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Tree growth, mortality and recruitment in four tropical wet evergreen forest sites of the Kolli hills, eastern ghats, India

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Abstract: Patterns of tree growth, mortality and recruitment in four permanent plots of tropical wet evergreen forest in Kolli hills of the eastern ghats, India, were investigated between 1996 and 1999. Permanent tree plots of 2 ha (200 m x 100 m) were established in four evergreen forest sites- Perumakkai shola (PS), Vengodai shola (VS), Kuzhivalavu shola (KS) and Mottukadu shola (MS) along an elevational and disturbance gradient. A total of 3814 trees ≥30 cm girth at breast height from 78 species and 36 families were enumerated. There was no change in species richness during the study period. Mean stand basal area increased by 4.1 %. Basal area increment was maximum in the highly disturbed site MS and minimum in the relatively undisturbed site PS (11.6% and 1.7% respectively). Range of growth variation in species increased with forest disturbance and conspecifics exhibited variation within and across sites. Mortality was independent of tree size. Mortality rates exceeded recruitment rates and the stand turnover time was calculated to be 136 years.

Resumen: Entre 1996 y 1999 fueron investigados los patrones de crecimiento, mortalidad y reclutamiento de árboles en cuatro parcelas permanentes de bosque siempreverde tropical en las colinas Kolli de los Gates Orientales, India. Las parcelas permanentes de 2-ha (200 m x 100 m) para los árboles fueron establecidas en cuatro sitios de bosque siempreverde, Perumakkai shola (PS), Vengodai shola (VS), Kuzhivalavu shola (KS) y Mottukadu shola (MS), a lo largo de un gradiente de elevación y disturbio. En total fueron enumerados 3814 árboles ≥ 30 cm de perímetro a la altura del pecho, pertenecientes a 78 especies y 36 familias. No hubo ningún cambio en la riqueza de especies durante el periodo de estudio. El área basal promedio de los rodales se incrementó en un 4.1 %. El incremento en área basal alcanzó su máximo en el sitio MS, que estaba fuertemente perturbado, y su mínimo en el sitio PS, relativamente poco perturbado (11.6% y 1.7%, respectivamente). La amplitud de la variación del crecimiento en las especies se incrementó con el grado de disturbio del bosque y los individuos conespecíficos mostraron variación dentro y entre sitios. La mortalidad fue independiente del tamaño del árbol. Las tasas de mortalidad excedieron a las de reclutamiento y se calculó que el recambio en los rodales es de 136 años.

Resumo: Os padrões de crescimento arbóreo, a mortalidade e a regeneração em quatro parcelas permanentes em floresta sempre verde tropical húmida nos montes de Kolli, nos Gates Orientais, Índia, foram investigados entre 1996 e 1999. As parcelas permanentes de 2 ha (200 m x 100 m) foram instaladas em quatro estações florestais sempre verdes – Peramakkai shola (PS), Vengodai shola (VS), Kuzhivalavu shola (KS) e Mottukadu shola (MS) ao longo de um gradiente elevacional e de alteração. Foi enumerado um total de 3814 árvores ≥ 30 cm de perímetro à altura do peito de um conjunto de 78 espécies e de 36 famílias. Não ouve mudança na riqueza específica durante o período de estudo. A área basal média da parcela cresceu 4,1 %. O acréscimo da área basal foi máximo na estação fortemente disturbada MS e mínimo na esta-

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ção relativamente pouco alterada PS (11,6% e 1,7%, respectivamente). O intervalo de variação do crescimento em espécies aumentou com a alteração da floresta e os elementos da mesma espécie exibiram variação dentro e através das estações. A mortalidade foi independente da dimensão das árvores. As taxas de mortalidade excederam a regeneração e o tempo de retorno da parcela foi calculado em 136 anos.

Key words: Anthropogenic impact, biomonitoring, eastern ghats, permanent research plots, tree growth, turnover.

Introduction

The installation and re-inventory of permanent tree plots are important prerequisites for the investigation of tropical forest diversity and ecological processes (Phillips *et al.* 1998). Many ecological studies examine population changes using census information gained by counting and later recounting a defined sample and assessing survivors, losses and gains (Sheil & May 1996).

Primary forests of Asia, particularly those of the western ghats and eastern ghats of India are disappearing at an alarming rate due to anthropogenic activities and are replaced by forests comprising secondary species or their land use pattern changes (Parthasarathy 1999). Studies reporting demographic parameters of a wide variety of species from a single community are needed to properly evaluate life history paradigms of tropical forest trees (Hubbell & Foster 1986).

The large-scale loss of primary forests comes at a time when our knowledge on their structure and dynamics is woefully inadequate (Hubbell & Foster 1992). This lays emphasis on a ground – based monitoring network of long–term, fully identified tropical forest plots (Phillips 1995). Phillips (1996) analysed tree turnover data from 67 mature forest sites, representing most of the major tropical forest regions of the world and found that there has been a significant increase in tree turnover since 1950's. The effects of increased tree turnover may include impacts on future global atmosphere, climate and biodiversity.

In India, permanent tree plots have been established in Mudumalai Game Reserve (Sukumar *et al.* 1992, 1998), Uppangala reserve forest (Pascal & Pelissier 1996) and in Varagalaiar, Anamalasis (Ayyappan & Parthasarathy 1999). Data on tree mortality is available for a thirty – seven year period from the Devimane, Katlekan and Malimane areas of the western ghats (Rai 1981). Quantitative biodiversity inventories have been conducted in the Shervarayan (Kadavul & Parthasarathy 1999a), Kalrayan (Kadavul & Parthasarathy 1999b) and Kolli hills (Chittibabu & Parthasarathy 2000), but no studies on growth, mortality and recruitment exist to date in these areas.

The Indian eastern ghats is delimited in the north by the khondmal hills of Orissa. The middle section extends from Krishna (Andhra Pradesh) to near about Chennai (Tamil Nadu) and includes the Nallamalai, Palkonda and Velikonda hills. The last section runs in a S–SW direction meeting the western ghats in the Nilgiris, and near which are the Javadis, the Kolli hills, the Pachaimalai, the Kalrayan, the Shervarayan and tha Biligirirangan hills (Legris & Meher–Homji 1984). These hills possess patches of evergreen forest (locally known as 'sholas') at higher elevations. During May 1996 and June 1997, four permanent plots were established in the wet evergreen forests of the Kolli hills, easttern ghats for the purpose of quantitative plant biodiversity inventory (Chittibabu & Parthasarathy 2000). This paper presents the results of the recensus carried out in 1999 to assess growth, mortality and recruitment of all trees ≥ 30 cm gbh (girth at breast height).

Study area

The study area is situated in the Kolli hills (11°10′ – 11°30′ N and 78°15′ – 78°30′ E) of the eastern ghats, south India. The Kolli hills like other hills of the southern eastern ghats comprises masses of charnockite associated with gneisses and various metamorphic rocks. The mountainous part has a thin veneer of soil and the plains possess ferruginous sandy soil. The study was carried out in four sites of tropical evergreen forest, namely, Perumakkai shola (PS; elevation 1000 m), Vengodai shola (VS; 1050 m), Kuzhivalavu shola (KS, 1200 m) and Mottukadu shola (MS; 1250 m). These sholas are located 1 to 7 km apart.

Climatological data of Salem (11°39′ N and 78°10′ E, 278 m above mean sea level), the nearest station to the study area, available for a 30 year period (1951-1980), reveals a mean annual temperature of 28.3°C and a mean annual rainfall of 1014 mm. The mean monthly temperature ranged from 25°C during December – January to 31°C in April-May for the same period (minimum temperature 19.2°C, maximum 37.2°C). The study area normally receives bulk of its rainfall during the south-west (June-September) and north-east (retreating) monsoons (October-November), every year.

Evergreen forests in the eastern ghats occur in isolated patches and the Kolli hills harbour such forests from 900 m above mean sea level. The Kolli hills *per se* covering an area of 282.93 km^2 consists of heterogenous vegetation along an elevation gradient. The foothills bear scrub vegetation, and dry deciduous, mixed deciduous and evergreen forests with increasing elevation. The evergreen patches of forests are 2-3 storied and have robust, tall (~30 m) trees with dense crowns.

Eventhough the Kolli hills comes under the reserve forest category, the inhabitants have unlimited and unspecified rights of felling, lopping and herding cattle for grazing or browsing. For the past five years, removal of c. 600 Mg of soil day^{-1} for cement and aluminium factories is an indication of human exploitation of natural resources in the area. Further reports on disturbance (Chittibabu & Parthasarathy 2000) revealed the following: (a) browsing by cattle and goats (~30 cows and ~50 goats everyday) in the highly disturbed site MS, (b) firewood collection in sites KS and MS and (c) cultivation of horticultural crops like pineapple, banana, jackfruit, mango, pepper, cloves and agricultural crops like paddy, ragi and tapioca close to the sites KS and MS. Based on the above mentioned activities our four study sites can be graded as relatively undisturbed (site PS), sporadically disturbed (site VS), frequently disturbed (site KS) and highly disturbed (site MS). The increasing order of disturbance shall be represented as PS<VS<KS<MS.

Methods

One plot of 2 ha (200 m x 100 m) of largely mature phase forest was investigated in each of the four sites. During the initial inventory (Chittibabu & Parthasarathy 2000), all trees ≥30 cm gbh were identified and appended with sequentially numbered aluminium tags. The permanent tree plots were each sub-divided into two hundred 10 m x 10 m quadrats. Each tree tag number was verified and its species reconfirmed by collecting a voucher specimen and its girth measured at breast height (1.3 m); those with buttresses were measured above the latter. Field assistants were equipped with measuring tapes and a 1.3 m pole to facilitate uniform measurement of girth. In the case of trees with multiple stems, each stem was measured separately. In the case of trees that had lost their tags, the species and its girth was compared to previous data and also to its nearest neighbors to ensure measurement of all trees. Original inventory trees that were dead or had disappeared were classified as dead. Trees whose stems had broken off or been cut, but were resprouting were considered alive. Each 10 m x 10 m quadrat was scanned for recruits to 30 cm gbh. Recruits were appended with aluminium tags (number distinguishable from those of original inventory) and voucher specimens were collected. All trees were identified from their vegetative and reproductive features using the regional floras (Gamble & Fischer 1915-1935; Henry *et al.* 1987, 1989; Matthew 1991; Nair & Henry 1983) and the field key of Pascal & Ramesh (1987). A six-letter code was assigned to all species (for floristic structure) with the first three letters denoting the generic name and the next three letters, the specific epithet. For taxa with variety or subspecies names, an additional three-letter code was given. Voucher specimens were corroborated with the herbarium of Botanical Survey of India, Coimbatore (MH) and deposited in the herbarium of School of Ecology, Pondicherry University. Fieldwork on recensus was conducted in June 1999 and December 1999.

Growth was measured for all trees of the original inventory in cm and rounded it off to the nearest mm. Due to the difficulty involved in measuring the girth of strangling figs and their host trees, they were excluded from the analysis. The population structure and basal area for all trees ≥30 cm gbh were recorded using data of girth frequency

Table 1. Changes in species richness, density and basal area between 1996 inventory and 1999 recensus of trees ≥ 30 cm gbh in four sites of tropical evergreen forest in the Kolli hills, eastern ghats.

Variables	Site									
	PS		VS		KS		MS		Total	
	1996	1999	1996	1999	1996	1999	1996	1999	1996	1999
Number of species	58	57	51	51	42	42	39	39	78	78
Mean stand density (stems ha^{-1})	527	529	576	569	326	326	485	485	478	477
Mean stand basal area (m^{2}ha^{-1})	53.0	53.9	46.6	48.0	51.5	53.8	23.3	26.0	43.6	45.4

collected during the 1996 initial census and the 1999 recensus. The minimum, median and maximum girth increment rates were calculated for all species, and the results presented here are for those species represented by ≥ 25 individuals in each 2 ha plot.

Mortality was defined as death or disappearance. Four different modes of death were recorded: cut, uprooted, standing dead and trunk snapped off. Mortality rate (m) was calculated using the formula $m = 1/t\ [(N_0\text{-}N_t)/N_0]$, where N_0 is number of trees in original inventory, N_t is number of trees after the 1999 recensus, t is the time between N_0 and N_t (Sheil & May 1996). A Chi-square test was performed (Sokal & Rohlf 1995) to examine the relationship between tree girth class and mortality.

During the re-enumeration of trees, individuals recruiting into the 30 cm girth class were recorded. Stand turnover time, i.e. the number of years necessary for all of the originally inventoried trees to die, was calculated as number of original inventory trees/dead trees/years of observation (Rankin de Merona *et al.* 1990).

Results

Changes in forest structure and species composition

The density of trees showed little change over the three-year interval in the four sites of tropical wet evergreen forest at Kolli hills, eastern ghats (Table 1). The mean stand basal area increased by 4.1%, i.e. from 43.6 m^2 ha^{-1} in 1996 to 45.4 m^2 ha^{-1} in 1999. In the highly disturbed site MS, the mean basal area in 1999 was 26.0 m^2 ha^{-1}, 11.6% more than 1996. In the relatively undisturbed site PS, the increase in mean basal area was just 1.7% for the same period. The girth class distributions in 1996 and 1999 for the four sites do not show much change (Fig. 1).

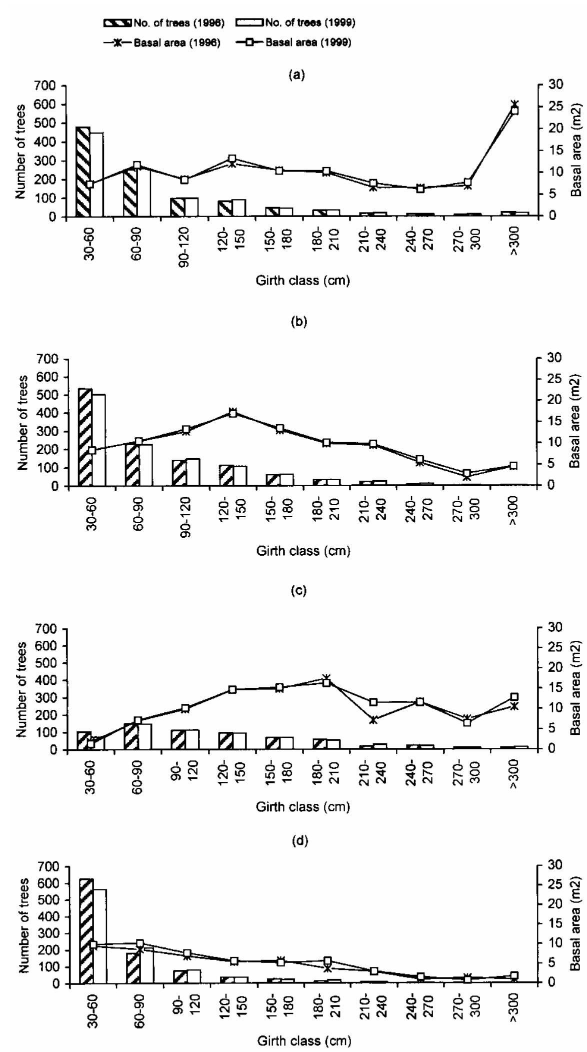

Fig. 1. Girth class distribution and basal area representation of each girth class of trees ≥30 cm gbh in 1996 inventory and 1999 recensus in the four sites – (a) site PS, (b) VS, (c) KS, and (d) MS of the Kolli hills, eastern ghats.

The total species richness of the four study plots remained the same (78 species) over three years (Table 1). In site PS, the loss of a lone individual of *Ficus beddomei* (Moraceae) brought the species richness down to 57. The best-represented families in terms of density were Melastomataceae (847), Lauraceae (738 individuals in 8 ha), Oleaceae (244), Euphorbiaceae (241), and Moraceae (202), (Table 2). The most speciose families were Moraceae (10 species), Lauraceae (8 species), Euphorbiaceae (7 species), and Meliaceae (4 species) (Appendix 1).

Patterns of growth

Growth in terms of girth increment per tree ranged from 1.42 cm yr^{-1} in site PS, 1.74 cm yr^{-1} in VS, 2.94 cm yr^{-1} in KS and 2.60 cm yr^{-1} in MS. The minimum, median and maximum growth rates in terms of girth increment were calculated for all species and results presented here are for species represented by ≥25 individuals in each site (11 species in site PS, 11 species in VS, 8 species in KS, 7 species in MS, a total of 23 species, Fig. 2). Minimum girth increment rates ranged between almost no growth in *Meliosma simplicifolia* (Sabiaceae) and *Persea macrantha* (Lauraceae) in site KS to 0.8 cm yr^{-1} in *Phoebe wightii* (Lauraceae) in site MS. Mean of minimum girth increment rates was 0.3 cm yr^{-1}. Maximum girth increment rates varied from 1.0 cm yr^{-1} (*Persea macrantha* in site VS) to 5.2 cm yr^{-1} (*Syzygium cumini* [Myrtaceae] in site MS) and the mean was 2.6 cm yr^{-1}. Median girth increment rates ranged from c. 0.8 cm yr^{-1} (*Antidesma menasu* [Euphorbiaceae] and *Alseodaphne semecarpifolia* [Lauraceae] in site PS, *Olea dioica* [Oleaceae] and *Artocarpus heterophyllus* in VS, *Memecylon umbellatum* [Melastomataceae] and *Persea macrantha* in KS) to 1.6 cm yr^{-1} (*Syzygium cumini* and *Phoebe wightii* in MS). The mean of median girth increment rates was 0.9 cm yr^{-1}. The means of the minimum, median and maximum girth increment rates for each of the sites were 0.25, 0.76 and 2.55 cm yr^{-1} respectively (site PS), 0.25, 0.71 and 1.75 cm yr^{-1} (VS). 0.24, 1.0 and 3.18 cm yr^{-1} (KS), and 0.5, 1.49 and 3.36 cm yr^{-1} (MS). The difference between minimum and maximum girth increment rates was least for *Persea macrantha* (0.7 cm yr^{-1}, site VS) and greatest for *Meliosma simplicifolia* (5.1 cm yr^{-1}, site KS, Fig. 2). The mean difference in girth increment of trees in the four study sites was 2.31 cm yr^{-1} which was approached by *Olea dioica* (2.4 cm yr^{-1}) in VS, *Memecylon umbellatum* and *Persea macrantha* (2.33 and 2.26 cm yr^{-1}) in site KS and *Phoebe wightii* (2.5 cm yr^{-1}) in site MS.

Mortality

A total of 84 trees died during the period 1996 and 1999 in the four study sites. The annual mortality rate (m), for the entire forest stand was calculated to be 0.73%. Mortality rates for individual sites ranged from 0.51% in site PS, 0.51% in VS, 0.52% in KS and 0.53% in MS (Table 2). There is no evidence that mortality is dependent on tree size ($\chi^2 = 15.03$, $p < 0.02$, d.f. = 6). The number of trees dying in each site ranged from 16 trees in site PS, 25 in VS, 23 in KS and 20 trees in site MS (Table 2). In site PS, all trees died of natural

Table 2. Summary of tree mortality and recruitment during 1996-1999 with probable cause of death and original inventory population in the four sites of the Kolli hills, eastern ghats.

Dead tree status	Number of trees in each site				
	PS	VS	KS	MS	Total by category
Cut	0	6	11	14	31
Uprooted	8	9	4	1	22
Standing dead	4	5	4	5	18
Trunk snapped off	4	5	4	0	13
Total number of trees	1054	1151	651	969	3825
Total dead trees by site	16	25	23	20	84
Mortality rate (% yr^{-1})	0.51	0.51	0.52	0.53	0.73
Recruitment by site	21	12	22	18	73
Recruitment rate (% yr^{-1})	0.66	0.35	1.13	0.62	0.64

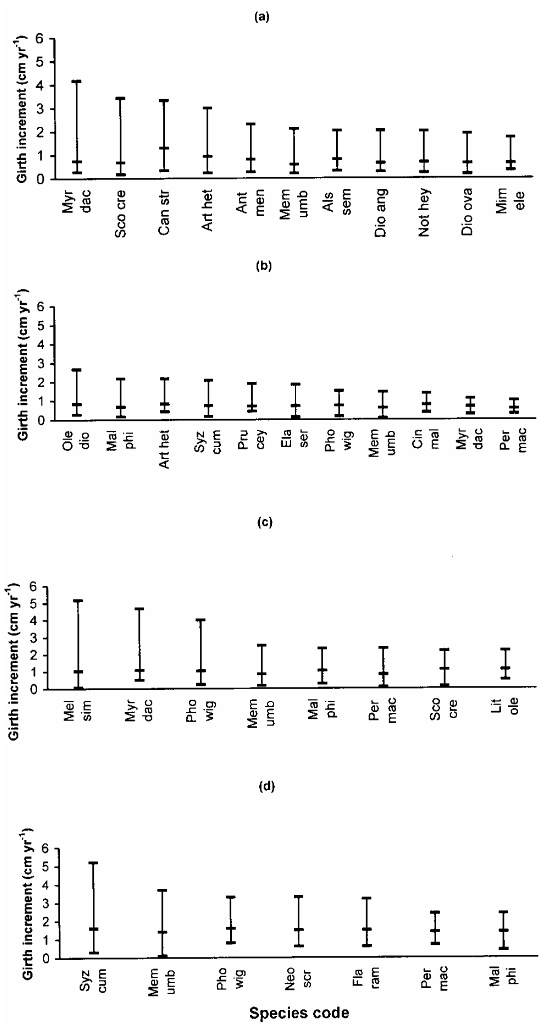

Fig. 2. Minimum, median and maximum girth increment rates presented in decreasing order of variation, i.e. difference between maximum and minimum girth increment rate of species represented by ≥25 individuals in each of the site – (a) site PS, (b) VS, (c) KS and (d) MS of the Kolli hills, Eastern Ghats. Key to the species codes: Myr dac – *Myristica dactyloides,* Sco cre – *Scolopia crenata*, Can str – *Canarium strictum*, Art het – *Artocarpus heterophyllus*, Ant men – *Antidesma menasu*, Mem umb – *Memecylon umbellatum*, Als sem – *Alseodaphne semecarpifolia*, Dio ang – *Diospyros angustifolia*, Not hey – *Nothopegia heyneana*, Dio ova – *Diospyros ovalifolia*, Mim ele – *Mimusops elengi*, Ole dio – *Olea dioica*, Mal phi – *Mallotus philippensis*, Syz cum – *Syzygium cumini*, Pru cey – *Prunus ceylanica*, Ela ser – *Elaeocarpus serratus*, Pho wig – *Phoebe wightii*, Cin mal – *Cinnamomum malabatrum*, Per mac – *Persea macrantha*, Mel sim – *Meliosma simplicifolia*, Lit ole – *Litsea oleoides*.

causes, as opposed to site MS, where illegal tree felling caused 70% of deaths. Stand turnover time was calculated to be 136.6 years.

Recruitment

A total of 73 trees were added to the forest stand during the 1999 recensus (Table 2), resulting in an annual recruitment rate of 0.63%. Recruitment rates calculated for individual sites ranged from 0.66% in site PS, 0.35% in VS, 1.13% in KS, and 0.62% in MS (Table 2). Species whose density was greater than 150 individuals in the 8 ha (7 species) represented a large proportion (52%) of the recruits. The annual turnover rate was calculated to be 0.68%. The number of trees recruiting into each site was variable with site KS having the most recruits (22 individuals, Table 2).

Discussion

There has been no discernable change in forest structure and species composition between the 1996 inventory and 1999 recensus. Thus a three-year period appears to be too less a time frame to reveal noticeable changes in tropical evergreen forest tree communities. A marginal reduction in the tree density from 3825 stems (478 stems ha^{-1}) in 1996 to 3814 stems (477 stems ha^{-1}) in the 1999 Kolli hills recensus, is comparable to that reported during the first recensus in Sungei Menyala, Malaysia (537.5 stems ha^{-1} in 1947 to 518.5 stems ha^{-1} in 1951 – Manokaran & Kochummen 1987).

An upward trend in basal area – a 4.1% increase overall and an 11.6% increase in site MS in particular were noticed. This marked increase in site MS is probably due to growth induction by way of disturbance regimes such as cattle grazing (leading to the addition of more organic matter into the system through dung or pellets) and tree felling. A similar growth behaviour has been reported for Moraceae trees in Sarawak, Malaysia, where trees growing in a logged environment exhibited more growth than trees in primary forest (Primack *et al.* 1985). Stimulation of individual diameter increment due to logging has also been reported for trees ≥ 30 cm gbh in a dense moist evergreen forest in Kadamakal, Indian western ghats (Elouard *et al.* 1997). In the relatively undisturbed site PS, the increase in basal area was only 1.7%. The greater tree density in site PS (529 stems ha^{-1}) when compared to site KS (326 stems ha^{-1}) and MS (485 stems ha^{-1}) could have probably led to a lesser growth due to competition, as indicated by only a slight increase in basal area.

The total species number of the four study sites remained unchanged at 78 species, eventhough in site PS, the lone individual of *Ficus beddomei* (gbh 5 m) was uprooted by a storm in 1998 (C.V. Chittibabu pers. comm.), thus reducing the species number in that site from 58 to 57 species. Species represented by just a few individuals in each site can be considered at risk to become locally extinct due to environmental stochasticity, a problem encountered with small populations (Gilpin & Soule 1986).

The mean gbh increment per tree was maximum in the frequently disturbed site KS (2.94 cm yr^{-1}). When gbh values are converted to mean dbh (diameter at breast height) increment to enable comparison with other works, the values are 0.94 cm yr^{-1} and 0.45 cm yr^{-1} in KS and PS respectively. Taylor *et al.* (1996) have reported a mean annual dbh increment of 0.44 cm yr^{-1} for trees $\geq$ 9.5 cm dbh in Mpanga, Uganda. The values of mean dbh increment for trees $\geq$ 30 cm gbh in the Kolli hills, eastern ghats, is greater than that of 0.27 cm yr^{-1} exhibited by trees $\geq$ 30 cm dbh in Mount Bellenden-Ker, Queensland (Herwitz & Young 1994).

There is a great variation in the growth of trees of the same species both within and across sites. Of the 23 species for which minimum, median and maximum growth rates are presented (Fig. 2), *Meliosma simplicifolia* displayed the widest range of growth behaviour, showing almost zero growth when it occurred in the forest interior (under shade) to 5.1 cm yr^{-1} in forest edges (well exposed to light) in site KS. Six species showed a > 3.5 cm yr^{-1} difference between their maximum and minimum growth rates and could be considered as fast growing species ideal for afforesting degraded sites. Elouard *et al.* (1997) reported a similar inter- and intra-specific variability in individual diameter increment of trees $\geq$ 30 cm gbh in the forests Kadamakal, Indian western ghats. In the highly disturbed site MS, the median growth rate of *Memecylon umbellatum* was 1.4 cm yr^{-1}, as opposed to 0.57 cm yr^{-1} for the same species in the relatively undisturbed site PS. *Memecylon umbellatum* accounts for 39% of the stand density in site MS and such a nearly monospecific dominance could probably be achieved and maintained by a faster growing tree.

Growth variation (as indicated by the means of minimum, median and maximum girth increment rate) is quite low in the relatively undisturbed site PS (0.25, 0.76 and 2.55 cm yr^{-1} respectively) when compared to the highly disturbed site MS (0.5, 1.49 and 3.36 cm yr^{-1}). This may probably be attributed to two reasons. Firstly, under the natural undisturbed setting, evergreen forest trees grow slowly and secondly, increased competition because of greater stand density affecting growth.

Tree mortality exceeded recruitment in the Kolli hills study sites, and this can be linked to the fact that 37% of the total deaths was due to felling. The resultant turnover rate of 0.68% in this forest is low when compared to neotropical (1.84% in Anangu, Ecuador- Korning & Balslev 1994; 0.91% in Reserva Ducke, Brazil- Rankin de Merona *et al.* 1990; and 2.15% in La Selva, Costa Rica-Lieberman & Lieberman 1987) and Asian tropical (0.89% in Sungei Menyala, Malaysia-Manokaran & Kochummen 1987; 1.89% in Pasoh, Malaysia-Condit *et al.* 1992 and 1.36% in Lambir, Malaysia-Hall 1991) forests. There is a necessity for collecting long-term data on rates of tropical tree growth, mortality and recruitment over large periods of time in order to improve our limited understanding of forest functioning. However, it is important to follow a uniform and unbiased protocol for collecting and processing data from long-term permanent sample plots (Sheil 1995).

Conclusion

There is an urgent need for collecting data on tropical forest tree dynamics, especially those of growth, mortality and recruitment, because forest degradation and habitat fragmentation are the main causes for the loss of biodiversity. Conservation and increasing the protection given to reserve forests in India, particularly those of the western ghats and eastern ghats are necessary because protected areas in India have historically been established on an *ad hoc* basis with little attention given to the conservation value of an area (Ramesh *et al.* 1997). The patchy nature of 'sholas' itself calls for better protection than what is accorded to them presently. Illegal felling of trees is a problem to reckon with in most reserve forests, and the best way to solve it is legally, and with the full involvement of the local communities living in the area. The very nature of the two of the permanent plots in this study (PS and VS), being sacred groves, has kept them pristine and undisturbed. This demonstrates the power of local involvement and participation in protecting natural resources.

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