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Floristic inventory of woody plants in a tropical montane (shola) forest in the Palni hills of the Western Ghats, India

PRIYA DAVIDAR[1*], D. MOHANDASS[1] & S. LALITHA VIJAYAN[2]

[1]Department of Ecology and Environmental Sciences, Pondicherry University, Puducherry 605 014, India; [2]Salim Ali Center for Ornithology and Natural History, Anaikattty P.O., Coimbatore 641 108, India

Abstract: Woody plants (≥ 1 cm dbh) were inventoried in December 2004 in a tropical montane (shola) forest in the Kukkal Reserve Forest, Palni hills, India. Twelve randomly placed 30 × 30 m plots were used for sampling the vegetation. The total area sampled was 1.08 ha. All woody stems were permanently tagged and dbh at 1.3 m above ground level was recorded. Identifications were made using floras and confirmed at herbaria. The sampling adequately captured the species diversity in the shola. The species abundance distribution did not differ significantly from log normal indicative of a diverse tropical community. A total of 2279 stems belonging to 83 species, 68 genera and 40 families were inventoried. Of these, 16 species from 12 genera and 12 families were lianas. About 30% of the species were endemic to the Western Ghats. Species diversity as measured by Fisher's alpha index was 13.15 for trees and 4.54 for lianas, and basal area was 62 m^2 ha^{-1} for trees and 0. 58 m^2 ha^{-1} for lianas. The most abundant species (≥ 1 cm dbh) was *Psychotria nilgiriensis* var. *astephana* (Rubiaceae), which accounted for 12% of the stems sampled. *Xantolis tomentosa* var. *elengioides* had the largest basal area. Lauraceae was the dominant family accounting for 20% of the stems. Montane evergreen forests, which are unique to the higher elevations of the Western Ghats, should be conserved on a priority basis.

Resumen: En diciembre de 2004 se llevó a cabo un inventario de las plantas leñosas (≥ 1 cm dap) en un bosque montano tropical (shola) en la Reserva Forestal Kukkal, colinas Palni, India. Para el muestreo de la vegetación se usaron doce parcelas de 30 x 30 m colocadas de forma aleatoria. El área total muestreada fue 1.08 ha. En todos los tallos leñosos se colocaron marcas permanentes y se registró su diámetro a un altura de 1.3 m sobre el piso (dap). Las identificaciones se hicieron usando floras y fueron confirmadas en herbario. El muestreo capturó de forma adecuada la diversidad de especies en el shola. La distribución de la abundancia de las especies no difirió significativamente de la log normal, indicando una comunidad tropical diversa. En total se inventariaron 2279 tallos pertenecientes a 83 especies, 68 géneros y 40 familias. De éstos, 16 especies de 12 géneros y 12 familias fueron lianas. Alrededor de 30% de las especies resultaron ser endémicas de los Gates Occidentales. La diversidad de especies, medida a través del índice alfa de Fisher, fue 13.15 para los árboles y 4.54 para las lianas, y el área basal fue 62 m^2 ha^{-1} para los árboles y 0.58 m^2 ha^{-1} para las lianas. La especie más abundante (≥ 1 cm dap) fue *Psychotria nilgiriensis* var. *astephana* (Rubiaceae), la cual representó 12% de los tallos muestreados. *Xantolis tomentosa* var. *elegnioides* tuvo la mayor área basal. Lauraceae fue la familia dominante, representando 20% de los tallos. Los bosques montanos perennifolios, exclusivos de las porciones más elevadas de los Gates Occidentales, deberían ser conservados de forma prioritaria.

* *Corresponding Author*; e-mail: pdavidar@gmail.com

Resumo: Em Dezembro de 2004 foram inventariadas as plantas lenhosas (≥ 1 cm DHP) de uma floresta tropical montana (shola) na Reserva Florestal de Kukka, nas colinas de Palni na Índia. Para amostragem da vegetação foram usadas doze parcelas casuais de 30 x 30 m. A área amostrada total foi de 1,08 ha. Todos os caules lenhosos foram marcados permanentemente e os DHP, a 1,3 m acima do solo, foram registados. As identificações foram efectuadas com recurso a floras e confirmadas no herbário. A amostragem capturou adequadamente a diversidade específica na "shola". A distribuição da abundância específica não diferiu significativamente da distribuição logarítmica normal indicativa da comunidade tropical. Foram inventariados um total de 2279 troncos pertencendo a 83 espécies, 68 géneros e 40 famílias. Destes, 16 espécies de 12 géneros e 12 famílias eram lianas. Cerca de 30% das espécies eram endémicas dos Gates Ocidentais. A diversidade das espécies, medida pelo índex alfa de Fisher, foi de 13,15 para as árvores e 4,54 para as lianas sendo a área basal de 62 m^2ha^{-1} para as árvores e 0,58 m^2ha^{-1} para as lianas. A espécie mais abundante (≥ 1 cm DHP) foi a *Psychotria nilgiriensis* var. *astephana* (Rubiaceae) que representava 15 dos caules amostrados. A *Xantolis tomentosa* var. *elegnioides* tinha a área basal maior. As Lauraceae eram a família representando 20% dos troncos. As florestas montanas sempre verdes, que são únicas nas elevações mais elevadas dos Gates Ocidentais devem ser conservadas numa base prioritária.

Key words: India, Palni hills, plant inventory, sholas, species diversity, tropical montane forest, western ghats.

Introduction

Many quantitative plant inventories have been undertaken in tropical forests (Ashton 1977; Condit *et al.* 1996; Duivenvoorden 1994; Gentry 1982, 1988; Phillips & Gentry 1994; Valencia *et al.* 1994). These provide useful information on the distribution and abundance of species and insights into processes that control tree diversity in tropical rain forests (Davidar *et al.* 2005; Duivenvoorden 1994; Gentry 1982, 1988; Phillips & Gentry 1994; ter Steege *et al.* 2003; Valencia *et al.* 1994).

Permanent plots have been found to be very useful for inventorying plant species and for monitoring forest dynamics over time (Condit 1995). Large plots are more efficient at sampling rare species, whereas small plots are useful in sampling variation in species distribution over larger scales (Condit 1995). Both large and small permanent-plot tree inventories have been used in forests in the Indian subcontinent. In lowland rain forests, a large 30-ha permanent plot in Varagaliar (Ayyappan & Parthasarathy 1999), a 3.12 ha plot in Uppangala Reserve Forest, Karnataka (Pascal & Pelissier 1996), and a 50 ha permanent plot in the dry forest of Mudumalai Wildlife Sanctuary (Sukumar *et al.* 1992) are part of these initiatives. Plot inventories of woody plants have not been conducted in the shola forests of the Palni hills so far, and this is the first attempt to do so.

The upper ranges of the Nilgiris and Palnis are noted for their unique flora. The characteristic vegetation is the tropical montane evergreen forests, known also as the shola forest. The sholas are dense evergreen forests, which occur naturally as patches confined to valleys, hollows and depressions of the mountains, separated by rolling grasslands. The shola trees are of rain forest origin and are robust and branchy with dense crowns. Branches are very often clothed with epiphytes: moss, ferns, lichens and orchids.

Blasco (1970) has recorded 223 plant species known only from the sholas and grasslands of the higher altitude ranges of the western ghats. The shola forest harbors many endemic and rare plant species that cannot regenerate in grasslands and exposed sites due to lack of tolerance to fire and frost (Meher-Homji 1967). The extent of shola forests has dwindled in the past century due mainly to conversion to plantations. Current threats are from livestock grazing, fuel-wood harvest and agricultural expansion. Therefore, it is important to conduct floristic analysis of shola forests and to monitor populations over time using

permanent plots. Such information can help in the conservation and management of shoal forest. We conducted an inventory of woody plant species in Kukkal shola of the Palni Hills and assessed floristic richness, stem densities, species diversity, endemism, and basal area.

Study area

The study area was located in the Palni Hills, a mountain range in southern India, which is an eastward extension of the Western Ghats (Fig. 1). The Palni Hills covers an area of 2000 km^2 and the upper Palnis have an average elevation of ~2000 m. The underlying geological formations are pre-Cambrian in origin and are comprised of mainly metamorphic rocks, gneisses, charnockites and crystalline schists. The soil texture varies from clay to clay-loam and soils are acidic in nature and contain a high percentage of iron and alumina. Accumulation of humus in the top layers of the shola soil gives it a black color (Meher-Homji 1967).

This study was carried out in Kukkal shola which is part of the Kukkal Reserve Forest located at latitude 10° 16' N and longitude 77° 22' E about 33 km from Kodaikanal, the main township in the Palni hills (Fig. 1). Elevation within the shola range between 1812 and 2005 m amsl. The original extent of the Kukkal shola was over 300 ha but it has been extensively destroyed in places due to agricultural expansion, livestock grazing, harvesting of fuel-wood and other products (Matthew 1999). The undisturbed section of the shola is <100 ha in area.

Rainfall is received from both the SW and NE monsoon winds. Mean annual rainfall for Kodaikanal over a four-year period (2001-2004) was 1690 mm (Fig. 2). The dry season, defined as the number of continuous months with <100 mm

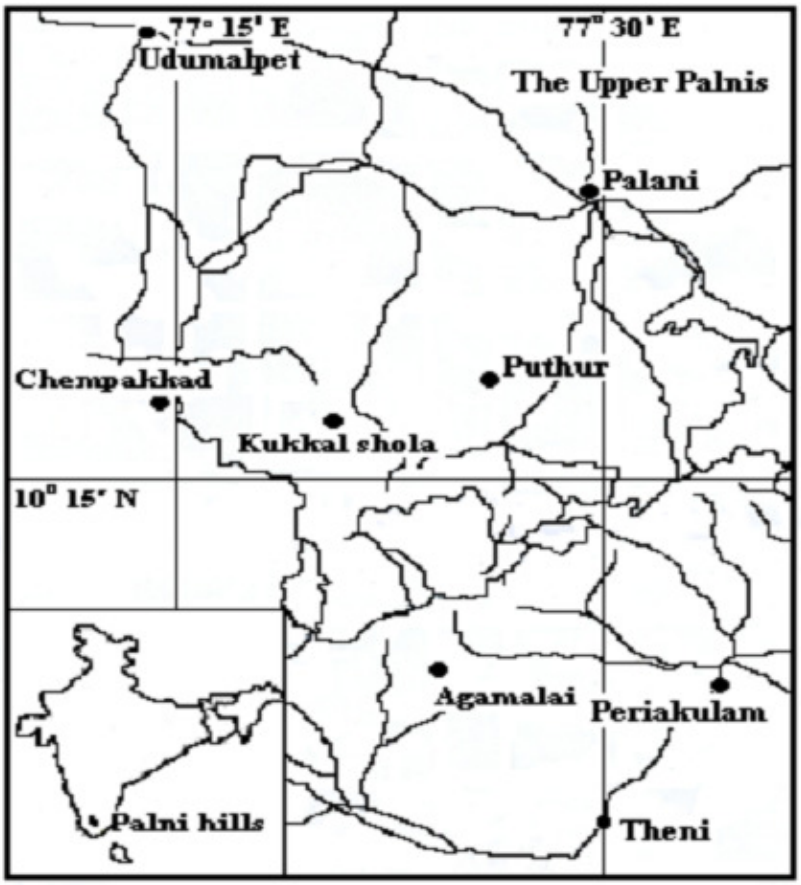

Fig. 1. Map of the Palni Hills with the location of Kukkal shola (scale 1:250,000).

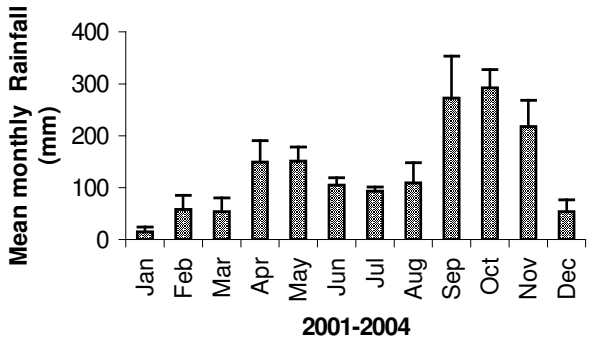

Fig. 2. Mean monthly rainfall in the study region (± S. E.) for five years (2001 to 2004) obtained from the Department of Meteorology and Statistics, Govt. of Tamilnadu, India.

average rainfall, was from December through March with a shorter period in July (Fig. 2).

Materials and methods

We carried out the inventory of woody plants in December 2004 using 12 plots of dimension 30 × 30 m covering a total area of 1.08 ha. Multiple smaller plots enabled us to sample a larger diversity of habitats within the shola than would just one large plot. The plot dimensions were adjusted for slope. The 12 plots were randomly selected in the relatively undisturbed areas of Kukkal. Among the 12 plots, 3 were in moderately disturbed sites, and the rest in undisturbed sites. Each plot was divided into 10 x 10 m subplots and all stems ≥ 1 cm dbh (≥ 3 cm girth at breast height) were identified and their girth measured at 1.3 m above the ground level. The girth was converted to dbh for the analysis. Each stem individual was tagged with sequentially numbered aluminum tags. In the case of trees that branch below 1.3 m, each branch was measured and tagged separately. All tagged individuals were identified to species using various floras (Fyson 1932; Gamble 1935; Matthew 1999). Nomenclature of species followed the Flora of Tamilnadu and Flora of Palni hills (Henry *et al.* 1987; Henry *et al.* 1989; Matthew 1999; Nair & Henry 1983). The identity of each voucher specimen was confirmed at the herbaria of the Botanical Survey of India, Coimbatore and at the French Institute of Pondicherry. A specimen of each species was deposited in the herbarium at the Department of Ecology and Environmental Sciences, Pondicherry University.

The data for all the plots were consolidated and the total number of species and the number of stems were estimated. Basal area per individual at 1.3 m above the ground was calculated using the formula: $(Dbh)^2 *(\pi/4)$. The basal area of all stems was summed and the total adjusted to 1 ha to give basal area estimates for one ha of shola forest (m^2 ha^{-1}). In plants that branch below 1.3 m above the ground, two calculations were made: the first using only the main trunk and the second using the trunk and branches as is the convention for floristic studies in India.

Fisher's alpha was used to assess species diversity since it is fairly independent of plot size (Dallmeier & Comiskey 1998; Fisher *et al.* 1943). To see whether the species abundance pattern followed a log normal distribution, the number of individuals per species was transformed into logarithmic values using base 10, and the species abundance distribution was tested for normality. The geographical distribution of species was noted from the literature (Ahmedullah & Nayar 1986; Matthew 1999; Ng 1978; Ramesh *et al.* 1997; Saldanha 1996; Whitmore 1972, 1973).

Results and discussion

Shola forest structure

The Kukkal shola was a closed canopy forest and the sampled area within the 12 plots had closed canopies without gaps. The emergent trees, consisting predominantly of *Xantolis tomentosa* var. *elengioides*, *Cassine paniculata* and *Beilschmiedia wightii*, were about 25 to 30 m in height. The canopy layer was formed of species such as *Olea paniculata, Beilschmiedia wightii* and *Phoebe paniculata* with an average height of about 20 m. The understorey consisted of small trees of about 5 m in height. The 21 largest trees with dbh >100 cm were *Xantolis tomentosa, Cinnamomum perrottetii, Olea paniculata, Beilschmiedia wightii* and *Cassine paniculata.*

Species richness, density and basal area

The cumulative species-area curve reached an asymptote within nine plots (Fig. 3). The species abundance distribution did not differ significantly from a log normal, but there was an excess of species with only one record (Fig. 4), typical of species rich tropical forests. These results also

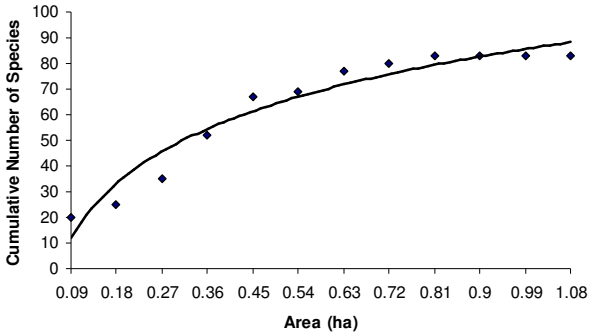

Fig. 3. The accumulation of species with increasing number of plots. The number of new species reaches an asymptote in nine plots (0.81 ha).

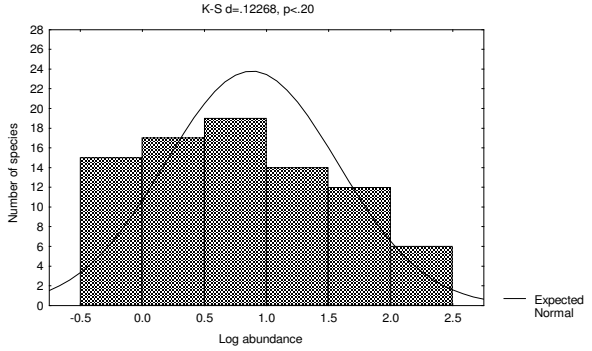

Fig. 4. Log_{10} abundance distribution of species. The log abundance distribution does not significantly differ from a log normal distribution.

demonstrate that the sampling protocol used in this inventory efficiently captured the species diversity in Kukkal shola.

A total of 2279 woody plants belonging to 83 species, 68 genera and 40 families were inventoried in the 1.08 ha (Table 1). Of these, 2130 were trees belonging to 67 species, 56 genera and 33 families and 149 were lianas belonging to 16 species, 12 genera and 12 families. When only stems ≥ 10 cm dbh were considered, there were 45 tree species in 36 genera and 23 families (Table 1). Trees with branches <1.3 m above the ground constituted 14% of the plants sampled.

Overall Fisher's alpha was 16.9 and of this 13.15 was for trees and 4.54 for lianas (Table 1). In the ≥1 cm dbh class, basal area for all species was 62.01 m^2 ha^{-1}, and of this 61.42 m^2 ha^{-1} was for trees and 0.58 m^2 ha^{-1} for lianas. For the ≥ 10 cm dbh class the basal area was 58.76 m^2 ha^{-1}. When branches were included for plants branching below 1.3 m above ground, the basal area was 66.06 m^2 ha^{-1}m for the ≥1 cm dbh class, and 61.92 m^2 ha^{-1} for the ≥10 cm dbh class (Table 1).

The most abundant species was *Psychotria nilgiriensis* var. *astephana* (Rubiaceae), which accounted for 12% of the stems sampled, followed by *Maesa indica (*Myrsinaceae), which accounted for 10% of the stems (Appendix 1). *Xantolis tomentosa* (Roxb) Rafin var. *elengioides* (A. DC.) had the highest basal area.

Species richness and diversity decreased with increasing tree-diameter size class. The ≥ 1 to < 5 cm dbh class had the most species but the lowest basal area, whereas the ≥ 30 cm dbh class had fewer species but high basal area (Table 2). Therefore, basal area values are contributed disproportionately by large trees >30 cm dbh, whereas smaller trees and shrubs increase the diversity of species.

Among the 40 families, Lauraceae (16%), Rubiaceae (7%), Myrsinaceae (4%), Symplocaceae (4%), Myrtaceae (4%) and Oleaceae (4%) contributed the most stems (Table 3). Lauraceae

Table 1. Inventory details of woody plants in Kukkal Reserve Forest, Palni Hills.

Category	All species (dbh)		Trees and shrubs (dbh)		Lianas (dbh)	
Lower dbh	≥ 1 cm	≥ 10 cm	≥1 cm	≥10 cm	≥1 cm	≥10 cm
Number of Individuals	2279	500	2130	487	149	13
Plants ha^{-1}	2110	463	1972	451	138	12
Species richness	83	49	67	45	16	4
Number of genera	68	40	56	36	12	4
Number of families	40	27	33	23	12	4
Fisher 's alpha	16.9	13.45	13.15	12.1	4.54	1.97
Basal area (m^2 ha^{-1}) main trunk	62.01	58.76	61.42	58.47	0.58	0.29
Basal area (m^2 ha^{-1}) including branches	66.06	61.92	65.46	61.63	0.6	0.29

was the most species rich (3 genera and 13 species), followed by Rubiaceae (6 genera and 6 species). Lauraceae had the highest basal area (Table 3).

Of the 67 species of trees with known distributions, 21 (30%) were endemic to the Western Ghats, 22 (31 %) were distributed in Indo-

Table 2. Species richness, stem density, species diversity and basal area of stems of different diameter classes in 12 plots (1.08 ha).

DBH class	Species richness	Number of individuals	Fisher's alpha	Basal area (m^2 ha^{-1})	
				Main trunk	Including branches
≥ 1 to ≤ 5	66	1211	14.98	1.21	1.55
> 5 to ≤10	55	568	15.04	2.03	2.59
> 10 to ≤ 20	34	252	10.59	3.85	5.33
> 20 to ≤ 30	24	70	12.9	3.21	4.03
> 30	25	178	7.92	51.70	52.56

Table 3. Family level richness of woody plants in Kukkal shoal.

Family	Number of species	Number of individuals	Basal area (m^2 ha^{-1})	
			Main trunk	Including branches
Lauraceae	13	464	26.83	27.16
Rubiaceae	8	431	0.65	0.74
Myrsinaceae	3	295	0.86	0.93
Symplocaceae	3	242	1.78	1.9
Icacinaceae	2	97	0.53	0.56
Staphyleaceae	1	75	0.76	0.78
Ericaceae	2	68	2.09	3.7
Euphorbiaceae	2	59	0.80	0.87
Caprifoliaceae	1	55	1.00	1.08
Flacourtiaceae	2	52	0.56	0.56
Myrtaceae	3	46	0.72	0.72
Vaccinaceae	1	46	0.67	1.19
Rhamnaceae	1	44	0.29	0.29
Oleaceae	2	37	3.68	3.72
Sapotaceae	2	37	17.65	18.59
Buxaceae	1	30	0.03	0.05
Annonaceae	1	27	0.10	0.1
Piperaceae	3	27	0.05	0.05
Celastraceae	2	17	1.20	1.22
Rosaceae	6	16	0.14	0.14
Elaeagnaceae	1	15	0.07	0.07
Theaceae	1	14	0.03	0.05
Rutaceae	1	12	0.03	0.03
Acanthaceae	2	10	0.02	0.02
Erythroxylaceae	1	10	0.08	0.08
Berberidaceae	2	9	0.01	0.01
Ulmaceae	2	9	0.67	0.72
Asteraceae	1	5	0.02	0.02
Meliaceae	1	5	0.04	0.04
Tiliaceae	1	5	0.00	0.00
Santalaceae	1	4	0.01	0.01
Caesalpiniaceae	1	3	0.00	0.00
Magnoliaceae	1	3	0.06	0.06
Papilionaceae	2	3	0.01	0.01
Loganiaceae	1	2	0.01	0.01
Apocynaceae	1	1	0.00	0.00
Elaeocarpaceae	1	1	0.54	0.55
Hypericaceae	1	1	0.00	0.00
Moraceae	1	1	0.01	0.01
Sapindaceae	1	1	0.01	0.02

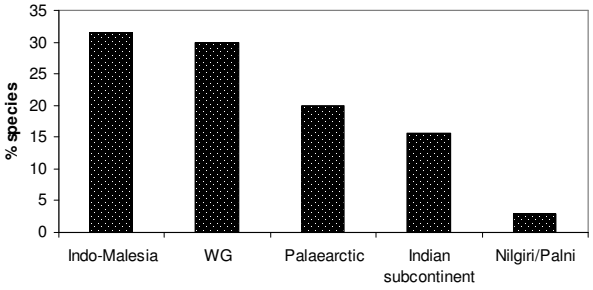

Fig. 5. The geographical distribution of species in five regions. A high proportion of the species belonged to the Indo-Malesian and Western Ghats region.

Malesia, 11 (16%) were restricted to the Indian subcontinent and 2 (3%) were endemic to Nilgiri and Palni hills (Fig. 5). Four of the 16 species of lianas (25%) were endemic to the Western Ghats. One species, *Coffea arabica* was introduced.

Species richness in montane evergreen forests called sholas is relatively lower than for other types of wet evergreen forests in the western ghats of India but similar to that of shola forests in the Nilgiris. We recorded 83 woody plant species (≥ 1 cm dbh), of which 67 were trees in 1.08 ha of forest in Kukkal shola. Narendran *et al.* (2001) recorded 67 woody species ha^{-1}, among which 45 were trees (≥ 3 cm dbh), in one ha of shola forest in the Nilgiri mountains which lies about 150 km north of the Palnis.

Species richness for the ≥ 10 cm dbh class ranged between 32 to 84 species ha^{-1} in low (< 800 amsl) and medium (> 800 to < 1500 amsl) elevation wet evergreen forests in the Western Ghats (Parthasarathy & Karthikeyan 1997; Parthasarathy 1999, 2001; Srinivas & Parthasarathy 2000). Alpha diversity of trees was correlated with increased seasonality in the evergreen forests of the Western Ghats (Davidar *et al.* 2005). Therefore the long dry season and lower annual rainfall in Kukkal compared with other sites in the Western Ghats has probably resulted in fewer species and lower alpha diversity.

Tree densities of 451 stems ha^{-1} (≥ 10 cm dbh) was lower than the mean values for low and medium elevation wet evergreen forests in the Western Ghats where stem densities ranged from 446 to 1576 stems ha^{-1} (Ayyappan & Parthasarathy 1999; Ganesh *et al.* 1996; Parthasarathy 1999, 2001; Parthasarathy & Karthikeyan 1997; Pascal & Pelissier 1996; Srinivas & Parthasarathy 2000). Stem densities in tropical forests have been shown to increase with annual rainfall (Davidar *et al.* 2005; ter Steege *et al.* 2003), and therefore, stem densities in Kukkal shola were towards the lower end of the range.

The basal area values (main trunk: 62.01 m^2 ha^{-1}, with low branches, 66.06 m^2 ha^{-1}) fell within the range of basal areas (36 to 94 m^2 ha^{-1}) reported in the Western Ghats from low and medium elevation forests (Ayyappan & Parthasarathy 1999; Ganesh *et al.* 1996; Parthasarathy 1999, 2001; Parthasarathy & Karthikeyan 1997; Pascal & Pelissier 1996; Srinivas & Parthasarathy 2000; Swamy *et al.* 2000).

Endemism

The proportion of Western Ghats endemics (30%) was lower than that reported for the low and medium elevation wet evergreen forests of the Western Ghats (Ramesh *et al.* 1997). Many of the species were widely distributed in the Indo-Malesian region, and only 3% were restricted to the Nilgiri and Palni hilltops. The low proportion of mountain top endemics suggests that these forests have been isolated fairly recently in the geological time scale and were probably continuous with wet forests of the middle and lower elevations when warmer and wetter climates prevailed in the subcontinent. Blasco (1970) recorded 18 species that were endemic to the Palni hills, but his list includes herbs.

Family level characteristics

Gentry (1988) noted that there are similarities in family level dominance among tropical rain forests worldwide. Families such as Leguminosae tended to be dominant in lowland Neotropical forests whereas Dipterocarpaceae was dominant in tropical Asian forests. At medium elevations, Lauraceae, Euphorbiaceae and Clusiaceae tended to replace these families. In this study, Lauraceae and Rubiaceae were the dominant families. Rubiaceae was dominant probably because of the lower dbh limit used for this inventory since the Rubiaceae tend to be small trees. In terms of basal area, Lauraceae was the dominant family as for other tropical montane forests (Losos & Leigh 2004). Gentry (1988) suggested that the similarities in family level dominance in different

tropical forests worldwide could be the result of selection at higher taxonomic levels, via family and genus specific pests and pathogens, whereas species compositions might be more stochastically determined. Novotny *et al.* (2002) have shown that host specialization of pests in tropical rain forests tends to be at higher taxonomic levels.

Lianas

Only sixteen species of lianas were recorded, of which four species were large (≥ 10 cm dbh). Lianas constituted 9% of the stand density. The stem density and species richness of lianas was similar to that of other tropical forests (Ganesh *et al*. 1996; Muthuramkumar & Parthasarathy 2000). Rhamnaceae and Annonaceae contained the most species. Four (25%) were endemic to the western ghats, higher than in Veerapuli and Kalamalai Forest Reserve of the southern Western Ghats (Swamy *et al*. 2000).

Conclusions

The shola forests of the western ghats are mostly found in the Palnis and the Nilgiris. Most of these forests have been converted to plantations and agriculture since the colonial era. The few sholas that remain are under threat from anthropogenic pressure due to the collection of forest products and livestock grazing. These species are unable to regenerate in the open conditions because they are evergreen broad leaved species intolerant to frost and fire (Meher-Homji 1967). Matthew (1999) has reported that several plant species in the Palni ranges are threatened with extinction. The Kukkal shola is the only large and continuous patch of forest near Kodaikanal. Therefore, it is imperative to enforce strict conservation measures to protect this shola patch.

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Appendix 1. Floristic information pertaining to the woody plant species (≥ 1 cm dbh) recorded in Kukkal shola.

Species	Family	Habit	Number of individuals	Basal area (m^2 ha^{-1})		Relative density (%)
				Main trunk	Including branches	
Psychotria nilgiriensis var. *astephana* (Hook.f.) Deb & Gang.	Rubiaceae	Shrub	282	0.43	0.47	12.3
Maesa indica (Roxb.) DC.	Myrsinaceae	Tree	239	0.65	0.68	10.4
Phoebe paniculata Nees.	Lauraceae	Tree	175	7.07	7.27	7.6
Symplocos foliosa Wight.	Symplocaceae	Tree	167	1.38	1.39	7.3
Neolitsea cassia (L.) Kosterm.	Lauraceae	Tree	161	3.00	3.00	7.0
Lasianthus acuminatus Wight.	Rubiaceae	Shrub	132	0.19	0.24	5.7
Nothapodytes nimmoniana (Graham) Mabberley	Icacinaceae	Tree	86	0.43	0.44	3.7
Beilschmiedia wightii (Nees) Benth. ex Hook. f.	Lauraceae	Tree	75	7.92	8.04	3.2
Turpinia nepalensis Wall. & Wight & Arn.	Staphyleaceae	Tree	75	0.76	0.78	3.2
Symplocos cochinchinensis (Lour.) Moore subsp. *laurina* (Retz.)	Symplocaceae	Tree	74	0.39	0.50	3.2
Rhododendron arboreum J. E. Smith subsp. *nilagirium* (Zenk.) Tagg	Ericaceae	Tree	67	2.09	3.70	2.9
Viburnum cylindricum Buch. - Ham. ex D. Don	Caprifoliaceae	Tree	55	1.00	1.08	2.4
Daphniphyllum neilgherrense Thw.	Euphorbiaceae	Tree	46	0.72	0.79	2.0
Vaccinium neilgherrense Wight.	Vacciniaceae	Tree	46	0.67	1.18	2.0
Ventilago madraspatana Gaertn.	Rhamnaceae	Liana	45	0.29	0.30	1.9
Casearia zeylanica Thwaites	Flacourtiaceae	Tree	44	0.55	0.55	1.9
Xantolis tomentosa (Roxb.) Rafin. var. *elengioides* (A. DC.)	Sapotaceae	Tree	37	17.65	18.58	1.6
Ardisia rhomboidea Wight.	Myrsinaceae	Tree	36	0.05	0.06	1.5
Olea paniculata R. Br.	Oleaceae	Tree	30	3.68	3.73	1.3
Sarcococca saligna (D. Don) Muell.-Arg.	Buxaceae	Shrub	30	0.03	0.05	1.3
Desmos lawii (Hook. F. & Thoms.) Safford	Annonaceae	Liana	27	0.10	0.10	1.1
Syzygium densiflorum Wall.ex Wight & Arn.	Myrtaceae	Tree	25	0.16	0.16	1.1
Myrsine wightiana (Wall. Ex DC)	Myrsinaceae	Tree	20	0.16	0.19	0.8
Syzygium tamilnadensis Rathakr. & Chithra nom.	Myrtaceae	Tree	19	0.56	0.57	0.8
Litsea glabrata (Wall. Ex Nees) Hook.f.	Lauraceae	Tree	16	0.48	0.48	0.7
Elaeagnus kologa Schlecht.	Elaeagnaceae	Liana	14	0.07	0.07	0.6
Eurya nitida Korth.	Theaceae	Tree	14	0.03	0.04	0.6
Glochidion velutinum Wight.	Euphorbiaceae	Tree	13	0.08	0.08	0.5
Piper trichostachyon (Miq.) C. DC.	Piperaceae	Liana	13	0.01	0.01	0.5
Toddalia asiatica (L.) Lam.	Rutaceae	Liana	12	0.03	0.03	0.5
Gomphandra coriacea Wight.	Icacinaceae	Tree	11	0.10	0.13	0.4
Neolitsea scrobiculata (Meisner) Gamble.	Lauraceae	Tree	11	0.04	0.04	0.4
Cassine paniculata (Wight & Arn.) Lobr.-Callen	Celastraceae	Tree	10	0.96	0.96	0.4
Erythroxylum moonii Hochr.	Erythroxylaceae	Tree	10	0.08	0.08	0.4
Piper mullesua Buch.-Ham. Ex D. Don	Piperaceae	Liana	10	0.02	0.02	0.4
Flacourtia indica (Burm. F) Merr.	Flacourtiaceae	Tree	9	0.11	0.12	0.3
Tarenna asiatica (L.) Kuntze ex K. Schum,. var. *asiatica forma rigida* (Wight)	Rubiaceae	Shrub	9	0.01	0.01	0.3
Debregeasia longifolia (Burm. f.) Wedd	Ulmaceae	Tree	8	0.15	0.19	0.3
Mahonia leschenaultii (Wall. ex Wight & Arn)	Berberidaceae	Tree	8	0.01	0.01	0.3
Xenacanthus pulneynensis (Clarke) Bremek	Acanthaceae	Shrub	8	0.01	0.01	0.3
Jasminum brevilobum A. DC.	Oleaceae	Liana	7	0.01	0.01	0.3

Continued

Appendix 1. Continued.

Species	Family	Habit	Number of individuals	Basal area (m^2 ha^{-1})		Relative density (%)
				Main trunk	Including branches	
Cinnamomum perrottetii Meisner	Lauraceae	Tree	6	6.03	6.03	0.2
Euonymus crenulatus Wall. ex Wight & Arn.	Celastraceae	Tree	6	0.13	0.16	0.2
Cissampelopsis walkeri (Arn.) C. Jeffrey & Y.L. Chen	Asteraceae	Liana	5	0.02	0.02	0.2
Grewia glabra Blume. non Rottler ex Spreng.	Tiliaceae	Tree	5	0.00	0.00	0.2
Litsea wightiana (Nees) Hook.f.	Lauraceae	Tree	5	0.05	0.05	0.2
Ophiorrhiza roxburghiana Wight.	Rubiaceae	Tree	5	0.01	0.01	0.2
Trichilia connaroides (Wight & Arn.) Bent var. *connaroides*	Meliaceae	Tree	5	0.04	0.04	0.2
Neolitsea fischeri Gamble.	Lauraceae	Tree	4	0.02	0.02	0.1
Osyris quadripartita Salz.	Santalaceae	Shrub	4	0.01	0.01	0.1
Prunus ceylanica (Wight) Miq.	Rosaceae	Tree	4	0.11	0.11	0.1
Caesalpinia decapetala (Roth) Alston	Caesalpiniaceae	Tree	3	0.00	0.00	0.1
Michelia nilagirica Zenk.	Magnoliaceae	Tree	3	0.06	0.06	0.1
Piper argyrophyllum Miq.	Piperaceae	Liana	3	0.01	0.01	0.1
Rosa leschenaultiana Red. & Thory ex Wight & Arn.	Rosaceae	Liana	3	0.00	0.00	0.1
Rubus ellipticus Smith.	Rosaceae	Shrub	3	0.00	0.00	0.1
Cinnamomum malabathrum (Burm. F.) Blume	Lauraceae	Tree	2	0.80	0.80	0.1
Cinnamomum wightii Meisner	Lauraceae	Tree	2	0.58	0.58	0.1
Coffea arabica L.	Rubiaceae	Shrub	2	0.01	0.01	0.1
Crotalaria formosa Graham ex Wight & Arn.	Papilionaceae	Shrub	2	0.00	0.00	0.1
Cryptocarya bourdillonii Gamble	Lauraceae	Tree	2	0.02	0.02	0.1
Cryptocarya neilgherrensis Meisner	Lauraceae	Tree	2	0.75	0.75	0.1
Gardneria ovata Wall.	Loganiaceae	Liana	2	0.01	0.01	0.1
Litsea floribunda (Blume) Gamble	Lauraceae	Tree	2	0.02	0.02	0.1
Photinia integrifolia Lindl. var. *sub-lanceolata* Miq.	Rosaceae	Tree	2	0.02	0.02	0.1
Rubus rugosus Smith var. *thwaitesii*	Rosaceae	Shrub	2	0.00	0.00	0.1
Strobilanthes lurida Wight.	Acanthaceae	Shrub	2	0.00	0.00	0.1
Syzygium lanceolatum (Lam.) Wight & Arn.	Myrtaceae	Tree	2	0.00	0.00	0.1
Berberis tinctoria Lesch.	Berberidaceae	Shrub	1	0.00	0.00	0.04
Celtis tetrandra Roxb.	Ulmaceae	Tree	1	0.52	0.52	0.04
Chasalia curviflora (Wall. Ex Kurz) Thw. var. *ophioxyloides*	Rubiaceae	Shrub	1	0.00	0.00	0.04
Derris brevipes (Benth.) Baker var. *brevipes*	Papilionaceae	Liana	1	0.00	0.00	0.04
Dodonaea viscosa (L.) Jacq	Sapindaceae	Tree	1	0.01	0.02	0.04
Elaeocarpus glandulosus Wall.	Elaeocarpaceae	Tree	1	0.54	0.57	0.04
Ficus drupacea Thunb.	Moraceae	Tree	1	0.01	0.01	0.04
Gaultheria fragrantissima Wall.	Ericaceae	Tree	1	0.00	0.00	0.04
Hedyotis stylosa R.Br. ex Wight & Arn.	Rubiaceae	Shrub	1	0.00	0.00	0.04
Hypericum japonicum Thunb. ex Murr.	Hypericaceae	Shrub	1	0.00	0.00	0.04
Isonandra perrottetiana A. DC.	Sapotaceae	Tree	1	0.06	0.06	0.04
Mussaenda hirsutissima (Hook. F.) Hutchinson	Rubiaceae	Liana	1	0.00	0.00	0.04
Rauvolfia densiflora (Wall.) Benth. Ex Hook. f.	Apocynaceae	Shrub	1	0.00	0.00	0.04
Rubus racemosus Roxb.	Rosaceae	Shrub	1	0.00	0.00	0.04
Symplocos pendula Wight.	Symplocaceae	Tree	1	0.01	0.01	0.04