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ORIGINAL PAPER

# Structure and floristic composition of tree stand in tropical forest in the Eastern Ghats of northern Andhra Pradesh, India

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**Abstract:** The changes in species composition, abundance and forest stand structure were analyzed across altitudinal regimes in tropical forests of Eastern Ghats of northern Andhra Pradesh, India. Three 1-ha plots were established with one each in low, medium and high altitudes. A total of 153 species, 2129 stems (709 stems ·ha$^{-1}$) of ≥10 cm girth were enumerated. Species richness and diversity pattern varied along altitudinal gradient and increased with the altitude. Species richness varied from 52 to 110 species·ha$^{-1}$ and stand density from 639 to 836 stems·ha$^{-1}$ with average basal area of 34.39 m$^2$·ha$^{-1}$. Shannon–Wiener index (H') ranged from 4.55 to 5.17. Low altitude (i.e., Site 1) is dominated by *Xylia xylocarpa* (59.22) and *Lagerstroemia parviflora* (23.90), medium altitude (i.e., Site 2) by *Xylia xylocarpa* (45.50) *Bursera serrata* (17.29), and high altitude (i.e., Site 3) has *Schleichera oleosa* (28.25) *Pterocarpus marsupium* (26.55) as predominant species. Taxonomically, Rubiaceae (12 species), Fabaceae (12), Euphorbiaceae (11), Rutaceae (7) and Lauraceae (7) were dominant families. Density-wise, Fabaceae, Combretaceae, Euphorbiaceae, Anacardiaceae and Myrtaceae were abundant. Thus, conservation assessment based on altitudinal regimes and the information on species structure and function can provide baseline information for monitoring and sustaining the biodiversity.

**Keywords**: altitude; conservation; diversity; Eastern Ghats; species composition

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## Introduction

Altitudinal gradient has an effect on pattern of diversity of the plant species, which creates variation in climatic pattern and soil differentiation (Lomolino 2001). Tropical forests are highly diverse (Letcher 2010) due to species interaction and niche variation (Volkov 2009), which is a result of favorable climatic conditions like humidity and temperature (Ojo and Ola-Adams 1996). Understanding of vegetation composition, diversity of species and their habitats, and comparison with similar other habitats, may become a tool to estimate the level of adaptation to the environment and their ecological significance. Over the decades, forests in the peninsular India were destructed at an alarming rate, which was largely addressed in many tropical and subtropical countries, although the data were scarce on structure and functional dynamics of these forests (Parthasarathy et al. 1997; Reddy et al. 2007).

Therefore, information on floral composition, diversity and biomass is absolutely essential in understanding the forest ecosystem dynamics (Reddy et al. 2008). Conservation management also requires data on plant species diversity and the forest community structure in order to chalk out necessary actions. In peninsular India, a few quantitative phytodiversity inventories are available from the forests of the Western Ghats (Parthasarathy et al. 1992; Ganesh et al. 1996; Pascal et al. 1996; Parthasarathy et al. 1997a; Ayyappan et al. 2004; Giriraj et al. 2008; Anitha et al. 2009; Swamy et al. 2010) and the Coromandel Coast (Parthasarathy et al. 1997). Eastern Ghats remain as a neglected area with very few attempts made for such studies in Eastern Ghats of Tamil Nadu (Kadavul et al. 1999 a&b; Jayakumar et al. 2002; Natarajan et al. 2004). These kinds of studies were not attempted in the state of Andhra Pradesh, which covers a major part of the Eastern Ghats. Hence, the current investigation was carried out to determine the species richness and population density of trees in the tropical forests of the Eastern Ghats of northern Andhra Pradesh, India.

## Materials and methods

### Study area

The Eastern Ghats are located along the Peninsular India extending over 1750 km with average width of about 100 km. The study area is between 11º30'−21º00' N latitude and 77º22'−85º20' E longitude. The wide range of topography and other physical features of the Eastern Ghats, provided by the hills raising from almost sea level to about 1672 m altitude, shaped the land to harbour rich and varied flora (Meher-Homji 2001). Several large rivers like Mahanadi, Godavari, Krishna, cut the range into discontinuous blocks of hills along the East Coast.

The studied areas with three 1-ha plots are located in the contiguous tract of Sileru-Maredumilli hills of northern Eastern Ghats, covering three districts (*viz*. Khammam, East Godavari and Visakhapatnam) of Andhra Pradesh, India (Fig. 1). These forests are classified as South Indian Moist Deciduous and Orissa Semi evergreen forests (Champion et al. 1968). The three plots are at different elevation-gradient lying in low-lying areas of 400-600 m, mid elevation of 600–800 m and high altitude of 800–1000 m. Thus, these study sites showed variability in climatic and topographic pattern even though their geographic range is contiguous. Three 1-ha plots were established at three different sites: Site 1 is located about 2 km from Sukkumamidi, a tribal hamlet, which receives mean annual rainfall about 1 200−1 400 mm and elevation ranging from 400–600 m. Site 2 is located about 6 km from Maredumilli tribal village, receives mean annual rainfall about 1 400−1 600 mm with an elevation of 600–800 m. Site 3 is located about 2 km from Lankapakala tribal hamlet receives mean annual rainfall 1 600−1 800 mm and an elevation of 800–1 100 m. All the three study sites were relatively undisturbed. There are no records on the intensity and the extent of disturbance.

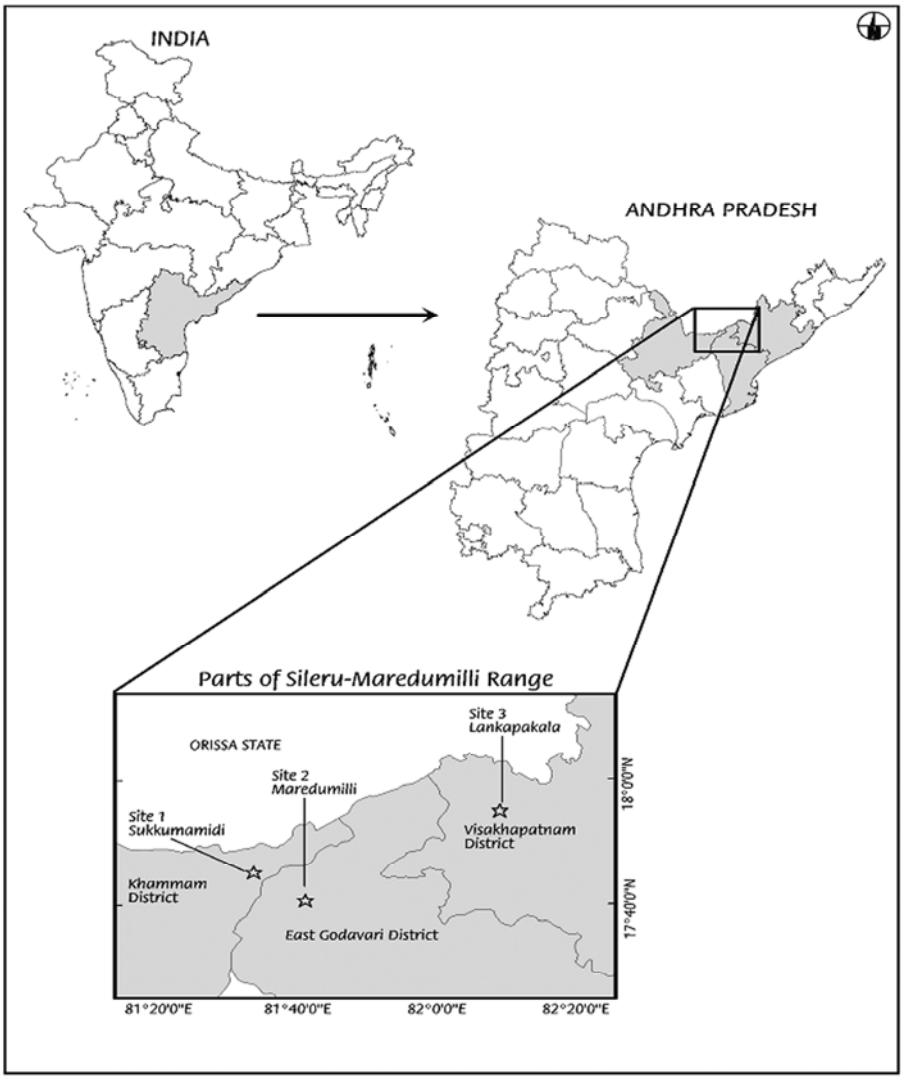


**Fig. 1 Location map of Sileru-Maredumilli hill ranges in Eastern Ghats of northern Andhra Pradesh, India**

Field methods

Phytosociological data were collected in quadrants of 100 m×100 m which are subgrided into 20 m × 20 m and were systematically surveyed for all trees of girth at breast height (≥10 cm) (gbh - above 130 cm from the ground). The collected species were identified with the help of the Flora of Presidency of Madras (Gamble and Fischer 1915−1935), Flora of Tamil Nadu Carnatic (Matthew 1984), and specimens were preserved in Herbarium of Kakatiya University (KUH), Warangal (Andhra Pradesh).

Data analysis

For species diversity and evenness, Shannon index (H'), Simpson's index (λ) (Magurran 1988), Hill diversity (Hill 1973), and Sorensen's similarity indexes were calculated. The floristic structure was studied using Importance Value Index (IVI) of Curtis and Mcintosh (1950). This index is generally calculated as the sum of the relative frequency (rF), relative density (rD) and relative basal area (rBA) for each species. The species-area curve was plotted by sequential arrangement for sub-plots of 100 $m^2$×10 $m^2$.

## Results

In the three 1-ha plots in the Sileru-Maredumilli range, a total of 153 trees were inventoried with girth ≥10 cm, belonging to 112 genera and 49 families. Plot-wise species richness was 52, 110 and 77 respectively with a major difference between the plots (Table 1). The mean density was 709 trees $ha^{-1}$ and the basal area 34.3 $m^2 \cdot ha^{-1}$. The Shannon index (H') in 3 ha was 5.68, but varied largely in different plots (4.55, 5.05 & 5.17), with Simpson's value ranging from 0.92 to 0.96. Hill diversity was least at site 2 (12.05) and maximum at site 3 (22.78). The species-accumulation curves for the three sites were initially steep. Only in site 1, there is tendency towards flattening, whereas in the case of other two sites the curve didn't reach an asymptote (Fig. 2).

A total of 2129 stems were enumerated in three 1-ha areas (Table 1). Stem density was highest in site 2 (836 stems·$ha^{-1}$), least in site 1 (639 stems·$ha^{-1}$) and intermediate in site 3 (654 stems·$ha^{-1}$). The mean stand density for the study area was 709 stems·$ha^{-1}$. Basal area in all the plots, ranges from 30.95 $m^2$ (site 1) to 39.96 $m^2$ (site 3). Basal area contribution was medium in site 2 (32.25 $m^2$) and the mean stand basal area for the 3-ha is 34.39 $m^2$ (Table 1). The density of different tree species is greatly differ within the three 1-ha areas (Appendix 1). The top ten tree species (total individuals) accounted for 47% of stand density (1 010 individuals out of the 2 129 individuals) and 54% of the basal area. *Xylia xylocarpa*, *Pterocarpus marsupium*, *Schleichera oleosa* are the major predominant species. *Xylia xylocarpa* alone contributed to 16% of the stand density and 25% of Importance Value Index (IVI). The top ten predominant species with their density, IVI and basal area are given in Table 2. Species similarity between different sites was studied using presence/absence data. 33% of the species recorded are found to be similar between site 1 and site 3. In site 2 and site 3, there are 50% common species (Table 1). In study sites, species represented by ≤2 individuals were considered as rare/infrequent species, which accounted for 41% (63 out of 13 species).

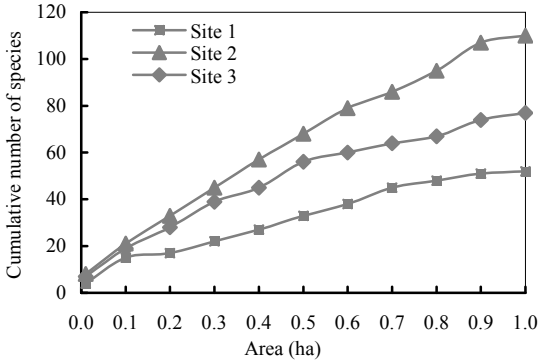


**Fig. 2 Species accumulation curve for three different sites**

**Table 1. Consolidated details of woody species inventory in three 1-ha plots in the Eastern Ghats of northern Andhra Pradesh**

| Description | Site 1 | Site 2 | Site 3 | Total for three hectares |
|---|---|---|---|---|
| No. of woody species | 52 | 110 | 77 | 153 |
| No. of genera | 42 | 92 | 64 | 112 |
| No of families | 26 | 41 | 37 | 49 |
| Density (stems·$ha^{-1}$) | 639 | 836 | 654 | 2129 |
| Species diversity (H') | 4.56 | 5.05 | 5.18 | 5.68 |
| Simpson index | 0.93 | 0.92 | 0.96 | 0.96 |
| Hill diversity | 13.36 | 12.05 | 22.78 | 23.11 |
| Basal area ($m^2 \cdot ha^{-1}$) | 30.96 | 32.26 | 39.97 | 34.39 |
| No. of shrub species | 80 | 24 | 30 | 107 |
| No. of herb species | 64 | 84 | 66 | 162 |
| Similarity Index | | | | |
| Site 1 | --- | 44 | 33 | |
| Site 2 | | --- | 50 | |
| Site 3 | | | --- | |

Taxonomically, there were 49 plant families and 112 genera. In the three 1-ha areas, the number of species in each family varied from 1 to 12. Nearly 43% (*i.e.* 21 families) were represented by single individual. Rubiaceae and Fabaceae were the most common families with 12 species each, followed by Euphorbiaceae (11 species), Rutaceae and Lauraceae each with 7 species (Table 3). Fabaceae contributed to 28% of the stand density followed by Combretaceae (8%), Euphorbiaceae (6%), Anacardiaceae (6%) and Myrtaceae (5%). Fabaceae contributed to the bulk (26%) of basal area. Woody species richness as well as density decreased with increasing girth class in all the three sites (Fig. 3). Girth class having <60 cm gbh contributed to about three fourth of species richness, medium stems (60−150 cm gbh) to about one third and large stems (>150 cm gbh) to about one third to one tenth in the three study sites. The stems (30–90 cm gbh) accounted for more than 50% of stand density. Population

structure of the four dominant species revealed that *Xylia xylocarpa*, *Pterocarpus marsupium*, *Schleichera oleosa* and *Grewia tiliaefolia* had a clear expanding population structure occupying majority of space, with greater representation in all size classes.

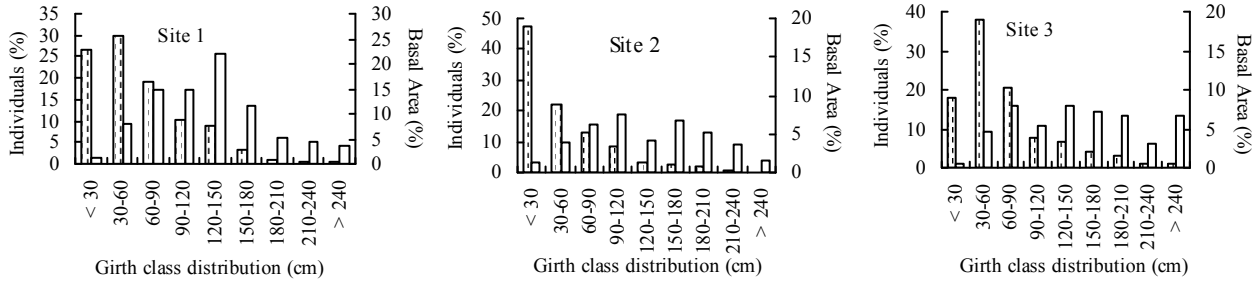


**Fig. 3 Population structure of woody species based on girth class frequency and basal area in three study sites**

No of individuals (%) Basal Area (%)

**Table 2. Density, IVI and basal area of the ten most important species in three study sites**

| Species | Site1 | | | Site2 | | | | Site3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | IVI | Density | BA | Species | IVI | Density | BA | Species | IVI | Density | BA |
| *Xylia xylocarpa* | 61.0 | 131 | 6.8 | *Xylia xylocarpa* | 45.8 | 211 | 6.0 | *Schleichera oleosa* | 28.7 | 68 | 6.3 |
| *Lagerstroemia parviflora* | 24.6 | 64 | 2.0 | *Bursera serrata* | 17.6 | 62 | 2.7 | *Pterocarpus marsupium* | 27.4 | 63 | 5.5 |
| *Dillenia pentagyna* | 19.7 | 39 | 2.2 | *Terminalia alata* | 14.0 | 36 | 2.5 | *Michelia champaca* | 15.8 | 22 | 3.4 |
| *Anogeissus latifolia* | 15.4 | 31 | 1.6 | *Pterocarpus marsupium* | 13.0 | 46 | 1.8 | *Grewia tiliaefolia* | 13.5 | 44 | 1.4 |
| *Buchanania lanzan* | 15.1 | 41 | 0.7 | *Ouigenia ougenensis* | 11.3 | 29 | 1.9 | *Mangifera indica* | 13.2 | 17 | 3.2 |
| *Pterocarpus marsupium* | 13.9 | 20 | 2.2 | *Grewia tiliaefolia* | 8.7 | 37 | 0.8 | *Gmelina arborea* | 12.8 | 27 | 1.9 |
| *Terminalia bellirica* | 13.8 | 16 | 2.8 | *Syzygium cumini* | 7.3 | 31 | 0.6 | *Mallotus philippensis* | 12.3 | 45 | 0.6 |
| *Dendrocalamus strictus* | 12.6 | 40 | 0.1 | *Sterculia villosa* | 6.4 | 7 | 1.2 | *Garuga pinnata* | 11.8 | 23 | 2.0 |
| *Cleistanthus collinus* | 11.5 | 29 | 0.7 | *Diospyros sylvatica* | 6.3 | 25 | 0.5 | | | | |
| *Terminalia alata* | 10.9 | 19 | 1.5 | *Mangifera indica* | 5.6 | 6 | 1.1 | | | | |

**Notes**: Abbreviations: IVI is Importance Value Index; BA = Basal area.

**Table 3. Distribution of number of species, individuals and IVI with respect to family**

| Sl | Family | No. of Species | No. of Individuals | IVI | Sl | Family | No. of Species | No. of Individuals | IVI |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Euphorbiaceae | 12 | 131 | 12.97 | 26 | Poaceae | 2 | 62 | 5.09 |
| 2 | Fabaceae | 12 | 590 | 56.27 | 27 | Burseraceae | 2 | 89 | 11.47 |
| 3 | Rubiaceae | 11 | 75 | 9.11 | 28 | Flindersiaceae | 1 | 1 | 1.36 |
| 4 | Rutaceae | 7 | 30 | 4.79 | 29 | Cordiaceae | 1 | 2 | 1.42 |
| 5 | Lauraceae | 7 | 45 | 6.5 | 30 | Flacourtiaceae | 1 | 2 | 1.41 |
| 6 | Anacardiaceae | 7 | 120 | 15.94 | 31 | Linaceae | 1 | 2 | 1.44 |
| 7 | Meliaceae | 6 | 23 | 5.49 | 32 | Lythraceae | 1 | 2 | 1.4 |
| 8 | Annonaceae | 6 | 35 | 4.68 | 33 | Ochnaceae | 1 | 2 | 1.42 |
| 9 | Bignoniaceae | 6 | 52 | 7.87 | 34 | Pittosporaceae | 1 | 2 | 1.72 |
| 10 | Ebenaceae | 6 | 68 | 8.42 | 35 | Dipterocarpaceae | 1 | 3 | 1.53 |
| 11 | Moraceae | 5 | 6 | 3.13 | 36 | Capparaceae | 1 | 4 | 1.52 |
| 12 | Oleaceae | 5 | 19 | 3.91 | 37 | Melastomataceae | 1 | 4 | 2.17 |
| 13 | Verbenaceae | 5 | 59 | 8.61 | 38 | Asclepiadaceae | 1 | 5 | 2.24 |
| 14 | Combretaceae | 5 | 162 | 22.19 | 39 | Lecythidaceae | 1 | 6 | 1.96 |
| 15 | Araliaceae | 3 | 4 | 2.4 | 40 | Rhamnaceae | 1 | 6 | 2.29 |
| 16 | Sapotaceae | 3 | 11 | 2.92 | 41 | Bombacaceae | 1 | 7 | 4.51 |
| 17 | Apocynaceae | 3 | 12 | 2.6 | 42 | Stilaginaceae | 1 | 8 | 1.77 |
| 18 | Clusiaceae | 3 | 19 | 3.21 | 43 | Malvaceae | 1 | 10 | 2.68 |
| 19 | Myrtaceae | 3 | 115 | 11.87 | 44 | Arecaceae | 1 | 11 | 2.74 |
| 20 | Ehretiaceae | 2 | 4 | 1.61 | 45 | Cochlospermaceae | 1 | 11 | 2.46 |
| 21 | Samydaceae | 2 | 6 | 2.3 | 46 | Magnoliaceae | 1 | 23 | 6.37 |
| 22 | Urticaceae | 2 | 6 | 1.66 | 47 | Dilleniaceae | 1 | 59 | 8.58 |
| 23 | Loganiaceae | 2 | 7 | 3.24 | 48 | Tiliaceae | 1 | 84 | 8.73 |
| 24 | Celastraceae | 2 | 11 | 2.6 | 49 | Sapindaceae | 1 | 93 | 14.32 |
| 25 | Sterculiaceae | 2 | 21 | 5.11 | | | | | |

## Discussion

A total of 153 species, 112 genera and 49 families were stated in three 1-ha areas of the tropical forests in northern Andhra Pradesh. Species richness (52−110 species·ha$^{-1}$) and species diversity (5.68) of all the three sites are proportionately higher as compared to the other sites in the Eastern Ghats. The mean value of 80 species·ha$^{-1}$ recorded in the present study is higher than that of 43 species·ha$^{-1}$ in Shervarayan hills (Kadavul et al. 1999a), 47 to 61 species·ha$^{-1}$ in Nelliampathy (Chandrasehkara et al. 1994), 57 species·ha$^{-1}$ in Mylodai forest of Courtallum (Parthasarathy et al. 1997a). Species number per ha found in the present study is smaller in comparison results from Malaysian lowland rain forests, which have 164 and 176 species (Malaysia – Smith 1966), 150 species (Indonesia – Whitmore 1990), 223 and 214 species·ha$^{-1}$ (Malaysia - Proctor et al. 1983). The wide range of species number 52−110 found in the present study plots can be attributed to the change in elevation and bioclimatic variations. As compared to the tropics, neo-tropics show a much more complicated situation. In some 1-ha plots of tropical rain forests, 91 species (Guiana, Davis et al. 1933), 87 species (Brazil et al. 1950) and 83 species (Venezuela et al.1989) with gbh >10 cm were reported. This value is lower than that from the forest investigated in Xishuangbanna, SouthWest China with 119 species (Cao et al. 1997) and in present study (153 species). Such species diversity pattern may diminish as a function of altitude (Lieberman et al. 1996).

The mean stand density of 709 stems·ha$^{-1}$ in the present three plots and density in range of 639−836 stems·ha$^{-1}$ found in the tropical forests of northern Andhra Pradesh are well within the range of 276−905 stems·ha$^{-1}$ reported for trees ≥10 cm gbh in the tropics (Ghate et al. 1998). This range of stand density in the present study is higher, compared to other Eastern Ghats sites (Shervarayan hills, Kadavul et al. 1999a; Kalrayan hills, Kadavul et al. 1999b; Coromandel coast, Parthasarathy et al. 1997) and lower from other Western Ghats sites (Courtallam reserve forest, Parthasarathy et al. 1997a; Sengaltheri forest Parthasarathy 2001 and Kakachi reserve forest, Ganesh et al. 1996). Low stand density was observed in other tropical sites across the world, Costa Rica from 448 to 617 stems·ha$^{-1}$ (Heaney et al. 1990), Brazil from 420 to 777 stems·ha$^{-1}$ (Campbell et al. 1992), Malaysia from 250 to 500 stems·ha$^{-1}$ (Primack et al. 1992). The species-accumulation curve for the three different sites varied because of the changes in topography and rainfall. In site 1, species-accumulation curve clearly showed tendency towards flattening, compared to the other sites (Fig. 2). Similar patterns were noticed in different areas of the Eastern and Western Ghats (Kadavul et al. 1999a & b; Parthasarathy 1999; 2001).

The most obvious variation in tree species and the proportion of dominant species in the three sites can directly be attributed to altitudinal and rainfall distribution. Particularly species richness increases at moderate elevation. But beyond the altitude range, there is tendency towards decline (Giriraj et al. 2003); similar pattern was observed in site 2. In site 1 with less rainfall (*i.e.* low altitude), *Xylia xylocarpa*, *Lagerstroemia parviflora*, *Dillenia pentagyna* and *Anogeissus latifolia* are predominant species; In site 2 (*i.e.* medium altitude) with some moisture**,** there are indicating species like *Xylia xylocarpa*, *Bursera serrata*, *Terminalia alata* and *Pterocarpus marsupium*. In site 3, species with more evergreen element are composed of *Schleichera oleosa*, *Michelia champaca*, *Grewia tiliaefolia* and *Mangifera indica* because of high altitude and rainfall (Table 2). Species rarity (those represented by ≤2 individuals) of 41% obtained in the present study area is higher as compared to dry evergreen forest sites Kuzhanthaikuppam and Thirumanikkuzhi (26% and 31% respectively) on the Coromandel Coast (Parthasarathy et al. 1997b) and lower than that of (43%) Vellimalai, in the Kalrayan hills, Eastern Ghats (Kadavul et al. 1999b). This value is also lower than that of other tropical forests, 50% in West Java (Meijer 1959), 55.4% in New Guinea (Paijmans 1970), 59% in Jengka forest reserve, Malaysia (Ho et al. 1987).

The overall expanding population structure indicates that these sites have typical mature stands with good regeneration. This is in conformity with that of three tropical dry evergreen forests on the Coromandel coast, India (Parthasarathy et al. 1997b; Parthasarathy et al. 1997; Kadavul et al. 1999), and also with other forest inventories from Malaysia (Ho et al. 1987), Costa Rica (Lieberman et al. 2007; Nadkarni et al. 1995) and Brazilian Amazon (Swaine et al. 1987; Campbell et al. 1992). Current study identified 49 families and the most predominant families are Rubiaceae (12 species) and Fabaceae (12). There are similar predominance families to be recorded from Shervarayan hills (Kadavul et al. 1999a). Steege et al. (2000) and Martin et al. (1997) reported that Leguminosae is the most abundant family in neo-tropical forests. The top 10 families in this study have 53% of IVI value (159 out of 300), which include Euphorbiaceae, Rutaceae, Lauraceae and Anacardiaceae (Table 3). The number of similar families (49 families) was recorded by Santos et al. (2003) in Cachoeira forest, Campinas, São Paulo State, and the most important families of them were Myrtaceae (14 species), Rutaceae and Fabaceae (13).

Girth class frequency distribution showed an inverse 'J' shaped curve. The population structure of trees in all the three study sites are in conformity with that of many other forest stands in the Eastern and Western Ghats such as Shervarayan hills (Kadavul et al. 1999a); Kalrayan hills (Kadavul et al. 1999b); Kakachi (Ganesh et al. 1996); Uppangala (Pascal et al. 1996); Mylodai-Courtallum reserve forest (Parthasarathy et al. 1997a). In Site 3, large size poles (*i.e.* >120 cm having 104 individuals) have attained greatest biovolume increment due to less competition among saplings and also large spacing between trees.

## Conclusions

Quantitative floristic data from the present study are highly useful for the forest management practices. Presence of high species richness and diversity, mean stand density and species rarity indicates the uniqueness and potentiality of Sileru-Maredumilli

hills for conservation of ecosystem in its totality. The problem of different anthropogenic activities like intentional forest fire, tree cutting, lopping, grazing, fuel wood extraction, medicinal plants collection is observed in periphery of study sites, which should be checked practically and must be given highest priority for habitat conservation. The primitive tribes residing in the study area are solely dependent on these forests for their livelihood. The immediate attention on people's participation is most essential for effective conservation. The present study will serve as a primary input towards further study on biodiversity characterization, gradient based community structure, carbon pool assessment, etc. These hill ranges need to be included under Protected Area Network (PAN) in view of their naturalness and possible threat of anthropogenic pressure. Further, there is need of thorough study on spatial distribution pattern, ecological niches, pollination, germination compatibility, phenology of flora in addition to utilization of geoinformatics for decision making and monitoring of natural resources.

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**Appendix 1. Population of all woody species ≥ 10 cm gbh in three study sites**

| Sl | Species | Site 1 | Site 2 | Site 3 | Total |
|---|---|---|---|---|---|
| 1 | *Xylia xylocarpa* (Roxb.) Taub. (Fabaceae) | 131 | 211 | --- | 342 |
| 2 | *Pterocarpus marsupium* Roxb. (Fabaceae) | 20 | 46 | 63 | 129 |
| 3 | *Schleichera oleosa* (Lour) Oken (Sapindaceae) | 16 | 9 | 68 | 93 |
| 4 | *Grewia tiliaefolia* Vahl (Tiliaceae) | 3 | 37 | 44 | 84 |
| 5 | *Terminalia alata* Heyne ex Roth. (Combretaceae) | 19 | 36 | 16 | 71 |
| 6 | *Lagerstroemia parviflora* Roxb. (Myrtaceae) | 64 | 2 | --- | 66 |
| 7 | *Bursera serrata* Wall.ex Colebr. (Burseraceae) | --- | 62 | --- | 62 |
| 8 | *Dillenia pentagyna* Roxb. (Dilleniaceae) | 39 | 13 | 7 | 59 |
| 9 | *Mallotus philippensis* (Lam) Muell.- Arg. (Euphorbiaceae) | --- | 9 | 45 | 54 |
| 10 | *Buchanania lanzan* (Roxb.) (Anacardiaceae) | 41 | 8 | 1 | 50 |
| 11 | *Dendrocalamus strictus* (Roxb.) Nees (Poaceae) | 40 | 10 | --- | 50 |
| 12 | *Syzygium cumini* (L.) Skeels (Myrtaceae) | 1 | 31 | 16 | 48 |
| 13 | *Gmelina arborea* Roxb. (Verbenaceae) | 11 | 7 | 27 | 45 |
| 14 | *Cassia fistula* L. (Fabaceae) | --- | 6 | 37 | 43 |
| 15 | *Ouigenia ougenensis* (Roxb.) Hochr. (Fabaceae) | --- | 29 | 13 | 42 |
| 16 | *Diospyros sylvatica* Roxb. (Ebenaceae) | 6 | 25 | 10 | 41 |
| 17 | *Anogeissus latifolia* (Roxb. ex DC.) Wall ex Guill. & Perr. (Combretaceae) | 31 | 6 | --- | 37 |
| 18 | *Cleistanthus collinus* (Roxb.) Hook f. (Euphorbiaceae) | 29 | --- | --- | 29 |

**Continued Appendix 1**

| Sl | Species | Site 1 | Site 2 | Site 3 | Total |
|---|---|---|---|---|---|
| 19 | *Litsea glutinosa* (Lour) Robinson (Lauraceae) | 2 | 8 | 19 | 29 |
| 20 | *Garuga pinnata* Roxb. (Burseraceae) | 4 | --- | 23 | 27 |
| 21 | *Terminalia chebula* Retc. (Combretaceae) | 5 | 7 | 14 | 26 |
| 22 | *Terminalia bellirica* (Gaertn.) Roxb. (Combretaceae) | 16 | 3 | 6 | 25 |
| 23 | *Mangifera indica* L. (Anacardiaceae) | --- | 6 | 17 | 23 |
| 24 | *Michelia champaca* L. (Magnoliaceae) | --- | 1 | 22 | 23 |
| 25 | *Oroxylum indicum* (L.) Vent. (Bignoniaceae) | --- | 9 | 14 | 23 |
| 26 | *Semecarpus anacardium* L.f. (Anacardiaceae) | 8 | 13 | --- | 21 |
| 27 | *Sterculia villosa* Roxb. ex DC. (Sterculiaceae) | --- | 7 | 13 | 20 |
| 28 | *Miliusa tomentosa* (Roxb.) Sinclair (Annonaceae) | --- | 11 | 8 | 19 |
| 29 | *Haldinia cordifolia* (Roxb.) Ridsd. (Rubiaceae) | 6 | 9 | 3 | 18 |
| 30 | *Bridelia retusa* (L.) Spreng. (Euphorbiaceae) | 9 | 7 | --- | 16 |
| 31 | *Garcinia xanthochymus* Hook.f. ex.T. (Clusiaceae) | --- | --- | 16 | 16 |
| 32 | *Gardenia latifolia* Ait. (Rubiaceae) | 13 | 2 | 1 | 16 |
| 33 | *Macaranga peltata* (Roth) Jacobs (Euphorbiaceae) | --- | 8 | 7 | 15 |
| 34 | *Zanthoxylum rhetsa* (Roxb.) DC. (Rutaceae) | --- | 15 | --- | 15 |
| 35 | *Dalbergia latifolia* Roxb. (Fabaceae) | 10 | 4 | --- | 14 |
| 36 | *Diospyros melanoxylon* Roxb. (Ebenaceae) | 12 | --- | 2 | 14 |
| 37 | *Bambusa arundinacea* (Retz.) Roxb. (Poaceae) | --- | 12 | --- | 12 |
| 38 | *Dolichandrone atrovirens* (Roth.) Sprague (Bignoniaceae) | --- | 2 | 10 | 12 |
| 39 | *Caryota urens* L. (Arecaceae) | --- | 8 | 3 | 11 |
| 40 | *Cochlospermum religiosum* (L.) Alston (Cochlospermaceae) | 11 | --- | --- | 11 |
| 41 | *Lannea coromondelica* (Houtt.) Merr. (Anacardiaceae) | 7 | 3 | 1 | 11 |
| 42 | *Mitragyna parvifolia* (Roxb.) Korth. (Rubiaceae) | 8 | 3 | --- | 11 |
| 43 | *Nothopegia heyneana* (Hook.f) (Anacardiaceae) | --- | 3 | 8 | 11 |
| 44 | *Stereospermum chelinoides* (L.f.) A.DC. (Bignoniaceae) | 6 | 5 | --- | 11 |
| 45 | *Aphanamixis polystachya* (Wall.) Parker (Meliaceae) | --- | 3 | 7 | 10 |
| 46 | *Cassine glauca* (Rottb.) O. Kuntz (Celastraceae) | --- | 4 | 6 | 10 |
| 47 | *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G.Don (Apocynaceae) | 10 | --- | --- | 10 |
| 48 | *Kydia calycina* Roxb. (Malvaceae) | --- | 2 | 8 | 10 |
| 49 | *Morinda pubescens* J.E.Smith. (Rubiaceae) | 3 | 4 | 3 | 10 |
| 50 | *Polyalthia cerasoides* (Roxb.)Bedd. (Annonaceae) | --- | 10 | --- | 10 |
| 51 | *Schrebera sweitinioides* Roxb. (Oleaceae) | --- | 10 | --- | 10 |
| 52 | *Hymenodictyon excelsa* (Roxb.) Wall. (Rubiaceae) | 8 | 1 | --- | 9 |
| 53 | *Madhuca indica* J.F. Gmel. (Sapotaceae) | 4 | 5 | --- | 9 |
| 54 | *Aegle marmelos* (L.) Correa (Rutaceae) | 7 | 1 | --- | 8 |
| 55 | *Antidesma menasu* Miq. (Stilaginaceae) | --- | --- | 8 | 8 |
| 56 | *Bombax ceiba* L. (Bombacaceae) | 1 | 3 | 3 | 7 |
| 57 | *Callicarpa arborea* Roxb. (Verbenaceae) | --- | 1 | 6 | 7 |
| 58 | *Careya arborea* Roxb. (Lecythidaceae) | 6 | --- | --- | 6 |
| 59 | *Ziziphus xylopyrus* (Retz.) Willd. (Rhamnaceae) | --- | 3 | 3 | 6 |
| 60 | *Albizzia odoratissima* (L.f.) Benth. (Fabaceae) | 3 | 1 | 1 | 5 |
| 61 | *Bridelia tomentosa* L. (Euphorbiaceae) | --- | --- | 5 | 5 |
| 62 | *Cinnamomum caudatum* Nees. (Lauraceae) | --- | 2 | 3 | 5 |
| 63 | *Diospyros montana* Roxb. (Ebenaceae) | --- | 4 | 1 | 5 |
| 64 | *Holarrhena antidysenterica* Wall. ex DC. (Asclepiadaceae) | --- | 2 | 3 | 5 |
| 65 | *Trema orientalis* (L.) Blume (Urticaceae) | --- | --- | 5 | 5 |
| 66 | *Bauhinia malabarica* Roxb. (Fabaceae) | 3 | 1 | --- | 4 |
| 67 | *Casearia elliptica* Willd. (Samydaceae) | --- | 4 | --- | 4 |
| 68 | *Cipadessa baccifera* (Roth) Miq. (Meliaceae) | --- | 1 | 3 | 4 |
| 69 | *Diospyros peregrina* (Gaertn.) Guerke (Ebenaceae) | 3 | 1 | --- | 4 |
| 70 | *Emblica officinalis* Gaertn. (Euphorbiaceae) | --- | 4 | --- | 4 |
| 71 | *Litsea monopetala* (Roxb.) Pers (Lauraceae) | --- | 1 | 3 | 4 |

**Continued Appendix 1**

| Sl | Species | Site 1 | Site 2 | Site 3 | Total |
|---|---|---|---|---|---|
| 72 | *Maerua apetala* (Roth) Jacobs (Capparaceae) | --- | --- | 4 | 4 |
| 73 | *Memecylon edule* Roxb. (Melastomataceae) | --- | 1 | 3 | 4 |
| 74 | *Olea glandulifera* Wall.ex. G.Don (Oleaceae) | --- | 1 | 3 | 4 |
| 75 | *Phoebe lanceolata* Nees. (Lauraceae) | --- | 4 | --- | 4 |
| 76 | *Radermarchera xylocarpa* (Roxb.) Schum. (Bignoniaceae) | --- | 4 | --- | 4 |
| 77 | *Strychnos potatorum* L.f. (Loganiaceae) | 2 | 1 | 1 | 4 |
| 78 | *Trichilia connaroides* (Wight & Arn.) Bentvelizen (Meliaceae) | --- | 4 | --- | 4 |
| 79 | *Vitex altissima* L.f. (Verbenaceae) | 1 | 3 | --- | 4 |
| 80 | *Alphonsea maderaspatna* Bedd. (Annonaceae) | --- | --- | 3 | 3 |
| 81 | *Bauhinia racemosa* Lam (Fabaceae) | --- | 3 | --- | 3 |
| 82 | *Bauhinia semla* Wunderl. (Fabaceae) | --- | --- | 3 | 3 |
| 83 | *Dalbergia paniculata* Roxb. (Fabaceae) | 1 | 1 | 1 | 3 |
| 84 | *Ehretia laevis* Roxb. (Ehretiaceae) | --- | --- | 3 | 3 |
| 85 | *Gardenia gummifera* L.f. (Rubiaceae) | 3 | --- | --- | 3 |
| 86 | *Gardenia resinifera* Roth (Rubiaceae) | 3 | --- | --- | 3 |
| 87 | *Knema attenuata* (Hk. & thw.) Warb. (Dipterocarpaceae) | --- | 3 | --- | 3 |
| 88 | *Limonia crenulata* Roxb. (Rutaceae) | --- | 2 | 1 | 3 |
| 89 | *Strychnos nux-vomica* L. (Loganiaceae) | 3 | --- | --- | 3 |
| 90 | *Terminalia paniculata* Roth (Combretaceae) | --- | --- | 3 | 3 |
| 91 | *Artocarpus heterophyllus* Lam. (Moraceae) | --- | 2 | --- | 2 |
| 92 | *Buchanania angustifolia* Roxb. (Anacardiaceae) | 1 | 1 | --- | 2 |
| 93 | *Casearia graveolens* Dalz. (Samydaceae) | --- | 1 | 1 | 2 |
| 94 | *Chionanthus malabarica* (Wall.ex G.Don) Bedd. (Oleaceae) | 1 | 1 | --- | 2 |
| 95 | *Cordia macleodii* Hook. F & Thoms (Cordiaceae) | --- | 2 | --- | 2 |
| 96 | *Diospyros assimilis* Bedd. (Ebenaceae) | --- | --- | 2 | 2 |
| 97 | *Diospyros candollena* Wight (Ebenaceae) | --- | --- | 2 | 2 |
| 98 | *Drypetes sepiaria* (Wight & Arn.) Pax & Hoffm (Euphorbiaceae) | --- | --- | 2 | 2 |
| 99 | *Flacourtia indica* (Burm.f.) Merr. (Flacourtiaceae) | --- | 2 | --- | 2 |
| 100 | *Garcinia spicata* (Wight & Arn.) Hook.f. (Clusiaceae) | --- | --- | 2 | 2 |
| 101 | *Ochna squarrosa* Linn. (Ochnaceae) | 2 | --- | --- | 2 |
| 102 | *Olea polygama* Wight (Oleaceae) | --- | 2 | --- | 2 |
| 103 | *Pittosporum nepaulense* (DC.) Rehder & Wilson (Pittosporaceae) | --- | 2 | --- | 2 |
| 104 | *Premna integrifolia* Linn. (Verbenaceae) | --- | 2 | --- | 2 |
| 105 | *Schefflera stellata* (Gaertn.) Harms (Araliaceae) | --- | 2 | --- | 2 |
| 106 | *Soymida febrifuga* (Roxb.) A.Juss. (Anacardiaceae) | 2 | --- | --- | 2 |
| 107 | *Suregada multiflora* (Juss.) Bail. (Euphorbiaceae) | --- | --- | 2 | 2 |
| 108 | *Toona ciliata* Roem. (Meliaceae) | --- | --- | 2 | 2 |
| 109 | *Walsura trifolia* (A.Juss.) Harms (Meliaceae) | --- | 1 | 1 | 2 |
| 110 | *Wendlandia heynei* (Roem.&Schult.) Santapau & Merchant (Rubiaceae) | --- | 2 | --- | 2 |
| 111 | *Woodfordia fruticosa* (L.) Kurz. (Lythraceae) | --- | 2 | --- | 2 |
| 112 | *Ximenia americana* L. (Linaceae) | --- | 2 | --- | 2 |
| 113 | *Acronychia pedunculata* (L.) Miq (Rutaceae) | --- | 1 | --- | 1 |
| 114 | *Actinodaphne maderaspatana* Bedd. ex Hook.f. (Lauraceae) | --- | --- | 1 | 1 |
| 115 | *Albizzia procera* (Roxb.) Benth. (Fabaceae) | --- | 1 | --- | 1 |
| 116 | *Alphonsea sclerocarpa* Thw. (Annonaceae) | --- | --- | 1 | 1 |
| 117 | *Alstonia scholaris* (L.) R.Br (Apocynaceae) | --- | 1 | --- | 1 |
| 118 | *Anthocephalus chinensis* (Osbeck) Merr. (Rubiaceae) | --- | --- | 1 | 1 |
| 119 | *Atalantia monophylla* (L.) Correa (Rutaceae) | --- | 1 | --- | 1 |
| 120 | *Beilschmiedia roxburghiana* Nees (Lauraceae) | --- | 1 | --- | 1 |
| 121 | *Bischofia javanica* Blume (Euphorbiaceae) | --- | --- | 1 | 1 |
| 122 | *Celastrus paniculatus* Willd. (Celastraceae) | --- | 1 | --- | 1 |
| 123 | *Chloroxylon swietenia* Dc. (Flindersiaceae) | --- | --- | 1 | 1 |
| 124 | *Chrysophyllum roxburghii* Don. (Sapotaceae) | --- | 1 | --- | 1 |
| 125 | *Cleistanthus patulus* (Roxb.) Muell-Arg. (Euphorbiaceae) | --- | --- | 1 | 1 |

**Continued Appendix 1**

| Sl | Species | Site 1 | Site 2 | Site 3 | Total |
|---|---|---|---|---|---|
| 126 | *Deccania pubescens* (Roth) Tirveng. (Rubiaceae) | --- | 1 | --- | 1 |
| 127 | *Drypetes roxburghii* (Wall.) Hurusawa (Euphorbiaceae) | --- | 1 | --- | 1 |
| 128 | *Ehretia acuminata* R.Br. (Ehretiaceae) | --- | --- | 1 | 1 |
| 129 | *Erythrina suberosa* Roxb. (Fabaceae) | 1 | --- | --- | 1 |
| 130 | *Ficus asperrima* Roxb. (Moraceae) | --- | --- | 1 | 1 |
| 131 | *Ficus benghalensis* L. (Moraceae) | 1 | --- | --- | 1 |
| 132 | *Ficus oligodon* Miq. (F. pomifera Wall ex.King) (Moraceae) | --- | --- | 1 | 1 |
| 133 | *Ficus virens* Ait. (Moraceae) | --- | 1 | --- | 1 |
| 134 | *Garcinia cambogia* Desr. (Clusiaceae) | --- | 1 | --- | 1 |
| 135 | *Glochidion zeylanicum* (Gaertn.) Juss (Euphorbiaceae) | --- | 1 | --- | 1 |
| 136 | *Heterophragma roxburghii* DC. (Bignoniaceae) | --- | 1 | --- | 1 |
| 137 | *Isonandra villosa* Wight (Sapotaceae) | --- | 1 | --- | 1 |
| 138 | *Ligustrum gamblei* Ramam. (Oleaceae) | --- | 1 | --- | 1 |
| 139 | *Limonia acidissima* L. (Rutaceae) | --- | 1 | --- | 1 |
| 140 | *Limonia alata* Wall. ex Wt. & Arn (Rutaceae) | --- | --- | 1 | 1 |
| 141 | *Litsea deccanensis* Gamble (Lauraceae) | --- | 1 | --- | 1 |
| 142 | *Miliusa velutina* Hook.f. & Thoms (Annonaceae) | --- | 1 | --- | 1 |
| 143 | *Polyalthia suberosa* (Roxb.)Thw. (Annonaceae) | --- | 1 | --- | 1 |
| 144 | *Schefflera clarkiana* Craib (Araliaceae) | --- | --- | 1 | 1 |
| 145 | *Schefflera roxburghii* Gamble (Araliaceae) | --- | 1 | --- | 1 |
| 146 | *Sterculia urens* Roxb. (Sterculiaceae) | 1 | --- | --- | 1 |
| 147 | *Stereospermum colais* (Dillwyn) Mabb. (Bignoniaceae) | 1 | --- | --- | 1 |
| 148 | *Syzygium heyneanum* (Duthie) Wall.ex Gamble (Myrtaceae) | --- | 1 | --- | 1 |
| 149 | *Tectona grandis* L.f. (Verbenaceae) | --- | 1 | --- | 1 |
| 150 | *Trewia nudiflora* L. (Urticaceae) | --- | --- | 1 | 1 |
| 151 | *Wendlandia thyrsoidea* (Roem.&Schult.) Santapau & Merchant (Rubiaceae) | --- | 1 | --- | 1 |
| 152 | *Wrightia arborea* (Dennst.) Mabb. (Apocynaceae) | --- | 1 | --- | 1 |
| 153 | *Xylosma longifolium* Clos (Meliaceae) | --- | --- | 1 | 1 |
| | **Grand Total** | **639** | **836** | **654** | **2129** |