

Community structure and species diversity of Saddle Peak forests in Andaman Island

K.P. TRIPATHI, S. TRIPATHI, T. SELVEN, K. KUMAR, K.K. SINGH, SHANTA MEHROTRA
& P. PUSHPANGADAN

*Pharmacognosy & Ethnopharmacology Division, National Botanical Research Institute,
226001, Lucknow*

Abstract: Saddle Peak forests, declared as a National Park, in Diglipur forest division of north Andaman (13°15' to 13° 41' N and 92° 37' to 93° 7' E) are characterized as humid tropical evergreen forests. A few species like *Aglaia andamanica*, *Artocarpus gomeziana*, *Bombax insignie* were common in all the studied sites. Among species, in littoral forests *Mimusops littoralis*, *Artocarpus gomeziana*, and in inland forest *Pterocymbium tinctorium*, *Tabernaemontana crispa*, were dominant. In foothill forest *Artocarpus chaplasi*, *Mallotus peltatus* (male), were abundant whereas in middle saddle peak forest area *Zanthoxylon budrunga*, *Parishia insignis* and *Mesua ferrea* were the most abundant species. Across the sites the population density increased from 459 to 2681 plants per hectare from littoral to middle saddle peak forest site, but the reverse was true for basal area which decreased from 74 to 48 m² ha⁻¹. The species richness (61) as well as Shannon Wiener's diversity index (3.58) were highest in foothill forest. Beta diversity was maximum in inland forest (5.1) and minimum in middle saddle peak forest (1.54). Heterogeneity was almost similar in foothill and middle saddle peak forests and it was relatively less in littoral forest zone. Mean girth showed a decreasing pattern from littoral forest (183) to middle saddle peak forest (39) similar to basal area. Size variation was greatest in foothill forest site showing a highest degree of asymmetry. Population structures for different forests have been prepared and interpreted.

Resumen: Los bosques de Saddle Peak, declarados Parque Nacional en la División Forestal Diglipur, en el norte de Andaman (13°15' a 13° 41' N y 92° 37' a 93° 7' E) están caracterizados como bosques tropicales húmedos perennifolios. Algunas especies, por ejemplo *Aglaia andamanica*, *Artocarpus gomeziana* y *Bombax insignie*, fueron comunes a todos los sitios estudiados. En el bosque de litoral dominaron *Mimusops littoralis*, *Artocarpus gomeziana*, y en el bosque de tierra adentro las dominantes fueron *Pterocymbium tinctorium* y *Tabernaemontana crispa*. En el bosque de piedemonte *Artocarpus chaplasi* y *Mallotus peltatus* fueron abundantes, mientras que en el área forestal de Middle Saddle Peak, *Zanthoxylon budrunga*, *Parishia insignis* y *Mesua ferrea* fueron las especies más abundantes. Entre sitios, la densidad poblacional incrementó desde el litoral hasta el sitio forestal de Middle Saddle Peak, de 459 a 2681 plantas por hectárea, pero lo contrario ocurrió para el área basal, la cual decreció de 74 a 48 m² ha⁻¹. La riqueza de especies (61) y el índice de diversidad de Shannon Wiener (3.58) alcanzaron sus máximos en el bosque de piedemonte. La diversidad beta mostró su máximo en el bosque de tierra adentro (5.1) y su mínimo en el bosque de Middle Saddle Peak (1.54). La heterogeneidad fue casi igual en los bosques de piedemonte y en los de Middle Saddle Peak, y fue relativamente menor en la zona del bosque litoral. La circunferencia promedio de los árboles mostró un patrón decreciente desde el bosque litoral (183) hasta el bosque de Middle Saddle Peak (39), y lo mismo sucedió con el área basal. La variación de tamaño fue máxima en los bosques de piedemonte, lo que muestra el mayor grado de asimetría. Se obtuvieron e interpretaron las estructuras poblacionales para diferentes bosques.

Resumo: As florestas "Saddle Peak", declaradas como Parque Nacional na divisão florestal em Diglipur no norte de Andaman (13° 15' a 13° 41' N e os 92° 37' e 93° 7' E), são caracterizadas como flo-

restas tropicais sempreverdes. Algumas espécies como a *Aglaia andamanica*, *Artocarpus gomeziana*, *Bombax insignie* eram comuns em todas as estações estudadas. Entre as espécies nas florestas litorâneas verificou-se que a *Mimusops littoralis*, *Artocarpus gomeziana* eram as espécies dominantes e que na floresta de interior dominavam a *Pterocymbium tinctorium*, *Taberneamontana crispa*. Na floresta, no sopé das colinas, a *Artocarpus chaplasi*, *Mallotus peltatus* (masculina), eram abundantes enquanto na zona central da floresta "saddle peak" a *Zanthoxylon budrunga*, *Parishia insignis*, *Mesua ferrea* eram as espécies mais abundantes. Através das várias estações a densidade da população aumentou das 459 para as 2681 plantas por hectare do litoral até ao meio da estação florestal "saddle peak", mas o reverso era verdadeiro para a área basal que decresceu dos 74 aos 48 m² ha⁻¹. A riqueza em espécies (61) bem como o índice de diversidade de Shannon Wiener (3,58) foi o mais alto no sopé da colina. A diversidade Beta foi máxima na floresta no interior (5,1) e mínima na zona central da floresta "saddle peak" (1,54). A heterogeneidade foi quase semelhante no sopé e na zona central da floresta e ligeiramente menor na zona litorânea da zona florestal. O perímetro médio mostrou um padrão de decréscimo do litoral (183) para a zona central (39) semelhante à área basal. A variação dimensional foi mais elevada no sopé da estação florestal, mostrando o maior grau de assimetria. As estruturas de comunidade para as diferentes florestas foram preparadas e interpretadas.

Key words: Community structure, species diversity, population density, species richness and heterogeneity.

Introduction

Andaman and Nicobar Island (319 Island), extended over 8,293 km² in the Bay of Bengal (Dutta *et al.* 1985), are geographically one of the most scenic, beautiful, historic, and sociologically most interesting areas of the Indian republic. In this Island 80% area of the total surface is covered by forest with about 300 species of vascular plants and characterized as humid tropical evergreen forest (Dagar 1989).

North Andaman, a major group of Islands, is rich in species diversity. Saddle Peak forest zone (732 m from sea level) represented as a National Park occurs in this area. It is the highest point of these Islands possessing several endemic species.

Very little information exists on the ecological aspects of the forest communities of Andaman Islands. Some ethnobotanical studies were conducted (Awasthi 1987; Dagar 1989; Dagar & Dagar 1991, 1996; Thoyabathri 1980; Yoganarsimha *et al.* 1983). Also the natural regeneration status of tropical evergreen forests of the Andaman Islands was studied (Elkunchwar *et al.* 1997). The present study attempts to investigate the community structure, species diversity and population distribution of perennial plant communities in four different forest types of study area.

Materials and methods

Saddle Peak forests (13°15' to 13°41' N and 92°37' to 93°7' E) are characterized as humid tropical evergreen forests. Four sites were selected at distinct conditions (littoral, inland, foothill and middle forest areas of saddle peak). Evergreen, semi evergreen and moist tropical deciduous tall trees characterize the vegetation of these stands. Fifteen quadrats (15 x 15 m) were laid in each stand. In each quadrat the trees and tall shrubs were enumerated and measured for girth (GBH) at breast height (130 cm from ground level). To determine the maturity of the forest trees individuals were classified in a series of girth classes at the intervals of 50 cm in littoral and inland and 20 cm in foothill and middle saddle peak forest. Species structure (frequency, density, abundance, basal area, importance value index) and species diversity index were computed from the quadrat data following Misra (1968).

Importance value index (IVI) was calculated by summing up relative frequency, relative density and relative dominance values in a particular stand. Species diversity index (H') was determined separately from the Shannon Wiener's information function (Shannon & Weaver 1963).

$$H^{-} = - \sum p_i \log_2 p_i$$

where, $p_i = n_i/N$, which denotes the importance probability of each species in a population; n_i = importance value for each species; N = total of importance value.

Concentration of dominance (Cd), known as Simpson index, was measured according to Simpson (1949): Index of dominance (Cd) = $\sum (n_i/N^2)$.

Species richness or variety index (d) is the mean number of species per sample and determined using the formula of Margalef (1958). Species richness index (d) = S/\sqrt{N} ; where, S = number of species, N = number of individuals of all species.

Equitability or evenness (e) refers to the degree of relative dominance of each species in that area. It was calculated according to Pielou (1966) as: Equitability (e) = $H^{-}/\log S$; where, H^{-} = Shannon Wiener's index and S = Number of species. Species heterogeneity is defined as the reciprocal of Simpson's index or under root of concentration of dominance (Cd). Species heterogeneity = $1/\sqrt{Cd}$.

Beta diversity (β) – diversity at a zone was computed following Whittaker (1972) as: (β) = Total number of species in all 4 sites/average number of species of 4 sites.

Dispersion, skewness and kurtosis are the different characteristics of the frequency distribution curve for all the individuals in a stand. Skewness is defined as the shape of the frequency distribution curve and the dispersion indicates the amount of the spread on either side of the central value. Kurtosis means the nature of frequency at the middle of the entire range. It denotes the apex of the distribution curve i.e., relative flatness or pointedness. These were calculated as: Dispersion = S^2/mean , where S^2 = variance; Skewness = μ_3^2/μ_2^3 ; Kurtosis = μ_4/μ_2^2 ; where μ^2 , μ^3 and μ^4 are the second, third and fourth order or moments about the mean, respectively.

Result and discussion

Perennial plant species of Saddle Peak forest consisted of about 111 species belonging 38 families. Features of vegetational analysis of littoral, inland, foothill and middle saddle peak forest are presented in Table 1. Site by site patterns are as follows:

Littoral: A total of 25 species are present in this site, of these *Mimusops littoralis* Kurz. with 100%

frequency, maximum density (141 individuals ha^{-1}), IVI (89) and BA (13 $\text{m}^2 \text{ha}^{-1}$), is the most abundant species of littoral forests. This species along with *Artocarpus gomeziana* Wall. ex Trec., *Sideroxylon longipetiolatm* King & Prain, contributes 37% basal area of all species in this site (Table 1).

Inland: Inland forests contain 46 species. None of the species shows greater dominance. *Pterocymbium tinctorium* (Bl.) Merr. with IVI (32) and basal area (9 $\text{m}^2 \text{ha}^{-1}$) appears most dominant. However, its population density (48 individuals ha^{-1}) was comparatively less than *Tabernaemontana crispa* Roxb. (129 individuals ha^{-1}) which also showed maximum (82%) frequency (Table 1).

Foothill: The foothill site of Saddle peak is most species rich (61) and shows mixed nature with none of species having greater dominance. *Artocarpus chaplasi* Roxb. with highest IVI (20) and basal area (8 $\text{m}^2 \text{ha}^{-1}$) appears most important. Among others, *Mallotus peltatus* (Gies) Muell-Arg (male) and *Mangifera andamanica* King. (IVI-15) each were important (Table 1).

Middle Saddle Peak: A total of 40 species constitute the middle saddle peak forest site *Zanthoxylon budrunge* (Roxb.) Wall ex DC. had greatest IVI (32) and basal area (11.64 $\text{m}^2 \text{ha}^{-1}$). *Aglaia andamanica* Hiern and *Tabernaemontana crispa* Roxb. had maximum Shannon Wiener's diversity index (0.198) corresponding to population density (207 individuals ha^{-1}). The species like *Aglaia andamanica* Hiern, *Calamus andamanicus* Kurz., *Calamus longisetus* Griff., *Champeria mainillana* (Bl.) Merr., *Garcinea cowa* Roxb., *Sideroxylon ferrugineum* Hook & Arn., *Sterculia parviflora* Roxb. and *Zanthoxylon rhetsa* (Roxb.) DC. were found most frequently in stand with maximum percent frequency (100%) (Table 1).

The distribution of species along the increasing girth sizes acquired different shapes in different sites (Fig. 1). In Littoral forest the species richness was relatively high in 100-300 cm girth class, whereas in Inland site species were almost uniformly distributed over the entire range of size class except in last few classes. In the foothill forest, the number of species was highest in initial girth class of 0-20 cm while in middle Saddle peak site maximum species were found in 20 to 40 cm

girth class. Besides, some of the species continuously occurred up to bigger size classes covering about 18 classes of 20 cm interval in the Foothill forest,

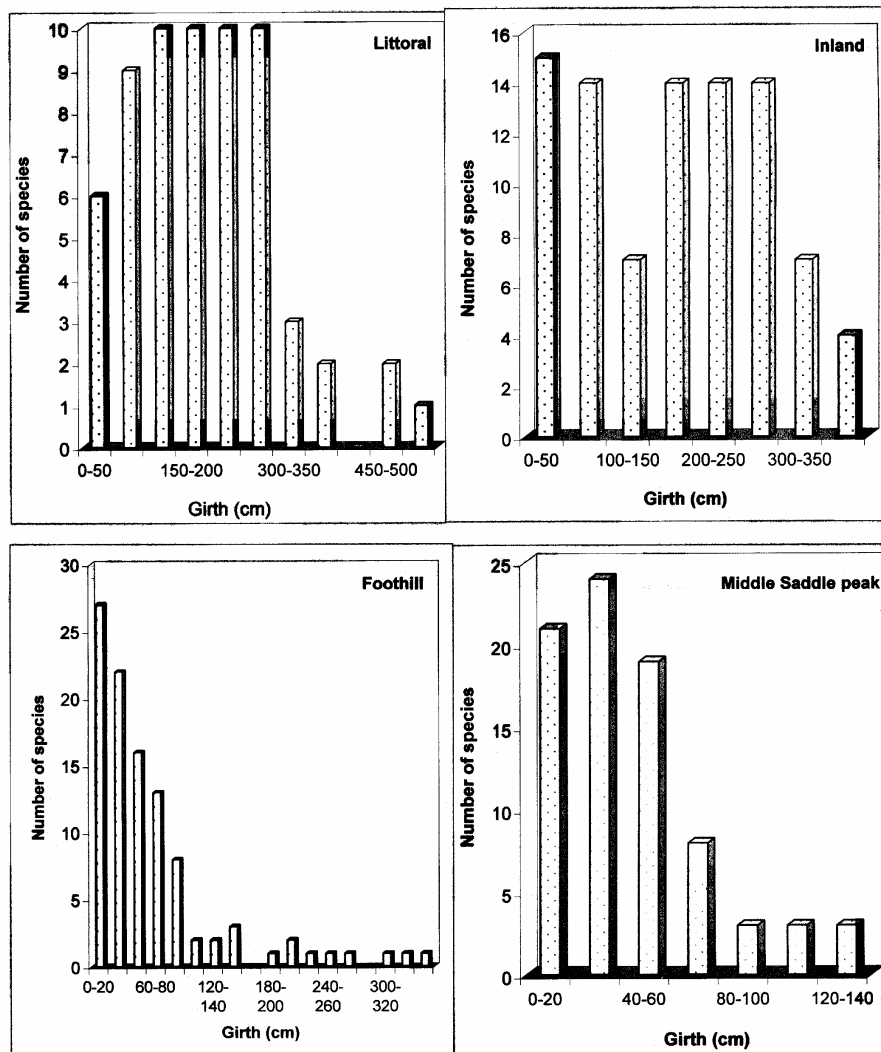


Fig. 1. Distribution of species along with size class of different forests in Saddle peak of Andaman island.

which were terminated within 7 classes of 20 cm intervals in middle Saddle peak forest.

Population size, plant diversity and some mathematical indices of plant diversity of different sites was compared (Table 2). Basal area was greatest for littoral forest ($74 \text{ m}^2 \text{ ha}^{-1}$) and lowest in middle saddle peak forest ($48 \text{ m}^2 \text{ ha}^{-1}$). However, the patterns of density are just reverse (Table 2). Maximum species (61) were recorded in foothill forest and minimum (25) in littoral forest. These sites showed much variation in β diversity ranging from 5.1 (inland forest) to 1.54 (middle saddle peak forest area). Heterogeneity ranged from 24.4 (middle saddle peak) to 7.9 (littoral) and it is almost

similar in foothill and middle saddle peak forest area.

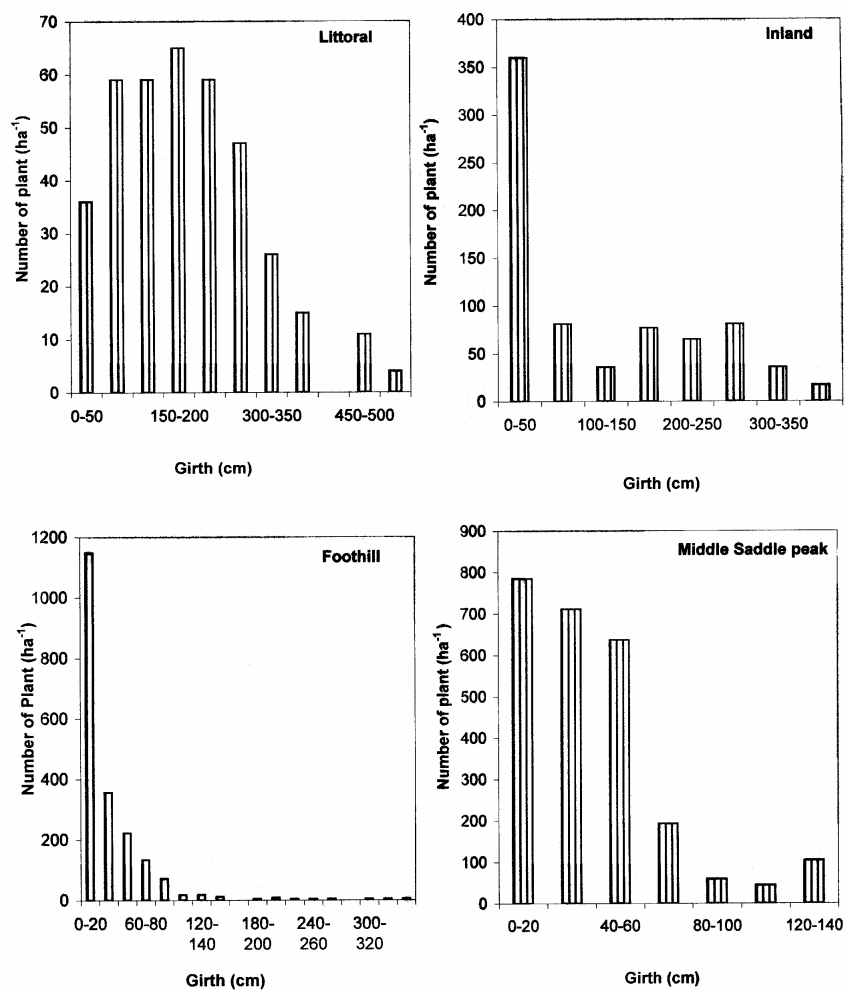
Richness index varied from 2.25 (littoral forest area) to 3.94 (foothill forest area) while equitability (e) did not vary (from 0.82 – littoral to 0.93 – middle saddle peak forest) significantly. Shannon Wiener's index of diversity, which is one of the most popular measures of general diversity index (Table 2), ranged from 2.63 (littoral forest) to 3.58 (foothill forest). Dominance was found more with concentration of fewer species in littoral forest with greatest value (0.126). In other stands dominance was equally shared by multiple species.

Table 2. Population size, plant diversity and mathematical indices of plant diversity at four sites of Saddle Peak forests of Andaman Island.

Parameters	Littoral forest	Inland forest	Foothill forest	Middle Saddle peak
Population density (no. ha ⁻¹)	459	752	2133	2681
Basal area (m ² ha ⁻¹)	74	63	52	48
Species richness (number)	25	46	61	40
β-Diversity	4.2	5.1	2.77	1.54
Heterogeneity	7.9	17.8	24.4	24.4
Richness index (d)	2.25	3.37	3.94	2.97
Equitability (e)	0.82	0.88	0.87	0.93
Shannon Wiener's index (H)	2.63	3.36	3.58	3.42
Concentration of dominance (C)	0.126	0.056	0.041	0.041

Concentration of dominance ranged from 0.041 (middle saddle peak forest) to 0.126 (littoral forest).

The entire plant population of all the four sites was grouped under different size classes (Fig. 2).

**Fig. 2.** Distribution of plant population in different size classes of Saddle peak forests of Andaman island.

In general, larger accumulation of individuals in first few groups is characteristic of all but littoral forest, which had greater representation in middle size classes. The configuration and structure indicate a 'L' shape, positively skewed asymmetrical distribution of plant populations with increasing size of girth class in inland, foothill and middle saddle peak forest. In littoral forest most population existed in middle size classes, approaching to a normal distribution.

The size distribution quotient was derived to understand the pattern of population dynamics (Table 3). The weighted mean girth of tree species varied from 39 cm (middle saddle peak) to 183 cm (littoral forest). The coefficient of variance (CV%) was relatively less, in littoral, inland and middle saddle peak area in comparison to foothill site ranging from 10.47 (littoral) to 47.62 (foothill site). Index of dispersion (variance/mean) ranged from 2.01 (littoral) to 8.96 (foothill) showing a random distribution of individuals. The degree of asymmetry (skewness) ranged from 0.023 (littoral) to 3.54 (foothill) with a platykurtic frequency distribution as shown by their kurtosis values.

In presently studied forests the tree density ranged from 459 (littoral) to 2681 (middle saddle peak) individuals ha⁻¹, which is compatible to tropical and evergreen forests where tree population has been recorded to as low as (40 individuals ha⁻¹) in subtropical wet forest and as high as 2005 individuals ha⁻¹ in evergreen forest of Brazil or even more (3310-3167 individuals ha⁻¹) in mangrove forest of Guiana (Gilliam *et al.* 1995; Haase 1998; Rao *et al.* 1990). Basal area has been reported as 17 to 40 and 20 to 75 m² ha⁻¹ for dry and wet forest of the world, respectively (Murphy & Lugo 1986). Therefore, the values of present study (48 to 74 m² ha⁻¹) are well comparable with the range.

The species richness of trees ranged from 25 (littoral forest) to 61 (foot hill forest) which is com-

parable with reports available for rain forest (43), moist forest (45), temperate forest, (50) and 40 year-old rehabilitated forest (45) in one-hectare plot area (Brockway 1998; Strasberg 1996; Tripathi 2001; Verma *et al.* 1997). In these forests the species richness positively correlated with diversity index. Species diversity (richness) and dominance (Simpson index) are inversely related to each other and are in agreement to Zobel *et al.* (1976).

Importance value index for individual species in this forest ranged from 1 to 89. The upper range was slightly higher than the reports for subtropical tree species of wet hill forest of India (11 to 52) and to that of tree species of protected forest of Orissa 12 to 55 (Rao *et al.* 1990; Verma *et al.* 1997). Shannon Wiener's index of diversity (H) of presently studied forest (2.6 to 3.6) could be compared with tropical rain forest (3.8 to 4.8) of Silent Valley, India and Barro Colorado Island (Knight 1975; Singh *et al.* 1984). While the Sannon Wiener's index of general diversity for a dry tropical forest of India ranged from 1.9 to 2.8 (Singh & Singh 1991) and for a rehabilitated tropical forest in north India ranged from 3.25 to 3.99 (Tripathi 2001). The higher values of rehabilitated forest was due to their protection from biotic disturbances and introduction of many species through plantations.

In all 111 species belonging to 38 families contributed to composition of Saddle peak forest. A few species like *Aglaia andamanica* Hiern, *Artocarpus gomeziana* Wall ex Trec., *Bombax insigne* Wall. were common in all the sites. The population density ranged from 459 to 2681 individuals ha⁻¹ with their basal area from 48 to 74 m² ha⁻¹, respectively. Foothills were relatively good for high species diversity. Mean girth showed a decreasing pattern from littoral forest (183 cm) to middle saddle peak forest (39 cm). Similar is true for basal area. Size variation was greatest in foothill forest site showing the highest degree of asymmetry as

Table 3. Population size distribution quotients in four sites of Saddle Peak forests of Andaman Island.

Parameters	Littoral forest	Inland forest	Foothill forest	Middle Saddle peak
Mean girth (cm)	183	117	40	39
Variance (CV %)	10.47	18.12	47.62	38.14
Standard deviation (SD)	19.17	21.26	18.80	14.79
Index of dispersion (I.D.)	2.01	3.86	8.96	5.64
Skewness	0.023	0.769	3.54	1.89
Kurtosis	2.03	1.95	0.59	0.022

shown by skewness.

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