

Population Structure, Age Gradations, and Regeneration Status of *Pterocarpus dalbergioides* Roxb., An Endemic Species of Andaman Islands, India.

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ABSTRACT

The increasing forest fragmentation rate stresses the necessity of conservation of species by restoring their habitat sites. Particularly, endemic species deserve much attention as they show a narrow range of distribution. The present study is focused on the population structure, age gradations, and regeneration status of *Pterocarpus dalbergioides* Roxb., an endemic species of the Andaman Islands. The results of this analysis showed *Pterocarpus dalbergioides* as a dominant species occurring in both Andaman semi evergreen and Andaman moist deciduous forests, contributing high stem density and basal area compared to other species. The study also provided information on regeneration status, indicating poor seedling and saplings growth of the species. Age structure study showed that it will take approximately 10 years for *Pterocarpus dalbergioides* to attain a girth of 30 cms and the species at the study site are about 150 years old. Finally, it is concluded that the species is affected by both logging operations as well as poor regeneration growth which may result in the extinction of this endemic species of Andaman Islands.

(Keywords: spatial distribution, padauk, species diversity, age gradations, conservation, extinction)

INTRODUCTION

Species in habitat generally interact with each other as well as with the environment in which

they survive and this is primary for the determination of species spatial pattern distribution. Spatial distribution of species in nature mainly depends on the potential resource availability, their utilization, seed dispersal capacity, seed viability, competition with other species, etc. If all of these conditions go well for a species, the species can establish itself within the locality and show a wide range of distribution. In addition to above, a balanced proportion of species regeneration, as well as cutting ratio, should also be maintained to prevent the species from becoming extinct, and this is very crucial in case of endemic species which show a very narrow restricted distribution.

Population studies pertaining to specific species are always beneficial in identifying the species spatial distribution and its regeneration status. In the present scenario, like other major tropical rain forests of the world, the Andaman Forests are also subjected to deforestation leading to the fragmentation of the forest system and resulting in the extinction of valuable species from their native habitats. This problem is a significant issue for endemic plants, because these species show special preferential adaptive habitats and confine themselves to particular niches. If these habitats are destroyed, the population of the species decreases, leading to extinction. This is the case with the species *Pterocarpus dalbergioides* Roxb. (Fabaceae), the Andaman Padauk, an endemic species whose population is effected by logging operations on one hand, and poor regeneration status, on another hand. FAO has prioritized the pattern of distribution, economic importance of

this species and reported the threat of extinction due its very poor seed germination, finally declaring it as “Reserved Tree”.

Species based population studies were not recorded so far in Andaman Islands and a majority of previous work was focused on exploring the vegetation for specimen collections rather than ecological surveys, particularly in the north Andaman Islands. Recently, biodiversity studies in the north Andaman islands were carried out to define the vegetation types, fragmentation status, and biological richness of the area using remote sensing and GIS (Prasad, 2006; Prasad *et al.*, 2007a, 2007b; Prasad, 2008; Reddy & Prasad, 2008; Porwal *et al.*, 2003). The present study is unique and carried out for the first time in the north Andaman Islands. The objective of the study is to analyse:

- 1) Species richness and diversity of Padauk bearing forest.
- 2) Population structure, spatial distribution pattern, age gradations, and regeneration status of the species *Pterocarpus dalbergioides* Roxb (Padauk).

Ecology, Morphology and Uses - Pterocarpus dalbergioides ‘the pride of Andaman Islands’, is one of the top value durable timber trees of India. It is a common endemic taxon showing a narrow range of distribution, occurring only in Andaman Islands, and does not occur in Nicobar Islands. The trees are scattered throughout the moist deciduous and semi-evergreen forests and grow on the well-drained lower slopes of the hills and on undulating terrain of plains. The trees are characterized by alternate compound leaves with alternate leaflets, yellow coloured flowers in racemes (panicled), and one or two seeded indehiscent flat orbicular pods, with seeds surrounded by wide circular wing. They are large, heavily buttressed, growing up to 450 cms in circumference at 1.3 m and 18 m height to the first branch. Wood is often brilliant red in colour, hence the name vermillion is given to this species. Padauk, often referred as East Indian mahogany or Indian redwood, is bestowed with high economic importance value and is used in high-class joinery, furniture, cabinetry, fancy turnery, carving and sculpting, inlay, flooring, knife handles, veneer and tool handles, boat building, paddles, oars, agricultural implements, billiard tables, decorative woods, and in dye making.

MATERIALS AND METHODS

Phytosociological data collection was carried out in the North Andaman part of Andaman Islands. North Andaman forms the largest island of Andaman Islands and is located between 12^o 95” N and 92^o 86” E covering an area of 1458 sq. km. The vegetation belongs to the island ecosystem and continuous showers brought from the monsoons, helps in maintaining luxuriant, species, rich green vegetation in these islands.

Though climatically, not much variation is perceptible in these islands, the vegetation types such as evergreen, southern hill top evergreen, semi evergreen, moist deciduous, littoral, and mangroves are mainly the outcome of the climate of edaphic factors and of the availability of fresh water. *Dipterocarpus* and *Myristica sps* are typical emergents of the evergreen community and *Pterocarpus dalbergioides* (Padauk), the present study species, dominates both semi evergreen and moist deciduous forests to such an extent that often these forest types are referred as Padauk forest.

About 106 field plots of 0.1 ha size were randomly surveyed covering both the Padauk bearing forest *viz.* Andaman semi evergreen (2A/C1) and Andaman moist deciduous (3A/C1) forest types (Champion and Seth, 1968). Phytosociological data collection includes measurement of tree girth >30 cms, total tree height (m), and recording information about seedling and sapling strata within each 0.1 ha sample plot. Species were identified using flora and herbaria available at Botanical Survey of India, Port Blair as well as with help of forest officials and local taxonomist. Data was analyzed for species richness, species diversity, Important Value Index, spatial distribution of species using Standardized Morisitas Index, and girth class distribution to reveal the information about the population structure and regeneration status. To estimate the population structure diameter classes were delineated at 30 cm intervals.

RESULTS AND DISCUSSION

Species richness and diversity - Analysis results showed, species richness to be 199 and species diversity of 6.0 indicative of potential species rich conditions of island ecosystem. Out of 199 species *Pterocarpus dalbergioides*, is represented by 34 stems / ha with a basal area of

12.15 sq. m /ha (i.e., 5.4% of stem density and 27.24 % of basal area per hectare is contributed by the species). This captures the dominance scenario of *Pterocarpus dalbergioides*, which occupies a major portion of basal area and stem density compared to remaining 198 species, showing its high competitive strength for resource competition with other species (Table 1).

Species Association - The Important Value Index, which is the sum of the relative density, relative basal area, and relative frequency of species, indicated *Pterocarpus dalbergioides* as the dominant species in the entire study. The important co-dominant and associated species include *Diospyros oocarpa*, *Celtis wightii*, *Aglaia oligophylla*, *Dipterocarpus gracilis*, *Pterocymbium tinctorium*, etc. (Table 1).

In general the species composition of Padauk often changes and to certain extent depends on the nature of soil. In the regions where patches of sandy soil occur, it shows association with evergreen species like *Dipterocarpus gracilis*, *Canarium euphyllum*, *Artocarpus chaplasha*, and in the regions where the proportion of clay is high, it forms an association with deciduous species like *Diospyros oocarpa*, *Celtis wightii*, *Terminalia bilalata*, etc. (Devraj, 2001).

Species Spatial Distribution- The dispersion value obtained from Standardized Morisita's Index

showed a clumped distribution pattern for Padauk. Generally adult distributions of many tropical forest trees are clumped (Hubbell, 1980) resulting in localized aggregation of the species. Basically the available resource limitation and inter & intra species competition determines the distribution pattern of the species (Kadavul and Parthasarathy, 2001), which may result in random, clumped, or regular distribution. The clumped nature often restricts the wide distribution of species at the same time affecting the regeneration status.

Girth Class Wise Tree Distribution - The girth class wise stem density showed an on going reproduction status with increase in number of stems up to girth class 180 cm and thereafter intermittent decrease in higher girth classes. The discontinuity observed in girth class wise stem density could be attributed to the site characteristic variations, canopy conditions and anthropogenic disturbances. Basal area and mean height almost showed an increasing trend from lower to higher girth classes indicative of successional climax stages. About 38.7% of stem density is contributed by girth classes between 120-209 cm and 52.7% of basal area by girth classes > 240 cm. This gives the idea of maximum stem counts by lower girth classes and high basal area by higher girth classes, which is a general phenomenon of tropical forest. (Figure 1; Table 2).

Table1: Species Richness and Diversity Analysis Results of Padauk Forest.

Species diveristy parameters		Important Value Index of dominant species	
Overall		Dominant Species	IVI
Species richness	199	<i>Pterocarpus dalbergioides</i>	36.94
Species diversity	6.0	<i>Diospyros oocarpa</i>	16.17
Stem/ha	631	<i>Celtis wightii</i>	8.63
Basal area/ha	44.6	<i>Aglaia oligophylla</i>	8.21
<i>Pterocarpus dalbergioides</i>		<i>Dipterocarpus gracilis</i>	7.95
Stem/ha	34	<i>Pterocymbium tinctorium</i>	7.28
Basal area/ha	12.15	<i>Tetrameles nudiflora</i>	7.22
Morisita's Index	0.5	<i>Diospyros pilosula</i>	7.18

Table 2: Tree Girth class wise stem density, Basal area and Mean height of *Pterocarpus dalbergioides*.

Girth classes	No. of Stems	Basal area (sq.mts)	Mean Height	Stem density (%)	Basal Area (%)
30-59	34	0.6	7.7	9.5	0.4
60-89	24	1.1	10.6	6.7	0.9
90-119	32	2.9	12.7	9.0	2.2
120-149	41	6.0	12.2	11.5	4.7
150-179	51	10.8	12.9	14.3	8.4
180-209	46	13.8	14.7	12.9	10.7
210-239	25	10.0	14.1	7.0	7.8
240-269	35	17.6	15.0	9.8	13.6
270-299	14	9.3	15.7	3.9	7.2
300-329	25	19.1	16.8	7.0	14.8
330-359	7	6.8	16.9	2.0	5.3
>360	23	30.9	14.6	6.4	24.0

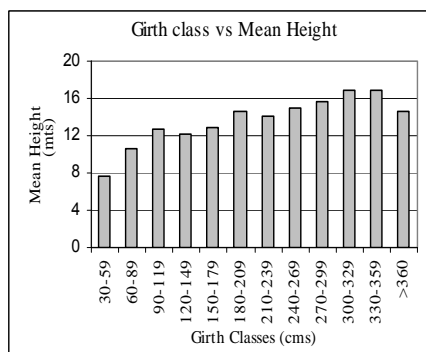
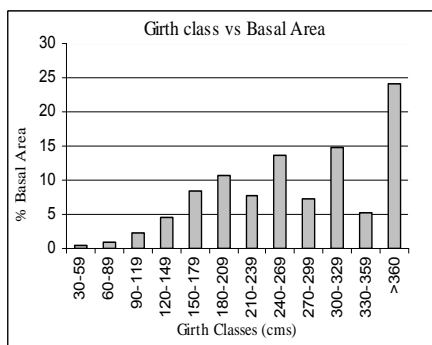
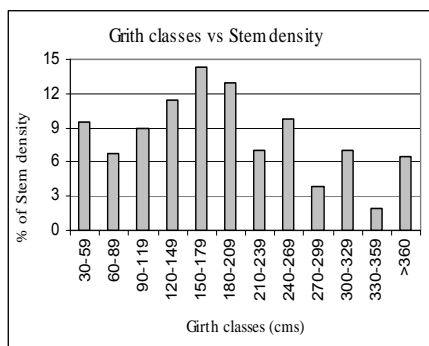


Figure 1: Relationship Between the Stem density, Basal Area, and Mean Height in various tree girth classes of *Pterocarpus dalbergioides*.

Age Estimation - Since there is not much variation in site characters between south and north Andaman, the species growth phenomenon may remain common in both the area. The working plan report of Andaman Forest Division (1916) provided information on the *Pterocarpus dalbergioides* growth rates observed in plantations of south Andaman (Table 3). Using this information various regression models were developed and finally the best-fitted model was selected to estimate the age of Padauk species encountered during the sampling study (Table 4). The result of fitting several curvilinear models to the data explains the linear model to be highly correlated (99.92%) and describes the relationship between Girth and Age as:

$$\text{Age} = -0.992235 + 0.369427 \times \text{Girth}$$

As the p-value obtained is less than 0.1, and correlation of coefficient is equal to 0.9996, there exists a statistically significant relationship between age and girth variables at 99% confidence levels (Figure 2). The estimated age results showed that it will take approximately 10 years or more for Padauk species to attain a girth of 30 cm and the species in the sampled study area are approximately 150 years old. Approximately 14.3% of stem density are in the age group of 54-65 and 2% of stem density are of 121-132 age group. About 38.7% of stem densities are within age group of 43-77 years old (Table 5).

Regeneration Status- Generally, the measurement of spatial distribution of a species is scale-dependant and depends on the total net observations done for the purpose.

Table 3: *Pterocarpus dalbergioides* Rate Growth in Plantations Observed at South Andaman during 1916 (Devraj, 2001).

Age in years	Mean girth			Mean height	
	Feet	Inches	Cms	Feet	Cms
2	0	3	7.5	6	1.8
4	0	5	12.5	13	3.9
6	0	7.5	18	20	6
8	0	10	25	27	8.1
10	1	0	30	34	10.2
15	1	5.5	43.7	46	13.8
20	1	11	57.5	55	16.5
25	2	4	70	63	18.9
30	2	9	82.5	70	21

Table 4: Application of Various Regression Models to Derive Age and Girth Relationship in *Pterocarpus dalbergioides*.

Model	Correlation	R-Squared
Linear	0.9996	99.92%
Multiplicative	0.9983	99.66%
Double reciprocal	0.9919	98.38%
Square root-Y	0.9892	97.85%
Square root-X	0.9872	97.45%
S-curve	-0.9598	92.12%
Logarithmic-X	0.9499	90.24%
Exponential	0.9427	88.87%
Reciprocal-X	-0.8069	65.10%

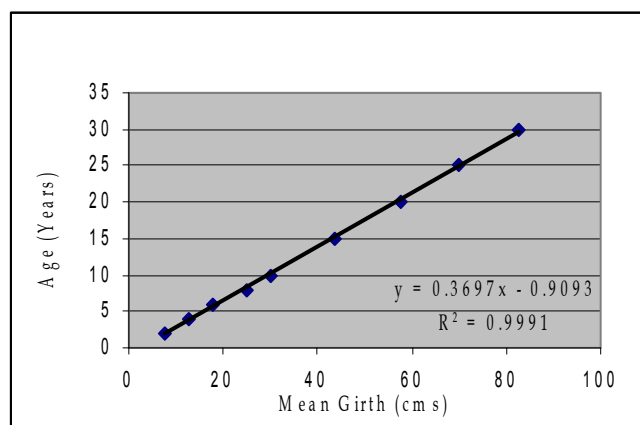


Figure 2: Linear Regression between Age and Girth classes of *Pterocarpus dalbergioides*.

Table 5: Estimated Age of *Pterocarpus dalbergioides* in each Girth Class.

Girth (cms)	Estimated Age (years)	% of Stems
30-59	10-21	9.5
60-89	21-32	6.7
90-119	32-43	9.0
120-149	43-54	11.5
150-179	54-65	14.3
180-209	66-77	12.9
210-239	77-87	7.0
240-269	88-98	9.8
270-299	99-109	3.9
300-329	110-121	7.0
330-359	121-132	2.0
>360	132-143	6.4

During the entire sampling study of 106 sample plots of 0.1 ha size, no single sapling or seedling data was recorded for Padauk, indicating a very poor regeneration status. Based on the Janzen (1970) and Connell (1971) models it can be explained that the species aggregation is restricted by host specific predators and pathogens that cause mortality of seeds and seedling near the parent trees (Igor Debski *et al.*, 2000).

The species *Pterocarpus dalbergioides* can be considered as non-persistent dominant colonizers of large-scale disturbances with shade intolerant seedlings, which might have been subjected to severe stress during their early germination and growing conditions. Padauk can also be treated as large gap species, which stabilizes its population when large gaps are created by disturbances, and declines in the seedling and sapling numbers when the canopy closes (Denslow, 1987). Further survival of seedlings is greatly affected by the ambient environment, biotic and abiotic factors (Putul Bhuyan *et al.*, 2002) that can be attributed to the external factors like canopy conditions, anthropogenic disturbances, and edaphic factors or internally due to physiological factors like seed dormancy, poor seed germination capacity etc.

CONCLUSIONS

Based on the present study, it is apt to consider the species as a threatened species, which may soon step into the next class of IUCN category (Extinction). Presently, anthropogenic disturbances does not show much influence on the population structure of the species, but higher rates of forest fragmentation and illicit cutting of large trees, coupled with poor seedling germinations, could finally lead to the extinction of species.

Many cut stumps of the species were observed during this field work. The agenda of biodiversity stresses the necessity of species conservation in protected and reserved forest, at the same it should also maintain a hospitable environment for the survival of endemic species. Though efforts of the forest department involved in some areas of the Padauk plantation, rigorous conservative steps should be taken for the proper growth and sustainability of the species, to retain the pride of Andaman Islands.

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