International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor- 5.46, Volume 4, Issue 10, October 2017
Website- www.aarf.asia, **Email** : editor@aarf.asia , editoraarf@gmail.com

DIVERSITY AND COMPOSITION OF CLIMBING PLANTS IN TROPICAL DRY FORESTS OF NORTHERN ANDHRA PRADESH, INDIA

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ABSTRACT

Climber diversity wasanalysed in two dry tropical forest sites (1 ha each) in northern Andhra Pradesh. A total of 3191 individuals enumeratedin the present study were belonging to57 species (51 in thesite I and 42 in site II) from 43 genera and 26 families. In study site I, climbers represented with 26 species and woody climbers with 19 species whereas, study site II showed 43 climber species and 34 woody climber species. The basal area ranged 0.72-2.15 m^2/ha. The mean woody climber stem density was 438 stems/ha.Leguminosae was the most vine speciose family. Maximum species were stem twiners (65%) and seed dispersal through abiotic means are greater (67%). Acacia caesia is the dominant species in both the study sites. Dominant woody climbers were well represented in climber population which indicates that they have good regeneration status. The present study reveals that the tropical dry forest sites of northern Andhra Pradesh restore substantial climber diversity as similar to other parts Eastern Ghats and tropics. The variation in climber species richness, abundance, basal area and distribution pattern between the sites could be attributed to differences in geographical location, grazing and anthropogenic pressures.

Key words: Tropical forest, Vine diversity, Lianas, Seasonal forest, Species richness

INTRODUCTION

Climber and woody climbers are abundant, well diverse plant forms and constitute an important structural and functional components in particular to tropical forest ecosystems

(Anbarashan & Parthasarathy, 2013). They play a vital role in forest dynamics by maintaining key ecological functions of forest ecosystems i.e transpiration, carbon cycling, forest regeneration, pollination, seed dispersal, phenology, biological diversity management etc., (Gandhi, 2016; A. H. Gentry & Dodson, 1987; Naveenkumar, Arunkumar, & Sundarapandian, 2017; Reddy & Parthasarathy, 2006; S. Schnitzer & Bongers, 2002). Unlike trees, climbers are weak-stemmed plants, so they depend on neighboring plants/trees for their physical support (den Dubbelden & Oosterbeek, 1995; Richards, 1952). According to (Kelly, 1985), climbers are often called as "vines" and woody climbers as "lianas". Climbers climb by means of different modes and by adaptations hence classified into scrambles (Sc), root climbers (Rc), stem twiners (St), tendril climbers (Tc) and hook climbers (Hc) (Putz & Mooney, 1991; Schimper, 1903)

Woody climbers interact strongly with tree growth and reproduction, increase in their abundance resulted in the increase of tree mortality rate (Phillips et al., 2002)(Ingwell, Joseph Wright, Becklund, Hubbell, & Schnitzer, 2010; Phillips et al., 2002; S. A. Schnitzer & Carson, 2010; Wright et al., 2005). The evidences of climber dominance in certain forest ecosystems i.e. temperate (Allen, Sharitz, & Goebel, 2007) and tropical (Phillips et al., 2002; Swaine & Grace, 2007; Wright, Calderón, Hernandéz, & Paton, 2004) are also attributed to climate change (Malhi & Wright, 2004). Hence, bringing the importance for the distribution and diversity studies to understand the nature of climber distributional patterns and also to employ proper management strategies for the care and wealth of forest ecosystems.

Even though our knowledge on demographic and community structure of climbers are improving day by day, thepresent study is intended to focus on community structure of climbers and woody climbers in the tropical forests in northern Andhra Pradesh.

MATERIALS AND METHODS

Fieldwork was carried out in two 1-ha study sitesin tropical dry deciduous of northern Andhra Pradesh(Fig.1). Each study plot was subdivided into 10 × 10 m sub-grids. All climbers(≤2.5 cm girth at breast height) and woody climbers (≥2.5 cm gbh) were enumerated and diameter was measured at 1.3 m from the rooting point.All specimens of the climber and liana species were identified with regional floras (Gamble & Fischer, 1915; Rao, 1999) Shannon index, dominance Index, Fisher's alpha and evenness index were computed using past software package(Hammer, Harper, & Ryan, 2009).

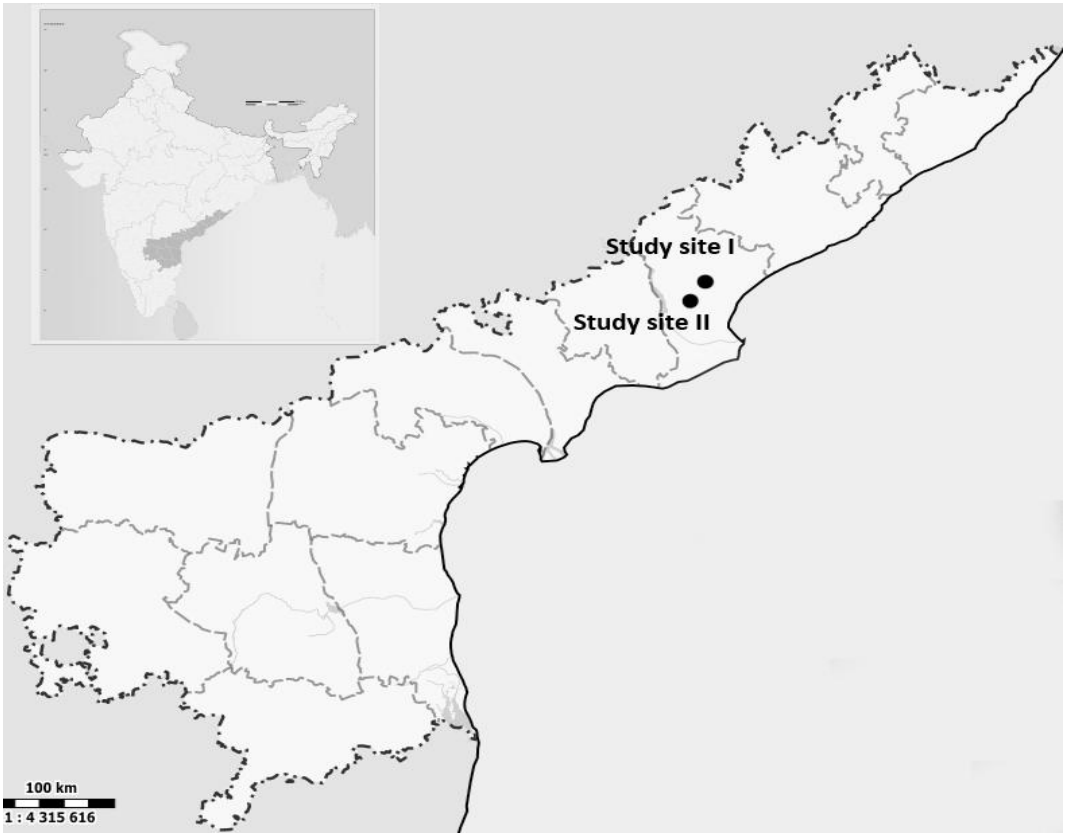

Fig 1. Location of the study sites in Andhra Pradesh, India.

RESULTS

Field inventory yielded a total of 57 species belonging to 43 genera and 26 families. In study site I, climbers represented with 26 species and woody climbers with 19 species whereas, study site II showed 43 climber species and 34 woody climber species (Table 1). However, study Site I showed the highest species richness (51 species). A total of 3191 individuals were enumerated from the two study sites (2 ha), of which climbers contributed 72.5% and woody climbers shared 27.5%.Climber density was greater in study site II than study site I while thereverse trend was observed in the case of woody climbers. Similarly, basal area of woody climbers also showed the highest value in study site I. On the contrary, greater basal area of climbers was observed in study site II.Shannon Index, Evenness index and Fisher's alpha values of both climbers and woody climberswere higher in study site II compared to study site I whereasthe dominance index values showed areverse trend.

Table 1. Summary of climber diversity inventory in tropical dry forest of northern Andhra Pradesh, India.

Variable	Climbers		Woody climbers		Total	
	Site I	Site II	Site I	Site II	Site I	Site II
Species richness	26	43	19	34	51	42
Density (No/ha)	887	1428	453	423	2315	876
Basal area (m^2/ha)	0.028	0.034	2.12	0.68	2.15	0.72
Dominance Index	0.14	0.07	0.20	0.11	0.08	0.10
Shannon Index	2.35	3.04	1.97	2.73	3.06	2.78
Evenness index	0.40	0.49	0.38	0.45	0.42	0.38
Fishers alpha	5.02	8.35	4.01	8.71	9.22	9.20

Acacia caesia (469 individuals),*Dioscoreabulbifera* (228 individuals),*Cissampelos glaberrima* (208 individuals) and*Ventilagodenticulata* (147 individuals) were the top four abundant climber species together contributing 49% of total climber abundance (2315 individuals)(Table2.). In woody climbers,*Acacia caesia*(184 individuals), *Combretumdecandrum*(109 individuals), *Combretum ovalifolium* (109 individuals) and *Getonia floribunda*(84 individuals) were the top four dominant species contributing 55% of entire woody climbers abundance (876 individuals).Eighteen species are common to both the study sites. A total of 30 species present in study site II which are not represented in study site I.

Table 2. Density of climbers in tropical dry forest ecosystem in northern Andhra Pradesh, India.

Species	**Family**	**Density (No./ha)**					
		Climbers		**Woody climbers**		**Total**	
		Site I	**Site II**	**Site I**	**Site II**	**Site I**	**Site II**
Abrus precatorius L.	Papilionaceae	0	0	0	4	0	4
Acacia caesia (L.) Willd.	Mimosaceae	254	215	149	35	403	250
Acacia concinna (Willd.) DC.	Mimosaceae	2	0	1	0	3	0
Acacia pennata (L.) Willd.	Mimosaceae	0	11	0	2	0	13

Ampelocissus tomentosa (B.Heyne& Roth) Planch.	Vitaceae	59	1	26	3	85	4
Aristolochiaindica L.	Aristolochiaceae	0	16	0	0	0	16
Aristolochia bracteolata Lam.	Aristolochiaceae	0	33	0	0	0	33
*Asparagus racemosus*Willd.	Liliaceae	35	2	7	0	42	2
Aspidopterys indica (Willd.) W.Theob.	Malpighiaceae	0	21	0	15	0	36
Bauhinia vahlii Wight &Arn.	Leguminosae	69	66	45	9	114	75
*Buteasuperba*Roxb.	Leguminosae	2	1	0	11	2	12
Caesalpinia bonduc (L.) Roxb.	Leguminosae	0	0	0	3	0	3
Calamus viminalis Willd.	Arecaceae	0	0	4	0	4	0
*Canavaliacatharticа*Thouars	Leguminosae	51	0	1	0	52	0
Cardiospermum halicacabum L.	Sapindaceae	0	5	0	0	0	5
Cayratia pedata (Lam.) Gagnep.	Vitaceae	0	16	0	7	0	23
Cayratia trifolia (L.) Domin	Vitaceae	0	29	0	3	0	32
Celastrus paniculatus Willd.	Celastraceae	2	48	0	17	2	65
Cissampelos glaberrima A.St.-Hil.	Menispermaceae	14	194	0	0	14	194
Cissusrepens Lam.	Vitaceae	0	17	0	11	0	28
*Combretumdecandrum*Jacq.	Combretaceae	97	0	109	0	206	0
Combretum ovalifolium Roxb.	Combretaceae	0	37	0	109	0	146
Cryptolepisdubia (Burm.f.) M.R.Almeida	Asclepiadaceae	2	10	1	1	3	11
Cyphostemma auriculatum (Roxb.) P.Singh&B.V.Shetty	Vitaceae	0	2	0	2	0	4
Dalbergia horrida (Dennst.) Mabb.	Leguminosae	0	13	0	9	0	22
Derris oblonga Benth.	Leguminosae	3	2	0	0	3	2
Derris trifoliata Lour.	Leguminosae	2	0	2	0	4	0
Dioscoreabulbifera L.	Dioscoreaceae	140	88	21	3	161	91
Dioscorea alata L.	Dioscoreaceae	1	0	1	0	2	0

Dioscorea glabra Roxb.	Dioscoreaceae	0	4	0	0	0	4
Dioscorea hamiltonii Hook.f.	Dioscoreaceae	12	24	6	4	18	28
Dioscorea hispida Dennst.	Dioscoreaceae	14	28	1	2	15	30
Dioscorea oppositifolia L.	Dioscoreaceae	1	71	0	1	1	72
Dioscorea tomentosa J.Koenig ex Spreng.	Dioscoreaceae	0	20	0	0	0	20
Entada rheedii Spreng.	Mimosaceae	0	0	0	5	0	5
*Getonia floribunda*Roxb.	Combretaceae	2	30	22	62	24	92
Gymnema sylvestre (Retz.) R.Br. ex Sm.	Apocynaceae	0	1	0	0	0	1
Hemidesmus indicus (L.) R. Br. ex Schult.	Asclepiadaceae	0	94	0	0	0	94
Hiptage benghalensis (L.) Kurz	Malpighiaceae	0	8	0	16	0	24
Ichnocarpus frutescens (L.) W.T.Aiton	Apocynaceae	0	0	0	4	0	4
Ipomoea asarifolia (Desr.) Roem. &Schult.	Convolvulaceae	0	1	0	3	0	4
Ipomoea hederifolia L.	Convolvulaceae	0	3	0	0	0	3
Jasminum angustifolium var. sessiliflorum (Vahl) P.S.Green	Oleaceae	0	14	0	0	0	14
Jasminum arborescens Roxb.	Oleaceae	0	0	0	1	0	1
Macrotyloma uniflorum (Lam.) Verdc.	Leguminosae	0	4	0	0	0	4
Marsdenia tenacissima (Roxb.) Moon	Asclepiadaceae	3	10	0	1	3	11
Mucuna pruriens (L.) DC.	Leguminosae	0	3	0	0	0	3
Naravelia zeylanica (L.) DC.	Ranunculaceae	0	72	0	11	0	83
*Olax scandens*Roxb.	Olacaceae	0	3	0	3	0	6
Persicaria glabra (Willd.) M.Gómez	Polygonaceae	0	2	0	1	0	3
*Smilax zeylanica*L.	Smilacaceae	15	19	1	5	16	24
*Stemona tuberosa*Lour.	Stemonaceae	18	0	2	0	20	0
*Symphorema involucratum*Roxb.	Lamiaceae	57	46	49	5	106	51

Tinosporasinensis(Lour.) Merr.	Menispermaceae	0	23	0	31	0	54
Toddalia asiatica (L.) Lam.	Rutaceae	5	0	0	0	5	0
Tragia involucrata L.	Euphorbiaceae	1	0	0	0	1	0
*Ventilagodenticulata*Willd.	Rhamnaceae	26	121	5	24	31	145

The climbing mechanism was dominated by stem twining type (65%) followed by tendril climbing type (14%), scrambler-armed (12%) and scrambler-unarmed (9%) types (Table 3. & Figure 2.).Capsule (25%) and pod (25%) are the major fruit types observed in the present study followed by berry (20%) and drupe (9%). Seed dispersal through abiotic means is greater (67%) than those of biotic seed dispersal (33%) in thepresent study.

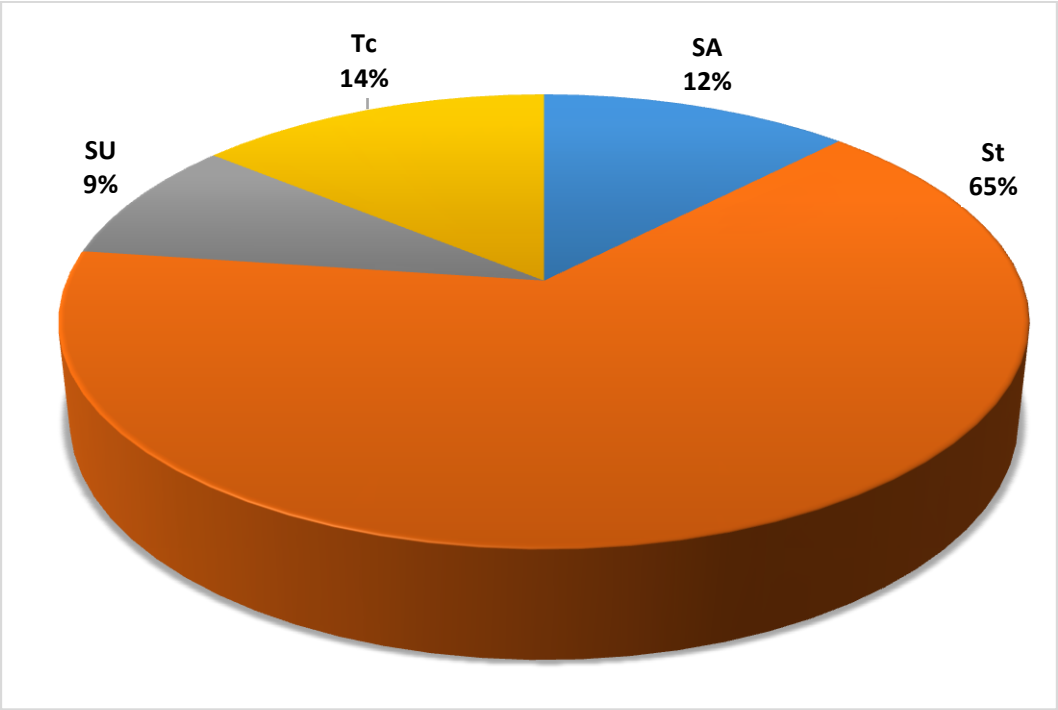

Fig 2. The proportion of climber species following different climbing mechanisms(SA scrambler-Armed, St stem twiner, SU scrambler-Unarmed, Tc Tendril climber, Hc hook climber, Rc root Climber.) in tropical dry forest of northern Andhra Pradesh, India.

Table 3. Climbing mechanisms and dispersal modes of climbers in tropical dry forest ecosystem in northern Andhra Pradesh, India.

Liana species	Climbing mechanism	Dispersal mode
Abrus precatorius L.	St	Ab
Acacia caesia (L.) Willd.	SA	Ab
Acacia concinna (Willd.) DC.	SA	Ab
Acacia pennata (L.) Willd.	SA	Ab
Ampelocissus tomentosa (B.Heyne& Roth) Planch.	Tc	Bi
Aristolochiaindica L.	St	Ab
Aristolochia bracteolata Lam.	Tc	Ab
*Asparagus racemosus*Willd.	SA	Bi
Aspidopterys indica (Willd.) W.Theob.	St	Bi
Bauhinia vahlii Wight &Arn.	St	Ab
*Buteasuperba*Roxb.	St	Ab
Caesalpinia bonduc (L.) Roxb.	SA	Ab
Calamus viminalis Willd.	SA	Bi
*Canavaliacathartica*Thouars	St	Ab
Cardiospermum halicacabum L.	St	AB
Cayratia pedata (Lam.) Gagnep.	Tc	Bi
Cayratia trifolia (L.) Domin	Tc	Bi
Celastrus paniculatus Willd.	Su	Bi
Cissampelos glaberrima A.St.-Hil.	St	Bi
*Cissusrepen*s Lam.	Tc	Bi
*Combretumdecandrum*Jacq.	St	Ab
Combretum ovalifolium Roxb.	St	Ab
Cryptolepisdubia (Burm.f.) M.R.Almeida	St	Ab
Cyphostemma auriculatum (Roxb.) P.Singh&B.V.Shetty	St	BI
Dalbergia horrida (Dennst.) Mabb.	St	Ab
Derris oblonga Benth.	St	Ab
Derris trifoliata Lour.	St	Ab
Dioscoreabulbifera L.	St	Ab

Dioscorea alata L.	St	Ab
Dioscorea glabra Roxb.	St	Ab
Dioscorea hamiltonii Hook.f.	St	Ab
Dioscorea hispida Dennst.	St	Ab
Dioscorea oppositifolia L.	St	Ab
Dioscorea tomentosa J.Koenig ex Spreng.	St	Ab
Entada rheedii Spreng.	SU	Ab
*Getonia floribunda*Roxb.	St	Ab
Gloriosa superba L.	Tc	Bi
Gymnema sylvestre (Retz.) R.Br. ex Sm.	St	Ab
Hemidesmus indicus (L.) R. Br. ex Schult.	St	Ab
Hiptage benghalensis (L.) Kurz	SU	Ab
Ichnocarpus frutescens (L.) W.T.Aiton	St	Ab
Ipomoea asarifolia (Desr.) Roem. &Schult.	St	Ab
Ipomoea hederifolia L.	St	Ab
Jasminum angustifolium var. sessiliflorum (Vahl) P.S.Green	St	Bi
Jasminum arborescens Roxb.	St	Bi
Macrotyloma uniflorum (Lam.) Verdc.	St	Bi
Marsdenia tenacissima (Roxb.) Moon	St	Ab
Mucuna pruriens (L.) DC.	St	Ab
Naravelia zeylanica (L.) DC.	Tc	Ab
*Olaxscandens*Roxb.	SU	Bi
Smilax zeylanica L.	Tc	Bi
Stemonatuberosa Lour.	St	Ab
*Symphoremainvolucratum*Roxb.	SU	Bi
Tinosporasinensis (Lour.) Merr.	St	Bi
Toddalia asiatica (L.) Lam.	SA	Bi
Tragia involucrata L.	St	Ab
*Ventilagodenticulata*Willd.	St	Ab

SA-scrambler-Armed, St-stem twiner, SU-scrambler-Unarmed, Tc-Tendril climber, Hc-hook dlimber, Rc-root Climber. Ab-abiotic, Bi-biotic.

Leguminosae (9), Dioscoreaceae (7) and Vitaceae (5)were most vine speciose families in the present study (Table 4). Whereas Mimosaceae, Combretaceae and Diascoreaceae were the dominant families in terms of climber abundance.Fourteen families were representedby only one species. A total of 10 families which were present in study site II are not represented in study site I and 4 families which occurred in study site I are notrepresented in study site II.

Table 4. Family-wise contribution of climbers in tropical dry forest ecosystem in northern Andhra Pradesh, India.

Family	Genus	Species	Density
Mimosaceae	2	4	674
Combretaceae	2	3	468
Dioscoreaceae	1	7	442
Leguminosae	8	9	296
Menispermaceae	2	2	262
Rhamnaceae	1	1	176
Vitaceae	4	5	176
Lamiaceae	1	1	157
Asclepiadaceae	3	3	122
Ranunculaceae	1	1	83
Celastraceae	1	1	67
Malpighiaceae	2	2	60
Aristolochiaceae	1	2	49
Liliaceae	1	1	44
Smilacaceae	1	1	40
Stemonaceae	1	1	20
Oleaceae	1	2	15
Convolvulaceae	1	2	7
Olacaceae	1	1	6
Rutaceae	1	1	5
Sapindaceae	1	1	5
Apocynaceae	2	2	5

Arecaceae	1	1	4
Papilionaceae	1	1	4
Polygonaceae	1	1	3
Euphorbiaceae	1	1	1

DISCUSSION

Climber and woody climber diversity, population and climbing pattern are playing a significant role in maintaining biodiversity and balance ecosystem to support different ecosystem services(A. H. Gentry & Dodson, 1987; S. Schnitzer & Bongers, 2002). A total of 57 climber species (42-51 species/ha) were documented in two 1-ha plots of the tropical dry forest study sites of northern Andhra Pradesh region. Woody climber species richness(19-34 species /ha)documented in the current study is comparable to species richness reported in forest ecosystems of tropics (2-36 species/ha in tropical evergreen forests, India, Parthasarathy et al. 2004; 21-26 species/ha intropical dry evergreen forests, India, Reddy and Parthasarathy 2006; 15-24 species/ha in tropical evergreen forest,Agumbe, Western Ghats,Padaki and Parthasarathy 2000; 11-31 species/ha in tropical dry evergreen forests of Coromandel Coast, India, Vivek and Parthasarathy 2014; 38 species/2ha in tropical dry forest,Lankamalla wildlife sanctuary, Andhra Pradesh, India, Mastan et al. 2015), higher than the species richness reported by few studies (9-21 species/ha tropical evergreen forests of Indian Eastern Ghats, Chittibabu and Parthasarathy 2001;14-22 species/1.25 ha in Javadi hills of Eastern Ghats, Naveenkumar et al. 2017and lower than the species richness(53species/9ha) reported in Mudumalai Wildlife sanctuary (Joseph, Reddy, Pattanaik, & Sudhakar, 2008), 38-53 species/ha in tropical seasonal rain forest in Xishuangbanna, SW China(Lü, Tang, Feng, & Li, 2009) and 42-52 species/ha in lowland tropical rainforest in Hainan Island, South China (Ding and Zang 2009). 65 species/ha in Barro Colorado Island, Panama (Putz 1984).The Shannon's diversity index values recorded in the present study (climber and woody climber) are well within the range recorded in the tropics i.e from 2.8 to 3.71and evenness index recorded is below (0.38-0.49) the tropical range covered (0.83-0.89) (Barik, Adhikari, Chettri, & Singh, 2015). The variation in species richness in different forest ecosystems in tropics due to geographical location, rainfall patterns, dry season length and level of anthropogenic pressures(A. Gentry, 1991; Molina-Freaner & Tinoco-Ojanguren, 1997; Putz & Chai, 1987; S. A. Schnitzer & Bongers, 2011; S. A. Schnitzer & Carson, 2001). This could be the reason for variationin species richness among the study sites.

The mean abundance of climbers in the present study is 1595/ha. The density of woody climbers recorded in the present study (423-453 stems/ha) is within the range ofwoody climber density recorded in the tropics i.e 220-460 stems/ha (Barik et al., 2015) and the values are comparable to the values reported by other studies (31-492 stems/ha, Anbarashan and Parthasarathy 2013; 373 stems/ha Muthuramkumar and Parthasarathy 2000), higher than 152-280 stems/ha reported by Addo-Fordjour et al. 2009 and lower than woody climber density reported by few studies (582 stems/ha Muthumperumal and Parthasarathy 2013; 726-1002 stems/ha, Pandian and Parthasarathy 2016;596-875/ha in Javadi hills of Eastern Ghats, Naveenkumar et al. 2017;882 stems/ha, Campbell and Newbery 1993). Thus variation in climber and woody climber populations between the study sites may be due to human activities, grazing, adult tree composition, canopy structure and microclimate(Ibarra-Manríquez & Martínez-Ramos, 2002; Molina-Freaner & Tinoco-Ojanguren, 1997; Putz & Chai, 1987; S. A. Schnitzer & Carson, 2001).

The woody climber basal area recorded in the present study ranged from 0.68 - 2.12 m^2/ha with a mean of 1.4 m^2/ha is higher than the tropical woody climber studies reported in India (0.4 m^2/ha, Muthuramkumar and Parthasarathy 2000;0.14-0.43 m^2/ha, Padaki and Parthasarathy 2000) and also comparable to few studies in India (0.86-2.06 m^2/ha, Pandian and Parthasarathy 2016;0.06-3.28 m^2/ha,Gandhi 2016; 0.47-1.12 m^2/ha, Naveenkumar et al. 2017).The study site II is closer to human habitat compared to study site I and it is subjected to grazing and seasonalfires, hence the woody climber establishment to adult stage is facing narrow opportunity. In study site II the density of woody climbers is more or less equal to the study site I but thebasal area of the woody climbers in study site I havegreater basal area compared to study site I which explain large diameter stems which were establishedearlier and ecosystem is facing low disturbance compared to study site II.

In terms of richness, stem twining mechanism was dominant in the present study which was also observed in other studies(Chittibabu & Parthasarathy, 2001; Ghollasimood, Faridah-Hanum, Nazre, & Kamziah, 2012; C. Muthumperumal & Parthasarathy, 2010; Naidu, Kumar, & Venkaiah, 2014; Parthasarathy, Muthuramkumar, & Sridhar Reddy, 2004; Putz & Chai, 1987)followed by tendril climbers which are confined to less diameter support(Parthasarathy, Muthuramkumar, & Sridhar Reddy, 2004; Venkateswaran & Parthasarathy, 2003).According to Dewalt et al. (2000) in Panamanian lowland forests, anabundance of stem twiner climbing mechanism was an indicator of amature forest stand.

The present study reveals the climber species diversity in tropical dry forest sites of northern Andhra Pradesh region restores substantial climber diversity as similar to other parts India. The variation in species richness, abundance and thebasal area between the sites may be attributed to differences in geographical location, grazing and anthropogenic pressures. *Acacia caesia* is the dominant species in both the study sites. Monodominance in plant community generally indicates that the habitat is under anthropogenic pressure.Dominant woody climbers were well represented in climber population which indicates that they have good regeneration status. However, 30 species present in study site II were not present in study site I, this observation enlightens that more disturbance provides aconducive environment for theestablishment of climber species. In order to understand the mechanism of climber distribution and abundance, further research on theinteraction of climbers with trees is required.

ACKNOWLEDGEMENTS

We thank state forest department, Andhra Pradesh for giving permission to execute field work. We thank UGC, Govt. of India for providing fellowship under UGC-BSR(RFSMS) scheme. We are also grateful to thankDr.N. Parthasarathy, Department of Ecology and Environmental Science, Pondicherry University, and Dr. S. Karuppusamy, Department of Botany, The Madura College, Madurai for identification of plant species.

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