

Impact of Altitude on Population Structure and Regeneration Status of Two *Rhododendron* Species in a Temperate Broad Leaved Forest of Arunachal Pradesh, India

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Abstract An attempt had been made to study the impact of altitude on population structure and regeneration status of two *Rhododendron* species as well as its associated species in a temperate forest of Arunachal Pradesh. Population structure was worked out based on the density of seedlings, saplings and adults while, the regeneration status was determined from the population size of seedlings, saplings and adults. The mid altitude site (Hanuman Camp) has highest density (2692 individuals ha⁻¹) comprising of seedlings, saplings and adults of all species followed by lower altitude (Shagong) site (2379 individuals ha⁻¹) and lowest at (Yarlung) higher altitude site (2180 individuals ha⁻¹). However, the relative proportion of seedlings of all woody species was recorded highest in low altitude site, while it was lowest in higher altitude. Conversely, the relative proportion of saplings and adults were highest in higher altitude. The selected *Rhododendron* species shows reverse J shaped population structure and fair regeneration status in all study stands having higher number of seedlings compared to saplings. However, the number of saplings is less than the adults. It was observed that the seedling populations dominate the overall population of the selected *Rhododendron* species. Moreover, it was found that although altitude does not affect regeneration status, but affects the population structure of the selected *Rhododendrons*. The fluctuation in population density of seedlings, saplings and adults along the altitudinal gradient may be linked with the prevailing environmental factors.

Keywords Population Size, Biotic and Abiotic factors, Canopy, growth

1. Introduction

Population is a basic community component i.e., the population structure has a direct impact on the community structure, which in turn demonstrates the development trend of the community[1,2]. The population structure of a tree species reflects its biological and ecological characteristics [3] and it refers to the distribution of individuals in different height classes to provide the regeneration profile. Although diameter/girth at breast height (DBH/GBH) is the most commonly used size variable in the analysis of population structure, height class distribution for seedlings and saplings have also been used for the study of population structure of tree species[4-6]. The inclusion of seedlings and saplings in plant population structures would provide better information about the status of the species at early stage of

regeneration. Plants maintain and expand their populations in time and space by the process of regeneration. Population dynamics of plant species can be described by demographic variables such as the recruitment, mortality and growth rates of individuals[7] and the balance among these variables has been found to regulate the dynamics and the structure of a population[8]. Regeneration of any species is restricted to a peculiar range of habitat conditions and the extent of those conditions is a major determinant of its geographic distribution[9]. However, natural regeneration of a tree species largely depends on production and germination of seeds, establishment of seedlings and saplings[10].

The pattern of population dynamics of seedlings, saplings and adults of a plants species can exhibits the regeneration profile, which is used to determine their regeneration status[11,12]. A population with sufficient number of seedlings and saplings depicts satisfactory regeneration behaviour, while inadequate number of seedlings and saplings of the species in a forest indicates poor regeneration[13,14]. The density of seedlings and saplings are considered as regeneration potential of a species. Good and Good[15] con-

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sidered three major components for successful regeneration of a species viz., ability to initiate new seedlings, ability of seedlings and saplings to survive and ability of seedlings and saplings to grow. Moreover, plants could generally grow and survive in a limited range of environmental gradients, e.g. temperature and light availability[16] and variation in these factors play important roles in shaping the age structure and forest regeneration at different altitudes[17]. The population structure is the integrated exhibition of the status, function, development process and trends of tree species[2]. Thus, the regeneration type, dynamic process and trends of the community can be confirmed or speculated according to the characteristics of population structure[3]. Population structure studies along altitudinal gradients of a mountain would be helpful in understanding the influences of environmental factors on the regeneration of natural forests[18].

Arunachal Pradesh, by virtue of its geographical position, climatic conditions and altitudinal variations, is a biodiversity rich region in northeast India. *Rhododendrons* form the dominating species all along the cool temperate, subalpine and alpine zones in Arunachal Himalaya. About 85% of the Indian *Rhododendron* species are found in Arunachal Himalaya[19]. The *rhododendrons* in Arunachal Pradesh are also experiencing the impact of disturbance, which is resulted due to the shrinkage of green cover. This phenomenon is clearly visible in the temperate and sub alpine zones of Arunachal Himalaya, where ecosystem and the land physiography are supposed to be fragile and easily disturbed. The major threats to *rhododendrons* are large-scale deforestation of their suitable habitats and unsustainable extraction for firewood by local people[19]. Moreover, till date no detailed studies on population structure and regeneration status of *Rhododendron* species with reference to altitude particularly in Arunachal Himalaya have been carried out. Keeping this in view, an attempt had been made to assess the impact of altitude on population structure and regeneration status of two selected *Rhododendron* species (viz., *Rhododendron kenderickii* and *Rhododendron grande*) as well as its associated species in West Siang district of Arunachal Pradesh. *R. kenderickii* is reported as rare in Arunachal Himalaya[19,20] while, *R. grande* is threatened in Sikkim Himalaya[21].

2. Materials and methods

2.1. Study site

Arunachal Pradesh, the largest state in northeastern region of India forms a major part of Eastern Himalaya and is predominantly hilly and mountainous[22]. The state is also recognized as one among the 200 globally important ecoregions[23]. The *Rhododendron* forest under the present study was located in Mechuka valley in West Siang district of Arunachal Pradesh, northeast India (Figure 1). The West Siang district lies between 27°32' to 28°59' N latitude and 93°58' to 94°58' E longitude. The district is spread over 7,813 sq. km and constitutes 9.33% of the total geographi-

cal area of the state. The total forest cover of the district is 6,719 sq. km (86 % of the total geographical area), out of which very dense forest comprises of 2,478 sq. km, moderately dense forest 2,741 sq. km and open forest covers about 1,501 sq. km[24]. Mechuka falls under the Himalayan range and is characterised by rough topography with mountains, deeply incised valleys, escarpments and plateaus. Mechuka is bordered by Upper Siang district in the north-east, Upper Subansiri district in southwest, whereas the northwestern side is bordered by China. Climate of Mechuka can be characterized into four distinct seasons viz. winter with temperature below freezing point when maximum snowfall occurs, spring with little rainfall, rainy with highest rainfall and autumn with little shower. The precise age of the forest of the study area is not known due to non-availability of the forest history with the local forest department. Thick spongy humus layer covers the forest floor. The dominant species of the study area is *Rhododendron kenderickii*, *R. grande*, *Abies densa*, *Taxus wallichiana*, *Pinus wallichiana* etc. The forest is in climax stage and very old aged. The soil is coarse textured with sandy to loamy in nature and the pH ranged from 4.08 – 4.71. The organic carbon content ranged from 4.87% – 6.89% while, the total nitrogen, available phosphorus and exchangeable potassium content ranged from 0.15% – 0.25%, 0.007% – 0.01% and 0.37% – 0.43% respectively. The rock types in Mechuka can be categorised into two distinct groups namely Meta-sedimentaries and Gneisses[25].

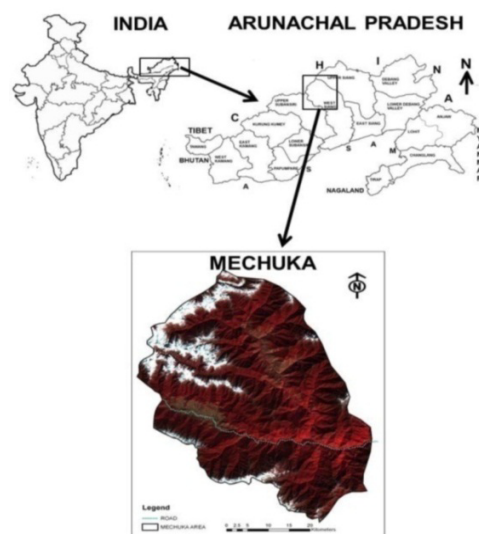


Figure 1. Map showing the study site

The forests of the study site exposed to various kinds of disturbances such as fuel wood collection, logging, clear felling, extraction of timber, fodder and other non-timber forest products by the local people. On the contrary, the area is shared with the international border to China and consequently the forests are recently being affected by the process of road construction and bunker preparation. For the present study the *Rhododendron* forest of the study site was divided

into three study stands at different altitudinal zones viz, lower study stand (1900–2100m) at Shagong, middle study stand (2100–2300m) at Hanuman camp and the upper study stand (>2300m) at Yarlung.

2.1. Methods

2.1.1. Population Structure

Population structure of all the woody species occurring in each study stands along the altitudinal gradient was studied using quadrat method. Forty quadrats of 10 m x 10 m were laid randomly in each stand. The seedlings were also recorded within the same 10 m x 10 m quadrats as they are sparsely distributed. Species were identified and densities of seedlings (≤ 50 cm in height), saplings (≤ 10 cm collar circumference at the base and > 50 cm height) and adults (≥ 10 cm girth at breast height, i.e. 1.37 m above ground level) were determined. Specimens of all species were collected and herbariums were prepared following Jain and Rao[26] and identification was done following flora references like Materials for the flora of Arunachal Pradesh, Flowers of Himalaya and Flora of Assam etc. The relative proportion of the seedlings, saplings and adults to total density of tree species in each study stand was calculated.

2.1.2. Regeneration Status

Regeneration status of species was determined based on population size of seedlings and saplings[27]: good regeneration, if seedlings $>$ saplings $>$ adults; fair regeneration, if seedlings $>$ or $\leq$ saplings $\leq$ adults; poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be $<$, $>$ or $=$ adults).

3. Results

3.1. Tree Species Composition

The number of tree species encountered from the study sites varied from stand to stand. Highest number of tree species (21) was recorded from Hanuman Camp, followed by Yarlung (19) and least number from Shagong (15). Hanuman Camp has highest density (2692 individuals ha^{-1}) of total seedlings, saplings and adults followed by Shagong (2379 individuals ha^{-1}) and lowest at Yarlung (2180 individuals ha^{-1}) (Table 1).

3.2. Population Structure

The population structure of tree species in terms of the proportion of seedlings, saplings and adults varied greatly in the three study stands (Figure 2). The relative proportion of seedlings was recorded highest in Shagong, while, it was lowest in Yarlung. On the other hand, the relative proportion of saplings and adults were highest in Yarlung followed by Hanuman Camp. The distribution of seedlings, saplings and adults along the altitudinal gradient also showed variations among species (Table 2).

Table 1. Floristic composition and density of individuals (ha^{-1}) in the three study stands

Name of species	Density (ha^{-1}) (Seedling + Sapling + Adult)		
	Shagong	Hanuman Camp	Yarlung
<i>Abies densa</i> Griff.	62	15	16
<i>Acer caesium</i> Wall. ex Brandis	—	164	—
<i>Alnus nepalensis</i> D.Don.	113	—	—
<i>Castanopsis armata</i> Roxb.	—	—	26
<i>Castanopsis tribuloides</i> (Smith) A. DC.	129	150	—
<i>Castanopsis indica</i> Roxb.	27	50	—
<i>Cinnamomum glaucescens</i> Nees.	—	—	53
<i>Cornus capitata</i> Wallich	—	30	—
<i>Eurya acuminate</i> DC.	—	—	22
<i>Eurya</i> sp.	83	139	—
<i>Grewia</i> sp.	—	—	23
<i>Illicium griffithii</i> Hook.f. & Thomson	430	439	445
<i>Leea</i> sp.	33	22	27
<i>Litsea sericea</i> (Nees) Hook. f.	184	136	166
<i>Litsea glutinosa</i> (Lour.) Rob- inson	—	38	109
<i>Litsea</i> sp.	—	—	105
<i>Lyonia ovalifolia</i> (Wall.) Drude	99	—	—
<i>Magnolia hodgsonii</i> Hook.f. & Thomson	98	47	40
<i>Persea</i> sp.	—	13	—
<i>Pinus wallichiana</i> A.B. Jacks.	139	—	18
<i>Prunus cerasoides</i> D.Don.	—	27	—
<i>Quercus lamellosa</i> Sm.	163	—	7
<i>Rhododendron arizelum</i> I. B. Balfour & Forrest	—	124	154
<i>Rhododendron grande</i> Wight	342	576	283
<i>Rhododendron kenderickii</i> Nutt.	447	420	296
<i>Rhododendron</i> sp.	—	216	334
<i>Taxus wallichiana</i> Zuccarni.	30	33	43
<i>Tsuga</i> sp.	62	13	—
Unidentified 1	—	23	—
Unidentified 2	113	17	13
Total	2379	2692	2180

The selected *Rhododendron* tree species shows good population structure in all the study stands with seedlings, saplings and adults. However, there is a variation in density (ha^{-1}) of seedlings, saplings and adults in the three study stands. *R. kenderickii* exhibits gradual decrease in density (ha^{-1}) of seedlings and adults from Shagong to Yarlung while, density (ha^{-1}) of sapling was highest in Hanuman Camp. On the other hand, *R. grande* has highest density (ha^{-1}) of seedlings, saplings and adults in Hanuman Camp followed by Shagong and Yarlung. However, sapling density (ha^{-1}) is more in Yarlung compared to Shagong (Figure 3). In spite of this variation in density of seedlings, saplings and adults, a reverse J shaped population structure was shown by both the selected *Rhododendron* species in the three respective study stands (Figure 4).

Table 3 shows the density (ha^{-1}) and basal area ($\text{m}^2 \text{ha}^{-1}$) of the selected *Rhododendron* species in the three study stands. *R. kenderickii* is the main dominant species in Shagong, while, it occurs as a co-dominant species in Yarlung. *R. grande* dominates the study stand at Hanuman Camp.

Moreover, it was found that among the three study stands *R. kenderickii* has highest density in Shagong while, lowest in Yarlung. Similarly *R. grande* has highest density in Hanuman Camp while, lowest in Yarlung.

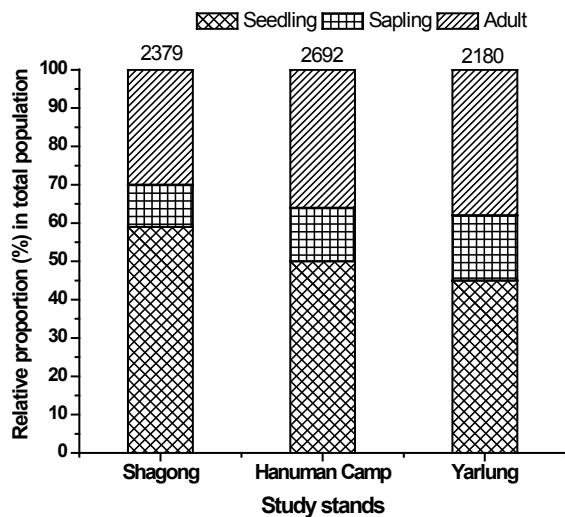


Figure 2. Population structure of tree species in the three study stands

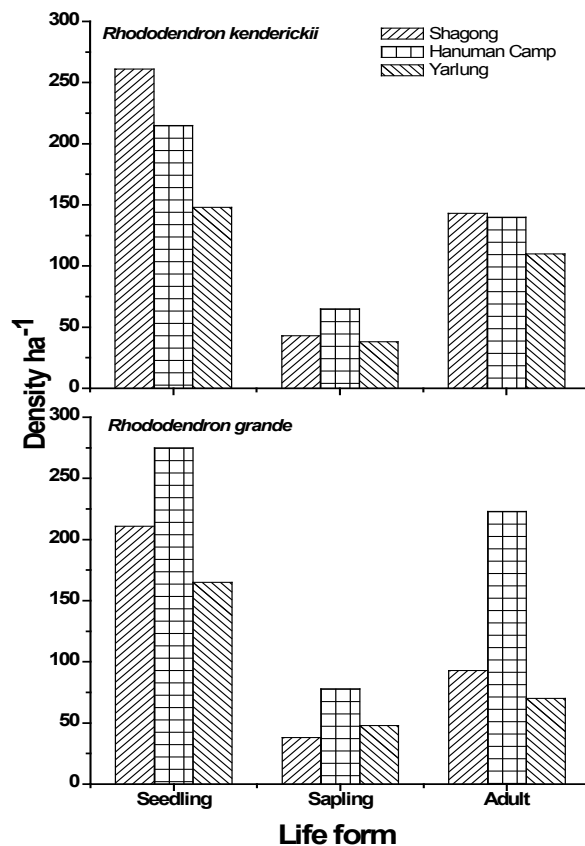


Figure 3. Variation in density (ha^{-1}) of seedlings, saplings and trees of the selected *Rhododendron* species in the three study stands

3.3. Regeneration status

Out of the 15 tree species recorded from Shagong, 67% shows fair regeneration and 6% have good regeneration, 7% poor regeneration while, remaining exhibits no regeneration.

In Hanuman Camp out of the 21 tree species recorded, 5% exhibits good regeneration, 38% fair regeneration, 26% poor regeneration and 27% no regeneration. On the other hand, out of the 19 tree species recorded in Yarlung, 5% shows good regeneration, 42% fair regeneration, 26% poor and 27% exhibits no regeneration (Figure 5).

The selected *Rhododendron* species (viz., *Rhododendron kenderickii* and *R. grande*) shows fair regeneration in all the study stands having higher number of seedlings compared to saplings. However, the number of saplings is less than the adults (Table 2).

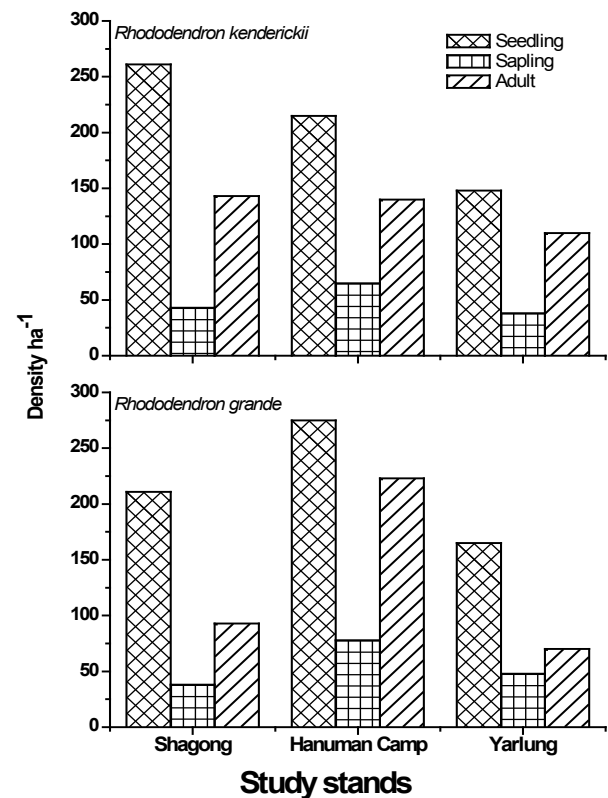


Figure 4. Population structure of the selected *Rhododendron* species at the three study stands

4. Discussion

The future community structure and regeneration status of the plant species could be predicted from the relative proportion of seedlings, saplings and adults in the total populations of various species in the forest. The overall population structure of tree species in the three study stands showed that contribution of seedlings was highest to the total population followed by adults and saplings. Variation in proportion of seedlings, saplings and adults were observed in all study stands. This differences in relative proportion of seedlings, saplings and adults among the three study stands may be due to the interactive influence of an array of biotic and abiotic factors[28]. According to Jones *et al.*[29], seedling layer in various forests differs in composition from their respective over storey.

The variation among the population size of seedlings, saplings and adults at the three study stands may be due to the variation in climatic as well as edaphic factors required by the selected *Rhododendron* species for growth and survival. Tasfeye et al.[30] also reported similar variation in seedling density among species along altitudinal gradient in dry Afromontane forest, Southern Ethiopia. Inspite of variation in density the selected *Rhododendron* species (viz., *R. kenderickii* and *R. grande*) exhibit reverse J shaped distribution in all the study stands. Paul[31] also reported similar type of distribution from temperate broad-leaved forest of rhododendrons (*R. arboreum*, *R. arboreum* ssp. *delavayi* var. *delavayi*, *R. barbatum* and *R. kesangiae*). Moreover, Miyadokoro et al.[32] from subalpine old-growth coniferous forest, central Japan reported reverse J shaped distribution. Shrestha[33] has also reported that population of *Betula utilis* both in mixed and pure forests nearly resembled a reverse J-shaped in forest trans-Himalayan dry valley in Manang (central Nepal). Wangda and Ohsawa[34] have reported that three types of population structure i.e. unimodal, sporadic and reverse-J shaped by the dominant species along the altitudinal gradient in dry valley slopes of the Bhutan Himalaya. Duan et al.[17] studied the population structure of *Larix chinensis* in Qinling Mountains (China) and reported that population structure in the low altitude transect was

closed to bell-shaped and characterized by the dominance of adult trees while, a reverse-J shape age structure was found in the mid-altitude transect. Multi-modal age distribution was found in the high altitude transect, and was caused by lack of young seedlings and saplings. Yang[35] have also reported that the main populations of Badaling forest in Beijing, China can be divided into 4 types of population structures: sporadic type (*Quercus mongolica*), reverse J type (*Tilia mandshurica* and *T. mongolica*), unibar type (*Fraxinus rhynchophylla*) and ladder type (*Betula dahurica* and *Acer mono*). Moreover, Zegeye et al.[36] studied the population structure of woody species in Tara Gedam and Abebaye forests, northwestern Ethiopia and reported that all the woody species shows a reverse J type population structure. Reverse “J” distribution is considered as an indication of stable population structure with fairly good regeneration status[37-39]. Further, it was also reported that the seedling pool of *Rhododendron simiarum* were abundant and the age structure was stable and population can stably expand in the community. It might be determined by its biological characteristics and the integrated environmental influence[40]. The population structure variations among the selected *Rhododendron* species in three study stands might be ascribed to the differences in their habitats and existing micro environmental factors[41].

Table 2. Distribution of seedlings, saplings and adults (density ha⁻¹) and regeneration status of different tree species in the three study stands

	Shagong			Status	Hanuman Camp			Status	Yarlung			Status
	SE	SA	AD		SE	SA	AD		SE	SA	AD	
<i>Abies densa</i>	45	—	17	FR	—	5	10	PR	—	3	13	PR
<i>Acer caesium</i>	—	—	—	—	124	10	30	FR	—	—	—	—
<i>Alnus nepalensis</i>	61	25	27	FR	—	—	—	—	—	—	—	—
<i>Castanopsis armata</i>	—	—	—	—	—	—	—	—	—	3	23	PR
<i>Castanopsis tribuloides</i>	79	13	37	FR	77	20	53	FR	—	—	—	—
<i>Castanopsis indica</i>	—	—	27	NR	—	3	47	PR	—	—	—	—
<i>Cinnamomum glaucescens</i>	—	—	—	—	—	—	—	—	10	13	30	FR
<i>Cornus capitata</i>	—	—	—	—	—	—	30	NR	—	—	—	—
<i>Eurya acuminate</i>	—	—	—	—	—	—	—	—	—	5	17	PR
<i>Eurya</i> sp.	46	10	27	FR	96	13	30	FR	—	—	—	—
<i>Grewia</i> sp.	—	—	—	—	—	—	—	—	—	—	23	NR
<i>Illicium griffithii</i>	279	81	70	GR	268	91	80	GR	245	110	90	GR
<i>Leea</i> sp.	—	3	30	PR	—	5	17	PR	—	—	27	NR
<i>Litsea sericea</i>	98	13	73	FR	76	20	40	FR	90	33	43	FR
<i>Litsea glutinosa</i>	—	—	—	—	—	5	33	PR	47	15	47	FR
<i>Litsea</i> sp.	—	—	—	—	—	—	—	—	62	13	30	FR
<i>Lyonia ovalifolia</i>	61	8	30	FR	—	—	—	—	—	—	—	—
<i>Magnolia hodgsonii</i>	45	3	50	FR	—	—	47	NR	—	—	40	NR
<i>Persea</i> sp.	—	—	—	—	—	3	10	PR	—	—	—	—
<i>Pinus wallichiana</i>	104	15	20	FR	—	—	—	—	—	5	13	PR
<i>Prunus cerasoides</i>	—	—	—	—	—	—	27	NR	—	—	—	—
<i>Quercus lamellosa</i>	112	18	33	FR	—	—	—	—	—	—	7	NR
<i>Rhododendron arizelum</i>	—	—	—	—	91	13	20	FR	66	28	60	FR
<i>Rhododendron grande</i>	211	38	93	FR	275	78	223	FR	165	48	70	FR
<i>Rhododendron kenderickii</i>	261	43	143	FR	215	65	140	FR	148	38	110	FR
<i>Rhododendron</i> sp.	—	—	—	—	128	38	50	FR	152	55	127	FR
<i>Taxus wallichiana</i>	—	—	30	NR	—	—	33	NR	—	3	40	PR
<i>Tsuga</i> sp.	—	—	—	—	—	—	13	NR	—	—	—	—
Unidentified 1	—	—	—	—	—	10	13	PR	—	—	—	—
Unidentified 2	—	—	—	—	—	—	17	NR	—	—	13	NR

SE= Seedling, SA= Sapling, AD= Adult, GR= Good regeneration, FR= Fair regeneration, PR= Poor regeneration, NR= No regeneration

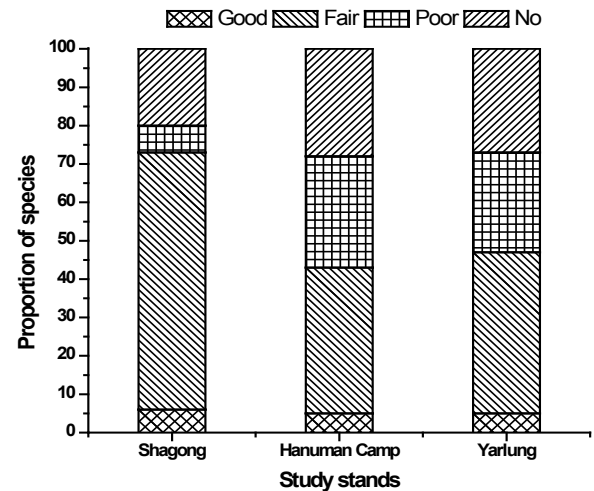
Table 3. Density of individuals (ha^{-1}) and basal area ($\text{m}^2 \text{ha}^{-1}$) of selected *Rhododendron* tree species in the three study stands

Study stands	Name of Species	Density (ha^{-1})	Basal Area ($\text{m}^2 \text{ha}^{-1}$)
Shagong	<i>Rhododendron kenderickii</i>	143	3.18
	<i>Rhododendron grande</i>	93	6.65
Hanuman Camp	<i>Rhododendron kenderickii</i>	140	2.77
	<i>Rhododendron grande</i>	223	9.19
Yarlung	<i>Rhododendron kenderickii</i>	110	3.4
	<i>Rhododendron grande</i>	70	3.5

The overall regeneration status of the tree species in the study stands exhibit fair regeneration with density of sapling population less than seedlings and adults. The seedling and sapling densities in forest understories are not stable, rather it is dynamic in nature and this dynamism may vary among various species[42]. The change in density is due to mortality, which could include abiotic stresses such as light, drought and biotic factors that include herbivory, disease or competition[43]. Successful regeneration of any type of species can only occur if the right amount of growing space becomes available for the establishment and subsequent growth of seedlings[44]. Ericaceous understory plants in general and rhododendron species in particular were shown to compete with and in some cases, totally inhibit canopy tree regeneration in temperate forest ecosystems throughout the northern hemisphere[45-48]. Shagong have the highest number of species, which shows fair regeneration. This could be due to enough solar radiation, nutrients availability etc. which help the tree species in better regeneration. Pokhreyal *et al.*[49] also reported presence of tree species with higher proportion of fair regeneration from Phakot and Pathri Rao watersheds in Garhwal Himalaya. In contrast, Tiwari *et al.*[50] have reported tree species with 81.8% good regeneration status from Garhwal Himalaya. On the other hand, Chauhan *et al.*[51] studied the regeneration and tree diversity and reported that only 32.5 % of the total 126 species shows good regeneration in natural and planted forest in Katarniaghat Wildlife Sanctuary. Zegeye *et al.*[35] also mention poor regeneration status of few species in temperate forest of north eastern Ethiopia and emphasized on conservation priorities of those species. Moreover, the variation in seedling density among species along the altitudinal gradient may be due to change in climatic condition (low temperature, rainfall and high humidity) which would restrict the distribution of some species as well as germination and establishment of seedlings[52, 53].

The selected *Rhododendron* species in all the three study stands shows fair regeneration with higher number of seedlings followed by adults and saplings. Similar kind of findings i.e. fair regeneration of rhododendrons has been reported from temperate broad-leaved forest of Arunachal Pradesh[30]. The presence of high number of seedlings of the selected rhododendrons indicates that seedlings were the main mode of regeneration. During the study, it was observed that very few *Rhododendron* seedlings were found beneath the canopy, but they are abundant in open places like steep slopes, forest margins and bank of streams. This may

be because of the reason that light is an absolute requirement for germination of *Rhododendron* seeds[54-57]. The presence of larger number of seedlings might be attributed to the establishment of microsites, which facilitates the germination of large number of *Rhododendron* seeds in open places.

**Figure 5.** Regeneration status of tree species in the three study stands

The low sapling population of the selected species in the three respective study stands in spite of the presence of high number of seedlings as well as adults may be attributed to the adverse impact of environmental factors prevalent during the sapling growth resulting into large-scale death of saplings and small trees before they reach to the canopy. Similar observation was reported by Shrestha[58] for *Quercus semecarpifolia* in the Himalayan region. Moreover, close canopy and insufficient light intensity along with thick litter layer[59] at the ground surface may reduce the establishment capacity of *Rhododendron* seedlings and saplings. Kameyama *et al.*[60] reported that growth and survival of seedlings of *Rhododendron metternichii* Sieb. et Zucc. var. *hondoense* Nakai were highly dependent on the ground conditions and the canopy cover in Mt. Kamakuraji of Hiroshima Prefecture, Japan. Moreover, in a mature forest with closed canopy, seedling establishment is constrained by lower light intensity on the ground surface. Thus, they were well represented at the adult stage but not by sapling stage, as seedlings require light environment[61,62]. Koirala[63] reported that the closed canopy in a climax *Rhododendron* forest might be the reason for low seedlings and saplings density of *Rhododendron* species.

5. Conclusions

It can be concluded that, seedling populations in all the three study stands dominate the overall population of the selected *Rhododendron* species. Moreover, it was found that although altitude does not affect regeneration status of the selected *Rhododendron* species, but affects the population structure. The fluctuation in population density of seedlings, saplings and adults along the altitudinal gradient may be

linked with the prevailing environmental factors. The selected *Rhododendron* species have fair regeneration status in all study stands as indicated by low population size of saplings compared to seedlings and adult, which may be due to close canopy as well as absence of other favorable environmental factors such as light, temperature, moisture, nutrients etc. for growth and survival.

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