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***Research Article***

# DIVERSITY AND DISTRIBUTION OF CLIMBING PLANTS IN DRY DECIDUOUS FOREST OF NORTH ANDAMAN, ANDAMAN ISLANDS, INDIA

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## ABSTRACT
Climbing plants can have a large impact on the diversity, dominance, structure and dynamics of tropical dry deciduous forests. In present study, a total of 174 climbing plants belonging to 32 species, 28 genera, and 14 families were identified. The most dominant family is Convolvulaceae (21.95%). These consisted of 30 herbaceous climber and 11 liana species. Twinner was the most predominant (70.73%) climbing mechanism. The dominant specie recorded from this forest was *Calamus andamanicus*, (IVI-54.11) and *Erycibe expansa* shows the highest frequency (70%). Most of the species were randomly distributed (95.12%).

***Keywords****: Diversity, Climbing Plants, Dry Deciduous, Andaman*

## INTRODUCTION
Climbing plants are more diverse and abundant being commonly associated with tropical forests than in temperate forests (Putz, 1984; Gentry, 1991; Richards, 1996). In tropical rain forest, they comprise about 25-30% of species diversity (Schnitzer and Bongers, 20002). Climbers play important ecological roles in the forest ecosystem dynamics and functioning (Nabe-Nielsen, 2001; Bongers *et al*., 2002).

In almost all the works on the flora of different countries, the climbers are nearly neglected. The publication by Putz & Mooney (1991) led to renewed interest on this group probably after Darwin (1887). In the past 25 years, with the recognition of their importance in forest ecology, climber related research began slowly to increase (Schnitzer & Bongers, 2002).

Few ecological studies on climbing plants are available from the forests of Sarawak (Proctor *et al.*, 1983; Putz & Chai, 1987), Sabah, East Ma-laysia (Campbell & Newbery, 1993), Queensland, Australia (Hegarty, 1989, 1990), Hunter Valley, New South Wales (Chalmers & Turner, 1994), Knysna, South Africa (Balfour & Bond, 1993), Itu-ri, Congo (Makana *et al.*, 1998), Costa Rica (Lie-berman *et al.*, 1996), Barro Colorado island, Panama (Putz, 1984) and in the subtropical humid forest of Bolivia (Pinard *et al.*, 1999). Such studies are lacking from Indian forests, except for the some recent works in the forest of Anamalais, Western Ghats (Muthuramkumar & Parthasarathy, 2000); the Kalrayan hills, Eastern Ghats (Kadavul & Parthasarathy, 1999).

North Andaman, a major group of islands, is rich in species diversity. Although the study of climbing plants of Andaman has increased dramatically in recent years (Ghosh and Mukherjee, 2006; Prasad *et al*., 2009; Ghosh *et al*., 2013; Ghosh and Pandey, 2013; Ghosh, 2013a, b, 2014a, b). But no information exists on the ecological aspects of the dry deciduous forest communities these Islands. Therefore, the specific objective of the present study was to determine the phyto-sociology of climbing plants in the dry deciduous forest.

## MATERIALS AND METHODS
The North Andaman is the northernmost island of the Andaman region and includes about 70 other smaller islands. It is located between 13°41′ N to 12°50′ N latitudes and 92°11′ E

to 93°07′ E longitudes, covering an area of 1458 km$^2$, and is separated from the Middle Andaman by Austin Strait.

The phytosociological study in this region was carried out during the years 2001-2004, through quadrate sampling method. Twelve quadrate plots (32 x 32 m) were studied for recording ground covers (Mishra, 1966; Malhotra, 1973; Das & Lahiri, 1997; Rai *et al.*, 2011) (Figure 1). In each quadrate the climbing plants were enumerated and measured for girth (GBH >0.3 cm) at breast height. The collected voucher specimens were processed into mounted herbarium sheets following the conventional methodology (Jain & Rao, 1977) and were identified and deposited at CUH Herbarium.


**Figure1: Maps showing location of Andaman & Nicobar Islands**

Climbing mechanisms were also studied for each species and classified them based on observations in the field and reliable references (Putz, 1984). The collected field-data were analyzed for Species structure (frequency, density, abundance, basal area, importance value index (IVI), using the formula as suggested by Mishra (1966), Phillips (1959), Das & Lahiri (1997) and Ghosh (2012). The species diversity was determined using Shannon-Weiner's Index (1963).

## RESULTS AND DISCUSSION

### *Diversity of Climbing Plants*

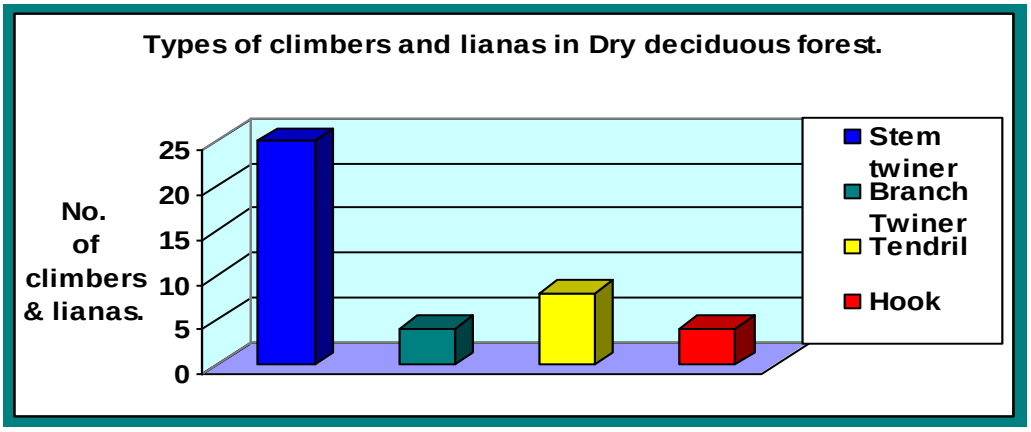


**Figure2: Diversity of Climbing Plants in Dry deciduous forest**

In the study area, a total of 41 species of climbers and lianas were recorded, of which 40 species are angiosperms, and one species is a Pteridophyte (*Lygodium flexuosum*). Within the angiosperms, 32 species are from the dicotyledons (28 genera, 14 families) and 8 species are from the monocotyledons (6 genera, 3 families). In such forest, 30 species (73.17 %) are climbers and 11 species (26.82 %) are lianas.

The most diverse families in terms of species richness were Convolvulaceae (21.95%), Vitaceae (9.75%) and Arecaceae, Cucurbitaceae, Menispermaceae, Papilionaceae (7.31 %) (The details of the determined phytosociological values are recorded in Table 1).

**Table 1: Phytosociological analysis of the recorded species**

| Sl. | Specimen name | Family | D | RA | RD | RF | Rel. Dom | IVI | A/F Ratio |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Abrus pulchellus* Wall. ex. Thw. | Papilionaceae | 20 | 2.707 | 0.271 | 1.087 | 0.016 | 1.374 | 20 |
| 2 | *Aganosma marginata* (Roxb.) G. Don | Apocynaceae | 100 | 1.353 | 1.353 | 3.261 | 1.562 | 6.176 | 3.333 |
| 3 | *Byttneria grandifolia* DC. | Sterculiaceae | 200 | 2.707 | 2.707 | 1.087 | 1.082 | 4.876 | 20 |
| 4 | *Calamus andamanicus* Kurz | Arecaceae | 166.7 | 2.256 | 2.256 | 3.261 | 48.59 | 54.11 | 5.556 |
| 5 | *Cayratia japonica* (Thunb.) Gagnep. | Vitaceae | 300 | 4.06 | 4.06 | 1.087 | 0.209 | 5.357 | 30 |
| 6 | *Cissus pentagona*Roxb. | Vitaceae | 200 | 2.707 | 2.707 | 1.087 | 0.151 | 3.945 | 20 |
| 7 | *Cissus elongata*Roxb. | Vitaceae | 100 | 1.353 | 1.353 | 2.174 | 0.141 | 3.669 | 5 |
| 8 | *Cocculus pendulus* (J.R. & G. Forst.) Diels | Menispermaceae | 100 | 1.353 | 1.353 | 2.174 | 0.145 | 3.673 | 5 |
| 9 | *Combretum roxburghii* Spreng. | Combretaceae | 150 | 2.03 | 2.03 | 2.174 | 3.390 | 7.595 | 7.5 |
| 10 | *Cryptolepis buchananii* Schultes | Asclepiadaceae | 150 | 2.03 | 2.03 | 2.174 | 0.612 | 4.816 | 7.5 |
| 11 | *Cucumis melo* L. | Cucurbitaceae | 250 | 3.383 | 3.383 | 2.174 | 0.178 | 5.736 | 12.5 |
| 12 | *Cuscuta reflexa* Roxb. | Convolvulaceae | 100 | 1.353 | 1.353 | 2.174 | 0.016 | 3.543 | 5 |
| 13 | *Daemonorops kurzianus Becc* | Arecaceae | 200 | 2.707 | 2.707 | 1.087 | 10.46 | 14.26 | 20 |
| 14 | *Dinochloa scandens* (Bl.) Kuntze | Poaceae | 200 | 2.707 | 2.707 | 2.174 | 1.661 | 6.542 | 10 |
| 15 | *Erycibe expansa* Wall. ex G. Don | Convolvulaceae | 142.9 | 1.933 | 1.933 | 7.609 | 0.086 | 9.628 | 2.041 |
| 16 | *Evolvulus alsinoides* (L.) L. | Convolvulaceae | 275 | 3.722 | 3.722 | 4.348 | 0.087 | 8.157 | 6.875 |
| 17 | *Heterostemma tanjoreense* Wight & Arn. | Asclepiadaceae | 233.3 | 3.158 | 3.158 | 3.261 | 2.482 | 8.901 | 7.778 |
| 18 | *Hiptage thothathrii* Balakr. & Srivastava | Malpghiaceae | 400 | 5.413 | 5.413 | 1.087 | 11.21 | 17.71 | 40 |
| 19 | *Ipomoea obscura* (L.) Ker Gawler | Convolvulaceae | 233.3 | 3.158 | 3.158 | 3.261 | 0.058 | 6.477 | 7.778 |
| 20 | *Ipomoea nil* (L.) Roth | Convolvulaceae | 150 | 2.03 | 2.03 | 2.174 | 0.023 | 4.228 | 7.5 |
| 21 | *Jasminum angustifolium* (L.) Willd. | Oleaceae | 300 | 4.06 | 4.06 | 1.087 | 0.328 | 5.476 | 30 |
| 22 | *Jasminum lanceolaria* Roxb. | Oleaceae | 100 | 1.353 | 1.353 | 2.174 | 0.440 | 3.968 | 5 |
| 23 | *Luffa cylindrica* (L.) M. | Cucurbitaceae | 233.3 | 3.158 | 3.158 | 6.522 | 0.125 | 9.805 | 3.889 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Roemer | | | | | | | | |
| 24 | *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | 200 | 2.707 | 2.707 | 3.261 | 0.049 | 6.017 | 6.667 |
| 25 | *Merremia umbellata subsp. orientalis* (H. Hallier) van Ooststroom | Convolvulaceae | 200 | 2.707 | 2.707 | 1.087 | 0.020 | 3.814 | 20 |
| 26 | *Momordica charantia* L. | Cucurbitaceae | 200 | 2.707 | 2.707 | 1.087 | 0.019 | 3.814 | 20 |
| 27 | *Operculina turpethum* (L.) S. Manso | Convolvulaceae | 150 | 2.03 | 2.03 | 4.348 | 0.206 | 6.585 | 3.75 |
| 28 | *Paederia foetida* L. | Rubiaceae | 100 | 1.353 | 1.353 | 2.174 | 0.028 | 3.556 | 5 |
| 29 | *Pycnarrhena longifolia* (Decne ex Miq.) Bece. | Menispermaceae | 166.7 | 2.256 | 2.256 | 3.261 | 1.493 | 7.009 | 5.556 |
| 30 | *Sphenodesme involucrata* (Presl) Robinson | Verbenaceae | 150 | 2.03 | 2.03 | 2.174 | 0.132 | 4.336 | 7.5 |
| 31 | *Stephania japonica* var: *discolor* (Bl.) Forman | Menispermaceae | 200 | 2.707 | 2.707 | 1.087 | 0.230 | 4.024 | 20 |
| 32 | *Stictocardia tiliifolia* (Desrousseaux) H. Hallier | Convolvulaceae | 200 | 2.707 | 2.707 | 1.087 | 0.636 | 4.43 | 20 |
| 33 | *Strophanthus wallichii* A. de Candolle | Apocynaceae | 150 | 2.03 | 2.03 | 2.174 | 7.487 | 11.69 | 7.5 |
| 34 | *Tetrastigma leucostaphyllum* (Dennst.) Alston ex Mabb. | Vitaceae | 216.7 | 2.932 | 2.932 | 6.522 | 3.758 | 13.21 | 3.611 |
| 35 | *Thunbergia alata* Bojer ex Sims | Thunbergiaceae | 200 | 2.707 | 2.707 | 1.087 | 0.167 | 3.961 | 20 |
| 36 | *Thunbergia grandiflora* (Rottler) Roxb. | Thunbergiaceae | 171.4 | 2.32 | 2.32 | 7.609 | 0.850 | 10.78 | 2.449 |
| 37 | *Tridynamia megalantha* (Merr.) Staples | Convolvulaceae | 200 | 2.707 | 2.707 | 1.087 | 0.275 | 4.069 | 20 |
| 38 | *Tylophora. indica* (Burm.f.) Merr. | Asclepiadaceae | 200 | 2.707 | 2.707 | 2.174 | 0.461 | 5.342 | 10 |
| 39 | *Uvaria andamanica* King | Anonaceae | 300 | 4.06 | 4.06 | 1.087 | 0.942 | 6.089 | 30 |
| 40 | *Vigna adenantha* (G. F. Meyer) Marechal & Stainier | Papilionaceae | 100 | 1.353 | 1.353 | 2.174 | 0.017 | 3.545 | 5 |
| 41 | *Vigna unguiculata* (L.) Walp. ssp. *cylindrical* (L.) van Eseltine | Papilionaceae | 100 | 1.353 | 1.353 | 2.174 | 0.145 | 3.673 | 5 |

*(D= Density; RA = Relative Abundance; RD = Relative Density; RF = Relative Frequency; IVI = Importance Value Index; A/F Ratio= Abundance/ Frequency Ratio).*

Within the 41 species, 25 species (62.97%) are stem twiners, 8 (19.51%) tendril climbers, 4 (9.75%) branch twiners, and 4 (9.75%) hook climbers (Figure 2).

### *Frequency and Density of Species*

It was found that *Erycibe expansa* and *Thunbergia grandiflora* show the highest frequency (70%) with densities of 10/hec. and 12/hec. respectively, followed by *Luffa cylindrica* and *Tetrastigma leucostaphylla* (frequency: 60%, and density of 14/hec. and 13/hec.respectively); *Calamus andamanicus* and *Pycnarrhena longifolia* (frequency: 30%, with density: 5/hec.); and *Heterostemma tanjorense* and *Ipomoea obscura* (frequency: 30%, with density: 7/hec.). *Luffa cylindrica* shows the highest density (14/hec.) with higher frequency (60%); followed by *Thunbergia grandiflora Erycibe expansa, Cayratia japonica, Jasminum angustifolium var. angustifolium,* and *Uvaria andamanica (*density: 10-12/hec. and highest frequency of 70%). It could be observed that except *Erycibe expansa* and *Thunbergia grandiflora,*

all the other species show linear progression of density and frequency with regression value ($R^2$) =0.813 (Figure 3).

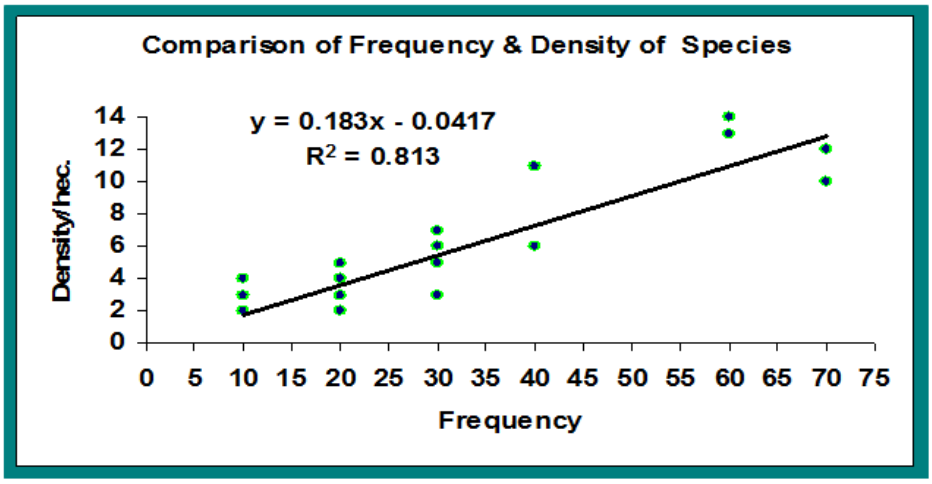


**Figure: 3. Comparison of frequency and density of species**

***Relative Abundance and Relative Frequency of Species***

It has been observed that *Hiptage thothathrii* shows highest relative abundance (5.4132) with frequency of 10% in the forest followed by *Cayratia japonica*, *Jasminum angustifolium* var. *angustifolium* and *Uvaria andamanica* (rel. abund.- 4.0599, with frequency 10%); *Evolvulus alsinoides* (rel. abund.- 3.7216, with frequency 40%). It has been further observed that in three species *Heterostemma tanjoreense*, *Ipomoea obscura* and *Luffa cylindrica*, the relative abundance is same (3.1577), but their frequencies are different (30- 60%). The frequency of the entire species group found in the Dry deciduous forest with their respective relative abundance (Figure 4) show linear progression of distribution with regression value ($R^2$) =0.8396.

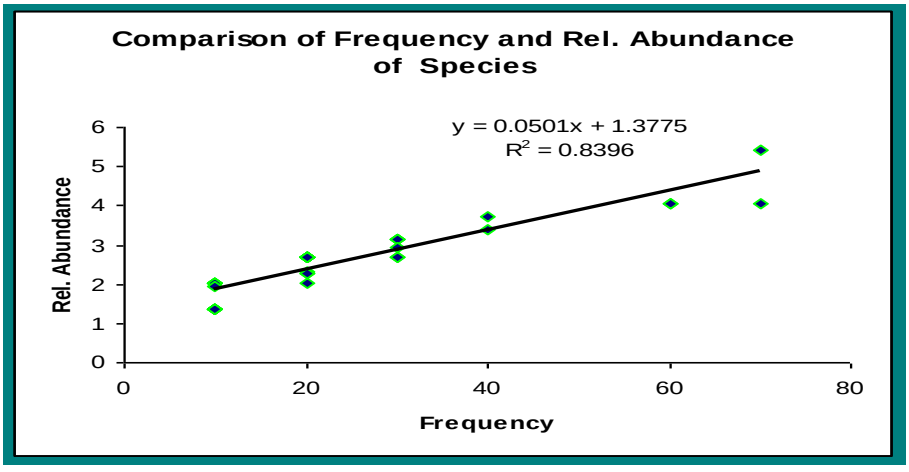


**Figure: 4. Comparison of Relative Abundance and frequency of Dry deciduous forest**

***Density Rank Relation of Species***

Observation shows that *Luffa cylindrica* has highest density (14/hec) in the first rank, followed by *Tetrastigma leucostaphyllum* (13/hec), *Thunbergia grandiflora (*12/hec*), Evolvulus alsinoides* (11/hec*)* and density 2/ha, are more than 17 species. Except *Luffa cylindrica*, other species show exponential pattern with regression value ($R^2$) =0.9455 (Figure 5).

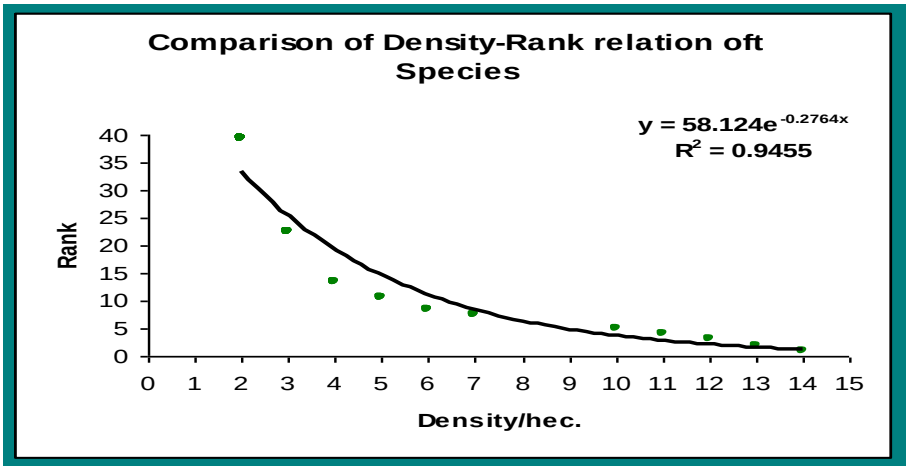


**Figure5: Comparison of density-rank relation of species**

***Mean and Variance Analysis of Species***

It is evident that species showing values ranging from 0.5-0.7 and 1.5667-1.1667 (Figure 6) of mean and variance respectively are generally aggregated. The common aggregated species are: *Cucumis melo, Heterostemma tanjoreense*. Species with values mean and variance ranging from 0.2-1.4 and 0.1778-2.3222 respectively are generally random in distribution in the habitat. The common randomly distributed species are: *Erycibe expansa, Evolvulus alsinoides, Luffa cylindrical, Operculina turpethum, Tetrastigma leucostaphyllum, Thunbergia grandiflora* etc.

Degree of freedom is 9. The species are aggregated in distribution showing 0.0127405 to 0.0171049 probabilities with chi square values ranging from 20.1429 to 21, whereas species of random distribution show probability of 0.025169 to 0.741312 with chi square values ranging from 6 to 19.

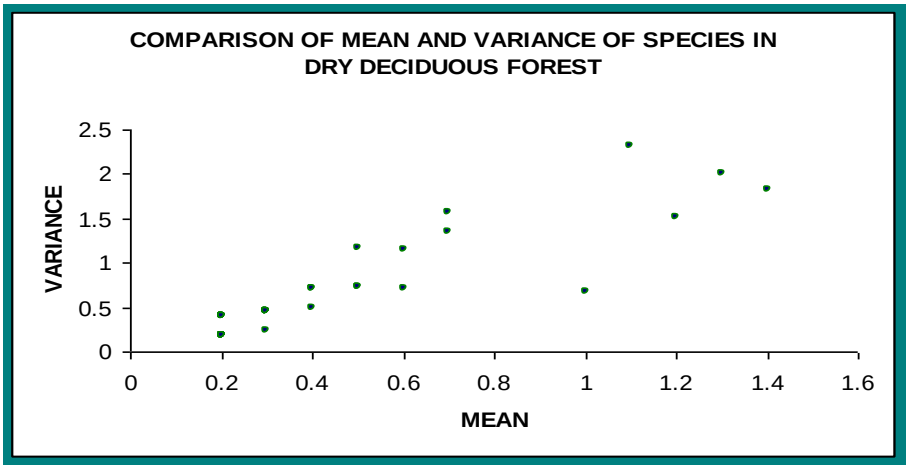


**Figure 6: Comparison of mean and variance of species**

***Importance Value Index***

*Calamus andamanicus,* shows the highest IVI (54.11), followed by *Hiptage thothathrii* (17.71), *Daemonorops kurzianus* (14.25), *Tetrastigma leucostaphylla* (13.21), *Strophanthus wallichii* (11.69), *Thunbergia grandiflora* (10. 77). The minimum IVI (1.37) is found in species *Abrus pulchellus* (Appendix: 10A). Except the species having IVI more than 18, other species show power pattern with regression value ($R^2$) =0.9238 (Figure 7).

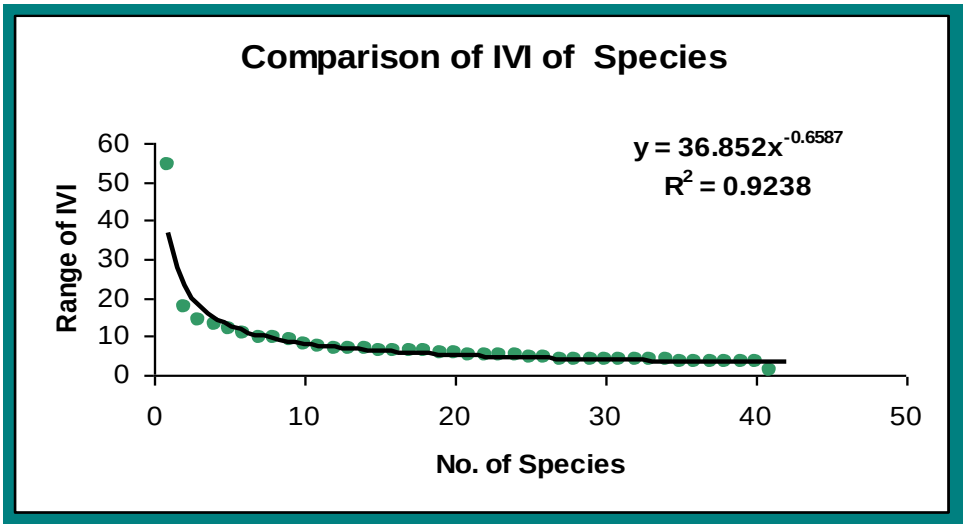


**Figure7: Comparison of IVI of dry deciduous forest species**

### *Species Richness (S) and Diversity (N1) of Plots*

**S**howed that the plot numbers 2 and 4 show high species richness (S >_21), the diversity of these plots are relatively high (*N1*> 28.05) in comparison to plot numbers 3 and 6 where species richness is high (S <18) but the diversity is relatively low (*N1* = <9.9). It is also found that the plot numbers 7 and 9 show high diversity (*N1*=<10.42), but their species richness is low (S=<16). Plots like 1, 5 and 10 show more or less proportionate S and *N1* values (Figure 8).

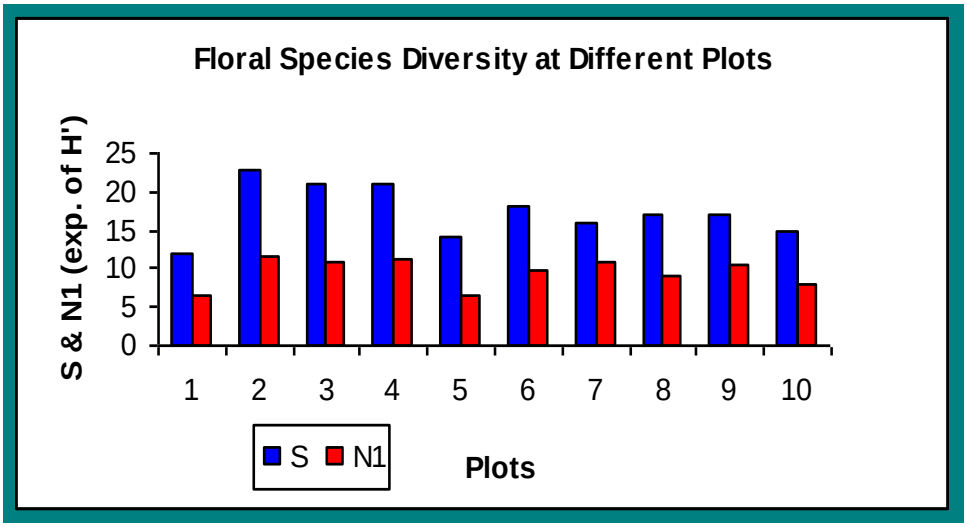


**Figure8: Comparison of species richness (S) and diversity (N1) of plots**

### *Taxonomic Similarity of Different Plots*

It has been observed that the plots 4th and 7th, situated in the Radhanagar region with the highest similarity (48.8095). Plots 1st and 5th are quite far from each other, show relatively low similarity (38.0952) and together with plots 4th, 8th, 9th, and 10th are more or less similar in species composition with similarity (39.1143). Plots 3rd and 11th far from each other but show much similarity (>36). Plots 3rd, and 6th, are far from each other and show different species composition with low similarity (>30). Plot 2nd is entirely of different composition and is found as a separate cluster from the rest (Figure 9).

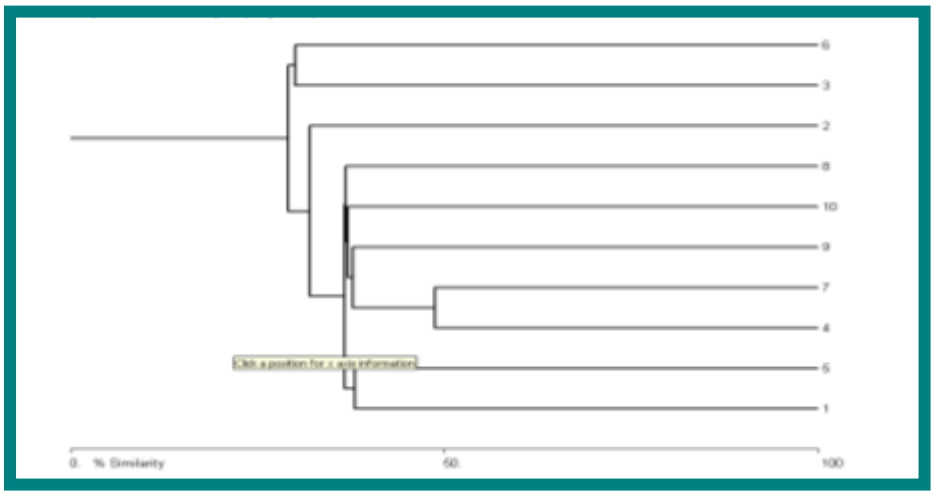


**Figure 9: Dendogram of taxic similarity of dry deciduous plots**

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**REFEREENCES**
**Balfour AD and Bond WJ (1993).** Factors limiting climber distribution and abundance in a Southern Aferican forest. *Journal of Ecology* **81** 93-99.
**Bongers F, Schnitzer SA and Traore D (2002).** The importance of lianas and consequences for forest management in West Africa. Bioterre Rev. Int. Sci. de la Vie et la Terre, No. specia, 1: 59-70.
**Campbell EJF and Newberry DM (1993).** Ecological relationships between lianas and trees in lowland rain forest in Sabah, East Malaysia. *Journal of Tropical Ecology* **9**(4) 469-490.
**Chalmers AC and Turner JC (1994).** Climbing plants in relation to their supports in a stand of dry rainforest in the Hunter Valley, New South Wales. *Proceedings of the Linnean Society of New South Wales* **114**(1-4) 73-90.
**Darwin C (1867).** On the movements and habits of climbing plants. *Journal of the Linnean Society (Botany)* **9** 1-118.
**Das AP and Lahiri AK (1997).** Phytosociological studies on the ground covering flora in different types of vegetation in Tiger Hill, Darjeeling District, West Bengal (India). *India Forums* **123**(12) 1176 -1187.
**Gentry AH (1991).** The distribution and evolution of climbing plants. In: *The Biology of Vines* edited by Putz FE & Mooney HA (Cambridge University Press, Cambridge, UK) 3–49.
**Ghosh A (2012).** Diversity of Climber and Liana of North Andaman with special reference to ecology. Ph.D. Thesis, University of Calcutta. Calcutta: 65-70.
**Ghosh A (2013a).** Diversity and distribution of climbing plants in littoral forest of North Andaman, Andaman Islands, India. *Indian Journal of Plant Sciences* **2**(3) 35-42.
**Ghosh A (2013b).** Taxonomic diversity of climbing plants of North Andaman forest. India. *Indian Journal of Plant Sciences* **2**(4) 20-43.
**Ghosh A (2014a).** Diversity and distribution of climbing plants in Mangrove forest of North Andaman Islands. *International journal of Pharmacy and Life science* **5**(4) 3463-3466.
**Ghosh A (2014b).** Survey and presence class of climbing plants in the flora of Andaman Islands, India. *International Journal of Innovative Research and Review* **2**(1) 35-46.
**Ghosh A and Mukherjee PK (2006).** Diversity of Climbers and Lianas of North Andaman. *National Conference on Forest Biodiversity Resourse: Exploration, Coservation and management.* Madurai Kamraj Univ., Madurai.

**Ghosh A, Chaudhury K and Mukherjee PK (2013).** An interactive approach of remote sensing and geographical information system in the understanding of north Andaman forest. *Bioherald: An International Journal of Biodiversity & Environment* **3**(1) 37- 40.
**Ghsoh A and Pandey HP (2013).** Community structure and distribution of climbing plants in Moist Deciduous forest of North AndamanIslands, India. *Bioherald* **3**(2): 97-104.
**Hegarty EE (1989).** The climbers-lianes and vines. Ecosystems of the World 14B. *Tropical Rain Forest Ecosystems*. edited by Lieth H & Werger MJA (Elsevier, Amsterdam, the Netherlands) 339-353.
**Hegarty EE (1990).** Leaf life span and leafing phenology of lianas and associated trees during a rainforest succession. *Journal of Ecology* **78** 300-312.
**Jain SK and Rao RR (1977).** *A Handbook of field and Herbarium Methods* (Today and tomorrow's Printers and Publishers, New Delhi) 1977.
**Kadavul K and Parthasarathy N (1999).** Lianas in two tropical semi-evergreen forest sites on the Kalrayan hills, Eastern Ghats, south India. *Tropical Biodiversity* **6** 197-208.
**Lieberman D, Lieberman M, Peralta A and Hartshorn GS (1996).** Tropical forest structure and composition on a large-scale altitudinal gradient in Costa Rica. *Journal of Ecology* **84** 137–152.
**Makana JR, Hart TB and Hart JA (1998).** Forest structure and diversity of lianas and understory treelets in monodominant and mixed stands in the Ituri forest, Democratic Replublic of Congo. In: *Forest Biodiversity Research, Monitoring and Modelling: Conceptual background and old world case studies*. Man and the Biosphere Series, edited by Dallmier F & Comiskey JA (UNESCO, Paris, France: Parthenon Publishing Group Ltd) **20** 429-446.
**Malhotra SK (1993).** Studies on the Limestone Vegetation of Sahasradhara near Dehra Dun-Phytosociological Studies: Importance Value Index. *India Forums* **99**(2) 102 - 115.
**Mishra R (1966).** *Ecology Workbook* (Oxford & I.B.H. Calcutta).
**Muthuramkumar S and Parthasarathy N (2000).** Alpha diversity of lianas in a tropical evergreen forest in the Anamalais, Westtern Ghats, India. *Diversity and distributions* **6** 1-14.
**Nabe-Nielsen J (2001).** Diversity and distribution of lianas in a neotropical rain forest, Yasuni National Park, Ecuador. *Journal of Tropical Ecology* **17**(1) 1-19.
**Philips EA (1959)**. *Methods of Vegetation study* (Henry Holt and Co. Inc. New York, U.S.A.).
**Pinard MA, Putz FE, Rumiz R and Jardim A (1999).** Ecological characterization of tree species for guiding forest management decisions in seasonally dry forest in Lomerro, Bolivia. *Forest Ecology and Management* **13** 201-213.
**Prasad PRC, Reddy CS, Lakshmi RKV, Kumari PV and Raza SH (2009).** Angiosperms of North Andaman, Andaman and Nicobar Islands, India, *Check list* **5**(2) 254-269.
**Proctor J, Anderson JM, Chai P and Vallack HW (1983).** Ecological studies in four contrasting lowland rainforests in Gunung Mulu National Park, Sarawak. I. Forest environment, structure and floristics. *Journal of Ecology* **71** 237-260.
**Putz FE (1984).** The natural history of lianas on Barro Colorado Island, Panama. *Ecology* **65** 1713-1724.
**Putz FE and Chai P (1987).** Ecological studies of lianas in Lambir National Park, Sarawak, *Malaysia. Journal of Ecology* **5** 523-531.
**Putz FE and Mooney HA (1991)**. *The Biology of Vines* (Cambridge University Press, Cambridge).
**Rai U, Das AP and Singh S (2011).** Understanding the forest types in lower hills of Darjiling Himalaya using satellite and ground truth data. In *Recent Studies in Biodiversity and Traditional Knowledge in India.* Edited by Ghosh C & Das AP (Sarat Book House, Kolkata) 203-213.
**Richards PW (1996)**. *The tropical rain forest: an ecological study* (Cambridge University Press, Cambridge) **2**nd edition 575.
**Schnitzer SA and Bongers F (2002).** The ecology of lianas and their role in forests. *Trends in Ecology and Evolution* **17** 223-230.
**Shannon CE and Weiner W (1963).** *Mathematical Theory of Communication* (University of llinios Press, Illinios, U.S.A.).