Taxonomic Diversity of Lianas in Tropical Forests of Northern Eastern Ghats of Andhra Pradesh, India

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Abstract

Lianas are important in forest ecosystem and strongly influence the forest dynamics and diversity. Lianas are common in the tropical moist deciduous and rain forests, which are competing with other forest trees. Little information is known on the habitat specialization in tropical lianas diversity and the root causes for variation among forests in liana species composition. A total of 170 liana species (≥ 1.5 cm girth at breast height) representing 109 genera and 43 families were reported in 5×5 m quadrate samples along with their climbing modes in the tropical forests of northern Eastern Ghats of Andhra Pradesh, India. A total of 210 grids were sampled in study area and reported that Convolvulaceae was the dominant family with 23 species followed by Papilionaceae, 22 species and Asclepiadaceae, 19 species and Ipomoea was the largest genera. Woody lianas were dominated by 128 species and these are classified into six climbing modes consisting in stem climbers (53.5%) that were the most predominant followed by stragglers-unarmed (14.7%), stragglers armed and tendril climbers (13.5% each), root climbers (2.9%) and hook climbers (1.8%). The most dominant liana species in the northern Eastern Ghats were Acacia sinuata and Bauhinia vahlii. The results of this investigation suggests that better management and protection is an important for in situ conservation of liana diversity and involving local people is emphasized.

Keywords: climbing modes, conservation, diversity, Eastern Ghats, lianas

Introduction

Lianas are long-stemmed woody vines, which are fixed in the soil at ground level and depend on the physical support of other plants to reach the forest canopy (Araujo and Alves, 2010; Schnitzer and Bongers, 2002). These are prominent features of most tropical forests, where their leaves can constitute a large amount of the total area of the entire forest community (Putz and Mooney, 1991). Lianas make use of much greater ecological consequence than their size suggests and represent less than 5.0% of tropical forest biomass but up to 40% of leaf productivity (Hegarty and Caballe, 1991; Heidjen and Phillips, 2008). They struggle strongly with trees, very much reducing tree growth, tree reproduction and greatly increasing tree mortality (Wright et al., 2005; Schnitzer and Carson, 2010; Ingwell et al., 2010) and altering the course of regeneration in forests (Schnitzer et al., 2000). The density of lianas was greater than ever before and significantly increased their diversity during the last two decades of the twentieth century (Phillips et al., 2002).

The ecological importance of lianas is well documented, since they are of fundamental importance in the functioning of ecosystems as competing with trees either directly or indirectly. They act as key ecological components of whole forest in transpiration, carbon sequestration and forest regeneration (Schnitzer and Bongers, 2002). Lianas play a significant ecological role in different patterns of pollination, dispersal and phenological systems, provide several resources, and play vital roles in the protection of biological diversity (Reddy and Parthasarathy, 2006). The wealth and species diversity of lianas also depend upon a number of abiotic factors, including total occurrence of rainfall with seasonal variations, soil fertility and disturbances (Schnitzer, 2005). The main causes of the disturbance of lianas are the tree fallings not only important for sustaining the liana species but also maintain diversity that leads to increased development of lianas (Yuan et al., 2009; Reddy and Parthasarathy, 2003). The development of highest frequency of lianas is mainly because of declining the rainfall but several factors that are known to favour them are the increase anthropogenic impacts (Londe and Schnitzer, 2006). Lianas act as an indicator species response to increase CO2 concentrations and benefit from other anthropogenic
The Eastern Ghats are a long chain of broken hills and elevated plateaus and one of the nine floristic regions in India, running along the east coast of India in the states of Odisha, Andhra Pradesh, Tamil Nadu and Karnataka and lies between Mahanadhi and Vaigai rivers. The present study was carried out in northern Eastern Ghats of Andhra Pradesh, which lies between latitudes of 16° 15' and 19° 12' N and eastern longitudes of 80° 50' and 84° 47' E runs through five districts, namely Srikakulam, Vizianagaram, Visakhapatnam, East Godavari and West Godavari. The highest elevation measures about 1615 m above the msl in this region. Geological formation of the region consists chiefly in Charnokites and Kondalites and varied metamorphic rocks. Soils of northern Eastern Ghats is loamy, black, lateritic and alluvial. Lateritic soils are the common type along the deciduous forests of the area. The climate of the district is characterized by uncomfortably hot during summer and pleasantly cold during winter. There are three distinct seasons in a year; winter (November to February), summer (March to June) and rainy season (July to October). The maximum temperature ranges from 28°–46.2° C and minimum temperature ranges between 12.9°–27° C. The maximum rainfall is 1300 mm per annum in south-west monsoon period. At all the plots, a similar pattern of temperature and rainfall prevails throughout the year. The relative humidity varied between 70–88%. The forests in northern Eastern Ghats are broadly classified into Tropical Semi-evergreen, Tropical Moist Deciduous, Tropical Dry Deciduous, Tropical Thorny-Scrub vegetation and Tropical Dry Evergreen forest types (Champion and Seth, 1968).

The field work was carried out in a total 210 grids in the forests of northern Eastern Ghats of Andhra Pradesh for enumeration of lianas. The entire stretch of northern Eastern Ghats of Andhra Pradesh was divided into 6.25 × 6.25 km grids and within each grid a 0.5 ha transect (5m × 1km) was laid. Depending on the shape of the forest stand, these transects were divided into 5 x 200m sub transects. All lianas – 1.5 cm gbh (5 gbh, girth at breast height) were enumerated in the whole transects, and those of herbaceous vines of < 1.5 cm gbh only in the beginning and end of the transects. The collected specimens were identified with the help of florists (Gamble and Fischer, 1915-1935; Rao and Kumari, 2002 – 2008). The voucher specimens were deposited in the Botany Department Herbarium (BDH), Department of Botany, Andhra University, Visakhapatnam.

Results and discussion

The study area contained a total of 170 liana species representing 109 genera and 43 families, recorded from northern Eastern Ghats of forests in the total of 210 grids (Tab. 1). Muthumperumal and Parthasarathy (2009) enumerated 175 angiosperm climbing plants in 150 grids of southern Eastern Ghats; 60 liana species found in Maruthamalai hills of southern Western Ghats (Sarvalingam and Rajendran, 2012); 93 climbing plant species reported in land Atlantic forest, northern Brazil (Araujo and Alves, 2010); the total number of climbers that are found in Puerto Rico and the Virgin Islands amounts to 386 (Acevedo-Rodríguez, 2005). The present study identified a genus and species ratio of 1:1.55. Out of 170 species, only one species was Gymnosperm i.e. Gymnosperm i.e. Gnetum ula and 169 species consist of 108 genera and 42 families were angiosperms. Among the angiosperms, there were 154 species representing 36 families of dicotyledons and 15 species belonging to 6 monocotyledon families.

The most specious families investigated in the present study include Convolvulaceae (23 species), Papilionaceae (22 species), Asclepiadaceae (19 species), Cucurbitaceae (9 species), Dioscoreaceae, Menispermaceae and Vitaceae (8 species each) etc., while in southern Eastern Ghats Asclepiadaceae, Cucurbitaceae, Papilionaceae, Apocynaceae, Vitaceae and Menispermaceae formed the most dominant families (Muthumperumal and Parthasarathy, 2009). Papilionaceae, Cucurbitaceae, Convolvulaceae and Asclepiadaceae formed the common liana families in Maruthamalai hills of Western Ghats (Sarvalingam and Rajendran, 2012). Families such as Smilaceae, Menispermaceae, Passifloraceae, Cucurbitaceae and Convolvulaceae are entirely dominated by species with a climbing habit (Araujo and Alves, 2010). According to Gentry (1991) New World families, with the highest diversity of climbing plants, are Apocynaceae (esp. Asclepiadoideae), Convolvulaceae and Papilionaceae. The dominant genera in the present study were Ipomoea (9 species), Dioscorea (8 species), Argyreia and Merremia (5 species each). Muthumperumal and Parthasarathy (2009) recorded that Jasminum, Acacia, Argyreia and Capparis were the most abundant genera in southern Eastern Ghats, while in Maruthamalai hills of Western Ghats Ipomoea and Bignonioideae were the dominant genera (Sarvalingam and Rajendran, 2012).

The most dominant liana species in the study are Acacia sinuata (Mimosaceae), Bauhinia tobbii (Caesalpinaceae), Calycapteris floribunda (Combretaceae), Combretum allidum (Combretaceae), Dioscorea pentalyyxa (Dioscoreaceae), Timospora cordifolia (Menispermaceae) Schefflera stellata (Araliaceae) and Ziziphus oenoplia (Rhamnaceae). The rare species were Anodendron paniculatum (Apoecynaceae), Aristolochia tagala (Aristolochiaceae), Clematis sinicalifolia (Ranunculaceae), Entada purshae (Mimosaceae), Gnetum ula (Gnetaceae), Leptadenia reticulata (Asclepiadaceae), Uncaria sessilifructus (Rubiacceae) and Vanilla wightiana (Orchidaceae).

The enumerated lianas classified into woody vines (128 species) and herbaceous vines (42). The mechanisms of the climbers to get attached to their host plants play a major role
in their distribution (Nabe-Nielsen, 2001). In this study, six major mechanisms of climbing systems were recognized: stem twiners (53.5%) followed by stragglers-unarmed (14.7%), stragglers-armed (13.5%), tendril climbers (13.5%), root climbers (2.9%) and hook climbers (1.8%). Several authors have reported that stem twiners were most common in the different tropical forests (Ghollasimood et al., 2012; Parthasarathy et al., 2004; Kuze and Bongers, 2005). Burnham (2004) suggested that the basic information about lianas regarding the location of the species is hard to compile because vouchering, reporting and sampling have been standardized for comparable tree communities.

Tab. 1. List of liana species in northern Eastern Ghats of Andhra Pradesh

| No. | Plant species                  | Family           | Category | Climbing mode |
|-----|--------------------------------|------------------|----------|---------------|
| 1   | Abrus precatorius L.           | Papilionaceae    | WV       | ST            |
| 2   | Acacia caeca (L.) Willd.       | Mimosaceae       | WV       | Str-A         |
| 3   | Acacia pennata (L.) Willd.     | Mimosaceae       | WV       | Str-A         |
| 4   | Acacia siinata (Lour.) Merr.   | Mimosaceae       | WV       | Str-A         |
| 5   | Acacia torta (Roxb.) Craib.    | Mimosaceae       | WV       | Str-A         |
| 6   | Aganosma dichotoma (Roth) K. Schum. | Apocynaceae     | WV       | ST            |
| 7   | Ampelocissus latifolia (Roxb) Planch. | Vitaceae     | WV       | TC            |
| 8   | Ampelocissus tomentosa (Roth) Planch. | Vitaceae     | WV       | TC            |
| 9   | Anamitra cocculus (L.) Wt. & Arn. | Menispermaceae    | WV       | ST            |
| 10  | Anodendron paniculatum (Roxb.) DC. | Apocynaceae     | WV       | ST            |
| 11  | Argyreia arakuenesis Bal.      | Convolvulaceae   | WV       | ST            |
| 12  | Argyreia daltonii Cl.          | Convolvulaceae   | WV       | ST            |
| 13  | Argyreia involucrata Cl.       | Convolvulaceae   | WV       | ST            |
| 14  | Argyreia nervosa (Burm.f.) Boj. | Convolvulaceae   | WV       | ST            |
| 15  | Argyreia roxburghii Choisy     | Convolvulaceae   | WV       | ST            |
| 16  | Aristochloia indica L.         | Aristolochiaceae | HY       | ST            |
| 17  | Aristochloia tagala Cham.      | Aristolochiaceae | WV       | ST            |
| 18  | Asparagus racemosus Willd.     | Liliaceae        | HV       | Str-A         |
| 19  | Atylosia albicans (Wt. & Arn.) Benth. | Papilionaceae   | WV       | ST            |
| 20  | Atylosia scaraboides (L.)Benth. | Papilionaceae    | WV       | ST            |
| 21  | Atylosia volubilis (Blanco) Gamble | Papilionaceae     | WV       | ST            |
| 22  | Bauhinia vahlii Wt. & Arn.     | Caesalpiniaceae  | WV       | Str-UA        |
| 23  | Bridelia stipularis (L.) Bl.   | Euphorbiaceae    | WV       | Str-UA        |
| 24  | Butea superba Roxb.            | Papilionaceae    | WV       | Str-UA        |
| 25  | Caesalpinia decapetala (Roth) Alston | Caesalpiniaceae    | WV       | Str-A         |
| 26  | Caesalpinia digyna Rotl.       | Caesalpiniaceae  | WV       | Str-A         |
| 27  | Calycopteris floribunda Lam.   | Combretaceae     | WV       | ST            |
| 28  | Cannabalis gigantea (Jacq.) DC. | Papilionaceae     | WV       | ST            |
| 29  | Cannabalis virosa (Roxb.) Wt. & Arn. | Papilionaceae     | WV       | ST            |
| 30  | Capparis divaricata Lam.       | Capparaceae      | WV       | Str-A         |
| 31  | Capparis zeylanica L.          | Capparaceae      | WV       | Str-A         |
| 32  | Cardiopeum baccatebunum L.     | Sapindaceae      | HV       | TC            |
| 33  | Carissa carandas L.            | Apocynaceae      | WV       | Str-A         |
| 34  | Carissa inermis Vahl.          | Apocynaceae      | WV       | Str-A         |
| 35  | Cassytha filiformis L.         | Lauraceae        | HV       | ST            |
| 36  | Cayratia curcula (Roxb.) Gamble | Vitaceae        | WV       | TC            |
| 37  | Cayratia pedata (Lam.) Gaengep. | Vitaceae        | WV       | TC            |
| 38  | Cayratia trifolia (L.) Dom.    | Vitaceae        | WV       | TC            |
| 39  | Celastrus paniculatus Willd.   | Celastraceae     | WV       | Str-UA        |
| 40  | Ceropogia bulbosa Roxb.        | Asclepiadaceae   | HV       | ST            |
| 41  | Cissampelos pareira L.         | Menispermaceae   | HV       | ST            |
| 42  | Cissus quadrangularis L.       | Vitaceae        | WV       | TC            |
| No. | Scientific Name | Family | Status |
|-----|----------------|--------|--------|
| 43  | Cissus repanda Vahl. | Vitaceae | WV TC |
| 44  | Cissus vitiginea L. | Vitaceae | WV TC |
| 45  | Clematis gourianana DC. | Ranunculaceae | WV Str-UA |
| 46  | Clematis royleri Rehder | Ranunculaceae | WV Str-UA |
| 47  | Clematis viscidiflora Wall. | Ranunculaceae | WV Str-UA |
| 48  | Clitoria ternatea L. | Papilionaceae | WV ST |
| 49  | Coccinia grandis (L.) Voigt | Cucurbitaceae | WV TC |
| 50  | Cuculus hirsutus (L.) Diels | Menispermataceae | WV ST |
| 51  | Combretum albidum G. Don | Combretaceae | WV ST |
| 52  | Combretum roxburghii Spreng. | Combretaceae | WV ST |
| 53  | Cryptolepis buchanani Roem. & Schult. | Asclepiadaceae | WV Str-UA |
| 54  | Cryptolepis elegans Don | Asclepiadaceae | WV ST |
| 55  | Cynanchum callialatum Wt. | Asclepiadaceae | WV ST |
| 56  | Dalbergia volubilis Roxb. | Papilionaceae | WV Str-UA |
| 57  | Derris scandens (Roxb.) Benth. | Papilionaceae | WV ST |
| 58  | Dioscorea anguina Roxb. | Dioscoreaceae | HV ST |
| 59  | Dioscorea bulbifera L. | Dioscoreaceae | HV ST |
| 60  | Dioscorea gladra auct. | Dioscoreaceae | HV ST |
| 61  | Dioscorea hamaltonii Hook.f. | Dioscoreaceae | HV ST |
| 62  | Dioscorea hispida Dennst. | Dioscoreaceae | HV ST |
| 63  | Dioscorea oppositifolia L. | Dioscoreaceae | HV ST |
| 64  | Dioscorea pentaphylla L. | Dioscoreaceae | HV ST |
| 65  | Dioscorea tomentosa Spreng. | Dioscoreaceae | HV ST |
| 66  | Diplocyclos palmatus (L.) Jeffrey | Cucurbitaceae | WV TC |
| 67  | Dolichos trilobus L. | Papilionaceae | HV ST |
| 68  | Embelia ribes Burm.f. | Myrsinaceae | WV Str-UA |
| 69  | Entada parvicaulis DC. | Mimosaceae | WV Str-UA |
| 70  | Flagellaria indica L. | Flagellariaceae | WV TC |
| 71  | Galactia longiflora Benth. | Papilionaceae | HV ST |
| 72  | Gloriosa superba L. | Liliaceae | HV RC |
| 73  | Gnetum ula Brongh | Gnetaceae | WV Str-UA |
| 74  | Gouania leptostachya DC. | Rhamnaceae | WV TC |
| 75  | Grewia rhamnifolia Roth. | Tiliaceae | WV Str-UA |
| 76  | Gymnostema cochinchenense (Lour) Kurz. | Cucurbitaceae | WV ST |
| 77  | Hemidesmus indicus var. indicus (L.) R. Br. | Asclepiadaceae | HV TC |
| 78  | Hemidesmus indicus var. pubescens (Wt. & Arn. Hook.f. | Asclepiadaceae | HV ST |
| 79  | Hewittia scandens (Milne) Mabb. | Convolvulaceae | WV ST |
| 80  | Hiptage benghalensis (L.) Kurz. | Malpighiaceae | WV Str-A |
| 81  | Holostemma ado-kidum Schult. | Asclepiadaceae | WV Str-UA |
| 82  | Hoya pendula Wt. & Arn. | Asclepiadaceae | WV ST |
| 83  | Hugonia mystax L. | Linaceae | WV Str-UA |
| 84  | Ipomoea hederifolia L. | Convolvulaceae | WV ST |
| 85  | Ipomoea obscura (L.) Ker-Gawl.) | Convolvulaceae | HV ST |
| 86  | Ipomoea nil (L.) Roth | Convolvulaceae | HV ST |
| 87  | Ipomoea purpurea L. | Convolvulaceae | HV ST |
| 88  | Ipomoea rheedifolia L. | Convolvulaceae | HV ST |
| 89  | Ipomoea nil (L.) Roth | Convolvulaceae | HV ST |
| 90  | Ipomoea obscura (L.) Ker-Gawl.) | Convolvulaceae | HV ST |
| 91  | Ipomoea purpurea L. | Convolvulaceae | HV ST |
| 92  | Ipomoea rheedifolia L. | Convolvulaceae | HV ST |
| 93  | Ipomoea staphylinia Roem. & Schult. | Convolvulaceae | WV ST |
| 94  | Ipomoea tubinata L. | Convolvulaceae | WV ST |
| 95  | Ipomoea wightii (Wall.) Choisy | Convolvulaceae | WV ST |
| No. | Scientific Name | Family           | HV  | ST  |
|-----|-----------------|------------------|-----|-----|
| 63  | Jacquemontia paniculata (Brum.) Hallier.f. | Convolvulaceae | HV  | ST  |
| 64  | Jasminum angustifolium Vahl | Oleaceae | WV  | ST  |
| 65  | Jasminum arboreum Roxb. | Oleaceae | WV  | ST  |
| 66  | Jasminum roxburghianum Wall. | Oleaceae | WV  | ST  |
| 67  | Leptadenia reticulata (Retz.) Wt. & Arn. | Asclepiadaceae | HV  | ST  |
| 68  | Mallotus repandus Muell.-Arg. | Euphorbiaceae | WV  | Str-A |
| 69  | Merremia hederacea (Burm.f.) Hallier f. | Convolvulaceae | HV  | ST  |
| 70  | Merremia tridentata (L.) Hallier f. | Convolvulaceae | HV  | ST  |
| 71  | Merremia tridentata ssp tridentata (Desr.) Oostr. | Convolvulaceae | HV  | ST  |
| 72  | Merremia umbellata (L.)Hallier f. | Convolvulaceae | HV  | ST  |
| 73  | Merremia vitifolia (Burm.f.) Hallier f. | Convolvulaceae | WV  | ST  |
| 74  | Millietia auriculata Brandis | Papilionaceae | WV Str-UA |
| 75  | Millietia racemosa (Wt. & Arn. Benth.) | Papilionaceae | WV Str-UA |
| 76  | Mimosa inta L. | Mimosaceae | WV Str-A |
| 77  | Momordica charantia L. | Cucurbitaceae | WV TC |
| 78  | Momordica dioica Willd. | Cucurbitaceae | WV Str-UA |
| 79  | Morinda umbellata L. | Rubiaceae | WV Str-UA |
| 80  | Mucuna gigantea DC. | Papilionaceae | WV ST |
| 81  | Mucuna monosperma Wt. | Papilionaceae | WV ST |
| 82  | Mucuna nigricans (Lour.) Steud. | Papilionaceae | WV ST |
| 83  | Mucuna pruriens (L.) DC. | Papilionaceae | WV ST |
| 84  | Mukia maderaspatana (L.) Roem. | Cucurbitaceae | WV TC |
| 85  | Naravalia zeylanica (L.) DC. | Rubiaceae | WV TC |
| 86  | Olax scandens Roxb. | Olacaceae | WV Str-UA |
| 87  | Oplia amentacea Roxb. | Opiliaceae | WV ST |
| 88  | Pisonia aculeata L. | Nyctaginaceae | WV Str-A |
| 89  | Reissantia indica (Willd.) Halle | Celastraceae | WV Str-UA |
| 90  | Rivea hypocrateriformis (Desr.) Choisy | Araceae | WV RC |
| 91  | Rubia cordifolia L. | Rubiaceae | WV ST |
| 92  | Rubus ellipticus Sm. | Rosaceae | WV Str-A |
| 93  | Rubus niveus Thunb | Rosaceae | WV Str-A |
| 94  | Salacia chinensis L. | Celastraceae | WV Str-UA |
| 95  | Sarcochroa acidum (Roxb.) Voigt | Asclepiadaceae | WV Str-UA |
| 96  | Schefflera rosburgii Gamble | Araliaceae | WV Str-UA |
| 97  | Schefflera stellata (Gaertn.) Harms | Araliaceae | WV Str-UA |
| 98  | Schusslera venulosa (Wt. & Arn.) Harms | Araliaceae | WV Str-UA |
| 99  | Scindapsus officinalis (Roxb.) Schott. | Araceae | WV RC |
| 100 | Scalopera trilobatum | Araceae | WV Str-A |
| 101 | Stachyurus japonicus | Celastraceae | WV Str-UA |
| 102 | Synsepalum officinale (Roxb.) Schott. | Araceae | WV RC |
| 103 | Solanum lycopersicum L. | Solanaceae | WV Str-A |
| 104 | Solanum sisymbriifolium (Lam.) Gandhi | Cucurbitaceae | WV TC |
| 105 | Solanum tuberosum Lour. | Saponaceae | WV RC |
| 106 | Stephania japonica (Thunb.) Miers. | Menispermaceae | WV ST |
| 107 | Stephania racemosa (Roxb.) | Verbenaceae | WV ST |
| 108 | Thunbergia fragrans Roxb. | Acanthaceae | WV ST |
Conclusion

Lianas play a key role in the ecology and dynamics of forests and may be helpful in conservation of forest resources. The present study has shown that the tropical forests of northern Eastern Ghats harbor a high floristic diversity of lianas, which contribute to the overall biodiversity of the forests. These forests are deteriorating under constant anthropogenic activities. The present data of floristic diversity of lianas would be useful in species conservation and management. The importance of climbers can be useful to biologists in the establishment of a standardized methodology and to provide these data on the structural threats to tropical forests for a global audience.

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References

Acevedo-Rodriguez P (2005). Vines and climbing plants of Puerto Rico and the Virgin Islands Contribution from the United States National Herbarium 51:1-483.
Araujo D, Alves M (2010). Climbing plants of a fragmented area of lowland Atlantic Forest, Igarassu, Pernambuco (northeastern Brazil). Phytotaxa 8:1-24.
Burnham RJ (2004). Alpha and beta diversity and distribution of lianas in Yasuni, Equador. Forest Ecol Manag 190:43-55.
Champion HG, Seth SK (1968). The revised forest types of India. Government of India, New Delhi.
Gamble JS, Fischer CEC (1915-1935). Flora of the Presidency of Madras. London: Adlard & son. Vols. I-III.
Gentry AH (1991). The distribution and evaluation of climbing plants: p. 3-49. In: Putz FE, Mooney HA (Eds.). The biology of vines, Cambridge University Press, Cambridge, U.K.
Gollasimood S, Faridah-Hanum I, Nazre M, Kamziah AK (2012). Abundance and distribution of climbers in a coastal hills forest in Perak, Malaysia. Journal of Agricultural Science 4(5):245-254.
Hegarty, EE, Caballe G (1991). Distribution and abundance in forests: p. 313-335. In: Putz FE, Mooney HA (Eds.). The biology of vines, Cambridge University Press, Cambridge, U.K.
Heijden GMF, Phillips OL (2008). What controls liana success in neotropical forests? Global Ecol Biogegr 17:372-378.
Ingwell LL, Wright SJ, Becklund KK, Hebbell SP, Schnitzer SA (2010). The impact of lianas on 10 years of tree growth and mortality on Barro Colorado Island, Panama. J Ecol 98:879-887.
Kuzee ME, Bongers F (2005). Climber abundance, diversity and colonization in degraded forests of different ages in Côte d'Ivoire: p. 67-84. In: Bongers F, Parren MPE, Traore D. (Eds.). Forest climbers of West Asia: Diversity, Ecology and Management. CABI Publishing.
Londre RA, Schnitzer SA (2006). The distribution of lianas and their change in abundance in temperate forests over the past 45 years. Ecology 87:2973-2978.
Muthumperumal C, Parthasarathy N (2009). Angiosperms, climbing plants in tropical forests of southern Eastern Ghats, Tamil Nadu, India. Checklist 5(1):092-111.

Nabe-Nielsen J (2001). Diversity and distribution of lianas in a neotropical rainforest, Yasuni National Park, Ecuador. J Trop Ecol 17:1-19.

Parthasarathy N, Muthuramkumar S, Reddy MS (2004). Patterns of liana diversity in tropical evergreen forests of peninsular India. Forest Ecol Manag 190:15-31.

Phillips OL, Martinez RV, Arroyo L, Baker TR, Killeen T, Lewis SL, Malhi Y, Mendosa AM, Neill D, Vargas PN, Alexiades M, Ceron C, Fiore AD, Erwin T, Jardim A, Palacios W, Saldias M, Vinceti B (2002). Increasing dominance of large lianas in Amazonian forests. Nature 418:770-774.

Putz FE, Mooney HA (1991). The Biology of vines, p. 53-72 In Cambridge University Press, Cambridge, United Kingdom.

Rao GVS, Kumari GR (2002-2008). Flora of Visakhapatnam district. Andhra Pradesh. Vol. I &II. Botanical Survey of India. Kolkata.

Reddy MS, Parthasarathy N (2006). Liana diversity and distribution on host trees in four inland tropical dry evergreen forests of peninsular India. Trop Ecol 47(1):109-123.

Reddy MS, Parthasarathy N (2003). Liana diversity and distribution in four tropical dry evergreen forests on the Coromandel coast of south India. Biodivers Conserv 12:1609-1627.

Sarvalingam A, Rajendran A (2012). Diversity of liana species in Maruthamalai hills of southern Western Ghats, India. Phytotaxonomy 12:131-135.

Schnitzer SA, Carson WP (2010). Lianas suppress tree regeneration and diversity in tree fall gaps. Ecol lett 13:849-857.

Schnitzer SA, Kuzee ME, Bongers F (2005). Disentangling above-and below-ground competition between lianas and trees in a tropical forest. J. Ecol 93:1115-1125.

Schnitzer SA, Bongers F (2002). The ecology of lianas and their role in forests. Trends in Ecology and Evolution 17(5):223-230.

Schnitzer SA, Dalling JW, Carson WP (2000). The impact of lianas on tree generation in tropical forest canopy gaps: Evidence for an alternative pathway of gap-phase regeneration. J Ecol 88:655-666.

Yuan C, Liu W, Tang CQ, Li XS (2009). Species composition, diversity and abundance of lianas in different secondary and primary forests in a subtropical mountainous area, SW China. Ecol Res 24:1361-1370.

Wright SJ, Jaramillo AM, Pavon J, Condit R, Hubbell SP, Foster RB (2005). Reproductive size thresholds in tropical trees: variation among individuals, species and forests. J Trop Ecol 21:307-3115.

Zotz G, Cueni N, Korner C (2006). In-situ growth stimulation of a temperate zone liana (Hedera helix) in elevated CO₂. Functional Ecology 20:763-769.