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STUDIES ON THE FLORA OF PERIYAR TIGER RESERV

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ABSTRACT

A study on the Flora of Periyar Tiger Reserve was carried out during June 1993 to September 1997. The areas lies (between 9°16' and 9°36' North latitude and 76°57' and 77°25' East longitude) along the Western Ghats in Idukki Revenue District. The Tiger Reserve which has an area of 777 km^2 including the Periyar lake spread over 26 km^2, constitutes 16% of the area of Idukki District.

During the present study, 1965 taxa (species and infraspecific) were collected and described. Dicotyledons dominate with 1440 species in 613 genera under 137 families. Monocotyledons are represented by 525 species in 210 genera under 22 families. Poaceae with 168 species among monocots and Fabaceae with 155 species among dicots are dominant families. Among the 159 families, 28 dicot and 6 monocot families are represented by single species each. Among the 1272 species that are considered endemic to the Southern Western Ghats, 515 species were collected from the Tiger Reserve. During the study 150 species that have been placed under various threat categories could be collected. These include 17 species categorised as 'possibly extinct'.

The floristic analysis shows that the first 9 dominant families of South India are dominant in the Tiger Reserve also. About 49 percent of species belongs to the first 10 dominant families.

One new species of Orchid viz. *Habenaria periyarensis* Sasi. *et al* was described from the Tiger Reserve during the present study. *Vanda thwaitesii, Symplocos obtusa* var. *pedicellata, Ficus costata* and *F. caulocarpa* are new records for India. *Eulophia sanguinea* is a new record for South India. Species like *Achyranthes aspera* var. *pubescens, Alternanthera paronychioides, Arthraxon meeboldii, Brachiaria brizantha, Bulbophyllum macraei, Cyperus oatesii, Dimeria mooneyi, Fimbristylis aestivalis, F. bisumbellata, F. dura, F. glabra, F. monticola, Glycosmis angustifolia, Lobelia zeylanica, Oxalis latifolia, Polygala jacobii, Premna paucinervis, Rotala ritchiei, Scleria annularis, S. pergracilis, Setaria verticillata, Strobilanthes consanguineus, Strobilanthes jeyporensis, Tragus biflorus* and *Tripogon pauperculus* are new records of occurrence in Kerala.

The occurrence of 1965 species in an area of 777 km^2 indicates the richness and diversity of flora of the Tiger Reserve. So far, from nowhere in the subcontinent such a large number of taxa have been reported from an area comparable to that of Periyar Tiger Reserve. The highest estimated number of species is 2000 for the Agasthymala region of Western Ghats, having an area of 2000 km^2 (Nair & Daniel, 1986). Nayar (1997) estimated that there are about 3800 species of flowering plants in Kerala. Thus, the 1965 species recorded from the Tiger Reserve forms more than 50 per cent of the estimated flowering plants of Kerala.

1. INTRODUCTION

The Periyar Tiger Reserve, one among the 12 protected forest areas in Kerala is located in the Idukki Revenue District of the State. The Tiger Reserve with an area of 777 km^2 is the largest sanctuary in Kerala. The Periyar lake was created in 1895 by building a dam across the Mullaperiyar river. The lake has an area of 26 km^2. The forest around the lake was declared as reserved forest in 1899 and later in 1933 into a sanctuary, the Nellikkampetty Game Sanctuary. The sanctuary was brought under 'Project Tiger' in 1977 (Asari, 1985).

The Tiger Reserve is well known for its rich wildlife and scenic beauty. The management practices followed were with more emphasis on wildlife. Except for occasional collection of specimens by the Scientists of Botanical Survey of India, which resulted in finding some interesting taxa, the Tiger Reserve has not been subjected to detailed floristic study. Due to the varied climatic conditions, the Tiger Reserve possesses rich and diverse flora. Major part of the Tiger Reserve comes under the Anamalai-High Ranges, one of the centres in the Western Ghats with a high percentage of endemism (Nayar, 1997). The project for studying the flora was taken up with the co-operation and financial support from the Wildlife Wing of Kerala Forest Department.

1.1 Review of earlier work

The Periyar Tiger Reserve is located in Idukki District. Idukki is the largest district of Kerala with an area of 4998 km^2. Unlike other districts of Kerala the flora of Idukki has not yet been completely explored. The first botanical collection from the district was made by Beddome in 1882 from Peermade and adjacent Anamudi, which were part of the erstwhile princely state of Travancore (Vivekananthan, 1981). Barnes, Beddome, Bourdillon, Meebold and Venkoba Rao made collections in the late 19^{th} century and early 20^{th} century and their collections were cited by Hooker (1872-1897) and Gamble and Fischer (1915-1936). Barnes (1939) dealt with the Gesneriaceae of High Ranges. Sebastine and Vivekananthan (1967) and Shetty and Vivekananthan (1971) published brief accounts on the flora of Anamudi and Devikulam. Vivekananthan (1978) dealt with the vegetation of Periyar Tiger Reserve and also listed out 12 rare and threatened plants. Studies by Shetty and Vivekananthan (1968, 1969, 1970, 1973, 1975); Sharma *et al* (1974); Nayar (1974); Sreekumar *et al* (1983a, 1983b); Nair and Sreekumar (1985); Pandurangan and Nair (1995) resulted in the discovery of new taxa from the district. Among the new taxa, *Cassia intermedia* and *Gomphostemma keralensis* were from the Periyar Tiger Reserve. Shetty and Vivekananthan (1972) reported the occurrence of some rare and little known taxa. Nagendran *et al* (1976-77) and Bhaskar and Razi (1978) made collections of Podostemaceae and Balsaminaceae. Mohanan *et al* (1984) reported some rare and interesting plants from the Idukki Hydroelectric Project Area. Balasubramanyam *et al* (1989) listed out some of the plants from the proposed Pooyamkutty Hydroelectric Project Area. Sasidharan *et al* (1996) provided an account of Cryptogamic and Phanerogamic flora of the Medicinal Plant Conservation Area in the Eravikulam National Park.

From the literature it is seen that the flora of the Tiger Reserve has not been studied in detail when compared to other parts of the district. Blatter (1928) reported 34 orchids from the High-wavy Mountains of Madurai district which is contiguous to the Periyar Tiger Reserve. These include 3 new species viz., *Chrysoglossum halberghii, Eria pseudoclavicaulis* and *Odontochilus rotundifolius* and a new variety, *Dendrobium nutans* var. *rubrolabris.* Among these, *Odontochilus rotundifolius* was transferred to a new genus *Aenhenrya* (Sathish Kumar and Rasmussen, 1997). Except for *Chrysoglossum halberghii,* which is considered extinct, all the other orchids were reported from the Periyar Tiger Reserve (Sasidharan *et al,* 1997). Sharma and Rathakrishnan (1978) reported *Acampe ochracea, Gastrochilus dalzellianus* and *Oberonia gammiei,* from the Tiger Reserve as new records for Kerala. Srivastava *et al* (1994) reported 64 species of grasses from the Tiger Reserve. Recently Thothathri and Ravikumar (1997) described *Mucuna pruriens* var. *thekkadiensis.* During our studies occurrence of some interesting plants was reported from the Tiger Reserve (Augustine *et al,* 1995; Rajesh *et al,* 1996; 1997 &1997a).

2. STUDY AREA

2.1 Location

The Periyar Tiger Reserve lies between $9^0$16' and $9^0$36' North latitude and $76^0$57' and $77^0$25' East longitude in Idukki Revenue district of Kerala State (Map). The Reserve has an area of 777 km^2 including the Periyar Lake having an area of 26 km^2. The boundaries are Madurai and Ramanadhapuram districts in the east, Kottayam district in the west and Pathanamthitta district in the south.

2.2 Topography

Periyar Tiger Reserve has a much undulated terrain ranging in altitude from 100 m (Pambavalley) to 2016 m (Vellimala) above sea level. The conspicuous peaks are Pachayarmala, Vellimala, Kottamala, Sunderamala, Chokkampetti mala and Karimala. The Periyar River originating from Chokkampettimala flows towards the North. Its major tributaries are Mullayar and Churakkottayar. The Western part of the Reserve (Mount Plateau) in drained by Pamba and Azhutha rivers which form the boundary of the Reserve.

2.3 Geology, rock and soil

The underlying rock formations consist mainly of granites and gneisses. Laterite occurs at the lower reaches of the Reserve. The soil in mainly fine loamy in character as it is derived from disintegrated laterite and gneisses. In higher altitudes the soil is coarse being with large amount of quartz gravel formed from crystalline rock. The soil is acidic (Asari, 1985).

2.4 Climate

The Tiger Reserve has a humid climate without much seasonal variations. The temperature varies between 15^0C and 31^0C with April-May being hottest months and December-January the coolest. The area receives both the South-West and the North-East monsoons with maximum rainfall in July and minimum in January. The average rainfall is 2500 mm per year.

2.5 Vegetation

By following Chandrasekharan (1962) and Champion & Seth (1968), the vegetation of the Tiger Reserve can be classified into the following types

1. West coast tropical evergreen forests (evergreen)
2. West coast semi-evergreen forests (semi-evergreen)
3. Southern moist mixed deciduous forests (moist deciduous)
4. Southern hill-top tropical evergreen forests (hill-top evergreen)
5. Southern montane wet temperate forests (shola)
6. South Indian sub-tropical hill savannahs (savannah)
7. Southern wet montane grasslands (grassland)

West coast tropical evergreen forests

This forest type is found in Koruthode-Sabarimala-Poonkavanam areas where the altitude ranges from 100 to 1300 m. Comparatively taller trees with straight trunks are found in these evergreen forests. The major associations of trees in these areas are Mesua-Palaquium-Cullenia association, Hopea-Dipterocarpus-Vateria association and Polyalthia-Myristica-Calophyllum association. The top canopy members are *Hopea parviflora, Dipterocarpus indicus, D. bourdillonii, Polyalthia coffeoides, Palaquium ellipticum, Pterygota alata, Vateria indica, Calophyllum polyanthum, Antiaris toxicaria, Artocarpus hirsuta, Holigarna grahamii, Diospyros buxifolia, Lophopetalum wightianum, Myristica dactyloides, Kingiodendron pinnatum, Dysoxylum malabaricum, Tetrameles nudiflora, Elaeocarpus tuberculatus*, etc.

The trees of middle canopy are *Diospyros bourdillonii, D. candolleana, D. paniculata, Drypetes elata, D. malabarica, Humboldtia vahliana, Garcinia spicata, Hydnocarpus pentandra, Semecarpus travancorica, S. auriculata, Knema attenuata, Baccaurea courtallensis, Aglaia lawii, A. barberi, Garcinia morella, Otonephelium stipulaceum, Dimocarpus longan,* etc.

The lower storey trees are *Orophea uniflora, O. erythrocarpa, Meiogyne ramarowii, M. pannosa, Goniothalamus rhynchantherus, Aphanamixis polystachya*, etc.

The shrubby plants are mainly *Psychotria spp., Glycosmis macrocarpa, Amomum muricatum, Strobilanthes warreensis, S. heyneanus*. Major climbers are *Combretum ovalifolium, Gnetum ula, Strychnos colubrina, Entada rheedei, Loeseneriella bourdillonii,* etc.

West coast semi-evergreen forests

This forest type covers an area of around 190 km^2 of the Tiger Reserve. It is found in Thekkady, Swamikkayam and Vallakkadavu areas. The three tier structure of the tree canopy is evident in this forest type too.

The top canopy is composed of trees like *Terminalia bellirica, Myristica dactyloides, Ficus drupacea, Ficus nervosa, Ficus virens, Bischofia javanica, Syzygium hemisphericum, S. gardneri, Mangifera indica, Tetrameles nudiflora, Toona ciliata, Elaeocarpus tuberculatus, Chukrasia ciliata, Litsea oleoides, L. glabrata, Actinodaphne bourdillonii*, etc.

The middle canopy trees are *Syzygium cumini, Litsea floribunda, Litsea deccanensis, Dimocarpus longan, Harpullia arborea, Diospyros ovalifolia, D. candolleana, Mastixia arborea* var. *meziana, Otonephelium stipulaceum, Pterospermum reticulatum, Cinnamomum spp., Vitex altissima, Viburnum punctatum, Chionanthus mala-elengi, Croton malabaricus, Trewia nudiflora, Turpinia malabarica, Phoebe lanceolata*, etc.

The lower storey trees are *Clausena indica, Aidia gardneri, Ixora brachiata, Archidendron monadelphum, Memecylon talbotianum, M. edule, Syzygium mundagam, Croton laccifer*, etc.

The shrubs consist mainly of *Cipadessa baccifera, Turraea villosa, Psychotria spp., Gomphandra coriacea, Allophylus cobbe, A. concanicus, Strobilanthes anceps, S. pulneyensis*, etc. Major lianas are *Entada scandens, Gnetum ula, Reissantia indica*, etc.

Southern moist mixed deciduous forests

Around 100 km^2 of the Reserve is under this forest type. It is found at Thaannikkudy, Mullakkudy, Edappalayam, Pambavalley and Methaganam areas. The three tier canopy structure is discernible in this forests also.

The upper canopy trees are *Pterocarpus marsupium, Tectona grandis, Terminalia paniculata, T. crenulata, Bombax ceiba, Tetrameles nudiflora, Actinodaphne malabaricum, Dalbergia lanceolaria, Dalbergia sissoides, Grewia tiliifolia, Stereospermum colais, Lagerstroemia microcarpa, Diospyros montana, Sterculia villosa, Xylia xylocarpa*, etc.

Middle canopy trees are *Olea dioica, Litsea coriacea, Careya arborea, Buchanania lanzan, Phyllanthus emblica, Glochidion ellipticum, G. tomentosum*, etc.

The lower storey trees are *Wrightia tinctoria, Helicteres isora, Catunaregam spinosa, Clausena dentata*, etc.

The shrubby layer is composed of *Solanum torvum, S. anguivi, Lantana camara, Ixora malabarica, Pavetta tomentosa, Desmodium pulchellum, Flemingia strobilifera, Desmodium triangulare, Chromolaena odorata*, etc.

Southern hill-top tropical evergreen forests

This type of forest is found in places south of Mlappara, east of Mullakkudy and Thaannikkudy, where the altitude in between 1300 and 1700 m.

Dysoxylum-Palaquium-Cullenia association is found in places above Mullakkudy and Thaannikkudy. The upper storey trees in these areas are *Dysoxylum binectariferum, Palaquium ellipticum, Cullenia exarillata, Mesua ferrea, Acrocarpus fraxinifolius, Meliosma pinnata* var. *arnottiana, Syzygium gardneri, Litsea oleoides, Cassine paniculata,* etc.

The trees of middle canopy are *Casearia rubescens, C. ovata, Hydnocarpus alpinia, Diospyros ovalifolia, D. neilgherrense, Bhesa indica, Elaeocarpus glandulosum, Coffea crassifolia, Drypetes wightii, Lepisanthes tetraphylla, Agrostistachys borneensis, Scolopia crenata, Chionanthus ramiflorus*, etc.

The lower storey trees are *Goniothalamus wightii, Meiogyne pannosa, Microtropis stocksii, Aglaia simplicifolia, Acronychia pedunculata, Erythroxylum monogynum, Meliosma simplicifolia*.

The shrubby plants are mainly *Strobilanthes spp. Lasianthus spp., Dendrocnide sinuata, Psychotria spp., Euonymus crenulatus, Dichapetalum gelonioides, Saprosma foetida, Tabernaemontana gamblei*, *Amomum muricatum*, etc.

Evergreen forests south of Mlappara along Aladi-Chokkampetti Hills are with Cullenia-Mesua-Acrocarpus association. Top canopy trees are *Cullenia exarillata, Mesua ferrea, Acrocarpus fraxinifolius, Syzygium hemisphericum, S. zeylanicum, Elaeocarpus tuberculatus*, *Myristica dactyloides, Canarium strictum,* etc.

Middle canopy trees are mainly of *Coffea crassifolia, Gordonia obtusa, Lepisanthes tetraphylla, Dysoxylum beddomei, Hydnocarpus alpinia, Agrostistachys borneensis*, etc.

The lower storey trees are *Aporusa ficiforme, Meiogyne pannosa, Microtropis stocksii, Litsea ligustrina, Diospyros ovalifolia*, etc.

Shrubby plants are mainly *Saprosma foetida, Strobilanthes spp., Lasianthus spp., Octotropis travancorica, Excoecaria robusta, Tabernaemontana gamblei,* etc. Viable population of *Podocarpus wallichianus,* the only indigenous South Indian conifer is also seen south of Mlappara.

Southern montane wet temperate forests

This forest type is found in Vellimala, Kottamala, Uppermanalar, Pachayarmala, Sunderamala, Chokkampettimala, Mangaladevi and Kalvarimala. The canopy stratification is not found in this forest type. The trees have with short bole and stout branches. The major trees are *Garcinia cowa, Syzygium rubicundum, Eugenia discifera, S. parameswaranii, Cinnamomum wightii, Phoebe wightii, Bhesa indica, Actinodaphne campanulata, Alseodaphne semecarpifolia, Vernonia travancorica, V. arborea, Litsea wightiana, Cryptocarya stocksii, Neolitsea fischeri, Xantolis tomentosa, Ternstroemia japonica,*

Rhododendron arboreum, *Cryptocarya stocksii, Actinodaphne campanulata, Alseodaphne semecarpifolia, Casearia sp., Rapanea capitellata,* etc.

Shrubby plants include of *Mallotus muricatus, Symplocos pulchra, S. macrophylla, S. monantha, Rauvolfia verticillata, Elaeagnus conferta, Calamus brandisii, Strobilanthes anceps, S. pulneyensis, S. luridus, S. micranthus, S. homotropus, S. foliosa, S. gracilis,* etc.

South Indian subtropical hill savannahs

Large tracts of savannahs are found at Thaannikkudy, Edappalayam, Manakkavala and Kavalappara areas. Major trees found in this forest types are *Terminalia paniculata, T. chebula, Careya arborea, Pterocarpus marsupium, Phyllanthus emblica, Buchanania lanzan, Dalbergia sissoides, Dillenia pentagyna, Anogeissus latifolia,* etc. Shrubs include *Ziziphus rugosus, Desmodium pulchellum, Vernonia divergens, V. indica,* etc. The dominant grasses are *Themeda cymbaria, Chrysopogon hackelii, Cymbopogon flexuosus, Apluda mutica, Panicum spp., Ischaemum timorense, Eulalia trispicata, Capillipedium assimile,* etc.

Southern montane wet grasslands

Extensive grasslands are found in Arjunankotta, Uppupara, Kavalappara, Mangaladevi, Kumarikulam, Palkachimala, Kathiramudi, Swamikkayam mala and Kalvarimala. About 57 km^2 area is dominated with grass growth. Major part of the grassland was converted into Eucalyptus plantations in the past. Among the savannahs and grasslands there are patches of marshy areas where a mixed growth of grasses like *Panicum spp., Leersia hexandra, Eragrostis spp., Isachne kunthiana, Pseudoraphis spinescens* along with a rich population of sedges is found. Major grasses are *Chrysopogon zeylanicum, Themeda cymbaria, Tripogon bromoides, Arundinella ciliata, A. mesophylla, A. leptochloa, A. purpurea, Dimeria lawsonii, D. thwaitesii, Apocopis mangalorensis, Eulalia trispicata, Ischaemum commutatus,* etc. Apart from grasses, shrubs like *Phoenix humilis, Strobilanthes kunthianus, Indigofera pulchella, I. wightii, Lilium wightianum, Hypericum mysorense, Thalictrum japonicum,* etc. are also seen along with a rich herbaceous population.

Extensive tracts of reed brakes are met along the eastern sides of the Periyar River, especially at Melmala, Manikkamala and Odamala areas. Major components of these reed brakes are *Pseudoxytenanthera monadelpha, P. bourdillonii and Ochlandra travancorica*. Gregarious growth of *Bambusa arundinacea* is seen along the rocky river banks at Thaannikkudy and Mullakkudy areas.

Four abandoned Cardamom plantations are also found in the Tiger Reserve. They are Lakshmippara, Mlappara, Naduthottam and Umikuppan estates. These are left for natural forest growth. Cashew (*Anacardium occidentale*) is raised in plantations of few acres at Koruthode. Exotic weeds like *Mikania cordata, Lantana camara* and *Chromolaena odorata* have established in disturbed forest areas and plantations.

3. METHOD

The flora is the result of repeated seasonal collections of plant specimens from the Tiger Reserve and extensive field studies during 1993-1997. Data on altitude, habit, habitat, occurrence, flowering and fruiting were recorded for each specimen collected. Flowers and fruits were also preserved in spirit for further studies. The herbarium specimens were prepared as per standard specification (Fosberg & Sachet, 1965; Bridson & Forman, 1991). The specimens were identified with pertinent literature and by comparing with authentic specimens in MH, KFRI and CALI. Those which needed further confirmation were referred to experts in the concerned groups in India as well as abroad. Apart from those collected during the study period, specimens collected earlier from the study area available at KFRI Herbarium were also referred for the study. Brief diagnostic description were prepared for each taxon based on the specimen studied and field observations.

3. 1 Format of the Flora

Families are arranged according to the classification system of Bentham and Hooker (1868-83) with necessary modifications in accordance with their current status. Keys to the genera and species are provided to facilitate easy identification of the taxa. Under the families, the genera and species are arranged alphabetically. The correct and up to date name of the species is followed by basionym, if any, and important synonyms. Exhaustive citations of floras have been avoided due to paucity of space and restricted to Wight (1838-53), Hooker (1872-97), Gamble (1915-36) and recent revisions and monographs. Illustrations are also provided for species which are not illustrated earlier. A brief diagnostic description is followed by flowering, fruiting and distribution data. The collection number(s) of the specimens studied were also cited. All the specimens are lodged in KFRI Herbarium (KFRI), otherwise mentioned. The abbreviations used in the text *Fl.*, *Fr.*, Dist., *NS*, *JA* and *KPR* denote Flowering, Fruiting, Distribution, N. Sasidharan, Jomy Augustine and K. P. Rajesh respectively.

4. RESULTS

4.1 Floristic analysis

During the study, 1965 species of flowering plants belonging to 823 genera under 151 families are collected and described. Dicotyledons have 1440 species belonging to 613 genera under 128 families. Monocotyledons are represented by 525 species in 210 genera under 23 families. Poaceae with 168 species in 76 genera is the largest. Leguminosae with 155 species in 52 genera comes next. Orchidaceae is the third largest with 145 species in 60 genera. Among the rest of the families Cyperaceae has 91 species in 15 genera, Rubiaceae with 90 species in 34 genera, Asteraceae with 84 species in 43 genera, Euphorbiaceae with 81

species in 35 genera, Acanthaceae with 70 species in 21 genera, Lamiaceae with 47 species in 14 genera and Lauraceae with 36 species in 9 genera. Among the 151 families, 28 dicot and 6 monocot families are represented by single species each.

A comparison of the relative dominance of families of South India and that of the Tiger reserve shows some interesting data. The first two largest families of South India namely Poaceae and Fabaceae are well represented in the study area too. Orchidaceae stands third in the order of dominance in South India. Cyperaceae, the 4th dominant family in the study area is 5th in South India. Rubiaceae is the 5th dominant family in Tiger Reserve and is the 9th dominant family in South India. Asteraceae and Euphorbiaceae are the 6th and 7th dominant families. They are 7th and 6th in South India respectively. Acanthaceae, the 8th family in the Periyar Tiger Reserve is the 4th dominant family of South India. Lamiaceae and Lauraceae are the 9th and 10th dominant families in the Tiger Reserve. Except Asclepiadaceae which is the 10th dominant family of South India, all the other 9 families are dominant in the study area, though their ranks are slightly altered.

There are 26 genera with more than 10 species in each. They are *Impatiens* (28), *Strobilanthes* (23), *Crotalaria* (22), *Cyperus* (20), *Desmodium* (20), *Fimbristylis* (18), *Ficus* (18), *Oberonia* (17), *Habenaria* (15), *Syzygium* (15), *Diospyros* (15), *Eriocaulon* (14), *Vernonia* (13), *Ipomoea* (13), *Phyllanthus* (12), *Litsea* (12), *Hedyotis* (12), *Solanum* (12), *Psychotria* (11), *Blumea* (11), *Bulbophyllum* (11), *Dendrobium* (11), *Justicia* (10), *Cassia* (10), *Symplocos* (10), *Lindernia* (10). There are 467 genera represented by single species each.

4.2 Endemic plants

There are 1,923 taxa of flowering plants endemic to Peninsular India (Ahmedullah & Nayar, 1987). Out of the estimated 3,800 species of flowering plants in Kerala, 1272 are endemic to the Southern Western Ghats (Nayar, 1996). There are no endemic families in South India. Of the 58 endemic genera of Western Ghats, *Anaphyllum, Aenhenrya, Helicanthes, Indobanalia, Indotristicha, Smithsonia* and *Solenocarpus* are found in the study area. The endemic genera like *Nilgirianthus, Phlebophyllum. Taeniandra and Xenacanthus of Acanthaceae* are treated here under *Strobilanthes* following the broader concept of the genus.

Among the 1965 species of flowering plants collected from the Tiger Reserve, 515 are Southern Western Ghat endemics which form about 26 percent. In the study area Orchidaceae stands first with 55 endemic species, Rubiaceae has 35, Acanthaceae has 32, Poaceae and Fabaceae have 25 each, Lauraceae, Balsaminaceae and Euphorbiaceae have 25 each, Lamiaceae has 19, Melastomataceae has 18 and Asteraceae with 11 endemic species.

There are 86 species of *Impatiens* in South India of which 78 are endemics and 20 of them are confined to the Anamalai-High Ranges. Out of the 28 species of *Impatiens* collected during the study, 26 are endemic to South India. The genus *Strobilanthes* shows a high percentage of endemism, *ie*, 43 out of the 46 species and 5 varieties in South India are

endemics. In Periyar Tiger Reserve, the genus is represented by 23 species of which 18 are endemic to South India. *Crotalaria* is reported to have 75 species in South India and 36 of them are endemics. From the Tiger Reserve 22 species were collected including 9 endemics. *Syzygium* is represented in South India by 33 species of which 21 are endemics. From the Tiger Reserve 14 species were collected including 6 endemics. *Sonerila* has a relatively high percentage of endemism, *ie*, out of the 27 species reported from South India, 25 are endemics. All the 8 species collected from the Tiger Reserve are endemics. Out of the 16 endemic species of *Litsea*, 10 are found in the study area. There are 31 species of *Ceropegia* including 27 endemics in South India. From the Periyar Tiger Reserve 8 species were collected including 6 endemics. The genus *Hedyotis* is fairly well represented in South India by 51 species with 30 endemics. Twelve species of *Hedyotis* including 9 endemics were collected fom the Tiger Reserve. There are 30 species of *Vernonia* reported from South India and 25 of them are endemics. Out of the 13 species collected from the study area, 11 are endemics to South India. *Oberonia* has 17 species in the Tiger Reserve including 10 endemics. Fifteen species of *Habenaria* could be collected from the study area of which 11 are endemic to South India. *Bulbophyllum* is represented by 11 species including 9 endemics. *Dendrobium* has 11 species, of which 8 are endemic to South Indian.

Nayar (1996) has identified 5 centers of endemism in Southern Western Ghats namely Agasthymalai Hills, Anamalai-High Ranges, Palani Hills, Nilgiri-Silentvalley-Wyanad-Kodagu and Shimoga-Kanara. The Tiger Reserve falls within the Anamalai-High Range centre. Nayar (1996) estimated that there are 94 species endemics exclusively to this region. During the present study 25 species endemic to the Anamalai-High Ranges were collected. Among the 515 endemic species collected from Tiger Reserve, *Actinodaphne campanulata, Euonymus paniculata, Memecylon subcordatum, Eugenia calcadensis, Syzygium parameswaranii, Pothos thomsonianus, Marsdenia tirunelvelica, Pogostemon travancoricus, Trias bonaccordensis, Phyllanthus beddomei* and *Impatiens viridiflora* considered restricted to the Agasthyamala regions. *Photinia serratifolia, Actinodaphne salicina, Symplocos macrophylla* ssp. *microphylla*, *Symplocos pulchra* var. *pulchra, Paracroton integrifolius, Curcuma haritha, Bulbophyllum aureum, B. elegantulum, Eria polystachya, Habenaria cephalotes, Spiranthes sinensis* and *Arisaema tylophorum* considered restricted to the Nilgiri-Silent Valley-Kodagu region were also collected from the Tiger Reserve. *Vaccinium neilgherrense* and *Anisochilus argenteus* considered confined to the Palni Hills were also collected from the Tiger Reserve.

4.3 Rare and threatened plants

The rare and threatened plants of South India are relatively well documented by Joseph (1977), Henry *et* al (1979), Jain & Sastry (1984), Ahmedullah & Nayar (1987) and Nayar & Sastry (1987, 1988, 1990). Nayar (1997) listed out 1272 endemic taxa in Kerala and 460 of

them are placed under threat categories. Vivekananthan (1978) published a list of 12 rare and threatened plants in the Periyar Tiger Reserve. During the present study 150 species that have been placed under various threat categories could be collected. The rare and threatened species collected are listed in Table I.

Table I. List of Rare and Threatened Species

Species	Family	Status	References
Actinodaphne campanulata Hook. f.	Lauraceae	Rare	Nayar, 1997
Aenhenrya rotundifolia Gopalan	Orchidaceae	Rare	Nayar, 1997
Aglaia barberi Gamble	Meliaceae	Rare	Ahmedullah & Nayar, 1987
Allophylus concanicus Radlk.	Sapindaceae	Rare	Nayar & Sastry, 1988
Amomum pterocarpum Thw.	Zingiberaceae	Rare	Nayar & Sastry, 1988
Anacolosa densiflora Bedd.	Olacaceae	Possibly extinct	Nayar, 1997
Anaphyllum wightii Schott	Araceae	Threatened	Nayar, 1997
Andrographis explicata (Clarke) Gamble	Acanthaceae	Rare	Nayar, 1997
Anisochilus argenteus Gamble	Lamiaceae	Rare	Nayar & Sastry, 1990
Anisochilus sericeus Benth.	Lamiaceae	Critical	Nayar, 1997
Ardisia blatteri Gamble	Myrsinaceae	Possibly extinct	Nayar, 1997
Ardisia sonchifolia Mez	Myrsinaceae	Insufficiently known	Nayar, 1997
Ardisia stonei Sasidh. & Sivar.	Myrsinaceae	Rare	Nayar, 1997
Arisaema barnesii Fischer	Araceae	Threatened	Nayar, 1997
Arthraxon lanceolatus (Roxb.) Hort.	Poaceae	Threatened	Nayar, 1997
Aspidopterys canarensis Dalz.	Malpighiaceae	Vulnerable	Nayar, 1997
Begonia albo-coccinea Hook. f.	Begoniaceae	Vulnerable	Nayar, 1997
Begonia trichocarpa Clarke	Begoniaceae	Vulnerable	Nayar & Sastry, 1990
Belosynapsis vivipara (Dalz.) Sprag. et Fish.	Commelinaceae	Rare and Threatened	Nayar & Sastry, 1987
Bentinckia condapanna Berry ex Roxb.	Arecaceae	Threatened	Nayar, 1997
Boesenbergia pulcherrima (Wall.) O. Ktze.	Zingiberaceae	Threatened	Nayar, 1997

Bulbophyllum aureum (Hook. f.) J. J. Sm.	Orchidaceae	Endangered	Nayar, 1997
Bulbophyllum elegantulum (Rolf.) Smith.	Orchidaceae	Vulnerable	Nayar & Sastry, 1987
Bulbophyllum fusco-purpureum Wight	Orchidaceae	Threatened	Nayar, 1997
Bulbophyllum kaitiense (Wight) Reich.	Orchidaceae	Vulnerable	Nayar & Sastry, 1988
Calamus brandisii Becc. Calamus vattayila Renuka	Arecaceae Arecaceae	Threatened Fragmented populations	Nayar & Sastry, 1988 Nayar, 1997
Capparis fusifera Dunn	Capparaceae	Rare	Nayar, 1997
Casearia rubescens Dalz.	Flacourtiaceae	Possibly extinct	Nayar, 1997
Cayratia pedata (Lam.) Juss. ex Gagnep var. glabra Gamble	Vitaceae	Vulnerable	Nayar & Sastry, 1988
Ceropegia beddomei Hook. f.	Asclepiadaceae	Endangered	Nayar & Sastry, 1988
Ceropegia maculata Bedd.	Asclepiadaceae	Possibly extinct	Nayar & Sastry, 1988
Ceropegia metziana Miq.	Asclepiadaceae	Rare	Nayar & Sastry, 1988
Ceropegia pussila Wight & Arn.	Asclepiadaceae	Rare	Nayar & Sastry, 1987
Coffea crassifolia Gamble	Rubiaceae	Possibly extinct	Nayar, 1997
Cordia octandra DC.	Boraginaceae	Possibly extinct	Nayar, 1997
Crotalaria barbata Grah. ex Wight & Arn.	Fabaceae	Rare	Nayar, 1997
Crotalaria clarkei Gamble	Fabaceae	Threatened	Sanjappa, 1991
Crotalaria fysonii Dunn.	Fabaceae	Rare	Nayar & Sastry, 1988
Crotalaria grahamiana Wight & Arn.	Fabaceae	Rare	Nayar, 1997
Crotalaria obtecta Grah. ex Wight & Arn.	Fabaceae	Rare	Sanjappa, 1991

Crotalaria peduncularis Grah. ex Wight & Arn.	Fabaceae	Possibly extinct	Nayar & Sastry, 1987
Cyclea fissicalyx Dunn	Menispermaceae	Insufficiently known	Nayar, 1997
Dalbergia beddomei Thoth.	Fabaceae	Endangered	Nayar, 1997
Debregeasia ceylanica Hook. f.	Urticaceae	Threatened	Vivekananthan, 1968
Dendrobium haemoglossum Thw.	Orchidaceae	Threatened	Vivekananthan, 1968
Derris benthamii (Thw.) Thw. var. wightii Thoth.	Fabaceae	Endangered	Nayar, 1997
Desmodium ferrugineum Wall. ex Thoth.	Fabaceae	Vulnerable	Nayar, 1997
Desmos viridiflorus (Bedd.) Safford	Annonaceae	No recent collections	Nayar, 1997
Dictyospermum ovalifolium Wight	Commelinaceae	Rare	Nayar & Sastry, 1987
Didymocarpus fischeri Gamble	Gesneriaceae	Vulnerable	Nayar, 1997
Didymocarpus ovalifolia Wight	Gesneriaceae	Vulnerable	Nayar, 1997
Diplocentrum congestum Wight	Orchidaceae	Possibly extinct	Nayar, 1997
Dipterocarpus bourdillonii Brandis	Dipterocarpaceae	Endangered	Nayar, 1997
Drypetes malabarica (Bedd.) Airy Shaw	Euphorbiaceae	Threatened	Nayar, 1997
Dysoxylum beddomei Hiern	Meliaceae	Vulnerable	Nayar, 1997
Dysoxylum ficiforme (Wight) Gamble	Meliaceae	Rare	Nayar, 1997
Elaeocarpus munronii (Wight) Mast.	Elaeocarpaceae	Rare	Nayar & Sastry, 1990
Embelia adnata Bedd.	Myrsinaceae	Narrow distribution	Nayar, 1997
Epithema carnosum (G. Don) Benth. var. hispida Clarke	Gesneriaceae	Rare	Nayar, 1997
Euonymus paniculatus Wight ex Laws.	Celastraceae	Critical	Nayar, 1997
Euonymus serratifolius Bedd.	Celastraceae	Critical	Nayar & Sastry, 1987
Exacum anamalayanum Bedd.	Gentianaceae	Rare	Nayar, 1997

Exacum courtallense Arn.	Gentianaceae	Rare	Nayar, 1997
Garcinia wightii Anders.	Clusiaceae	Endangered	Nayar, 1997
Glochidion bourdillonii Gamble	Euphorbiaceae	Rare	Nayar, 1997
Glochidion johnstonei Hook. f.	Euphorbiaceae	Rare (isolated population)	Nayar, 1997
Glycosmis macrocarpa Wight	Rutaceae	Rare	Ahmedullah & Nayar 1987
Goniothalamus rhynchantherus Dunn	Annonaceae	Rare	Nayar, 1997
Hedyotis anamalayana (Gamble) R. Rao & Hemad.	Rubiaceae	Critical	Nayar, 1997
Hedyotis bourdillonii (Gamble) R. Rao & Hemad.	Rubiaceae	Vulnerable	Nayar & Sastry, 1988
Hedyotis swertioides Hook. f.	Rubiaceae	Rare	Nayar & Sastry, 1988
Helichrysum perlanigerum Gamble	Asteraceae	Critical	Nayar & Sastry, 1987
Hoya retusa Dalz.	Asclepiadaceae	Threatened	Vivekananthan, 1968
Hoya wightii Hook. f.	Asclepiadaceae	Threatened	Vivekananthan, 1968
Humboldtia bourdillonii Prain	Caesalpiniaceae	Possibly extinct	Nayar & Sastry, 1987
Ilex gardneriana Wight	Aquifoliaceae	Possibly extinct	Nayar & Sastry, 1990
Impatiens herbicola Hook. f.	Balsaminaceae	Vulnerable	Nayar, 1997
Impatiens leptura Hook. f.	Balsaminaceae	Endangered	Nayar, 1997
Impatiens rupicola Hook. f.	Balsaminaceae	Endangered	Nayar, 1997
Impatiens verecunda Hook. f.	Balsaminaceae	Critical	Nayar, 1997
Isachne setosa Fischer	Poaceae	Threatened	Nayar, 1997
Isonandra stocksii Clarke	Sapotaceae	Endangered	Nayar & Sastry, 1990
Ixora johnsoni Hook. f.	Rubiaceae	Rare	Nayar, 1997
Ixora monticola Gamble	Rubiaceae	Vulnerable	Nayar, 1997
Kingiodendron pinnatum (Roxb. ex DC.) Harms	Caesalpiniaceae	Rare	Nayar, 1997
Kunstleria keralensis Mohanan & Nair	Fabaceae	Rare	Nayar, 1997
Lasianthus strigillosus Hook. f.	Rubiaceae	Vulnerable	Nayar, 1997

Marsdenia tirunelvelica Henry & Subram.	Asclepiadaceae	Rare	Nayar & Sastry, 1988
Medinilla malabaricum Bedd.	Melastomataceae	Vulnerable	Nayar, 1997
Memecylon flavescens Gamble	Melastomataceae	Endangered	Nayar & Sastry, 1990
Memecylon lawsonii Gamble	Melastomataceae	Rare and Endangered	Ahmedullah & Nayar, 1987
Mesua ferrea L. ssp. pulchella Vesque var. coromandeliana Mahesh.	Clusiaceae	Endangered	Nayar, 1997
Mycetia acuminata (Wight) O. Ktze.	Rubiaceae	Rare	Nayar, 1997
Myriactis wightii DC. var. bellidioides Hook. f.	Asteraceae	Endangered	Nayar, 1997
Myristica malabarica Lamk.	Myristicaceae	Rare	Ahmedullah & Nayar, 1987
Nothopegia racemosa (Dalz.) Ramam.	Anacardiaceae	Possibly extinct	Nayar, 1997
Oberonia bicornis Lindl.	Orchidaceae	Rare	Stephan & Vajravelu, 1991
Octotropis travancorica Bedd.	Rubiaceae	Rare	Ahmedullah & Nayar, 1987
Orophea uniflora Bedd.	Annonaceae	Rare	Nayar & Sastry, 1988
Osbeckia aspera (L.) Blume var. travancorica (Gamble) Hansen	Melastomataceae	Possibly extinct	Nayar, 1997
Pavetta calophylla Bremek.	Rubiaceae	Rare	Nayar, 1997
Pecteilis gigantea (Smith) Rafin.	Orchidaceae	Threatened	Vivekananthan, 1968
Peucedanum anamallayense Clarke	Apiaceae	Endangered	Nayar & Sastry, 1990
Phaeanthus malabaricus Bedd.	Annonaceae	Vulnerable	Nayar & Sastry, 1990
Piper barberi Gamble	Piperaceae	Vulnerable	Henry et al 1979
Plectranthus rivularis Wight ex Hook. f.	Lamiaceae	Critical	Nayar, 1997
Pogostemon travancoricus Bedd.	Lamiaceae	Vulnerable	Nayar & Sastry, 1990

Pothos armatus Fischer	Araceae	Threatened	Nayar, 1997
Pothos thomsonianus Schott	Araceae	Threatened	Nayar, 1997
Premna glaberrima Wight	Verbenaceae	Rare	Nayar, 1997
Psychotria anamalayana Bedd.	Rubiaceae	Rare	Nayar, 1997
Psychotria keralensis Deb & Gang.	Rubiaceae	Rare(insufficiently known)	Nayar, 1997
Psychotria macrocarpa Hook. f.	Rubiaceae	Rare	Nayar, 1997
Pterospermum reticulatum Wight. & Arn.	Sterculiaceae	Rare	Nayar, 1997
Rauvolfia micrantha Hook. f.	Apocynaceae	Rare	Nayar, 1997
Rhododendron arboreum Smith ssp. nilagiricum Tagg.	Ericaceae	Rare	Nayar, 1997
Rotala ritchiei (Clarke) Kochne	Lythraceae	Vulnerable	Nayar & Sastry, 1987
Sageraea grandiflora Dunn	Annonaceae	Endangered	Nayar, 1997
Salacia beddomei Gamble	Hippocrateaceae	Rare	Nayar, 1997
Salacia macrosperma Wight	Hippocrateaceae	Rare	Nayar, 1997
Schefflera bourdillonii Gamble	Araliaceae	No recent collection	Nayar, 1997
Semecarpus auriculata Bedd.	Anacardiaceae	Vulnerable	Nayar, 1997
Semecarpus travancorica Bedd.	Anacardiaceae	Rare	Nayar, 1997
Smilax wightii DC.	Smilacaceae	Rare	Nayar & Sastry, 1987
Smithia venkobarowii Gamble	Fabaceae	Possibly extinct	Nayar, 1997
Solenocarpus indica Wight & Arn.	Anacardiaceae	Rare	Nayar, 1997
Sonerila grandiflora R. Br. ex Wight & Arn.	Melastomataceae	Rare	Nayar, 1997
Sonerila sahyadrica Giri & Nayar	Melastomataceae	Rare	Nayar, 1997
Sonerila speciosa Zenk.	Melastomataceae	Vulnerable	Nayar, 1997
Strobilanthes jeyporensis Bedd.	Acanthaceae	Endangered	Nayar & Sastry, 1987
Strobilanthes lawsonii Gamble	Acanthaceae	Rare	Nayar, 1997
Symplocos monantha Wight	Symplocaceae	Possibly extinct	Nayar, 1997
Symplocos wynaadense (O. Ktze.) Nooteb.	Symplocaceae	Rare	Ahmedullah & Nayar, 1987

Symplocos macrophylla Wall. ex A. DC. ssp. macrophylla	Symplocaceae	Rare	Henry *et al*, 1987
Syzygium benthamianum (Wight ex Duthie) Gamble	Myrtaceae	Rare	Nayar, 1997
Syzygium bourdillonii (Gamble) Rathakr. & Nair	Myrtaceae	Possibly extinct	Nayar, 1997
Syzygium mundagam (Bourd.) Chitra	Myrtaceae	Rare	Ahmedullah & Nayar, 1987
Syzygium occidentalis (Bourd.) Gandhi	Myrtaceae	Rare	Nayar, 1997
Taeniophyllum scaberulum Hook. f.	Orchidaceae	Possibly extinct	Nayar, 1997
Tarenna monosperma (Wight & Arn.) Raju	Rubiaceae	Critical	Nayar, 1997
Trichosanthes anamalaiensis Bedd.	Cucurbitaceae	Rare	Nayar, 1997
Tylophora rotundifolia Buch.-Ham. ex Wight	Asclepiadaceae	Rare	Stephan & Vajravelu, 1991
Vanasushava pedata (Wight) Mukh. & Const.	Apiaceae	Rare	Nayar & Sastry, 1988
Vernonia heynei Bedd. ex Gamble	Asteraceae	Vulnerable	Nayar, 1997
Vernonia multibracteata Gamble	Asteraceae	Possibly extinct	Nayar & Sastry, 1997
Vernonia peninsularis (Clarke) Clarke ex Hook. f.	Asteraceae	Vulnerable	Nayar, 1997
Vernonia saligna DC.	Asteraceae	Vulnerable	Nayar, 1997
Vernonia salvifolia Wight	Asteraceae	Endangered	Nayar, 1997

Among the 150 threatened category species collected from the Tiger Reserve, 17 are considered 'possibly extinct' (Nayar. 1997) viz. *Ardisia blatteri* Gamble, *Cordia octandra* DC, *Ceropegia maculata* Bedd., *Anacolosa densiflora* Bedd., *Casearia rubescens* Dalz., *Coffea crassifolia* Gamble, *Crotalaria peduncularis* Grah. ex Wight & Arn., *Diplocentrum congestum* Wight, *Humboldtia bourdillonii* Prain, *Ilex gardneriana* Wight, *Nothopegia racemosa* (Dalz.) Ramam., *Osbeckia aspera* Blume var. *travancorica* (Gamble) Hansen, *Smithia venkobarowii* Gamble, *Symplocos monantha* Wight, *Syzygium bourdillonii* (Gamble) Rathakr. & Nair, *Taeniophyllum scaberulum* Hook. f. and *Vernonia multibracteata* Gamble. Of these *Ardisia blatteri* Gamble, *Cordia octandra* DC.,

Ceropegia maculata Bedd., *Coffea crassifolia* Gamble, *Diplocentrum congestum* Wight, *Osbeckia aspera* var. *travancorica* Hansen, *Smithia venkobarowii* Gamble were recently relocated (Sasidharan & Sivarajan, 1996; Sasidharan, 1997). Others are collected for the first time after their type collections.

5. DISCUSSION

The Periyar Tiger Reserve situated along the Southern Western Ghats in Idukki district is the largest protected area in Kerala. Part of the Tiger Reserve comes under the Anamalai-High Range endemic centre. Due to the varied climatic conditions and wide range in the altitude, seven major vegetation types are found in the region.

Angiosperms, the dominant plant group studied during the project period, has a representation of 1965 taxa (species and infraspecific). They belong to 814 genera under 151 families. Among the 1965 species, 515 are Southern Western Ghat endemics and 150 of them belong to threat categories including 17 species considered 'possibly extinct'.

The occurrence of 1965 species in an area of 777 km^2 indicates the richness and diversity of the flora of the Tiger Reserve. Nayar (1997) has estimated that there are about 3,800 flowering plants in Kerala. Thus the flora of the Tiger Reserve form more than half of the estimated flora of the state. The major families and genera are fairly well represented in the flora of the Tiger Reserve. The family Poaceae, which is the first dominant family in South India is represented by 162 species. Sreekumar & Nair (1991) reported 296 species of grasses from Kerala, belonging to 24 tribes. Of these, members of *Aleuropodeae, Arundineae, Phareae, Thysanolaeneae* and *Zoysieae* are confined to lowlands and backwater habitats. Further, 107 species prefer to the plains including coastal belts. After excluding the species belonging to the above habitats, the occurrence of 162 species in the Tiger Reserve is perhaps the richest assemblage of grass flora in the state. Similarly the presence of 145 Orchids out of the 216 reported from Kerala (Manilal & Sathish Kumar, 1993) is the highest number from a District.

The finding of 150 species belonging to the threat categories also reveals the need for further quantification studies to ascertain their correct status. The forests of the Tiger Reserve are relatively less disturbed and virtually undistributed forests are found at Kottamala, Uppermanalar, Chokkampetti, Sunderamala, Aladi and Poonkavanam. The conversion of grasslands into Eucalyptus plantations have reduced the population of threatened species like *Ceropegia maculata, C. beddomei, C. pussila, Lilium wallichianum, Habenaria spp., Peucedanum anamallayense*, *Pecteilis gigantea*, *Rotala ritchiei*, *Smithia venkobarowii*, *Vernonia multibracteata,* etc., which are found in the grasslands.

In the present study, only Angiosperms were covered. One new species *Habenaria periyarensis* Sasi. *et al* were described. Another 14 specimens are not agreeing with the known taxa and are probably new ones. Among the 1965 species collected from the Tiger Reserve, 4 are new records for India and 14 are new records for Kerala. It is very important

to study the non-flowering plants also to have an in-depth knowledge on the plant diversity of the Tiger Reserve.

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