

## PLANT ASSOCIATION AND STRATIFICATION STUDIES IN THE FORESTS OF SINGALILA RANGE, DARJEELING

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In between 1800 and 3000 m altitudes, two forest types - Lower mixed broadleaved forests and Upper mixed broadleaved forests could be identified. The former was 'closed' forest having three association sets while the latter had 'closed' forest of three association sets and 'open' forest of two association sets. All these forests had three layer stratification. For a temperate vegetation, the density and diversity of trees, shrubs and herbs were very high and it appeared to be in the stable mid-successional stage.

**Keywords :** Broadleaved forest; Closed forest; Open forest; Plant association; Profile diagram.

### Introduction

The flora of Darjeeling have been studied by many botanical explorers<sup>1-3</sup> and through their collective effort, the richness of the region have become well known. However, the forest structures were never properly illustrated in these works and it is for this reason that a quantitative study was carried out in some of the thickly wooded hills. As a part of that endeavour, plant associations were determined and profile diagrams for the pictorial representation of cover and stratification of the forests were made. The same is presented in this paper.

### Materials and Methods

Field work was carried out in the Sirikhola catchment area of Singalila range. The latter occupies the north-western part of Darjeeling that borders with Nepal and runs along the north-south direction from West Bengal to Sikkim. Aided by topographic maps more than hundred sample plots (100 m<sup>2</sup>) were laid in between 1800 and 3000 m altitudes covering different aspects, slope angles and physiognomy. Samplings were done at every season for three consecutive years. After preparing the floristic checklist the plant associations were established on the basis of growth form, life form, periodicity, stratification, sociability-dispersion, frequency, density, cover, dominance and community coefficient<sup>4</sup>. Profile diagram was prepared according to the methods of Knight<sup>5</sup>. At each forest type a single resultant profile diagram was ultimately drawn from five randomly placed 25 x 4 m plots.

The study region experienced typical Himalayan temperate climate, which was strongly influenced by monsoon. There were three clear seasons, spring, monsoon and

winter and the annual precipitation was nearly 300 cm. The general weather was damp, cool and foggy. Soil were deep, dark, well drained, acidic sandy loam, rich in organic matters but deficient in lime.

### Results and Discussions

The forests along the entire gradient were East Himalayan Moist Temperate type - dominated by the hardwood broadleaved species. Altogether 199 species of higher plants (under 63 families) were recorded. Out of these a staggering 106 species were herbs and then there were 24, 32, 14, 11 and 12 species of trees, shrubs, grass-bamboos, climbers and epiphytes respectively. The forests were entirely 'closed' i.e. having >40% cover, though there were few 'open' (10-40% cover) patches as well above 2500m. On the basis of species composition and association, two distinct forest types could be identified.

#### I. Lower Mixed Broadleaved Forests

These were 'closed' broadleaved forest tracts in between 1800 and 2300m altitudes.

The associations observed were-

*Castanopsis purpurella* - *Quercus lamellosa*

- *Viburnum mullaha*;

*Symplocos lucida* - *Michelia doltsopa* -

*Eurya acuminata*;

*Symplocos racemosa* - *Lithocarpus pachyphylla* - *Cinnamomum impressinevrium*.

Occasionally *Tsuga dumosa* and *Cryptomeria japonica* appeared in the clearings as plantation species. Tree density and diversity were 740 ha<sup>-1</sup> and 3.4 respectively. There were many important associated shrubs like *Rubus ellipticus*, *Eupatorium adenophorum*, *Osbeckia sikkimensis*, *Dichroa febrifuga*, *Daphne papyracea*, *Cautleya gracilis* and



*Gaultheria hookerii*. Their density and diversity values were as high as  $8620 \text{ ha}^{-1}$  and 4.0 respectively.

The profile diagram (Fig. 1) of the forests in this zone showed three distinct strata. The species constituting each stratum were-

Top layer : *C. purpurella*; *Q. lamellosa*; *L. pachyphylla*; *T. dumosa*; *C. japonica*.

Middle Layer : *Spp. of Symplocos*; *M. dolisopa*; *E. acuminata*, *C. impressinervium*; *V. mullaha*.

Lower Layer : *Spp. of Rubus*; *D. papyracea*; *E. adenophorum*; *D. febrifuga*; *C. gracilis*; *O. sikkimensis*; *H. uralum*.

In these forests high density of *Symplocos*, *Eurya* and shrubs gave strong middle and lower layers and in comparison the top layer species were less numerous to form a dominant canopy cover.

## II. Upper Mixed Broadleaved Forests

The forests of this zone stretched between 2300 and 3000 m altitudes and two subtypes were recognizable.

i. 'Cosed' broadleaved forests between 2300 and 2700 m altitudes.

The association observed were-

*Lithocarpus pachyphylla* - *Rhododendron arboreum* - *Acer campbellii*;

*Betula alnoides* - *Eurya carvinervis* - *Alnus nepalensis*;

*Rhododendron grande* - *Ilex depyrena* - *Acer thomsonii*.

*Magnolia campbellii* occurred occasionally with either of these associations. Tree density and diversity were  $840 \text{ ha}^{-1}$  and 3.4 respectively. Shrubs were rather less extensives. Few important ones were *Daphne bholua*, *Viburnum erubescens*, *Rubus rugosus* and *Rubus senchalensis*. Their density and diversity were moderate  $4680 \text{ ha}^{-1}$  and 2.9 respectively.

The profile diagram (Fig. 2) of these forests also showed three distinct strata. The species comprising the stratum were-

Top layer : *L. pachyphylla*; *Spp. of Acer*; *A. nepalensis*; *M. campbellii*; *R. grande*; *B. alnoides*.

Middle layer : *E. carvinervis*; *R. arboreum*; *I. depyrena*.

Lower layer : *D. bholua*; *V. erubescens*; *Spp. of Rubus*; *Bamboo*; *A. molle*.

The forests showed remarkably strong top layer where the plants had high cover and biomass. As a result the middle and lower layers were not too distinct except at open patches.

ii. 'Open' broadleaved - coniferous forests between 2500 and 3000 m altitudes.

The associations observed were-

*Rhododendron grande* - *Magnolia campbellii*- *Symplocos lucida* - *Ilex insignis*; *Rhododendron arboreum* - *Tsuga Dumosa* - *Abies densa* - *Acer thomsonii*.

There were frequent occurrence of planted *Cryptomeria*. The tree density and diversity were  $620 \text{ ha}^{-1}$  and 2.9 respectively. Some of the common shrubs were *Berberis concinna*, *Daphne bholua*, *Viburnum erubescens*, *Hypericum uralum* and *Rosa sericea*. Their density and diversity were merely  $3080 \text{ ha}^{-1}$  and 2.8 respectively.

The forests here being 'open' did not therefore show clear stratification. At places where trees were better preserved, there appeared three strata (Fig. 3). The species comprising each stratum were-

Top layer : *A. densa*; *C. japonica*, *T. dumosa*; *M. campbellii*; *R. grande*; *A. thomsonii*.

Middle layer : *I. insignis*, *R. arboreum*; *S. lucida*.

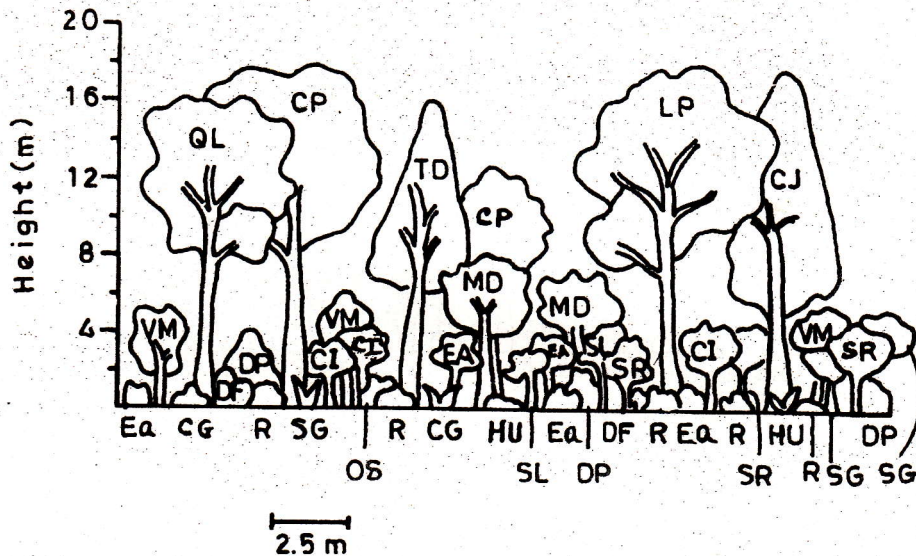
Lower Layer : *B. concinna*; *D. bholua*; *V. erubescens*, *R. sericea*; *Bamboo*; *H. uralum*.

The top and the middle layers in these forests were feeble and as a result the lower layer assumed significance.

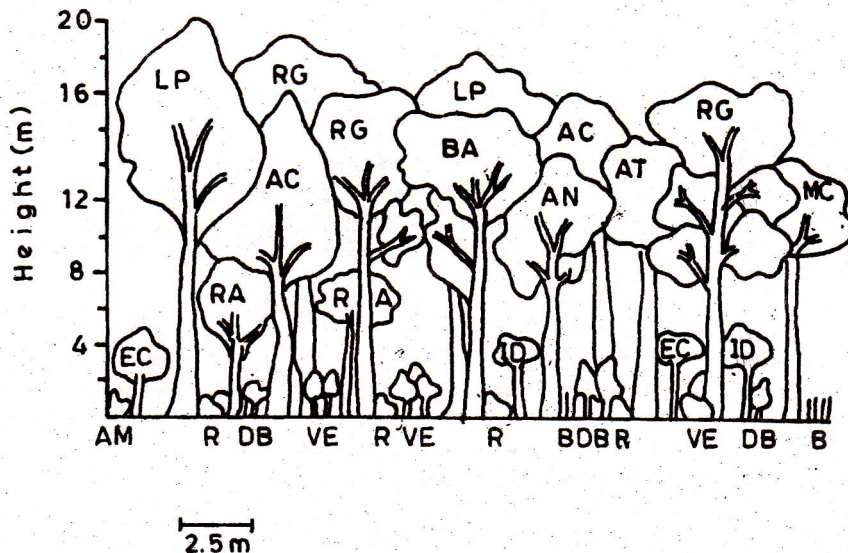
## Other plant layers

The entire region showed splendid density and diversity of the herbs and this has been a characteristic feature of the vegetation of Darjeeling<sup>6</sup>. Among the many herbs those showing preference for the Lower mixed broadleaved forests were *Anemone vitifolia*, *Erigeron karwinskianus*, *Galinsoga parviflora*, *Mazus pumilus* and *Swertia bimaculata*. Their enormous range of density and diversity over the seasons were  $51-165 \text{ m}^2$  and 3.9-4.4 respectively. On the other hand, herbs showing preference for Upper mixed broadleaved forests were *Anaphalis spp.*, *Arisaema griffithii*, *Fragaria rubiginosa*, *Meconopsis paniculata*, *Primula spp.*, *Stellaria media*, *Swertia chirayita* and *Viola pilosa*. Their

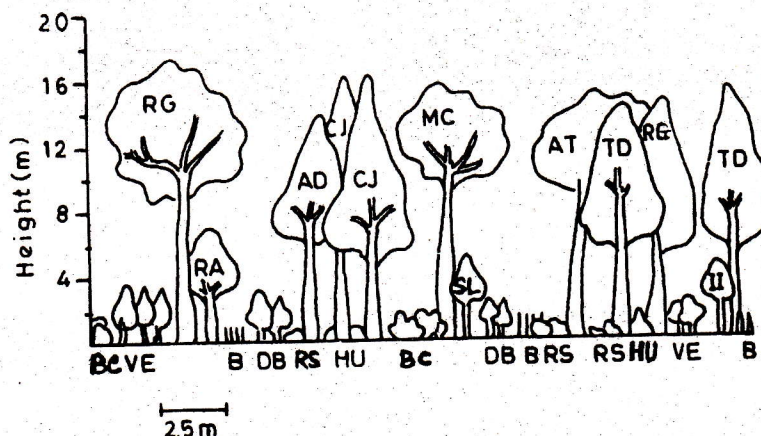




**Fig.1.** Profile diagram of the 'closed' Lower mixed broadleaved forest. Legend : CP= *Castanopsis purpurella*; C G = *Cautleya gracilis*; Cl= *Cinnamomum impressinervium*; CJ= *Cryptomeria japonica*; DP= *Daphne papyracea*; DF= *Dichroa febrifuga*; EA = *Eurya acuminata*; Ea = *Eupatorium adenophorum*; HU = *Hypericum uralum*; LP = *Lithocarpus pachyphylla*; MD = *Michelia doltsopa*, OS = *Osbeckia sikkimensis*; QL = *Quercus lamellosa*; R = *Rubus* spp.; SG = *Symplocos glomerata*; SL = *Symplocos lucida*; SR = *Symplocos racemosa*; TD = *Tsuga dumosa*; VM = *Viburnum mullaha*.



**Fig.2.** Profile diagram of the 'closed' Upper mixed broadleaved forests. Legend : AC= *Acer campbellii*; AT = *Acer thomsonii*; AM = *Aconogonum molle*; AN = *Alnus nepalensis*; B = *Bamboo*; BA = *Betula alnoides*; DB = *Daphne bholua*; EC = *Eurya carvinervis*; ID = *Ilex depyrena*; LP = *Lithocarpus pachyphylla*; MC = *Magnolia campbellii*; RA = *Rhododendron arboreum*; RG = *Rhododendron grande*; R= *Rubus* spp.; VE = *Viburnum erubescens*.



**Fig.3.** Profile diagram of the 'open' Upper mixed broadleaved forests. Legend : AD = *Abies densa*; AT = *Acer thomsonii*; B = Bamboo; BC = *Berberis concinna*; CJ = *Cryptomeria japonica*; DB = *Daphne bholua*; HU = *Hypericum uralum*; II = *Ilex insignis*; MC = *Magnolia campbellii*; RA = *Rhododendron arboreum*; RG = *Rhododendron grande*; RS = *Rosa sericea*; SL = *Symplocos lucida*; TD = *Tsuga dumosa*; VE = *Viburnum erubescens*.

range of density and diversity were equally high 60-179 m<sup>2</sup> and 3.5-4.2 respectively. Unfortunately the climbers in these forests were much disturbed due to random collection for ethno-medicinal purposes. Besides, by virtue of number of species and their density, climbers were rather insignificant. However the epiphytes were numerically very high as the huge canopy cover provided excellent habitats. The grasses (grass lands) however, did not form an important vegetational component in the hills of Darjeeling<sup>7</sup> and the occasional degraded forests lands were mainly colonized by bamboos (*Arundinaria spp.*).

### Conclusions

The study across the 1200m gradient of Singalila range depicted a very rich flora. Over 62% (125 spp.) of the recorded plants of these forests were found to be utilisable. In spite of that, the forests were mixed, dense and 'closed'. The species diversity was higher than most of the Himalayan and world temperate vegetations<sup>8,9</sup>. The mixed nature of the flora proved a mid-successional stage<sup>10</sup> and that is the time when diversity value is believed to be maximum<sup>11</sup>. Conifers in the forests were few and their numbers increased marginally with altitude<sup>12</sup>. The vegetation here was thus advanced in the successional scale and appeared to be more stable than the western Himalayas where at

the same altitude conifers dominate<sup>13</sup>.

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