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Comparative assessment of floristic structure, diversity and regeneration status of tropical rain forests of Western Ghats of Karnataka, India

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Abstract: Tropical forests are one of the richest landscapes in terms of its richness, diversity and endemicity. The present study was carried out in the Central Western Ghats: one of the hottest hotspot of biodiversity. The aim of the study was to compare floristic diversity in tropical wet evergreen forest between northern and southern parts of Western Ghats of Karnataka. Kodagu district in southern part and Uttara Kannada district in northern part was chosen to assess the same, as these two districts cover highest forest cover in the Western Ghats of Karnataka. In each district all the evergreen forests were sampled with 1000 m X 5 belt transacts. Totally 22 such samplings were done both southern and northern part of Western Ghats. In each of these transacts all the trees measuring e" 30 gbh were enumerated and botanically identified to the species level and the same was used for computation of diversity indices. The richness and diversity was comparatively higher in southern part compared to northern part of Western Ghats, where as the richness of threatened tree species was comparatively higher in northern part of Western Ghats. In addition to the species richness and diversity, the paper also deals with the dominant tree species and families in both the region.

Keywords: Diversity, Evergreen forests, Northern region, Southern region, Species richness

INTRODUCTION

The most striking feature of the earth is the existence of life and the most striking feature of life is diversity (Ram *et al.,* 2004). Much of this diversity is concentrated in the tropics particularly where the conditions are hot and wet. Tropical forests contain over half of the world's biodiversity (WCMC, 1992 and Robinson, 2008). Tropical forests of India are in Assam and the Western Ghats and off shore in the Andaman and Nicobar islands. In the Western Ghats mountains of Karnataka state, rain forests occur up to 1200 m above mean sea level (Rai and Proctor 1986).

Floristic inventory and diversity studies help us to understand the species composition and diversity status of forests (Phillips *et al.,* 2003), which also offer vital information for forest conservation (Gordon and Newton, 2006). Quantitative inventories, moreover, help identify species that are in different stages of vulnerability (Padalia *et al.,* 2004) as well as the various factors that influence the existing vegetation in any region (Parthasarathy, 1999). In this context, the present study was carried out in the rain forests regions of Western Ghats of Karnataka state in particular Kodagu and Uttara Kannada districts to throw light on floristic structure, diversity and regeneration status of rain forest tree species.

MATERIALS AND METHODS

The present study was conducted in the Western Ghats region of Karnataka: one among the 34 hotspots of biodiversity in the world. Since, Kodagu district in southern part of Western Ghats and Uttra Kannada district in northern part of Western Ghats region of Karnataka are having largest area under tree cover and also under tropical rain forests (FSI, 1995), these two regions were chosen for the present study.The study area was divided into grids of 6.25 km^2 by using MapInfo software. In each region 11 grids (Fig 1.) under wet evergreen forests were chosen for the present study. The sampling was undertaken based on the methodology developed by Department of Biotechnology (DBT) sponsored project on 'Mapping and quantitative assessment of geographical distribution and population status of plant resources of Western Ghats' (DBT Grid method) (Shivraj *et al.,* 2000). In each grid a total area of 5000 m^2 was sampled using belt transects of 1000 meter length and 5 meter width. Depending on the heterogeneity of the grid the 1000 meter belt transect was divided into two belt transects of 500 length and 5 meter width. In

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order to place this belt transects randomly in the 6.25 km^2 grid, Normalized Difference value Index (NDVI) was used, which was calculated by using satellite images of different seasons and the average of different seasons was finally computed (Fig 2.) . Within each belt transect two smaller quadrates of 5 m^2 were laid for regeneration studies.

All the trees≥30 cm at 1.37 meter height (gbh) within the transect were botanically identified to the species level by using field guides (Pascal and Ramesh, 1987) and local floras Saldanha,1996; Keshavmurthy and Yoganarasimhan, 1990; Bhat, 2003). The regeneration of tree species enumerated were grouped into four regeneration classes cviz., Class I - upto 40 cm height, Class II - 40-100 cm height, Class III – more than 100 cm height and less than 10 cm gbh and Class IV - more than 100 cm height and 10-30 cm gbh.

The data was used to compute, species richness (Menhinick's index) diversity (Shannon's diversity) Importance value index (Curtis and McIntosh, 1951) for species and families, density and basal area, girth class distribution. Student't' test was used to know level of significance of species richness, density and basal area between the two regions.

RESULTS AND DISCUSSION

Species richness and diversity of trees: Species richness is the simplest way to describe community and regional diversity (Magurran, 1988) and this variable number of species forms the basis of many ecological models of community structure (Macarthur and Wilson, 1967; Connell, 1999). Richness and diversity of tree species was comparatively higher in southern part of Western Ghats (3.45 and 4.49) compared to northern part of Western Ghats (2.99 and 4.08) as indicated by Menhinick's index and Shannon's diversity respectively (Table 1), which is on par with the earlier studies by (Elouard, 2000).

The mean number of species reported from the present study was intermediate between the earlier reports by Pascal (1986) Kushalappa and Kushalappa (1998). The mean number of species richness in evergreen forests of northern part of Western Ghats of Karnataka was relatively higher the earlier reports by Chandran and Gadgil (1993). Number of genera and families in evergreen forests of Kodagu and Uttara Kannada were higher than in the evergreen forests of Kerala (Bhuyan *et al.*, 2003). There was no significant difference in the richness of threatened and endemic species between southern and northern part of Western Ghats of Karnataka (Table 2)

Importance value of tree species: Importance Value Index indicates the dominant species and their importance in a community. *Lagerstroemia lanceolata* was the most

Table 1. Tree species richness and diversity.

Diversity and richness parameters	Southern region	Northern region
No. of Individuals	2700	2295
Menhinick's index	3.45	2.99
Shannon's diversity index	4.49	4.08
Avalanche	1.53	1.88

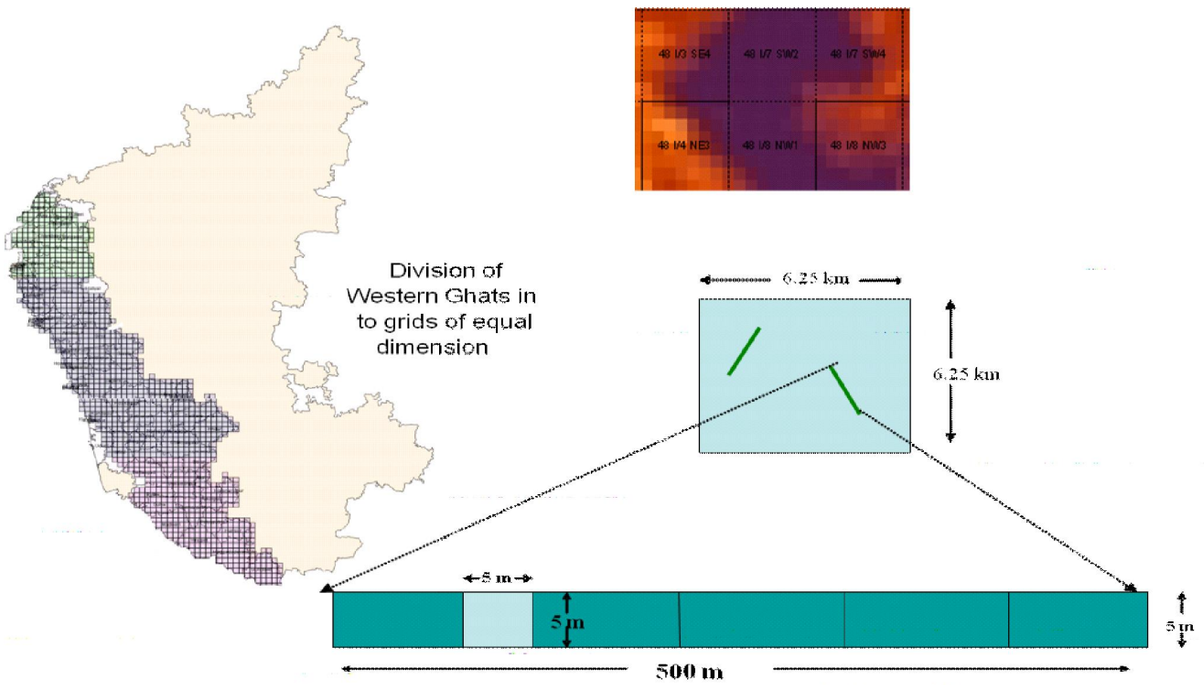

Fig. 1. *Pictorial representation of DBT grid sampling design.*

Southern regio

Table 2. Richness of species, genera and families per hectare in the tropical rain forests of Western Ghats of Karnataka

Richness parameters	Southern region	Northern region	
	Mean±SD	Mean ± SD	P value
Species observed	111.82±26.65	94.55±13.09	0.038108
Genera richness	91.82±24.99	78.00±10.39	0.076401
Family richness	57.64±12.29	52.00±6.00	0.125731
Threatened species richness	13.64±4.63	16.73±4.22	0.093345
Threatened genera richness	12.00±3.69	14.00±3.46	0.139566
Threatened family richness	11.09±3.02	12.55±3.24	0.188681
Endemic species richness	30.18±10.10	31.27±4.13	0.378349
Endemic genera richness	25.09±7.45	25.64±3.56	0.420336
Endemic family richness	18.36±4.72	20.55±2.38	0.116079

Table 3. Dominant tree species tropical rain forests of Western Ghats of Karnataka**.**

Southern region		Northern region	
Species	**IVI**	**Species**	**IVI**
L. lanceolata	10.82	*K. attenuata*	15.86
E. tuberculatus	10.72	*O. dioica*	14.96
D. longan	10.51	*S. pinnata*	14.80
C.strictum	9.37	*H. ponga*	11.27
H. glabra	8.66	*S. gardneri*	7.83
A. hirsutus	8.47	*F. nervosa*	7.18
M. ferrea	7.23	*D. indicus*	7.09
S. alata	6.61	*A. roxburghii*	6.93
O. dioica	5.67	*H. grahamii*	6.79
T. ciliate	5.05	*G. gummi-gutta*	6.75

Table 4. Dominant threatened trees in the tropical rain forests of Western Ghats of Karnataka.

Southern region		Northern region	
Species	IVI	Species	IVI
C. strictum	9.37	*K. attenuate*	15.86
A. hirsutus	8.47	*G. gummi-gutta*	6.75
D. indicus	2.74	*P. macrantha*	5.76
M. dactyloides	2.35	*D. paniculata*	4.93
G. gummi-gutta	2.25	*G. morella*	4.31
P. macrantha	2.18	*D. candolleana*	3.98
M. malabarica	1.38	*M. dactyloides*	3.48
M. neriifolia	1.36	*A. hirsutus*	2.52
G. Morella	1.25	*H. pentandra*	2.42
C.macrocarpum	0.87	*C. strictum*	2.41

dominant tree in southern region and the other dominant trees were *Elaeocarpus tuberculatus, Dimocarpus longan, Canarium strictum, Hopea glabra* (Table 3). It is interesting to note that a deciduous tree is the most dominant one indicating that the forests have been subjected disturbances resulting in modification of forest structure and composition. The dominant species obtained from the present study is on contrast with the other studies by FSI (1995); Kushalappa and Kushalappa (1998); Jeevan (2007).

Knema attenuata (15.86 out of 300) was most dominant species in evergreen forests of northern region and other dominant trees were *Olea dioica, Spondias pinnata, Hopea ponga, Syzygium gardneri*, which is on par with the earlier report (Chandrashekarareddy, 2007).

Endemics are believed to be vulnerable to extinction because of their restricted distributions. A large number of endemic trees in the Western Ghats are also evergreen (Ramesh and Pascal, 1997). *H. glabra* and *Knema attenuate* in southern and northern regions respectively

Northern region

Table 5. Ten dominant endemic trees in the tropical rain forests of Western Ghats of Karnataka.

Southern region		**Northern region**	
Species	IVI	Species	IVI
H. glabra	8.66	*K. attenuata*	15.86
F. beddomei	4.36	*H. ponga*	11.27
D. malabaricum	4.28	*D. indicus*	7.09
D. paniculata	3.62	*H. grahamii*	6.79
P. ellipticum	3.45	*G. gummi-gutta*	6.75
A. barberi	3.00	*I. brachiata*	5.41
C. malabathrum	2.82	*H. arnottiana*	5.31
D. indicus	2.74	*D. paniculata*	4.93
C. apetalum	2.53	*D. candolleana*	3.98
H. grahamii	2.42	*M. malabarica*	3.68

Table 6. Mean density and basal area of trees species (per hectare) and their level of significance

Parameters	**Southern region**	**Northern region**	**P value**
Mean density of total tree species	491.09 ±48.04	417.77±118.44	0.069
Mean density of endemic trees	110.91±52.96	193.45±108.69	0.025*
Mean density of threatened trees	54.73±29.78	89.09±49.77	0.043*
Mean basal area total tree species	47.12 ±16.88	41.54 ±8.10	0.336
Mea basal area of endemic trees	11.51441±9.93	12.59436±7.94	0.402
Mean basal area of threatened trees	7.03±7.59	6.35±2.77	0.376

*Significant ($p < 0.05$)

Table 7. Richness and diversity of regenerates in the tropical rain forests of Western Ghats of Karnataka

Diversity parameters	**Southern region**	**Southern region**
Total number of individuals captured	234	355
Menhinick's index	6.47	5.84
Shannon's diversity Index	4.33	4.33
Avalanche index	1.70	1.35

have ranked first among the ten dominant endemic trees. *Diospyros paniculata*, *Dipterocarpus indicus*, *Holigarna grahamii* were the other three dominant trees common in both the regions. Among the threatened tree species, *Canarium strictum* (9.37) in southern region and *Knema attenuata* (15.86) in northern region ranked first. *C. strictum, Artocarpus hirsutus, Myristica dactyloides, Garcinia gummi-gutta,* and *Persea macrantha* were common in both the regions (Tables 4 and 5). The varied distribution and dominance of species across the sites could be attributed to the topography of the region and micro environmental condition (Pelissier, 1997).

Importance value of families: Euphorbiaceae was the most dominant family in southern region followed by Anacardiaceae, Moraceae, Lauraceae, Sapindaceae, Dipterocarpaceae, Elaeocarpaceae, Meliaceae, Oleaceae and Sapotaceae. The relative diversity of families was very low in Sapindaceae, Elaeocarpaceae and Oleaceae (Fig. 3). Among the dominant families Anacardiaceae was the only family which is common to both the regions.

Table 8. Level of significance of richness of regenerates in the tropical rain forests of Western Ghats of Karnataka.

Richness parameters	**Southern region**	**Northern region**	
	Mean ± SD	**Mean ± SD**	**P value**
Species richness	472.73 ± 133.11	347.11 ± 142.81	0.0197
Genera richness	413.22 ± 109.12	337.19 ± 137.12	0.0697
Family richness	317.36 ± 81.86	252.89 ± 85.46	0.0489
Threatened Species richness	79.34 ± 31.78	28.10 ± 23.52	0.0007
Threatened Genera richness	72.73 ± 25.71	28.10 ± 23.52	0.0010
Threatened family richness	67.77 ± 20.07	28.10 ± 23.52	0.0011
Endemic species richness	152.07 ± 46.19	67.77 ± 34.58	0.0005
Endemic genera richness	140.50 ± 39.07	67.77 ± 34.58	0.0011
Endemic family richness	132.23 ± 29.42	54.55 ± 35.44	0.0002

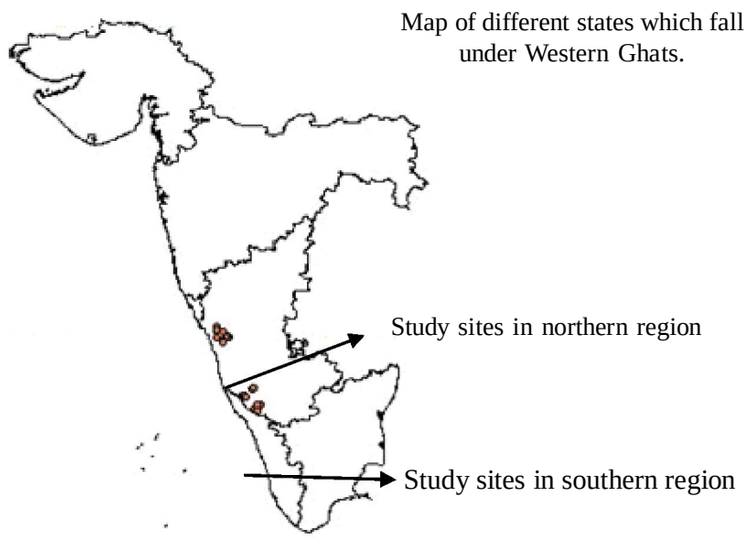

Fig.2. *Location of study sites in the Western Ghats region of Karnataka state.*

The dominance of this family was mainly contributed by *Anacardium occidentale* which is being planted extensively in the forested areas of both the regions for commercial harvesting of its seeds and fruits. It is interesting to note that Moraceae family consisting of keystone species (Ficus species) is one of the dominant families in the forests southern region. Dipterocarpaceae and Lauraceous had highest proportion of endemic and threatened species which is present only in southern region. Pascal (1988) had also reported that Dipterocarpaceae, Euphorbiaceae, Anacardiaceae and Meliaceae were some of the dominant families reported from the evergreen forests of this region.

Family Importance Value Index varied drastically among the top ten families in the northern region. The most dominant family was Anacardiaceae, followed by Annonaceae, Apocynaceae, Bignoniaceae, Bombacaceae, Burseraceae, Celastraceae, Clusiaceae, and Cornaceae (Fig 4). Even though the relative diversity of Anacardiaceae was low, relative density and relative dominance contributed for the dominance of the family. Chandrashekarareddy (2007) has also indicated that, Anacardiaceae was the most dominant family in this region. The dominant families of the present study were similar to that of earlier study by Parthasarthy (1999). This trend indicates the tolerance of members of these families to wider ecological amplitude.

Density and basal area: Mean density of tree species

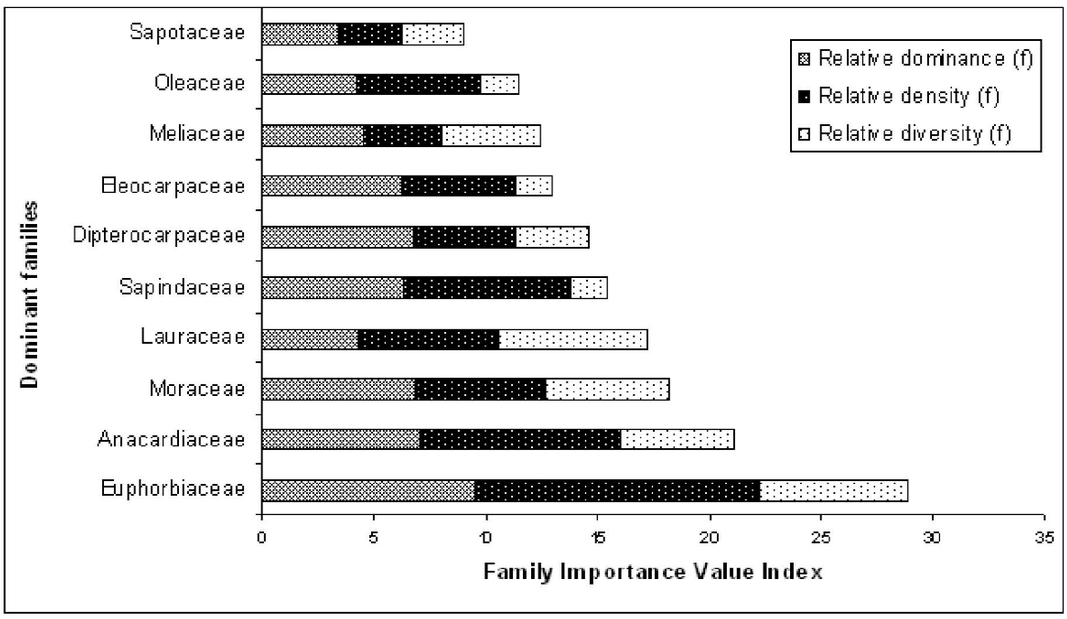

Fig. 3. *Dominant families based on family importance value index (FIVI) in the southern region of Western Ghats of Karnataka*

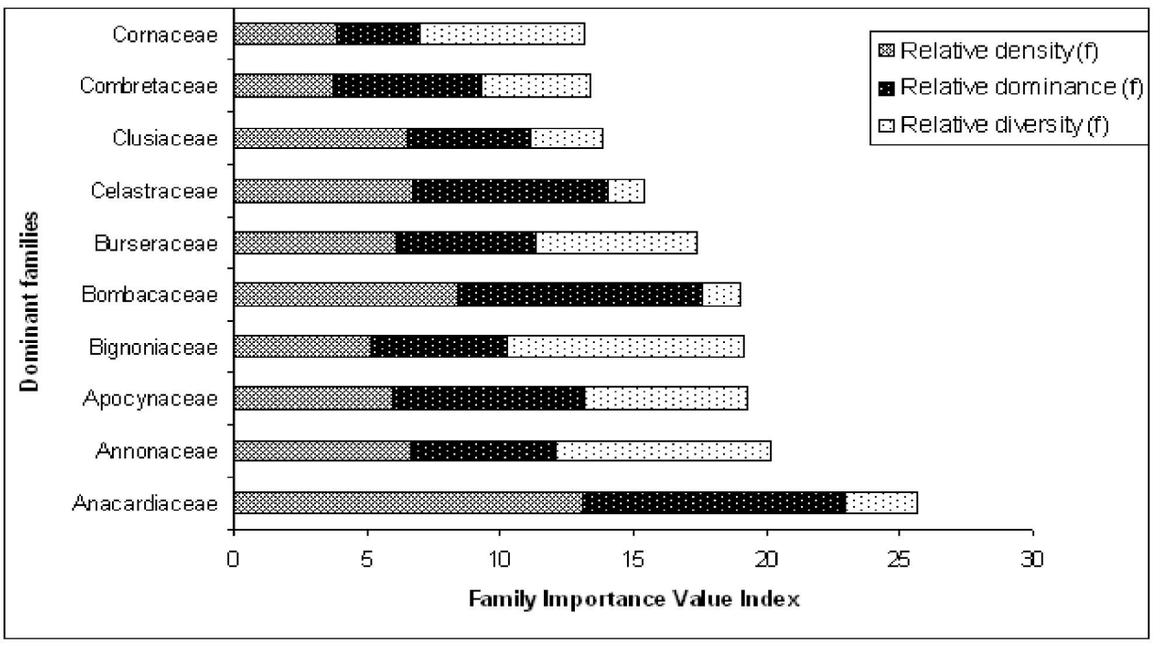

Fig 4. *Dominant families based on family importance value index (FIVI) in the northern part of Western Gats of Karnataka.*

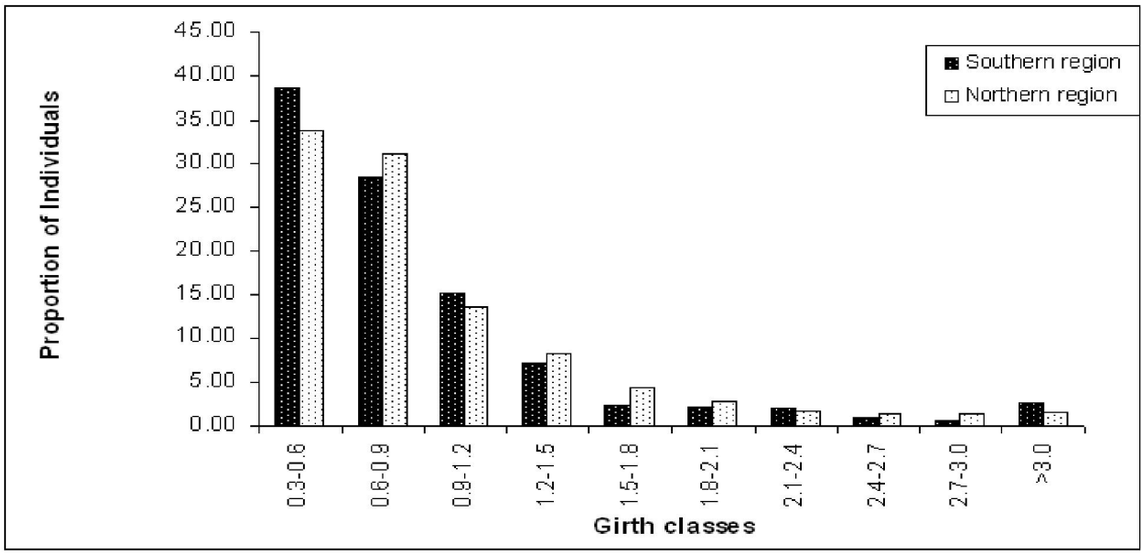

Fig. 5. *Girth class distribution of tree species in evergreen forests of Kodagu and Uttara Kannada (D max = 0.049651)*

were relatively higher in southern region (491.09 ± 48.04/ ha) than in northern region (417.77 ± 118.44) (Table 6). The mean number of stems in both the regions were comparable with the mean density of 419 tree/ ha in the Western Ghats region (Parthasarthy, 2001; Ghate *et al.*, 1998; Parthasarthy, 1998; Ganesh *et al.*, 2001) and intermediate between the earlier reports by Jeevan (2007) Kushalappa and Kushalappa (1996), Chandran and Gadgil, (1993) and Chandrashekarareddy (2007) in the present study locations.

Basal area of all the tree species, threatened trees and endemic trees (47.12 ±16.88, 11.51441±9.93 and 7.03±7.59) respectively were also comparatively higher in evergreen forest of southern Western Ghats region of Karnataka compared to northern region (41.54 ±8.10, 12.59436±7.94 and 6.35±2.77) (Table 6). The values of basal area in the forests of southern region were intermediate between the basal area values reported for worked and unworked forests reportted by Kushalappa and Kushalappa, 1996 and on par with the earlier reports by Chandran and Gadgil, 1993; Ayappa and Parthsarthy, 1999 and Misra, 2001.

Girth class distribution of tree species: Highest proportion of stems were recorded in the girth classes

between 0.3 to 0.9 meters and their distribution pattern has followed inverse 'J' shape pattern in evergreen forests of both the regions (Fig 5) indicating normal distribution of stems across the girth classes (healthiness of forests). Similar pattern of girth class distribution of tree species were also reported by Pascal and Pelisser, 1996; Parthasarthy, 1999; Ganesh *et al.,* 2001; Raghu, 2003 and Chandrashekarareddy, 2007 from the different evergreen forests of Western Gahts .

Richness and diversity of regenerates in evergreen forests of northern and southern part of Western Ghats of Karnataka

The regeneration of tree species in the tropical evergreen forests was higher in southern part of Western Ghats (6.47 as indicated by Menhinick's index) compared to that of northern part of Western Ghats of Karnataka (5.84). Even though the diversity of tree species was relatively higher in southern region, diversity of regenerates was similar in both northern and southern part of Western Ghats of Karnataka. Avalanche index of regenerates was higher in southern part of Western Ghats of Karnataka (1.70) indicating the regenerates were of different genera and families compared to northern part of Western Ghats of Karnataka (1.35) (Table 7). Density of regenerates (per ha) was significantly higher in southern part of Western Ghats (472.73±33.11) compared to northern part of Western Ghats (347.11±142.81). The regeneration of tree species is greatly influenced by interaction of biotic factors and the environment factors (Boring *et al.,* 1981; Lange and Graham, 1983 and Khan *et al.,* 1986). Such favored interactions and also relatively lower disturbance levels as evidenced by Cumulative Disturbance Index could be attributed to healthy regeneration in southern part of Western Ghats compared to that of northern part of Western Ghats.

Regeneration of threatened and endemic trees species was also better in terms of number of regenerates per hectare (Table 8) in southern part of Western Ghats compared to that of northern part. Regenerates of threatened and endemic tree species and there belongingness to different genera and families was significantly higher in southern region compared to northern region indicating higher heterogeneity of future forests of southern forests southern region of Western Ghats of Karnataka.

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