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Floristic composition and ecological assessment of tree species diversity in tropical forests of Srikakulam and Vizianagaram districts of Andhra Pradesh, India

Duvvada Srinivasa Rao*, Prayaga Murty Pragada and Owk Aniel Kumar

Department of Botany, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India

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Abstract

Background and Aim: Phytosociological investigation of vegetation serves as a pre-requisite for investigating the details of the primary productivity of an ecosystem. The present study deals with Environmental Statistics and Ecological Assessment of tree species diversity in Srikakulam and Vizianagaram districts of Andhra Pradesh, India. **Methods:** The present investigation deals with the comparison of species diversity indices of plant species i.e., Simpson's index, Shannon –wiener index, species richness with other counter parts. Importance Value Index = Relative density + Relative frequency + Relative dominance Based on the frequency classes of tree species were determined. According to Raunkiaer classify to There are 5 frequency classes, i.e. 'A' class with the species of frequency ranging from 1-20%; 'B' class 21- 40%; 'C' class 41-60%; 'D' class 61-80% and 'E' class 81- 100% based on the frequency pattern of the community, the homogeneity and heterogeneity of the vegetation. **Results:** The study resulted in documentation of total 165 tree species, belonging to 119 genera and 50 families were recorded, and 160 are dicots and 5 are monocots. The ecological studies have taken up to visualize the positive impact of protection on tree diversity. **Conclusion:** An understanding of the distribution of tree species and their assemblages must play an important role in elucidating the larger patterns of distribution of diversity. The quantitative inventory of tree species diversity revealed a considerable variation in the composition of dominant species and density in various forest areas and the estimations of IVI have helped to understanding the ecological significance of the species, present in different communities.

Keywords: *Floristic composition, Ecological assessment, tree species diversity, Srikakulam and Vizianagaram*

1. Introduction

In peninsular India quantitative phytodiversity inventories are available from the forest of the Western Ghats[1]; however Eastern Ghats remains as a neglected area for studies. This kind of studies were poorly explored, except a few reports [2-8] for these aspects in the protected areas and also in Southern Eastern Ghats of Andhra Pradesh, which encompasses major portions of Eastern Ghats. Analysis of the quantitative relationship among the plant species growing around an area reflects structural property of the community. This study is not only to describe the vegetation, but also to predict its pattern and classify it is a meaningful way[9]. Phytosociological investigation of vegetation serves as a pre-requisite for investigating the details of the primary productivity of an ecosystem. There is a dearth of such studies on tropical and subtropical Indian forests. Data from inventorying and monitoring are essential to identify the key issues for policy and management goals in the age of intellectual property rights. Such data can be used for environmental impact assessment studies in future especially with reference to conservation priority areas. In Andhra Pradesh the hilly region of Eastern Ghats is divided in to Northern, Central and Southern Ghats. The Northern Eastern Ghats portion covers the district of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari and Khammum. Forests are endowed with rich, varied and endemic flora. The climate of Eastern Ghats typically tropical enough to support the most luxuriant type of vegetation and maintain rich biodiversity .But these forests are subject to over exploitation to meet the growing demands for cultivation practices , firewood, fodder for live stock and

**Corresponding author*
Full Address :
Department of Botany, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India
Phone no. +919703784552
E-mail: srinivas.duvvada@gmail.com

wood exploitation for domestic and commercial utilization for these reasons , excessive use of these forests ecosystems and unplanned development of tribal ecohamlets has led to alarming levels of degradation with the possibility of losing biological diversity and Environmental quality of the region[10]. Srikakulam and Vizianagaram districts are located in Andhra Pradesh, are known for its rich and varied flora because of its pleasant temperature, moderate rainfall and soil, it has unique position in the Eastern Ghats, which cover Northern part of Eastern Ghats. Hence the present study was under taken to determine the structure and tree composition in tropical deciduous forests of Eastern Ghats of Andhra Pradesh, India, with special reference to Srikakulam and Vizianagaram districts. To revisit the study area for seasonal sampling latitude, longitude and altitude are noted using GPS (Global positioning system) The ecological studies have taken up to visualize the positive impact of protection on tree diversity. An understanding of the distribution of tree species and their assemblages must play an important role in elucidating the larger patterns of distribution of diversity. The present investigation deals with the comparison of species diversity indices of plant species i.e., Simpson's index[11], Shannon –wiener index[12], species richness with other counter parts. The main aim of the study is to delineate phytosociological attributes and to present a data base on diversity and distribution patterns of trees in Srikakulam and Vizianagaram districts.

2. Study area

India is one of the megabiodiversity centres of the world and majority of its people live in villages and rural areas. The area under study includes the two districts Srikakulam and Vizianagaram lies on the East coast of India lies between latitudes 17° – 15¹ and 19° – 12¹ North and longitudes in between 83° – 17¹ and 84° – 47¹ East with a total geographical area of 12,376 sq.Km. The area is with 37 mandals of Srikakulam district and 34 mandals of Vizianagaram district. The area is devided in to agency area and plain areas. The tribal population residing in the agency is 3,24,252 when compared with the total population of 47,86,847. The history of Srikakulam and Vizianagaram is connected with hoary past of Kalinga, one of the political divisions of ancient India. Only in modern times, the upper part of Kalinga was gradually merges into Orissa State and lower part into Andhra region. This region consists of different types of soils like red soils, loamy soils, sandy loams, with varying proportions of sand and clay and they constitute 96% of the total area. Red sandy soils are the common type. The deltaic alluvial soils are present along hilltops and in low-lying areas of the eastern and northern parts of the district. The climate of the region is generally tropical. The temperature in the hill areas is cooler than in plains because hills receive heavier rainfall. The mean maximum temperature is 30-40 °C April-May and the mean minimum temperature is 17.4 °C December-January during the summer season till the onset of the South-West monsoon the heat is oppressive and the day temperature is May sometimes go about 43 °C. The aboriginal culture and the vegetation pattern of the area have been much influenced by the topography and climate. The rainfall in the region is considerably more in the hilly areas as compared to the plains. The annual normal rainfall is 1131 mm (i.e., 61% from South West monsoon and 2.2% from North East monsoon) is shared by summer showers and winter rains. This region consists of 12,376 sq.km geographical area with a forest area of 1,84,007 hectares. The Srikakulam district with one forest division with 3 forest ranges and Vizianagaram district with one forest division with 4 forest ranges.

3. Material and Methods

The phytosociological attributes: frequency, density, &Basal area and their relative values and Importance Value Index (IVI) were calculated the following principles

Density=Total number of Individuals in all sampling units / Total number of sampling units studied

Frequency= No .of sampling units in which species occur x 100 / Total number of sampling units

Basal area = $Cbh^2/4\pi$

Where Cbh = Circumference of the tree at breast height.

Relative density = Density value of species x 100 / Sum of density value of all species

Relative frequency =Frequency value of species x 100 / Sum of frequency value of all species

Relative dominance= Total basal area of the species x 100 / Total basal area of all species

Importance Value Index = Relative density + Relative frequency + Relative dominance Based on the frequency classes of tree species were determined. According to Raunkiaer classify to There are 5 frequency classes, i.e. 'A' class with the species of frequency ranging from 1-20%; 'B' class 21- 40%; 'C' class 41-60%; 'D' class 61-80% and 'E' class 81- 100%.) based on the frequency pattern of the community, the homogeneity and heterogeneity of the vegetation. If the values are high with respect to B, C and D, then the community is said to be heterogeneous where as higher values of E indicates the homogeneous nature. Ecologist have developed and proposed a number of indices of species diversity from time to time, the values of which depend upon mathematically combined effects of species richness (S) and evenness (E). Species diversity richness is an

expression of community structure. It is described as the number of species present in a sample or habitat per unit area. The simplest species richness index is based on the total number of species and the total number of individuals in a given sample or habitat, higher the value greater the species richness. Species dominance is measured by using this index

$Cd = \sum(ni/N)^2$

ni = Total number of individuals of each species

N = Total number of individuals of all species

Shannon – wiener Index (1963)

It is also called species diversity index. This index is based on information theory and improves upon the Simpson's by giving more importance to the rare species.

$H= \sum(ni/N)\log(ni/N)$

ni = Total no. of individuals belonging to ith species

N = Total number of individuals in the sample.

*For the preparation of dendrogram for hierarchical cluster analysis origin software has been used

4. Results

In the present study, a total of 165 tree species, belonging to 119 genera and 50 families were recorded, and 160 are dicots and 5 are monocots. These species are recorded from site-I and site-II. The predominant species of this category are *Wrightia tinctoria, Lannea coromandelica, Diospyros sylvatica, Dalbergia paniculata, Chloroxylon swietenia, Cleistanthus collinus, Xylia xylocarpa, Alangium salvifolium, Cassia fistula and Morinda tinctoria* etc at. Site-I. *Shorea robusta, Xylia xylocarpa, Cleistanthus collinus, Wrightia tinctoria, Lannea coromandelica, Anogeissus latifolia, Dalbergia paniculata, Chloroxylon swietenia, Tamarindus indica and Mangifera indica* etc. at site-II. The total families recorded in the present study are 50,of these 48 are dicots 2 are monocots i.e Poaceae and Arecaceae among these 22 are monotypic, viz., representing only by one species. 2 are monocot families: When both the study sites are pooled together the first 10 largest families with more than 6 species Rubiaceae and Mimosaceae are the largest representing families with 13 species each. Euphorbiaceae and Moraceae occupies the second position with 12 species followed by Fabaceae and Verbenaceae (9) each; Rutaceae, Anacardiaceae, Combretaceae and Ebenaceae representing (6) each.

4.1 Site –Wise analysis of species

In the present study, tree species of the study area pertaining to individual sites has revealed interesting results. Out of the 165 species recorded in study area Site -I and Site-II, site-II harbours 165 species, and Site-I represents 129 species. This analysis has been presented in Table I. A maximum of 36 species are exclusively found in the Site-II. A total of 129 species are commonly present in the site-I & II. A comparative analysis was made for various taxa encountered in Site-I with Site-II. has been shown in the (Table I). From the table-1, it is evident that the number of families, genera, species and number of individuals in site-II is higher than the site-I.

4.1.1 Frequency of species

The frequency classes of the species encountered in site I&II, further the frequency formula for each class also determined. The results obtained were presented in (Suppl. table I & II) The analysis on the frequency classes of species encountered in site-I revealed the following results. Out of 129 species, A class was represented by72 species followed by 26 under B, 13 under C and 7 under D, 11 species under E and in site-II A class was represented by 109 species followed by 33 under B, 16 under C and 3 under D, 4 species under E this results showing the heterogeneity of vegetation in the both sites (Table II).

4.2 Phytosociological studies

A total of 129 species were recorded from site-I and 165 species from site-II**).** In site –I, the total density of tree species was 118 plants km^{-1} out of which *Wrightia tinctoria* shared (5.86%) followed by *Lannea coromandelica* (4.47%), *Diospyros sylvatica* (4.45%), *Dalbergia paniculata* (3.69%), *Chloroxylon swietenia* (3.54%), *Cleistanthus collinus* (3.5), *Xylia xylocarpa* (3.06%), *Alangium salvifolium* (3.00%) and *Cassia fistula* (2.4%) were the 10 dominant species (Suppl. table

Table I: Detailed information at both sites

Area	Site-1	Site-2	Total study area
Number of species	129	165	165
Number of genera	96	119	119
Number of families	46	50	50
Number of individuals	4744	8442	13186

Table II : Raunkiaer law of Frequency Classes

Sl. No	Frequency classes	Site-I	Site-II
1	A: 01-20	72	109
2	B:21-40	26	33
3	C:41-60	13	16
4	D:61-80	7	3
5	E:81-100	11	4
6	Total	129	165

I). The total density of tree species was 127 plants km-^{1} out of which *Shorea robusta* (5.52%) *Xylia xylocarpa* (4.15%) , *Cleistanthus collinus* (4.01%) , *Wrightia tinctoria* (3.64%), *Lannea coromandelica* (3.50%), *Anogeissus latifolia*(3.42%), *Dalbergia paniculata* (3.15%), *Chloroxylon swietenia* (2.70%)*Tamarindus indica* (2.63%) were dominant 10 species in site –II (Suppl. table II). The total basal area of the all species in site-I was 856521cm/ km^{-1} out of which *Mangifera indica*(9.32%) followed by *Tamarindus indica*(7.24%), *Dendrocalamus stricta* (5.29%) ,*Lannea coromandelica* (4.50%), *Dalbergia paniculata (*4.46%), *Caryota urens* (3.84%), *Diospyros sylvatica* (2.82%),*Wrightia tinctoria* (2.77%) *Xylia xylocarpa*(2.72%) were dominant (Suppl. table I). The total basal area of the species was 3658175cm / km^{-1} out of these *Tamarindus indica* (11.34%) *followed by Shorea robusta* (9.20%), *Mangifera indica* (7.40%),*Anogeissus latifolia and Xylia xylocarpa*(3.95%), *Lannea coromandelica*(3.49%), *Terminalia alata*(3.30%), *Terminalia bellerica* (3.17%), *Dalbergia paniculata* (2.89%) were dominant in Site-II (Suppl. table II). Basal area, Density, Frequency and their relative values for determining the distribution pattern and Importance Value Index (IVI) of the tree species encountered in site- I. A total of 129 tree species were recorded from 40 transects. *Mangifera indica* is the most important species followed by *Lannea coromandelica,Wrightia tinctoria, Dalbergia paniculata, Tamarindus indica, Diospyros sylvatica,Cleistanthus collinus,Xylia xylocarpa,Chloroxylon swietenia, Terminalia alata* were recorded in Site-I (Suppl. table I). Important Value Index (IVI) of individual tree species encountered in the site-II *Tamarindus indica* as the most important species followed by *Shorea robusta, Mangifera indica, Xylia xylocarpa, Anogeissus latifolia, Lannea coromandelica, Cleistanthus collinus, Dalbergia paniculata, Wrightia tinctoria , Terminalia alata etc* were recorded (Suppl. table II).

Density, Frequency, Relative density, Relative frequency and Relative abundance values were taken for the preparation of single link cluster analysis and result revealed that the majority of the species formed the similar groups except *Mangifera indica* and *Tamarindus indica* which forms the dissimilar groups in Site-I. In site -II *Shorea robusta, Schleichera oleosa ,Lannea coromandelica ,Mangifera indica* and *Tamarindus indica* formed dissimilar group(scale 0-25), remaining species forms the similar groups in single link cluster analysis (Suppl. fig I & II) A total of 4744 and 8442 individuals were recorded in Site- I and Site -II respectively. The height and girth based analysis were presented in (Fig I, II, III, IV). The number of species on the basis of height and girth were greater in Site-II than the Site-I. Fig I Shows the height based analysis in different groups (0 - 35 meters) at study site -1.Among these groups , maximum number of plants (4108) were present in 5 to10 meters height category, and followed by 11- 15 (380) and 0 – 5 (368) groups ,from 16 - 20 meters category onwards number of plants decreased with a minimum plants (4) in 26-35 groups (Fig I)**.** Similar analysis was conducted in Site-2(Fig II). In this study area also maximum number of plants (5659)were reported in 5-10 meters category followed by 11 - 15 (1395) and 0- 5 (1135) groups . From 16 - 20 meters category onwards number of plants decreased with a minimum of plants (5) was present in 31 - 35 meters height category. Based on number on relation to height wise calculation in study sites (Both Site-I and Site-II) reflects the presence of more number of plants with height of 5 - 10 meters only. Few species in this area attained maximum height of 35 meters plant populations at two study sites were segregated based on this girth classes, and identified the maximum number of plants belongs to the specific groups (Fig III) shows the presence of plant species in different girth groups at study Site -I maximum number of plants (2225) were present in 0 - 29 cm girth class. The number of plants decreased from 0 - 29 cm girth class with minimum

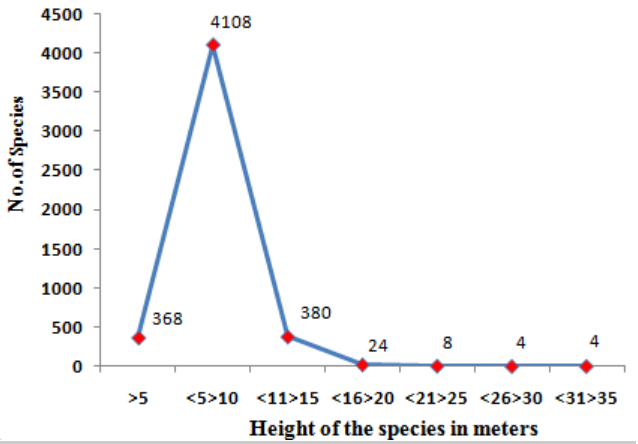

Fig I: Height based analysis at Site-I

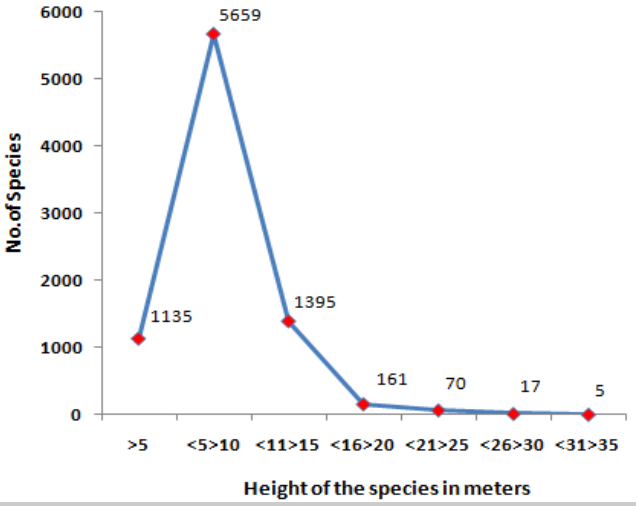

Fig I: Height based analysis at Site-II

90-119 cm girth class. Fig V shows the height of the plant populations at Site-I and Site-II. Plants were segregated in different class based on their height in meters (1 - 35 meters) maximum numbers of plants were recorded in 5 - 20 meters class for Site –I and Site-II. Minimum numbers of plants were reported in different class's ranges from 16 to 35 meters. In all these classes maximum number of plants were present in Site-II regarding the girth of the plants. Fig VI shows the girth of the plant populations in various girth classes. In Site-I more number of plants with less than 29 cm girth was reported in the remaining girth classes (30-120) maximum plants were recorded in Site-II (Fig VI)**.** Important Value Index (IVI) was divided for 129 species at Site –I and for 165 species at Site-II. Fig VII shows the highest important value index for 10 species at Site-I , highest value 11.94 was obtained for the species. Among these *Mangifera indica* followed by *Lannea coromandelica* (11.69) *Wrightia tinctoria* (11.01) with minimum value for *Terminalia alata* (6.6). Fig VIII shows the highest important value index for 10 species, out of 165 species maximum IVI value was obtained for *Tamarindus indica* (15.60) and minimum value for *Terminalia alata* (7.13) . Species IVI values from Site-I and Site –II indicates that 12 species having highest IVI values than the remaining species.

4. Discussion and Conclusion

Phytosociological investigations were carried out in two different study areas in the Srikakulam and Vizianagaram districts of Andhra Pradesh information collected in these sites were tabulated and a comparative analysis has been made for various taxa encountered in site –I with Site –II. The number of families, genera and species in site –II are higher than the site –I. The number of trees are less in site-I than site –II; it indicates that the climatic and other parameters are allowable in site –II than the site-I. The predominant forest areas of the study regions [Site-I (Srikakulam district), Site-II (Vizianagaram district)] in Andhra Pradesh are tropical deciduous forests (Champion and Seth 1968). Studies in these two sites reveal that the most abundant families were Rubiaceae, and Mimosaceae (13), Moraceae (12), Euphorbiaceae (11), Fabaceae (9), Verbenaceae (9) Rutaceae, Anacardiaceae, Combretaceae and Ebenaceae (6) each representing respectively. In the present study , the basal area for tree species 856521.0987 cm^2/ m^2 and 3658175.717 cm^2/ m^2 in site-I and Site-II respectively. More basal area in site –II may be attributed to higher plant density. Tree species richness varied according to the disturbance gradient in the different stands, a total of 4744 and 8442 individuals, belonging to 165 species, 119 genera among 50 families from 106 line transects in both sites respectively (Table 9-10). Species richness ranges from 58 to 9 in a transects, recorded in the present study. Species richness was more 58 for (SE-3, 65 N-3) at Andra and has least species diversity 9 at Sukkapudivalasa (SE-2, 65N-5) in site-II (Table-10). In site-I species richness was recorded high at Haddubangi (SW-3, 65 N-14) with 47 species and has least species diversity 9 at Korasanda (SE-1, 74 B-1). In tropical rain forests, the range of tree species count per hectare is about 20 to maximum of 223.[13] India occupies only 2.4% of the world's land area but its contribution to the world's biodiversity is approximately 8% of the total number of species [14]. which is estimated to be 1.75 million (As per Global Biodiversity Assessment of UNEP of 1995, described number of species so far is 1.75 million). Of these, 126 188 have been described in India. It may be the consequence of direct competition for water or soil nutrient status or due to other topographic features. Girth class wise frequency population structure of trees exhibited in both sites are in conformity with other forest stands in Eastern Ghats such as Shervarayan hills[15] Kalraya hills[16] Southern Andhra Pradesh[17]. Species richness and density decreased with the increasing tree size classes in both sites, the small stems contributed biggest fraction of total density and whereas largest size (>120) contributed small fraction. Such a distribution is similar to that found in the tropics and the subtropics. The population of valuable plants are decreasing in study area of Andhra Pradesh, due to the loss of habitat, collection and utilization of valuable plants by the local tribal and other people. In recent years the number of valuable plants have been endangered and rare. So the exploitation of plants for their medicinal value and ornamental use must be carried out, but proper care should be taken for their conservation by both *in-situ* as well as *ex-situ* conservation methods. For this request we made to the Forest Department, Government of Andhra Pradesh and Non Government Organizations to implement or undertake programmes in conserving the valuable plants in this region. The author hopes that the phytosociology of Srikakulam and Vizianagaram districts would be a great source of information and technical data to the academic and Research Institutes like Botanical Survey of India, Department of Biotechnology, Government of India, New Delhi, National Botanical Research Institute – Lucknow, Institute of Wood Science and Technology – Bangalore, and other Institute of Wood Science and Technology – Bangalore, and other Institutes which depend on plant populations in the Eastern Ghats of Andhra Pradesh. In conclusion it is suggested; in this context that phytosociological analysis is very important in predicting the ecological patterns and classifying the forests in meaningful way. In Eastern Ghats the phytosociological studies are very few hence there is a need to improve such type of studies in order to know the patterns of

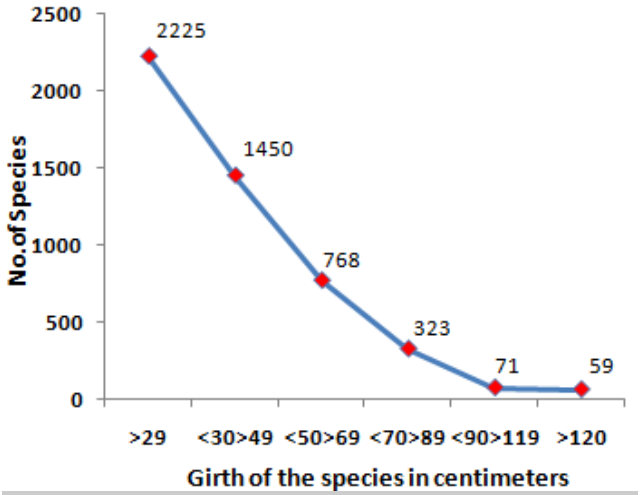

Fig III: Girth based analysis at Site-I

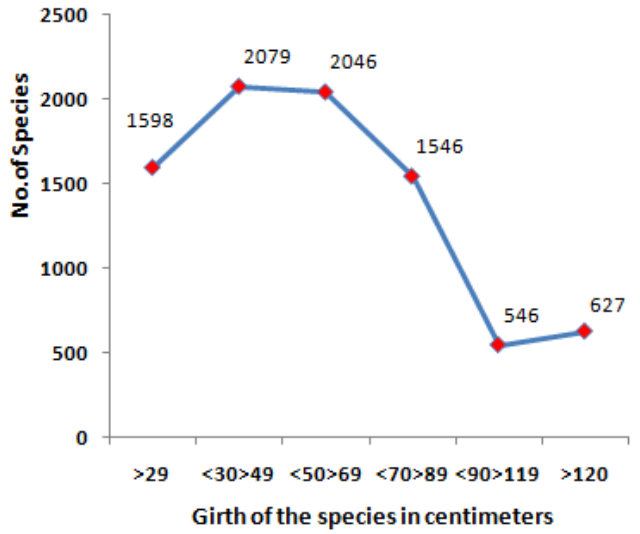

Fig IV: Girth based analysis at Site-II

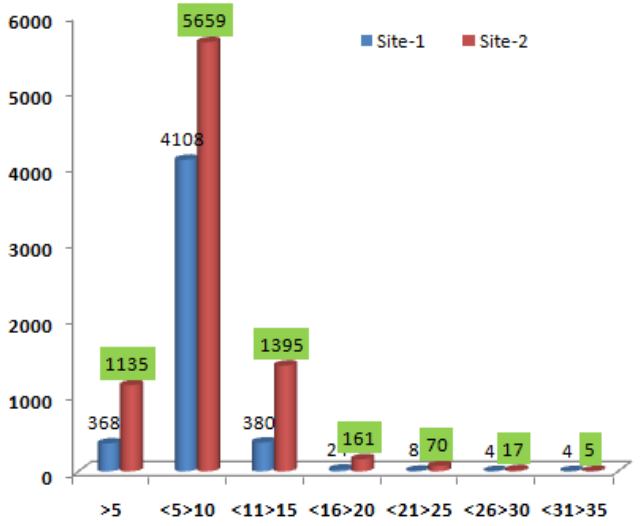

Fig V: Comparison on the bases of height at both sites

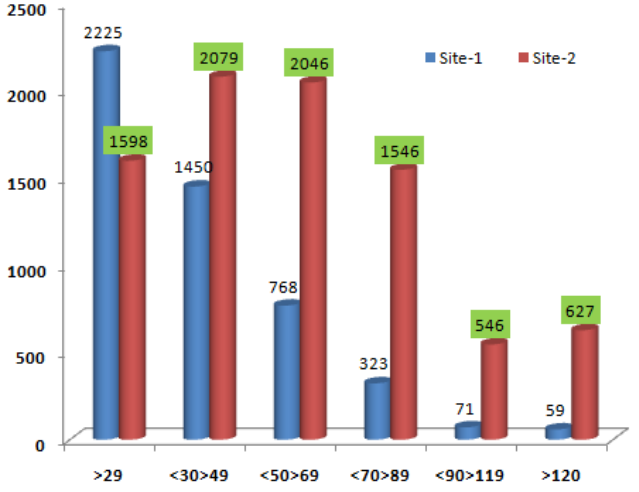

Fig VI: Comparison on the bases of girth at both sites

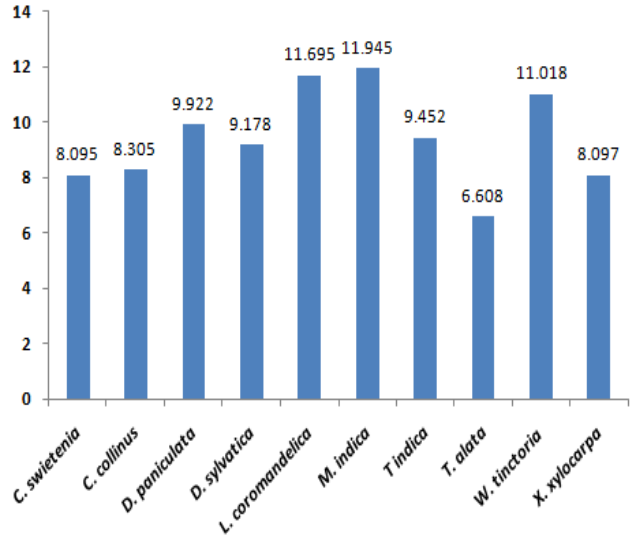

Fig VII: Top 10 species based on IVI values at Site-1

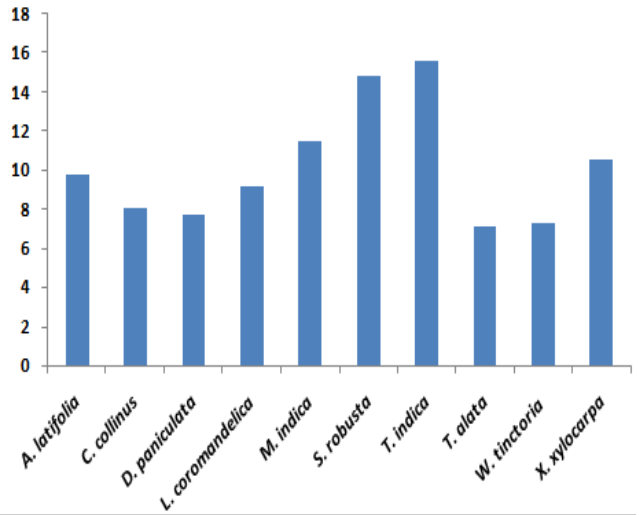

Fig VIII:Top 10 species based on IVI values at Site-II

number of plants (59) were recorded in more than 120 cm girth class. Fig IV shows the girth wise distribution of plant population at study Site -II in this study area maximum number of plants (2079) were reported in 30 - 49 cm girth class , followed by 2046 plants at 50 - 69 cm , 1598 plants at 0 - 29 cm girth class , minimum number of plants (546) were present at 90 - 119 cm girth class (Fig III) In site –I at 120 cm girth class minimum number of plants were reported but in the Site –II at 120 cm girth class more number of plants were present than

ecosystem. The present study will serve as a primary input towards monitoring and sustaining the phytodiversity and also would help in understanding the threats that are being faced by the tropical forests and would help in deriving conservation policies. There is a lack of data on the depletion of tree species populations in the dry deciduous forests of India. Depletion of tree species, especially in species-poor systems, will influence the integrity of local forest ecosystems and will tend to lead to genetic impoverishment of species. The objective of the present study was to identify the declining species populations in the tropical dry deciduous forest of Srikakulam and Vizianagaram districts of Andhra Pradesh. The quantitative inventory of tree species diversity revealed a considerable variation in the composition of dominant species and density in various forest areas and the estimations of IVI have helped to understanding the ecological significance of the species, present in different communities.

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Conflict of interest

The author's declares none.

References

1. Sudhakar Reddy. C. & Ugle P. Tree species diversity and distribution patterns in tropical forest of Eastern Ghats, India: a case study. *Life Science Journal,* **5(4)** (2008). 87-93
2. Ravi Prasad Rao B. Sacred groves in Southern Andhra Pradesh, India. Paper presented in International conference on Conservation of Tropical Species, Communities and Ecosystem.(Abstract). 2-6 December. Trivandrum, India,(1998).
3. Sunitha, S. & Ravi Prasad Rao B. Sacred groves in Kurnool district, Andhra Pradesh. In: Sivadasan & Philip Mathew (eds.) Biodiversity, Taxonomy and Conservation of Flowering Plants. Mentor Publishers, Calicut, (1999) pp. 367- 373
4. Ravi Prasad Rao B., Suresh Babu M.V., Sridhar Reddy M., Madhusudhana Reddy A., Srinivasa Rao, V., Sunitha S. &. Ganeshaiah K.N. Sacred groves in southern eastern ghats, India: Are they better managed than forest reserves? *Tropical Ecology* **52 (1)** (2011),79-90.
5. Srinivasa Rao D, Prayaga Murty P. & O. Aniel Kumar. Vegetation composition, Tree species diversity and soil types: A case study from the Tropical forests of Eastern Ghats of Vizianagaram, India. *International Journal of Current Science* **10 E** (2014) 78-87
6. Prayaga Murty, P. & Narasimha Rao G.M., Phytosociological attributes of Mangrove plant populations at Peddavalasala of Gautami Godavari Estuary of Andhra Pradesh, India. *Advances in Pollen Spore Research*. (2013) 303-309.
7. Srinivasa Rao D., Prayaga Murty P. & Venkaiah M. Phytosociological Observations on Tree Species Diversity of Tropical Forest of Srikakulam District, Andhra Pradesh, India. *Indian Journal of Plant Sciences* **2(4)** 2013 89-108
8. Pratap Chandra, P., Ajay Kumar, M., Pradosh Kumar A.& Akhil Kumar D. Plant diversity in tropical deciduous forests of Eastern Ghats, India: A landscape level assessment. *International Journal of Biodiversity and Conservation.* **5(10)** (2013) 625-639.
9. IIorkar, V.M.& Khatri, P.K. Phytosociological study of Navegaon National Park (Maharashtra). *Indian Forester,* **129** (2003) 377-387.
10. Subba Rao, M.V., Ecology and management of mammalian resources of Eastern Ghats. Final Technical Report, Ministry of Environment and forests, Government of India, New Delhi.(1993).
11. Simpson E.H., Measurement of diversity, Nature, **163** (1949), 688-688.
12. Shanon CE, Weaver W. The Mathametical Theory of Communication .The University of Illinois Press, Urbana IL. (1963).
13. Parthasarathy, N. & Sethi P., Tree and liana species diversity and population structure in a tropical dry evergreen forest in South India. *Tropical Ecology,* **38** (1997) 19-30.
14. Khoshoo, T.N. 'Biodiversity in the Indian Himalayas: conservation and utilization'. In *Banking on Biodiversity,* edited by Sheggi P Kathmandu: International Centre for Integrated Mountain Development (1996).
15. Kadavul, K. & Parthasarathy N., Plant biodiversity and conservation of tropical semi-evergreen forest in the Shervarayan hills of Eastern Ghats, *India, Biodiversity and Conservation,* **8** (1999) 421-439.
16. Kadavul, K. and Parthasarathy N. Structure and composition of woody species in tropical semi-evergreen forest of Kalrayan hills, Eastern Ghats, India. *Tropical Ecology,* **40** (1999) 247-260.
17. Reddy, C.S., Prachi, U., Murthy, M.S.R.& Sudhakar,S. Quantitative structure and composition of tropical forests of Mudumalai Wildlife Sanctuary, Western Ghats, India. *Taiwania,* **53(2)** (2008) 150-156.