, 1984) <sup>[27]</sup> and degraded Sal forests in north-eastern U.P. (Pandey and Shukla, 2001) <sup>[28]</sup>. A few studies documented vegetation structure of the dry deciduous forests in lateritic zone of West Bengal (Gupta Joshi, 2012; Pradhan and Rahaman 2015) <sup>[29, 30]</sup>. However barring a preliminary work on *Shorea robusta* (Nag and Gupta Joshi, 2014) <sup>[31]</sup> studies on population structure and regeneration status of dry forest species are lacking. Hence the present study was undertaken to analyse the natural regeneration status of selected dry deciduous forest species in lateritic zone.

### Materials and Methods

#### Study area

The present study was conducted in eight dry deciduous forests in the lateritic zone of West Bengal- Ballavpur wildlife sanctuary (WLS) situated in the Birbhum district (23°39'25"N to 87°41'39"E); Garhjungle forest, situated in the Burdwan district (23°40'54.4"N to 87°40'20.2"E); Aduriya beat forest- a natural forest present in Burdwan district of West Bengal (23°34'30.20"N to 23°32'38.09"N and 87°31'44.88"E to 87°34'20.88"E); Illambazar forest- a natural disturbed forest present in the Birbhum district of West Bengal (23°36'58.01" N to 23°38'46.93" N and 87°32'58.06" E to 87°36'04.14" E); Ganpur is a natural forest present in Birbhum district of West Bengal

(23°34'45"N to 24°04'12"N and 87°32'20" E to 87°39'96"E); Garh Joypur is a natural forest with some planted area present in Purulia district of West Bengal (23°24'87"N to 24°03'64"N and 86°09'61" E to 87°38'77"E); Murguma forest is present in the hilly range of Ayodhya mountain in Purulia district of West Bengal (23°17'51.44"N to 23°19'12.69"N and 86°02'6.50" E to 86°04'0.70" E) and Garh Panchakot is the forest area of Panchet hills situated in the Purulia district of West Bengal (23°36'23.78" N to 23°38'42.01" N and 86°44'30.20" E to 86°47'10.51" E). The annual rainfall is around 150-200 mm between the months of June and September.

### Data collection and analysis

Total nine tree species were selected after consulting the literature and forest officials of Ballavpur WLS. To assess the population structure and regeneration status, quadrats of 10 x 10 m<sup>2</sup> were laid randomly (Misra, 1968) [32]. Total 94 quadrats (10 each in Illambazar, Aduriya, Ganpur, Garh Joypur; 12 each in Ballavpur and Garhjungle; 15 each in Murguma and Garh Panchakot) were laid approximately 100m apart from one another. The latitude and longitude of each quadrat was noted using a Geological Positioning System (GPS). In each quadrat the number and diameter at breast height (dbh) or girth at breast height (gbh) of all the trees (individuals having dbh ≥ 1cm; Sukumar *et al.* 1992) [33] were recorded. Plants with dbh less than 1cm were considered as seedling (upto 20cm height) or sapling (>20cm height), and their number and height were recorded. Total number of plants in a quadrat represented density per quadrat which was finally expressed as number per hectare (N/ha). Basal area (m<sup>2</sup>) was calculated from dbh as:

$$\text{Basal area (m}^2\text{)} = \pi \times \text{dbh}^2 \div 4 \times 10000 = 0.00007854 \times \text{dbh}^2$$

Basal area of a quadrat was estimated by summing the individual basal areas in the quadrat. The result was finally expressed as m<sup>2</sup>/ha. Mean density and mean basal area of a site were estimated by averaging the values of density and basal area of all the quadrats in that site, respectively. The trees were divided into different dbh classes, and distribution of density (N/ha) and basal area (m<sup>2</sup>/ha) in different diameter classes was done to check the population

status. For assessing regeneration, following definitions (Shankar, 2001) [5] were used-  
 Number of seedlings > number of saplings > number of trees- good regeneration;  
 Number of seedlings > or ≤ number of saplings ≤ number of trees- fair regeneration;  
 No seedling, only sapling- poor regeneration;  
 Only adult trees- no regeneration;  
 Only seedlings/saplings- not abundant.

The seedling, sapling and tree data had non-normal distribution (Shapiro-Wilk p<0.05) in the present study. So non-parametric Friedman test was done to determine if seedling, sapling and tree densities of the nine species differ significantly in the eight sites. Multiple pairwise comparisons using Nemenyi's procedure was done to identify which pairs of species are different. The statistical tests were done in XLSTAT2016.

## Results and Discussion

### Population and regeneration status

The regeneration status of the selected tree species showed difference in the seedling and sapling demography among the eight study sites. All the selected species were not recorded from the eight sites. The overall structure of the eight forests comprised of 15.82% seedlings, 59.35% saplings and 24.82% adult trees. The highest percentage (61.02%) of trees within a site was found at Garh Joypur forest and the lowest (10.78%) at Ganpur forest. The highest sapling percentage (73.91%) was observed at Ganpur forest and the lowest (31.90%) at Garh Joypur forest, while the maximum seedling percentage (25.88%) was recorded at Ballavpur WLS and the minimum (7.06%) at Garh Joypur forest (Fig. 1).

Regeneration was better at the Ganpur forest with its high seedling density (3290/ ha) and saplings (15900/ha), followed by Aduriya forest where the number of seedlings was 2780/ha and the number of saplings 9720/ha, while the smallest number of seedlings as found at Garh Panchakot (260/ha) and saplings (940/ha). Presence of sufficient number of seedlings, saplings and young trees in a given population indicate successful regeneration (Pokhriyal *et al.*, 2010) [34] and the number of seedling of any species can be considered as the regeneration potential of that species (Negi and Nautiyal, 2005) [35].

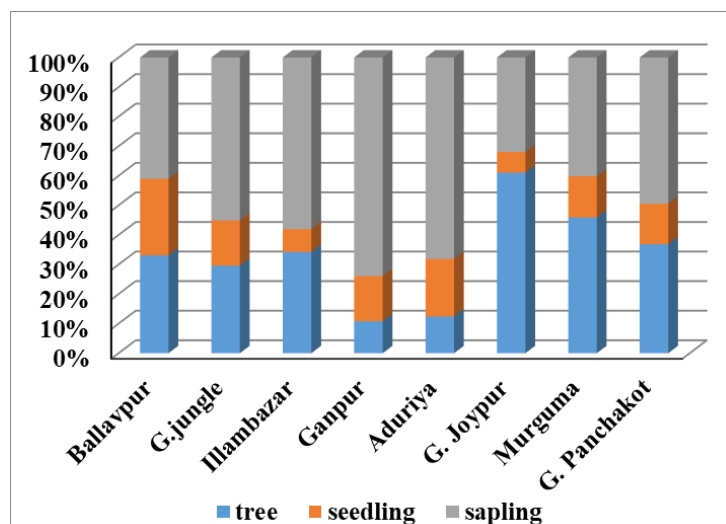


Fig 1: Seedling sapling and tree percentage at different sites

**Table 1:** Seedling, sapling and tree densities at various sites (N/ha)

Tree species	Density of seedlings, saplings and trees (N/ha)																							
	Ballavpur			Garhjungle			Illambazar			Ganpur			Aduriya			Garh Joypur			Murguma			Garh Panchakot		
	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr	Sd	Sp	Tr
<i>Shorea robusta</i> Gaertn.	1016.7	1975	1425	700	3391.6	2233.3	240	2480	1540	840	8680	1600	1870	4570	1330	nil	nil	nil	226.7	700	720.1	113.3	553.4	186.7
<i>Buchanania lanzan</i> Spreng.	283.3	116.6	50	141.7	1433.2	550	50	960	510	170	3700	60	480	3090	150	nil	nil	nil	33.3	320	300	0	200	66.8
<i>Pterocarpus marsupium</i> Roxb.	33.3	16.7	100	8.3	24.9	25	nil	nil	20	300	230	30	10	100	180	nil	nil	nil	nil	nil	nil	nil	nil	nil
<i>Madhuca longifolia</i> var. <i>latifolia</i> (Roxb.) A.Chev.	166.7	74.9	83.3	766.7	908.3	325	320	1170	650	1980	3290	630	420	1960	110	nil	nil	nil	113.3	86.7	86.4	73.3	86.7	126.6
<i>Butea monosperma</i> (Lam.) Taub.	nil	8.3	75	nil	83.3	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	330	1490	2850	13.3	6.7	13.4	53.3	140.1	93.5
<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight & Arn.	266.7	558.3	316.7	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	20	nil	119.9
<i>Terminalia bellirica</i> (Gaertn.) Roxb.	nil	8.3	183.4	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	20.1	nil	26.7	73.4
<i>Phyllanthus emblica</i> L.	nil	41.6	25	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
<i>Gmelina arborea</i> Roxb.	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	33.5

At Ballavpur WLS, eight out of nine selected species were found. Out of them two species viz., *Buchanania lanzan* and *Madhuca longifolia* var. *latifolia* showed good regeneration as density of seedlings was higher than that of saplings and trees. *Shorea robusta* and *Terminalia arjuna* showed fair regeneration because of the higher number of plants concentrated at sapling stage. The remaining four species, *Pterocarpus marsupium*, *Butea monosperma*, *Terminalia bellirica* and *Phyllanthus emblica* showed poor regeneration. *Gmelina arborea* was not found in any stage.

At Garh jungle forest out of nine species only five were recorded. Among them *Shorea robusta* and *Madhuca longifolia* var. *latifolia* showed fair regeneration. Whereas, *Butea monosperma* was found in sapling stage only and showed poorest regeneration among all.

At Illambazar forest, only four species were found. Among them *Shorea robusta*, *Buchanania lanzan* and *Madhuca longifolia* var. *latifolia* showed fair regeneration. While no regeneration of *Pterocarpus marsupium* was recorded. It might be due to human interference at the study site.

At Ganpur forest, only four selected species were found. Among them only *Pterocarpus marsupium* showed good regeneration. Other three, *Shorea robusta*, *Buchanania lanzan* and *Madhuca longifolia* var. *latifolia* showed fair to poor regeneration.

At Aduriya forest, *Shorea robusta*, *Buchanania lanzan*, *Madhuca longifolia* var. *latifolia* and *Pterocarpus marsupium* were found and all of them showed fair regeneration.

At Garh Joypur forest, the vegetation was dominated by *Butea monosperma*. It is the only forest from where no other selected tree species was recorded. The regeneration was fair. Number of trees were more than the number of

seedlings at this site, may be due to poor survival rate of seedlings.

At Murguma forest, total five selected species were found out of nine. *Madhuca longifolia* var. *latifolia* showed good regeneration. *Shorea robusta*, *Buchanania lanzan* and *Butea monosperma* showed fair regeneration. *Terminalia bellirica* showed poor regeneration because only trees were present. Absence of seedlings or saplings may be due to poor germination rate of seeds.

At Garh panchakot forest, out of nine selected, seven species were found. *Shorea robusta*, *Madhuca longifolia* var. *latifolia*, *Butea monosperma* and *Terminalia Arjuna* showed fair regeneration. *Buchanania lanzan*, *Terminalia bellirica* showed poor regeneration as most of the plants were in tree form and very little seedlings or saplings were found. *Gmelina arborea* showed no regeneration. Those species which have nearly equal number of representatives at each of the three life stages are expected to remain dominant in the near future (Bhuyan *et al.*, 2003) [25].

Only two species *Shorea robusta* and *Madhuca longifolia* were always recorded with seedlings, saplings and trees. *Butea monosperma*, *Terminalia bellirica* and *Phyllanthus emblica* of Ballavpur WLS, *Pterocarpus marsupium* of Illambazar forest, *Terminalia bellirica* of Murguma and Garh panchakot forest, *Buchanania lanzan* and *Gmelina arborea* of Garh panchakot were without seedlings. Tree seedling recruitment is either limited by low or uncertain seed supply and establishment, or limited by lack of suitable micro-sites and factors that affect early seedling growth and mortality (Clark *et al.*, 1999) [36]. Saplings of *Pterocarpus marsupium* at Illambazar forest, *Terminalia bellirica* at Murguma, *Terminalia arjuna* and *Gmelina arborea* at Garh panchakot were absent in the study area. High mortality of

seedlings may be a possible reason for low recruitment of saplings of these tree species and may decline further in the future (Ballabha *et al.*, 2013) [26]. Sagar and Singh (2005) [37] found that saplings were not successfully converting into adult trees in their study sites. Regeneration of tree species is affected by fire (Murthy *et al.* 2002) [38], grazing, light, canopy density, soil moisture, soil nutrients and anthropogenic pressure (Cierjacks and Hensen 2004, Shrestha *et al.* 2007, Sagar and Singh 2005, Mishra *et al.* 2004) [39, 40, 37, 41]. The presence of good regeneration potential shows the suitability of a species to a given environment (Dhaukhandi *et al.* 2008) [42]. But when the forest areas are in abundance of only adults and the absence or low population of seedlings and saplings, they are expected to face local extinction in future (Dalling *et al.*, 1998) [43]. Species like *Terminalia bellirica*, *Phyllanthus emblica* and *Gmelina arborea* had either no or a very small

number of seedlings or saplings which indicates that these species have poor regeneration potential. The forests were dominated by small sized trees in all the eight sites and exhibited reverse J shaped diameter density distribution. There was a sharp decline in tree density with increase in diameter class and mature trees with high diameters were absent (Fig. 2). Decrease in tree density with increase in diameter class has been reported earlier in North-East India (Upadhaya *et al.*, 2004; Mishra *et al.*, 2005; Khumbongmayum *et al.*, 2006) [44, 45, 46] and the lateritic zone of West Bengal (Gupta Joshi, 2012; Nag and Gupta Joshi, 2014) [29, 31]. Decline in the number of individuals from lower class to higher class, indicating expanding population (Sahu *et al.*, 2012) [24] and healthy recruitment of the individuals in the site, which is also been confirmed by Rajkumar and Parathasarathy (2008) [47].

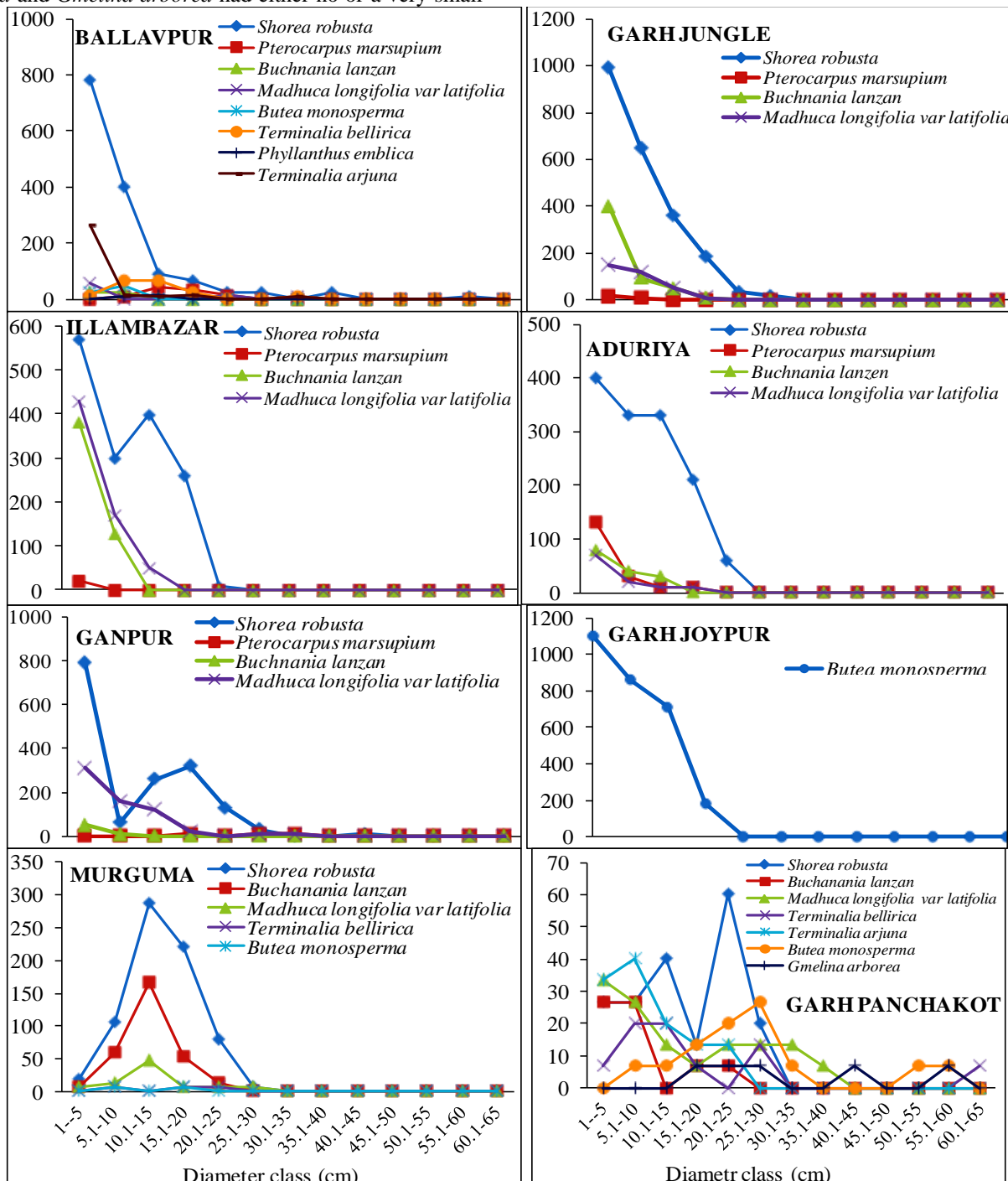


Fig 2: Density of tree species in different diameter class at study sites.

### Effect of site on population and regeneration status

The Friedman's Q statistic for seedling density (39.912), sapling density (42.358) and tree density (34.415) was significantly higher than its critical value 15.507 (degree of freedom 8,  $p < 0.0001$ ). So seedling, sapling and tree densities of the nine species differed significantly in the eight sites. Table 2 shows the multiple pairwise comparisons identifying the pairs of species which are different from

each other. Tree densities of *Phyllanthus* and *Shorea*, and *Gmelina* and *Shorea*; sapling densities of *Gmelina* and *Shorea*, *Terminalia arjuna* and *Shorea*, *Phyllanthus* and *Shorea*, *Terminalia bellirica* and *Shorea*, and *Gmelina* and *Buchanania*; and seedling density of *Terminalia bellirica* and *Shorea*, *Phyllanthus* and *Shorea*, *Gmelina* and *Shorea*, *Terminalia bellirica* and *Madhuca*, *Phyllanthus* and *Madhuca*, and *Gmelina* and *Madhuca* are different.

**Table 2:** Multiple pairwise comparisons showing groups of species

Species	Sum of ranks	Mean of ranks	Groups		
<b>Seedlings</b>					
<i>Terminalia bellirica</i>	25.500	3.188	A		
<i>Phyllanthus emblica</i>	25.500	3.188	A		
<i>Gmelina arborea</i>	25.500	3.188	A		
<i>Terminalia arjuna</i>	33.000	4.125	A	B	
<i>Butea monosperma</i>	37.000	4.625	A	B	
<i>Pterocarpus marsuoiium</i>	38.000	4.750	A	B	
<i>Buchanania lanzan</i>	50.500	6.313	A	B	
<i>Madhuca longifolia var latifolia</i>	60.500	7.563		B	
<i>Shorea robusta</i>	64.500	8.063		B	
<b>Saplings</b>					
<i>Gmelina arborea</i>	23.000	2.875	A		
<i>Terminalia bellirica</i>	27.000	3.375	A	B	
<i>Phyllanthus emblica</i>	27.000	3.375	A	B	
<i>Terminalia arjuna</i>	30.000	3.750	A	B	
<i>Pterocarpus marsuoiium</i>	34.500	4.313	A	B	C
<i>Butea monosperma</i>	40.000	5.000	A	B	C
<i>Madhuca longifolia var latifolia</i>	52.500	6.563	A	B	C
<i>Buchanania lanzan</i>	58.500	7.313		B	C
<i>Shorea robusta</i>	67.500	8.438			C
<b>Trees</b>					
<i>Phyllanthus emblica</i>	22.500	2.813	A		
<i>Gmelina arborea</i>	23.000	2.875	A		
<i>Terminalia arjuna</i>	34.000	4.250	A	B	
<i>Terminalia bellirica</i>	34.500	4.313	A	B	
<i>Butea monosperma</i>	36.000	4.500	A	B	
<i>Pterocarpus marsuoiium</i>	40.500	5.063	A	B	
<i>Buchanania lanzan</i>	48.500	6.063	A	B	
<i>Madhuca longifolia var latifolia</i>	53.500	6.688	A	B	
<i>Shorea robusta</i>	67.500	8.438		B	

Natural regeneration through seeds is often dependent upon environmental conditions during germination period and seedling establishment phase (Saikia and Khan, 2013) [21]. Cause of seedlings not coming up frequently might be that the species have produced seeds but the environment is not supporting their proper establishment. Due to large human dependence on forest resources, inadequate regeneration of the constituent species is a general phenomenon in Indian forests (Shankar, 2001) [5]. Rising anthropological pressure of human and cattle in these forests has become a serious problem for their sustainability as they are the main source of timber, fuel wood and other non-timber forest products (Rai *et al*, 2019) [48]. Thus, in forest management, it is necessary to consider how human activities and natural conditions in the environment are affecting diversity and regeneration of forests.

### Conclusions

The population status of selected tree species had highest representation by saplings followed by trees and lowest by seedlings indicating an overall fair regeneration. Small sized trees having reverse J shaped diameter density distribution dominated all the eight sites. Effect of site on population

status and regeneration of different species was significant. All the selected species were not recorded from the eight sites. Six of the selected species were without seedlings in few sites and only two species, *Shorea robusta* and *Madhuca longifolia var latifolia*, were always present in seedling, sapling and tree stage. Rising anthropogenic pressure of human and cattle need management attention to ensure the sustainable regeneration of selected tree species.

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