

Population structure and Regeneration of *Croton scabiosus* Bedd. (Euphorbiaceae) in dry forests of South Eastern Ghats of YSR Kadapa District, Andhra Pradesh, India

ABSTRACT

Croton scabiosus Bedd. (Euphorbiaceae), an endemic tree of dry forests of South Eastern Ghats, is categorized as avVulnerable tree. For effective conservation of this species studies on its population structure and regeneration are required ~~and hence the present investigation has been undertaken~~. The population structure and regeneration of *Croton scabiosus* was studied in 11 localities of dry forests of Kadapa district, India, by laying 66 quadrats ~~each~~ of 5x200m in size. A total of 2571 ~~tree~~ individual strees with a range of 61-100 trees (<20cm gbh) in each quadrat were recorded. In the regeneration category 8.8% of seedlings and 49.7% saplings were recorded. In addition, *C. ~~scabiosus~~* is associated with 54 tree species belonging to 39 genera and 21 families. The most commonly associated tree species are: *Acacia caesia*, *Acacia chundra*, *Cleistanthus collinus*, *Gardenia gummifera*, *Mimosa intsia*, *Ochna obtusata*, *Strychnos nux-vomica*, *Pterocarpus santalinus* and *Wrightia tinctoria* ~~in dry forests of Kadapa district~~. The Mmajority (76%) of the individuals occurred in the lower 10-30 cm gbh class ~~(76%)~~, followed by 30-40cm gbh class (7.9%). A reverse 'J' shaped curve of population structure was observed. In certain sites *C. ~~scabiosus~~* formed the dominant lower canopy tree in the elevation range of 155m-328m.

Keywords: *Croton scabiosus*, Endemic tree, Vulnerable, Dry forests, Population structure, Regeneration ~~Regeneration~~.

1. INTRODUCTION

Tropical dry forest accounts for 38.2% of the total forest cover of India [1]. These dry forests not only constitute a rich species diversity, generate a variety of natural resources, but also promote livelihood security to local communities [2]. Tropical dry forests occur in climates s with seasonal rainfall, with a mean annual rain fall of 250-2000mm and Potential Evapo-transpiration of (PET) > 1 [3]. The distribution of plants is determined by climatic variables like

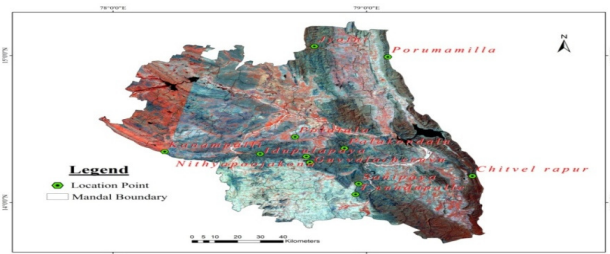
rainfall, temperature, soil conditions, moisture, nutrient availability and competition between plant species for crown and root space as well as human interference [4].

Croton scabiosus Bedd. (Euphorbiaceae), a small deciduous tree of 4-6m in height, ~~belonging to the family Euphorbiaceae~~ is endemic to South Eastern Ghats of Andhra Pradesh [5, 6, 7]. This species is represented by small populations, with a scattered distribution in dry deciduous forests (Fig -1) of South Eastern Ghats of Andhra Pradesh [8]. It is principally (??) found in Ananthapuramu, Kadapa and Nellore Districts of South Andhra Pradesh, India. It is listed as vulnerable according to IUCN Red list status [8]. This species is medicinally important, as the seeds are used as an antidote for snake bite and scorpion sting by the local people [9]. It has a very attractive silvery to golden foliage, ~~which and~~ can be recommended as an ornamental garden plant [10]. Its populations in the natural habitat in Kadapa forests are primarily threatened by forest fires, fungal infection of seeds and poor germination [7]. As this is an endemic and medicinally important species, and its populations are small and declining in the native habitats, studies on regeneration and phytosociological information ~~are is~~ necessary for its conservation.

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2. MATERIALS AND METHODS

Study Area



Location Map of the Study Area

YSR Kadapa district is located between 13°43' and 15°14' North latitude and 77°55' and 79°29' East longitude. The total geographical area of the district is 15,379 km², in which the forest area comprising is 5,050 km², which is 32.87% of the district area. Day temperature reaches maximum 46°C in the month of May and minimum 31°C in December in Kadapa district. Average rainfall is 700mm. The present study ~~was has been~~ undertaken in the dry deciduous forests of Kadapa district in 11 places, namely: Idupulapaya, Palakondalu, Nithyapooja Kona, Porumamilla, Joythi, Kanampalli (Pulivendula), Sundupalli, Sanipaya, Polathala, Guvvalacheruvu, and

Chitvel-Rapur hills. These 11 locations (Fig. 5) are identified based on forest vegetation of *Croton scabiosus* species distribution. The study was carried out at each location to assess the density $4.04/0.6\text{ha}^{-1}$ in totally 6.6ha, population and regeneration status of the tree species. All the study sites consist of dry deciduous forests, except in Sundupalli and Pulivendula hills where the forests are scrub type.



Dry forest of Chitvel –Rapur Dry forest of Guvvalacheruvu



Scrub of Sundupalli Scrub of Pulivendula

Fig. 1 Population of *Croton scabiosus* in Chitvel-Rapur, Guvvalacheruvu, Sundupalli and Pulivendula forests.

Data collection and analysis

The study was carried out in 11 study sites; in each site six belt transects of $5 \times 200\text{m}$ were laid, which formed 0.6ha in each area, and 6.6ha in total field by study area. In each site *C. scabiosus* trees $>10\text{cm gbh}$ (write out abbreviation at 1st mention) were inventoried, their gbh was noted at 1.37m and their height was recorded. The regeneration was studied by counting all encountered seedlings ($<10\text{cm}$) and saplings (1m height) encountered were counted. Population structure of *C. scabiosus* was assessed by frequency histogram by categorising the density into $10\text{-}20\text{cm}$, $21\text{-}30\text{cm}$ and $31\text{-}40\text{cm gbh}$ class. The trees were categorised into height classes from 1m to 8m in height. In all study sites with *C. scabiosus*, associated tree species like *Acacia chundra*, *Chloroxylon swietenia*, *Gardenia gummifera*, *Mimosa intsia*, *Pterocarpus santalinus* and *Wrightia tinctoria* were also recorded (why? State reason).

3. RESULTS

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Comment [M3]: I assume by density you mean individuals per area? Or are you referring to nearest neighbor distance?

Comment [M4]: How many classes were there, and how were they defined?

A total of 1068 *C. retusus* trees (≥ 10 gbh), 1277 saplings and 226 seedlings in 6.6 ha area, with a range of 61-100 individuals in 5x200m quadrat (0.6ha) were recorded. The gbh class distribution showed that 12.95% of 10-20 gbh class, 20.7% of 21-30 gbh class and 7.9% of 31-40 gbh class (Fig -2). The saplings are 49.7% and seedlings are 8.8%. The height class distribution revealed that 49.7% of individuals i.e., saplings are below 2m height, 30.76% trees are in the 2-3m height class, while 8.63% trees are 4-5m height and only 0.02% trees are 6-8m height (Fig-3). Regeneration of *C. retusus* was poor in all the sites studied. The regeneration distribution shows that the saplings are 49.7% and seedlings are 8.8%. Highest regeneration status (19.16%) was observed in Sundupalli forest and lowest regeneration was in Porumamilla (3.92%) and Pulivendula (3.50%) forests. The poor regeneration may be due to rocky habitat (Fig-4). The total basal area value is 7.74m²/ha with a range of 25% - 75% and the average height is 3m. *Croton scabiosus* tree height and the calculated basal area showed a marked strong relationship. The detailed analysis among the quadrats reveals that seedlings are present in only 35 quadrats out of all the 11 localities studied. Highest percentage of seedlings growth occurred in Sundupalli. It may be due to good soil and climatic condition favourable for growth and almost no human interference and the lowest seedling growth on rocky habitats of Pulivendulaghats and Porumamilla. More population of *C. retusus* was observed in Palakondalu and Sanipaya, but in these two areas the percentage of seedlings is very low compared to trees and saplings. This may be due to recurrent forest fires and anthropogenic disturbances. In the rocky hilly areas of Porumamilla and Pulivendulaghat the trees are more and regeneration of seeds is very poor as the hills are rocky and lack of adequate soil for germination of seeds.

Comment [MJ5]: See comment 6 below

Comment [MJ6]: Duplication with above – see comment 5

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Throwing together results (as this paper does) from scrub and dry forests gives an overall impression of the study area, but say nothing about the various ecosystems (dry vs scrub) and the variations encountered. This lessens the impact of this paper and its value. This also impacts negatively on the proposed recommendations; because it does not address individual ecosystems (dry and scrub). Thus it is unclear why you mention scrub/dry and then throw everything together.

Suggest 8 paragraphs:

Paragraph 1-4: focusing on POPULATION STRUCTURE

1st present overall results of all forests

2nd present results from dry forests

3rd present data from scrub forest

4th highlight differences in various (scrub vs dry) forests

Paragraph 5-8: focusing on Regeneration follows the same format as suggested above

It must be made clear in the figures legends below that these are overall results.

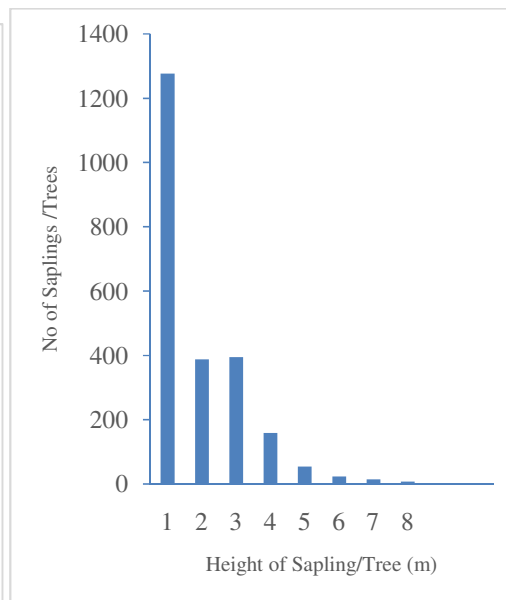
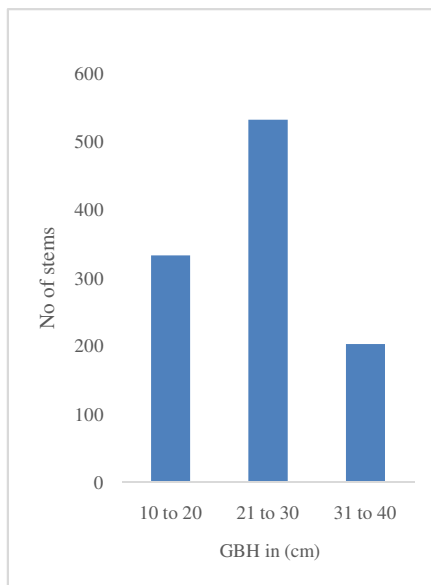


Fig -2 ~~Number-~~ of stems in *Croton scabiosus* **Fig -3** *Croton scabiosus* sapling/tree height

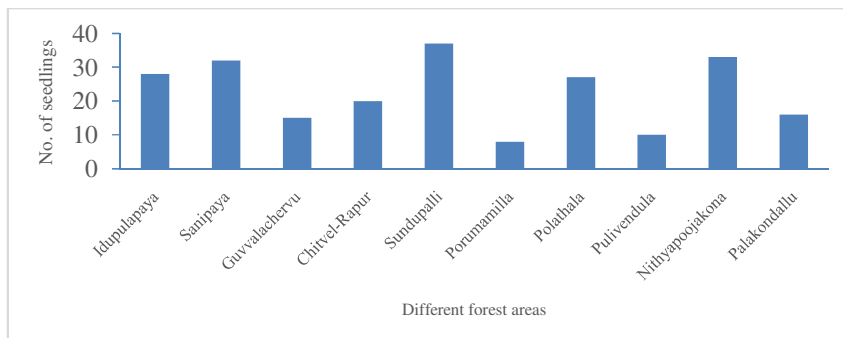


Fig - 4 No.of seedlings in different forest areas

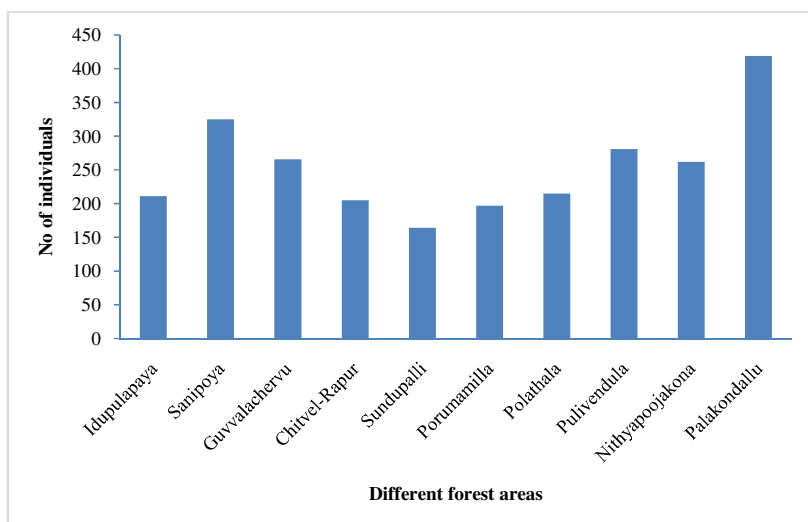


Fig -5Population structure of *Croton scabiosus* in different forests of Kadapa district.

Table -1 Associated Tree species with *Croton scabiosus*

Sl.No	Tree Species	Family
1	<i>Acacia caesia</i> (L.) Willd.	Mimosaceae
2	<i>Acacia chundra</i> (Rottler) Willd.	Mimosaceae
3	<i>Aegle marmelos</i> (L.) Correa	Rutaceae
4	<i>Albizia amara</i> (Roxb.) B.Boivin	Mimosaceae
5	<i>Anogeissus latifolia</i> (Roxb.ex DC.)	Combretaceae
6	<i>Atalantia monophylla</i> DC.	Rutaceae
7	<i>Bauhinia racemosa</i> Lam.	Fabaceae
8	<i>Boswellia ovalifoliolata</i> N.P.Balakar. & A.N.Henry	Burseraceae
9	<i>Boswellia serrata</i> Roxb.ex Colebr.	Burseraceae

10	<i>Bridelia montana</i> (Roxb.) Willd.	Euphorbiaceae
11	<i>Buchanania axillaris</i> (Desr.) Ramam.	Anacardiaceae
12	<i>Cassia fistula</i> L.	Caesalpiniaceae
13	<i>Cassine glauca</i> (Rottb.) Kuntze	Celastraceae
14	<i>Ceiba pentandra</i> (L.) Gaertn.	Bombacaceae
15	<i>Cleistanthus collinus</i> (Roxb.) Benth.	Euphorbiaceae
16	<i>Chloroxylon swietiana</i> DC.	Rutaceae
17	<i>Cochlospermum religiosum</i> (L.) Alston	Cochlospermaceae
18	<i>Commiphora caudata</i> (Wight & Arn.) Engl.	Burseraceae
19	<i>Dalbergia lanceolaria</i> L.f.	Fabaceae
20	<i>Dalbergia latifolia</i> Roxb.	Fabaceae
21	<i>Deccania pubescens</i> (Roth) Tirveng.	Rubiaceae
22	<i>Diospyros chloroxylon</i> Roxb.	Ebenaceae
23	<i>Diospyros melanoxylon</i> Roxb.	Ebenaceae
24	<i>Dolichandronea torevirens</i> (Roth) K. Schum.	Bignoniaceae
25	<i>Erythroxylum monogynum</i> Roxb.	Erythroxylaceae
26	<i>Ficus benghalensis</i> L.	Moraceae
27	<i>Ficus mollis</i> Vahl	Moraceae
28	<i>Ficus religiosa</i> L.	Moraceae
29	<i>Ficus virens</i> Aiton	Moraceae
30	<i>Gardenia gummifera</i> L.f.	Rubiaceae
31	<i>Gardenia resinifera</i> Roth	Rubiaceae
32	<i>Grewia flavescens</i> Juss.	Tiliaceae
33	<i>Grewia hirsuta</i> Vahl	Tiliaceae
34	<i>Grewia tiliaefolia</i> Vahl	Tiliaceae
35	<i>Hardwickia binata</i> Roxb.	Caesalpiniaceae
36	<i>Lannea coromandelica</i> (Houtt.) Merr.	Rutaceae
37	<i>Mimosa intsia</i> L.	Mimosaceae
38	<i>Madhuca longifolia</i> (J. Kong ex L.) J.F. Macbr.	Sapotaceae
39	<i>Naringicrenulata</i> (Roxb.) Nicolson	Rutaceae
40	<i>Ochna obtusata</i> DC.	Ochnaceae
41	<i>Phyllanthus emblica</i> L.	Euphorbiaceae
42	<i>Polyalthia cerasoides</i> (Roxb.) Bedd.	Annonaceae
43	<i>Premna latifolia</i> Roxb.	Verbenaceae
44	<i>Premna tomentosa</i> Willd.	Verbenaceae
45	<i>Pterocarpus santalinus</i> L.f.	Fabaceae
46	<i>Radermachera xylocarpa</i> (Roxb.) Roxb. ex K. Schum.	Bignoniaceae
47	<i>Santalum album</i> L.	Santalaceae
48	<i>Strychnos nux-vomica</i> L.	Loganiaceae
49	<i>Strychnos potatorum</i> L.	Loganiaceae
50	<i>Syzigium alternifolium</i> (Wight) Walp.	Myrtaceae
51	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae
52	<i>Terminalia chebula</i> Retz.	Combretaceae
53	<i>Terminalia tomentosa</i> Wight & Arn.	Combretaceae
54	<i>Wrightia tinctoria</i> R.Br.	Apocynaceae

Table-2 Associated Trees with *Croton scabiosus* in different forests of Kadapa districts

Forest area	Eleva	Fores	Associated Trees
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	tion	t type	
Chitvel - Rapur	261-510m	Dry forest	<i>Limoniaacidissima, Radermacheraxylcarpa, Ficusvirens, Mimosa intsia</i> etc.
Idupulapa ya	275m - 598m	Dry forest	<i>Anogeissuslatifolia, Dolichondroneatrovirens, Grewiahirsuta, Gardenia resinifera, Hardwikiabinata</i> etc.
Guvvalach eruvu	467m - 519m	Dry forest	<i>Chloroxylonswietenia, Gardenia gummifera, Gardenia resinifera, Pterocarpussantalinus, Ochnaobtusata</i>
Nithyapoo jakona	407m - 597m	Dry forest	<i>Boswelliaserrata, Ceibapentandra, Cleistanthuscollinus, Cochlospermumreligiosum, Deccania pubescens, Cleistanthuscollinus</i> etc.
Palakondalu	155m - 328m	Dry forest	<i>Cleistanthuscollinus, Gardenia gummifera, Gardenia latifolia, Pterocarpussantalinus, Mimosa intsia, Ochnaobtusata, Buchananiaaxillaris.</i>
Polathala	215m - 368m	Dry forest	<i>Acacia chundra, Brideliamentana, Diospyroschloroxylon, Dolichondroneatrovirens</i> etc.
Porumamil la	478m - 592m	Dry forest	<i>Atalantiamonophylla, Cassia fistula, Diospyrusmelanoxylon, Phyllanthusemblica</i> etc.
KanamPalli	268m - 462m	Scrub forest	<i>Anogeissuslatifolia, Gardenia gummifera, Wrightiatinctoria</i> etc.
Sanipaya	205m - 706m	Dry forest	<i>Anogeissuslatifolia, Aeglemarmelos, Hardwickiabinata</i> etc.
Sundupalli	208m - 515m	Scrub forest	<i>Anogeissuslatifolia, Acacia chundra, Bauhinia racemosa</i> etc.
Joythi	392m - 635m	Dry forest	<i>Croton scabiosus</i> is not found

Comment [MJ10]: What does this mean?? Either list them all, or do not list any!

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4. DISCUSSION

Endemic plants are restricted to particular geographical areas [5]. Most of the endemic plant species are under threat due to loss of habitat, forest degradation, unsustainable biotic interference and exploitation according to the report of Conservation Assessment and Management Planning (CAMP) Workshop for medicinal plants of Andhra Pradesh [11]. Some of the endemic species were assessed under different categories namely *Cycasbeddomi* (Critical Endangered), *Hildegardiapopulifolia* (Vulnerable), *Pterocarpussantalinus* (Endangered), *Shoreaumbaggaia* (Endangered), *Syzygiumalternifolium* (Endangered), and *Terminalia pallida* (Endangered). Conservation status for three

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species, *Cycas beddomei* Dyer, *Hildegardia populifolia* Schott & Endl. and *Croton scabiosus* Bedd. was reported by Rao *et al.* (12, 13, 7). In the study areas *Croton scabiosus* was found in the elevation range of 208m -706m. Population structure of *Croton scabiosus* showed that saplings are 49.7% followed by that of trees with 41.5% and seedlings with 8.8%. The highest percentage of gbh class 21-30cm (20.7%) indicates the prevailing disturbances are providing a threshold to the girth increment for the tree. The availability of high number in >30 cm gbh category indicates that the prevalent disturbance condition and harsh environmental conditions have a role in gbh increment among the tree individuals. It usually grows in low to middle foot hills along *Cleistanthus collinus*, *Mimosa intsia*, *Pterocarpus santalinus* and *Anogeissus latifolia* indicating a preference of dry conditions for the *Croton scabiosus* tree.

Are the various graphs discussed? Are the various tables discussed?

Comment [MJ14]: So what does this imply?

Comment [MJ15]: Results with no discussion – thus relocate to results section

Comment [MJ16]: What does the literature say about this?

Comment [MJ17]: What does the literature say about this?

5. CONCLUSION

The regeneration status of *Croton scabiosus* in various forests of Kadapa district is very low. The establishment, survival and growth of seedling is governed by several biotic and abiotic factors. Recurring forest fires and nutrient poor rocky habitat are the main abiotic factors which cause poor regeneration. Flower and fruit predation by beetles and fungal infestation of fruit and seeds, poor germination and anthropogenic disturbances are the important biotic factors for the recruitment and population expansion. Hence proper conservation measures have to be formulated to protect the species, taking into account its medicinal and economic values. Awareness programmes regarding the importance of forests, controlling forest fires and motivating the village people towards sustainable harvesting of forest products may help minimize the pressure on this species.

Acknowledgements

The authors are grateful to University Grant Commission, New Delhi, India for the financial support to the project and Forest Department, Andhra Pradesh for giving permission to work in the forests of Kadapa District.

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Comment [MJ18]: This will obviously change as the results and discussion sections are modified to reveal new insights.

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