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Floristic Composition, Diversity and Status of Threatened Medicinal Plants in Tropical Forests of Malyagiri Hill Ranges, Eastern Ghats, India

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1. Introduction

Tropical and subtropical forests harbour maximum diversity of plant species found on the earth (WCMC, 1992). These forests are rich in medicinal and economically important plants. Exploitation of these forests has resulted in rapid loss of tropical forests and it is recognized as one of the serious environmental and economic problems all over the world (Hare et al., 1997). A study on floristic composition and species diversity of threatened medicinal plants of tropical forests is ecologically significant besides its usefulness in forest management.

Malyagiri hill ranges belonging to Eastern Ghats of India lies between 21^0 23′ 30″ N latitude and $85^0$16′ 58″ E longitude, located in the Pallahara Sub-division of Angul District in Odisha. The whole area is endowed with rising and falling hills interspersed with small plains and winding strips of valleys. There are as many as 4 perennial water-falls with dense forests in the northern part known as “Nagira”. These provide a congenial niche for the luxuriant growth of marshy plants of various types. “Mankra” a tributary of Brahmani flows in the west of Pallahara which keeps the sub-division aside from National Highway 6. The Lord Siva temple at hill base of Khuluri reserve forest with a perennial water-fall increases the beauty of nature and is a popular tourist place..

The soils of Malyagiri are mainly red and form clays and clay-loams in the valleys (Patra & Choudhury, 1989). The hill ranges experience an extreme climate comprising of 3 distinct seasons; summer, rainy and winter. It enjoys an average annual rainfall of 1421 mm. The highest temperature of 43.9^o C is recorded in May and it drops to $14.6\ ^0$c in December.

Malyagiri hill range harbours floristically important tropical deciduous forest of Eastern Ghats, India. The wide range of topographic and climatic conditions favour luxurious growth of vegetation in this hill range (Patra & Choudhury, 1989). Many of the plants have immense medicinal properties. Due to over-exploitation of medicinal plants, fuel wood collection, habitat destruction and grazing, plant diversity of Malyagiri hill range is declining at an alarming rate (Sahu et al., 2010). This may lead to extinction of many valuable species. However, barring a few floristic and ethnobotanical works (Brahmam &

Saxena, 1990; Patra & Choudhury, 1989; Saxena & Dutta, 1975; Saxena et al., 1991), no quantitative study analyzing the vegetation structure of the forest has been undertaken. Therefore, a detailed study was undertaken to analyze the diversity, distribution and population structure of tree species in these forests.

2. Materials and methods

2.1 Field sampling and data analysis

Vegetation analysis was carried out during March 2007 to December 2009 by laying 60 quadrants for each element of vegetation. For all trees ≥15 cm girth at breast height (GBH) were sampled through 20 x 20 m quadrants with sampling intensity of 0.001% based on random sampling methods in tropical dry deciduous forest stand of 2.4 ha area. Individuals with less than 15cm GBH were considered as saplings. The shrubs were sampled through 5 x 5 m and herbs, climbers and saplings were sampled by laying 1 x 1 m quadrants. Herbarium specimens were prepared and the species were identified with the help of regional flora (Gamble & Fischer, 1915-1935; Saxena & Brahmam, 1996). The specimens were deposited in the herbarium (RRL-B) at Institute of Minerals and Materials Technology, Bhubaneswar. The vegetation data were analyzed for 57 tree species. Abundance (A), Frequency (F), Relative frequency (RF), Density (D), Relative density (RD), Basal Area (BA), Relative Basal Area (RBA), Importance Value Index (IVI), Shannon -Wiener index (Shannon and Weaver, 1963) and Simpson's index (Simpson, 1949) were calculated using the quadrant data and following the methods of Misra (1968). IVI of each species was calculated by summing the RF, RD and RBA following the methods of Curtis (1959). Abundance to Frequency (A/F) ratio of each species was calculated to study the dispersion pattern. The range of values for determining dispersion pattern were: regular (< 0.025), random (0.025-0.05) and contiguous (> 0.05) (Curtis and Cottam, 1956). Population structure of tree species was analyzed across the five girth classes. The status and degree of threat to medicinal plants in their natural habitat has been indicated by classifying them according to Red Data Book categories, as defined by the IUCN (Maheswari, 1977; Melville, 1970-71).

Shannon and Weiner's Index (1963) was calculated as follows:

$$H' = - \Sigma p_i \log p_i$$

Where, $p_i = n_i / N$

n_i = Importance value for species "i"

N = Total of importance value

Concentration of dominance was calculated following Simpson (1949):

$$Cd = \Sigma p_i^2$$

Where p_i is same as the Shannon– Wiener Index.

3. Results and discussion

The dominant forest type of Malyagiri hill range is tropical dry deciduous forest (Champion and Seth, 1968). A total of 1063 trees belonging to 57 species were recorded from 60 sample

plots. The dominant tree species in descending order of IVI are *Shorea robusta* Gaertn.f. (44.67), *Terminalia alata* Heyne ex Roth. (31.98), *Madhuca indica* Gmel. (17.3), *Anogeissus latifolia* (Roxb. Ex DC.) Wall.ex Guill. & Perr. (15.64), *Diospyros melanoxylon* Roxb. (13.41) (Table-1).

Name of the species	**F (%)**	**D (ind. ha^{-1})**	**BA (m^2. ha^{-1})**	**IVI**	**Distribution**
Aegle marmelos (L.) Corr.	16.7	8.8	0.12	5.17	C
Albizia lebbeck (L.) Benth.	3.3	0.8	0.04	0.93	C
Alstonia scholaris (L.) R.Br.	3.3	0.8	0.01	0.73	C
Anogeissus latifolia (Roxb. ex DC.) Wall.ex Guill. & Perr.	50.0	12.5	0.01	15.64	Ra
Bauhinia purpurea L.	1.7	0.8	0.01	0.45	C
Bombax ceiba L.	3.3	1.3	0.01	0.72	C
Bridelia retusa (L.) Spreng.	1.7	0.3	0.01	0.26	C
Buchanania lanzan Spreng.	38.3	24.5	0.34	8.15	C
Careya arborea Roxb.	5.0	2.5	0.03	1.47	C
Casearia graveolens Dalz.	18.3	10.8	0.11	5.74	C
Cassia fistula L.	11.7	3.3	0.04	2.63	C
Chloroxylon swietiana DC.	15.0	6.5	0.07	4.01	C
Cleistanthus collinus (Roxb.) Benth.ex.Hook.f.	26.7	15.8	0.12	8.13	C
Dalbergia paniculata Roxb.	1.7	0.3	0.02	0.46	C
Dalbergia sisoo Roxb.	1.7	0.3	0.01	0.35	C
Diospyros malabarica (Desr.) Kostel.	20.0	14.0	0.49	6.24	C
Diospyros melanoxylon Roxb.	36.7	19.0	0.56	13.41	Ra
Diospyros montana Roxb.	8.3	4.5	0.16	3.36	C
Erythrina variegata L.	1.7	0.3	0.69	5.32	C
Ficus benghalensis L.	1.7	0.3	0.01	0.26	C
Ficus semicordata Buch.-Ham.ex J.E.Sm.	3.3	0.8	0.02	0.74	C
Ficus mollis. Vahl	16.7	7.0	0.11	4.61	C
Gardenia latifolia Ait.	8.3	5.8	0.13	3.38	C
Glochidion velutinum Wight	3.3	1.3	0.04	1.02	C
Gmelina arborea Roxb.	28.3	14.5	0.21	8.67	C
Haldinia cordifolia (Roxb.) Ridsd.	1.66	0.8	0.05	0.8	C
Ixora pavetta Andr.	10	5.0	0.03	2.67	C
Lagerstroemia parviflora Roxb.	13.3	7.0	0.30	5.58	C
Lannea coromandelica (Houtt.) Merr.	1.7	0.8	0.01	0.39	C
Macaranga peltata (Roxb.) Muell.-Arg.	31.7	17.8	1.23	17.3	C
Madhuca indica Gmel.	3.3	1.3	0.01	17.3	C
Mangifera indica L.	15.0	9.5	1.00	11.54	C

Name of the species	F (%)	D (ind. ha^{-1})	BA (m^2. ha^{-1})	IVI	Distribution
Melastoma malabathricum L.	35.0	18.3	0.26	10.75	Ra
Mitragyna parvifolia (Roxb.) Korth.	13.3	6.3	0.10	3.94	C
Morinda pubescens Sm.	1.7	0.3	0.01	0.27	C
Murraya paniculata (L.) Jack	13.3	6.5	0.06	3.71	C
Nyctanthes arbor-tristis L.	10.0	3.3	0.04	2.39	C
Phyllanthus emblica L.	5.0	2.5	0.04	1.6	C
Polyalthia cerasoides (Roxb.) Bedd.	8.3	4.5	0.04	2.42	C
Protium serratum (Wall. ex Colebr.) Engl.	1.7	0.3	0.03	0.46	C
Pterocarpus marsupium Roxb.	15.0	7.0	0.09	4.25	C
Pterospermum acerifolium (L.) Willd.	13.3	5.3	0.09	3.63	C
Pterospermum xylocarpum (Gaertn.) Sant & Wagh	6.7	3.8	0.04	2	C
Randia malabarica Lam.	1.7	0.3	0.01	0.26	C
Schleichera oleosa (Lour.) Oken	10.0	10.8	0.32	6.17	C
Semecarpus anacardium L.f.	3.3	1.3	0.02	0.86	C
Shorea robusta Gaertn.f.	73.3	59.5	2.88	44.67	Ra
Strychnos potatorum L.f.	11.7	6.5	0.23	4.74	C
Symplocos racemosa Roxb.	11.7	8.3	0.05	3.84	C
Syzygium cumini (L.) Skeels	13.3	6.3	0.21	4.74	C
Terminalia alata Heyne ex Roth.	65.0	49.5	1.62	31.98	Ra
Terminalia arjuna (Roxb.ex DC.) Wight & Arn.	3.3	2.0	0.31	3.13	C
Terminalia bellirica (Gaertn.) Roxb.	5.0	1.5	0.07	1.5	C
Terminalia chebula Retz.	3.3	1.3	0.02	0.87	C
Wendlandia tinctoria (Roxb.) DC.	23.3	12.0	0.16	7.05	C
Xylia xylocarpa (Roxb.) Taub.	10.0	5.8	0.11	3.37	C
Ziziphus xylocarpus (Retz.) Willd.	5.0	32.5	0.01	1	C

Note: F- Frequency; D- Density; BA-Basal Area; IVI-Importance Value Index; Ra: Random; C: Contiguous

Table 1. Phytosociological characteristics of Tree species in Malyagiri hill range, Eastern Ghats

The luxuriant growth of herbs, shrubs and climbers increased the density of the forest vegetation. Among the herbs, *Chromolaena odorata* (L.) R.King & H.Robins., *Andrographis paniculata* (Burm.f.) Wall.ex Nees, *Elephantopus scaber* L., *Curculigo orchioides* Gaertn. were

most common species. Important shrub species were *Combretum roxburghii* Spreng., *Holarrhena pubescence* (Buch.-Ham.) Wall.ex G.Don, *Woodfordia fruticosa* (L.) Kurtz, *Lantana camara* L., *Helicteres isora* L. and *Ixora pavetta* Andr. The dominant climbers were *Dioscorea bulbifera* L., *Smilax macrophylla* Roxb., *Ampelocissus latifolia* (Roxb.) Planch. and *Bauhinia vahlii* Wight & Arn.

However, Malyagiri hill range is severely affected by anthropogenic activities. Unsustainable collection of medicinal plants (*Oroxylum indicum* (L.) Vent. and *Cycas cicinalis* L.) for selling purposes by the local people of Pallahara Sub-division (Sahu et al., 2010) is prominent. Most of the local people depend upon the forests for their livelihood for which collection of leaf from *Bauhinia vahlii* Wight & Arn. (Leaf tray), *Phoenix sylvestris* (L.) Roxb. (for brooms, mats etc.), *Diospyros melanoxylon* Roxb. *(*Bidi) and firewood collection are very common. These are the indications to the anthropogenic activities going on in and around Malyagiri hill ranges.

Out of 57 tree species, five species were randomly distributed and 52 species were contiguously distributed. The study reveals prevalent clumping nature of tree species in the tropical forest of Malyagiri hill ranges. Odum (1971) stated that contiguous distribution is the commonest pattern of plant distribution in nature. Kumar and Bhatt (2006) also reported that most species follow contiguous distribution pattern in foot-hills forests of Garhwal Himalaya and Rao et al. (1990) had similar findings for tree species of a subtropical forest of north-east India. The Shannon-Wiener index (H') was 3.38 and Simpson's index was 1.0. These values indicate that tropical deciduous forests are species diverse systems. The diversity value (H') of 3.38 falls within the range of 0.83-4.1 reported by earlier workers for Sal forest (Rasingam & Parathasarathy, 2009; Shukla, 2009; Singh et al., 1985; Tripathi & Singh, 2009; Visalakshi, 1995).

The mean tree density of the forest was 443 ha^{-1}. The mean stand density of the forest is well within the range of 276-905 stems ha^{-1} reported for trees ≥15 cm GBH in other tropical forests (Bhadra et al., 2010; Nirmal Kumar et al., 2010; Sahu et al., 2007). The value obtained for basal area in the present study is comparable to the Indian tropical forests (Visalakshi, 1995).

Stem density and species richness consistently decreased with increasing girth class of tree species beyond 30-50 cm GBH class (Fig. 1). The highest GBH was in *Ficus benghalensis* (458 cm) followed by *Mangifera indica* (378 cm), *Shorea robusta* (230 cm), *Madhuca indica* (215 cm) and *Schleichera oleosa* (210 cm). Girth class frequency showed reverse J-shaped population structure of trees, which is in conformity with other forest stands in Eastern Ghats such as Shervarayan hills (Kaduvul and Parthasarathy, 1999a) and Kalrayan hills (Kaduvul and Parthasarathy, 1999b).

The mean tree height was 10 m with a height range of 1 to 35 m. Tree distribution by height class intervals shows that 39.1% of individuals were in the height class of 5-10 m, followed by 24.3% in the height class of 10-15 m and 20.4% in the height class of 0-5m (Fig. 2). Only 5.73% of individuals were in the height class of >20 m. The tallest trees were *Shorea robusta* (35 m), *Mangifera indica* (33 m), *Terminalia bellirica* (32 m), *Syzygium cumini* (32 m), *Diospyros malabarica* (27).

The data on species/genus (S/G) ratio helps to compare the rate of species development because high ratio indicates recent diversification. Tropical areas have low species/genus ratio, indicating that the tropical species have emerged over a long period of time (Ricklefs

and Miller, 2000). In the present study, all the study sites show lower S/G ratio in the tree layer (1.18), thus showing conformity with the findings of Ricklefs and Miller (2000).

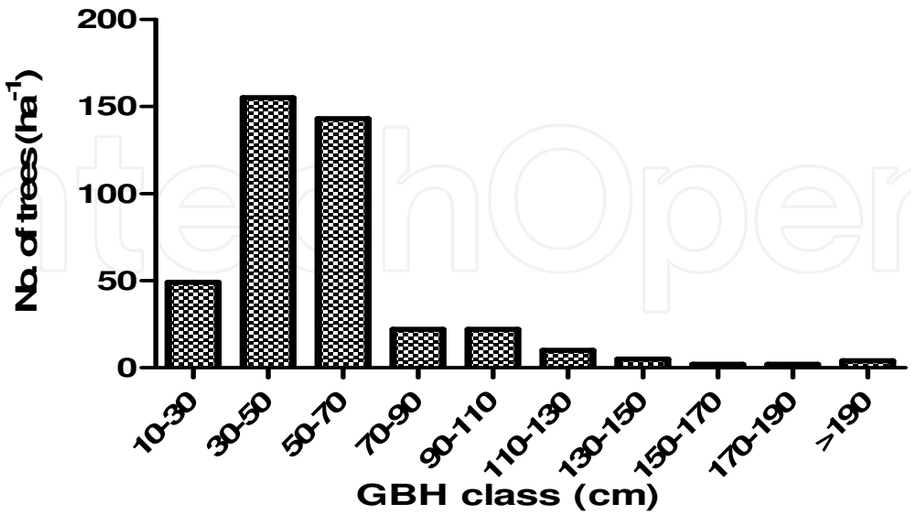

Fig. 1. Distribution of trees in different Girth classes in Malyagiri hill ranges, Eastern Ghats

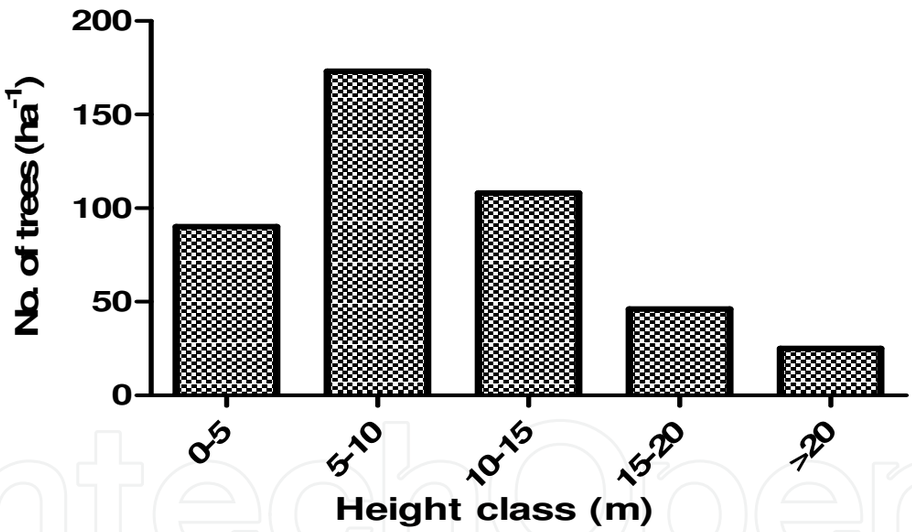

Fig. 2. Distribution of trees in different Height classes in Malyagiri hill ranges, Eastern Ghats

The invasive, exotic species were also found, which can be a serious threat to the forest ecosystem in the future. Important among them are *Ageratum conyzoides* L., *Chromolaena odorata* (L.) R. King & H. Robins., *Crotalaria pallida* Ait., *Hyptis suaveolens* (L.) Poit., *Lantana camara* L., *Mimosa pudica* L., *Parthenium hysterophorus* L. and *Triumfetta rhomboidea* Jacq.

Girth class frequency showed J-shaped population structure of trees exhibited in the study sites are in conformity with many other forest stands in Eastern and Western Ghats such as Shervarayan hills (Kadavul and Parathasarthy, 1999a); Kalrayan hills (Kadavul and Parthasarathy, 1999b); Kakachi (Ganesh et al., 1996); Andaman Islands (Rasingam & Parathasarathy, 2009).

4. Documentation of threatened medicinal plants

Rapid destruction of forests causes severe damage to natural forest of the hill range, thus threatening the very survival of several indigenous medicinal plants. Recent news paper has highlighted the rate of medicinal plants (*Oroxylum indicum* (L.) Vent. and *Cycas cicinalis* L.) collection for selling purposes by the local people of Pallahara Sub-division in Malyagiri hill range (Sahu et al., 2010). Unsustainable collection of medicinal plants has placed them in threatened and vulnerable categories in Conservation Assessment and Management Plan (Ved et al., 2007) of Odisha. Table 2 highlights the 2 critically endangered, 6 endangered and 10 vulnerable species along with their botanical name, voucher specimen number, family, locality, local name, life form, distribution and IUCN status. So it is critical to conserve these medicinal plants locally if not globally. This may be planned through in-situ or ex-situ conservation methods, for preserving the biodiversity of the state of Odisha. In-situ conservation method should be implemented to conserve the medicinal plant resources in their natural habitat (National Park/Wildlife Sanctuary/Biosphere Reserve). Therefore, it is suggested that Malyagiri hills should be declared as a Wildlife Sanstuary in earlier possible. Threatened medicinal plants which will be extinct in near future should be conserved through ex-situ conservation (Botanical gardens, Arboreta or Seed banks).

Sl. No.	Botanical name, Voucher specimen No.	Family, Locality	Local Name	Life form	Distribution	IUCN Status
1	*Caesalpinia digyna* Rottl., 8502	Caesalpiniaceae, Allora	Gilo	Shrub	Peninsular India	Vulnerable
2	*Celastrus paniculata* Willd., 9996	Celastraceae, Kerjeng	Pengu	Climbing Shrub	Myanmar, Thailand	Vulnerable
3	*Garcinia xanthochymus* Hook.f., 8572	Clusiaceae, Panichua	Satyamba	Tree	Eastern Himalayas, Odisha, Myanmar, Thailand	Vulnerable
4	*Gardenia gummifera* L.f., 9759	Rubiaceae, Kerjeng	Gurudu	Shrub	Peninsular India	Vulnerable
5	*Gloriosa superba* L., 11624	Liliaceae, Pallahara	Nanangalia	Climbing herb	Tropical India, S. Africa, Malesia	Vulnerable
6	*Litsea glutinosa* (Lour.) Robins., 8636	Lauraceae, Khuludi	Ledhachhali	Tree	India, Sri Lanka, Malesia	Endangered
7	*Mesua ferrea* L., 12027	Clusiaceae, Khuludi	Nageswar	Tree	Eastern Himalayas, Andaman & Nicobar, Tropical Asia	Endangered
8	*Oroxylum indicum* (L.) Vent., 11811	Bignoniaceae, Khamar	Phanphania	Tree	India, Sri Lanka, Indonesia	Endangered

Sl. No.	Botanical name, Voucher specimen No.	Family, Locality	Local Name	Life form	Distribution	IUCN Status
9	*Paederia foetida* L., 8641	Rubiaceae, Pallahara	Gandhali	Climbing Shrub	North-East India,Andaman & Nicobar, Thailand	Vulnerable
10	*Piper longum* L., 8438	Piperaceae, Pallahara	Pipali	Herb	India, Sri Lanka, Malay	Endangered
11	*Polyalthia cerasoides* (Roxb.) Bedd, 8224	Annonaceae, Allora	Ojhar	Tree	Assam, Odisha,Silhet, Pegu	Vulnerable
12	*Pterocarpus marsupium* Roxb., 10129	Fabaceae, Kerjeng	Bija	Tree	Andhra Pradesh, Bihar, Kerala, Karnataka, Sri Lanka	Endangered
13	*Pueraria tuberosa* (Willd.) DC., 9659	Fabaceae, Khuludi	Bhuin kakharu	Climber	India	Vulnerable
14	*Rauvolfia serpentina* (L.) Benth. Ex Kurtz, 8245	Apocynaceae, Pallahara	Patalagarud	Undershrub	Tropical Himalaya, Deccan Peninsula,Malaya, Sri Lanka	Critically Endangered
15	*Scindapsus officinalis* (Roxb.) Schott, 10139	Araceae, Allora	Kelikadali	Climer	Tropical Himalaya,Sikkim, Andaman,Myanmar	Vulnerable
16	*Strychnos potatorum* L.f., 8820	Strychnaceae, Kerjeng	Nirmali	Tree	West Bengal, Bihar, Sri Lanka, Myanmar	Vulnerable
17	*Symplocos racemosa* Roxb., 12025	Symplocaceae, Khuludi	Lodha	Tree	NE India, Tamil Nadu, Karnataka, Thailand	Endangered
18	*Uraria picta* (Jacq.) Desv.ex DC., 10925	Fabaceae, Khuludi	Ishwarjata	Undershrub	Himalaya, Sri Lanka, SE Asia	Critically Endangered

Table 2. List of Threatened Medicinal plants in Malyagiri hills, Odisha

5. Conclusion

Reverse J-shaped population structure of trees denotes an evolving or expanding population, which needs to be maintained. The unsustainable collection of medicinal plants such as the bark of *Oroxylum indicum* (L.) Vent. and whole plant of *Gloriosa superba* L. and *Uraria picta* (Jacq.) Desv.ex DC., need to be checked to maintain the favourable population structure. Study on floristic composition and diversity will be useful to the conservation researchers and scientists and also to the forest managers for effective management of the forest ecosystem. The present investigation highlights the presence of threatened medicinal

plants which need immediate attention for conservation and propagation through in-situ, ex-situ or latest biotechnological approaches (Gene banks, DNA and Pollen storage etc.)

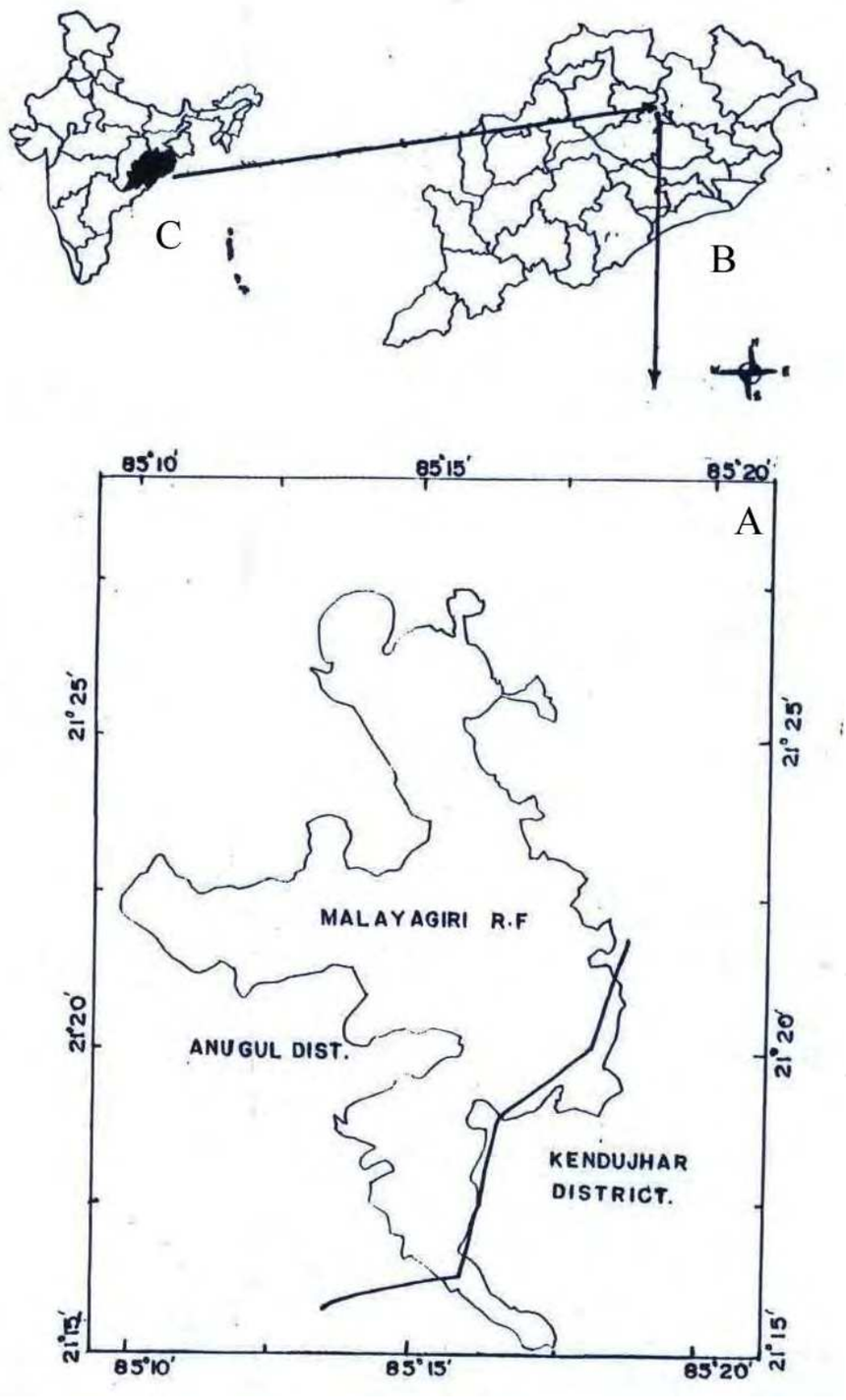

Fig. 3. Study area

Some Threatened Medicinal Plants of Malyagiri hill ranges, Odisha, India

Oroxylum indicum (L.) Vent.

Polyalthia cerasoides (Roxb.) Bedd

Cymbidium aloifolium (L.) Sw.

Uraria picta (Jacq.) Desv.ex DC.

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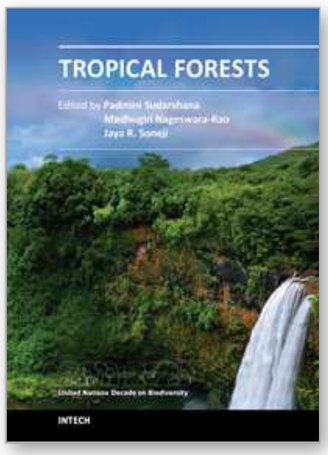

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The astounding richness and biodiversity of tropical forests is rapidly dwindling. This has severely altered the vital biogeochemical cycles of carbon, phosphorus, nitrogen etc. and has led to the change in global climate and pristine natural ecosystems. In this elegant book, we have defined "Tropical Forests" broadly, into five different themes: (1) tropical forest structure, synergy, synthesis, (2) tropical forest fragmentation, (3) impact of anthropogenic pressure, (4) Geographic Information System and remote sensing, and (5) tropical forest protection and process. The cutting-edge synthesis, detailed current reviews, several original data-rich case studies, recent experiments/experiences from leading scientists across the world are presented as unique chapters. Though, the chapters differ noticeably in the geographic focus, diverse ecosystems, time and approach, they share these five important themes and help in understanding, educating, and creating awareness on the role of "Tropical Forests" for the very survival of mankind, climate change, and the diversity of biota across the globe. This book will be of great use to the students, scientists, ecologists, population and conservation biologists, and forest managers across the globe.

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