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FLORISTIC COMPOSITION AND REGENERATION STATUS OF *Emblica officinalis* GAERTN. IN TWO SEMI-EVERGREEN FOREST STANDS OF MANIPUR, INDIA

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KEYWORDS

Emblica officinalis

Floristic composition

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Regeneration

ABSTRACT

The present study deals with the floristic composition and regeneration status of *Emblica officinalis* Gaertn. in two forest stands viz., Laimaton & Zaujangtek of Manipur, India. Total 24 species belonging to 19 families and 23 genera at Laimaton and 21 tree species belonging to 12 families and 20 genera at Zaujangtek in the woody layer were recorded. The woody layer was dominated by *Quercus serrata* Murray in both the stands. The density of the trees was conspicuously higher (781 individuals/ha^{-1}) at Laimaton forest stand than Zaujangtek forest stand (483 individuals/ha^{-1}). Peilou's Evenness index revealed more consistency in species distribution at Zaujangtek forest stand. Shannon's Species Diversity Index showed that a relatively higher diversity (H'= 2.91364) at Laimaton forest stand than Zaujengtek stand (H'= 2.82724). The dominance diversity curve for the woody layer in both the forest stand showed normal distribution pattern of the species.

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1 Introduction

Emblica officinalis Gaertn. is an important non-timber forest product (NTFP) deciduous tree species, grows in humid tropical environment, mostly dispersed in evergreen forests and native to tropical South – Eastern Asia, Particularly Central, Southern and North eastern India (Firminger, 1947), ascending to 1450m in the Himalayas (Brandis, 1906). The medicinal properties of this species have been well reported by many authors (Bhattacharya et al., 2000; Jose et al., 2001; Nosal'ova et al., 2003; Perianayagam et al., 2004; Scartezzini et al., 2006; Yokozawa et al., 2007; Sumitra et al., 2009; Gaire & Subedi, 2014), its fruits are diuretic and laxative and useful in the disorder associated with the digestive system and are also prescribed in the treatment of jaundices and coughs (Krishnaveni & Mirunalini, 2010; Kulkarni & Ghurghure, 2018). The diverse use of this species is one of the reasons for its excessive harvest from the natural population. Anthropogenic disturbances are reported to bring changes in the overall community structure of a forest (Shafroth et al., 2002) which in turn can ultimately affect community and population dynamics. The importance of disturbances for maintaining community composition (Gross et al., 1998; Elderd, 2003) and determining population dynamics (Smith et al., 2005) has been well recognized in the tropical and extra-tropical systems.

Ngariyan hill biodiversity in Manipur, India is severely threatened by natural and anthropogenic disturbances (Sudhar Reddy, 2013; Singh et al., 2018). Over the years, the forests in the hills are under pressure through continuous extraction of timber, fuel wood, bamboo and collection of other non-timber forest products by the forest dependent people living in and around the forests. Human interferences are nevertheless critical factors which regulate the spatial and temporal pattern of vegetation in an ecosystem (Chapin et al., 1993). Determining composition, structure and function of a forest ecosystem is of great ecological value for understanding not only energy flow within the ecosystem but will also serve as an indicator of ecological impact. Forest diversity is the main income source for the people living in Ngariyan hill range, among these *E. officinalis* fruit is most commonly explored for the livelihood. Thus the level of extraction, need of the local people and other anthropogenic activities are likely to affect the floristic composition and vegetation structure of this hill range (Lalfakawma et al., 2009). Hence, an accurate data on biodiversity of this area is essential for proper management and conservation.

Although large number of studies are undertaken on the nutritional and medicinal aspects of *E. officinalis* (Nosal'ova et al. 2003; Maurya & Srivastava 2011) but information on the population structure of *E. officinalis* is not well reported (Srivasuki, 2012; Prakash et al., 2012). Besides this, the regeneration status would provide indication on future compositional change of the species to the forests. The objective of this paper were to assess the floristic composition and the regeneration status of *E. officinalis*, in two forest stands subjected to anthropogenic disturbance, in Manipur, India.

2 Materials and Methods

Present study was conducted in Ngariyan hill range of Senapati district of Manipur, India involving two forests stands located around Laimaton and Zaujangtek village (Figure 1), these two villages were subjected to anthropogenic disturbances. The forest sites for Laimaton village being mildly disturbed (disturbance index 40%) while it is highly disturbed for Zaujangtek village (disturbance index 70%), this disturbance index was calculated on the basis of the ratio of the number of cut stump to the total stump present in the site (Bhuyan et al., 2003). The woody layer was analyzed by lying transect (500 m length x 10 m width) in each site, wherein 20 permanent quadrats (10x10 m) were randomly laid for phytosociological analysis. All the individuals ≥10 cm girth at breast height (gbh) at 1.37 m from ground layer were enumerated and were taken to calculate the basal area of the tree. The phytosociological analysis was done by following standard methods given by Misra (1968) and Mueller-Dombois & Ellenberg (1974). The frequency, density and importance value index (IVI) of all observed species were calculated. Tree species diversity index (*H'*); Concentration of dominance of trees (*Cd)*; Tree species richness index (*SRI*) and evenness index (*E)* was calculated by using the formula as given below:

a) Shannon–Weiner diversity index, *H'* (Shannon & Weiner, 1963):

$$H' = -\sum_{5=1}^{s} pilnpi$$

Where, *H'* is the Shannon–Weiner diversity index, *pi* is the proportion of individuals in the i^{th} species i.e. (ni/N).

b) Simpson Index of Dominance, *Cd* (Simpson, 1949):

$$Cd = \sum_{i=0}^{n} \mathrm{p}i^2$$

Where, p_i = proportion of individual in the i^{th} species.

c) Margalef richness index, *SRI* (Margalef, 1958):

$$SRI = \frac{S-1}{ln(N)}$$

Where, *S* is the total number of species, *N* the number of individuals

d) Evenness index, E (Pielou, 1975)**:**

$$E = \frac{H'}{ln\, S}$$

Where, *H*' is the Shannon–Weiner diversity index; *S* is the total number of species.

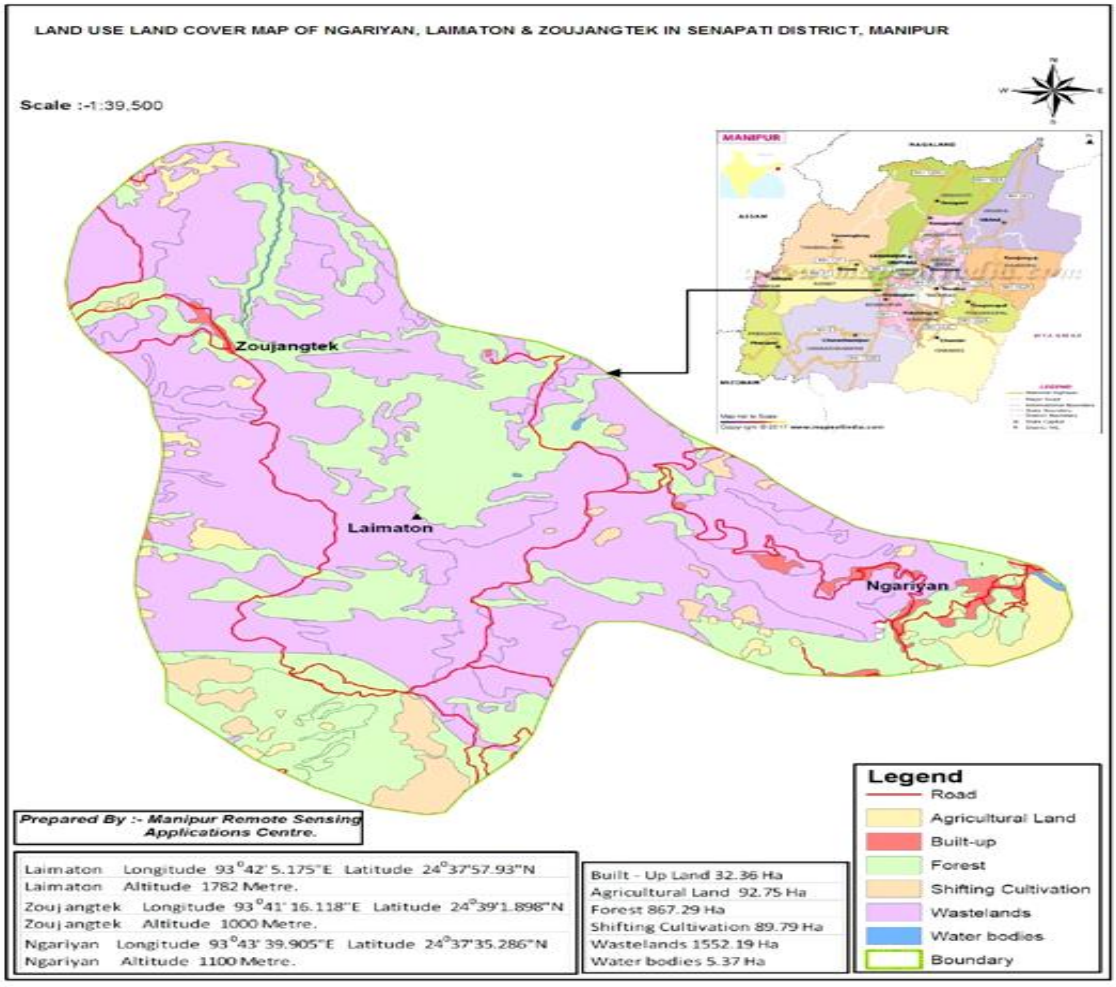

Figure 1 Map showing location of the study sites.

e) Sorensen's similarity index (Sorensen, 1948):

$$S = \frac{2C}{A + B}$$

Where, S = Sorensen's similarity coefficient; A = Number of species present in sample A; B = Number of species present in sample B; C = Number of species present in both samples

For studying the regeneration status of *E. officinalis*, 10 permanent plots of 0.1 ha (100m x 10m) homogenous to the site were selected and sampled once a year. All the individuals belonging to seedlings and saplings were counted from each plot and their density was estimated. The seedlings and saplings encountered during the survey were divided into three categories; (i) short seedlings with <10 cm height, (ii) medium seedling with >10 cm to 20 cm height and (iii) tall seedlings with >20 cm to 30 cm height. The sapling population was divided into two categories; (i) young saplings (>30.0 cm height but <10.0 cm circumference) and (ii) old saplings (>10.0cm to 30.0cm dbh). Those saplings (>30cm dbh) was considered as tree. The regeneration status of E. *officinalis* was determined based on the population size of seedlings, saplings and adults (Khan et al., 1987).

3 Results

3.1 Floristic composition of woody layer

A total of 24 species belonging to 19 families and 23 genera was reported from the Laimaton forest stand, whereas 21 tree species belonging to 12 families and 20 genera were reported from the Zaujengtek forest stand. In general, the woody layer consisted of both evergreen and deciduous broad-leaved trees, whose height did not reach beyond 25 m. The woody layer was dominated by *Quercus serrata* in both the forest stand and this was followed by *Gmelina*

arborea and *Emblica officinalis* (Table 1). Laimaton forest stand registered a higher density of tree height (782 individual's ha^{-1}) in its woody layer than Zaujengtek forest stand (483 individual's ha^{-1}) however; concentration of dominance was almost similar in both forest stands. Peilou's Evenness index reveals that Zaujengtek forest stand had slightly more consistency in species distribution (Table 2). Further, Shannon's species diversity index showed that Laimaton forest stand have relatively higher diversity (H'= 2.91364) than

Table 1 Floristic composition, basal area (m^2ha^{-1}), density (ha^{-1}), importance value index (IVI) of woody layer two forest stands of Manipur.

SPECIES	LAIMATON FOREST STAND			ZAUJANGTEK FOREST STAND		
	Basal area	Density	IVI	Basal area	Density	IVI
Aegle marmelos (L.) Correa	0.19 ±0.004	12.00	7.26	-	-	-
Albizia lebbeck (L.) Benth	0.21±0.004	18.00	8.21	-	-	-
Albizia stipulata (Roxb.) H.L Boivin	0.42±0.004	32.00	12.49	0.22±0.004	16.00	13.15
Artocarpus lakoocha Roxb.	0.19±0.003	14.00	7.09	-	-	-
Bauhinia purpurea L.	0.23±0.01	19.00	7.08	0.25±0.01	17.00	13.79
Bombax ceiba L.	0.34±0.005	15.00	9.61	-	-	-
Callicarpa arborea Roxb.	0.22±0.005	17.00	8.71	-	-	-
Castanopsis hystrix Hook. f. & Thomas ex A.DC.	0.56±0.01	49.00	16.54	0.38±0.01	33.00	17.27
*Cinnamomum tamala*Nees	-	-	-	0.19±0.005	13.00	11.99
Cinnamomum zeylanicum (Nees).	0.26±0.01	26.00	10.72	0.08±0.004	6.00	4.87
Dipterocarpus tuberculatus Roxb.	0.31±0.01	28.00	11.49	0.09 ±0.004	8.00	6.38
Emblica officinalis Gaertn.	1.29±0.02	90.00	28.89	0.59 ±0.01	42.00	26.37
Erythrina suberosa Roxb.	0.15±0.004	9.00	5.05	-	-	-
*Eucalyptus globules*Labill	-	-	-	0.10±0.01	6.00	5.22
Ficus semicordata Buch. Ham. Ex Roxb.	0.38±0.01	23.00	10.49	-	-	-
Gmelina arborea Roxb.	1.13±0.01	92.00	27.59	0.56± 0.02	37.00	23.25
Grewia microcos L.	-	-	-	0.63±0.02	37.00	23.52
Grevillea robusta A Cunn. ex R. Br.	-	-	-	0.09±0.004	4.00	4.59
Litsea polyantha Juss.	0.29±0.002	23.00	10.62	0.18 ±0.01	13.00	10.28
Michelia champaca L.	0.32±0.01	21.00	10.63	-	-	-
Parkia roxburghii G. Don	-	-	-	0.19±0.01	11.00	10.72
Pasania pachyphylla (Kurz) Schottky	0.67±0.01	54.00	17.81	0.56±0.01	38.00	24.19
Phoebe hainesiana Brandis	0.43±0.01	29.00	11.76	0.66±0.02	36.00	23.82
Pinus kesiya Royleex Gordon	0.36±0.01	31.00	12.29	-	-	-
Quercus serrata Murray	1.31±0.02	104.00	30.87	0.68±0.02	52.00	26.96
Rhus semialata Murray	-	-	-	0.27±0.01	20.00	14.77
Schima wallichii (Korth) Bloembergen (Elm.) Bloembergen	0.36±0.01	28.00	11.47	0.27±0.01	19.00	13.14
Tectona grandis L. f.	0.19±0.003	16.00	8.24	0.18±0.004	11.00	10.62
Toona ciliata M. Roem.	0.44±0.01	28.00	12.66	0.14±0.005	11.00	9.25
Zanthoxylum acanthopodium DC.	0.04±0.003	4.00	2.39	0.09±0.01	9.00	5.83

Number given after ± represent SEM

Table 2 Consolidated details on the diversity index, concentration of dominance, stand density of the trees in the woody layer of two forest stands of Manipur, India

Parameters	LAIMATON FOREST STAND	ZAUJANGTEK FOREST STAND
Number of family	19	12
Number of genera	23	20
Number of species	24	21
Density (number of trees ha^{-1})	782	483
Concentration of dominance	0.06859	0.06888
Diversity index (H')	2.91364	2.82724
Peilou's Evenness Index	0.9168	0.92863
Species richness	3.45249	3.23624

Table 3 Population structure of *E. officinalis* in two forest stands of Manipur.

Girth class (cm)	Individuals (Number ha^{-1})	
	Laimaton Forest Stand	Zaujangtek Forest Stand
0-5	83.00±13.00	69.00±3.00
5-10	19.00±1.00	17.00±2.00
10-15	14.00±1.00	7.00±0.00
15-20	18.00±1.00	10.00±1.00
20-25	10.00±1.00	7.00±0.00
25-30	22.00±2.00	16.00±1.00
>30	55.00±3.00	32.00±2.00

Number given after ± represent SEM

Zaujengtek stand (H'= 2.82724). The dominance diversity curve for the woody layer in both the forest stand showed normal distribution pattern of *E. officinalis* (Figure 2).

3.1 Population structure and regeneration status of *E. officinalis*

The girth class distribution of *E. officinalis* in both the forest stand is shown in Table 3. A higher number of individuals at each girth class were found at Laimaton forest stand than Zaujengtek forest stand. Among the girth class, the individuals having >30 cm dbh were significantly ($P<0.05$) higher at Laimaton forest stand than Zaujengtek forest stand. The population density of seedlings and saplings also varied greatly between the stands and census (Table 4, Figure 3). The short and medium seedlings were always higher ($P<0.05$) at Laimaton forest stand as compared to the Zaujengtek forest stand. Similar results were obtained in case of young and old samplings of *E. officinalis*. The number of samplings (10-30 cm gbh) too had a markedly ($P<0.05$) presence at Laimaton forest stand than Zaujengtek forest stand (Table 5). A higher proportion of seedlings were found at Zaujengtek forest stand while a reverse trend was found for the proportion of trees in this stand (Table 5).

Table 4 Population density (number ha^{-1}) of seedlings and saplings of *E. officinalis* in both forest stand of Manipur, India

REGENERATION STATUS	LAIMATON FOREST STAND		ZAUJANGTEK FOREST STAND	
	1st census (2015)	2nd census (2016)	1st census (2015)	2nd census (2016)
Seedling				
Short	98.00 ±12.09	71.00 ±10.27	65.00 ±12.22	65.00 ±20.07
Medium	35.00 ±5.82	54.00 ±6.53	34.00 ±3.06	50.00 ±4.22
Tall	16.00 ±3.39	21.00 ±2.33	14.00 ±2.67	23.00 ±3.00
Saplings				
Young	38.00 ±6.46	55.00 ±6.19	30.00 ±6.32	51.00 ±12.42
Old	80.00 ±10.85	86.00 ±10.35	46.00 ±11.18	49.00 ±9.94

Number given after ± represent SEM

Table 5 Regeneration status (number ha^{-1}) of *E. officinalis* in both the forest stands of Manipur.

	LAIMATON FOREST STAND	ZAUJANGTEK FOREST STAND	F ratio	P value (P<0.05)
Life stage of *Emblica officinalis*				
Seedling (stems < 10cm cbh) ha^{-1}	147.00 ±17.07	113.00 ±14.30	10.54**	0.004
Sapling (stems 10-30cm cbh) ha^{-1}	118.00 ±11.53	76.00 ±13.68	0.07^{NS}	0.79
Tree (stems > 30cm cbh) ha^{-1}	90.00 ±13.58	42.00 ±9.64	8.31**	0.009
Proportion to total population density(%) ha^{-1}				
Seedling	41.41%	48.92%		
Sapling	33.24%	32.90%		
Tree	25.35%	18.18%		

±SEM = Standard Error Mean, * = Significant at P < 0.05, ** = Significant at P < 0.01, ^{NS} = Not significant

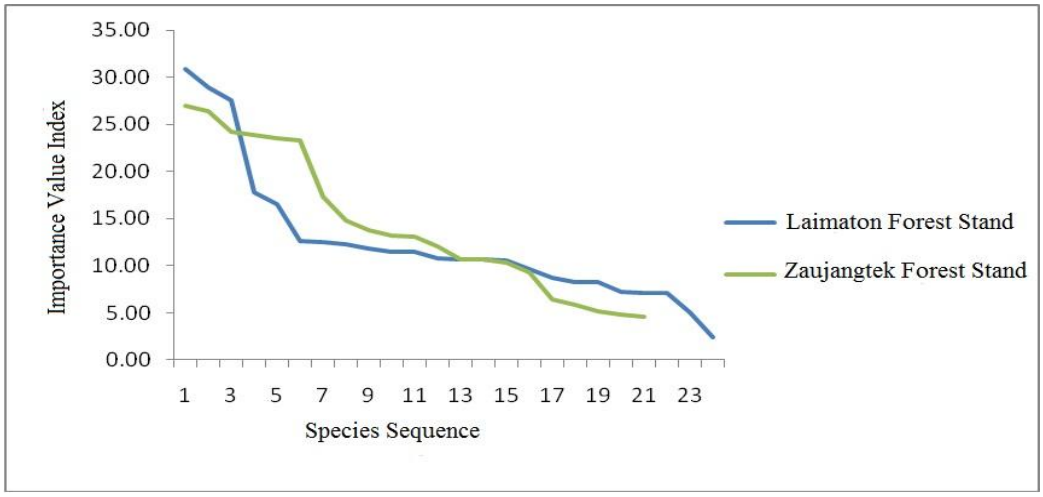

Figure 2 Dominance – diversity curve for woody layer in both the forest stands of Manipur, India

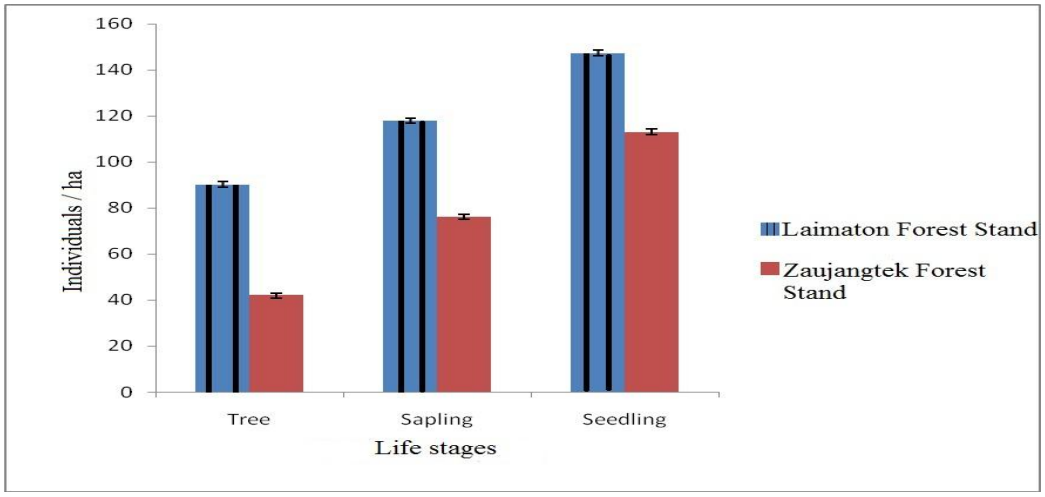

Figure 3 Mean density of tree, sapling and seedling of *E. officinalis* in both forest stand of Manipur, India

4 Discussion

The floristic compositions of both the forest stands are slightly varied. As expected the number of tree species was relatively higher at Laimaton forest stand than Zaujengtek forest stand and was related to the local disturbances that the sites received on account of felling of tree species. The role of locality factors in bringing change to community composition is well reported by various researchers (Walther et al., 2002; Parmesan & Yohe, 2003; Theoharides & Dukes, 2007; Panitsa et al., 2010; Majumdar & Datta, 2015). The anthropogenic activities cause disturbance to the site leading to creation of different niches for the establishment and onward growth of tree seedlings. The species diversity and richness had a higher tendency in Laimaton forest stand as compared to Zaujengtek forest stand. On the contrary, Pilou's evenness index was higher in the Zaujengtek forest stand as compared to the Laimaton forest stand. According to Kumar & Sahoo (2004) uncontrolled lopping and felling of trees for fuel wood, fodder forage and grazing, light conditions etc. can play prominent roles in contributing to species diversity. Tree fall gaps favours regeneration of many species enhancing species diversity (Brokaw & Busing 2000; Schnitzer et al., 2000; Schnitzer et al., 2004). The dominance diversity curve in present study followed a normal distribution pattern indicating more equitable sharing of resources within the community. The IVI value of *E. officinalis* ranged from 2.39 to 30.87 which showed good regeneration. The population density of seedling of *E. officinalis* was significantly

($P<0.05$) higher at Zaujengtek forest stand than Laimaton forest stand, obviously due to canopy opening or canopy gaps caused because of high level of tree extraction in the former. Further, exposure to sunlight and water could be important reasons for regeneration, growth and development of this species (Seng et al. 2004).

Findings on the ranges of tree density among the two forest stands (483-781 trees ha^{-1}having>30 cm dbh) are within those of estimate from other studies of tropical evergreen forest within India (294-1173 trees ha^{-1}) (Kumar et al. 2006). The density recorded in the present study was also closed to semi-evergreen forest of northeast India (685-820 trees ha^{-1} in Manipur, Devi & Yadava, 2006; 338-5452 trees ha^{-1} in Arunachal Pradesh, Bhuyan et al., 2003), Eastern Ghats (640-986 ha^{-1}, Kadavul & Parthasarathy, 1999), south west India (635 trees ha^{-1}, Pascal & Pelissier, 1996) and in Andaman evergreen forests (1137 trees ha^{-1}, Padalia et al., 2004) but were somewhat higher than the values reported by Hossain et al. (1997) 369 trees ha^{-1}, Nath et al. (1998), 381 stem ha^{-1} and Biswas & Misbahuzzaman (2008) 384 stem ha^{-1} in Bangladesh. Density of trees generally vary with forest community type, forest age, class, tree species and size class, site history, site condition and other factors. The studies carried outside India on tropical forest too showed a wide range of densities of trees > 30cm gbh ranging from 98 trees ha^{-1} in Panamanian equatorial insular forests (Itow, 1986) to 1720 trees ha-1 in Amazonian tropical rain forests (Clark & Clark, 2000; Clark et al., 2015). The tree density of present study area can compare well with that reported from other tropical forests. The Shannon-wiener values for tree species diversity in the present study ranged from 2.91364 and 2.82724 in mildly disturbed and highly disturbed respectively, which are quite high compared to 2.20-2.65 for the tropical forests of Kadayar in the Western Ghats of southern India (Sundarapandian & Swamy, 2000). The diversity index for Indian forests ranged from 0.83 to 4.1 (Singh et al., 1984) and the value of diversity index of the present study therefore lies within the range and reflects high tree diversity in the study sites.

In general, both the sites registered good regenerations of *E. officinalis* reflected from the higher proportion of young individuals (seedling and saplings) compared to the old ones (trees). Good regeneration of this species indicates that the forest microclimate in both the sites was suitable for their regeneration. The presence of almost equal number of young and middle sized dbh class of the species indicate stable nature of these populations. However, there was a tendency of higher number of individuals in the intermediate class compared to lower and higher diameter class at Zaujengtek forest stand, which implies in an imbalance population structure and require urgent attention for management.

Increased seedling and sapling density at Laimaton forest stand than Zaujengtek forest stand may be due to enhanced seed availability and suitable microclimate. Nevertheless, this small scale disturbance that this site received increased the heterogeneity of forest floor, producing a variety of microclimate that favoured this co-existance of *E. officinalis* with other tree species in this site (Lusk, 1995; Christie & Armesto, 2003), however, the proportion of seedlings and saplings decreased at Zaujengtek forest site, may be due to lack of sufficient seed availability coupled with absence of regeneration niches and safe site in this site, as also argued for other tree species (Pathak & Shukla, 2004). Zaujengtek forest stand had lower number of tree, seedling and samplings compared to Laimaton forest stand, which clearly confirm that higher disturbance caused arrested growth of the saplings or delayed their establishment. The survival of the seedlings in this forest stand was poor which meant that the seeds reaching the ground were capable of germinating but failed to convert into early sapling stage due to high light and/or changing microclimate (Bankoti et al., 1986) and biotic influences (Duchok et al., 2005). This is further confirmed from a greenhouse experiment for the species which showed higher survival of seedling under partial shade than full sunlight (Lilabati & Sahoo, 2016). The results of this study indicate that the disturbance may not only influence diversity but also regeneration and dominance of tree species. The findings of the study are therefore vital for understanding the community dynamics and for promoting species restoration programme in Ngariyan hill range of Manipur, Northeast India.

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Conflict of Interest

Authors declare that there is no conflict of interests arising from this study.

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