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Patterns of liana diversity in tropical evergreen forests of peninsular India

N. Parthasarathy*, S. Muthuramkumar, M. Sridhar Reddy
Salim Ali School of Ecology and Environmental Sciences, Pondicherry University, Pondicherry 605 014, India

Abstract

The quantitative liana inventories made in five peninsular Indian independent forest sites, distributed in the Western Ghats, Eastern Ghats and on the Coromandel coast, were examined particularly with reference to site altitude and forest stature. Liana diversity totaled 148 species in 101 genera of 47 families, in a total sample of 47 ha. The coefficient of variability in species distribution among the five sites was used to identify an oligarchy in liana species by taking 55 abundant species from the species pool. Ordination analysis, based on presence–absence as well as relative density of liana species indicated a geographical differentiation among the five sites in both the ordinations with respect to site altitude. Liana density (stems > 1.6 cm diameter) decreased with increasing altitude, whereas richness was highest at intermediate elevations. The mean liana density across the forest sites showed a weak negative correlation with forest stature. The lianas encountered in the five study sites fell under six climber types, of which twining was the chief climbing mechanism, both in terms of species diversity and density, and tendril climbers were more abundant in dry evergreen forests than in the wet evergreen forests. In liana diaspore dispersal modes, the majority of evergreen forest species possessed animal dispersal guilds, whereas wind-dispersal was prevalent in semi-evergreen and dry evergreen forests.

Keywords: Climbing modes; Forest stature; Lianas; Ordination; Oligarchy; Site elevation

1. Introduction

Lianas, the woody vines, are abundant and diverse group of plants in forests throughout the world, particularly in the tropics (Schnitzer and Bongers, 2002). According to Gentry (1991a) lianas constitute ~25% of the woody stem density and species diversity in tropical forests. Liana density and diversity increase dramatically with decreasing latitude, more so than most other plant growth forms, with the exception of epiphytic plants (Schnitzer and Bongers, 2002). Besides contributing to density and diversity, lianas play a significant role in forest structure and functional aspects of tropical forests (Putz and Mooney, 1991). Recent studies on lianas have focused on the significant contribution of this life-form to the overall density and species diversity of tropical forests (Gentry and Dodson, 1987), mechanisms by which lianas alter the tropical forest diversity and regeneration (Schnitzer and Carson, 2001), harming some species while promoting others (Schnitzer et al., 2000), and the significant contribution of lianas to whole-forest transpiration and carbon sequestration (Schnitzer and Bongers, 2002).

The biological basis of the variation in liana species richness and density among tropical forests is poorly understood. Physical conditions and human activity both appear to be the important factors (Balfour and Bond, 1993). Lianas tend to be more frequent and larger at a lower elevation (Heaney and Proctor, 1990),

* Corresponding author. Tel.: +91-413-2655994/5x326; fax: +91-413-2655211.
E-mail addresses: partha@flashmail.com, npartha2@rediffmail.com (N. Parthasarathy).

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in bottomland, at the tops of slopes and at forest edges (Williams-Linera, 1990). Quantitative studies on lianas in the rain forest of La Selva in Costa Rica, along a gradient from near sea level to the summit of 2906 m a.s.l. revealed that the species richness, species density and forest stature reached a maximum at 300 m, and declined both above and below that altitude (Lieberman et al., 1996). Balfour and Bond (1993) found that the density of small climbers increased as the altitude decreased and diversity decreased with increasing altitude in the tropics. DeWalt et al. (2000) analyzed the changes in liana species and density along a forest chronosequence in central Panama and found that increasing tree diameter, decreasing light levels and increasing canopy height over succession led to decrease in liana density and diversity and a change in liana species composition. Few studies have explored whether lianas have habitat specificity and consistency in dominant species over large areas (Burnham, 2002) and how liana communities vary at landscape level where the climate is same with different vegetation and variation in soil-topographic features (Putz and Chai, 1987; Molina-Freaner and Tinoco, 1997; Ibarra-Manriquez and Martinez-Ramos, 2002).

Our knowledge on the demography and community dynamics of lianas in tropical forests is still rudimentary and fragmentary, particularly in India, where the ecology of lianas is virtually a blank. Considering this scientific gap, we conducted research on the diversity and ecology of lianas in the tropical wet evergreen forests of the Western Ghats and the Eastern Ghats and in the dry evergreen forests on the Coromandel coast of India. The objective of this paper is to analyze liana diversity and density in peninsular Indian forests with respect to geographical location, site altitude and forest stature.

2. Materials and methods

2.1. Study area

The data set on lianas used in this paper is based on the liana inventories carried out in five forest sites of

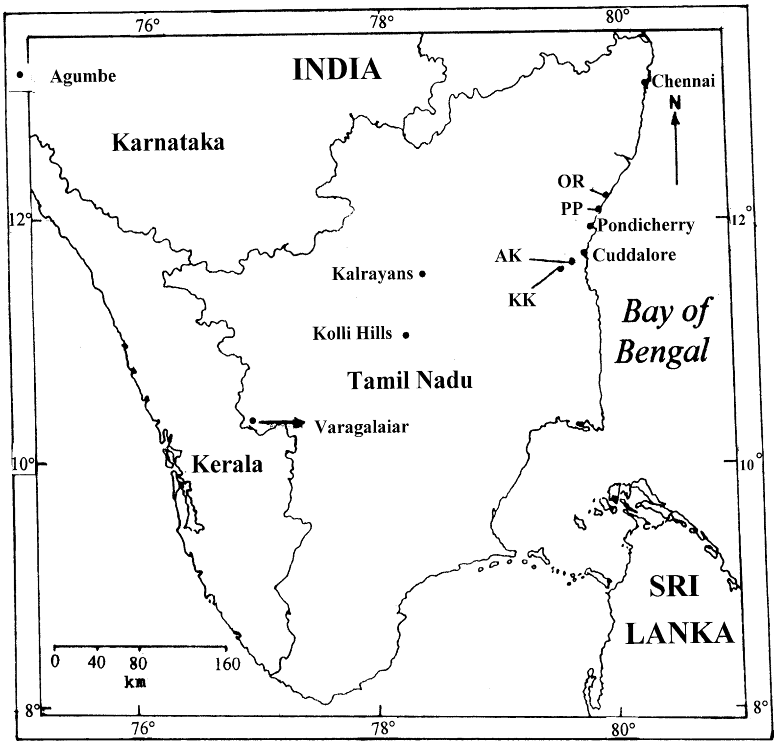

Fig. 1. Map showing location of all the five study sites in peninsular India.

Table 1
Details of the five peninsular Indian study sites where liana inventories were conducted

Location	Latitude and longitude	Altitude (m)	Mean rainfall (mm per year)	Length of dry season (months)	Forest type	Forest stature (m)	Reference
Coromandel coast				6–8			
Oorani (OR)	12°11′N and 79°57′E	~Sea level	1311		Dry evergreen forest	7	Reddy and Parthasarathy (2003)
Arasadikuppam (AK)	11°42′N and 79°36′E	~Sea level	1311		Dry evergreen forest	7	
Kuzhanthaikuppam (KK)	11°43′N and 79°39′E	~Sea level	1311		Dry evergreen forest	7	
Puthupet (PP)	12°04′N and 79°53′E	~Sea level	1311		Dry evergreen forest	7	
Western Ghats							
Agumbe	13°31′N and 75°06′E			5			
Plot 3		100	7000–7500		Lowland evergreen forest	7	Padaki and Parthasarathy (2000)
Plot 2		200	7000–7500		Lowland evergreen forest	7	
Plot 1		650	7000–7500		Lowland evergreen forest	25	
Varagalaiar	10°25′N and 76°52′E	600–660	1660	3–4	Lowland evergreen forest	35	Muthuramkumar and Parthasarathy (2000)
Eastern Ghats							
Kalrayan hills	11°38′–12°01′N and 78°37′–78°51′E			6			
Vellimalai (VM)		680	971		Semi-evergreen forest	13	Kadavul and Parthasarathy (1999)
Devanoor (DV)		760	971		Semi-evergreen forest	13	
Kolli hills	11°10′–11°30′N and 78°15′–78°30′E			5			
Perumakkai shola (PS)		1000	1014		Lower montane evergreen forest	18	Chittibabu and Parthasarathy (2001)
Vengodai shola (VS)		1050	1014		Lower montane evergreen forest	18	
Kuzhivalavu shola (KS)		1200	1014		Lower montane evergreen forest	18	
Mottukkadu shola (MS)		1250	1014		Lower montane evergreen forest	18	

peninsular India (Kadavul and Parthasarathy, 1999; Muthuramkumar and Parthasarathy, 2000; Padaki and Parthasarathy, 2000; Chittibabu and Parthasarathy, 2001; Reddy and Parthasarathy, 2003; Fig. 1). Table 1 provides the details on the geographical location, altitude, mean annual rainfall, length of dry season, forest type and stature of the five study sites. These forests varied considerably in their attributes. The distance between the five independent study sites ranged from 158 km between the Coromandel coast sites located near Pondicherry town and the Kalrayan hills to a maximum linear distance of about 535 km between the Coromandel and the farthest Agumbe sites. The distance between the study plots of a given forest site ranged from 16 to 60 km among the four sites of the Coromandel coast, 1.5 km for the three Agumbe plots, 6 km between the two Kalrayan plots and 1–7 km among the four plots of the Kolli hills.

Whereas the Varagalaiar site is a single block of large 30 ha contiguous plot measuring 500 m × 600 m area. The altitude of the five sites ranged from near sea level for all the Coromandel coast sites to 1250 m for one of the sites in Kolli hills. The Coromandel sites represent forests on relatively flat sites while the other sites are hill forests located on elevation gradient representing the lowland evergreen forests in Agumbe (100–650 m high) and Varagalaiar (600–660 m) in the Western Ghats. The Kalrayan hills represent medium elevation semi-evergreen forest and the Kolli hills sites at 1000–1250 m represent lower montane forest both in the Eastern Ghats.

Among the five study sites the Coromandel forests experience a longer dry season (6–8 months) followed by Kalrayans (6), Kolli hills and Agumbe (5) and Varagalaiar (3–4 months). The forest stature was as short as 7 m of mean tree height in the Coromandel forests to as high as 25 and 35 m, respectively, in Agumbe and Varagalaiar sites of the Western Ghats. Among the five study sites the extent of human disturbance ranged from a relatively undisturbed condition of Varagalaiar (Muthuramkumar and Parthasarathy, 2000) to a much disturbed site 'PP' in the Coromandel coast. The anthropogenic activities associated with Coromandel coast forests, which are 'sacred groves' endowing temples within the forest itself, include the temple visits, fuel wood collection, cutting wood for agricultural purpose as these are usually juxtaposed with agricultural lands (Reddy and Parthasarathy, 2003). Agumbe sites featured a varied degree of anthropogenic activities from nearly undisturbed in plot 1, illegally selective logged in plot 2 and litter removal, grazing in plot 3 (Padaki and Parthasarathy, 2000). Kalrayan hill sites that are temple forests are also subjected to human disturbances like temple visits, seed and fuel wood collection by the locals (Kadavul and Parthasarathy, 1999). Whereas the Kolli hill sites witnessed disturbance due to people's dependence on forests for fuel wood, fruit and herbal medicine (Chittibabu and Parthasarathy, 2001).

2.2. Methods

All lianas ≥1 cm dbh (diameter at breast height), rooted within the study plots were systematically enumerated in the 30 ha plot of Varagalaiar, Western Ghats and in the four 1 ha plots of Coromandel coast forests. Whereas in Agumbe, Kolli hills and Kalrayan hills, all lianas ≥1.6 cm dbh (5 cm gbh, girth at breast height) were enumerated and identified. To facilitate a valid comparison of the liana diversity and density, we used only lianas ≥1.6 cm dbh from the liana data sets. Liana diameters were measured at 1.3 m from their base. Fisher's α, an index of species diversity which is relatively unbiased by sample size (Magurran, 1988), was computed for all the sites. We examined the patterns of liana composition by using non-metric multidimensional scaling (NMS) ordination. The ordinations were based on the Sorenson's similarity matrices of species presence–absence data as well as the relative density, excluding five unidentified species. The contribution of lianas to the forest structure was analyzed by computing the ratio of both liana and tree species richness as well as the density of liana and tree individuals. Further, liana ecology was studied by analyzing their climbing mechanisms (Padaki and Parthasarathy, 2000) and dispersal modes. The statistic, coefficient of variation (CV – standard deviation/mean for a species) was computed to identify whether there is an oligarchy in liana species across the five forest sites. This would provide information on site differentiation with respect to species composition, whether species with a low CV regardless of absolute density are equitably distributed, or those with a high CV show a high degree of variability in their distribution.

3. Results

3.1. Liana diversity and density

The liana inventory in the total sample of 47 ha distributed in five sites of peninsular Indian forests yielded 16,255 liana individuals and 148 species in 101 genera and 47 families (Appendix A). In the total species pool, 26% of species occurred in Coromandel forests, 27% in Agumbe; whereas 51% of species were encountered in Varagalaiar and 19.6 and 17.6% of the species, respectively, in the Kalrayan and Kolli hills. The most diverse genera include *Derris* (7 species), *Capparis* (6 species), *Jasminum* and *Cissus* (5 species each) and *Cayratia* (4 species).

The per site species richness of lianas ≥1.6 cm dbh ranged from 26 to 65 species, in the five study areas,

Table 2
Summarized results of liana inventories of the five peninsular Indian sites

Location	Sampled area (ha)	Species richness		Density		Fisher's α	Number of climbing mechanism	Liana species/(tree species + liana species)	Liana density/(tree density + liana density)
		≥1 cm dbh	≥1.6 cm dbh	≥1 cm dbh	≥1.6 cm dbh				
Coromandel coast									
OR	1	24	19	812	702	4.64	4	0.49	0.63
AK	1	29	26	1163	538	5.39	4	0.63	0.57
KK	1	28	28	497	396	6.42	4	0.58	0.51
PP	1	28	22	835	702	5.58	4	0.51	0.59
Western Ghats									
Agumbe									
Plot 3	1	–	24	–	259	6.45	5	0.28	0.31
Plot 2	1	–	24	–	668	4.86	5	0.33	0.69
Plot 1	1	–	15	–	211	3.69	3	0.24	0.26
Varagalaiar	30	75	65	11200	5269	10.80	6	0.32	0.30
Mean per ha		37	28	373	176	10.12		0.30	0.29
Eastern Ghats									
Kalrayan hills									
VM	1	–	28	–	134	10.77	3	0.37	0.27
	1	–	19	–	93	7.22	3	0.30	0.12
Kolli hills									
PS1	1		16		55	7.9	4	0.23	0.09
PS2	1		15		58	7.06	3	0.25	0.11
VS1	1		12		95	3.65	3	0.26	0.16
VS2	1		14		61	5.63	3	0.35	0.11
KS1	1		9		17	9.5	3	0.22	0.04
KS2	1		2		8	0.86	2	0.07	0.03
MS1	1		13		49	5.78	3	0.22	0.07
MS2	1		10		41	4.21	3	0.22	0.07

while the species richness ranged between 2 and 36 species at the 1 ha scale across these forests. The density of lianas ≥1.6 cm dbh ranged from as high as 702 individuals ha^{-1} in site OR on the Coromandel coast to as low as 8 individuals ha^{-1} in one of the Kolli hill sites (Table 2). The density contribution of each site to the total density revealed that the Coromandel forests contributed the most (47%) whereas the Kolli hill sites contributed just 3% of density. The Western Ghats sites, Agumbe and Varagalaiar had 22 and 21% of total density, respectively, whereas the semi-evergreen forest of Kalrayan hills accounted for 7% of the total density. The log density of species revealed that majority of species occurred in low density. About 57% of species had ≤30 individuals, while 22.3% of species had >127 individuals, whereas just two species had >1024 individuals (Fig. 2).

About 69% of species occurred in only one of the five forest sites, 24% of species were present in two forest sites, while 5% of species were present in three forest sites, just 2% of species were recorded in four of the five study sites, and no species was common in all the five forest sites. The computed Fisher's α value was as high as 10.8 for Varagalaiar and in VM site of the Kalrayan hills. The α values ranged from 4.7 to 6.4 in the dry evergreen forests, 3.69 to 6.45 in the three Agumbe sites; whereas the values for 1 ha plots in Kolli hills varied from 0.86 to 9.5 (Table 2).

3.2. Predominant liana taxa

The three most speciose families, Vitaceae (13 species) Papilionaceae (11) and Apocynaceae (10) (Appendix A), contributed 23% of the total species

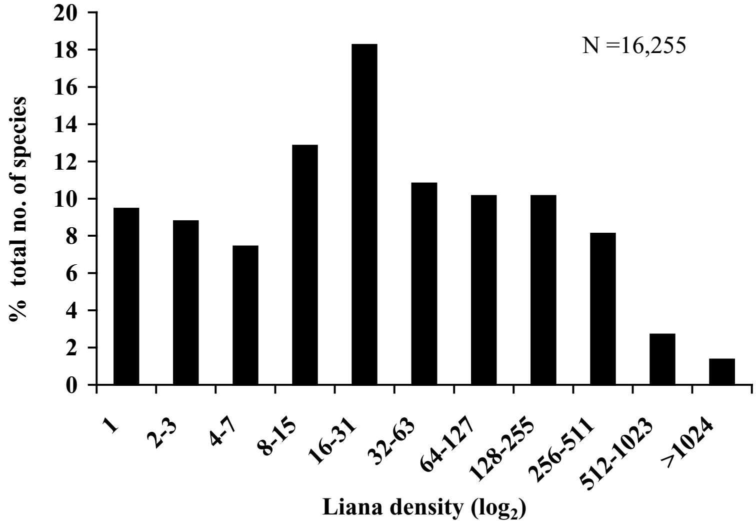

Fig. 2. Frequency distribution of liana species for various abundance classes plotted using the total density of lianas in the 47 ha studied.

richness, whereas a total of 16 families were represented by single species (Fig. 3). In dry evergreen forests, Capparaceae (4 species), Vitaceae (4), Papilionaceae (3), Asclepiadaceae (3) and Apocynaceae (2) were well represented. The semi-evergreen forest of Kalrayan hills contained Rhamnaceae (3 species), Asclepiadaceae (3) and Apocynaceae (2) as prominent families. While in the montane forest of Kolli hills, Vitaceae (3 species), Oleaceae, Mimosaceae, Rutaceae and Rubiaceae (2 species each) were the most speciose families. The lowland wet evergreen forest of Agumbe contained greater diversity of Papilionaceae (3), Rutaceae (3), Arecaceae, Connaraceae and Annonaceae (2 species each). The Varagalaiar site had seven species each in Apocynaceae and Vitaceae, whereas Papilionaceae included 6 species.

With respect to liana density among the peninsular Indian forest sites, Piperaceae, Apocynaceae, Olacaceae, Papilionaceae and Arecaceae were the most important families. In the Coromandel dry evergreen

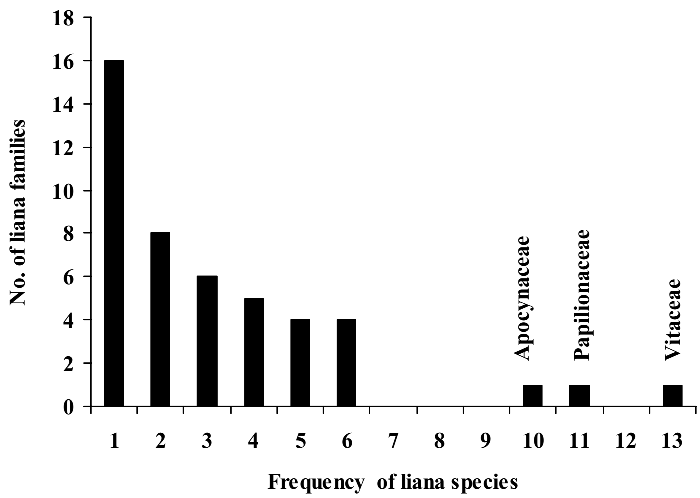

Fig. 3. Frequency of liana species with respect to families of the five peninsular Indian forests.

forest, Loganiaceae, Combretaceae and Papilionaceae contributed ~41% of its total density, whereas in Agumbe evergreen forest ~60% of the density were contributed by Arecaceae, Rubiaceae and Papilionaceae, while in the lowland evergreen forest of Varagalaiar ~38% of density was contributed by Piperaceae, Olacaceae and Apocynaceae. In the Kalrayan hills, Rhamnaceae, Apocynaceae and Papilionaceae formed about 48% of the density, whereas in Kolli hills Malpighiaceae, Oleaceae and Rutaceae contributed about 42% of the density.

3.3. Liana oligarchy in the five peninsular Indian forests

The CV was used to predict the consistency of species occurrence within a forest type. The species with both high dominance and low CV value reveal a high predictability of species in a particular site. CV of species density varied from 0 to 547 in the five peninsular Indian forests. In each site the dominant species exhibited different patterns. In the Coromandel dry evergreen forests, the top 10 abundant species contributed ~75% of the total density and the CV of these dominant species was <150 except for *Secamone emetica*, indicating a high predictability of dominant species in the dry evergreen forests. Whereas in the lowland evergreen forest of Agumbe the top 10 species contributed ~84% of the density but only four species had a CV <150 thus revealing an inconsistency in the occurrence of dominant species in Agumbe sites. In Varagalaiar lowland evergreen forest, the top 10 species contributed ~60% of the density and all the species scored a CV < 150, indicating a moderate predictability of the dominant species. In Kalrayan semi-evergreen forests the top 10 species formed ~68% of the density and the maximum CV of Kalrayan site was 141. Nine out of 10 species had a CV < 100, showing a high consistency of species dominance in Kalrayan hills. In Kolli hills the top 10 species contributed ~74% of the density and 9 out of 10 species had a CV < 150 revealing a high consistency of dominant species in this site.

3.4. Patterns of liana diversity

The NMS ordination of the five peninsular Indian forest sites based on the presence/absence based Sorenson's similarity matrix produced five clusters (Fig. 4a). The two closer clusters on the left side of the plot contained all the three sites of (A1–A3) Agumbe and 1–30 ha (V1–V30) of Varagalaiar. The second group of clusters comprised two sites of the Eastern Ghats one (Kolli hills) on the bottom right corner and the other (Kalrayan hills) along with the Coromandel dry forest sites placed on the upper right corner of the ordination. The relation between stand position and the first dimension score which usually reveals the maximum variation among the sites of the NMS ordination was negatively correlated with the mean canopy height ($r_s = -0.61$, $n = 47$, $P < 0.01$) and positively correlated with the altitude ($r_s = 0.455$, $n = 47$, $P < 0.01$).

The NMS ordination using relative density of liana species produced five clusters (Fig. 4b). The Kolli hills, Kalrayan hills and Coromandel coast forest sites figured on the right side of the ordination stand and the Agumbe and Varagalaiar sites on the left side of the ordination. The correlation between the stand positions along the first dimension scores vs. species density (we considered 55 species with at least 50 individuals) revealed that out of 55 abundant species just 13 were significantly correlated with first dimension scores, of which 9 species were exclusive to Coromandel dry evergreen forest and the rest four species were also dominant in the dry evergreen forests, but with sparse representation in the other forests.

3.5. Liana diversity and density in relation to forest stature and altitude

The five peninsular Indian forest sites that are located along an altitudinal gradient varied significantly in the mean density of lianas ($\geq$1.6 cm dbh) and forest stature (Tables 1 and 2). The density and richness of lianas were strongly correlated with geographical location as density decreased with increasing site altitude ($r^2 = 0.72$, $P < 0.05$ and $r^2 = 0.54$, $P < 0.05$; Fig. 5a and b, respectively). The mean liana density ranged from as high as 585 individuals ha^{-1} in the Coromandel forests to as low as 49 individuals ha^{-1} in the lower montane forests (~1000 m a.s.l.) of Kolli hills. The mean liana density across the forest sites showed a weak negative correlation with forest stature ($r^2 = 0.13$, $P < 0.05$).

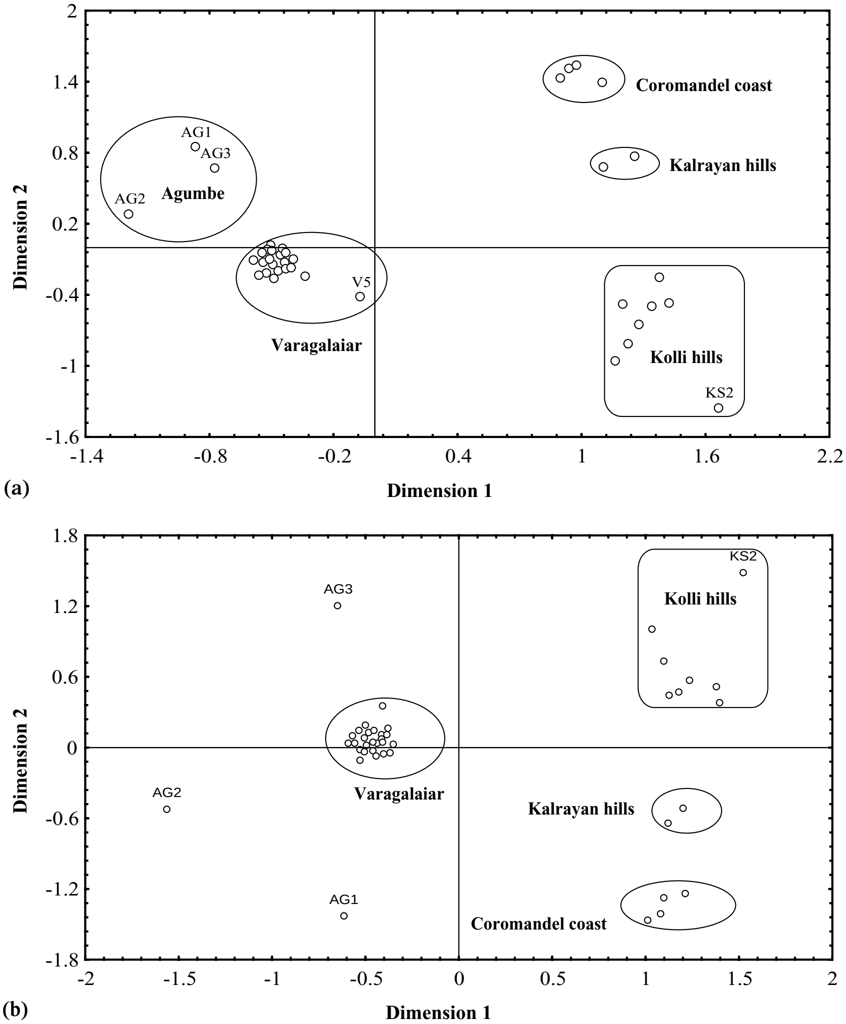

Fig. 4. (a) NMS ordination of five peninsular Indian forest sites (all lianas inventoried are included) using Sorenson's relative presence–absence matrix, presented in two dimensions (stress, 0.0896). (b) NMS ordination of five peninsular Indian forest sites using Sorenson's relative abundance matrix, presented in two dimensions (stress, 0.1118). The study sites in both the figures are indicated in codes: V1–V30 denote the thirty 1 ha subplots of Varagalaiar in Western Ghats; sites A1–A3 denote the three plots of Agumbe; sites PS1 and PS2, VS1 and VS2, KS1 and KS2; MS1 and M2 represent the site Kolli hills, Eastern Ghats; VM and DV represent two sites of Kalrayan hills, Eastern Ghats and those of OR, KK, AK and PP denote the four Coromandel forests.

The tall-statured (35 m) Varagalaiar forest contained mean density of 175.6 lianas ($\geq$1.6 cm dbh) whereas the short-statured (7 m) Coromandel dry evergreen forests had almost triple the density (Fig. 6). However, this negative relationship was driven primarily by the 7 m tall Coromandel forest, and the 13 and 18 m tall forests that had fewer lianas than the 35 m tall Varagalaiar forest.

3.6. Climbing mechanism

The total liana species enumerated in the peninsular Indian forests can be categorized into six climber types: twiners, tendril climbers, scramblers, root climbers, hook climbers and grapnel-like climbers (Table 3). Twining was the chief climbing mechanism both in terms of species richness (55%) and density

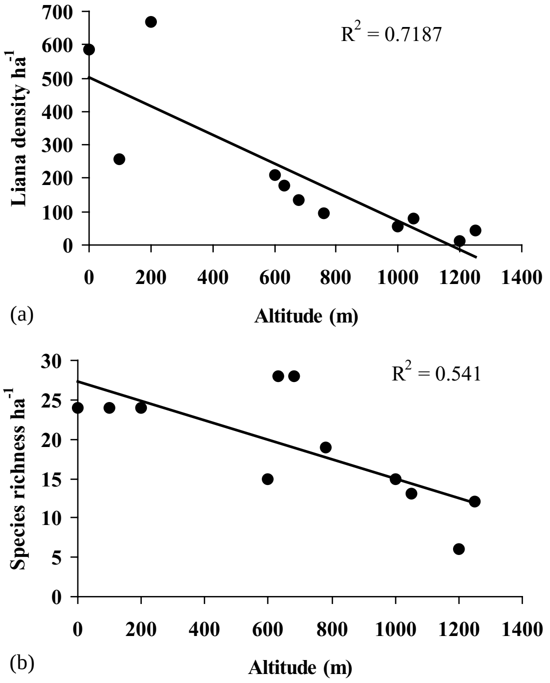

Fig. 5. The relationship between the altitude of the study sites: (a) mean liana density and (b) mean species richness on a per hectare scale.

(49%) when all the sites together, and when the individual forests were considered. Among the five sites Varagalaiar lowland evergreen forest was the only site that possessed all the six climbing modes. A range of 3–24% of individuals belonging to 26 species of six families among the five sites used tendrils for climbing. The highest density of tendril climbers (24%) was found in dry evergreen forests. The scrambler density ranged between 16 and 29% among the five sites and the lowland evergreen forest of Agumbe lacked this type. Root climbers of Piperaceae and Araceae were found in both Agumbe (5%) and Varagalaiar (14%) lowland evergreen forests and a single individual of Aracean root climber (*Raphidophora lacinata*) was found in Kolli hills. The rattan *Calamus* (Arecaceae) with a grapnel-like climbing mechanism was found in both Agumbe (*C. gamblei*, *C. thwaitesii*) and Varagalaiar (*C. gamblei*) sites.

3.7. Liana dispersal ecology

The mean number of liana species in each dispersal mode within the sites varied significantly. Among the five sites Varagalaiar showed the maximum variation, while Kalrayan hills showed minimum variation

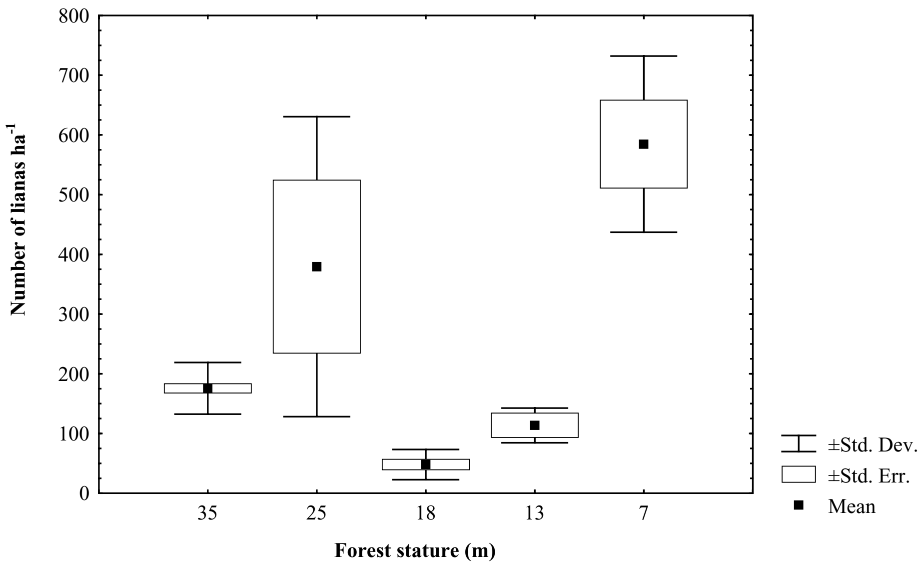

Fig. 6. Density of lianas in relation to forest stature (stand height of 35 m represents Varagalaiar, 25 m Agumbe, 18 m Kolli hills, 13 m Kalrayan hills, and 7 m Coromandel coast forests).

Table 3
Distribution of liana species diversity (*S*) and abundance (*A*, percentage of individuals) under various climbing mechanisms in the five peninsular Indian study sites

Climbing mechanism	Total number of species and percentage of individuals in:									
	Coromandel coast		Agumbe		Varagalaiar		Kalrayan hills		Kolli hills	
	S	*A*	*S*	*A*	*S*	*A*	*S*	*A*	*S*	*A*
Twiners	18	56.4	28	45.0	36	41.3	20	72.0	14	70.6
Scrambles	12	16.2	0	0.0	19	29.1	7	24.0	6	18.0
Root climbers	0	0.0	4	5.0	4	14.0	0	0.0	1	0.3
Hook climbers	1	3.6	3	9.0	3	8.4	0	0.0	0	0.0
Tendril climbers	8	23.6	3	4.0	12	2.7	2	4.0	5	11.2
Grapnel-like climbers	0	0.0	2	37.0	1	4.5	0	0.0	0	0.0

Table 4
Mean number and percentage of species under various dispersal modes in the five peninsular Indian sites

Study sites	Mean number and percentage of species under various dispersal modes				χ^2
	Zoochory	Autochory	Anemochory	Hydrochory	
Coromandel coast	19.0 (69.7)	3.0 (11.0)	5.3 (19.3)	–	$\chi^2 = 16.5$, d.f. = 2, $P < 0.01$
Agumbe	15.0 (76.1)	2.7 (13.7)	2.0 (10.2)	–	$\chi^2 = 45.4$, d.f. = 3, $P < 0.01$
Varagalaiar	26.4 (72.3)	4.5 (12.3)	5.5 (15.1)	0.1(0.3)	$\chi^2 = 16.5$, d.f. = 2, $P < 0.01$
Kalrayan hills	14.5 (61.7)	1.5 (6.4)	7.5 (31.9)	–	$\chi^2 = 10.8$, d.f. = 2, $P < 0.01$
Kolli hills	9.0 (78.9)	0.5 (4.4)	1.5 (13.2)	0.4 (3.5)	$\chi^2 = 17.9$, d.f. = 3, $P < 0.01$

(Table 4). There was no variation in dispersal modes across the five study sites ($\chi^2 = 7.9$, d.f. = 12, $P < 0.01$). Dispersal mode analysis of the five peninsular Indian sites revealed that animal dispersal species were prevalent in all the five sites. Among the five forest sites, a high percent of species with animal dispersal guild were found in the lower montane forest of Kolli hills (78.9%). Wind-dispersal mode was more common in the semi-evergreen forest of Kalarayan hills (32%) than the other sites. *Entada pursaetha*, found in Varagalaiar and Kolli hills, was the only species dispersed by water.

3.8. Liana diversity vs. tree diversity ratio

Among the five peninsular Indian sites the ratio of the liana species richness to the woody species richness ranged from a low of 0.23 for the Kolli hills of the Eastern Ghats to a high value of 0.55 in dry evergreen forests on the Coromandel coast (Table 2). The ratio of liana stem density to woody stem density was as low as 0.08 in the lower montane forest of Kolli hills to as high as 0.58 in dry evergreen forests.

4. Discussion

The vast majority of the species in our sites were site-specific and occurred in low density (Fig. 2). This trend conforms with the observation of Ibarra-Manriquez and Martinez-Ramos (2002) in Mexican rain forest. In our sites, only four species, *Hiptage benghalensis*, *Grewia rhamnifolia*, *Cayratia pedata* and *Aganosma cymosa*, showed a wide ecological amplitude and occurred in four out of the five sites, but all had considerable variation in their population density (Appendix A).

At higher taxonomic levels there is a commonality in plant families and genera across our sites in India. The fact that species of the same family or same genus tended to dominate different habitats supports the hypothesis that evolutionary niche differentiation has occurred within some liana phylogenetic lineages (Ibarra-Manriquez and Martinez-Ramos, 2002). The most species-rich families Vitaceae, Papilionaceae, Apocynaceae found in the five study sites were distinctly different from the neotropical forest species-rich families of the Bignoniaceae, Fabaceae and Malpighiaceae. Also the proportion of species comprised by first 10 families (49%) is slightly less than what has been reported in the neotropics (64–69%; Gentry, 1991a; DeWalt et al., 2000). In peninsular Indian forests, various genera of Papilionaceae dominated in different sites (e.g. *Derris ovalifolia* in dry evergreen forest, *Kunstleria keralense* in lowland forest of Agumbe and Varagalaiar and *Derris scandens* in Kalrayan hills). Whereas in Rutaceae *Luvunga sarmentosa* was dominant in Varagalaiar forest, but *Zanthoxylum tetraspermum* and *Toddalia asiatica* were dominant in the lower montane forest of Kolli hills. A similar pattern with congeneric species occur in the genera *Combretum* and *Calamus*: with *Combretum albidum* dominant in Coromandel dry evergreen forest and *Combretum latifolium* in the wet evergreen forest of Varagalaiar, while *Calamus thwaitesii* was predominant in plot 2 of Agumbe and *Calamus gamblei* in Varagalaiar.

The five peninsular Indian forest sites that are located in different geographical areas, under different forest types and varying rainfall patterns, showed no consistency in the composition of dominant species, but within each forest site there was a four to nine inordinately important species. This may be because the study plots were located along altitudinal gradients and the similar species between the two plots are much less in the Agumbe site resulting in the inconsistency of oligarchic species. The dominance of some oligarchic species may also be due to disturbance. For example, in one of the plots of Agumbe (plot 2) *C. thwaitesii* was abundant, probably due to disturbance such as selective logging.

Liana composition likely is a function of both stand age and geographical location (DeWalt et al., 2000) and disturbance (Laurance et al., 2001). Our ordination analysis revealed that species composition and density are the function of both altitude and geographical location of the sites. In both the presence–absence as well as density ordinations, the plot separation with respect to geographical locale is maintained except in Agumbe site when liana relative density was used in ordination analysis. Thus, the species composition as well as their density is markedly influenced by forest locality and type.

Gentry (1991a) reported that liana diversity decreased with increasing altitude. A similar trend was noticeable in peninsular Indian sites too ($r^2 = 0.54$, $P < 0.05$), but the diversity was higher in 600–700 m altitude. Our results are also in accordance with Lieberman et al. (1996), who found greatest species diversity and density ($\geq$10 cm dbh) in 300 m altitude when compared to <300 and >300 m altitude on the Atlantic slope of Costa Rica. Our correlations of liana diversity and density with altitude and canopy height may also be correlated with other factors, such as seasonality, rainfall, etc. Further, the slight correlation with canopy height is difficult to interpret because the density of lianas in the Coromandel site could be due to factors other than canopy height and thus the causal agent for canopy height or liana density is unknown. Based on the liana inventories of neotropical, African and Australian sites, the highest density of lianas occurred in areas with marked dry season that are transitional between the moist and the dry forests (Gentry, 1991a). Ibarra-Manriquez and Martinez-Ramos (2002) also obtained similar results. The highest liana density of the Coromandel dry evergreen forest, which experience 6–8 months of dry period, is also in conformity with the above reports. One of the lowland evergreen forest plots (plot 2) in Agumbe had density very close to dry evergreen forests, even though its length of dry period is short. This higher density of lianas in plot 2 was assigned to disturbance such as selective logging of the dipterocarp, *Vateria indica* (Padaki and Parthasarathy, 2000). In Kolli hill lower montane evergreen forest, the length of dry period was as same as Agumbe but the density of lianas is very low. The reason could be that the Kolli hill plots are of montane forest type and in montane forest systems, usually the herbaceous vascular and non-vascular epiphytic synusia replace liana community (Richards, 1996).

The appropriateness of a climbing method appears to vary with the type of support available and the height and structure of the forest canopy (Whitmore, 1974; Kelly, 1985). Twining was the chief climbing mechanism, both in terms of species diversity and density, in all our five study sites. Similar observation was made by Putz and Chai (1987) in Malaysian forests. As tendril climbers are restricted generally to less diameter supports (Putz, 1984), they are conspicuously abundant in the dry evergreen forests on the Coromandel coast due to the short stature of these forests as well as the preponderance of tree supports in 10–30 cm gbh class (Venkateswaran and Parthasarathy, in press).

In Mexican forests, Solorzano et al. (2002) reported that maximum number of liana species are wind dispersed and the single largest factor governing diaspore type is taxonomy and the predominance of certain families and genera that are predominantly wind dispersed. In the Charavalle dry forest of Venezuela, Wikander (1984) found more than 75% of climbers with wind-dispersed fruits or seeds, but in our dry evergreen forests only 23% of liana species are wind dispersed. The evergreen forests of Varagalaiar and Kolli hills comprised high prevalence of succulent diaspores (Table 4), indicating the faunal dependence of lianas for dispersal as also suggested by Gentry (1982, 1991b) that liana species are mostly wind-dispersed, although he noted that the species number decreased as rainfall increased, changing the prevalence to animal-dispersed species in wetter localities.

5. Conclusions

Liana species richness and density varied considerably across the five peninsular Indian study sites. Compared to other tropical forest sites, the liana diversity in India was low, especially in our wet evergreen forest sites. The fact that majority of lianas in evergreen forests have animal dispersal guilds reveals their faunal dependence and emphasizes the need for a holistic approach in conservation to protect forest sites with all biota, particularly the tree communities which provide physical support for lianas and fauna for seed dispersal. Overall, it is becoming clear that lianas are important players in many aspects of forest dynamics, far more important than was realized a decade ago (Schnitzer and Bongers, 2002). Keeping in this view, and as lianas are reported to play a key role in the ecology and dynamics of forests (Laurance et al., 2001), further research on the role of lianas in forest structure, stand dynamics and functioning particularly, liana reproduction ecology and resource use by faunal communities deserve investigation in our study sites. Such data are expected to be useful for forest conservation and management.

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Appendix A

Complete list of liana species enumerated in the five peninsular Indian study sites, along with their abundance, arranged in the increasing order of site elevation

Species		Altitude (m)														Total
		0 (AK)	0 (KK)	0 (PP)	0 (OR)	100 (AG)	200 (AG)	600 (AG)	660 (VA)	680 (VM)	760 (DE)	1000 (PS)	1050 (VS)	1200 (KS)	1250 (MS)	
Olax scandens Roxb.	Olacaceae	–	–	5	–	–	–	–	1512	–	–	–	–	–	–	1517
Piper nigrum L.	Piperaceae	–	–	–	–	17	37	–	1438	–	–	–	–	–	–	1492
Chilocarpus atrovirens (G. Don) Bl.	Apocynaceae	–	–	–	–	–	–	–	714	–	–	–	–	–	–	714
Strychnos minor Dennst.	Loganiaceae	292	30	151	150	–	–	–	–	–	–	–	–	–	–	623
Artabotrys zeylanicus J.D. Hook. and Thoms.	Annonaceae	–	–	–	–	3	21	6	588	–	–	–	–	–	–	618
Calamus Gamblei Becc. ex Becc. and J.D. Hook.	Arecaceae	–	–	–	–	–	–	20	498	–	–	–	–	–	–	518
Gnetum ula Brongn.	Gnetaceae	–	–	–	–	3	3	–	441	–	–	5	11	–	7	470
Kunstleria Keralense Mohanan and Nair	Papilionaceae	–	–	–	–	–	–	102	364	–	–	–	–	–	–	466
Luvunga sarmentosa (Blume) Kurz	Rutaceae	–	–	–	–	–	7	–	445	–	–	–	–	–	–	452
Combretum albidum G. Don	Combretaceae	102	162	20	125	–	–	–	–	5	1	–	–	–	–	415
Calamus thwaitesii Becc. and J.D. Hook.	Arecaceae	–	–	–	–	2	406	–	–	–	–	–	–	–	–	408
Ancistrocladus heyneanus Wall. ex Graham	Ancistrocladaceae	–	–	–	–	2	77	–	328	–	–	–	–	–	–	407
Connarus sclerocarpus (Wight and Arn.) Schellenb.	Connaraceae	–	–	–	–	–	–	1	385	–	–	–	–	–	–	386
Combretum latifolium Bl.	Combretaceae	–	–	–	–	–	–	–	364	–	–	–	–	–	–	364
Alangium salvijolium (L.f.) Wang.	Alangiaceae	–	–	–	–	39	6	1	257	–	–	–	–	–	–	303
Jasminum angustifolium (L.) Willd.	Oleaceae	34	9	130	81	–	–	–	–	7	4	5	3	2	10	285
Derris ovalifolia (Wight and Arn.) Benth.	Papilionaceae	168	–	1	113	–	–	–	–	–	–	–	–	–	–	282
Aganosma cymosa (Roxb.) G. Don	Apocynaceae	18	–	–	–	–	–	–	199	19	8	–	–	1	14	259
Erycibe paniculata Roxb.	Convolvulaceae	–	–	–	–	–	–	–	251	–	–	–	–	–	–	251
Hiptage benghalensis (L.) Kurz	Malpighiaceae	–	–	–	–	7	–	–	184	4	4	19	1	3	24	246
Reissantia indica (Willd.) Halle	Celastraceae	35	39	18	152	–	–	–	–	–	–	–	–	–	–	244
Grewia rhamnifolia Heyne ex Roth	Tiliaceae	11	18	72	47	–	–	1	84	–	8	–	–	–	–	241
Ventilago bombaiensis Dalz.	Rhamnaceae	–	–	–	–	–	–	–	239	–	–	–	–	–	–	239
Hippocrates bourdillonii Gamble	Hippocrateaceae	–	–	–	–	–	–	–	235	–	–	–	–	–	–	235
Croton caudatus Geiseler	Euphorbiaceae	–	–	–	–	–	–	–	235	–	–	–	–	–	–	235
Derris benthamii (Thw.) Thw.	Papilionaceae	–	–	–	–	–	–	–	213	–	–	–	–	–	–	213
Cayratia pedata (Lam.) Juss. ex Gagnep.	Vitaceae	–	–	–	7	–	–	–	173	7	1	11	–	–	4	203
Canthium angustifolium Roxb.	Rubiaceae	–	–	–	–	143	3	–	52	–	–	–	–	–	–	198
Anodendron rhinosporum Thw.	Apocynaceae	–	–	–	–	–	–	–	168	–	–	–	–	–	–	168
Ziziphus oenoplia (L.) Mill.	Rhamnaceae	4	19	1	–	–	–	–	142	–	–	–	–	–	–	166
Derris brevipes (Benth.) Baker	Papilionaceae	–	–	–	–	–	–	–	163	–	–	–	–	–	–	163
Secamone emetica (Retz.) R. Br. ex Schultes	Asclepiadaceae	149	2	–	–	–	–	–	–	2	–	–	–	–	–	153
Carissa spinarum L.	Apocynaceae	61	7	65	11	–	–	–	–	–	–	–	–	–	–	144
Piper mullesua Buch.-Ham. ex D. Don	Piperaceae	–	–	–	–	–	–	–	125	–	–	–	–	–	–	125

Appendix A. (*Continued*)

Species		Altitude (m)														Total
		0 (AK)	0 (KK)	0 (PP)	0 (OR)	100 (AG)	200 (AG)	600 (AG)	660 (VA)	680 (VM)	760 (DE)	1000 (PS)	1050 (VS)	1200 (KS)	1250 (MS)	
Zanthoxylum ovalifolium Wight	Rutaceae	–	–	–	–	–	–	–	123	–	–	–	–	–	–	123
Hugonia mystax L.	Linaceae	18	24	57	22	–	–	–	–	–	–	–	–	–		121
Pseudaidia speciosa (Bedd.) Tirveng.	Rubiaceae	–	–	–	–	–	–	–	114	–	–	1	–	1	–	116
Moullava spicata (Dalz.) Nicolson	Caesalpiniaceae	–	–	–	–	4	3	–	108	–	–	–	–	–		115
Ventilago madraspatana Gaertn.	Rhamnaceae	18	4	26	–	1	–	32	–	15	17	–	–	–	–	113
Gymnema sylvestre (Retz.) R. Br. ex Schultes	Apocynaceae	18	11	73	–	–	–	–	–	2	–	–	–	–	–	104
Premna corymbosa (Burm. f.) Rottl. and Willd.	Verbenaceae	28	17	42	16	–	–	–	–	–	–	–	–	–	–	103
Sarcostigma kleinii Wight and Arn.	Icacinaceae	–	–	–	–	–	1	2	92	–	–	–	–	–	–	95
Allophylus serratus (Roxb.) Kurz	Sapindaceae	–	–	–	–	–	–	–	91	–	–	–	–	–	–	91
Elaeagnus conferta Roxb.	Elaeagnaceae	–	–	–	–	–	–	–	83	–	–	–	–	–	–	83
Capparis brevispina DC.	Capparaceae	16	13	46	7	–	–	–	–	–	–	–	–	–	–	82
Jasminum azoricum L.	Oleaceae	–	–	–	–	–	–	–	47	–	–	8	4	–	19	78
Cissus quadrangularis L.	Vitaeceae	37	17	19	2	–	–	–	–	–	–	–	–	–	–	75
Coscinium fenestratum (Gaertn.) Coleb.	Menispermaceae	–	–	–	–	1	20	–	48	–	–	–	–	–	–	69
Anodendron paniculatum A. DC.	Apocynaceae	–	–	–	–	–	–	–	62	–	–	–	–	–	–	62
Rourea minor (Gaertb.) Alston	Connaraceae	–	–	–	–	6	–	19	36	–	–	–	–	–	–	61
Pachygone ovata (Poir.) Miers ex Hook.	Menispermaceae	28	–	24	6	–	–	–	–	–	–	–	–	–	–	58
Derris scandens (Roxb.) Benth.	Papilionaceae	–	41	–	–	–	–	–	–	9	5	–	–	–	–	55
Cansjera rheedii Gmel.	Opiliaceae	23	18	4	7	–	–	–	–	2	–	–	–	–	–	54
Uvaria narum (Dunal) Wall. ex Wight	Annonaceae	–	–	–	–	–	–	–	41	6	7	–	–	–	–	54
Bridelia scandens (Roxb.)Willd.	Euphorbiaceae	–	–	–	–	–	–	–	50	–	–	–	–	–	–	50
Caesalpinia cucullata Roxb.	Caesalpiniaceae	–	–	–	–	–	–	–	46	–	–	–	–	–	–	46
Salacia chinensis L.	Celastraceae	–	3	2	–	–	–	–	35	1	4	–	–	–	–	45
Capparis moonii Wight	Capparaceae	–	–	–	–	–	–	–	45	–	–	–	–	–	–	45
Zanthoxylum tetraspermum Wight and Arn.	Rutaceae	–	–	–	–	–	–	–	–	–	–	2	17	7	16	42
Butea parviflora Roxb.	Papilionaceae	–	–	–	–	–	–	–	41	–	–	–	–	–	–	41
Capparis zeylanica L.	Capparaceae	2	16	18	4	–	–	–	–	–	–	–	–	–	–	40
Smilax sp.	Liliaceae	–	–	–	–	–	35	–	–	–	–	–	–	–	–	35
Carissa inermis Vahl	Apocynaceae	–	–	–	–	–	–	–	35	–	–	–	–	–	–	35
Unidentified-1	Vitaceae	–	–	–	–	–	–	–	34	–	–	–	–	–	–	34
Chonemorpha fragrans (Moon) Alston	Apocynaceae	–	–	–	–	2	1	–	28	–	–	–	–	–	–	31
Pyrenacantha volubilis Wight	Icacinaceae	27	–	2	–	–	–	–	–	–	–	–	–	–	–	29
Acacia caesia (L.) Willd.	Mimosaceae	15	1	11	1	–	–	–	–	–	–	–	–	–	–	28
Plecospermum spinosum Trecul	Moraceae	–	–	11	3	–	–	–	–	4	4	3	1	–	2	28
Embelia basaal A. DC.	Myrsinaceae	–	–	–	–	–	–	–	3	–	–	3	12	3	6	27
Calycopteris Floribunda Lam.	Combretaceae	21	–	–	–	–	6	–	–	–	–	–	–	–	–	27
Diploclisia glaucescens (Blume) Diels	Menispermaceae	–	–	–	–	–	–	–	5	–	–	16	–	–	6	27
Morinda umbellata L.	Rubiaceae	–	–	–	–	–	–	–	–	–	–	13	2	2	9	26

Elaeagnus indica Servattaz	Elaeagnaceae	–	–	–	–	–	–	–	–	–	–	1	12	–	13	26
Capparis rotundifolia Rottb.	Capparaceae	–	–	–	25	–	–	–	–	–	–	–	–	–	–	25
Unidentified-2	Vitaceae	–	–	–	–	–	–	–	23	–	–	–	–	–	–	23
Strychnos vanprukii Craib	Loganiaceae	–	–	–	–	–	–	–	23	–	–	–	–	–	–	23
Hugonia ferruginea	Linaceae	–	–	–	–	2	20	–	–	–	–	–	–	–	–	22
Smilax zeylanica L.	Liliaceae	–	–	–	–	–	–	–	19	–	–	–	3	–	–	22
Toddalia asiatica (L.) Lam.	Rutaceae	–	–	–	–	–	–	–	–	–	–	–	18	4	–	22
Asparagus racemosus Willd.	Liliaceae	9	2	2	7	–	–	–	–	–	–	–	–	–	–	20
Tinospora cordiflia (Willd.) J.D. Hook. and Thoms.	Menispermaceae	–	–	–	15	–	–	–	–	1	2	–	–	2	–	20
Morinda reticulata Gamble	Rubiaceae	–	–	–	–	–	–	–	20	–	–	–	–	–	–	20
Sageretia filiformis (Schult.) Don	Rhamnaceae	–	–	–	–	–	–	–	–	6	14	–	–	–	–	20
Capparis sepiaria L.	Capparaceae	3	5	10	1	–	–	–	–	–	–	–	–	–	–	19
Ampelocissus tomentosa (Heyne ex Roth) Planch.	Vitaceae	–	19	–	–	–	–	–	–	–	–	–	–	–	–	19
Rivea hypocrateriformis (Desr.) Choisy	Convolvulaceae	9	6	1	2	–	–	–	–	–	–	–	–	–	–	18
Coccinia grandis (L.) Voigt	Cucurbitaceae	–	4	12	2	–	–	–	–	–	–	–	–	–	–	18
Phyllanthus reticulatus Poir.	Euphorbiaceae	–	–	–	–	–	–	–	18	–	–	–	–	–	–	18
Entada pursaetha DC.	Mimosaceae	–	–	–	–	–	–	–	9	–	–	6	3	–	–	18
Ziziphus rugosa Lam.	Rhamnaceae	–	–	–	–	–	–	–	12	–	–	–	5	–	–	17
Cissus vitiginea L.	Vitaceae	3	2	5	6	–	–	–	–	–	–	–	–	–	–	16
Abrus precatorius L.	Papilionaceae	6	2	7	–	–	–	–	–	–	–	–	–	–	–	15
Acacia torta Roxb.	Mimosaceae	–	–	–	–	–	–	–	–	6	–	8	–	–	1	15
Strychnos dalzellii C.B. Clarke	Loganiaceae	–	–	–	–	14	–	–	–	–	–	–	–	–	–	14
Passiflora calcarata Mast.	Passifloraceae	–	–	–	–	–	–	–	–	–	–	2	–	–	12	14
Pterolobium hexapetalum (Roth) Sant. and Wagh.	Caesalpiniaceae	–	4	–	–	–	–	–	–	7	2	–	–	–	–	13
Mucunapruriens (L.) DC.	Papilionaceae	–	–	–	–	–	–	–	13	–	–	–	–	–	–	13
Unona viridtjlora Bedd.	Annonaceae	–	–	–	–	–	1	11	–	–	–	–	–	–	–	12
Derris trifoliata Lour.	Papilionaceae	–	–	–	–	–	–	–	12	–	–	–	–	–	–	12
Ichnocarpus frutescens (L.) R. Br.	Apocynaceae	–	–	–	–	–	–	–	–	9	3	–	–	–	–	12
Cayratia tenuifolia (Wight and Arn.) Gagnep.	Vitaceae	–	–	–	–	–	–	–	11	–	–	–	–	–	–	11
Tetrastigma leucostaphylum (Dennst.) Alston	Vitaceae	–	–	–	–	–	–	–	11	–	–	–	–	–	–	11
Cissus glyptocarpa (Thw.) Planch.	Vitaceae	–	–	–	–	–	–	–	11	–	–	–	–	–	–	11
Bauhinia phoenicea Wight and Arn.	Caesalpiniaceae	–	–	–	–	–	10	–	–	–	–	–	–	–	–	10
Cissus heyneana (Wall. ex Lawson) Planch.	Vitaceae	–	–	–	–	–	–	–	–	–	–	2	8	–	–	10
Opilia amentacea Roxb.	Opiliaceae	–	–	–	–	4	2	2	–	–	–	–	–	–	–	8
Pothos scandens L.	Araceae	–	–	–	–	2	2	–	4	–	–	–	–	–	–	8
Anamirta cocculus (L.) Wight	Menispermaceae	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8
Celastrus paniculatus Willd.	Celastraceae	–	–	–	–	–	–	–	3	1	4	–	–	–	–	8
Parsonsia alboflavescens (Dennst.) Mabberley	Apocynaceae	–	–	–	–	–	–	–	8	–	–	–	–	–	–	8
Sarcostemma acidum (Roxb.) Voigt	Asclepiadaceae	5	2	–	–	–	–	–	–	–	–	–	–	–	–	7
Rhaphidophora laciniata (Burm. f.) Men.	Araceae	–	–	–	–	1	–	–	5	–	–	1	–	–	–	7
Argyreia daltoni Clarke	Convolvulaceae	–	–	–	–	–	–	–	–	5	2	–	–	–	–	7
Piper sp.	Piperaceae	–	–	–	–	–	–	6	–	–	–	–	–	–	–	6
Argyreia populifolia Choisy	Convolvulaceae	–	–	–	–	–	–	–	5	1	–	–	–	–	–	6
Cayratia sp.	Vitaceae	–	–	–	–	1	1	3	–	–	–	–	–	–	–	5
Erythropalum populifolium (Arn.) Mast.	Erythropalaceae	–	–	–	–	–	–	–	5	–	–	–		–	–	5

Appendix A. (*Continued*)

Species		Altitude (m)														Total
		0 (AK)	0 (KK)	0 (PP)	0 (OR)	100 (AG)	200 (AG)	600 (AG)	660 (VA)	680 (VM)	760 (DE)	1000 (PS)	1050 (VS)	1200 (KS)	1250 (MS)	
Tylophora indica (Burm. f.) Merr.	Asclepiadaceae	–	–	–	–	–	–	–	–	–	–	4	–	–	1	5
Derris heyneana (Wight and Arn.) Benth.	Papilionaceae	–	–	–	–	–	–	4	–	–	–	–	–	–	–	4
Mussaenda belilla Buch.-Ham.	Rubiaceae	–	–	–	–	–	–	–	4	–	–	–	–	–	–	4
Scutia myrtina (Burm. f.) Kurz	Rhamnaceae	–	–		–	–	–	–	–	2	2	–	–	–	–	4
Cayratia carnosa (Wall. ex Wight and Arn.) Gagnep	Vitaceae	–	–	–	–	–	–	–	–	–	–	1	2	–	–	3
Adenia wightiana (Wall. ex Wight and Arn.) Engler	Passifloraceae	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Unidentified-3		–	–	–	–	1	1	1	–	–	–	–	–	–	–	3
Jasminum multiflorum (Burm. f.) Andr.	Oleaceae	–	–	–	–	–	–	–	3	–	–	–	–	–	–	3
Acacia hohenackri Craib	Mimosaceae	–	–	–	–	–	–	–	3	–	–	–	–	–	–	3
Mimosa intsia L.	Mimosaceae	–	–	–	–	1	–	–	–	–	–	1	–	–	–	2
Unidentified-4		–	–	–	–	1	1	–	–	–	–	–	–	–	–	2
Capparis fusifera Dunn	Capparaceae	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Cosmostigma racemosum (Roxb.) Wight	Asclepiadaceae	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Hemidesmus indicus (L.) R. Br.	Asclepiadaceae	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
Jasminum ritchiei Clarke	Oleaceae	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
Passiflora subpeltata Ortega	Passifloraceae	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
Premna villosa Clarke	Verbenaceae	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
Schefflera venulosa (Wight and Arn.) Harms.	Araliaceae	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Salacia beddomei Gamble	Celastraceae	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Paramignya armata (Thw.) Oliver	Rutaceae	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Paramignya monophylla Wight	Rutaceae	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Derris thyrsiflora Benth.	Papilionaceae	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Unidentified-5		–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Jasminum sambac (L.) Ait.	Oleaceae	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Adenia hondala (Gaertn.) Wilde	Passifloraceae	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Cissus glauca Roxb.	Vitaceae	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Trichosanthes anaimalaiensis Bedd.	Cucurbitaceae	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Ceropegia thwaitesii J.D. Hook.	Asclepiadaceae	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Premna latifolia Roxb.	Verbenaceae	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Premna tomentosa Willd.	Verbenaceae	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Clematis gouriana Roxb. ex DC.	Ranunculaceae	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1

AK: Arasadikuppam; KK: Kuzhanthaikuppam; PP: Puthupet; OR: Oorani; AG: Agumbe; VA: Varagalaiar; VM: Vellimalai; DV: Devanoor; PS: Perumakkai shola; VS: Vengodai shola; KS: Kuzhivalavu shola; MS: Mottukkadu shola.

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