*Journal of the Department of Wildlife Conservation 2006-1: 115-125*

# STRUCTURAL CHARACTERISTICS AND FLORISTIC COMPOSITION OF THE HAKGALA STRICT NATURE RESERVE AT 1800m ELEVATION

R.M.W. RATHNAYAKE*

*Department of Wildlife Conservation, Sri Lanka*

## ABSTRACT

**The woody vegetation of Hakgala Strict Nature Reserve at an altitude of 1800 m was quantitatively studied by plot sampling. Twenty two species were found to be endemic. The exotic species, *Cestrum nocturnum* was the most abundant species at this altitude. Nineteen percent (11 species) of the species identified were present at less than 10 stems per ha density, and the most dominant gbh class was 10-20 cm. Only 19% of the species (11 species) was represented by 100 or more individuals per ha. Eighty eight per cent of species (50 species) were represented by less than 5% of the basal area. Based on the relative cover values of species, *Neolitsea fuscata*, *Michelia nilagirica* and *Semecarpus coriacea* were the dominant species found in the vegetation.**

**KEY WORDS**: Floristic composition

## INTRODUCTION

Upper Montane Rain Forests (UMRF) cover the higher parts of Sri Lanka ranging from 1500 m to the highest peak Piduruthalagala (2524 m), and these forests are characterized by a peculiar floristic composition within the Indo-Malaysian region (Werner, 1982). Generally a large proportion of the angiosperm flora of Sri Lanka is endemic and commonly found in the low country wet zone and montane zone.

Hakgala Strict Nature Reserve (HSNR) is located in botanically rich UMRF ranging from 1600 m to 2178 m elevation. The environmental conditions prevailing at different elevations could affect the physiognomy and florisitic composition of the forest at respective elevation (De Rosayro, 1958).

According to Grubb *et al.* (1963), the woody species i.e. trees and shrubs of UMRF exceeding 10cm gbh (girth at breast height) could be considered as woody vegetation. Wijesundara (1991) studied the phytosociology of HSNR, and Rathnayake *et al.* (1996) a & b studied the woody vegetation of the same forest at 1600 m elevation. Before these studies, species present in the UMRF in Sri Lanka have been identified by numerous authors (Vincent (1883), Chapman (1947), Koelmeyer (1957), Nisbet (1961) & Greller & Balasubramanian (1980)).

It could be considered that HSNR is at dynamic state, and knowledge of forest structure and floristics is necessary to the study of forest dynamics, plant-animal interactions and nutrient cycling.

The Objectives of the present study was to study the forest structure in terms of distribution of stem sizes and basal area and floristics.

## MATERIALS AND METHODS

### Study site

The study was carried out at mid elevation (1800m) of Hakgala Strict Nature Reserve (HSNR) which lies 6 km southeast of Nuwara Eliya in Central and Uva provinces (latitudes being between ($6^0 53'$ – $6^0 57'$ N and longitudes being between $80^0 46'$ and $80^0 50'$E) (Green (1990)), and the well known Hakgala Botanic Garden is situated in the bottom of this reserve. HSNR covers an area of approximately 1,142 ha, and is surrounded by Madulsima range on the east, Haputale on the south, Pedro range on the northwest, Adam's Peak and Elk Plains on the west and Udapussellewa range on the North East respectively. The HSNR consists of three peaks aligned in the eastwest direction, and it is ranging from 1600 m to 2173 m elevation. Numerous streams, streamlets, steep slopes, gullies and many rocky out crops are found in the reserve.

### Floristic composition and structural characteristics

Plant specimens were collected from the woody vegetation and herbarium specimens were prepared following herbarium techniques (Mitra, 1957). They were then identified in the National Herbarium, Peradeniya and in the Hakgala Botanic Garden. The identifications were confirmed by referring to the books (Dassanayake & Fosberg (1980) & Wijesinghe (1994))

For the quantitative survey, an undisturbed representative area of about 1 ha of the forest vegetation was selected. According to Yamada (1977) ten plots of 20 x 20 m were demarcated randomly in this area. Stem density, frequency and dominance (in terms of basal area) was estimated for each species of woody vegetation (Greig-Smith, 1957).

$$\text{Stem density of Species A in sample plot X} = \frac{\text{No. of stems of species A in sample plot X}}{\text{Area of sample plot X}}$$

$$\text{Dominance of Species A (relative cover value)} = \frac{\text{Total basal area of species A}}{\text{Sum of basal areas for all species}} \times 100$$

## RESULTS

Table1 shows the species composition of all species (gbh > 10 cm), life forms and endemicity. The distribution of species among taxa was uneven. A total of 57 species belonging to 43 genera and 27 families were recorded. Taxonomic richness (total number of taxa) was 127. About 12.3% (7 species) of the species belonged to the family Lauraceae; 10.5% (6 species) to Rubiaceae and 7 % (4 species) to each family of Myrtaceae and Symplocaceae. The vegetation also consisted of 77.2 % (44 species) trees and 22.8% (13 species) shrubs. About 38.6% (22 species) species was found to be endemic. The only exotic species found in the vegetation was *Cestrum nocturnum*.

**Table 1. Floristic composition of woody perennial vegetation in Hakgala Strict Nature Reserve at 1800 m elevation**

T= tree, S = Shrub,
*- endemic, #- Exotics

| Family & Species | Life Form |
|---|---|
| 1, Aquifoliaceae | |
| *Ilex walkeri* Wight & Gardn ex Thw. | T |
| 2. Anacardiaceae | |
| *Semecarpus coricea* Thw. | T* |
| 3. Asteraceae | |
| *Senecio corymbosus* Wall. Ex DC. | S |
| 4. Buxaceae | |
| *Sarcococca zeylanica* Bail. | S |
| 5. Caprifoliaceae | |
| *Viburnum erubescens* Wall. Ex DC. | T |
| *Viburnum coriaceum* Bl. | S |
| 6. Celastraceae | |
| *Euonymus revolutus* Wight | T* |
| *Microtropis Wallichiana* Wight ex Thw. | T* |
| 7. Clusiaceae | |
| *Calophyllum walkeri* Wight. | T* |

| Family & Species | Life Form |
|---|---|
| 8. Daphniphyllaceae | |
| *Daphniphyllum neilgherrense* (Wight) Thw. | T |
| 9. Elaeocarpaceae | |
| *Elaeocarpus montanus* Thw. | T* |
| 10. Ericaceae | |
| *Vaccinium symplocifolium* (G. Don ) Alston | S |
| 11. Euphorbiaceae | |
| *Glochidion coriaceum* Thw. | T |
| 12. Flacortiaceae | |
| *Caesaria thwaitessi* Briq. | T* |
| *Scolopia crassipes* Clos. | T* |
| 11. Icacinaceae | |
| *Apodytes gardneriana* Miers | T* |
| *Nothapodytes foetida* (Wight) Sleumer | T |
| 12. Lauraceae | |
| *Actinodaphne ambigua* (Meisn.) Hook. f. | T* |
| *Actinodaphne glauca* Nees | T* |
| *Actinodaphne speciosa* Nees | T* |
| *Actinodaphne* sp. 1 | T |

| | |
|---|---|
| *Cinnamomum ovalifolium* Wight. | T* |
| *Neolitsea fuscata* (Thw.) Alston | T* |
| *Neolitsea* sp. 1 | T |
| 13. Magnoliaceae | |
| *Michelia nilagirica* Zenker | T |
| 14. Melastomataceae | |
| *Memecylon rotundatum* (Thw.) Cogn. In DC. | S* |
| *Osbeckia* sp. | S |
| 15. Moraceae | |
| *Ficus microcarpa* L.f. | T |
| 16. Myrsinaceae | |
| *Ardisia gardneri* C.B. Clarke | S* |
| *Maesa perrottetiana* A.DC. | S |
| *Rapanea robusta* Mez. | T |
| 17. Myrtaceae | |
| *Eugenia mabaeoides* Wight | T* |
| *Syzygium assimile* Thw. | T |
| *Syzyfgium revolutum* Walp. | T |
| *Syzygium rotundifolium* Arn. | T* |
| 18. Oleaceae | |
| *Olea polygama* Wight | T |

| Family & Species | Life Form |
|---|---|
| 19. Rubiaceae | |
| *Canthium montanum* Thw. | T* |
| *Ixora calycina* Thw. | T |
| *Lasianthus gardneri* (Thw.) Hook. f. | S* |
| *Psychotria nigra* (Gaertn.) | S |
| *Psychotria zeylanica* Sohmer | S |
| *Tarenna flava* Alston | T |
| 20. Rutaceae | |
| *Acronychia pedunculata* (L.) Miq. | T |
| *Euoida lunu-ankenda* (Gaertn.) Merr. | T |
| 21. Sabiaceae | |
| *Meliosma simplicifolia* (Roxb.) | T |
| *Meliosma pinnata* (Roxb.) Max. in Walp. | T |
| 22. Sapindaceae | |
| *Allophyllus varians* (Thw.) Radlk. | T* |
| 23. Sapotaceae | |
| *Isonandra lanceolata* Wight | T |
| 24. Solanaceae | |
| *Cestrum nocturnum* L | S# |
| 25. Symplocaceae | |
| *Symplocos bractealis* Thw. | T* |
| *Symplocos cochinchinensis* (Lour.) S. Moor. | T |
| *Symplocos elegans* Thw. | T* |
| *Symplocos* sp. | T |

| | |
|---|---|
| 26. Theaceae | |
| *Eurya ceylanica* Wight | S |
| 27. Ulmaceae | |
| *Celtis Cinnamomea* Lindl. Ex Planch. | T |
| Unidentified sp.1 | T |
| Unidentified sp.2 | T |

## Structural characteristics

Table 2 provides trees and shrub families (> 10cm gbh) with percentage of mean total basal area and density (individuals $ha^{-1}$). Overall density of live stems in all size classes was calculated to be 2641 individuals $ha^{-1}$. At the family level, stem density and relative basal area differed between the stem size classes. Thirteen families of species were represented below 80cm gbh stems. Only two families i.e. Lauraceae and Rutaceae represented all the stem size classes. Above> 100cm gbh values were represented by 11 families. Families Caprifoliaceae, Elaeocarpaceae and Sapotaceae represented only 21 –20cm gbh stem size class. The highest relative basal area values were recorded for families, Lauraceae (22.1%), Magnoliaceae (13.7%) and Myrtaceae (11%). Except seven families i.e. Lauraceae, Magnoliaceae, Myrtaceae, Sabiaceae, Rubiaceae, Anacardiaceae and Rutaceae, other families showed less than 5% relative basal area. Families, Rubiaceae, Solanaceae, Lauraceae, Myrtaceae, Caprifoliaceae and Sabiaceae showed more than 100 individuals/stems $ha^{-1}$. Family Solanaceae (367 stems/individuals ha-1) represented the highest stem density. Four families i.e. Buxaceae, Celastraceae, Elaeocarpaceae, Melastomataceae and Sapotaceae were rarely found representing less than 5 stems/individuals $ha^{-1}$(Tables 2).

The stem density showed a reversed "J" shaped curve (Figure 1). The highest density was recorded for 10 –20 cm gbh stem size class and the lowest density class was > 100 cm gbh stems. Further Figure 2 and Table 2 show that 54.1% (1429 individuals $ha^{-1}$) fall in to the lowest girth class (i.e. 10-20 cm). Eleven species exceeded >100 cm girth (gbh) with a density of 43 individuals per ha.

**Table 2. Relative basal area values and density (number of individuals per ha) Values in each stem size class**

%BA- relative basal area

No.- density (number of individuals per ha)

| Family | Stem size class (gbh) cm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10-20 | | 21-40 | | 41-60 | | 61-80 | | 81-100 | | >100 | |
| | %BA | No. | %BA | No. | %BA | No. | %BA | No. | %BA | No. | %BA | No. |
| Anacardiaceae | - | - | - | - | - | - | 1.20 | 5 | 2.11 | 8 | 2.90 | 7 |
| Aquifoliaceae | 0.01 | 2 | 0.06 | 8 | 0.03 | 2 | 0.02 | 1 | - | - | - | - |
| Buxaceae | 1.80 | 83 | 2.0 | 69 | 0.08 | 9 | 0.05 | 3 | - | - | - | - |
| Caprifoliaceae | - | - | 0.01 | 3 | - | - | - | - | - | - | - | - |
| Celastraceae | 0.45 | 4 | 1.05 | 10 | 0.62 | 5 | - | - | - | - | - | - |
| Clusiaceae | 0.02 | 1 | 0.24 | 3 | - | - | - | - | 0.43 | 2 | 0.58 | 2 |
| Cornaceae | - | - | - | - | 0.03 | 1 | 0.37 | 3 | 0.21 | 1 | - | - |
| Daphniphyllaceae | 0.01 | 4 | 0.04 | 1 | - | - | - | - | - | - | - | - |
| Elaeocarpaceae | - | - | 0.03 | 3 | - | - | - | - | - | - | - | - |
| Ericaceae | 0.06 | 6 | 0.07 | 4 | - | - | - | - | - | - | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Euphorbiaceae | 0.01 | 2 | 0.14 | 12 | 0.06 | 3 | 0.10 | 2 | - | - | 0.20 | 1 |
| Flacourtiaceae | 0.12 | 5 | 0.12 | 4 | 0.48 | 3 | 0.17 | 1 | - | - | - | - |
| Icacinaceae | 0.16 | 24 | 0.17 | 17 | 0.21 | 2 | - | - | 0.37 | 2 | - | - |
| Lauraceae | 2.62 | 130 | 5.90 | 183 | 4.45 | 57 | 2.14 | 27 | 3.80 | 20 | 3.20 | 9 |
| Magnoliaceae | - | - | - | - | - | - | 4.70 | 12 | 1.40 | 3 | 7.56 | 10 |
| Melastomataceae | - | - | 0.12 | 2 | - | - | 0.16 | 1 | - | - | - | - |
| Moraceae | - | - | - | - | 0.14 | 2 | 0.48 | 4 | - | - | 0.39 | 1 |
| Myrsinaceae | 0.08 | 10 | 0.15 | 10 | 0.04 | 3 | - | - | - | - | - | - |
| Myrtaceae | 2.10 | 121 | 4.85 | 115 | 1.65 | 17 | 2.45 | 25 | - | - | - | - |
| Oleaceae | - | - | - | - | - | - | 0.20 | 3 | 0.62 | 2 | 1.05 | 2 |
| Rubiaceae | 5.15 | 687 | 2.32 | 84 | - | - | - | - | - | - | 0.89 | 1 |
| Rutaceae | 0.32 | 16 | 1.58 | 60 | 2.59 | 33 | 1.21 | 8 | 3.46 | 16 | 1.50 | 4 |
| Sabiaceae | - | - | 0.85 | 23 | 0.15 | 6 | 1.20 | 5 | - | - | 2.70 | 5 |
| Sapindaceae | 0.39 | 48 | 0.43 | 36 | 0.10 | 4 | 0.08 | 2 | 0.20 | 2 | - | - |
| Sapotaceae | - | - | 0.01 | 1 | - | - | - | - | - | - | - | - |
| Solanaceae | 0.94 | 206 | 0.95 | 147 | 0.13 | 14 | - | - | - | - | - | - |
| Symplocaceae | 1.23 | 51 | 0.22 | 5 | 1.00 | 12 | - | - | 0.73 | 3 | 0.51 | 1 |
| Theaceae | 0.30 | 29 | 0.61 | 26 | - | - | - | - | - | - | - | - |
| Ulmaceae | - | - | 0.37 | 5 | 0.89 | 4 | - | - | - | - | - | - |
| **Total** | **15.77** | **1429** | **22.29** | **831** | **12.65** | **177** | **14.53** | **102** | **13.33** | **59** | **21.48** | **43** |

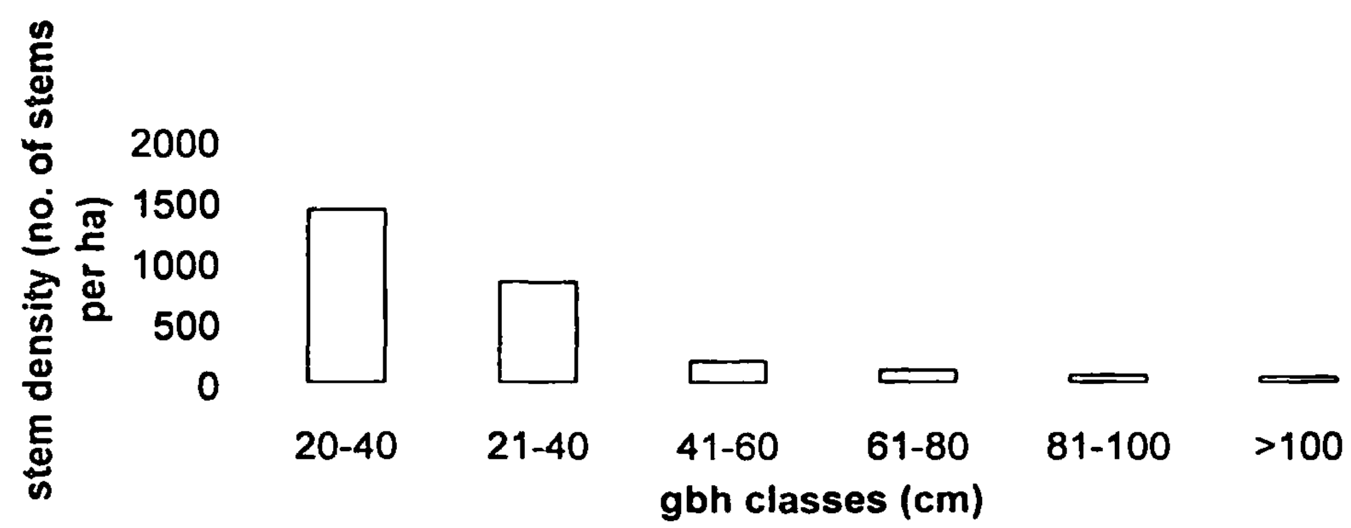


**Figure 1. Stem density classes of woody perennial vegetation at study site**

The total basal area (sum of the stem cross sectional area) at breast height extrapolated to per hectare basis) for the study area was 39.8m$^2$ ha$^{-1}$. The highest relative basal area was recorded for 21-40cm gbh stem size class i.e, 22.29 and the lowest relative basal area was recorded for 41 – 60cm gbh stem size class i.e. 12.65. (Table 2). The largest trees (> 100cm gbh), which constituted only 16% of the tabulated stems accounted for 21.5% of total basal area.

A dominance-diversity curve was computed at the species level by ranking the relative basal area of all stems > 10 cm gbh for trees and shrubs were identified (Figure 2). All but seven species i.e. *Neolitsea fuscata* (16.9 %), *Michelia nilagirica* (13.7%), *Meliosma simplicifolia* ( 9.4 %), *Semecarpus coriacea* (6.2%), *Syzygium rotundifolium* (5.9%) and *Acronychia pedunculata* (5.5%) and *Eugenia mabaeoides* (5%) constituted less than 5% of the percentage basal area.

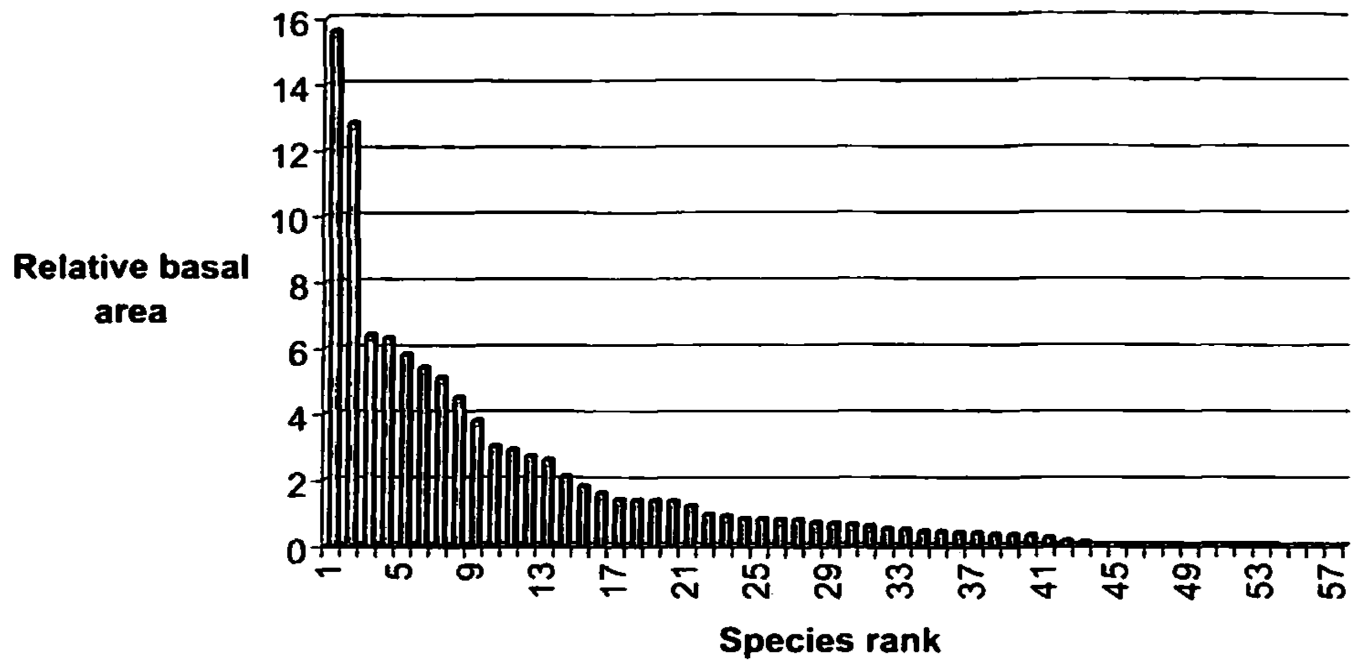


**Figure 2. Dominance diversity curve for the woody perennial vegetation at study site**

According to the dominance values (in terms of relative basal area values) different dominant families, genera and species were found (Table 2). Below 60 cm gbh classes, the dominant families were Lauraceae, Solanaceae and Myrtaceae. Within these three families, the genera of *Neolitsea, Cestrum* and *Eugenia* and species of *P.zeylanica, C.aurantiacum* and *N.fuscata* were the dominants. The dominant families above 60 cm gbh were Lauraceae, Magnoliaceae and Anacardiaceae . Within the dominant genera of *Neolitsea, Semecarpus* and Michelia, dominant species of *N.fuscata, S.coriacea* and *Michelia nilagirica* were found.

## DISCUSSION

From the results it was evident that the vegetation at 1800 m of HSNR was dominated by the families Lauraceae (12.3%, 7 species), Rubiacea (10.5%, 6 species), Myrtaceae (7%, 4 species) and Symplocaceae (7%, 4 species).Lauraceae commonly occurs elsewhere at this elevation, and has been reported as the dominant in the vegetation at this elevation. Dominance of Lauraceae at this site may reflect the abundance of several avian dispersers of this family. Taxonomic richness (total number of taxa) was quite high at the study site like other montane forests (Grubb *et al.* (1963), Heaney & Proctor (1990) & Tanner (1977)). The presence of 38.6% endemic species further reveals the importance the forest vegetation. Number of species found in the montane zone of Sri Lanka was 591, and 291 species were endemic (Abeywickrama, 1956). Trimen (1885) also has reported that about five sixth of the country's endemic species are present in the hill flora. According to Willis (Procteor *et al* (1988) and de Rosayro (1958), endemic species occurred in the montane rain forests mainly due to isolation of mountains, and isolated species may have evolved and became endemic. The only exotic species i.e. *Cestrum nocturnum* was found with the highest abundance, and it has been introduced to Sri Lanka through Hakgala Botanic Garden in 1889 (Trimen, 1890). This exotic species was considered as a weed of montane zone (Bond, 1952). According to Rathnayake *et al.* (1996)a, *C.nocturnum* was an exotic species found at 1600 m too, but it was absent at 2000m elevation probably due to the facts that the seeds or fruits of these two species are normally dispersed by birds (Alston, 1931), and at the higher elevations the birds could not disperse them successfully. Further, the presence of extreme environmental conditions (i.e. high wind velocity and high light intensity) at higher elevations, coiled already affect the survival of this species. According to the highest abundance of *C.nocturnum*_in HSNR it could be suggested that it could suppress the growth of other species present in the forest. At the moment this exotic species has spread through the lower elevation on to the higher elevations seriously threatening the endemic vegetation of the upper montane rain forests..

Stem density showed a reversed "J"-shaped curve which is typical for a mature stand, with many small stems compared to few large ones. The large size classes of stems were more variable spatially than small stems, so a large sample area would be needed to characterize composition and structural attributes of larger trees than small trees.

According to Figure 1, many individuals of woody perennial vegetation do not exceed 20 cm gbh, and smaller individuals of overstorey vegetation may allow saplings to share the space for exposing to the light. Generally, *C.nocturnum* shows low gbh classes and that could be helpful in the case of saplings of *C.nocturnum*. High gbh values (> 100 cm gbh) were recorded for *Michelia nilagirica, Semecarpus coriacea, Ficus* sp. and etc., and they may not allow saplings to share the space. Compared to other species therefore their relative densities were low.

Less than ten species showed more than 5% of relative basal area at each elevation, and they are the dominants. It could be suggested that these species might determine the future of whole forest. That means these species may affect the seed germination, growth of saplings and growth of other plants. The highest relative basal area values were recorded for *Michelia nilagirica* and *Neolitsea fuscata* at 1800 m as well as 1600 m studied", and they were not found at 2000 m elevation (Rathnayake *et al.*, 1996a) due to their huge and tall stems and presence of shallow soil depth and other unfavorable environmental conditions. It was not the highest basal area holding species at these two elevations, because *C.nocturnum* is shrub form with low gbh values.

The cover values give an idea of timber volume of the forest, although timber of this forest is not important in furniture industry. Relative basal area is a useful indicator of particular species in a forest and it may reflect the importance of the species in the community dynamics. Based on the overall relative cover values of species *Neolitsea fuscata, Michelia nilagirica* and *Semecarpus coriacea* were the dominants, and they could be considered as dominant species involved in community dynamics. They are endemic, and community dynamics mainly depend on these species too.

Sampled areas in comparable studies ranged from 400m$^2$ to 4000m$^2$ (present study). Taxonomic richness (total number of taxa) was quit high at HSNR like other montane rain forests (Grubb *et al.*, (1963), Heaney & Proctor (1990), Abeywickrama (1956) & Nadkarni *et al.*, (1995)). Some of families and genera found in Hakgala SNR are common at study sites of other montane, forests (Heaney & Proctor (1990), Tanner (1977), Proctoer *et al.*, (1988), Nadkarni *et al.*, (1995), Weaver & Murphy (1990), Edwards (1977) & Edwards & Grubb (1977)). In the present study, the most densest species was *C.nocturnum*, and the most dominant species was *Neolitsea fuscata*. Therefore the results of the present study were different from those of Wijesundara (1991), and these changes could be due to the forest die back, natural death of some trees and the greater distribution of *C.nocturnum*. At Barva forest in Jamaica, the dominant family was Euphorbiaceae (14.5% of basal area) (Tanner, 1977), whereas this taxon comprised only 0.5% of the total basal area only at 1800 m elevation in Hakgala SNR. The dominant family at Monteverde forests in Jamaica was Lauraceae (31% of total basal area) (Edwards, 1977), comprised only 5.8% of the basal area at the Barva site (Tanner 1977). In the present study, the dominant family was Lauraceae (i.e 22.9% of total basal area). This difference may result from different forest disturbance regimes; and climatic conditions.

The current data on tropical forests suggest the similar elevation and environmental conditions do not dictate similar structure and floristics in tropical montane vegetation. A larger body of information on environmental factors, especially those that influence patterns of disturbance and regeneration are necessary to explain the great variation exhibited in tropical montane forests. The results of the present study could be useful in measures pertaining to the conservation of naturally established flora in the upper montane rain forests. It is also recommended that regular floristic studies, both qualitative and quantitative, at least at 6 year intervals be carried out and in order to monitor the possible vegetation change that could occur overtime in this vegetation.

## REFERENCES

De Rosayro, R.A. (1958). The Climatic and Vegetation of the Knucles Region of Ceylon. Ceylon Forester 2 (3 & 4) : 201-260.

Grubb, P.J., Lloyd, J.R., Pennington, T.D. & Whitemore, T.C. (1963). A comparison of montane and lowland rain forest in Ecuador. The forest structure, physiognomy and floristics. Journal of Ecology **51**: 567-601.

Rathnayake, R.M.W., Jayasekera, L.R. & Solangaarachchi, S.M (1996). A quantitative study of overstorey vegetation of an upper montane rain forest. The Sri Lanka Forester **XXII** (3&4):43-49.

Rathnayake, R.M.W., Solangaarachchi, S.M. & Jayasekera, L.R. (1996). A quantitative study of pigmy forest at 2000 m in Hakgala Strict Nature Reserve. Proceedings of the Second Annual Forestry Symposium. Department of Forestry and Environment Science. University of Sri Jayawardenapura, Sri Lanka. pp. 215-222.

Vincent (1883). The Forests of Ceylon. Tropical Agriculturist **2** (1-12):280-281.

Werner, W.L. (1982). The Upper Montane Rain Forests of Sri Lanka. The Sri Lanka Forester **15** (3&4): 119-131.

Wijesundara, D.S.A.. (1991). Phytosociology of a montane forest in Sri Lanka. M.Phil. thesis, Faculty of Science, University of Peradeniya, Sri Lanka.

Chapman, V.J. (1947). The application of aerial photography to ecology as exemplied by the natural vegetation of Ceylon. Indian Forester **73** (7):287-314.

Koelmeyer, K.O. (1957). The climate classification and distribution of vegetation in Ceylon. The Ceylon Forester 3 (2): 144-163.

Nisbet, R.H.McD. (1961). A forest inventory of the Peak Wilderness-Agra Bopats Forest Area and part of the Kelani Valley Forest Area. Ceylon Government Press, Colombo. 58p.

Greller, A.M. & Balasubramaniam, S. (1980). A prelimiary floristic classification of the forests of Sri Lanka. Sri Lanka Forester 14 (3-4):163-170.

Green, M.J.B. (1990). IUCN Directory of South Asian Protected Areas. IUCN-The World Conservation Union, Cambridge, U.K pp. 211-212.

Mitra, J.N. (1957). An Introduction to Systemic Botany and Ecology. The World Press Private Ltd., Calcutta, India.

Dassanayake, M.D. & Fosberg, F.R. (1980- ). Revised Hand Book to the Flora of Ceylon. Parts I-VII. Amerind Publishing Co. (Pvt) Ltd., New Delhi, India.

Wijesinghe, Y. (1994). Checklist of Woody Perennial Plants of Sri Lanka. Forest Department, Sri Lanka. 20 p.

Yamada, L. (1977). Forest ecological studies of the montane forests of Mt. Pangrango, West Java. IV. Floristic composition along altitude. South East Asian Studies. 15: 226-254.

Greig-Smith, P. (1957). Quantitative Plant Ecology (3rd edition). Butterworth, London, England. 256 p.

Heaney, A. & Proctor, J. (1990). Preliminary studies on forest structure and floristics on Volcan Barva, Cota Rica. Journal of Tropical Ecology 6:307-320.

Tanner, E.V.J. (1977). Four montane rain forests of Jamaica: a quantitative characterization of the floristics, the soil and foliar mineral levels, and a discussuion of the interelations. Journal of Ecology 65:883-918.

Abeywickrama, B.A. (1956). The origin and affinities of the flora of Ceylon. Proc. Ann. Sess. Ceylon A.A.S. Part 2:99-21

Trimen, H. (1885). Remarks on the composition, geographical affinities and origin of the Ceylon flora. Journal of Royal Asiatic Society (ceylon Branch) 9.

Willis, J.C. (1908). The floras of Hill tops in Ceylon. Annals of the Royal Botanic Garden Peradeniya 4 (4): 131-138.

Trimen, H. (1890). Ceylon Administrative Reports. Royal Botanic Gardens, Peradeniya. Report of the Director for 1889 12 p.

Bond, T.E.T. (1952). Wild Flowers of the Ceylon Hills. Oxford University Press. 240 p.

Alston, A.H.G. (1931). A handbook to the flora of Ceylon. Vol. 6., Dulau, London.

Proctoer, J., Lee Y.F., Langley A.M., Munro W.R.C. & Nelson, T. (1988). Ecological studies on Gunung Silam, a small ultra basic mountain in Sabah, Malaysia. I. Environment, forest structure and floristics. Journal of Ecology 76:320-340.

Nadkarni N.M., Matelson T.J. & Haber W.A. (1995). Structural characteristics and floristic composition of a Neotropical cloud forest Monteverde, Costa Rica. Journal of Tropical Ecology 11:481-495.

Weaver, P.L. & Murphy, P.G. (1990). Forest structure and productivity in Puerto Rico's Luquillo Mountains. Biotropica 22:69-82.

Edwards, P.J. (1977). Studies in a montane rain forest in NewGuinea. II. The production and disappearance of litter. Journal of Ecology 65:971-922.

Edwards, P.J. & Grubb, P.J. (1977). Studies of mineral cycling in a montane rain forest in New Guinea. I. The distribution of organic matter in the vegetation and soil. Journal of Ecology 65:943-969.