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Floristic structure and diversity of a tropical montane evergreen forest (shola) of the Nilgiri Mountains, southern India

D. MOHANDASS & PRIYA DAVIDAR*

Department of Ecology and Environmental Sciences, Pondicherry University, Kalapet, Pondicherry 605 014, India

Abstract: We inventoried plants (≥ 1 cm diameter at breast height) in 19 montane evergreen forests (sholas) of total area 11.5 ha in the upper plateau (≈ 2000 m asl) of the Nilgiri Mountains in southern India. All plants meeting the size criterion were inventoried in sholas ≤1.26 ha, whereas in sholas >1.26 ha randomly laid 30×30 m (0.09 ha) plots were used. A total of 30495 individuals from 87 species, 65 genera and 42 families were recorded. Of these 57 species of trees, 13 lianas, 12 shrubs and 5 large herbs were recorded. Species diversity as measured by Fisher's alpha was 11, stem density was 2652 stems ha^{-1} and basal area 59.4 m^2 ha^{-1}. Most species (67 : 77%) were common (densities > 1 stem ha^{-1}), and widely distributed (36 : 41%) among sholas. The Nilgiri sholas shared 34 (47%) species with Kukkal shola located in the Palni hills, 150 km south of the study site. This suggests a common biogeographical heritage. The unique shola forest is endangered and needs to be conserved on a priority basis.

Resumen: Elaboramos un inventario de plantas (≥ 1 cm diámetro a la altura del pecho) en 19 bosques montanos perennifolios (sholas), en un área total de 11.5 ha en la meseta superior (≈ 2000 m snm) de las montañas Nilgiri, sur de la India. Todas las plantas que cumplían el criterio de tamaño fueron inventariadas en sholas ≤ 1.26 ha, mientras que en sholas > 1.26 ha se utilizaron parcelas de 30 × 30 m (0.09 ha), colocadas de manera aleatoria. Se registró un total de 30,495 individuos pertenecientes a 87 especies, 65 géneros y 42 familias. Entre ellas se registraron 57 especies de árboles, 13 lianas, 12 arbustos y 5 hierbas grandes. La diversidad de especies, medida con el índice alfa de Fisher, fue de 11, la densidad de tallos fue de 2652 tallos ha^{-1} y el área basal fue de 59.4 m^2 ha^{-1}. La mayoría de las especies (67: 77%) fueron comunes (densidades > 1 tallo ha^{-1}) y estuvieron ampliamente distribuidas (36: 41%) entre las sholas. Las sholas de Nilgiri compartieron 34 (47%) especies con la shola Kukkal ubicada en las colinas Palni, 150 km al sur del sitio de estudio. Esto sugiere que existe una herencia biogeográfica común. El bosque shola, único en su tipo, está amenazado y necesita ser conservado sobre una base de prioridades.

Resumo: Inventariaram-se plantas (≥ 1 cm de diâmetro à altura do peito) em 19 florestas montanas sempre verdes (sholas) com uma área total de 11,5 ha no planalto de topo (≈ 2000 m anm) nas montanhas Nilgiri no sul da Índia. Todas as plantas satisfazendo o critério dimensional definido foram inventariadas nas sholas ≤ 1,26 ha, enquanto que nas sholas > 1,26 ha foram usadas parcelas de 30x30 m (0,09 ha) distribuídos de forma casual. Foram registadas um total de 30495 indivíduos pertencentes a 87 espécies, 65 géneros e 42 famílias. Destas plantas registaram-se 57 espécies arbóreas, 13 trepadeiras, 12 arbustos e 5 ervas altas. A diversidade específica expressa pelo alfa de Fisher foi de 11, a densidade de troncos foi de 2652 troncos ha^{-1} e a área basal de 59,4 m^2 ha^{-1}. A maior parte das espécies (67: 77%) eram comuns (densidades > 1 tronco ha^{-1}) e largamente distribuídas entre as sholas (36: 41%). As sholas nos Nilgiri partilhavam 34 espécies (47%) com a shola Kukkal localizada nas colinas de Palni, 150 km a sul da área estudada. Isto sugere uma herança biogeográfica comum. A floresta "shola" única, está em perigo e necessita ser conservada numa base prioritária.

* *Corresponding Author*; e-mail: davidarp@si.edu, pdavidar@yahoo.com

Key words: Forest conservation, forest inventory, India, Nilgiri Hills, plant diversity, shola forest, tropical montane forest, Western Ghats.

Introduction

Plant inventories using permanent plots can provide information on changes in forest structure and diversity over time (Condit 1995; Phillips *et al.* 1994). Many tree census plots have been established in forest types throughout tropical regions to monitor forest dynamics over time and to assess the effects of disturbance and climate change on plant demography (Ashton 1998; Condit 1995; Laurance *et al.* 2004; Manokaran *et al.* 1992; Phillips *et al.* 1998, 2003). Permanent plots have been established in the Western Ghats in the low (Ayyappan & Parthasarathy 1999; Pascal & Pelissier 1996), and medium (Ganesh *et al.* 1996) elevation wet forests.

Tropical montane evergreen forest known as 'shola' forest occurs in the higher elevations of the Western Ghats and its associated hill range in southern India. It is discrete and patchy, usually confined to sheltered valleys, hollows and depressions and is surrounded by grasslands. It consists of stunted short boled evergreen trees that are unable to regenerate in open areas due to lack of tolerance to fire and frost (Meher-Homji 1967, 1987). These forests were found extensively in the higher elevations of the Nilgiris and Palni ranges in southern India, but due to agricultural expansion, conversion to plantations, livestock grazing pressure and development, a high proportion of this forest type has been destroyed. It has been estimated that half the shola forests in the Nilgiris have been destroyed since 1849 and that the current area under sholas is about 4225 ha (Kumar 1993). A large proportion of the loss is due to expansion of agriculture and plantations (Kumar 1993). There is severe ongoing anthropogenic pressure on the remaining shola forests, which will probably result in further loss unless conservation measures are undertaken.

In 2004 and 2005, we established a network of small plots in a montane evergreen forest located at an elevation of >2000 m amsl in the Palni ranges to assess changes in tree diversity and forest structure (Davidar *et al.* 2007). In the present study we established a network of plots in the shola forests of the Nilgiris, to document changes in the demography of the individual species with relation to human induced disturbance and climate change. The montane forests are probably more vulnerable to climate change, fire and human disturbance than the lowland forests, due to their small extent and harsher environment. Climate change has affected the dynamics of tropical forests in the Amazon and elsewhere (Baker *et al.* 2004; Laurance *et al.* 2004; Phillips *et al.* 2002). Monitoring population dynamics and structural characteristics of shola forests over time can provide insights into the responses of these forests to climate and environmental changes.

In this study we conducted an inventory of plants ≥1 cm dbh in 19 sholas of different sizes located in the Upper Bhavani Reserve Forest in the Nilgiris, to assess species richness and diversity, endemism, stem densities and basal area. We compared the floristics and structure of these sholas to that of the Kukkal shola located 150 km further south in the Palni ranges.

Materials and methods

Study area

The Nilgiri Mountains are located between 11 10´ and 11 30c N latitude and 76^{-1} 25´ and 77º 00´ E longitude at the junction of the Eastern (EG) and Western Ghats (WG), the two prominent mountain ranges that run almost parallel to the two coastlines of Peninsular India. The study site falls within the perimeter of the Nilgiri Biosphere Reserve (NBR) which has a representative selection of the major vegetation types of peninsular India such as evergreen and semi-evergreen forest, moist deciduous forest, tropical dry deciduous forest and tropical dry thorn forest (Champion & Seth 1968). Sholas are usually found at elevations >1500 m amsl and occur as patches interspersed with open grasslands. The Todas, the local ethnic group, are pastoralists and have traditionally been associated with this ecosystem (Hockings 1989, 1997).

The study area was located in the Upper Bhavani Reserve Forest (11º 14´ latitude N and 76º 33´ longitude E) about 60 km southwest of Ootacamund, the headquarters of the Nilgiri district (Fig. 1). The elevation in the study area ranges from 2200 to 2400 m amsl. Sholas were selected in two locations within the Reserve Forest, namely Korakundah and Upper Bhavani.

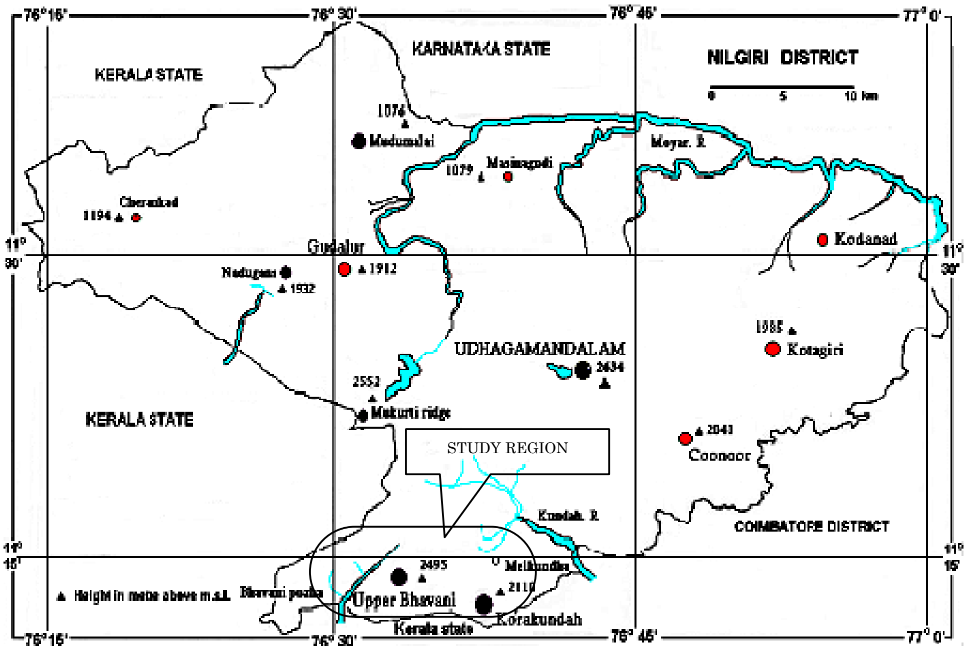

Fig. 1. Map of the Nilgiris district with location of the study area.

The climate in the study area was cold and dry with temperature ranging from 0º to 23 °C. Frost was frequent from December to February. The mean annual rainfall was around 2500 mm and the dry season lasts about 5 months (Fig. 2). Korakundah receives rainfall from both the SW and NE monsoons, whereas Upper Bhavani receives most of its rain from the SW monsoon.

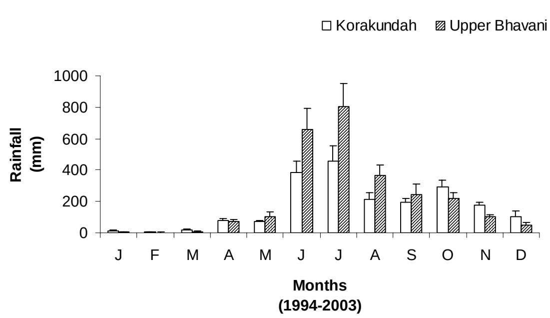

Fig. 2. Mean monthly rainfall (± S. D.) in Korakundah and Upper Bhavani over a 10 year period (1994-2003).

In the upper plateau of the Nilgiris, there has been extensive degradation of the forest and grasslands. Exotic species such as *Acacia dealbata, Eucalyptus globosus* and *Pinus patula* were introduced by the Forest Department in the Nilgiris several decades ago for commercial forestry (Jeyadev 1954). Tea plantations have also contributed to the loss of the original habitat. In the study site, there are three major settlements: the Toda villages, the staff of the Korakundah Tea Estate numbering about 600 households and the staff of the Forest Department and Tamilnadu Electricity Board. Current disturbance is minimal except for livestock grazing in the grasslands and swamps.

Methods

We sampled 19 large, medium and small sholas from November 2002 to September 2004. Some of these sholas were near roads and small settlements, but most were undisturbed and located in less accessible sites. The total area sampled was 11.5 ha. All plants were inventoried in 14 sholas ≤1.26 ha using 10 x 10 m subplots. In sholas >1.26 ha, plots of dimension 30×30 m (0.09 ha) were laid randomly within each shola. Each plot was divided into 10 × 10 m subplots. All individuals ≥ 1 cm dbh (diameter at breast height) were enumerated, identified and tagged with sequentially numbered aluminium tags. The sampling in the larger sholas was terminated when the species-accumulation curve reached an asymptote. The geographical coordinates of each plot were determined using a Geographical Positioning System (GPS). The slope correction was made for each plot using a slope meter.

All plant specimens were identified to species using various floras (Fyson 1986; Gamble 1967; Matthew 1999). Nomenclature followed the flora of Tamilnadu and Flora of Palni hills (Henry *et al.* 1987, 1989; Matthew 1999; Nair & Henry 1983). Identification of sample specimens was confirmed at the Botanical Survey of India, Coimbatore and the French Institute of Pondicherry. Herbarium specimens were deposited at Department of Ecology and Environmental Sciences, Pondicherry University.

Information pertaining to the geographical distribution of each species was obtained from the literature (Ahmedullah & Nayar 1986; Ng 1978; Ramesh *et al.* 1997; Saldanha 1996; Whitmore 1972, 1973), and the species were designated as: Nilgiri/Palni endemics, Western Ghats (WG) endemics, Indian subcontinent species (WG, Indian peninsula and Sri Lanka), species restricted to the Indian peninsula, Indo-Malayan/Australian species and Palaearctic species, i.e. those with northern affinities distributed in the higher altitudes of the Himalayas, China and Japan.

Data analyses

For the floristic analyses, all the data were pooled and the total number of species and individuals were tallied. Using the pooled data the overall species richness, genera and family level richness, stem densities ha^{-1}, species diversity and basal area (m^2 ha^{-1}) were calculated. The dominant species were considered to be those that were the most abundant in the inventory, and the dominant family was that represented by the most number of stems.

The species were arranged in descending order based on abundance. The natural logarithm of the total number of stems per species (N) was taken and a distribution was generated. A Wilks Shapiro test for normality was used to see whether the distribution differed significantly from log normal.

The number of sholas in which each species was recorded was determined and the frequency of occurrence was calculated as follows: Number of sholas in which a species was recorded/total number of sholas. Frequency ranges from 0 to 1, and a frequency of 1 indicates that the species was recorded in all the sholas. The distribution of the log transformed frequency values was performed.

Basal area was calculated using the formula: $(Dbh)^2 *(\pi/4)$. Basal area was calculated using the dbh values for the main stem (trunk) and not for low branches.

Fisher's alpha measure of diversity was used to assess species diversity since it is fairly independent of plot size (Condit *et al.* 1998; Fisher *et al.* 1943).

Statistica version 5.0 was used for the statistical analysis.

Results

The species area curves reached an asymptote in about 0.72 ha (8 plots, Fig. 3) in the larger sholas (>1.26 ha). The species abundance distribution did not differ significantly from a log normal distribution (Wilks Shapiro= 0.966, $p>0.50$, Fig. 4). The frequency distribution of species among sholas was bimodal with the majority

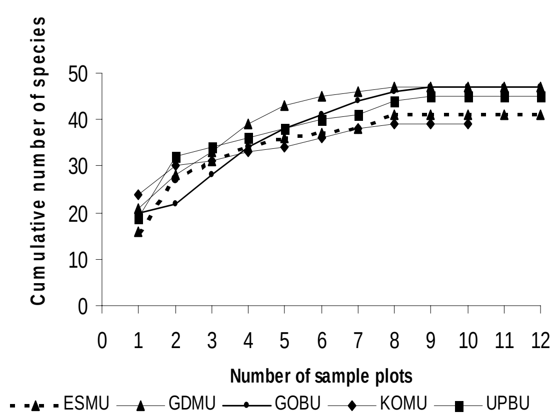

Fig. 3. Species-accumulation curves of trees in sholas >1.26 ha.

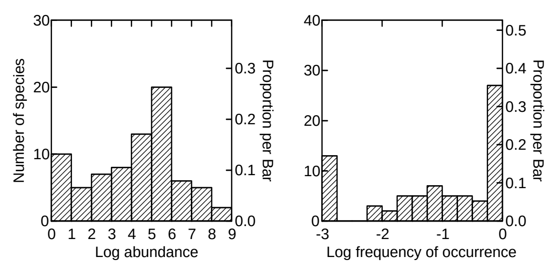

Fig. 4. (a) Log abundance distribution and (b) frequency (log) distribution of species among sholas.

Table 1. Inventory of all plants ≥1 cm dbh recorded in 19 sholas of total area 11.5 ha.

Variables	All species		Non-climbing plants		Lianas	
	≥1 cm dbh	≥10 cm dbh	≥1 cm dbh	≥10 cm dbh	≥1 cm dbh	≥10 cm dbh
Species richness	87	70	73	63	14	6
Number of genera	65	52	55	45	10	6
Number of families	42	34	33	28	9	5
Fisher's alpha	10.97	10.06	9.03	9.06	2.2	1.37
Total area sampled (ha)	11.5	11.5	11.5	11.5	11.5	11.5
Number of individuals	30495	9566	29205	9456	1290	108
Stem density (stems ha^{-1})	2652	832	2540	822	112.2	9.39
Basal area of main trunk (m^2 ha^{-1})	59.40	53.33	58.97	53.17	0.43	0.16

occurring in a large number of sholas, and some species in a limited number of sholas (Fig. 4). Nine species (10%) were recorded in all sholas, 28 species in ≥14 sholas (75%) and 36 species in ≥10 (47%) sholas. Fourteen species (16%) were recorded in only one shola, of which 6 species (7%) had only one record. Sixty seven species (77%) occurred at landscape densities >1 stem ha^{-1}.

Species richness, stem density and basal area

A total of 30495 individuals belonging to 86 species, 65 genera and 42 families were recorded. There were 57 species of trees, 13 lianas, 12 shrubs and 5 large herbs. Stem density was 2652 stems ha^{-1} and basal area 59.4 m^2 ha^{-1} for the ≥1 cm dbh class, and 832 stems ha^{-1} and 53.55 m^2 ha^{-1} for the ≥10 cm dbh class. Fisher's alpha and basal area were slightly lower for the ≥10 cm dbh class (Table 1).

Three species, *Psychotria nilgiriensis* (16%), *Lasianthus venulosus* (11%), shrubs, and *Litsea wightiana* (10%), a tree, were dominants and comprised over one-third of the stems sampled (Appendix Table 1). The dominant liana was *Gardneria ovata* Wall. representing 1.6% of the stems. Seven species had only one record (Appendix Table 1) and two of these were large herbs common in the edges, two were small shrubs and one, *Cassine paniculata* was a tall tree commoner in lowland forests. The genus *Cinnamomum* had the most species followed by *Symplocos* (4), *Syzygium* (3) and *Litsea* (3). There were 15 species of Lauraceae followed by 6 species of Rubiaceae (Table 2). Rubiaceae had the largest number of individuals (30% of stems), followed by Lauraceae (22%), Myrtaceae (9%) and Symplocaceae (7%). Lauraceae and Myrtaceae had the highest basal area (Table 2).

Geographical distribution

Of the species sampled 32 (37%) were endemic to the Western Ghats, 20 (23%) were distributed in Indo-Malesia, 12 (14%) were restricted to the Indian peninsula and 6 (7%) each were endemic in Nilgiri and Palni hills, and from the Palaearctic region (Fig. 5). One species *Cestrum elegans* was introduced.

Discussion

Our study of 19 montane evergreen shola forests of the Nilgiris shows an ecosystem with high levels of dominance, where three species represented over one-third of the stems, and low levels of rarity, with only six species represented by just one individual. Four of the six species with only one record were herbs and small shrubs growing mostly in open areas and edges. The rest of the species were intermediate in abundance and recorded at landscape densities >1 stem ha^{-1}. Many of the species were widely distributed among the sholas: 28 species were recorded in over 75% of the sholas, and 36 species in 47% of the sholas. Few species (16%) were restricted to one shola. We recorded 60 species of trees (≥1 cm dbh) which was similar to the 67 species recorded in a hectare of Thiashola, a large shola forest about 20 km east of the study area (Narendran *et al.* 2001), and 59 species recorded in Kukkal shola in the Palnis (Davidar *et al.* 2007).

Stem densities of trees (≥10 cm dbh) in the shola forests of the Nilgiris and Palnis (Davidar *et al.* 2007) were higher than those of medium

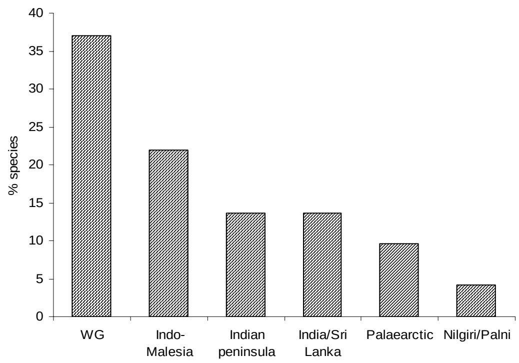

Fig. 5. The biogeographical distribution of all plant species.

elevation forests in Kalakad-Mundanthurai where stem densities were 583 stems ha^{-1} in Kakachi (Ganesh *et al.* 1996) and 574 - 915 stems ha^{-1} in Sengaltheri in the Kalakad-Mundanthurai Tiger Reserve in the southern Western Ghats (Parthasarathy 1999). Stem densities were also higher than in the low elevation (< 800 m amsl) wet evergreen forests where stem densities range between 270-673 trees ha^{-1} in Varagalaiar in the Anamalais (Ayyappan & Parthasarathy 1999) and 635 stems ha^{-1} in Uppangala in the central Western Ghats (Pascal & Pelissier 1996). This is probably because two of the most abundant species, *Psychotria nilgiriensis* and *Lasianthus venulosus* were shrubs that occurred at high densities in the understorey.

The basal area fell within the range of basal areas (36 to 94 m^2 ha^{-1}) reported from low and medium elevation forests in the Western Ghats (Ayyappan & Parthasarathy 1999; Davidar *et al.* 2007; Ganesh *et al.* 1996; Pascal & Pelissier 1996; Parthasarathy 1999, 2001; Parthasarathy & Karthikeyan 1997; Srinivas & Parthasarathy 2000; Swamy *et al.* 2000). Basal areas for low and medium elevation forests in the Western Ghats forests are generally higher than reported for forests at similar elevations in S.E. Asia (Kochummen *et al.* 1990; Manokaran & La Frankie 1990; Proctor *et al.* 1983) and the Neotropics (Leigh 1999). In part, this could be because branches below 1.3 m above ground level were included along with the main trunk in basal area calculations in some Indian plant inventories. In this study area, some large trees belonging to *Ilex denticulata* were over 100 cm in dbh.

Liana species were few (11 species), but similar to that recorded in other montane regions of the Western Ghats. A total of 15 liana species have been recorded in 3.82 ha of medium elevation forest in Kakachi in the southern Western Ghats (Ganesh *et al.* 1996). In low elevation forests, species richness of lianas (≥ 1 cm dbh) ranged from 26 to 48 species ha^{-1} in Varagaliar (Muthuramkumar & Parthasarathy 2000), and from 15 to 24 species ha^{-1} (≥ 5 cm gbh) in Agumbe (Padaki & Parthasarathy 2000). About 9 to 21 species ha^{-1} (≥ 5 cm dbh) have been recorded in the semi-evergreen forests in the Kolli hills, Eastern Ghats (Chittibabu & Parthasarathy 2000).

Liana density was lower (112 ha^{-1}) than that recorded in the Palni hills (132 ha^{-1}, Davidar *et al.* 2007). Lianas can be an indicator of disturbance (Schnitzer & Bongers 2002) and the low stem densities of lianas in the sholas in Upper Bhavani compared to that of the Palni hills, suggest that these sites are relatively undisturbed. Liana density was higher at Varagaliar, a low elevation wet evergreen forest in the Western Ghats (373 stems ha^{-1}, Muthuramkumar & Parthasarathy 2000), and similar to that of Kakachi, an undisturbed medium elevation forest in the southern Western Ghats (Ganesh *et al.* 1996). *Elaeagnus kologa* and *Gardneria ovata* were the most abundant lianas in this study area and were not common in the Palni hills (Davidar *et al.* 2007).

The structure and diversity of the montane shola forests of the Nilgiris was similar to that of the Palni hills. About 47% of the species were common, indicating a common heritage of the shola forests of the Nilgiris and Palnis, which are about 150 km apart. Both the Nilgiris and Palnis supported low-diversity forests with high basal area contributed by large trees (Davidar *et al.* 2007). The dominant species in both regions was a shrub, *Psychotria nilgiriensis*, which occurred at high densities. The dominant family was Lauraceae, which is among the families that dominate the wet evergreen forests of the Western Ghats (Parthasarathy 1999; Pascal & Pelissier 1996), Eastern Ghats (Chittibabu & Parthasarathy 2000), and S.E. Asia (Hara *et al.* 1997; Kochummen *et al.* 1990).

Species in both the Nilgiri and Palni sholas had similar biogeographical distributions. Less than 10% of species in each site were endemic to the Nilgiri and Palni hills. The Nilgiris had the highest proportion of Western Ghats endemics, followed by species of Indo - Malayan affinity. Similar proportions of Western Ghats endemics

Table 2. Family inventory of all plants ≥ 1 cm dbh recorded in 19 sholas of total area 11.5 ha.

Family	Species richness of family	Number of individuals	Basal area ($m^2 ha^{-1}$)
Rubiaceae	6	9006	3.72
Lauraceae	15	6799	11.92
Myrtaceae	4	2810	10.76
Symplocaceae	4	2262	2.43
Berberidaceae	2	1617	1.13
Euphorbiaceae	2	1320	3.02
Sabiaceae	1	965	2.05
Celastraceae	4	623	1.84
Buxaceae	1	522	0.22
Loganiaceae	1	494	0.10
Theaceae	2	474	3.13
Aquifoliaceae	2	451	8.68
Staphyleaceae	1	386	0.97
Myrsinaceae	1	374	0.43
Piperaceae	3	296	0.04
Elaeagnaceae	1	266	0.21
Ericaceae	2	240	1.43
Magnoliaceae	1	222	2.21
Rosaceae	6	200	0.32
Flacourtiaceae	1	181	0.88
Vacciniaceae	1	151	1.51
Pittosporaceae	2	142	0.46
Icacinaceae	2	102	0.03
Rutaceae	1	101	0.06
Sapotaceae	1	93	1.03
Lamiaceae	1	82	0.02
Oleaceae	2	62	0.26
Asteraceae	3	55	0.01
Caprifoliaceae	2	48	0.14
Elaeocarpaceae	2	42	0.29
Ulmaceae	1	31	0.06
Solanaceae	2	27	0.01
Araliaceae	1	14	0.02
Apocynaceae	1	13	0.00
Melastomaceae	1	13	0.00
Poaceae	1	8	0.00
Lobeliaceae	1	1	0.00
Papilionaceae	1	1	0.00
Passifloraceae	1	1	0.00

and Indo-Malayan species were represented in Kukkal (Davidar *et al.* 2007).

These similarities in species diversity, dominance and basal area suggest that either these species colonized the mountain tops from a common low elevation source during the geological periods when climates were warmer, or that species from both regions are remnants of once extensive forests, that have survived the stressful environment in the mountainous regions. Therefore, both colonization and extinction dynamics could have played a role in the floristic diversity and structure of these forest patches. The number of species endemic to the mountaintops of the Nilgiris and Palnis was low, suggesting that these forests have been isolated recently. Many of the shola species were widely distributed in the Western Ghats and were either WG endemics or of Indo-Malayan affinity. Few species were from the Palaearctic region.

In conclusion, the shola forests of the upper plateau of the Nilgiris are a unique ecosystem that harbours many plants endemic to the Western Ghats. Most of the species are abundant and widely distributed among sholas, indicating their tolerance to a stressful environment. Sholas are extremely vulnerable to disturbance because the saplings do not regenerate in the open grasslands due to lack of tolerance to fire and frost (Meher-Homji 1967, 1987). These forests provide a habitat for many forest dwelling vertebrates that are endemic to the Western Ghats and require strict protection to prevent loss of flora and fauna and to maintain montane watersheds.

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Appendix Table 1. Inventory of all plants ≥1 cm dbh recorded in 19 sholas of total area 11.5 ha.

Species	Family	Habit	Number of indivi-duals	Stem density ha^{-1}	Proportion of sholas in which recorded
Psychotria nilgiriensis Deb & Gang. var. nilgiriensis	Rubiaceae	Shrub	4746	412.70	1
Lasianthus venulosus Wight	Rubiaceae	Shrub	3383	294.17	1
Litsea wightiana Hook.f.	Lauraceae	Tree	2937	255.39	1
Symplocos foliosa Wt.	Symplocaceae	Tree	1739	151.22	1
Mahonia leschenaultii Takeda	Berberidaceae	Tree	1610	140.00	1
Neolitsea cassia Kosterm.	Lauraceae	Tree	1579	137.30	0.68
Syzygium tamilnadensis Rathakr. & Chithra nom.	Myrtaceae	Tree	1556	135.30	0.95
Daphniphyllum neilgherrense Thw.	Euphorbiaceae	Tree	1096	95.30	1
Cinnamomum wightii Meisner	Lauraceae	Tree	965	83.91	1
Meliosma simplicifolia Walp.	Sabiaceae	Tree	965	83.91	0.84
Saprosma fragrans Bedd.	Rubiaceae	Tree	624	54.26	0.63
Syzygium calophyllifolium Walp.	Myrtaceae	Tree	537	46.70	0.95
Sarcococca saligna Muell. Arg	Buxaceae	Shrub	522	45.39	0.63
Gardneria ovata Wall.	Loganiaceae	Liana	494	42.96	0.89
Rhodomyrtus tomentosa Hassk.	Myrtaceae	Shrub	388	33.74	0.79
Turpina nepalensis Wall. Ex Wight & Arn.	Staphyleaceae	Tree	386	33.57	0.58
Myrsine wightiana Wall.	Myrsinaceae	Tree	374	32.52	1
Symplocos obtusa Wall.	Symplocaceae	Tree	370	32.17	0.84
Microtropis ramiflora Wight.	Celastraceae	Tree	358	31.13	0.79
Litsea floribunda Gamble	Lauraceae	Tree	339	29.48	0.26
Syzygium densiflorum Wall.	Myrtaceae	Tree	329	28.61	0.89
Cinnamomum malabathrum Miq.	Lauraceae	Tree	316	27.48	0.58
Eurya nitida Korth.	Theaceae	Tree	301	26.17	0.95
Elaeagnus kologa Schlecht.	Elaeagnaceae	Liana	266	23.13	1
Ilex denticulata Wall.	Aquifoliaceae	Tree	245	21.30	0.84
Glochidion neilgherrense Wight.	Euphorbiaceae	Tree	224	19.48	0.89
Michelia nilagirica Zenk.	Magnoliaceae	Tree	222	19.30	0.95
Piper trichostachyon DC.	Piperaceae	Liana	221	19.22	0.95
Litsea oleoides Hook. f.	Lauraceae	Tree	207	18.00	0.42
Ilex wightiana Wall.	Aquifoliaceae	Tree	206	17.91	0.89
Hedyotis swertioides Hook.f.	Rubiaceae	Herb	205	17.83	0.53
Casearia thwaitesii Briq.	Flacourtiaceae	Tree	181	15.74	0.79
Cinnamomum macrocarpum Hook. f.	Lauraceae	Tree	175	15.22	0.58
Ternstroemia japonica Thunb	Theaceae	Tree	173	15.04	0.84
Rhododendron nilagiricum Zenk.	Ericaceae	Tree	161	14.00	0.79
Vaccinium neilgherrense Wight.	Vaccinaceae	Tree	151	13.13	0.79
Euonymus crenulatus Wall.	Celastraceae	Tree	139	12.09	0.42
Pittosporum dasycaulon Miq.	Pittosporaceae	Tree	136	11.83	0.79
Symplocos macrophylla Wall. subsp *macrophylla*	Symplocaceae	Tree	135	11.74	0.32
Microtropis ovalifolia Wight.	Celastraceae	Tree	125	10.87	0.37
Photinia integrifolia Lindl. var. *sub-lanceolata* Miq.	Rosaceae	Tree	116	10.09	0.84
Toddalia asiatica Lam	Rutaceae	Liana	101	8.78	0.79
Nothapodytes nimmoniana Mabberley	Icacinaceae	Tree	97	8.43	0.26
Isonandra perrottetiana DC.	Sapotaceae	Tree	93	8.09	0.32

Contd...

Appendix Table 1. Continued

Species	Family	Habit	Number of indivi-duals	Stem density ha^{-1}	Proportion of sholas in which recorded
Neolitsea scrobiculata Gamble	Lauraceae	Tree	92	8.00	0.26
Cryptocarya lawsonii Gamble	Lauraceae	Tree	84	7.30	0.21
Leucus lanceaefolia Desf.	Lamiaceae	Tree	82	7.13	0.79
Gaultheria fragrantissima Wall.	Ericaceae	Shrub	79	6.87	0.37
Olea paniculata R. Br.	Oleaceae	Tree	60	5.22	0.21
Cinnamomum walaiwarense Kosterm.	Lauraceae	Tree	56	4.87	0.21
Cissampelopsis walkeri C. Jeffrey & Y.L. Chen	Asteraceae	Tree	52	4.52	0.53
Tarenna asiatica Kuntze ex K. Schum. var. *asiatica*	Rubiaceae	Shrub	49	4.26	0.05
Piper schmidtii Hook. f.	Piperaceae	Liana	45	3.91	0.74
Elaeocarpus glandulosus Wall.	Elaeocarpaceae	Tree	39	3.39	0.32
Viburnum hebanthum Wight & Arn	Caprifoliaceae	Tree	36	3.13	0.37
Rubus ellipticus Smith.	Rosaceae	Liana	35	3.04	0.74
Cinnamomum riparium Gamble.	Lauraceae	Tree	32	2.78	0.26
Celtis timorensis Spanoghe.	Ulmaceae	Tree	31	2.70	0.21
Piper mullesua Buch.-Ham.	Piperaceae	Liana	30	2.61	0.42
Cestrum elegans Schlecht.	Solanaceae	Shrub	26	2.26	0.32
Rubus rugosus Smith var. *thwaitesii*	Rosaceae	Liana	22	1.91	0.53
Prunus ceylanica (Wight) Miq.	Rosaceae	Tree	19	1.65	0.26
Symplocos cochinchinensis Moore subsp. *laurina* (Retz.)	Symplocaceae	Tree	18	1.57	0.32
Schefflera capitata Harms	Araliaceae	Tree	14	1.22	0.32
Parsonsia alboflavescens Mabberley	Apocynaceae	Liana	13	1.13	0.26
Osbeckia leschenaultiana DC.	Melastomaceae	Herb	13	1.13	0.05
Lonicera ligustrina Wall.	Caprifoliaceae	Shrub	12	1.04	0.11
Phoebe paniculata Nees	Lauraceae	Tree	9	0.78	0.11
Arundinaria wightiana Nees var. *wightiana*	Poaceae	Herb	8	0.70	0.16
Berberis tinctoria Lesch.	Berberidaceae	Shrub	7	0.61	0.21
Rubus racemosus Roxb.	Rosaceae	Liana	6	0.52	0.32
Pittosporum tetraspermum Wight & Arn.	Pittosporaceae	Tree	6	0.52	0.16
Gomphandra coriacea Wight.	Icacinaceae	Tree	5	0.43	0.11
Elaeocarpus recurvatus Corner	Elaeocarpaceae	Tree	3	0.26	0.05
Rosa leschenaultiana Red. & Thory	Rosaceae	Liana	2	0.17	0.11
Vernonia pectiniformis DC.	Asteraceae	Shrub	2	0.17	0.05
Beilschmiedia wightii Benth. ex Hook. f.	Lauraceae	Tree	2	0.17	0.05
Cinnamomum sulphuratum Nees	Lauraceae	Tree	2	0.17	0.05
Cinnamomum verum Presl.	Lauraceae	Tree	2	0.17	0.05
Jasminum brevilobum DC.	Oleaceae	Liana	2	0.17	0.05
Lobelia leschenaultiana Skottsb.	Lobeliaceae	Herb	1	0.09	0.05
Moonia heterophylla Arn.	Asteraceae	Herb	1	0.09	0.05
Passiflora leschenaultii DC.	Passifloraceae	Liana	1	0.09	0.05
Crotalaria semperflorens Vent	Papilionaceae	Shrub	1	0.09	0.05
Solanum denticulatum Blume.	Solanaceae	Shrub	1	0.09	0.05
Cassine paniculata Lobr.-Callen	Celastraceae	Tree	1	0.09	0.05
Pavetta breviflora DC. var. *ciliolata* Gamble ex Bremek.	Rubiaceae	Tree	1	0.09	0.05