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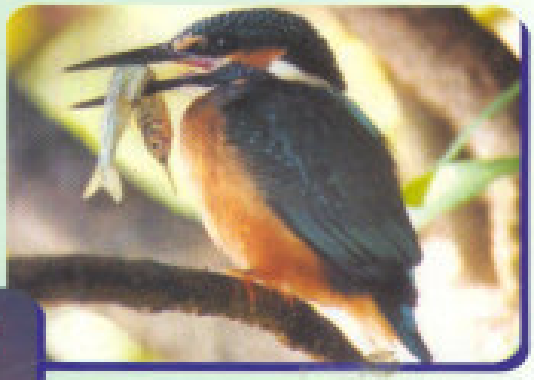
"BIODIVERSITY PROFILE OF TAMILNADU"





ENVIRONMENTAL INFORMATION SYSTEM (ENVIS) CENTRE
DEPARTMENT OF ENVIRONMENT, Government of Tamil Nadu
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FOREWORD

The term biodiversity refers to the variety and variability found among the living organisms. Three levels of biodiversity are recognized viz. Ecosystem diversity, Species diversity and Genetic diversity, among these Species diversity is easy to comprehend. The biodiversity database developed by the ENVIS Centre of the Department of Environment deals only with the species diversity. Tamil Nadu has a geographical area of 13 million hectares which constitutes about 4 % of the land area of the country. The state's rich biodiversity is facing a serious threat from growing human and livestock population and also from various developmental activities. Conserving the biodiversity in the wake of depleting natural resources has therefore assumed considerable importance. The State has had a long history of taxonomic surveys and ecological research; the available information on its biodiversity is rather scattered. Hence it was decided to develop a database on biodiversity of Tamil Nadu. In this connection a one-day workshop on **"Biodiversity of Tamil Nadu"** was organised on December 5, 2002 involving experts on floral faunal and microbial diversity from all over the state. I fondly recall the valuable contribution of late **Fr. K.M. Mathews** of the Rapinat Herbarium, Tiruchy on that occasion. During the workshop, it was decided to prepare a checklist of floral, faunal and microbial diversity of Tamil Nadu.

The database on floral diversity of Tamil Nadu was prepared under the guidance of **Dr. D. Narasimhan**, Lecturer, Centre for Floristic Research, Department of Botany, Madras Christian College and his research team comprising Ms. C. Chandrakala and Ms. A.K. Rathnakumari. A total of 5547 taxa that have been recorded include 5239 species, 72 subspecies and 548 varieties distributed in 231 families under 1668 genera. Dicots constitute a major part of the flora that account for 78 per cent comprising 1944 taxa of Polypetalae, 1720 taxa of Gamopetalae and 642 taxa of Monochlamydeae. Number of Monocots in Tamil Nadu includes 1241 taxa. Nearly 10 per cent of the flowering taxa of Tamil Nadu belong to Leguminosae (559 taxa) including families Caesalpiniaceae and Mimosaceae. Tamil Nadu has a rich grass flora; Grasses constitute 9% of the total taxa (494 taxa) of Tamil Nadu. The other dominant families of flora include Compositae (294 taxa), Rubiaceae (263 taxa) and Orchidaceae (210 taxa). About 270 taxa are strictly endemic to Tamil Nadu. Majority of these endemics are herbs occur in Southern Western Ghats covering Tirunelveli and Kanniyakumari districts. Orchids and grasses are the major endemic plant groups with 65 and 44 taxa respectively.

The database on Faunal diversity of Tamil Nadu has been prepared by **Dr. K. Venkataraman,** Joint Director, Marine Biological Station, Zoological Survey of India and his research team comprising Dr. M.C. John Milton, Mr. K.P Raghuram, Mr. B. Ashok Kumar, Mr. A. Gokul and Mr. M. Nithyanandan. The faunal diversity is spread over three major ecosystems viz. Freshwater, Marine and Terrestrial. A little over **595 freshwater fauna are occurring in Tamil Nadu**. They include species from Phylum Mollusca, Arthropoda, Amphibia, Fishes, Reptiles and Birds. In general, insects dominate the Freshwater fauna as in other states. However, the major group of insects such as Hemiptera, Coleoptera, Ephmeroptera and Odonata are dominant. Fauna belonging to all taxonomic categories from Protozoa to Mammalia are represented in the fresh water wetlands of Tamil Nadu.

The marine fauna is rich and varied; the 1076 k.m long coastline of Tamil Nadu encompasses almost all types of inter tidal habitats from hyper saline to brackish lagoons, estuaries, and coastal marsh and mudflats to sandy and rocky shores with varying degree of exposure and widely varying profiles. **A little over 2247 marine species have been reported in Tamil Nadu.** The major marine invertebrates include species from Phylum Porifera, Cnidaria, Mollusca, Crustacea, Echinodermata, Protochordata, Pisces, Reptiles, Aves and Mammalia. In Tamil Nadu nine species of sea snakes and five species of turtles have been reported. The seashore offers a variable feeding and breeding grounds for a number of birds. Over 120 species of Marine mammals are estimated to occur in world seas of which 29 are reported from seas around India including Tamil Nadu. The endangered sea cow *(Dugong dugong)* occurring in shore water of Gulf of Mannar is an added beauty to the Tamil Nadu coast.

Tamil Nadu is endowed with a rich terrestrial faunal diversity. The terrestrial ecosystem of Tamil Nadu can be divided into two natural division's viz. the eastern coastal plains and the hilly region along the north and the west. Of the total recorded forest area in the State, 13.7 % or 3134.70 sq km is dedicated to wildlife conservation covering two biosphere reserves of which one is marine, five national parks of which one is marine, eight wildlife sanctuaries and twelve bird sanctuaries. **Among the invertebrate fauna insect dominates the terrestrial ecosystem with 1282 species** of which 268 are Arachnids. Other than insects, eight species of isopods, 22 species of annelids and 60 species of land molluscs are reported from Tamil Nadu. Only scanty information is available on the diversity of protozoa, plant and soil nematodes and other terrestrial fauna of Tamil Nadu.

The fungal flora of Tamil Nadu has been explored by many mycologists over a period of more than 50 years. In fact the first fungus ever to be described from India is *Podaxon pistillaris* which was collected by Koenig, a Danish Missionary from Tranquebar. **Dr. K. Natarajan**, Emeritus Professor, CAS in Botany, University of Madras has compiled, **a total number of 1077 species in 370 genera,** all the species which are validly published up to the year 2000. His paper on **"Ectomycorrhizas in Tamil Nadu Forest"** is widely discussed in this special issue.

I am happy to be associated with this great work of bringing out a check list of the flora, fauna and fungi of Tamil Nadu through a web based Environmental Information System (ENVIS) Centre of the Department of Environment, Tamil Nadu. In order to have an overview of the Biodiversity of the state this special issue on **"Biodiversity Profile of Tamil Nadu"** is being published as a hard copy. I compliment Dr. D. Narasimhan, Dr. K. Venkataraman and Dr. K. Natarajan and their team for their excellent effort in making this book a reality. I am sure that this will be useful to the research students of Botany, Zoology and Mycology for a quick reference. I dedicate this book to the illustrious taxonomists of Tamil Nadu. I also welcome suggestions for further improvement of this endeavour.

(S. Balaji)

Floral Diversity of Tamil Nadu

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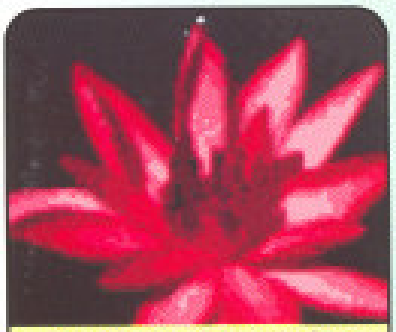

Fig.1, Nymphaea rubra

Tamil Nadu harbours diverse vegetation types. Eight different forest types of Champion & Seth (1968) including mangroves occur in Tamil Nadu. They are:

1. Tropical Wet Evergreen Forest
2. South Montane Wet Temperate Forest
3. Tropical Semi Evergreen Forest
4. Tropical Moist Deciduous Forest
5. Tropical Dry Deciduous Forest
6. Tropical Thorn Forest
7. Tropical Dry Evergreen Forest
8. Littoral and Swamp Forest
9. Grasslands

1. Tropical Wet Evergreen Forest:

They occur at an altitude of 1500 m or above and are restricted to Southern Western Ghats. The vegetation is characterized by three-tier organization of species. Tall trees, many of which attain a height of more than 40 m, form the uppermost tier or top canopy. This tier is represented by tree species such as *Antiaris toxicaria*, *Artocarpus heterophyllus*, *Artocarpus hirsutus*, *Calophyllum apetalum*, *Calophyllum austro-indicum*, *Hoppea parviflora*, *Palaquium ellipticum* and *Tetrameles nudiflora*. The second tier is composed of members of Elaeocarpaceae, Euphorbiaceae and Lauraceae. Some of the tree taxa of this tier include *Actinodaphne malabarica*, *Cinnamomum verum*, *Elaeocarpus serratus*, *Litsea spp.* and *Mallotus philippensis*. Shrubby species belonging to *Ixora*, *Pavetta* and *Strobilanthes* form the last tier of the vegetation. The forest floor supports rich herbaceous vegetation and the arborescent habitat provide a good niche for a number of epiphytic orchids and pteridophytic flora.

2. South Montane Wet Temperate Forest:

These are popularly known as "Shola Forest" and are confined to moist valleys and slopes of Nilgiri, Palani and Anamalai hills. Sholas occur as patches of forests alternating with grasslands thus forming shola - grassland complex. Species belonging to Berberidaceae, Ericaceae, Magnoliaceae, Myrtaceae, Rosaceae, Symplocaceae and Vacciniaceae are predominantly found in the Shola forests. Views on shola forests differ. Some consider shola forest as a climax forest type where as others consider this as a relict vegetation. According to Meher Homji these forests should be considered as Tropical Montane forest and not as Temperate Montane forests.

3. Tropical Semi Evergreen Forest:

These forests form a bridge between Wet Evergreen and Moist deciduous forest. They usually occur between 800 – 1200 m altitudes in Southern Western Ghats of Tamil Nadu. Many of the tree species are common to Wet Evergreen Forests. This forest type supports a good number of epiphytic orchids and canes.

4. Tropical Moist Deciduous Forest:

This forest type occurs between Semi Evergreen and Dry Deciduous forests. The arborescent flora is predominantly deciduous interspersed with Evergreen elements at the lower tier. Plants such as *Dillenia pentagyna*, *Mitragyna parvifolia*, *Tectona grandis* and *Terminalia paniculata* are the common floristic elements.

5. Tropical Dry Deciduous Forest:

They occur at altitudes between 400 – 600 m on well-drained shallow soils. This forest type supports a number of species of timber importance such *Anogeissus latifolia*, *Chloroxylon swietenia*, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Shorea roxburghii* and *Terminalia spp.*

6. Tropical Thorn Forest:

Southern Tropical Thorn forests mostly occur in the dry plains and on low elevation hillocks as well as at the foothills of Eastern and Western Ghats. They are characterized by the presence of species belonging to *Acacia*, *Capparis*, *Euphorbia*, *Mimosa* and *Ziziphus*.

7. Tropical Dry Evergreen Forest:

Tropical Dry Evergreen forests are restricted to East Coast of Tamil Nadu running from Pulicat at the Northern point to the Vedaranyam at the south covering a width of 60 km from East to West. Much of the original vegetation of this type is lost or severely degraded. What survives is about a per cent that is highly fragmented. A

good number of forest patches of this type are preserved in the form of sacred groves. Tropical Dry Evergreen Forests occur in three different habitats: (i) along the sandy coast, (ii) interior coastal plains with red laterite soils, (iii) isolated hillocks scattered along the coast. Characteristic species of this forest include *Atalantia monophylla*, *Diospyros chloroxylon*, *Drypetes sepiaria*, *Euphorbia nivulia*, *Garcinia spicata*, *Memecylon umbellatum*, *Pamburus missionis*, *Polyalthia korinthii* and *Pterosperum canescens*.

8. Littoral and Swamp Forests (Mangroves):

It mainly includes mangroves seen in intertidal zones. In Tamil Nadu mangrove vegetation is mainly seen in Pichavaram. Pichavaram covers an area of about 14 sq. km. of dense mangrove vegetation. Apart from Pichavaram they are seen in Gulf of Mannar and backwater regions of Ennore. In Tamil Nadu there are 22 species of mangroves under 16 genera and 13 families. The list of mangroves seen in Tamil Nadu are listed below.

Table 1: List of Mangroves in Tamil Nadu

No.	Binomial	Family
1.	*Acanthus ilicifolius* L	Acanthaceae
2.	*Aegiceras corniculatum* (L.) Blanco	Mrysinaceae
3.	*Avicennia alba* Blume	Avicenniaceae
4.	*Avicennia marina* (Forssk.) Vierh.	Avicenniaceae
5.	*Avicennia officinalis* L.	Avicenniaceae
6.	*Bruguiera cylindrica* (L.) Blume	Rhizophoraceae
7.	*Bruguiera gymnorrhiza* (L.) Savigny	Rhizophoraceae
8.	*Cerbera odollam* Gaertn.	Rhizophoraceae
9.	*Ceriops decandra* (Griff.) Ding Hou	Rhizophoraceae
10.	*Ceriops tagal* (Perr.) Robins	Rhizophoraceae
11.	*Dalbergia spinosa* Roxb.	Fabaceae
12.	*Excoecaria agallocha* L.	Euphorbiaceae
13.	*Heritiera littoralis* Dryand	Sterculiaceae
14.	*Kandelia candel* (L.) Druce	Rhizophoraceae
15.	*Lumnitzera racemosa* Willd.	Combretaceae
16.	*Myriostachya wightiana* (Nees ex Steud.) Hook. F.	Poaceae
17.	*Rhizophora annamalayana* Kathir.	Rhizophoraceae
18.	*Rhizophora apiculata* Blume	Rhizophoraceae
19.	*Rhizophora mucronata* Poir	Rhizophoraceae
20.	*Scyphiphora hydrophyllacea* Gaertn	Rubiaceae
21.	*Sonneratia apetala* Buch. – Ham.	Sonneratiaceae
22.	*Xylocarpus granatum* Koen.	Meliaceae

Fig.2, Mangrove vegetation at Pichavaram

9. Grasslands:

Grasslands can be divided into lowland and highland grasslands. Lowland grasslands lies up to 1000 m altitude and are very scattered and intermixed with the local forests. Fire is common during dry months, often due to anthropogenic factors. The dominant grasses are *Arundinella ciliata*, *A. mesophylla*, *Chrysopogon orientalis*, *Digitaria ciliaris*, *Eragrostis tenuifolia* and *Imperata cylindrica*. Common trees are *Mundelea sericea*, *Phoenix humilis* var. *pedunculata*. Common shrubs are *Hedyotis purpurascens* and *Uvaria rufescens*. Herbs found are species of *Biophytum*, *Crotalaria*, *Cyanotis*, and *Fimbristylis*. Orchids present include species of *Habenaria* and *Pectellis*. *Burmannia pusilla* and *Utricularia striatula* are seen in moist substratum.

High-level grasslands are seen in large areas on mountaintop with grasses, herbs and shrubs. Common grasses are *Agrostis peninsularis*, *Arundinella purpurea*, *Bromus ramosus*, *Chrysopogon zeylanicus*, *Isachne boumeorum* and *Tripogon bromoides*. Other associated species such as *Anaphalis bournei*, *Blumea hieracifolia*, *Drosera peltata*, *Osbeckia parvifolia*, *Vernonia peninsularis* also occur.

Psammophytic Vegetation:

It occurs along the coastal sands as well as on sands of riverbeds. Species such as *Boerhavia diffusa*, *Canavalia lineata*, *Cleome tenella*, *Cyperus arenaria*, *Hydrophylax maritima*, *Ipomoea biloba*, *Portuluca tuberosa*, *Spinifex littoralis* and *Tragus muricata* commonly occur on the coastal sands. Riverbeds are characterized by the presence of species such as *Citrullus colocynthis*, *Commelina attenuata*, *Glinus oppositifolius*, *Trichuriella monsoniae*, *Vahlia dichotoma*. An African weed, *Sesamum alatum*, has naturalized in several places along the coast during the past three decades.

Halophytic Vegetation:

This occurs close to littoral and swamp forests in the saline soils. Most common halophytes include *Aleuropus lagopoides, Arthrocnemum indicum, Atriplex repens, Fimbristylis triflora, Salicornia brachiata, Sesuvium portulucastrum, Sporobolus tremulus* and *Suaeda* spp.

Aquatic vegetation:

Presence of innumerable fresh water bodies in Tamil Nadu support a rich aquatic flora. Most common aquatic species are *Aponogeton spp. Aeschynomone aspera, Hydrilla verticillaster, Ipomoea aquatica, Necamandra spp., Nelumbo nucifera, Neptuna oleracea, Nymphaea spp. Nymphoides spp., Ottelia alismoides, Pistia stratioitis, Rotala spp. & Utricularia spp. Trapa natans* var. *bispinosa* is restricted to ponds of Kanniyakumari and Tirunelveli districts in Tamil Nadu. There are a number of aquatic grasses. *Hygroryza aristata, Leersia hexandra, Leptochloa spp, Oryza rufipogon Pseudoraphis echinata* and *Sacciolepis interrupta*. The aquatic habitat also harbours a rich sedge flora. Brachish water and seawater support a number of marine angiosperms commonly called as "Seagrasses". They include species of *Halodule, Halophila* and *Cymodocea*. Genera such as *Thalassia, Enhalus* and *Syringodium* are represented by a single species.

FLORISTIC ANALYSIS OF TAMIL NADU:

Of the estimated 17,000 flowering plants in India (Nayar, 1996), 5239 species occur in Tamil Nadu that accounts for nearly 1/3 of the total flora of India. Species and Generic diversity of Flora of Tamil Nadu is comparatively richer than the neighbourhood states. Kerala harbours 4465 species and 1315 genera (Sasidharan, 2003) whereas the plant diversity of Andhra Pradesh includes 2601 species and 1035 genera (Pullaiah, 2002). The state of Tamil Nadu harbours a total of 5547 taxa that include 5239 species, 72 subspecies and 548 varieties distributed in 231 families under 1668 genera. Dicots constitute a major part of the flora that account for 78 per cent comprising 1944 taxa of Polypetalae, 1720 taxa of Gamopetalae and 642 taxa of Monochlamydeae. Number of Monocots in Tamil Nadu includes 1241 taxa.

Nearly 10 per cent of the flowering taxa of Tamil Nadu belong to Leguminosae including families Caesalpiniaceae and Mimosaceae. Tamil Nadu has a rich grass flora thanks to the varied topography and climate. Grasses constitute 9% of the total taxa of Tamil Nadu. The other dominant families of flora include Compositae, Rubiaceae and Orchidaceae.

Table 2 : Ten Dominant Families

No.	Families	Genera	Species	Subspecies	Varieties
1.	Leguminosae	118	510	7	42
2.	Poaceae	144	451	2	41
3.	Compositae	102	264	2	28
4.	Rubiaceae	57	212	2	49
5.	Orchidaceae	67	196	2	12
6.	Euphorbiaceae	52	194	2	22
7.	Cyperaceae	16	188	4	18
8.	Acanthaceae	46	182	-	24
9.	Labiatae	31	143	-	28
10.	Myrtaceae	16	106	1	4

Over 270 taxa are strictly endemic to Tamil Nadu. Majority of these endemics are herbs occur in Southern Western Ghats covering Tirunelveli and Kanniyakumari districts. Orchids and grasses are the major endemic plant groups with 65 and 44 taxa respectively. A good number of endemic species constitute newly described species and varieties in the last fifteen years. (c.f. www.envis.tn.nic.in for detailed references for endemic taxa).

List of new taxa described in the last 15 years that are endemic to Tamil Nadu:

1. ***Polyalthia tirunelvellensis*** M. B. Viswan. & Manikandan
2. ***Nothopegia vajravelui*** Ravikumar & Lakshmanan
3. ***Rhizophora x annamalayana*** Kathir.
4. ***Syzygium sriganesanii*** Ravikumar & Lakshmanan
5. ***Syzygium zeylanicum*** (L.) DC. var. ***megamalayanum*** Ravikumar & Lakshmanan
6. ***Memecylon bremeri*** Viswanathan
7. ***Memecylon gopalanii*** Murugan et Manickam
8. ***Memecylon kollimalayana*** Viswanathan
9. ***Osbeckia tirunelvelica*** Manickam & Murugan
10. ***Sonerila inaequalis*** Murugan et Manickam

11. ***Sonerila kanyakumariana*** Gopalan & Henry
12. ***Sonerila parameswaranii*** Ravikumar & Lakshmanan
13. ***Schefflera maduraiensis*** Ravikumar & Lakshmanan
14. ***Hedyotis shettyi*** Ravikumar & Lakshmanan
15. ***Pavetta oblanceolata*** Bremek
16. ***Cissampelopsis ansteadii*** (Tad. & Jacob) C. Jeffrey & Y.L. Chen
17. ***Vernonia pothigaiana*** Chelladurai & Gopalan
18. ***Vaccinium leschenaultii*** Wight var. ***pubescens*** S.M. Rajendran, S.C. Agarwal & H.N. Verma
19. ***Symplocos pulchra*** Wight subsp. ***coriacea*** Gopalan & Henry
20. ***Ceropegia mannarana*** Umamahesw. & P. Daniel
21. ***Ipomoea pes-caprae*** (L.) R. Br. var. ***perunkulamensis*** Umamahesw. & P. Daniel
22. ***Premna balakrishnanii*** Rajendran & P.Daniel
23. ***Premna latifolia*** Roxb. var. ***henryi*** Narasimhan
24. ***Premna mundanthuraiensis*** Rajendran & P.Daniel
25. ***Anisochilus henryi*** Ravikumar & Lakshmanan
26. ***Leucas anandaraoana*** Umamahesw. & P. Daniel
27. ***Pogostemon hedgei*** V.S. Kumar & B. Sharma
28. ***Balanophora indica*** (Am.) Griff. var. ***agastyamalayana*** Viswanathan, Prem Kumar & Ramesh
29. ***Balanophora indica*** (Am.) Griff. var. ***tirunelveliensis*** Viswanathan, Prem Kumar & Ramesh
30. ***Claoxylon wightii*** Hook.f. var. ***angustatum*** Susila et Balakr.
31. ***Claoxylon wightii*** Hook.f. var. ***hirsutum*** (Hook.f.) Sushila et Balakr.
32. ***Euphorbia balakrishnanii*** Binojk. & Gopalan
33. ***Euphorbia cotinoides*** Miq.
34. ***Euphorbia vajravelui*** Binojk. & Balakr.
35. ***Glochidion balakrishnanii*** G.J. Jothi, V.S. Manickam, V. Sundaresan et M. Josphine Mary
36. ***Bulbophyllum agastyamalayanum*** Gopalan & Henry
37. ***Dendrobium dioidon*** *Reichb.f. subsp.* ***kodayarensis*** Gopalan & A.N. Henry
38. ***Dendrobium panduratum*** Lindl. subsp. ***villosus*** Gopalan & Henry
39. ***Eriocaulon panagudianum*** Ansari & Balakr.
40. ***Eriocaulon ramnadense*** Ansari & Balakr.
41. ***Acrachne sundararajii*** Umamahesw. *et al*
42. ***Chrysopogon copei*** Mohanan et Ravi
43. ***Dimeria balakrishnaniana*** K.Ravik., P.V. Sreek. & V. Lakshmanan
44. ***Eragrostis dayanandanii*** P. Ravichandran, S. Krishnan, N. P. Samson
45. ***Iseilema jainiana*** Umamahesw. & P. Daniel
46. ***Perotis indica*** (L.) Kuntze var. ***keelakaraiensis*** Umamahesw. & P. Daniel
47. ***Sporobolus hajrae*** Umamahesw. & P. Daniel

There are two biosphere reserves in Tamil Nadu namely Nilgiri Biosphere Reserve and Gulf of Mannar Biosphere Reserve. Nilgiri Biosphere Reserve harbours 3187 species (Vivekananthan *et al.* 1997) of flowering plants that accounts for 60 per cent of plants recorded from Tamil Nadu. About 80 per cent of flowering plants recorded from Western Ghats occur in Nilgiri Biosphere Reserve. Nilgiri Biosphere Reserve harbours 112 endemic species (c.f. www.envis.tn.nic.in for details). There are two genera that are endemic to Nilgiri Biosphere Reserve namely, *Baeolepis* Decne. ex Moq. (Periplocaceae) and *Silentvalleya* V. J. Nair *et al.* (Poaceae). Of 185 taxa that are recorded as threatened species from Southern Western Ghats 53 taxa are found in Nilgiris. Gulf of Mannar Biosphere Reserve is an aquatic Biosphere Reserve in Tamil Nadu. The angiosperm flora of Gulf of Mannar (Daniel & Umamaheswari, 2001) has a total of 784 taxa, which includes 764 species and 20 infraspecific taxa (sub-species/varieties). They belong to 433 genera and 113 families.

Species endemic to Gulf of Mannar:

1. *Acrachne henrardiana* (Bor) S. M. Phillips
2. *Acrachne sundararajii* Umamahesw. *et al.*
3. *Ceropegia mannarana* Umamahesw. & P. Daniel.
4. *Chloris wightiana* Nees ex Steud
5. *Ipomoea pes-caprae* (L.) R. Br. var. *perunkulamensis* Umamahesw. & P. Daniel

6. *Iseilema jainiana* Umamahesw. & P. Daniel
7. *Jatropha villosa* Wight var. *ramnadensis* Ramam.
8. *Leucas anandaraoana* Umamahesw. & P. Daniel
9. *Perotis indica* (L.) Kuntze var. *keelkavaiensis* Umamahesw. & P. Daniel
10. *Sporobolus hajrae* Umamahesw. & P. Daniel

MAJOR GAPS ON FLORAL DIVERSITY RESEARCH

The state of Tamil Nadu has been well explored for plant diversity for the past three centuries. However, there are regions that are under explored. These regions are floristically rich and harbour several endemic and threatened species as well as undescribed species. For example, exploration of Meghamalai in Theni district by Dr. K. Ravikumar has resulted in the discovery of 7 new taxa namely, *Nothopegia vajravelui* (Anacardiaceae), *Syzygium sriganesanii* (Myrtaceae), *Syzygium zeylanicum* var. *megamalayanam* (Myrtaceae), *Sonerila parameswaranii* (Melastomataceae), *Schefflera maduraiensis* (Araliaceae), *Hedyotis shettyi* (Rubiaceae) and *Anisochilus henryi* (Lamiaceae). Similarly, studies on Southern Western Ghats have resulted in several species being rediscovered after the type collection as well as in the discovery of many new taxa. Recently, *Syzygium gambleanum*, a supposed to be extinct species has been relocated from its type locality by Irwin *et al.* (2003).

Regions that need to be explored in detail include:

(1) Western Ghats of Kanniyakumari and Tirunelveli districts.

(2) Offshoots of Western Ghats such as Meghamalai and Azhagar Hills.

(3) Hill ranges of Eastern Ghats such as Kolli, Javadhi and Kalrayan.

(4) Specialized habitats such as hill streams and rivers.

Apart from areas that need a detailed exploration, there are several plant groups that need to be studied in detail. Families that possess more number of endemic taxa such as Balsaminaceae, Lauraceae, Myrtaceae and Melastomataceae require a thorough study. Similarly, Monocot families such as Arecaceae, Commelinaceae, Cyperaceae, and Orchidaceae also need to be studied in detail. Revision of a number of families and genera is an urgent necessity to comprehend the information that is available from different branches of Botany. Population biology of endemic and threatened species should be the focus for all taxonomists and ecologists as there is a paucity of data in this area. Preparation of precise distribution maps for such taxa using modern tools such as GIS is much needed.

There is a renewed interest in traditional systems of medicine and as a consequence in medicinal plant trade. Hence, floristic research should concentrate on a number of aspects of medicinal plants, not only to provide information, but also to monitor the bulk collection of medicinal plants.

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FAUNAL DIVERSITY OF TAMIL NADU

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Tamil Nadu is situated on the southeastern side of the Indian peninsula. It is bounded in the east by the Bay of Bengal, in the south by the Indian Ocean, in the west by the states of Kerala and Karnataka and in the North by Karnataka and Andhra Pradesh. Tamil Nadu has a total geographical area of 130 lakh ha. which amounts to 4% of the India's total land surface. It lies between 8° 04' N and 13° 34' N and 76° 14' E and 80° 21' E. Tamil Nadu falling within Deccan peninsula of India is a stable mass of Archaean and Pre-Cambrian formations, the areas covered by Gondwana and later formations as well as areas formed by Deccan lava flows. The major mountain-building disturbances in this area ceased in the Pre-Cambrian times but some minor folding, clock-faulting and epeirogenic movements affected the region during Post-Cambrian times. Tamil Nadu can be divided into four major geographical divisions such as the eastern and coastal plains, central uplands, western Karnataka plateau and the central Eastern Ghats.

Fig.1, Manjalar Dam

The general climate is moderately hot and dry in the plains of the State. However, temperature dips close to 0° C in the Western Ghats during winter. The average rainfall varies between 900 and 1200 mm/y. Rainfall in the range of 3000-5000 mm/y occurs in the Western Ghats while the rainshadow region of Coimbatore and adjacent areas receive less than 600 mm annually. Whereas the southwest monsoon is the major source of rain, the northeast monsoon hydrates the east coast during the colder part of the year. Tamil Nadu has a human population of 621.1 lakh (2001 Census) and a livestock population of 260 lakh. 17.4% of the land area (22.6 lakh ha) is classified as forests of which 86 % are reserve forests, 11 % reserve lands and 2.71% unclassified forests. The Tamil Nadu forest department is custodian of 22,870 sq km of forestland, which constitute 18 % of the total geographical area as against 33.33% required under National Forest policy, 1988.

ECOSYSTEMS DIVERSITY

Tamil Nadu has a conglomeration of different types of ecosystems rather than a particular type as in some other states of India. The geographical location of the State has bestowed it with major representative ecosystems. It has within its confines, areas representing different types of ecosystems like dry deciduous forests, moist deciduous forests, degraded shrub lands, dry evergreen forests or thorn shrub and small pockets of semi evergreen forests and sholas besides certain wetland ecosystems. Though most of the ecosystem types represented here are found in some of the other states, much of the thorn forests and scrublands of India are confined to Tamil Nadu, comprising a major part of this state. The whole eastern side of the state is protected by 1000 km of seacoast, which has all major types of ecosystems such as pelagic and benthic, estuarine, seaweed and sea grass, mangrove and coral reef ecosystems, peculiar to the state of Tamil Nadu. For the purpose of the present study the faunal diversity of Tamil Nadu is dealt under three major ecosystems namely freshwater, marine and terrestrial ecosystems.

FRESHWATER ECOSYSTEM

Amongst the inland wetlands, the freshwater wetlands include river systems, streams, irrigation canals, as well as reservoirs, lakes, ponds and marshes including rice fields. Tanks, reservoirs and other water bodies and marshes, freshwater lakes and reservoirs form the stagnant or lentic ecosystem and the running water bodies fall into the lotic ecosystem category. There are 32 river systems, 11 major reservoirs, 2,679 canals and 38,863 tanks in Tamil Nadu. The rivers of Tamil Nadu flow eastward from the Western Ghats and are entirely rain fed. Cauvery a perennial river fed by both the monsoons flows across Tamil Nadu cutting the state into two halves. The other perennial rivers are Palar, Cheyyar, Ponnaiyar, Moyar, Bhavani, Amaravathi, Vaigai, Chittar and Tamaraparani. The non-perennial rivers are the Vellar, Noyal, Suruli, Gunar, Valpar, Valparai and Varshali. The 760 km long Cauvery is the longest river of the state. The total length of the rivers of Tamil Nadu is 7420 km, the area of reservoirs is 0.52 lakhs ha (2% of India's total rivers and canals), the area of tanks and ponds 6.92 lakhs ha (24% of Indian's total tanks and ponds) and 63,000 h estuaries, backwaters and swamps. Tamil Nadu has 31 natural wetlands covering an area of 58,068 ha and 20,030 man-made wetlands with the area of 2,01,132 ha. The important reservoirs among these are presented in Table 1.

Table 1 : Important reservoirs in Tamil Nadu.

	Reservoirs	River on which Reservoirs are Situated	Location	Area (ha)
1.	Bhavanisagar	Bhavani	Coimbatore	7,861.840
2.	Stanley reservoir	Cauvery	Salem	15,343.750
3.	Poondi reservoir	Koraliyar	Chingelpet	3,263.400
4.	Other reservoirs	-	-	23,408.163
	Total			49,877.153

Four different categories of freshwater fauna are recognized in freshwater ecosystems of Tamil Nadu. The fauna under first category is truly aquatic in the sense that they spend whole of their life time (plankton, fish etc) in water medium, in the second category, fauna spend only a part of their life time in water and rest in other ecosystem such as terrestrial and aerial (some insects and amphibians) and the fauna under third category live on land or trees or both, and depend on aquatic ecosystems for food. There are also some others that make their home in wetland plants for shelter (such as, reed warblers) either permanently or for a prolonged period of time comprising a separate freshwater ecosystem associated fauna and forming the fourth category. These four different categories viz., permanently aquatic, temporarily aquatic, freshwater dependent and freshwater associated fauna comprise the faunal diversity of freshwater ecosystems in Tamil Nadu. All those animals, which live in and use freshwater ecosystem at some stage in their life cycle, should be considered in the context of faunal diversity of freshwater ecosystems.

The major groups of freshwater fauna occurring in Tamil Nadu are provided in Table 2. It is evident that 9% of the total freshwater fauna of India is represented in Tamil Nadu freshwater wetlands. In general, insects dominate the freshwater fauna as found in other states (about 3000 species). However, Table 2 contains only the major group of insects such as Hemiptera, Coleoptera, Ephmeroptera and Odonata. Other common insects *viz.* Diptera and a few other groups are not represented in the compilation since not much work has been carried out in Tamil Nadu on these. A total of 31 and 153 species of molluscs and fishes respectively, are so far recorded in Tamil Nadu. The Western Ghats (spread over southern states) exhibits a rich diversity of freshwater fish fauna. Of the 446 primary freshwater fishes known from India (Menon, 1993), 230 species are found in the Western Ghats, of which 118 are endemic to this region. A total of 116 species belonging to 46 genera and 20 families are reported from Nilgiri Biosphere Reserve of which 11 species are endemic to Nilgiri (falling under three states such as Tamil Nadu, Kerala and Karnataka). However, Tamil Nadu has as many as five endemic freshwater fishes such as *Puntius sharmai* Menon and Remadevi, *P. arulius thambrabaraniensis* Silas, *Horalabiosa palaniensis* Remadevi and Menon, *Heteropneustes longipectoralis* Remadevi and Raghunathan and *Homoloptera santhamparaiensis* Arunachalam, Johnson and Remadevi (according to Dr R. J. Ranjit Daniels there are more endemic species in Tamil Nadu). These figures are expected to increase manifold especially those of micro invertebrates and parasitic groups if these groups are extensively explored all over Tamil Nadu.

Table 2 : Number of animal groups and species occurring in freshwater wetlands in India and Tamil Nadu

Taxonomic groups	India Total	Indian Wetlands	Indian freshwater	Tamil Nadu Wetlands
Porifera	486	400	33	6
Cnidaria	852	540	10	?
Platyhelminthes	622	1200	50	?
Rotifera	330	330	320	26
Gastrotricha	100	80	23	?
Nematoda	2850	500	150	?
Acanthocephala	229	150	50	?
Mollusca	5070	2300	183	49
Annelida	840	500	350	?
Arthropoda	**68389**	**7302**	**4050**	**268**
Crustacea	2934	2000	800	100
Insecta	59353	5000	3000	18
Arachnida	5818	300	250	?
Bryozoa (Ectoprocta)	200	100	35	?
Tardigrada	32	20	10	?
Chordata	**4833**	**2260**	**966**	**229**
Pisces	2546	2000	742	153
Amphibia	209	150	150	25
Reptilia	456	50	24	9
Aves	1232	30	25	36
Mammalia	390	30	25	1
Total	85549	15680	6230	595

? = Data not available/Not Studied

Animals belonging to all taxonomic categories, from protozoa to mammals, occur in wetlands. Among the invertebrates, arthropods represented by Crustacea and many orders of insects, and molluscs are the most dominant components of wetland fauna. Among the crustacean zooplankton, Cladocera dominates the fresh water wetlands. One species of Notostraca, *Triops*, is considered to be a living fossil and has discontinuous distribution in the temporary ponds of Maduari and Thirunelveli. There are occurrences of several temperate, Ethiopian, Indo-Malayan, Australian and Palearctic

Fig.2, Kutralem falls, Tirunelveli

species of Cladocera in Tamil Nadu (Venkataraman, 2000). Several fish species have been introduced into India for pisicultural purpose since 1863 when Francis Day attempted to introduce the English trout, *Salmo trutta fario* Linnaeus in Nilgiri waters. Mainly human has brought these introduced fauna into India. However, birds and seed import from other countries have also played a major role in the dispersal of many aquatic organisms especially species of *Anostraca, Conchostraca and Cladocera* (Proctor *et al.*, 1967). Among, the fifty-five species of amphibians occurring both in freshwater and moist areas of evergreen forest, eight species are endemic to Tamil Nadu. The avifauna (commonly referred to as waterfowl) is particularly prominent and often occurs in large flocks. Mammals such as otters occur in Tamil Nadu wetlands (hill streams) whereas deer and water buffalo use wetlands principally for grazing.

MARINE ECOSYSTEM

The first study in India on marine fauna was on *Aplysia* and its purple colour by Ensign W. Francklin 1786-87 (Bengal to Persia in Pinkerton's Voyages And Travels, 1811) Bombay followed by Wallich's Marine algae on Herbarium (1822) (In Prodromus Florae Peninsulae Indiae Orientalis, 1834) along the coast of Hindustan and Madras.

However, major marine faunal studies in Tamil Nadu were consequent to the setting up of Madras Museum. The Madras Literary Society mooted the proposal for a museum in Chennai in 1846 and Sir Henry Pottinger, the then Governor, obtained the sanction of the Court of Directors of the East India Company in London. In January 1851, Dr. Edward Balfour, Medical Officer of the Governor's body guard was appointed as the first officer in charge of the Government Museum. The setting up of a marine aquarium in Chennai in the Marina Beach in 1909 followed this. Dr. E. Thurston the then Superintendent of the Museum first drew up the plans for the Madras Aquarium during 1905-1906. The aquarium was opened to the public on October 21, 1909. Today many famous collections available in the museum, starting from Great Indian Baleen Whale to molluscan shells, starfishes, sea urchins, insects and several hundreds of dry preserved specimens in boxes and cabinets are important for research.

The golden period of the study of marine fauna of Tamil Nadu is 1885 to 1978 when Dr. Edgar Thurston (1885 – 1908) was holding the charges of Superintendent of the Madras museum followed by Dr. J. R. Henderson (1908 – 1919), Dr. F. H. Gravely (1920 – 1940), Dr. A. Aiyappan (1940 – 1960) and Dr. S. T. Satyamurthi (1961 – 1978). During this period many surveys and publications were made on the marine fauna of Chennai and the adjacent areas of Tamil Nadu. When Dr. Frederic Henry Gravely took charge as Superintendent in 1920, the investigation of the littoral fauna of Krusadai Island in the Gulf of Mannar was undertaken. This investigation led to the revival of the Bulletin of the Madras Government Museum for the publication of the results of the researches. The collections were scientifically preserved, studied and interpreted by publishing research bulletins during the tenure of Dr. Gravely (1920 – 1940). Dr. Gravely's work on Mollusca helped in completing the gallery and the reserve collection in these two large Zoological groups (Gravely, 1927, 1942). In 1940, Dr. S. T. Satyamurti who joined as Curator, Zoology Section was promoted as Superintendent of the Museum. During the tenure of Dr. Satyamurti, the displayed collections in the galleries were interpreted and published as Guide Books. His noteworthy publications are on the Mollusca of Krusadai Island in the Gulf of Mannar "Amphineura and Gastropoda" Vol. I, "Scaphopoda, Pelecypoda and Cephalopoda" Vol. II and Echinodermata (Satyamoorthy, 1952, 1956, 1976).

Table 3 : Comparison of marine faunal diversity in the world, India and Tamil Nadu.

Group	World	India		
		Total	Marine	Tamilnadu
Protista	31250	2577	750	?
Mesozoa	71	10	10	?
Porifera	4562	519	486	313
Cnidaria	**9916**	**817**	**790**	**214**
Hydromedusae				***27***
Sea Anemones				***9***
Gorgonids				***3***
Scyphozoa				***32***
Siphonophore				***29***
Scleractinia				***82***
Soft corals				***32***
Ctenophora	100	12	12	?
Gastrotricha	3000	88	88	?
Kinorhyncha	100	99	99	?
Platyhelminthes	17500	4920	550	?

Group	World	India		
		Total	Marine	Tamilnadu
Annelida	12700	842	440	4
Mollusca	66535	5050	3370	336
Bryozoa	4000	194	184	?
Crustacea	35534	2994	2440	419
Meristomata	4	2	2	?
Pycnogonidae	600	16	16	?
Sipuncula	145	38	38	19
Echiura	127	33	33	?
Tardigrada	514	30	10	?
Chaetognatha	111	30	30	10
Echinodermata	6223	765	765	131
Hemichordata	120	12	12	1
Protochordata	2106	116	116	88
Pisces	21723	2546	1800	527
Amphibia	5150	204	3	?
Reptilia	5817	446	26	15
Aves	9026	1228	145	141
Mammalia	4629	372	29	29
Total =	241563	23960	12244+	2247+

?= Data not available / not studied

The marine fauna of Tamil Nadu is rich and varied. The coastline encompasses almost all types of intertidal habitat, from hyper saline and brackish lagoons, estuaries, and coastal marsh and mudflats, to sandy and rocky shores with varying degree of exposure and widely varying profile. Subtidal habitats are equally diverse. Each local habitat reflects prevailing environmental factors and is further characterized by its biota. Thus, the marine fauna itself demonstrates gradients of change throughout the Tamil Nadu coast.

Fig.3, Poomarichan Island, Gulf of Mannar Marine National Park

Among coastal wetlands, estuaries, mangroves and coastal lagoons are biodiversity-rich areas, whereas the other brackish water habitats have only a few specialised species. It is well known that the reduction in the number of species is greater in estuaries when compared to adjacent seas and in-flowing river system. However, as far as estuaries of Tamil Nadu are concerned, this statement is only partly true. There is lesser number of species in the adjacent seas when compared to the estuaries, but the upper riverine ecosystem does not harbour as many species as its estuary. It has been observed that as the distance increases from the sea the number of species decreases. Salinity becomes an important regulating factor. However, much study is to be conducted in the estuaries, mangroves and coastal lagoons of Tamil Nadu.

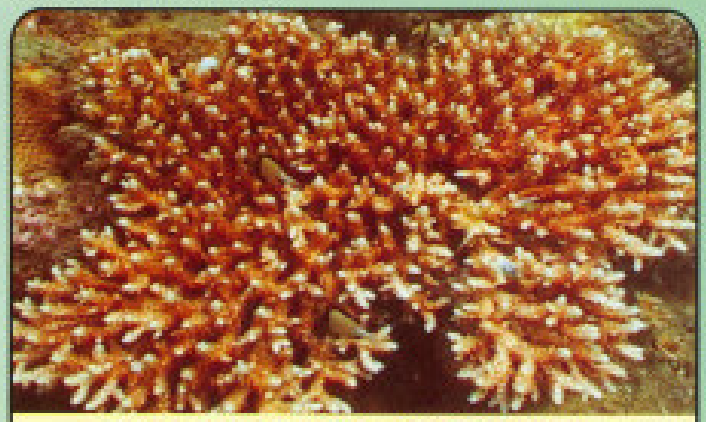

Fig.4, Acropora Sp., Gulf of Mannar

Out of the total 34 animal phyla in the world, 15 are represented by the taxa in the marine ecosystem. They may constitute either migratory or resident species. The former includes pelagic crustaceans, coelenterates (medusae), cephalopod molluscs, fishes, reptiles, birds and mammals. Amphibians are generally absent in marine ecosystem. The benthic macro fauna comprises resident species of polychaetes, molluscs, sipunculas and mud-burrowing fishes. Species of hard corals numbering 82 (hermatypic) are reported till today of which 5 species *viz. Montipora manoliensis, Montipora jonesi, Porites exserta, P. mannarensis, Goniopora nigra* recorded by Pillai (1983) are supposed to be endemic to Tamil Nadu. Among invertebrates, sponges, phoronids and echinoderms generally do not prefer estuarine ecosystem but are diverse in the marine habitat. In Tamil Nadu, 313 species of sponges and 131 species of echinoderms are recorded. Free swimmers or nekton are important components of marine biodiversity and constitute important fisheries of the world. The dominant taxa in the nekton of Tamil Nadu are fish (527 species) others being crustaceans (419 species), molluscs (336 species), reptiles (15 species) and mammals (29 species). Majority of the nektonic species is found in the coastal waters.

Fig.5, Starfish (*Protoreaster linckl*)

Among reptiles, sea snakes and turtles are important and represented worldwide by 50 and seven species respectively. These are generally oceanic forms but a majority of these often swim near to the shore and visit the shore at some part of their life. About 26 species of sea snakes belonging to one family, Hydrophiidae and five species of sea turtles were reported from seas around India. In Tamil Nadu nine sea snakes and five species of turtles have been reported till today. All the five species of turtles in their marine environment are known from Tamil Nadu. Turtles visit the shore of Tamil Nadu especially Chennai coast and some islands of Gulf of Mannar during breeding time (November to February) to lay their eggs. The shore visit of these turtles especially the Olive Ridley is a spectacular sight on the beaches of Chennai and near by areas. The Gulf of Mannar and Palk Bay have best nesting beaches for the leatherback, the hawksbill and the green turtle and also the Olive Ridley.

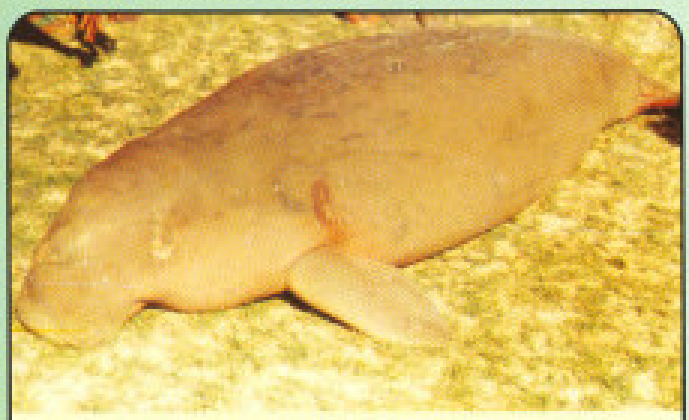

Fig.6, Sea Cow *(Dugong dugon)* from Gulf of Mannar

The seashore offers a variable feeding and breeding ground for a number of birds. It is difficult to define precisely the avian component of marine biodiversity. There are some special species, which are exclusively dependent on marine ecosystem while a few are generalists without much dependence on it. From the available data it has been inferred that 141 species occur in the coastal ecosystem.

Marine mammals belong to three orders, Sirenia, Cetacea and Carnivora. About 120 species are estimated to occur in World seas and of these 29 are reported from seas around India. All of them are reported in Tamil Nadu. But majority of these are oceanic forms and occasionally a few individuals may get stranded on the shore. The endangered sea cow occuring in near shore waters of Gulf of Mannar is an added beauty to the seas of Tamil Nadu.

MANGROVE ECOSYSTEM

Tamil Nadu has two major mangrove forests. Pichavaram mangrove is located 200 km south of Chennai City covering an area of 1100 ha. The whole mangrove consists of 51 small and large islands and is bathed with seawater during high tide and freshwater from irrigation channels during low tide. The Muthupet mangrove forest which spreads over an area of approximately 6,800 ha of which only 77.20 ha (4%) is occupied by well grown mangrove and the remaining 96% of the area is covered by poorly grown mangrove vegetation, is situated near

Fig.7, Mangroves in Nallathanni Island, GOMMNP

Point Calimere on the southeast coast of the Peninsular India (10° 25' N; 79° 39' E). It is situated at the southern end of the Cauvery Delta. At the tail end, it forms a lagoon before meeting the Palk Strait. Dense mangroves occupy the northern and western borders of the lagoon and the southern part is occupied by sand spit, which is devoid of mangrove vegetation.The Pichavaram and Muthupet mangrove ecosystems embrace a heterogeneous mixture of both plants and animals. The aquatic fauna comprises of juveniles and adults of finfish, shrimps, molluscs, crabs and benthic invertebrates. Finfishes consitute major portion of the total fish catch in the mangrove area. *Mugil cephalus, Liza dumerili, Chanos sp., Lelognathus sp., Siganus sp.* and *Etroplus sp.* are common. The prawn fishery is dominated by *Penaus indicus, P. monodon, Metapenaeus obsoni, M. monoceros and Macrobrachium sp.* and the crab fishery is dominated by *Scylla serrata* and *Portunus pelagicus*. Oyster (*Crassostrea madrasensis*) and clams (*Meretrix meretrix* and *M. casta*) are commercially important molluscs and herons, egrets, kingfishers, myna, plovers and sand pipers are the important avifaunas of this region.

SEA GRASS AND SEAWEED ECOSYSTEM

Sea grasses occur in the infratidal and midtidal zones of shallow and sheltered localities of sea, gulf, bays, backwaters and lagoons. They are submerged monocotyledonous plants and are adapted to the marine environment for completion of their life cycle under water. Mostly they occur along the East and West Coast of Indian main land and Andaman and Nicobar Islands. They form a dense meadow on sandy and coral rubble bottoms and sometimes in the crevices under water. Earlier studies have revealed that 14 species are found along the India coast.

Sea grasses are involved in cycling of nutrients. They provide food and shelter for diverse organisms and act as a nursery ground for many fishes of commercial importance and play a vital role in the fisheries production of the region. Studies on sea grasses started only during 1980s and some of the first reports are available only from Tamil Nadu. All the 6 Indian genera of sea grasses with 11 species are recorded from the Palk Bay region of Tamil Nadu. Of the 11 species, *C. serrulata*, *H. ovalis* sub sp. *ovalis*, *K. pinifolia* and *S. isoetifolium* are predominantly distributed. *H. wrightii* is occur only in Akkalmadam in Rameswaram. Thirteen species of sea grasses under six genera occur in the Gulf of Mannar Biosphere Reserve. Of these, *Halophila*, *Halodule*, *Enhalus* and *Cymodocea*

Fig.8, Sea Grass Ecosystem of Gulf of Mannar Island

are common. *Thalassia* and *Syringodium* are dominant in the areas of coral reefs and coral rubbles whereas the others are distributed in muddy and fine sandy soils. The unique ecological importance of the sea grasses is the conservation of rare and endangered animals such as marine turtles, dugongs, some common echinoderms, juvenile prawns and fishes. Other than these, the ecology and diversity of sea grass associated invertebrate fauna from Tamil Nadu is still not known.

Seaweeds are marine plants, belonging to lower Cryptogams. These are large and diversified groups with size ranging from single cell, such as *Chlamydomonas* to several meters in length (*Macrocystis*). The four classes of seaweeds are Chlorophyta (green algae), Phaeophyta (brown algae), Rhodophyta (red algae) and Cyanophyta (blue-green algae). In India so far 650 species of marine algae sea grass (including blue-green algae) with a maximum of 320 species of Rhodophyta followed by 165 species of Chlorophyta and 150 species of Phaeophyta have been recorded. Out of these Tamil Nadu (302) has the maximum, followed by Gujarat (202), Maharashtra (159), Lakshadweep group of Islands (89) and Goa (82).

In Tamil Nadu, seaweeds are exploited and used as raw material for the production of agar, alginates and seaweed liquid fertilizer. A little over 25 agar industries and 10 algin industries are situated at different places in the maritime states of Tamil Nadu, Kerala, Karnataka, Andra Pradesh and Gujarat. Red algae such as *Gelidiella acerosa*, *Gracilaria edelis*, *G. crassa*, *G. follifera* and *G. verrucosa* are being used for agar manufacture and brown algae *Sargassum* spp., *Turbinaria* spp. and *Cystoseira trinodis* for alginates and liquid seaweed fertilizer. The agar yielding seaweeds are being harvested since 1966 from the natural seaweed beds of Gulf of Mannar Islands, along the coastline from Rameswaram to Tuticorin in Gulf of Mannar area and Sethubava Chatram area in Palk Bay, Tamil Nadu.

CORAL REEF ECOSYSTEM

Coral reefs form the most dynamic ecosystem providing shelter and nourishment to thousands of marine flora and fauna. They are the protectors of the coastlines of the maritime states. A few genera of corals are supposed to be older than prairies. This unique ecosystem is most productive because of its symbiotic association with algae called Zooxanthellae. Though they are the builders of the most massive structures ever created by living beings on earth, they are very fragile and vulnerable to natural disturbances and human activities. Maritime states and their coastal population mostly depend upon the coral reef ecosystem for their day-to-day life.

In Tamil Nadu, the reefs are distributed along the southeast coast especially at Gulf of Mannar and Palk Bay region and at restricted places in Chennai, Pondicherry and Cuddalore coasts.

Fig.9, Seaward reefs at Nallathanni Island, GOMMNP

Among the other areas, Gulf of Mannar is supposed to be one of the hot spots for marine biodiversity in India and falls in the world's biologically richest Indo-Pacific realm. Coral reefs along with the mangrove and sea weed/ sea grass ecosystems support nearly 3,600 biological species in this reserve. The Gulf is not only the first marine biosphere reserve in India, but also the first in south and Southeast Asia. The area falling between longitudes 78° 08'E to 79° 30'E and latitudes 08° 35' N to 09° 25' N was declared as marine biosphere reserve by the Government of India on February 18, 1989 to conserve this unique ecosystem. The Gulf of Mannar Biosphere Reserve

(GoMBR) encompasses 21 islands. These are uninhabited islands, ranging in size from 0.25 ha to 130 ha, spreading along the coast for 170 km, with the closest being 500 m and the farthest, over 4 km from shore.

The Gulf of Mannar, which is globally significant because of its unique biological diversity, came to lime light mostly due to extensive scientific research activities. Some of the unique fauna occurring in the Gulf are at present commercially threatened due to over exploitation. Nearly 47 fishing villages dot the 180 km long reserve coastline. More than 50,000 people inhabiting the coastal villages depend on the marine resources of the Gulf for their livelihood. A little over 650 mechanized vessels and nearly 2500 non-mechanised vessels are being operated from 47 fishing villages. Methods used to exploit the seaweeds cause severe damage to coral reefs. Rapid industrialization around the reserve, usage of dynamite and trap fishing methods, poaching and commercial aquaculture are other major threats to coral reefs in these areas.

As per the studies carried out by the Zoological Survey of India, 25% of live cover of coral reefs in 1998 has increased to 45% in 2003, revealing the regeneration of these reefs after 1998 unprecedented coral bleaching which occurred throughout the world. The main component of the coral reefs, the Scleractinian fauna is represented by 82 species. The dominant genera include *Acropora, Montipora* and *Pocillopora* among the ramose forms and *Porites, Favia, Favites, Goniastrea, Platygyra* and *Symphyllia* among the massive forms.

Among the three groups of islands, Mandapam had a higher percentage of live coral cover (37.03%) than the other two groups (17.29% Keelakarai and 18.69% Tuticorin group; year 2000 survey). Among the life form categories, massive corals dominated the GoMBR (7.67 ± 2.23%). The reason for the dominance of massive corals over the other groups of corals in GoMBR may be explained as a consequence to the 1998-bleaching event. The fragile and most sensitive branching coral was the most affected life form category due to the rampant 1998 bleaching event (Venkataraman 2000). The destruction of reefs started from early sixties to a tune of 80,000 tons per year at Tuticorin and 250 m/day at Mandapam (Pillai, 1996). It resulted in the submergence of Poovarasanpatti and Villangu Chalii Islands (Venkataraman, 2000). The removal of sea weeds, operation of shore nets, gill nets, modified trawl nets and *Pari kuduus* to catch reef fish, anchoring of boats in the reef areas and stampeding of live corals in the process of picking seaweeds, siltation, microbial contamination due to sewage are the major threats posing on the coral reef ecosystem of Gulf of Mannar today.

TERRESTRIAL ECOSYSTEM

Tamil Nadu is endowed with a rich terrestrial faunal diversity. The terrestrial ecosystem of Tamil Nadu can be divided into two natural divisions *viz.* the eastern coastal plain and the hilly region along the north and the west. The range of the Western Ghats runs along the whole length of the western side of Tamil Nadu with a steep and rugged mass averaging 1220 m above MSL and rising to 2637 m at the highest point. The Palghat Gap, about 25 km in width, is the only marked break in the great mountain wall. To the south of this gap the mountain range is known as Anamalai

Fig.10, A view of Kodaikanal Lake

(Elephant Hills). To the east are the Palani Hills on which the famous hill station Kodaikanal is situated. The slopes of the Western Ghats are covered with lush evergreen forests. The Nilgiris and the Anamalai are the hill groups with the maximum height. In the famous Ootacamund area of the Nilgiris district (=Uthagamandalam) is the highest peak Doddabetta, 2637 m above MSL. The famous Nilgiri Biosphere Reserve (NBR) is situated in the South Western portion of the Western Ghats, covering an area of 5520.40 km² encompassing the three States of Karnataka, Tamil Nadu and Kerala. Of the total area of NBR, Tamil Nadu part constitutes 2537.60 km² including Mudumalai Wildlife Sanctuary, Coimbatore, Sathyamangalam, Nilgris South and Nilgris North Forest Divisions. The NBR of Tamil Nadu is known for sholas and grasslands, which constitute a unique ecosystem with distinct, faunal and floral composition. These areas are responsible for water harvesting and regular stream flow in the hills. The endangered Nilgiri langur is quite commonly seen in the sholas. Other vertebrates such as 116 species of freshwater fishes, 55 species of amphibians including 5 endemics, 21 species of reptiles, 313 species of birds and 97 species of mammals including 20 endemics of which Savis pigmy shrew, *Suncus etruscus perrotteti* and *S. murinus niger* are confined to NBR in their distribution. NBR is also known to harbour large population of Nigiri Tahr *Hemitragus hylocrius* and the lion tailed macaque *Macaca silenus* and probably South Indian population of Indian elephant *Elephas maximus*, tiger *Panthera tigris*,

gaur *Bos gaurus*, Sambar *Cervus unicolor* and Chital *Axis axis* as well as many lesser known groups of mammals. The rare bats include Peshwas bat *Myotis peshwa* and the hairy winged bat *Harpiocephalus harpia*.

Of the total recorded forest area in the State, 3134.70 sq km or 13.7% of the total forest area is dedicated to wildlife conservation covering two biosphere reserves of which one is marine, five national parks of which one is marine, eight wildlife sanctuaries and twelve bird sanctuaries besides an elephant rejuvenation camp at Mudumalai Sanctuary.

Table 4. Comparison of Terrestrial faunal diversity in the world, India and Tamil Nadu.

Group	World	India	Tamil Nadu
Protista	31250	2577	?
Platyhelmithes	17500	1622	P
Annelida	12700	840	22
Mollusca	66535	5070	60
Crustacea	**35534**	**2934**	**8**
Isopoda	4000	200	8
Insecta	**867391**	**59342**	**1282**
Thysonoptera	6000	691	292
Neuroptera	5000	315	20
Hemiptera	80000	650C	69
Dictyoptera			9
Homoptera			91
Coleoptera	350000	15000	26
Diptera	96600	6093	26
Isoptera	2000	300	61
Orthoptera	14491	759	71
Odonata	5500	491	71
Hymenoptera	100000	5000	119
Lepidoptera	142500	13000	125
Dermaptera	1800	320	17
Arachnida	**73440**	**5818**	**268**
Mesostigmata		107	27
Prostigmata		1125	135
Scorpionida		104	5
Diplopoda		162	14
Scolopendromorpha		73	14
Sphaerotheriida		45	39
Araneae		1035	34
Tardigrada	514	30	?
Amphibia	5150	204	47
Reptilia	5817	446	136
Aves	9026	1228	240
Mammalia	4629	372	103
Total =	**1056046**	**74626+**	**1898+**

P = parasites; ? = Data not available/not studied

Among the invertebrate fauna insect dominates the terrestrial ecosystem with 1282 species. Next to insects the arachnids with 268 species reported throughout Tamil Nadu. Other than insect eight species of isopods, 22 species of annelids and 60 species of land molluscs are reported from Tamil Nadu. Very less information is available on the diversity of protozoans, plant and soil nematodes and other terrestrial fauna of Tamil Nadu.

SPECIES DIVERSITY

Faunal diversity in Tamil Nadu is rich when compared to some of the other states of India. The wide variety in physical features and climatic conditions have resulted in a diversity of ecological habitats in Tamil Nadu like tropical forests, grasslands, fresh water wetlands, coastal and marine ecosystems, which harbour and sustain the immense faunal diversity. The mountain and forest ecosystem in the Western Ghats in the west (semi-evergreen, deciduous, dry moist extending over the major part of the state), the freshwater ecosystem spread over rivers, wetlands and estuaries, the semiarid ecosystem of Ramanathapuram districts and south east region, the mangrove ecosystem of the Pulicat, Muthupet and Pichavaram, rich coral reef ecosystem of Gulf of Mannar Biosphere Reserve and coastal-marine ecosystem along Chennai to Kanyakumari districts are the examples of the largest assemblages of habitats for faunal diversity. As in the case of other states of India, we have many published records of vertebrate fauna of Tamil Nadu. However, in the case of the lower group of organisms especially species rich groups such as arthropods, helminthes, annelids, protozoans and a few other minor phyla, the taxonomy is yet to be studied and reported.

SPECIAL FEATURES

The degree of endemicity of Tamil Nadu fauna varies from group to group. In Tamil Nadu, five species of freshwater fishes and eight species of amphibians are endemic. Snakes and lizards dominate among the reptiles of Tamil Nadu. One species each of crocodile *Crocodylus porosus* (at present extinct) and lizard *Varanus bengalensis*, five species of marine turtles and one species of snake *Python molurus* (Indian Rock Python), have been included in the endangered list among the reptiles. Among the birds found in Tamil Nadu, *Francolinus pondicerianus pondicerianus* (South Indian Gray Patridge) is endemic to the State while *Bubo bubo* (Great horned owl) and *Anthracoceros coronatus* (Malabar Pied hornbill) are among the rare ones. *Pavo cristatus* (Indian peafowl) is a protected species found here. Out of 93 species of mammals found in the State, Grizzled Giant squirrel *Ratufa macroura dandolena* is endemic. The habitats of some of the vulnerable/endangered categories of mammals that are found here extend beyond the State. *Loris tardigradus malabaricus* (Slender Loris), *Canis aureus* (Jackal), *Vulpes bengalensis* (Indian fox), *Cuon alpinus* (Indian wild

Dog), *Melursus ursinus* (Sloth Bear) *Mellivora capensis* (Honey Badger), *Panthera pardus* (Panther), *Panthera tigris* (Tiger), *Tragulus meminna* (Mouse Deer), *Tetracerus quadricornis* (Four-horned Antelope), *Bos gaurus* (Gaur) and *Gazella dorcas* (Chinkara) are considered as vulnerable. The status of Indian Pangolin *Manis crassicaudata* is considered as intermediate. Grizzled Giant squirrel is extremely rare and is represented by a few scattered populations in Tamil Nadu. Among the invertebrates, 4 species of rotifers *Lecane (Lecane) sola, Trichocerca tropis, Conochilus aeboreus, C. maduralensis* and a monotypic genus *Pseudoembata*, and hundreds of species of arthropods, annelids, nematodes are endemic to Tamil Nadu.

INTRODUCED FAUNA

The introduction of exotic species to the country took place long ago that many of them have now become pseudo-natives. Monoculture practices in Tamil Nadu of introduced flora with indigenous plant species have resulted in the degradation and disruption of natural communities upsetting their stability and biodiversity equilibrium. It has also been responsible for severe pest outbreaks and emergence of secondary pests.

Invasive species pose a grave threat to wetlands. Strangely, in the tropics, these species are often neotropical natives which have been introduced in the old world tropics including India either accidentally or intentionally. The more significant among the important and well-studied aquatic weeds are *Eichhornia crassipes* (water hyacinth), *Salvinia molesta*, *Pistia stratiotes*, *Alternanthera philoxeroides* and *Hydrilla verticillata* (Pieterse and Murphy 1990). Water hyacinth may be singled out for the degree to which it has received global attention (Gopal 1987). Similarly, the introduction of exotic fish like tilapia and grass carp for their ability to feed on organic wastes and herbaceous submerged vegetation has also caused a shift in the species composition of natural fish fauna and other biota. The adverse consequences on wetland functioning have not yet been properly understood. Tamil Nadu has a total of 56,000 ha of potential shrimp farming area. Though a total of 4455 ha have been developed in the State for shrimp farming, only 2900 ha are in use. Monoculture of shrimps and carp is practiced in fishery sector, while water hyacinth and lotus etc. are grown normally in freshwater systems covering vast expanse of water surface. Such monoculture of plant and fishes may inhabit other biota to flourish. Hence it should be discouraged.

The marine invasive species is yet to be ascertained excepting some of the known introductions such as an algae *Euchema cottonii* into the Palk Bay area to extract gelatin. Other important invasive such as *Eichhornia crassipes* (water hyacinth) and *Prosopis juliflora* can be found competing with mangroves in Pichavaram and Muthupet mangrove forests. A lot of studies have to be conducted in this area.

In the terrestrial region, the invasive fauna have become a real threat to the natives. Some of the Coleoptera and Heteroptera that have established as pests to some of the introduced plants have now become pests for a number of indigenous plants. They are also spreading to cultivars. *Antestia cruciata* of Heteroptera is a typical case. The outbreak of teak skeletonizer (*Eutectona machaeralis*) and teak defoliator (*Hyblaea puera*) in almost all the teak growing areas and the out break of *Pterorna plagiophleps* (Lepidoptera) on *Albizia falcataria* can be cited as other examples. Introduction of the exotic fodder plant *Lucaena leucocephala* (su-babul) has also brought along its pests, *Heteropsylla cubana* (Homoptera) and *Ithome lassula* (Lepidoptera) to Tamil Nadu. Other pest species such as *Leptocorisa varicornis* (Heteropteran paddy pest), Ophiomya *lantanae* and *Tropoicomyia coffeae* (Diptera), *Procecidochares utilis* (Diptera weed eradicator), *Teleonemia scrupulosa* (Hemipteran bug to control of *Lantana*) are other insect introductions that are devastating forest and domestic biodiversity. The exotic Rainbow Trout *Salmo gairdneni gairdnerii* and the African Cichlid, *Oreochromis mossambica* (popularly known as tilapia) have become naturalized in inland waters, significantly in many lakes and reservoirs associated with the river systems in Tamil Nadu.

VALUES

Wetlands provide the habitat for hundreds of species of plants and animals confined to freshwater ecosystems, and also support a much larger number of organisms, which utilize wetlands for a shorter period in their life cycle. High Primary and secondary by wetland organisms and their role in nutrient

Fig.11, *Panulirus versicolor* (Spiny Lobster from GOMBR)

dynamics confers upon wetlands many important values. Human beings have been exploiting a large number of freshwater organisms; particularly fish, since long before they learnt agriculture. Many other freshwater animals (like cranes, turtles) and plants (like lotus, water reeds and wild rice) have been a part of social and cultural life of humans in most parts of the world.

However, modern scientific studies have paid relatively less attention to the life in freshwater environments. Numerous wetland plants are extensively used as food, feed, fiber and fuel. Besides rice, the most common food plants include lotus (Nelumbo Mucifera), *Cyperus esculentus, Paspalum, Echinochloa, Eleocharis dulets, Acorus calamus, Typha angustata,* etc. *Cane* (*Calamus tenuis*) is widely used in

Fig.12, Amphiprion sebae (Clown Fish)

furniture. Reeds (*Phragmites karka*) and cattails (*Typha* sp.) are widely used for thatching roofs, making mats and baskets, and also as fuel and fodder. Most wetland grasses and herbaceous plants are grazed upon by cattle or are harvested for fodder. *Pandanus* sp. and *Vetiveria* yield essential oils.

Marine and coastal ecosystems and the diversity of species provide a wide range of important resources and services. Food from the sea in particular, fish, crustaceans and molluscs is a major source for human consumption.

Marine fish provided about 84 million tons of human

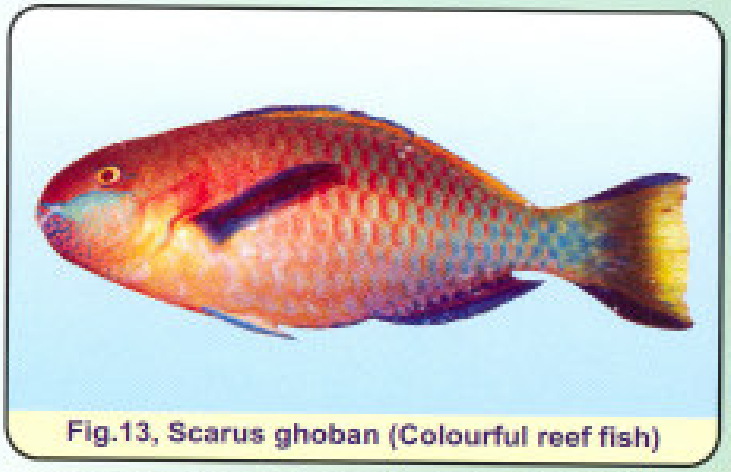

Fig.13, Scarus ghoban (Colourful reef fish)

food and livestock supplements in 1993 (FAO, 1995). The fishery producing this catch is a major source of employment for many of the world's coastal States. Small-scale fisheries harvest a large proportion of the world's catch. Fish accounts for about 25 % of the average individual's intake of animal protein worldwide (FAO, 1993), and the proportion is higher in many developing countries (WRI, 1996). Marine and coastal ecosystems also provide many critically important services for humanity such as a) storing and cycling nutrients, b) regulating water balances, c) buffering land and protecting it against erosion from storms and waves, d) filtering pollutants, e) playing an essential role in regulating planetary balances in hydrology and climate, and f) through the ocean's photosynthetic pump, removing the primary greenhouse gas, carbon dioxide from the atmosphere and producing one third to one half of the global oxygen supply. Coral reefs, estuaries, lagoons and shallow coastal waters are particularly valuable for human population because of the goods and services they provide. They are among the most biologically productive systems on the earth. Some like reefs and mangroves provide sea defence and buffer the impacts of tropical storms, mitigating the erosive effects of waves and storm surges. All these systems provide nurseries and feeding grounds for many coastal and pelagic species of fish. Marine species provide many other products as well, including edible seaweed, ingredients for food and cosmetics, industrial chemicals and dyes and a host of other products. Medical researches have already identified a number of marine organisms that produce previously unknown bioactive compounds, including antiviral and anti tumor agents, which may soon have medical applications.

This diversity of species and ecosystem in the marine and coastal environment is the foundation for the production of goods and services valuable to human communities. While we tend to measure the ocean's value in terms of harvests of particular species used for food or other purposes, marine and coastal ecosystems provide important ecological services that are rarely perceived until they are lost. Species do not live in isolation, but are part of, and dependent upon, vast ecological communities and systems. Thus exploitation of even a single stock of living marine resources is a biodiversity issue. The conservation of biodiversity is therefore an important part of managing economically valuable living resources.

The wealth of Tamil Nadu is mainly due to its natural resources, especially those wherein living systems play a vital role. The terrestrial ecosystems provide habitat to many species and genera of plants and animals, which are unique to the State. Several facts unknown to science pertaining to the flora and fauna are being brought to light frequently. Observably, a number of species particularly among invertebrates yet remain to be discovered in the State. The spurt of new taxa and records from biodiversity rich hot spots such as Western Ghats ecosystem and Gulf of Mannar Biosphere Reserve suggest that the ecosystem is a storehouse of invaluable biological wealth.

THREATS

Most wetlands in the Tamil Nadu have a multiple use profile and a large number of people directly depend on their resources. Under these circumstances it is difficult to enforce strict protection measures without coming into direct conflict with the people exploiting the wetland resources. Many shallow water bodies and marshes have filled up rapidly and the characteristic wetland vegetation has disappeared together with the dependent flora and fauna. Further, major impact on freshwater wetland biodiversity is due to the discharge into the water body (or wetland itself) of domestic sewage and industrial effluents and input of pesticides and herbicides with the runoff from surrounding landscape. Other human activities like washing, bathing and recreation in water, especially when extensive, also adversely affect the water quality and wetland biota. The exploitation of water resources by regulating river flows (dams, barrages, canals, levees) also has an impact particularly upon the biota of floodplains wetlands. Grazing by domestic cattle is an important activity in seasonal wetlands. Large amount of food for cattle is also harvested, and often even the subterranean parts are scrapped from these wetlands. It has been observed in many studies that overgrazing by domestic cattle in wetlands has an adverse impact on biotic composition and stream bank integrity, increasing siltation and runoff with a consequent loss of vegetation and fish. Grazing and fodder removal not only deplete the herbaceous vegetation but also affects other biota and soil properties, which may be beneficial or harmful for the wetland. The most common cause of wetland loss in Tamil Nadu has been the reclamation of land by draining and/or filling. Reclamation is done mostly for higher economic return since the land is brought under residential, industrial and commercial use and for construction of highways. Shallow marshes and flood plains are often the preferred sites for landfills with solid urban and construction wastes. Although the loss of wetlands through their reclamation has not been estimated in India, it is well known that a very large proportion of the natural wetlands have already been filled or drained for urban and industrial use. Adequate protection from direct influences like hunting and poaching detrimental to wildlife and waterfowl should be ensured. A major cause of degradation of many wetland habitats is over-exploitation of their resources, particularly the biological resources for food, feed, fiber and fuel. Resource use can be based on the carrying capacity of he wetland and the growth rates of the concerned biota. Removal of plants or animals in excess of their growth rates affects their population size and also the food-chain interactions. Excessive harvest of plant resources is bound to reduce the available niches and food of the animals. This also increases erosion through flow of water and nutrients, and consequently a change in water quality, which affects all other biota. The riverine and freshwater ecosystems are highly sensitive to any alteration or degradation of water quality. Today, the indigenous fish population is threatened in Tamil Nadu Rivers as well as freshwater wetlands. Dams on rivers obstruct the migration of fishes and other aquatic biota. Freshwater eels and other catadromous fishes are known to undertake long migration into deep sea for breeding. The offspring again ascend the river to return home. But dams prevent the adult eels to migrate to the sea for breeding, while the offsprings fails to find the homeward route. It is possible that due to such structures, migration of *Macrobrachium rosenbergii*, which lives in river and migrates to estuary for breeding, is hampered/obstructed. As a result, recruitment failures in prawn population are common in some areas of Tamil Nadu. The major adverse impact of industrial and sewage pollution are deoxy-generation, high BOD load, rapid eutrophiation and accumulation of heavy metals in the aquatic environment, which puts the biotic communities under severe stress. Besides the pollution and other effects, over-exploitation of fish and juveniles from the river systems are the root causes of loss of aquatic biota from the river and freshwater wetlands in India.

Though human impact on marine and coastal biodiversity are less understood and publicized than those on its terrestrial counterpart, their potential effects are no less threatening. The major direct threat to marine and coastal biodiversity can be divided into five interrelated categories: pollution (from land based and other sources), over exploitation of marine living resources, introduction of alien species, habitat degradation caused by coastal development, and global climatic change and ozone depletion. Some of the harmful human impacts on marine biodiversity stem from ignorance and lack of understanding of the importance of marine biodiversity and how it gets affected. Marine resources and biodiversity have traditionally been undervalued, which puts marine resources on a lower priority level, than land biodiversity. Unregulated use of resources, increase demand for the resources and rapidly expanding coastal development have put the marine resources at considerable risk.

Sedimentation: The construction of Ennore Port and dredging operations have resulted in deposition of large quantities of silt, consequently increased the turbidity in water causing damage to marine life. There are also reports available on the erosion of some areas in the North Chennai due to the construction of Ennore Port. Sedimentation is the major cause for the reduction in live coral cover of Gulf of Mannar Biosphere Reserve. Sedimentation reduces the sunlight reaching the bottom of the sea thereby decreasing the productivity of the ecosystem. In general, siltation and sedimentation due to erosion reduces the productivity in the shallow areas.

Disposal of Domestic Sewage: Demographic pressure in Chennai city has resulted in the production of enormous amount of domestic waste materials. These materials reach the marine environment directly through Coovum and Adyar River. These domestic wastes are discharged mostly in partially treated and untreated

Fig.14, Garbage and Sewage disposal at Keelakarai Cost

conditions. The capacity of the sewage treatment plants is to be increased to treat the total waste generated in Chennai and other major cities and towns of Tamil Nadu. The sewage also causes diseases to many organisms living in the coastal areas. This results in reduced growth rate and reproduction, which in turn affects the biodiversity.

Industrial waste: Tamil Nadu is one of the largest industrial States in India. The enactment of Water Pollution Act in 1974 and Environment Protection Act, 1986 have helped in regulating the disposal of industrial wastes. Most of the major industries treat their effluents and comply with the standards set for each type of industry. However, the problem of wastes generated by medium and small-scale industries are not dealt with effectively. Common treatment plants for small and medium scale industries have been set up in Tamil Nadu. These measures have resulted in reduction of pollution loads in the coastal waters to certain extent. Major industries like fertilizer, petro and agrochemical and chemicals are mainly located at Chennai, Ennore, Cuddalore and other areas of Tamil Nadu. Besides industrial and municipal wastes, port related operations such as continuous movement of marine vessels at Chennai and Tuticorin including oil transport as also the wastes of aquaculture and agriculture farms (near Thanjavour) are increasingly posing threats to the coastal water quality and to the biodiversity.

Over fishing: The variation in the production of marine fisheries in the past 50 years and in particular the drop in production after 1997 onwards indicates a series of crisis this sector is facing today. The status of fishing industry cannot be assessed based on catches alone. During 2002-2003, Tamil Nadu exported 61,612 metric tons of marine products. To achieve the above target 10,278 mechanized fishing boats and about 49000 traditional crafts of which 20,000 crafts motorized with outboard motors were engaged in marine fishing. Fishing operations with latest technologies are causing damage to the marine living resources. Along with increase in the targeted catch, a number of untargeted fish and other biota are removed from their habitat and discarded as waste. It is estimated that worldwide shrimp fishermen discard up to 15 million tones and other fishermen up to five million tones per year (Weber 1994). Shrimp trawlers probably have the highest rate of by catch bringing in up to 90% more of **"trash fish"**. Random capture techniques destroy immature fish and other non-targeted marine species. Gill nets used to catch fish bring in a host of other animals such as dolphins, turtles *etc.*

Tourism: Sandy beaches are the main attraction for tourists. Trampling of the beach sand and litter has changed the complexion of the Marina and other beaches along Chennai Coast. The beaches along the Chennai Coast have been attracting more and more number of tourists as well as locals. Other than the

Fig.15, Bear Shola Falls, Kodaikanal

major beach Marina, many new beaches are being used for recreation, which include some of the amusement parks and private beaches with hotels along the East Coast Road up to Mahabalipuram. Other coastal pilgrimage centers such as Rameswaram, Kanyakumari, Thiruchendur, Velankanni, Nagoor, Nagapatinam and many other smaller areas attract large number of tourists and generate unimaginable amount of waste material which finally reach the coastal waters. The beaches along the Tamil Nadu Coast are under tremendous pressure from tourism and garbage accumulation. Many of these areas previously ear marked for turtle nesting grounds now accumulate a lot of garbage and waste materials discarded by the visitors.

Tamil Nadu Coast is known for its rich biodiversity. It is also the zone of maximum human concentration. The problems in the zone are due to conflicting sectoral interests. There are several stakeholders representing both, the Government Departments and NGOs. The traditional fishermen and trawler operators exploit the living resources along the Chennai Coast to the

maximum. There is no proof to show that the existing catches have exceeded the maximum sustainable yield. Nevertheless, one thing is certain, coastal biodiversity is threatened by pollution especially from domestic sewage and run off from agricultural land. Destruction of habitat is another serious problem along the Tamil Nadu Coast. Many fishermen living along the Tamil Nadu Coast are ignorant of the Wildlife (Protection) Act 1972 and Coastal Regulation Zone Notification. Socioeconomic evaluation of coastal resources and Public involvement in the management are the two aspects, which ought to be considered for conservation and management of faunal resources of Chennai Coast.

CONSERVATION

There are only two laws, which deal with aquatic ecosystem (freshwater and marine) as a habitat, the Wildlife Act, 1972 and the Environment Protection Act, 1986. The Wildlife Act designates areas as Sanctuaries, National Parks and Closed Areas. Under the Environment Protection Act, the Central Government can declare ecologically sensitive areas as Protected Areas. The existing legal mechanism involved in demarcating/protecting wetland habitats as a Sanctuary, National Park or Protected Areas and its biodiversity by The Wildlife (Protection) Act, 1972, The Environment Protection Act, 1986, Water (Prevention and Control of Pollution) Act, 1974, The Land Acquisition Act, 1894, The Indian Fisheries Act, 1857, The Tamil Nadu Marine Fisheries Regulation Act 1983, The Forest Conservation Act, 1980, Tamil Nadu State Forest Act 1882, and Constitutional mandate for wetland protection through Articles 31A of the Constitution of India.

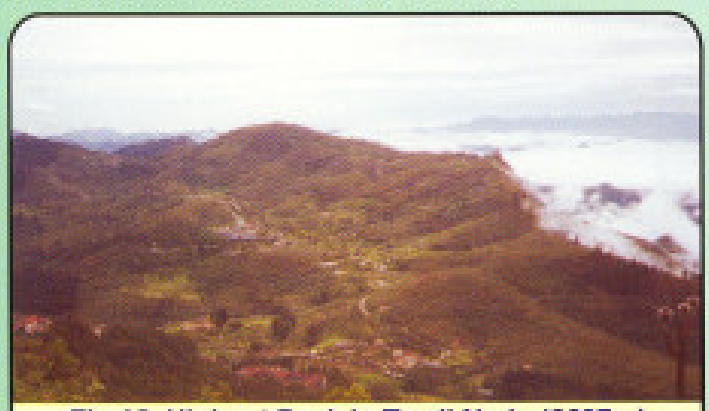

Fig.16, Highest Peak in Tamil Nadu (2637m) - Doddabetta in Nilgiri Hills.

The Union Government has signed and ratified several international conventions relating to oceans and related activities. The important ones are the following: MARPOL 1973/1978; London Dumping Convention 1972; Convention on Civil Liability for Oil Pollution Damages (CLC 1969) and its Protocol 1976; Fund 1971 and its Protocol 1979 and Convention on Biodiversity (1992). Many acts and rules related to coastal and marine activities existing in the country are being implemented in the State. The following are the important ones. Indian Fisheries Act 1897 and its Amendments 1920 and 1980; Indian Ports Act 1902; Merchant Shipping Act 1974; Wildlife Protection Act 1972; Water (Prevention and Control of Pollution) Act 1974; Indian Coast Guard Act 1974; and Marine Zones of India (Regulation of Fishing by Foreign Vessels) Act 1981 and Environment Protection Act 1986.

As per the Coastal Regulation Zone (CRZ) notification, Tamil Nadu had to prepare a Coastal Zone Management Plan identifying and classifying the CRZ areas within a year from the date of CRZ notification (Ministry of Environment and Forests Notification, August, 1994). The CRZ notification also stated that during the interim period till the coastal zone management plans are prepared and approved, all developments and activities within CRZ should not violate the provisions of this notification. As per the Environmental Protection Act, 1986 and Coastal Regulation Zone Notification 1991, the following activities are banned in the land part of the country as well as Tamil Nadu State. 1. Setting up and expansion of new industries, fish processing units except those, which require waterfront. 2. Manufacture or handling or storage of disposal of hazardous substances and discharge of untreated waste and effluents from industries, cities or towns and other human settlements. 3. Dumping of fly ash from thermal power stations and other solid waste dumping. 4. Land reclamation, bunding or disturbing the natural course of seawater. 5. Mining of sand, rocks and other substrate materials other than raw minerals. 6. Drawal of ground water within 200 m of high tide level. 7. Any construction activity between the low and high tide line, and 8. Altering of sand dunes and other natural features including landscape changes. In the ecologically sensitive areas, construction of civil and other man made structures like breakwaters for harbour, floating industries, laying of pipelines, reclamation of sea and its bed, sea bed mining and ship breaking activities are prohibited. However, they can be permitted at a no-impact distance from the outer limit of environmentally sensitive areas. Discharge of untreated and treated domestic, industrial, aquaculture wastes, nuclear and thermal power plants, dredged materials and operational discharges are prohibited in Environmentally sensitive areas. Although marine ecosystems have a larger coverage than the other ecosystems these are poorly represented among world's protected areas.

Consequently, effective research and extension programmes, which are critical to the conservation and management of marine ecosystem, have been given priority. Other than Fisheries Department of Tamil Nadu, Department of Environment and Forest, Gulf of Mannar Trust, the following institutions in Tamil Nadu are engaged in the research and extension as well as conservation and management of the Marine and Coastal Ecosystems: Central Marine Fisheries Research Institute (Ministry of Agriculture), Central Salt and Marine Chemical Research Institute, National Institute of Ocean Technology (Department of Ocean Development) Fishery Survey of India, Marine Product Export Development Authority,

Central Brackish water Aquaculture Research Institute, Aquaculture Authority of India, National Biodiversity Authority, Zoological Survey of India, Geological Survey of India, Botanical Survey of India, National Environmental Engineering Research Institute, Universities such as Anna University, Alagappa University, Annamalai University, Madurai Kamaraj University, Manonmaniam Sundaranar

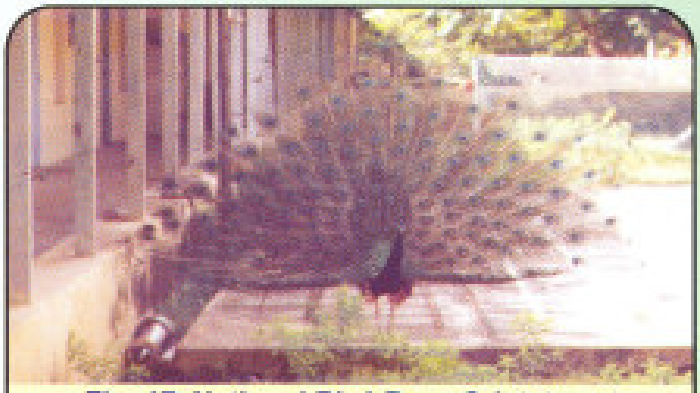

Fig. 17, National Bird *Pavo Cristatus* at Ramanathapuram District.

University, Tamil Nadu Veterinary and Animal Science University and important Non-Governmental Organizations such M.S. Swaminathan Research Foundation, Suganthi Devadhasan Marine Research Institute, East Coast Research and Development

Despite the above-mentioned acts, regulations and research in Tamil Nadu the marine ecosystems are being subject to over-exploitation of their resources. Besides over-exploitation, pollution from land-based sources is another major threat to marine resources. The population influx and increased tourism in some coastal places are responsible for indiscriminate destruction of marine resources. Recent spurt in aquaculture activities have increased the demographic pressure and the related environmental manipulation. All the above mentioned reasons lead to biodiversity conservation problems in Tamil Nadu which may be reduced by taking examples from other regions of the country and world where the marine ecosystem is conserved at a larger scale.

FUTURE DIRECTION

The faunal diversity of Tamil Nadu cannot be accurately estimated due to inadequate exploration of various ecosystems as well as lack of identification key to many invertebrate groups. The situation is also worst in case of microfauna and meiofauna that occur in freshwater and marine ecosystems. Furthermore, there are few expert taxonomists and taxonomic institutions in Tamil Nadu. All these make the estimation of species very difficult, even though there is a surge of interests on biodiversity studies in Tamil Nadu. Despite the growing importance of biomonitoring the status of all different ecosystems, hardly any effort is being devoted to the preparation of identification manuals and assessment of their diversity.

It is important to point out that a large number of fauna are known from their original collection and description only. In the absence of regular surveys and suitable identification keys, these have not been reported from the State. This does not necessarily imply a restricted distribution of these species but is definitely a great bottleneck in evaluation of true biodiversity in different habitats and in different parts of the State.

Protected areas are being managed for environmental protection, recreation and aesthetics and for the sustenance of all diverse renewable resources. The important and extensive productive ecotone zone and dependence of a diversity of flora and fauna on this and other zones, make ecosystem management more of a system management rather than species management. The following are some of the suggestion for conservation of faunal diversity in Tamil Nadu. 1. Core, buffer, controlled use area, wildlife refuges, intensive use areas, and multiple use area should be designated in different ecosystems. 2. A set of rules and regulations should be developed prescribing the activities that are allowed, restricted or prohibited and these should be clearly displayed and/or explained to all the visitors of the protected areas. 3. A well designed and equipped information and interpretation centre at each park is an essential part of the management. The centre should have adequate and detailed information about the layout, ecological, aesthetic and historical values. Life cycles of the plants and animals of the area, socio-economic benefits from the park ecosystem to the local communities and the importance of the park to key species should be explained graphically as well as in the form of pamphlets and other literature. Enhanced attention and better facilities will heighten people's awareness of the value of the park and in turn instill the desire to preserve the area.

Survey and inventory of all ecosystems in Tamil Nadu and their habitat needs must be documented before a proper management plan is made. Survey and inventorisation of the fauna, capacity building and training are the need of the hour. A long term monitoring and status of fauna and the ecosystem is important for conservation of faunal diversity of Tamil Nadu. Finally with a well-developed database on biodiversity of Tamil Nadu the managers can conserve the biodiversity and the ecosystems very effectively.

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ECTOMYCORRHIZAS IN TAMIL NADU FORESTS

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Ectomycorrhizas provide an intimate link between the soil environment and the functional nutrients absorbing systems of the plants. The ectomycorrhizae are a mutualistic association between plants and fungi that are crucial for the ecology of forests. The symbionts are usually woody plants on the host side and Basidiomycetes or Ascomycetes on the fungal side. Mycorrhizal plants are known to have higher levels of tolerance to toxic heavy metals, root pathogens, drought, high soil temperature, salinity of soil, soil pH and transplantation shock (1). Thus mycorrhiza has a number of practical applications in forestry. The biological requirement of many species of forest trees for ectomycorrhizal association was initially observed when attempts to establish plantations of exotic Pines routinely fail until the necessary symbiotic fungi were introduced. The primary purpose of inoculating these specialized fungi in world forestry is to provide seedlings with adequate ectomycorrhiza for survival after out planting in man made forests. Such treatments have proven essential in forestation of cut over lands and other treeless areas, introduction of exotic tree species and reclamation of adverse sites such as mine spoils (2).

The fungal vegetative body typically is a net work of hyphae spread out and concealed with in the substrate. These hyphae usually do not bear sufficient morphological characters for species recognition. Normally the fungi are identified on the basis of above ground fruiting structures (basidiomata). But many fungi do not produce these fruiting structures regularly. Under these circumstances it is difficult to identify the organisms. With recent developments in molecular techniques using DNA fingerprinting techniques it is now possible to distinguish the genotypes of fungal "individuals". Individuals of a given genotype are usually referred to as "clones" or "genets" (3,4).

It has been frequently observed that certain ectomycorrhizal fungal genera appear early in the successional sequence whereas others dominate in later stages of succession (5). The early colonizing species typically colonize efficiently in disturbed areas. Many early colonizers appear to have relatively small non persistent "genets". In contrast, fungi appearing late in succession have larger "genets" and temporarily persistent.

Extensive studies on the biodiversity of the members of the order Agaricales that contain large numbers of ectomycorrhizal species, have been made in the Nilgiri and Pulney hills by Prof. K. Natarajan and his colleagues in the Center for Advanced Studies in Botany, University of Madras. They have reported more than 150 species belonging to 40 genera from this region. This study has resulted in the identification of many ectomycorrhizal fungi in association with plantations of *Pinus petula*, *Eucalyptus grandis* and *Eucalyptus globulus*. (6,7,8,9,10,11,12). The following fungi have been found to be constantly associated with these trees: *Thelephora terrestris*, *Laccaria laccata*, *Laccaria fraterna*, *Rhizopogan luteolus*, *Amanita muscaria*, *Russula parazuaria*, *Scleroderma citrinum*, *Suillus brevipes and Suillus subluteus*. Among

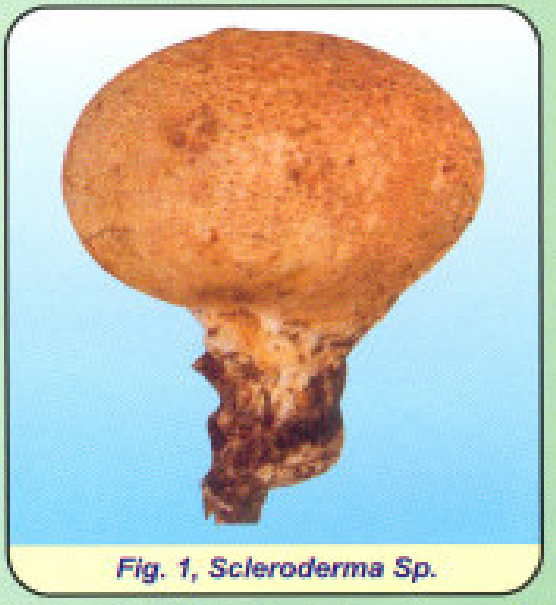

Fig. 1, Scleroderma Sp.

these fungi *Thelephora terrestirs*, *Laccaria laccata*, *Laccaria fraterna* and *Rhizopogan luteolus* have been found to be early colonizers whereas the other species mentioned above have been found to be late colonizers. In the Nilgiri and Pulney hills *Pinus petula* is extensively planted. There are plantations of different ages varying from 3-20 years. It was noted that there is a distinct pattern of succession in the occurrence of basidiomata of the different species of fungi with reference to the age of the plantation. For instance, basidiomata of *Thelephora terrestris* occurs only in young plantations (up to 7 years) whereas basidiomata of fungi such as *Amanita muscaria*, *Scleroderma citrinum* and *Suillus brevipes* were found to occur only in older plantations (12 years and above). On

Fig.2, Laccaria fraterna

the other hand basidiomata of fungi such as *Laccaria laccata* and *Rhizopogan luteolus* were found in both young and old plantations, more in the younger plantations and less in older plantations (13,14,15,16,17). On the basis of the suggestion that selection of a suitable ectomycorrhizal fungus for inoculation in the nursery stage with early stage fungus will be more successful than a late stage fungus, attempts were made with Nilgiri isolates of these fungi in nursery experiments. It was found that fungi such as *Laccaria laccata*, *Rhizipogan luteolus* and *Thelephora terrestris* produced extensive mycorrhizas in the nursery seedlings of *Pinus patula* whereas fungi such as *Amanita muscaria* and *Scleroderma citrinum* did not produce any mycorrhizae in the seedlings.

Similar studies were undertaken in another area of Western Ghats in Karnataka region in an area called Uppangala. The Uppangala forest is situated in the Kadamakkal Reserve Forest (Kodagu district) in the foot hills of the Western Ghats. The forest ecosystem is dominated by Dipterocarp trees such as *Dipterocarpus indicus*, *Vateria indica*, *Hopea ponga* and *Hopea parviflora*. Floristically, it belongs to the low elevation *Dipterocarpus indicus – Kingiodendron pinnatum – Humboldtia brunonis* type of wet evergreen forests.

Fig.3, Boletus Species

Dipterocarp trees are obligately ectomycorrhizal and extensive studies have been made on the association of ectomycorrhizal fungi with trees in mixed Dipterocarp forests in Thailand, Malay Peninsula and Indonesia. Similar work is lacking in the Southern forests in India. In a recent study in the Uppangala forest Prof. K. Natarajan and his colleagues have collected more than 180 species belonging to 43 genera of fungi belonging to the order Agaricales from this forest. Of these the following are known to be ectomycorrhizal: *Tricholoma* (1 sp.), *Laccaria* (2 spp.), *Russula* (15 spp.), *Amanita* (6 spp.), *Hebeloma* (1 sp.), *Inocybe* (3 spp.), *Cortinarius* (1 sp.), *Suillus* (2 spp.), *Strobilomyces* (3 spp.) and *Boletus* (10

Fig.4, Boletus Species

spp.). These fungi were collected in association with *Dipterocarpus indicus* , *Vateria indica* and *Hopea ponga*. The most dominant genus seems to be *Russula* followed by *Boletus* and *Amanita*.

Compared to the biodiversity of ectomycorrhizal fungi associated with *Pinus patula* and *Eucalyptus* spp., in the Nilgiri and Pulney hills, the fungi associated with Dipterocarp trees in the Uppangala forest in Karnataka is very rich.

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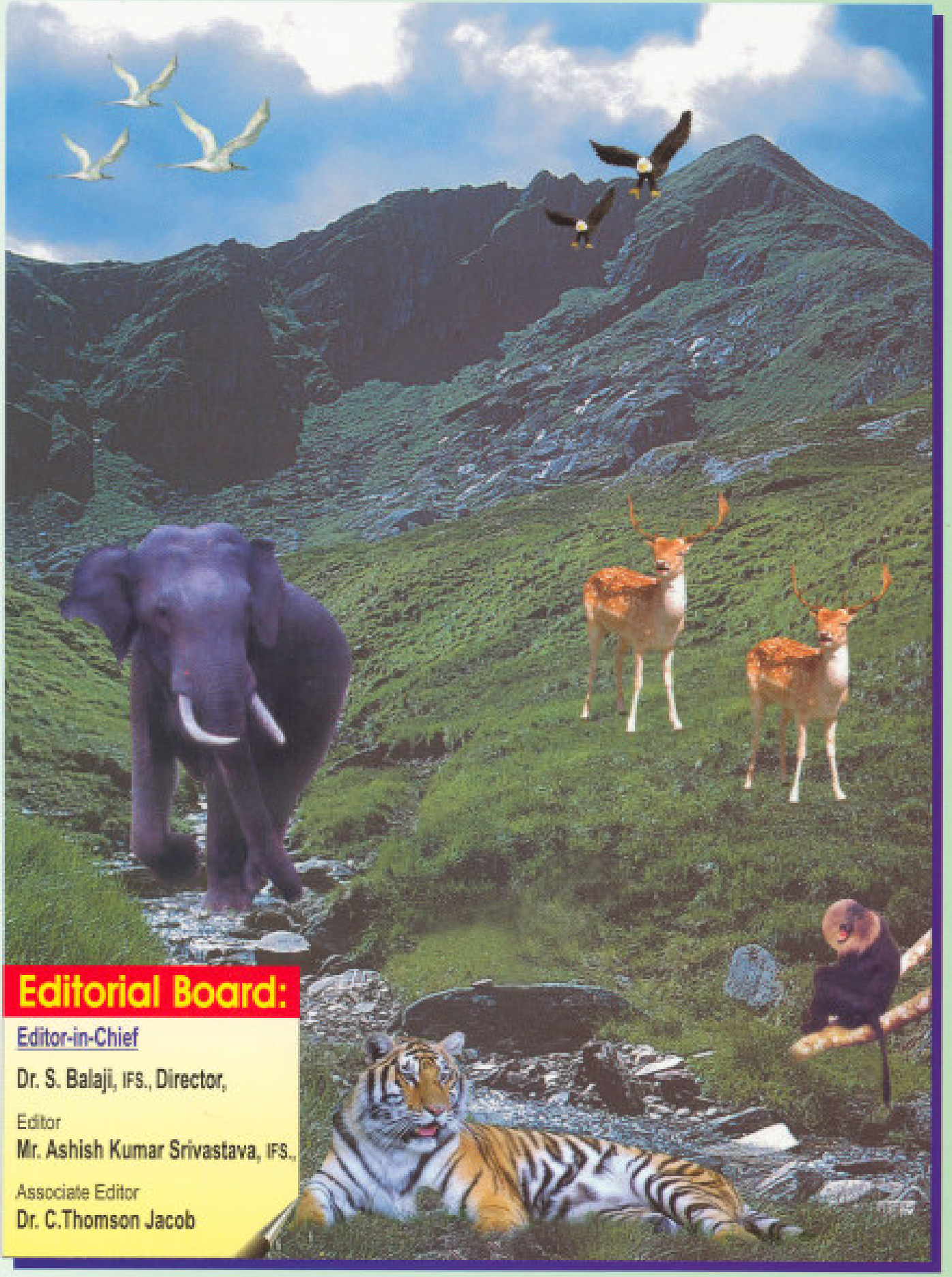

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