

Ecological niches and amplitudes of rare, threatened and endemic trees of Peppara Wildlife Sanctuary

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Identification and documentation of rare, threatened and endemic species is important in the conservation of biodiversity. These species usually have specific ecological niches, edaphic gradients, and vulnerable habitats. In the present study, habitats of Peppara Wildlife Sanctuary were analysed for ecological niches and amplitudes of rare, threatened and endemic tree species by stratified random sampling techniques. The study resulted in documenting 151 tree species belonging to 51 families with 62 endemics (41% of endemism), 6 rare and 8 threatened species.

INDIA has been identified as one of the top 12 mega-diversity countries of the world. Among the 18 hot spots recognized in the world, two are in India—Eastern Himalayas and Western Ghats¹. The Western Ghats, which is one of the nine biogeographic regions of India possess various types of tropical forests, ranging from wet evergreen to dry deciduous. Nearly 63% of the tree species of the low and the medium elevation evergreen forests of Western Ghats are endemic². This high level of diversity and endemism in the Western Ghats has conferred on them the hot spot^{1,3} status. Nayar³ has identified three endemic centres in Kerala—Agasthyamalai, Anamalai high ranges and Silent Valley—Wynad. IUCN (ref. 4) has identified Agasthyamalai and its environs as one of the three centres of plant diversity within India.

Agasthyamalai ranges, a compact block of hills situated at the southernmost end of the subcontinent has one of the richest flora in the Western Ghats. It is also one of the important centres of plant speciation. Many plants new to science have been discovered and described from Western Ghats, most of them either being narrow endemics⁵ or are with limited range. Extremely restricted areas have been reported as type localities for a number of species of plants, many of which are endangered or rare⁶. For example, Chemmunji peak area in the Agasthyamalai range is the type locality for half a dozen endemic species. The study area, Peppara Wildlife Sanctuary, selected for the present work comes under Agasthyamalai range. A detailed study of endemism in the Western Ghats is necessary to define the priorities in conservation policy⁷.

One of the challenges of the conservation of rare, threatened and endemic plants is the identification of

their ecological niches and the amplitude of distribution. Niches are defined as a cell of the multi-dimensional space formed by the environmental variables within which a particular species will always be found⁸. Ecological amplitude is the capability of a species to establish in various habitats lying along an environmental gradient. A species showing very low ecological amplitude has localized distribution because of the narrow range of conditions on which their growth depends. These species are called 'habitat specialist' because they have a significant positive association with their habitat or they cannot survive outside of their habitat⁹.

In order to categorize threatened species, IUCN (ref. 10) has updated the categories on the basis of geographical range, population and fragmentation. The threatened species categories now used in the Red Data Books and the Red List are critically endangered (facing an extremely high risk of extinction in the wild in the immediate future), endangered (not critical, but facing a very high risk of extinction in the wild in the near future), and vulnerable (not critical or endangered but facing a high risk of extinction in the wild in the medium-term future). Taxa listed as critically endangered qualify for vulnerable and endangered, and those listed as endangered qualify for vulnerable. Together these categories are described as 'threatened'.

A rare species is one that occurs in widely separated small sub-population so that inter-breeding between sub-populations is seriously reduced or restricted to a single population¹¹. They are not at present endangered or vulnerable but face a high risk of being so and usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range¹². A hypothetical rare species is one with narrow habitat range, low climate tolerance, specialized adaptation requiring an outside agency for pollination, poor dispersal strategies, few seeds per fruit and poor viability of seeds³.

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The spatial distribution of plants and location, their degree of habitat niche specialization and the spatial distribution of sensitive habitats are some of the major aspects to be analysed. It is relatively straightforward to classify species by their distribution among habitats defined by fixed topographic or edaphic features of the plot¹³. Most of the endemic species with a small geographic range end up as rare species and later threatened species unless their habitat is protected³. The present paper attempts to study the rare, endemic and threatened trees, their ecological tolerance, distribution, ecological niches and the spatial distribution of niches.

Study area

The study area forms a part of the Trivandrum district in Kerala. The area is enclosed within 8°34'30" to 8°41'25"N. latitude and 77°06'50" to 77°14'05"E longitude (Figure 1). The entire area lies within the catchment area of the Karamana river (Karamanayar) which originates from the slope of Chemmunjimottai, the highest peak of the sanctuary (1717 m). The terrain is undulating with elevation ranging from 100 m to 1717 m. The maximum mean daily temperature during March, the hottest month, is 32°C while it is 20°C in January, the coldest month. The mean annual rainfall is 320 cm (ref. 14). The area of the sanctuary is 75 km² and is covered by tropical and montane subtropical forests.

Methodology

The following forest types were identified based on Champion and Seth¹⁵: southern hilltop tropical ever-

green forest, west coast tropical evergreen forest, west coast semi-evergreen forest, pioneer euphorbiaceous scrub, southern secondary moist mixed deciduous forest, *Myristica* swamp forest, submontane hill valley swamp forest, riparian fringing forest, southern subtropical hill forest and *Ochlandra* reed brake. Stratified random sampling technique was used for sampling. 0.1 ha plots were selected from each forest type for detailed investigation. A total of 2.1 ha area was sampled and all tree species above 10 cm DBH were enumerated. Materials collected were identified and analysed using relevant literature, monographs and taxonomic revisions^{3,7,16}. Confirmation of identification was done by matching the specimens with authenticated specimens available at the Kerala Forest Research Institute's (KFRI) herbarium.

Results and discussion

Of the 151 tree species spread over 51 families, 62 species show endemism, (41%). A high degree of endemism is seen in the endemic forest type of the Western Ghats, i.e. *Myristica* swamp forest (61.11%). West coast evergreen forest comes next followed by southern hilltop tropical evergreen forest and riparian fringing forest (Table 1). The number of endemics is greater in the climax forests than in the secondary or derived ones, thereby accounting for the low percentage of endemism in the southern secondary moist mixed deciduous forest (10.25%) and pioneer euphorbiaceous scrub (23.80%). The high degree of endemism in the evergreen forests of the Western Ghats can be attributed to the isolation of the ghats from other moist formations and the prevailing drier climatic conditions in the surrounding areas¹⁷. *Myristica* swamp forest (57.60) and hilltop evergreen forest (57.04) show higher densities of endemic species while the density is low for southern secondary moist mixed deciduous forest (2.76). The hilltops in the Western Ghats in particular, harbour a high percentage of endemics because they act like 'islands amidst islands'. This isolation has facilitated the process of speciation leading to a phenomenon of 'vicariance' between sister species derived from a common ancestor, one of which thrives in the evergreen forests of the ghats and the other in the adjacent dry regions⁷.

Of the 62 endemic tree species, *Mesua nagassarium* occurs in 7 forest types and *Actinodaphne bourdillonii*, *Artocarpus hirsutus*, *Holigarna arnottiana* and *Vateria indica* in 6 of them (Table 2). This indicates that these species have high ecological amplitude and niche overlap. 32 species exhibit narrow ecological tolerance with a high degree of habitat specialization with 25 species among them exhibiting very low relative densities. Of the endemic species, *Mesua nagassarium* shows highest density (5.24), followed by *Holigarna arnottiana* (2.73), *Knema attenuata* (2.61), and *Vateria indica* (2.25).

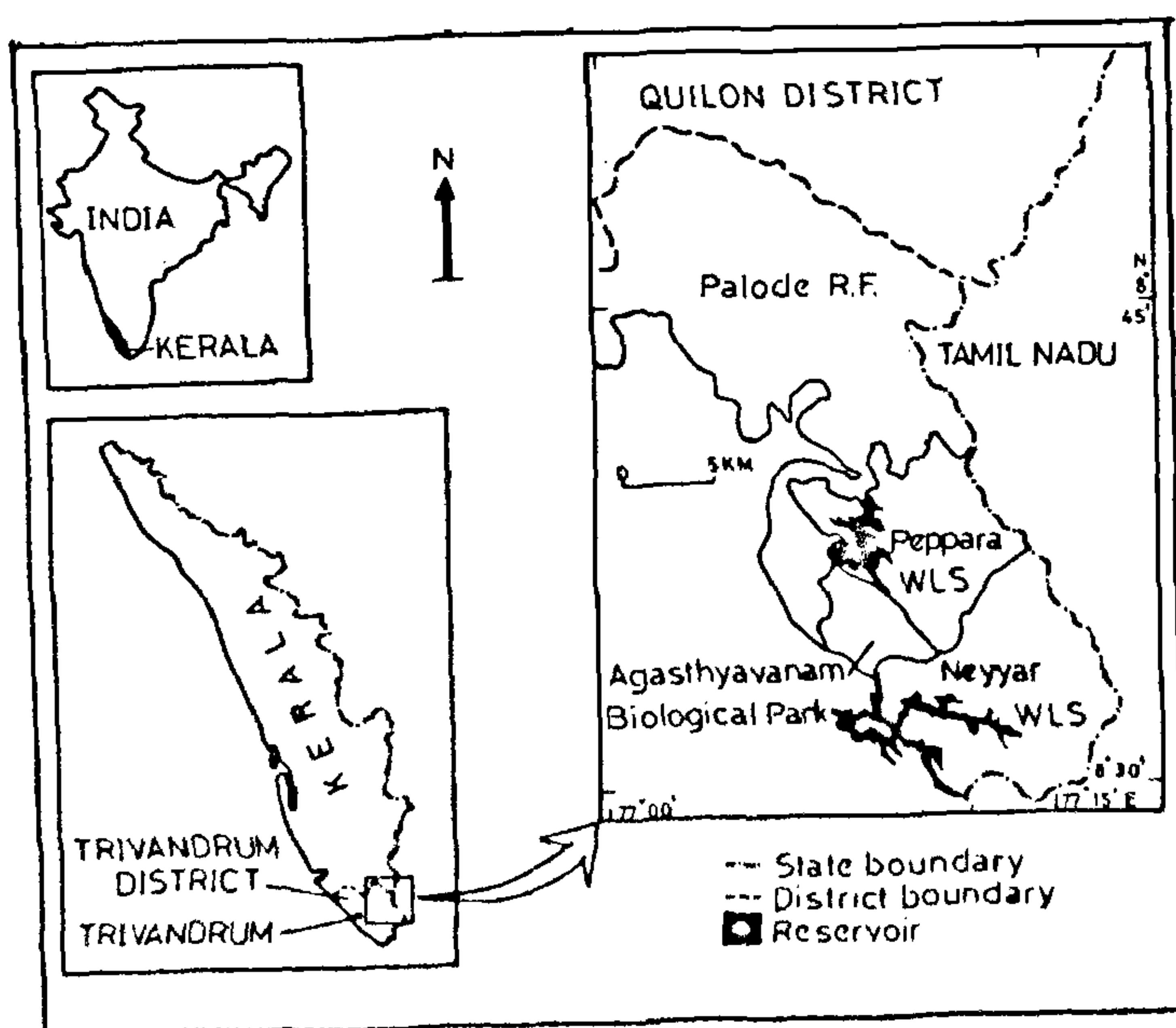


Figure 1. Location of the Peppara Wildlife Sanctuary.

GENERAL ARTICLES

Table 1. Total no. of species (T.Sp.), no. of endemics (NE), percentage of endemics (PD), relative densities of endemic species (RD) in forest types and no. of endemic habitat specialists (HS)

Forest type	T.Sp.	NE	PD	RD	HS
Southern hilltop tropical evergreen forest	27	12	44	57.04	3
West coast tropical evergreen forest	71	36	50.70	45.58	14
West coast semi-evergreen forest	68	27	39.70	36.57	7
Pioneer euphorbiaceous scrub	21	5	23.80	15.59	1
Southern secondary moist mixed deciduous forest	39	4	10.25	2.76	1
<i>Myristica</i> swamp forest	18	11	61.11	57.60	1
Sub-montane hill valley swamp forest	23	6	26.08	18.85	0
Riparian fringing forest	48	21	43.75	48.45	2
Sub-tropical hill forest	44	19	43.18	31.71	3

Table 2. Rare, threatened and endemic trees of Peppara Wildlife Sanctuary

Endemic species		Relative density of species in forest types									
		AD	HE	EG	SE	PE	MD	MS	SP	RF	SH
<i>Actinodaphne bourdillonii</i> Gamble		1.64	3.92	0.77	1.83	5.19				0.53	2.59
<i>Actinodaphne campanulata</i> J.HK. var. <i>obtusa</i> Gamble	T	0.16									1.52
<i>Actinodaphne malabarica</i> Balak.	R	0.20				1.30				0.51	
<i>Actinodaphne salicina</i> L.		0.21	1.96								
<i>Aglaiia elaeagnoidea</i> (Juss.) Benth var. <i>bourdillonii</i> (Gamble) Nair	R	0.33		0.30							
<i>Aglaiia minutiflora</i> Bedd.		0.02									0.26
<i>Allophylus serrulatus</i> Ra.		0.15			0.34					1.05	
<i>Arenga wightii</i> Griff.		0.01		0.13							
<i>Artocarpus hirsutus</i> Lam.		1.42		0.38	2.85	3.90	0.42		1.45	3.79	
<i>Atlantia wightii</i> Tanaka		0.01		0.17							
<i>Baccaurea courtallensis</i> (Wight) Muell.-Arg.		0.03			0.34						
<i>Bentinckia condapanna</i> Berry ex Roxb.	T	0.01									0.09
<i>Buchanania lanceolata</i> Wight		0.01			0.16						
<i>Canthium pergracilis</i> Bourd.		0.07		0.69							
<i>Calophyllum apetalum</i> Willd.		1.87		1.70	0.74			5.77		8.44	0.26
<i>Cinnamomum malabattrum</i> Burm. f.		0.04					0.37				
<i>Cinnamomum travancoricum</i> Gamble	T	0.05									0.52
<i>Cleistanthus travancorensis</i> Tablonzky		0.01			0.12						
<i>Cullenia exarillata</i> Robyns		1.24		5.18							6.01
<i>Diospyros candolleana</i> Wight		1.78	6.86	5.38	2.62					0.53	0.63
<i>Diospyros paniculata</i> Dalz.		0.01		0.14							
<i>Dipterocarpus bourdillonii</i> Brand.		0.23		1.46	0.37						0.26
<i>Elaeocarpus munronii</i> (Wight) Mast.		0.69								1.02	5.20
<i>Euodia lunu-ankenda</i> (Gaertn.) Merr. var. <i>tirunelvelica</i> Henry and Chandr.	R	0.14				1.30					
<i>Garcinia gummi-gutta</i> (L.) Robs.		0.28		1.76	0.26					0.57	
<i>Gluta travancorica</i> Bedd.		1.51	2.94	2.07	3.46					5.17	
<i>Gordonia obtusa</i> Wall. ex Wight and Arn		0.03		0.30							
<i>Goniothalamus rhynchantherus</i> Dunn	R	0.08		0.77							
<i>Holigarna arnottiana</i> J.HK.		2.73		2.25	2.10			7.69	7.25	4.40	0.92
<i>Hopia parviflora</i> Bedd.		1.91			2.69		0.33		4.35	8.56	1.26
<i>Humboldtia vahliana</i> Wight		0.41		2.72						1.02	
<i>Hydnocarpus macrocarpa</i> (Bedd.) Warb.	T	0.08								0.51	0.26
<i>Hydnocarpus pentandra</i> (Buch.-Ham.) Oken		0.56	2.94		2.12						
<i>Hymenodictyon obovatum</i> Wall		0.02								0.21	
<i>Kingiodendron pinnatum</i> (Roxb. ex DC.) Harms.	T	0.04		0.38							
<i>Knema attenuata</i> (Hook. f. and Thoms.)		2.61	0.98	2.02	2.01			15.3		3.26	
<i>Lagerstroemia microcarpa</i> Wight		0.34		0.24	0.68		1.64			0.53	
<i>Chionanthus leprocarpa</i> Thw.		0.05								0.51	

contd...

Table 2. contd...

<i>Var. courtallensis</i> (Bedd.) K. K. Nair								
<i>Litsea glabrata</i> Hook. f.	0.02	0.21						0.51
<i>Leptonychia moacurroides</i> Bedd.	0.02			0.26				
<i>Litsea ligustrina</i> (Nees) Hook. f.	0.02		0.24					
<i>Litsea oleoides</i> (Meissn.)	0.10	0.98						
<i>Mangifera indica</i> L.	0.23		0.30	1.26				0.53
<i>Mastixia arborea</i> ssp. <i>meziana</i> (Wang.) Mathew	1.17	0.98	0.85			1.92	2.90	3.88
<i>Meiogyne pannosa</i> (Dalz.) Sinclair	0.07		0.69					
<i>Mesua nagassarium</i> (Burm. f.) Kosterm	5.24		3.16	5.42	3.90			
<i>Milisia wightiana</i> Hook. f. and Thomas	0.02			0.19				
<i>Myristica fatua</i> Houtt. var. <i>magnifica</i> (Bedd.) J.	T	0.64					5.77	
<i>Myristica malabarica</i> Lam.	T	1.26		0.30			9.62	1.45
<i>Ormosia travancorica</i> Bedd.		0.03		0.30				
<i>Palaquium ellipticum</i> (Dalz.) Baillon		0.32		1.03			1.92	
<i>Pinanga dicksonii</i> (Roxb.) Blume		0.01		0.16				
<i>Poeciloneuron indicum</i> Bedd.		0.21	0.98	0.30	0.37			0.26
<i>Pterospermum rubiginosum</i> Heyne ex Wt. and Arn	R	0.08			0.74			
<i>Scolopia crenata</i> (Wt. and Arn.)		0.32			1.02		1.92	
<i>Semecarpus travancorica</i> Bedd.		0.08		0.73				
<i>Spondias indica</i> (Wt. and Arn.) Airy shaw and Forman		0.16		0.24	0.71			0.51
<i>Symplocos macrocarpa</i> Wt. and Cl. ssp. <i>kanarana</i> (Talbot) Noot.	R	0.09		0.60	0.26			
<i>Syzygium mundagam</i> (Bourd.) Chitra		1.17	3.92	2.37	2.12		1.92	0.26
<i>Syzygium occidentale</i> (Bourd.) Gandhi	T	0.03		0.30				
<i>Vateria indica</i> L.		2.25		5.20	1.53		3.85	1.45
<i>Vernonia travancorica</i> Hook. f.		0.57	4.90					5.76
								2.50
								0.31

R, Rare; T, Threatened; AD, Mean densities; HE, Southern hilltop evergreen forest; EG, West coast evergreen forest; SE, West coast semi-evergreen forest; MD, Secondary moist mixed deciduous forest; SP, Sub-montane hill valley swamp forest; PE, Pioneer euphorbiaceous scrub; MS, *Myristica* swamp forest; RF, Riparian fringing forest; SH, Subtropical hill forest.

Among the forest types, west coast evergreen forest has the maximum number of habitat specialists (14), followed by the west coast semi-evergreen forest (7). The rest show a comparatively low number of endemic species. The high degree of habitat specialists in west coast evergreen and semi-evergreen forests show the unique specialized niches (which provide particular growth factors due to microclimatic and edaphic conditions) and microclimatic conditions (regional difference in temperature, moisture and other factors due to topographic features¹⁸) prevailing in these forests. When compared to the percentage of endemic plants (41%) to their relative densities they show low representation of densities of endemic species. Of the 62 endemic species, the genus *Actinodaphne* comprises the highest number of species (4) followed by *Litsea* (3). *Aglaia*, *Cinnamomum*, *Diospyros*, *Hydnocarpus*, *Myristica* and *Syzygium* have two endemic species each. Among the 51 families, 8 have 40% or more endemic species with Dipterocarpaceae having 100% endemism (Table 3). Within the ghats, the variation in the degree of endemism is mainly determined by: (i) the increasing number of dry months from south to north, and (ii) the decrease in temperature with increase in altitude. These two

Table 3. Families with 40% or more endemism

Family	No. of species	No. of endemics	Percentage of endemism
Dipterocarpaceae	03	03	100.00
Lauraceae	11	09	81.81
Clusiaceae	05	04	80.00
Ebenaceae	03	02	66.66
Anacardiaceae	10	06	60.00
Myristicaceae	05	03	60.00
Flacourtiaceae	05	02	40.00
Myrtaceae	05	02	40.00

gradients also explain the numerous cases of vicariance encountered within the evergreen continuum. Local topographic varieties add another dimension to the floristic diversity and endemism. In this region, climatic shift is more rapid due to the foehn effect and to the gradual transformation in the rainfall pattern from the south-west monsoon regime (with a peak in July) to the two peak regime characterized by the dominance of rains during the north-east monsoon from October to December⁶.

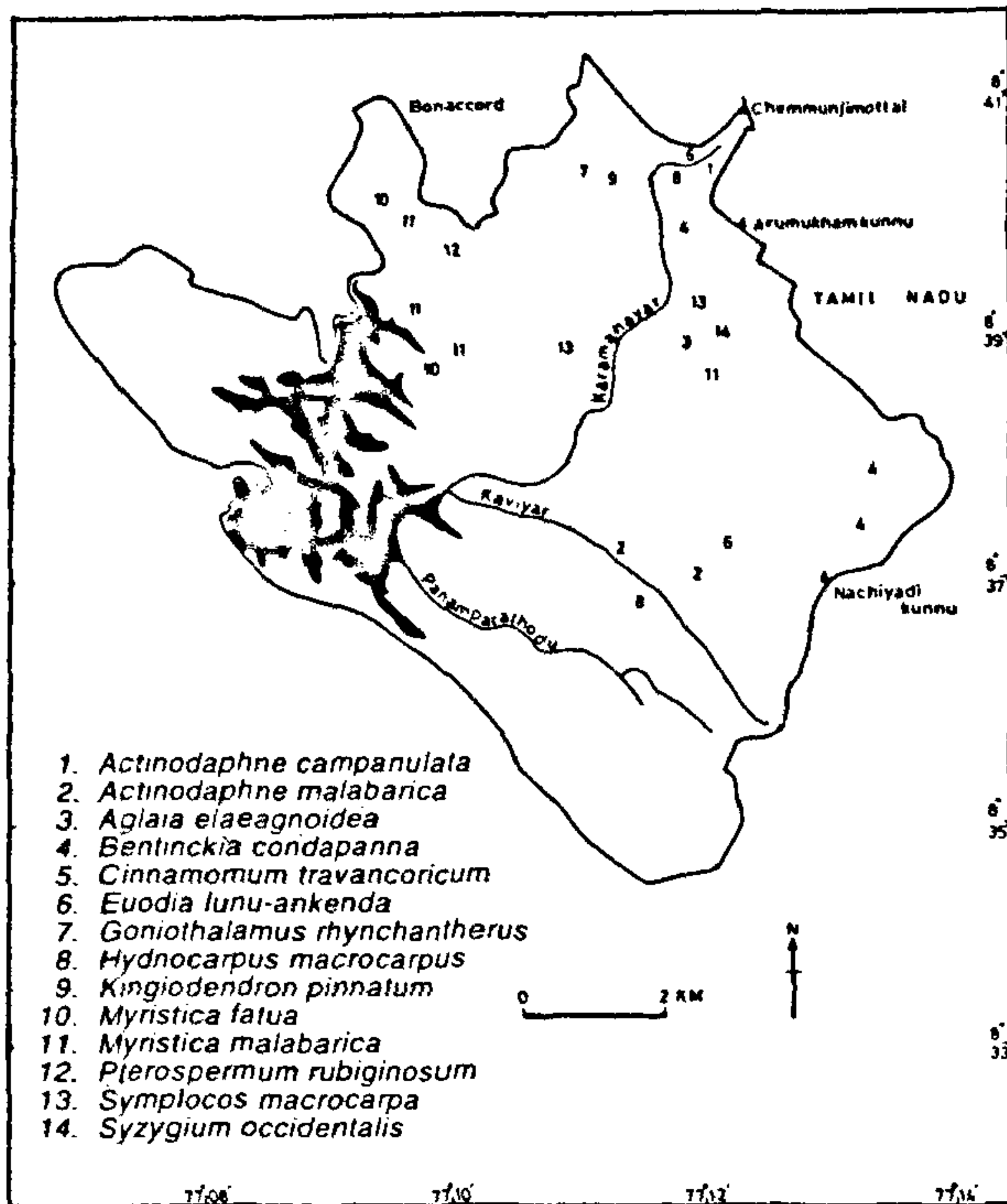


Figure 2. Distribution of rare and threatened trees in Peppara Wildlife Sanctuary.

The subtropical hill forest exhibits the highest number of threatened species (3) but with a very low density of species. The west coast evergreen forest shows 3 rare and 2 threatened species with good densities. Very high relative densities are exhibited by the threatened species of *Myristica* swamp forest (15.39). The derived secondary moist mixed deciduous forest lacks rare and threatened species. A total of 8 (5.29%) threatened species are recorded from the study area. There are 6 rare (3.97%) species also. The approximate location of the rare and threatened species is given in Figure 2. The location is the quadrat of occurrence of the rare and threatened species gathered using Global Positioning System (GPS). The relative densities of rare and threatened species exhibit low values as endemic species, i.e. 0.92 and 2.77, respectively. All rare and threatened trees are endemic and most of them are confined to the southern parts of the Western Ghats.

Conclusion

The foremost task in the conservation process is to rate different protected areas for their holdings of rare,

threatened and endemic species. The article gives basic knowledge about documentation of niches and amplitude of rare, threatened and endemic species in a regional scale. This documentation can help locate areas and habitats of high concentration of these species so that critical habitat/habitat sites would get priority for conservation.

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