

## SHRUBS AND CLIMBERS OF SINGALILA RANGE, DARJEELING (EASTERN HIMALAYAS) –AN ANALYSIS

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In the moist temperate forest of Singalila Range (Darjeeling) shrubs and climbers were studied at the elevations of 1900 m (stand 1), 2600 m (stand 2), 2800 m (stand 3) and 3000 m (stand 4). A total of 32 shrubs and 11 climbers were recorded. In the stands 1, 2, 3 and 4 there were 23, 12, 9 and 12 shrub species and 4, 6, 1 and 5 climber species respectively. The maximum shrub density was 8620 ha<sup>-1</sup> (stand 1) and minimum was 3080 ha<sup>-1</sup> (stand 3) while the same for climbers was 820 ha<sup>-1</sup> (stand 4) and 60 ha<sup>-1</sup> (stand 3) respectively. The diversity values ranged from 4.020 to 2.777 for shrubs and from 2.279 to 0 for climbers.

**Keywords :** Diversity; Himalayan temperate; Quantitative study; Stand.

### Introduction

By virtue of its position the Eastern Himalayas not only receive heavy precipitation but also because of land connection plants had migrated from many other floristic realms. This has rendered it as one of the richest botanical diversity centres of the sub-continent<sup>1</sup>. Darjeeling - an integral part of Eastern Himalayas, had been reported to harbour extremely rich and varied vegetation<sup>2</sup>. Das<sup>3</sup> had indicated that up to 18% and 11% of Darjeeling flora were comprised of shrubs and climbers respectively. Therefore it is imperative to analyse these two important plant habits since disturbances were wide spread in most of the forests all over the Himalayas<sup>4</sup>. Thus a quantitative study was carried out in the forests of Singalila Range to determine the composition and diversity of shrubs and climbers.

### Materials and Methods

The Singalila Range is located in the north-western part of Darjeeling between 26° 59' – 27° 40' N Lat. and 88° – 88° 13' E Long. It borders with Nepal and runs in the north-south direction from West Bengal to Sikkim. The study was performed at an elevation of 1800 to 3000 m above MSL and this particular tract was selected as it harboured original species composition.

The entire twelve hundred metres gradient experienced Himalayan temperate climate which was strongly influenced by monsoon. Meteorological data at 1900 m altitude (station I) showed mean monthly maximum and minimum temperatures to be 25.5°C and 1.9°C respectively. The same at 2800 m (station II) were 20°C and –0.5°C respectively. Station I and II received 2533 mm and 2736 mm of annual precipitations respectively.

After a tour of the region four distinguishable stands were identified along the gradient. Stand 1 located at 1900 m (W, SW, NW aspects) was a closed forest (*i.e.* more than 40% cover) of chestnuts and oaks while stand

2 at 2600 m (E, SE aspects) was also a closed forest but contained oaks, rhododendrons and maples. Stand 3 at 2800 m altitude (E, SE, NE aspects) was an open forest (*i.e.* 10-40% cover) of rhododendrons and conifers while stand 4 at 3000 m (W, SW aspects) was a scrubland without any tree cover. The shrubs and climbers were analysed by laying ten quadrates in each stand. The quadrates were of 25 x 4 m dimensions and this rectangular shape was found to be more appropriate than square quadrate of same size. The size and number of quadrates needed were determined in the field using the species-area curve method<sup>5</sup>. Frequency, density and abundance were calculated following Curtis and McIntosh<sup>6</sup>. The abundance to frequency ratio was used to interpret the distribution pattern of species<sup>7</sup>. By using density values similarity between stands were computed<sup>8</sup>. Species diversity, beta diversity and concentration of dominance were measured by Shannon-Wiener information function<sup>9</sup>, Whittaker<sup>10</sup> and Simpson's index<sup>11</sup> respectively.

### Results and Discussion

The forests in Singalila Range belonged to the East Himalayan moist temperate type. In the four stands, 32 shrub and 11 climber species under 18 and 9 families respectively were recorded. Out of these, 24 shrub and 8 climber species were found to be utilisable.

#### Shrub

In stand 1, 23 species of shrubs were present which gave a density of 8620 ha<sup>-1</sup>. *Strobilanthes pentastemonoides* was the dominant species and *Eupatorium adenophorum* and *Dichroa febrifuga* were the co-dominants. In the stands 2, 3 and 4 there were 12, 9 and 12 species respectively and had the densities of 4680 ha<sup>-1</sup>, 3080 ha<sup>-1</sup> and 6000 ha<sup>-1</sup> respectively. *Daphne bholua* and *Viburnum erubescens* were the dominant species of these stands (Table 1). The shrub layer in Singalila Range was thus richer than those in the Central Himalayas<sup>12</sup>. It had

been argued that poor shrub layer was due to the presence of high tree cover<sup>13</sup>. However such view did not hold good in Singalila Range because there were high tree basal covers of 48.23 m<sup>2</sup> ha<sup>-1</sup>, 63.04 m<sup>2</sup> ha<sup>-1</sup> and 30.33 m<sup>2</sup> ha<sup>-1</sup> in the stands 1, 2 and 3 respectively but none at stand 4<sup>14</sup>. In spite of this, richness and density of shrubs were maximum in stand 1 to be followed by stands 4, 2, 3. Thus showing that it was not tree cover but warmer and cooler environments that favoured shrub growth.

#### Climber

On the other hand climbers were not very numerous in Singalila Range where stands 1, 2, 3 and 4 had 4, 6, 1 and 5 species respectively and the densities were 760 ha<sup>-1</sup>, 640 ha<sup>-1</sup>, 60 ha<sup>-1</sup> and 820 ha<sup>-1</sup> respectively. *Clematis montana* and *Jasminum dispernum* were the dominants of stand 1 whereas *Kadsura heteroclita* and *Schisandra grandiflora* were the important ones in stands 2 and 4 (Table 2). The climbers therefore were rather poor in Singalila Range even though the cool-wet climate and presence of abundant support plants should have promoted their growth.

#### Distribution pattern

All the shrubs in stand 2 and most of them in stand 1 showed contagious distribution pattern while in stands 3 and 4 in addition to contagious pattern one third of the species were randomly distributed. The climber however had more random pattern in stand 4, equal proportion in stand 2 and total contagious distribution in stand 1 (Table 3). Evidently most of the shrubs and climbers in these stands were contagiously distributed which was typical of any natural forest<sup>15</sup>.

#### Similarity coefficient

The shrubs of stand 1 had low similarity coefficient values with the rest of the stands while there were much higher degree between the stands 2, 3 and 4. On the other hand climbers of stands 1-2 and stands 2-3 showed zero similarity and over all low values (Table 4). Stand 1 being located at much lower altitude than the other three stands, had different species composition and therefore few similar plants. Consequently there was either low or sometimes even zero degree of similarity with the rest. However presence of *Daphne bhoulua* and *Viburnum erubescens* in great number at the higher altitudes gave rise to higher shrub similarity in the stands 2, 3 and 4. Interestingly climber composition changed so much at each stand that some of them had no common species. It was only due to the presence of *Holboelia* and *Schisandra* in stands 2-4 that higher values were obtained.

#### Diversity

The shrub diversity values in the stands 2, 3 and 4 were similar and much less than that of stand 1. The climber diversity was maximum in stand 2, then followed by stands 4 and 1. The diversity in stand 3 was zero because of the

presence of a single species (Table 5). The diversity values in these stands of Singalila Range were found to be higher than those of Central Himalayan forests<sup>16</sup>. The noteworthy fact was the positive relation between shrub diversity and tree diversity (3.385, 3.369 and 2.917 in the stands 1, 2 and 3 respectively;  $r = +0.528$ ,  $y = 1.301 + 0.61x$   $P < 0.05$ )<sup>14</sup>. The earlier observation of Whittaker<sup>17</sup> that dominance of one stratum may affect the diversity of another stratum was thus not applicable over here. It appears that diversification of shrubs here was maximum in the relative warmer-drier (lower altitude) environments and successively went down towards cooler-wetter (higher altitude) conditions while the intermediate zone was most favourable to the climbers.

The beta diversity ( $\beta$ ) values for shrubs and climbers were 2.28 and 2.75 respectively indicating that response towards the rate of change in species composition across the gradient was greater for climbers. The  $\beta$  of shrubs in Singalila Range was lower than most Kumaun Himalayan forests suggesting that change of species were more rapid there<sup>18</sup>.

The dominance-diversity (d-d) curves had often been used to interpret community organization in terms of resource share and niche space<sup>10</sup>. Therefore the d-d curves of shrubs and climbers in these stands when drawn with respect to density values approached the Preston's log normal model<sup>19</sup> (Fig. 1). The curve for shrubs of stand 1 was flattened sigmoid type indicating high diversity. While rest of the shrub and climber curves were of intermediate sigmoid type inferring moderate diversity. These d-d curves were typical of stands with few dominants, larger number, of moderately important ones and a small amount of rare species. The greater species diversity in Singalila Range was because of the limited effect of Pleistocene glaciation in the Eastern Himalayas. Here the environment was relatively more stable in the geological past which ensured more speciation<sup>20</sup>. Besides, immigration of plants through land connections<sup>21</sup> and introduction of European and American elements also made contribution to the flora.

#### Conclusion

Darjeeling has a population density of 510 people/Km<sup>2</sup> and is among the most populous hill districts in the entire Himalayan range. When nearly two thirds of the above mentioned species are useful, it is no wonder that some of them have found mention in the Red Data book. The relative paucity of climber is attributed to the removal by authorities as it is considered as a pest - affecting the health of standing vegetation and also inhibits seedling regeneration. In spite of the apparent richness and diversity, plant conservation is essential in Singalila Range since the Eastern Himalayas is considered to be the 'cradle

**Table 1.** Frequency (F, expressed in %) and density (D, expressed in number per 100 m<sup>2</sup>) of shrubs in the four stands of Singalila Range. Family name given in parenthesis.

Species	Stand 1		Stand 2		Stand 3		Stand 4	
	F	D	F	D	F	D	F	D
<i>Aconogonum molle</i> (D. Don) Hara var. <i>molle</i> [Polygonaceae]	20	0.4	80	3.8			60	2
<i>Agapetes serpens</i> (Wt.) Sleumer [Ericaceae]	20	0.4						
<i>Berberis concinna</i> HK.f. et Thoms. [Berberidaceae]					60	2.4	60	1.6
<i>Boeninghousenia albiflora</i> (HK.) Mesn. [Rutaceae]	20	4.8						
<i>Cautleya gracilis</i> (Sm.) Dandy var. <i>gracilis</i> [Zingiberaceae]	80	3.4						
<i>Cirsium falconeri</i> (HK.f.) Petrauk. [Asteraceae]					60	1.4	60	1.6
<i>Curculigo capitulata</i> (Lour.) Kuntze [Hypoxidaceae]	20	0.2						
<i>Daphne bholua</i> Ham. Ex D. Don [Thymeliaceae]			100	9	100	9	100	14.2
<i>Daphne papyracea</i> Wall. [Thymeliaceae]	80	6						
<i>Dichroa febrifuga</i> Lour. [Hydrangeaceae]	100	8.6						
<i>Eupatorium adenophorum</i> Spreng. [Asteraceae]	60	10						
<i>Gaultheria hookerii</i> C.B.C. [Ericaceae]	60	6	20	0.6	40	3.6		
<i>Gaultheria pyrolloides</i> HK.f. et Thoms. ex Miq. [Ericaceae]							40	1.2
<i>Hypericum uralum</i> Ham. ex D. Doux [Hypericaceae]	20	3			40	3.2	20	0.4

Contd....

Table 1. Contd....

Species	Stand 1		Stand 2		Stand 3		Stand 4	
	F	D	F	D	F	D	F	D
<i>Ilex sikkimensis</i> Kurz [Aquifoliaceae]	20	1.6						
<i>Leycesteria formosa</i> Wall. [Caprifoliaceae]			20	0.6			40	1.4
<i>Neillia thyrsoiflora</i> D. Don [Rosaceae]	20	3.4						
<i>Osbeckia sikkimensis</i> Craib [Melastomataceae]	40	4.4						
<i>Rosa sericea</i> Lindl. [Rosaceae]					60	2.6	80	2.2
<i>Rubus acuminatus</i> Smith [Rosaceae]			40	2.2	60	1.6	80	6.4
<i>Rubus ellipticus</i> Smith [Rosaceae]	40	6						
<i>Rubus lineatus</i> Rinwardt [Rosaceae]	80	2.8						
<i>Rubus paniculatus</i> Smith [Rosaceae]	20	2.4						
<i>Rubus rugosus</i> Smith [Rosaceae]	40	2.4	80	5.2			40	0.6
<i>Rubus senchalensis</i> Hara [Rosaceae]			80	5.4			100	11.4
<i>Smilax rigida</i> Wall. ex Kunth [Smilacaceae]	20	0.6	20	1.6				
<i>Strobilanthes pentastemonoides</i> (Nees) T. Anders [Acanthaceae]	100	12.6	20	0.6				
<i>Urtica dioica</i> L. [Urticaceae]	40	1	40	0.6				
<i>Vaccinium vacciniaceum</i> (Roxb.) Sleumer [Vacciniaceae]	20	0.6	40	2				
<i>Viburnum erubescens</i> Wall. [Caprifoliaceae]	20	4	100	14.8	100	6.4	100	17
<i>Zanthoxylum armatum</i> DC. [Rutaceae]	20	0.6						
<i>Zanthoxylum oxyphyllum</i> Edgw. [Rutaceae]	20	2						
<b>Total</b>		<b>86.2</b>		<b>46.8</b>		<b>30.8</b>		<b>60</b>

**Table 2.** Frequency (F, expressed in %) and density (D, expressed in number per 100m<sup>2</sup>) of climbers in the four stands of Singalila Range. Family name given in parenthesis.

Species	Stand 1		Stand 2		Stand 3		Stand 4	
	F	D	F	D	F	D	F	D
<i>Aristolochia sp.</i> L. [Aristolochiaceae]			40	0.8				
<i>Cayratia pedata</i> (Lamk.) Juss. ex Gagnep. [Vitaceae]	20	0.8						
<i>Clematis montana</i> Ham. ex DC. [Ranunculaceae]	20	3.2			20	0.6	40	1.4
<i>Hedera nepalensis</i> K. Koch [Araliaceae]			40	0.6				
<i>Holboelia latifolia</i> Wall. [Lardizabalaceae]			40	1			60	1.6
<i>Jasminum dispernum</i> Wall. [Oleaceae]	20	2.4						
<i>Kadsura heteroclita</i> (Roxb.) Craib [Magnoliaceae]			60	2.4			80	1.6
<i>Schisandra grandiflora</i> (Wall.) Hk. f. et Thoms. [Schisandraceae]			40	1.4			80	3.2
<i>Tetrastigma serrulatum</i> (Roxb.) Planch. [Vitaceae]	20	1.2						
<i>Thunbergia coccinea</i> Wall. ex D. Don [Acanthaceae]			20	0.2				
<i>Thunbergia fragrans</i> Roxb. [Acanthaceae]							20	0.4
<b>Total</b>		<b>7.6</b>		<b>6.4</b>		<b>0.6</b>		<b>8.2</b>

**Table 3.** Distribution pattern of shrub and climber species in the four stands of Singalila Range. Percentage of the species is given in parenthesis.

	Stand 1			Stand 2			Stand 3			Stand 4		
	R	r	C	R	r	C	R	r	C	R	r	C
Shrub	-	2 (8.7)	21 (91.3)	-	-	12 (100)	-	3 (33.3)	6 (66.7)	-	4 (33.3)	8 (66.7)
Climber	-	-	4 (100)	-	3 (50)	3 (50)	-	-	1 (100)	-	3 (60)	2 (40)

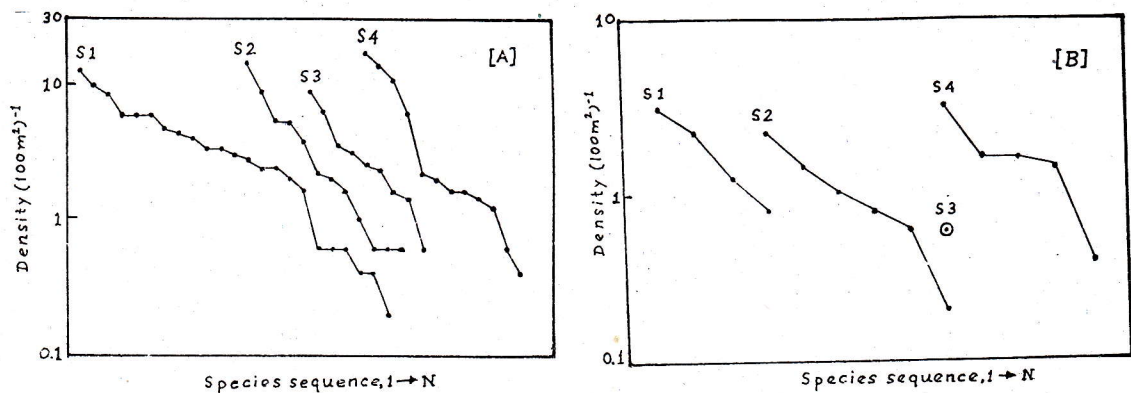
R – Regular; r – random; C – contagious

**Table 4.** Similarity coefficient of (A) shrub and (B) climber species in the four stands of Singalila Range.

Stands	(A)				Stands	(B)			
	1	2	3	4		1	2	3	4
1	100	13.835	18.120	7.387	1	100	0	14.634	17.722
2		100	46.902	64.794	2		100	0	54.795
3			100	49.780	3			100	13.636
4				100	4				100

**Table 5.** Species diversity (H) and concentration of dominance (cd) of shrubs and climbers in the four stands of Singalila Range.

	Stand 1		Stand 2		Stand 3		Stand 4	
	H	cd	H	cd	H	cd	H	cd
Shrub	4.020	0.076	2.917	0.175	2.817	0.171	2.777	0.187
Climber	1.814	0.313	2.279	0.239	0	1	2.100	0.259

**Fig.1.** Dominance - Diversity curves of (A) shrubs and (B) climbers for the four stands in Singalila Range, Darjeeling.  
Note : S1, S2, S3 and S4 denote stands 1, 2, 3 and 4 respectively.

of flowering plants<sup>22</sup>. While *Agapetes serpens* and *Rubus senchalensis* are important for being endemic species, *Kadsura heteroclita* and *Holboelia latifolia* are considered to be primitive flowering plants.

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