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ECOLOGICAL ANALYSIS OF *DIPTEROCARPACEAE* OF NORTH ANDAMAN FOREST, INDIA

PRASAD P. RAMA CHANDRA[1]

Abstract: Dipterocarpaceae is one of the important timber families of Andaman Islands whose members were largely exploited for their timber in the past. The current study discusses in detail about the family Dipterocarpaceae of North Andaman forest with reference to its species composition, population structure and other ecological entities. Data was analyzed using various ecological and statistical methods. Dipterocarps were encountered in 97 plots, occupying 80% of the sampled area with 68 stems ha^{-1} and basal area of 8.2 m^2 ha^{-1}. Dipterocarpaceae ranked 3rd with reference to stem density (11%) and 1st with respect to basal area (18%). The family showed five species *viz.*, *Dipterocarpus alatus*, *D. costatus*, *D. gracilis*, *D. grandiflorus* and *Hopea odorata* compounded from two genera – *Dipterocarpus* and *Hopea*. Keeping in view of the species demographic structure as well as regeneration status, conservative measures are suggested along with certain research questions which need immediate attention in the fragile insular ecosystems of Andaman Islands.

Key words: Andaman, dipterocarps, dispersion, endemic, regeneration, South East Asia

Introduction

Dipterocarpaceae is one of the main timber families in the forests of Southeast Asia that forms a high proportion of the emergent and main canopy strata of the forest [MANOKARAN, 1996]. The members of this family, besides playing a vital role as potential timber species that form an important means of economy in the timber market [APPANAH, 1998; POORE, 1989] also act as source of other non-timber products for the livelihood of the forest dwellers [PANAYOTOU & ASHTON, 1992]. The species of Dipterocarps often locally referred as Gurjan, are extensively utilized for the extraction of resins. From the oleoresins of *Dipterocarpus alatus* and *Dipterocarpus grandiflorus*, Gurjan oil is produced which is used as medicine to treat various skin ailments and ulcers. The resins also have industrial application as varnish and anti-corrosive coatings. The hard solid resin, commonly called as rock dammar, derived from *Hopea* species is used for making boats and handicrafts [SHIVA & JANTAN, 1998].

With reference to South Asia the family is distributed in India, Andaman & Nicobar Islands (A&N), Nepal, Bangladesh and Srilanka [ASHTON, 1982]. A detailed review on systematic distribution and taxonomical classification of Dipterocarpaceae globally was elucidated by MAURY-LECHON & CURTET (1998) and for Indian sub-continent by KUNDU (2008). The family Dipterocarpaceae derived its name from one of its important genera *Dipterocarpus* and has 17 genera with more than 500 species [MAURY-LECHON & CURTET, 1998] out of which, 10 genera and 99 species are exclusively found in South Asia (FAO 1985). Within the Indian forest scenario, the family is diversified by 31 species with 16 endemic (14 to peninsular India, one in North East and one in Andaman Islands) from 5 genera [TEWARY & SARKAR, 1987].

[1] Lab for spatial Informatics, International Institute of Information Technology, Gachibowli, 500032, Hyderabad – India, e-mail: rcprasad@iiit.ac.in

In the past and current scenario, forests are exploited beyond their limit, ultimately threatening the survival of the species. A successful management of recycling process provides continuous supply of goods and is true even with the plant resources. If the species are utilized proportionately without disturbing their ecological conditions and are allowed for regular natural regeneration process, they may sustain themselves to provide the un-intermittent supply of products. But due to lack of this awareness and illicit anthropogenic activities many species are facing risk of extinction. The same is the case with Dipterocarpaceae members of A&N which fall under one of the five phytogeographical regions that show wide distribution of the family [APPANAH, 1998].

The forests of A&N were virgin until the establishment of the penal colonies around 1857 and then exploitation for timber, predominantly of Padauk (*Pterocarpus*) and Gurjan (*Dipterocarpus*). Forests were logged for timber by adopting either clear felling system or selective felling system by the forest department depending on the necessity and suitability of the scheme [DEVRAJ, 2001]. Forests areas which were extracted have been regenerated naturally or artificially by proposing various forest working plans such as conversion working circle, protection working circle, minor forest produce circle etc., for sustainable management [BASU, 1990; DEVRAJ, 2001]. Apart from the logging actions of forest department, the forests of A&N were also exploited to major extent by the encroachment activities of Island settlers. The study of PRASAD & al. (2010) detailed various anthropogenic and natural driving factors that have affected the forest of North Andaman, threatening phytodiversity. The factors discussed are more or less similar in the other adjacent Islands of archipelago with profound contribution in the deterioration of forest ecosystem. Keeping in view of the importance of Dipterocarpaceae of A&N and the logging activities these Islands faced till recent past it is of prime importance to have a database with reference to their species composition and demographic structure. This is essential for setting up priorities for conservation of the species based upon their population structure and endemicity. However such kind of information for these Islands is scanty and limited. In this context, adding to the already existing database, the current study attempts to describe the ecological attributes and spatial distribution of the family Dipterocarpaceae of A&N archipelago.

Forests of A&N have mixed assemblage of species composition, showing similarities with the flora of mainland India, Malayasia and Indonesia [SINGH & al. 2002]. Several floristic [BHARGAVA, 1958; THOTHATHRI, 1961, 1962; BALAKRISHNAN & NAIR, 1977; DAGAR, 1989; REDDY & al. 2008; REDDY & PRASAD, 2008] and few ecological studies [PADALIA & al. 2004; TRIPATHI & al. 2004; PRASAD & al. 2007a, 2009a; RASINGAM & PARTHASARATHY, 2009; RAJKUMAR & PARTHASARATHY, 2008] were carried out to detail the structure, biological richness and diversity patterns of forest of Andaman Islands. However the family level species studies are new to these Islands and so far such kind of study was carried out by PRASAD & al. (2008) on Euphorbiaceae of North Andaman. Though Euphorbiaceae is one among the important species rich families, usually the forest of Southeast Asia are referred as *Dipterocarpus* forest, because of their distinct distribution in most of the Southeast Asian forests [APPANAH, 1998]. The spatial pattern of Dipterocarpaceae within A&N is unique and the family is represented only in Andaman Islands and absent in Nicobar [MATHEW & al. 2009].

Objective of the study

In general, majority of the field inventories focus on deriving the species richness and diversity at regional or at forest community levels. However, this type of studies usually specifies the phytodiversity patterns across the study area. A detail understanding about the species richness, spatial distribution and population structure of a plant family will help in the generation of quantitative database about the demography of the species within the family, their current status and threat they face if proper conservative steps are not initiated. It also helps in assessing the loss of ecological services rendered by the species for forest ecological dynamics and livelihood of the people, once the species enter into the phase of extinction. Towards this direction, the current study discusses in detail about the family Dipterocarpaceae of North Andaman forest of A&N archipelago with reference to its species composition, population structure and other ecological entities along with its occurrence, dominance and existence (?) in other adjacent Islands. The study provides an essential database of Dipterocarpaceae species towards their conservation efforts and supports further research for the future investigators to work on lesser known Dipterocarpaceae of Andaman forests.

Study area

The present study was carried out in the North Andaman (NA) forest of A&N (Fig. 1) which is one among the 14 identified Biosphere Reserves of India [DEVRAJ, 2001]. NA constitutes one of the important major Islands of A&N and lies between 12°95" N and 92°86" E covering an area of 1458 km^2. All the Islands of NA were declared either as protected areas or as wild life sanctuaries towards conservation measures [HANDBOOK, 1983]. Topography is undulating having hills and narrow valleys with highest elevation of 732 m above mean sea level represented by Saddle Peak, which is the top point in the entire A&N. Typical tropical rain forest climate exists in these Islands due to continuous showers from both south-west and north-east monsoons and with least temperature variations. The soils belong to Serpentine series with top soil having high base status and less nutrient values supporting dense evergreen forests of *Dipterocarpus* and its associates [DEVRAJ, 2001].

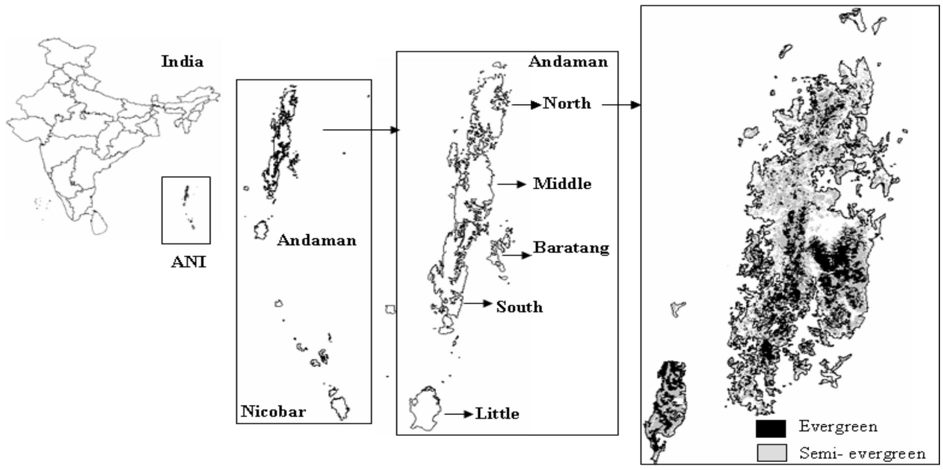

Fig. 1. Location map of the study area

Though the topographic variations are minor with poor soil conditions these Islands seize an extraordinary vivid biodiversity and endemism. As per CHAMPION & SETH (1968) major hinterland vegetation types of study area include Andaman evergreen, Andaman Semi evergreen and Andaman Moist deciduous.

Materials and methods

The detailed vegetation map prepared using satellite data [PRASAD & al. 2007b] formed basis for the selection of plots (0.1 ha size) for field inventory in two predominant forest types *viz* evergreen (EG) and semi-evergreen (SEG) of the study area. About 120 plots (62 in EG, 58 in SEG) covering entire NA forest were surveyed during field inventory for phytosociological data collection. The size of each sample plot was 32 x 32 m for trees, 10 x 10 m for saplings (two opposite corners of the main plot) and 1 x 1 m for seedlings (all the four corners of the main plot). Within each plot all the trees having diameter at breast height (DBH) > 30 cms were measured, with simultaneous investigation on sapling and seedling data.

The data was analyzed to extract the structural and ecological aspects of Dipterocarpaceae using various phytosociological approaches by deriving frequency, density, basal area to compute Important Value Index [CURTIS & MCINTOSH, 1950]. Calculation of IVI facilitates in identifying the dominant and co-dominant species along with their association to form community within the study area. Girth class analysis was performed to view the contribution of stem density and basal area by various girth classes. Braun-Blanquet system (1932) was used to depict the constancy (presence of occurrence of species within the sampled plots) classes as; Rare constancy (0-20%), low (21-40%), intermediate (41-60%), moderately high (61-80%) and high (81-100%). This analysis helps in assessing the population status of the species.

To analyze the association between the species, the traditional method of chi-squared procedure [WAITE, 2000] was used. Since sample size is <200 (120 plots), Yate's correction was applied to improve the performance of the test as follows.

$$\chi^2 = n(|ad - bc| - 0.5n)^2 / (a+b)(c+d)(a+c)(b+d)$$

Where n = number of plots sampled

a = plots showing presence of both the species

b = plots showing presence of first species and absence of second

c = plots showing absence of first species and presence of second

d = plots showing absence of both the species

However, this test was not performed for some species with small number of observations whose expected values are less than 5, even with Yate's correction. Alternatively Fisher's exact test (1954) was conducted for analyzing association among those species. The null hypothesis proposed for the both the tests is that the species are independent of each other.

The spatial distribution of species was derived using Index of Dispersion (ID) by calculating mean and variance of the species as follows (taken from WAITE, 2000).

ID = S^2 / m

where S^2 = the species variance

m = the species mean

Based on the ID values, distribution of species can be interpreted as random (ID = 1.0) clumped (ID >1.0) and regular (ID <1.0). Later chi-square test was applied to signify the departures in the values from unity. It is calculated as

$$\chi^2 = \text{ID (N-1)}$$

Where N = number of sample plots

Since N > 30 (120 plots) χ^2 was corrected using the following equation

$$d = \sqrt{2\chi^2} - \sqrt{2(N-1)-1}$$

Where *d* is the correction factor and used to define the distribution as
$d \leq 1.96$: the null hypothesis accepted (random)
$d < -1.96$: regular
$d > 1.96$: clumped

Results

The survey yielded a total of 7392 individuals from 60 families, 134 genera and 192 species. Out of 120 sampled plots, Dipterocarps were encountered in 97 plots *i.e* 80% of the sampled area was occupied by the species. This observation is apt with the ASHTON'S (1982) remark, who stated that 80% of the abundant, emergent individuals in lowland forest of Southeast Asia are Dipterocarps. Dipterocarpaceae ranked 3rd after Myristicacea and Sterculiaceae with reference to stem density (11%) and 1st with respect to basal area (18%). The results are similar to the study of MANOKARAN & al. (1990) in 50 ha plot of Pasoh reserve forest where Dipterocarps dominated the site with 9% stem density and 24% basal area. Dipterocarpaceae in NA forest with 68 stems ha^{-1}, covering basal area of 8.2 m^2 ha^{-1} showed five species *viz*., *Dipterocarpus alatus*, *D. costatus*, *D. gracilis*, *D. grandiflorus* and *Hopea odorata* compounded from two genera – *Dipterocarpus* and *Hopea*.

Among the two forest types sampled 76% of the Dipterocarps stem density (616) was recorded from EG. With reference to *D. alatus*, 9 out of the 10 individuals were represented in SEG while for *D. grandiflorus* 289 out of 295 were encountered in EG indicating the species ecological amplitude and preferential habitats. Values for stems and basal area ha^{-1} were more for *D. grandiflorus*. Maximum DBH was recorded in *D. gracilis* while minimum average DBH was observed in *D. grandiflorus.* Though *D. alatus* represented with a population of 10 individuals it has showed high average DBH. The Braun-Blanquet constancy classification scaled *D. alatus* (3.3%) and *D. costatus* (6.7%) under rare, *D. grandiflorus* (27.5%) and *Hopea odorata* (20.8%) at low and *D. gracilis* (46.7%) on intermediate constancy.

Tab. 1. Species parameters of Dipterocarpaceae

Species	*D. alatus*	*D. costatus*	*D. gracilis*	*D. grandiflorus*	*H. odorata*
Number of Plots in which species occurred	4	8	56	33	25
Stems recorded	10	43	417	295	46
Mean	0.08	0.36	3.48	2.46	0.38
Standard Deviation	0.54	1.86	7.19	5.52	0.90
Variance	0.74	1.36	2.68	2.35	0.95
Index of Dispersion	8.85	3.80	0.77	0.96	2.47
χ^2 correction factor	30.49	14.68	-1.85	-0.32	8.87
IVI	0.80	1.86	17.59	11.07	2.68
Stems ha^{-1}	1	4	35	25	4
Basal area ha^{-1}	0.2	0.4	4.4	2.6	0.5
Saplings ha^{-1} (%)	--	--	--	12.3	--
Seedlings ha^{-1} (%)	--	--	0.8	14.6	--
Max-DBH	302	301	452	404	300
Average-DBH	160	102	102	95	109

Understanding the distribution and dominance of the species is one of the important aspects of ecosystem research. Species, in general, tend to undergo intra-species and inter-species competitions for the deployment of available optimal resources in their niches. The one which is the successor of the struggle proves itself dominant by showing wide eco-regional distribution dominating the sites with their stem density, area occupancy, abundance, etc. So when one species is identified as dominant, it is also interesting to know about the species which are acting as competitors for the species. In other words, it is to make out the other co-dominant species that are associated with the dominant species and forms the distinct community. Based on the derived IVI value, *D. gracilis* (17.59) was found to be the dominant species both in Dipterocarpaceae as well as in the entire sampled area and forms a community with *Myristica glaucescens* and *Pterygota alata*. Though the other four species of Dipterocarpaceae, didn't dominate the study area they have their associated or neighbouring species based on IVI as follows: *D. grandiflorus* with *Artocarpus chaplasha* and *Celtis wightii*; *D. costatus* along *Mitragyna rotundifolia* and *Baccaurea sapida*; *D. alatus* with *Canarium manii* and *Antiaris toxicaria*; *H. odorata* under *Artocarpus lakoocha* and *Dillenia andamanica* community.

The χ^2 value obtained for the species *D. gracilis – D. grandiflorus*, *D. gracilis - H. odorata and D. grandiflorus – H. odorata* exceeded the values of $\chi^2 = 3.841$(p<0.05), $\chi^2 = 6.635$ (p<0.01) and χ^2 (p<0.001) with 1 degree of freedom respectively. Thus the null hypothesis of independence is rejected. Also, since the observed values are greater than the expected values there exists a positive association between the species (Tab. 2). Application of Fisher's exact test for the association of *D. alatus* and *D. costatus* with the other species showed significantly independent nature at 95% confidence interval with few exceptions (** in Tab. 2).

Tab. 2. Species association and independent distribution analysis

Test	Chi-Square test			Fisher's Test
Species association	Observed values	Expected Values	chi-values	P-values (95% CI)
D. gracilis – D. grandiflorus	33.0	15.4	49.11	--
D. gracilis – H. odorata	25.0	11.7	33.43	--
D. grandiflorus – H. odorata	25.0	6.9	78.72	--
D. alatus – D. costatus	--	--	--	0.22197*
D. alatus – D. gracilis	--	--	--	0.04471**
D. alatus – D. grandiflorus	--	--	--	0.00498**
D. alatus – H. odorata	--	--	--	0.45826*
D. costatus – D. gracilis	--	--	--	0.00169**
D. costatus – D. grandiflorus	--	--		0.00002**
D. costatus – H. odorata	--	--	--	0.0001**
CI - Confidence Interval, * Not significant, ** statistically significant				

The study of population structure provides information about the growth patterns and regeneration status of the species. The current analysis of girth wise stem and basal area distribution shows varied results for all the five species. With reference to high stem density, *D. alatus* showed equal number in both 60-90 cm and >240 cm class, while *H. odorata* showed in 60-90 cm. In the remaining three species more or less a reverse J shaped pattern was observed with high stem density in lower girth classes and low in higher implying negative exponential relationship. Except in *D. gracilis* and *D. grandiflorus*, the girth class 210-240 cm was completely absent in other species and in *D. alatus* even there was no representation of 120-150 cm girth class. With respect to basal area, an increasing trend was observed with low girth classes contributing low basal area and high by higher classes, with some exceptions in girth classes by different species as evident from the Fig. 2. In general an ideal representation of the girth classes in terms of stem density and basal area was shown by *D. gracilis*. The analysis of seedling and sapling data showed poor regeneration trend for all the five species. Overall observation of sampled data showed very low percent of saplings and seedlings for *D. grandiflorus,* only seedlings for *D. gracilis* and neither for the remaining three species (Tab. 1).

The *d* correction factor calculated for the five species showed two values *viz.*, >1.96 and < -1.96, rejecting the null hypothesis of random distribution ($d \leq 1.96$). Out of the five species, *D. alatus*, *D. costatus* and *Hopea odorata* showed clumped pattern ($d > 1.96$) following negative binomial distribution, while *D. gracilis* and *D. grandiflorus* followed regular distribution ($d < -1.96$) with positive binomial distribution (Tab. 1). The clumping pattern as observed in some of the species perhaps could be one of the reasons for their poor regeneration status.

All the five species encountered in the study area are labeled under different IUCN categories *viz.*, *D. grandiflorus* and *D. gracilis* as critically endangered, *D. alatus* and *D. costatus* – endangered and *Hopea odorata* under vulnerable categories (www.iucnredlist.org). The result of the Braun-Blanquet approach also confirms the rarity and low density of the species particularly *D. alatus* (endemic) *D. costatus* and *Hopea odorata*. The low population density coupled with listing under IUCN categories puts these species at high risk of threat and deserve special ecological importance for protection and conservation.

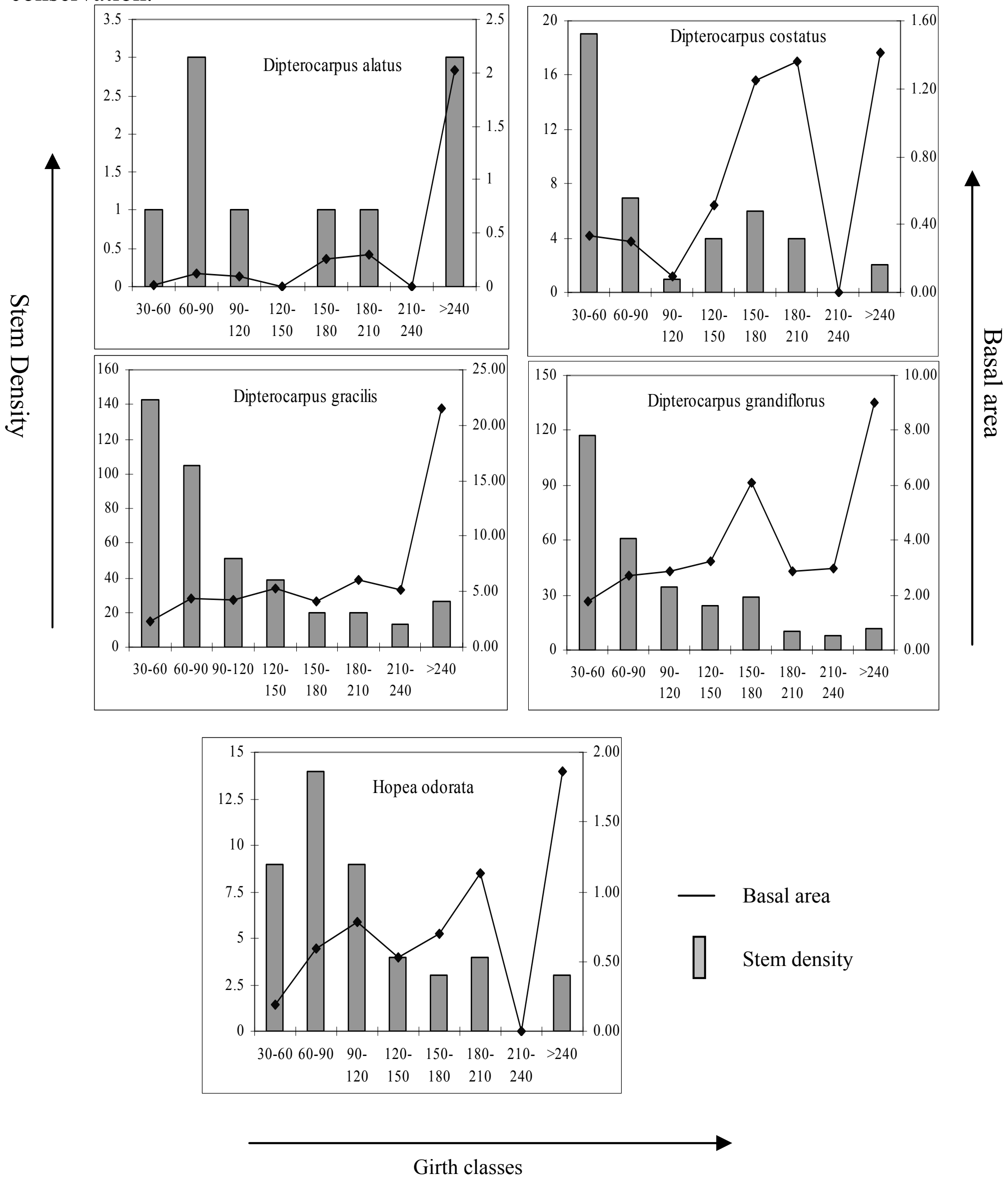

Fig. 2. Stem density and basal area distribution in different girth classes of *Dipterocarpaceae* species

Discussions

Dipterocarps are observed mostly on the low altitudinal zones [WHITMORE, 1988] and the number of individuals and species decreases with increasing altitude [DEVRAJ, 2001]. However in the current study, the altitude of sampled plots ranged between 10–350 m and doesn't show significant correlation between the species distribution and altitudinal levels. This distribution is similar to Peninsular Malaysia where the altitudinal zones of the family ranged between 0-300 m and the forest are usually referred as low-undulating Dipterocarp forest [SYMINGTON, 1943; WYATT-SMITH, 1963; APPANAH, 1998].

The constraint of accessibility restricted the researchers to explore these Islands widely in the past. Inspite of this barrier, some of the workers carried out floristic studies and contributed fundamental information about the floristic elements of these Islands. In the recent past, researchers started working on the diversity patterns in different Islands of A&N archipelago and provided detailed account on the vegetation structure and richness patterns of various forest types existing in these Islands (Tab. 3). In all these studies Dipterocarpaceae was observed as one of the dominant families either in terms of stem density or basal area or any other phytosociological parameter.

To sum up, the study carried out under the project *Biodiversity characterization at landscape level in Andaman and Nicobar Islands* by Department of Space and Department of Science and Technology, India [HANDBOOK, 2003] enumerated nine Dipterocarpaceae species from the random survey of 539 plots (0.1 ha & 0.04 ha sizes) in all the major Islands of A&N. However the report [HANDBOOK, 2003] did not provide information about Island wise distribution of the species. Hence the other possible sources of literature were surveyed to detail Island wise distribution of Dipterocarps.

PADALIA & al. (2004) worked on Andaman Islands and observed Dipterocarps dominating the site with 18% (EG) to 15% (SEG) of stem density and *D. turbinatus* as second dominant species based on IVI. However the study cited only 3 species of Dipterocarpaceae (Tab. 3). The study carried out by RASINGAM & PARTHASARATHY (2009) in the Little Andaman recorded Dipterocarpaceae as 4th dominant family contributing 6.77% of the stem density. They have encountered 3 species from the survey of 8 ha plots laid in four different vegetation types. An interesting comparative observation of their study with the current one is with reference to *D. alatus*, an endemic species of the Island. The current study recorded only 10 individuals (1 stem ha^{-1}) in contrast to their observation of 103 (13 stems ha^{-1}). So far there is no detailed information on the Dipterocarps of South Andaman. A survey conducted by PANDEY & al. (2006) on home gardens and home forest gardens in South Andaman listed *D. grandiflorus* as one of the top storey species.

Tab. 3. Distribution of Dipterocarps in Andaman Islands

S.No	Species	A&N Handbook (2003)	Andaman Islands Padalia & al. (2004)	North Andaman Prasad (current)	Middle Andaman Rajkumar and Parthasarathy (2008)	Baratang Islands Chauhan (2004)	Little Andaman Rasingam and Parthasarathy (2009)	South Andaman Pandey & al. (2006)
1	*Dipterocarpus alatus*	ψ		ψ			ψ	
2	*Dipterocarpus andamanicus*				ψ			
3	*Dipterocarpus costatus*	ψ		ψ	ψ			
4	*Dipterocarpus gracilis*	ψ	ψ	ψ			ψ	ψ
5	*Dipterocarpus grandiflorus*	ψ		ψ			ψ	
6	*Dipterocarpus griffithii*	ψ			ψ	ψ		
7	*Dipterocarpus incanus*	ψ			ψ			
8	*Dipterocarpus kerrii*				ψ			
9	*Dipterocarpus turbinatus*	ψ	ψ			ψ		
10	*Hopea helferi*	ψ						
11	*Hopea odorata*	ψ		ψ		ψ		
12	*Dipterocarpus grandis*		ψ --?					
	ψ – Present, ? – Doubtful record							

With respect to Middle Andaman, the study of RAJKUMAR & PARTHASARATHY (2008) on tree diversity using one ha plot each in two different locations of Andaman Giant EG forest, recorded a total of five Dipterocarpaceae species out of which two species *viz*., *D. kerrii* and *D. andamanicus* were not encountered in the previous and the current studies. They have also observed Dipterocarpaceae as dominant family in terms of stem density, basal area and biomass and listed *D. incanus* as abundant species. The research work of CHAUHAN (2004) in Baratang, a group of scattered Islands adjacent to Middle Andaman, listed three Dipterocarp species. One of the interesting observations (Tab. 3) with respect to Baratang and Middle Andaman is recording of *D. griffithii*. This species was not reported in other Islands of archipelago (except in HANDBOOK, 2003). This infers that the species is restricted to a group of Islands and since both are neighboring Islands, there is a possibility of occurrence of species in both the Islands. Results of the stratified random survey in EG forest of NA by PRASAD & al. (2007a) reported Dipterocarpaceae as dominant family based on the Family importance Value Index which is the sum of relative diversity, relative density and relative dominance.

From the above it is evident that these studies cumulatively provided the list of Dipterocarpaceae species that can be seen in Andaman Islands and also ranked it as one among the top families. They also conclude about the tracing of certain species which are having restricted distribution and require different sampling effort. For example, recording of *D. kerrii* and *D. andamanicus*, which were sampled only in Middle Andaman and none of the other surveys listed them. These lacunae can be attributed either to the sampling strategy adopted or site selected for study or can also be to the confined distribution of the species population.

Added to the above list of species, PADALIA & al. (2004) reported *D. grandis* in their work on phytosociological studies of Andaman Islands. But the literature survey on Dipterocarpaceae across the world did not yield such kind of species. Also the study [HANDBOOK, 2003] recorded *H. odorata* from mixed evergreen forest of Nicobar Islands, which is contradicting with the observations of SINGH & al. (2002) and MATHEW & al. (2010) who stated the absence of Dipterocarpaceae in Nicobar Islands. Both these information need to be further quantified and investigated. Apart from the species listed in the Tab. 3, DEVRAJ (2001) mentioned certain species of Dipterocarpaceae *viz*., *D. baudii*, *D. chartaceus*, *D. crinitus*, *D. dyeri*, *D. fagineus*, *D. hasseeltii*, *D. obtusifolius*, *D. oblongifolius*, *D. retusus*, *D. turbinatus*, *D. tuberculatus*, whose presence is doubtful in the Andaman Islands. However, the existence of some of these species like *D. turbinatus* [PADALIA & al. 2004; RAJKUMAR & PARTHASARATHY, 2008], *D. tuberculatus* [JHA & SARMA, 2008] *D. obtusifolius* (biotic.org) *D. baudii* and *D. dyeri* (apafri. org) were confirmed by some studies and elaborated investigations about their population structure needed to be worked out along with the status of other species from the above list which are not so far confirmed in A&N.

Hitherto *D. alatus* is considered to be the only endemic species of Dipterocarpaceae observed in the study area (Fig. 3) but SHIN & KYI (apafri. org, 2010) reported that *D. baudii* and *D. dyeri* are found only in Andaman and in that case they may also be considered as endemic too. Now the research question needed to be addressed is whether these species are really confined to these Islands? If these species are present in the Islands they should have been encountered in any of the floristic or ecological studies carried out till now. The possibility of their extinction couldn't be ruled out as forest of Andaman Islands are heavily exploited in the last four decades for valuable timber as well as a vast proportion of forest converted into settlement and agricultural purpose by the Island settlers [PRASAD & al. 2009b, 2010; Fig. 4]. Species which have narrow ecological amplitude doest not survive once their habitats are destroyed. It is also possible that these species may have very limited population in special pockets of Island vegetation in certain remote inaccessible location which has kept them isolated.

Fig. 3. *Dipterocarpus alatus* – An endemic and endangered species encountered in the study area

Fig. 4. *Dipterocarpus* species amidst agriculture field near the foothill of Saddle Peak National Park of North Andaman

One of the significant points from the above observations is with reference to the number of Dipterocarpaceae species. JACOB (1981) in his work on taxonomical distribution of Dipterocarpaceae cited presence of eight species of Dipterocarpaceae from Andaman Islands in contrast to the current study which showed 12 species compounded from the field studies and literature survey. Also he reported that the Dipterocarpaceae from Andaman Islands has only one endemic species contributing 12% of the endemicity while REDDY & al. (2004) enlisted two species *D. alatus* and *D. turbinatus* var. *andamanica*. So the issue to resolve is whether the increase in the species number as observed in the current study is real one or ambiguity in assigning the nomenclature to the species by various researchers. As mentioned by VASUDEVA RAO (2004) sometimes even within the same publication (local flora), the one and similar species is referred under two different names. He cited few species of Dipterocarpaceae from Andaman, which were misinterpreted as two different species eg., *D. griffithii* – *D. grandiflorus*; *D. turbinatus* – *D. gracilis*. Considering this statement, it has to be checked whether *D. turbinatus* var. *andamanica* and *D. andamanicus* are synonyms of single species or distinguishably two separate species?

Conclusions

Analysis of the current research and other relevant studies taken in the study area substantially supported Dipterocarpaceae as one the chief family contributing a good proportion of stem density and basal area to the vegetation of Andaman Islands. Depending on the different sampling methods adopted, in different location of the Islands one or other species of Dipterocarpaceae dominated the site. A cumulative number of species belonging to the family were derived from the available literature, but still existence of certain species is doubtful, which needs further exploration. Towards this future, investigation should focus on detailed systematic family level studies, utilizing different sampling strategies in all the Islands of archipelago, to enumerate complete family species richness, their demographic status and uncertainty among the species citation. The study also showed poor regeneration status of the Dipterocarps. This is important to consider, especially for the endemic species *D. alatus*, in the NA whose adult population is also very low (Fig. 3). The low population of the species may be due to delayed flowering, poor / slower germination rate or unable to compete with the dominant species under closed canopy conditions or other unfavorable site conditions. The Andaman canopy lifting system developed for improving the regeneration patterns in Dipterocarps [CHENGAPPA, 1944] should be reconsidered with high priority to save the population of the species from entering into the status of threatened or extinct.

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