# Mangroves of India : Potential Habitats for Unique Lichen Flora

**Nayaka, S., Upreti, D.K. and Ingle, K.K.**

Lichenology Laboratory, CSIR-National Botanical Research Institute
Rana Pratap Marg, Lucknkow - 226 001
Email : nayaka.sanjeeva@gmail.com

## Introduction

In India, it has been estimated that about 20% of the population live in the coastal areas. In the 21st century the development may concentrate in the coastal regions, resulting into migration of people towards coast. Coastal environment plays a vital role in nation's economy by virtue of the resources, productive habitats and rich biodiversity. The coastal areas are assuming greater importance in recent years, owing to increasing human population, urbanization and accelerated developmental activities. These anthropogenic activities have put tremendous pressure on the fragile coastal environment.

Mangrove forests are among the world's most productive ecosystems (Kathiresan 2003). Mangroves of India are very rich in biological diversity and high species complexity, and have some special features that are unknown in other countries (Singh, 2002). They play a decisive role as nursery ground for marine life and supply firewood, fuel and fodder for local needs. In Sundarbans alone, over 2.2 million people are associated with mangrove for their needs. In India, as per the estimate in 2003 area under mangrove cover was estimated to be 4,461 $km^2$ and major portion of it occur in east coast. West Bengal in the east with 2,125 and in the west coast Gujarat with 1,031 $km^2$ are the foremost sites for mangrove vegetation. Table 1 gives an extent of mangroves *vis-à-vis* biodiversity in India. There exists a significant positive correlation between extant of mangrove vegetation and total species diversity (Kathiresan 2003).

The lichens are unique group of terrestrial autotrophs having an ability to grow on any stable substratum and in any geographical region. They are very sensitive to microclimatic changes and well known indicators of air pollution. Hence, they are widely used as bio-monitors. In the world, about 13,000 species of lichens are recognized and this number rises to 20,000 if the orphaned species are also considered (Sipman and Aptroot 2001). The lichenological studies is in constant progress in India and Singh and Sinha (2010) catalogued 2,305 species under 305 genera and 74 families, out of which 520 (22.6%) are endemic to the country. This is the latest and authentic information available for Indian lichens. Over the years, it has been experienced that mangroves in India have rich and unique lichen flora, but they are least explored sites. The present communication aim to review the potentials of mangroves for lichen habitation.

Table - 1: **Extent of mangroves, floral and faunal species in India (after Kathiresan 2003)**

| State | Area sq. km (% of total) | No. of mangrove species | No. of faunal species | Total no. of species |
|---|---|---|---|---|
| **East coast** | 2758 (56.6%) | 63 | 1091 | 1154 |
| West Bengal | 2125 (43.63%) | 57 | 988 | 1045 |
| Orissa | 215 (4.41%) | 60 | 546 | 605 |
| Andhra Pradesh | 397 (8.15%) | 31 | 225 | 256 |
| Tamil Nadu | 21 (0.43%) | 24 | 648 | 813 |
| **Bay islands** | | | | |
| Andaman and Nicobar | 966 (19.83%) | 44 | 914 | 672 |
| West coast | 1147 (23.55%) | 37 | 344 | 381 |
| Gujarat | 1031 (21.17%) | 12 | 240 | 252 |
| Maharashtra and Goa | 113 (2.32%) | 24 | 196 | 220 |
| Karnataka | 5 (0.1%) | 29 | 13 | 102 |
| Kerala | Sparse | 27 | 70 | 97 |
| **Total** | **4871 (100%)** | **69** | **1469** | **1538** |

## Lichen study in mangroves - International Scenario

Literatures on mangrove lichens are rare. Many a time lichens of mangroves are included either within flora of a region or in monographic studies. Mangroves have rich and interesting lichen flora. Kathiresan and Qasim (2005) discussed in brief about the occurrence of lichens in mangrove forest of the world. Remolina *et al.* (2000) reported interesting species of *Peltigera* from mangrove swamps of Colombian Caribbean coast. Pinto Marcelo Marcelli (Sao Paulo, Brazil) carried out his Ph.D. thesis work on ecology of mangrove lichens in S.E. Brazil during 1987. Marcelli (1992) studied the environmental factors influencing pattern of lichen distribution in mangroves of south-east Brazil. Later, Benatti and Marcelli (2007) updated the existing list of lichens and described 81 lichen genera from southern Brazil and Itanhaém River mangrove. This illustrates the lichen richness in mangroves vegetation of tropical belt. Stevens (1979) surveyed mangroves along nearly 4,000 km coastline of eastern Australia, ranging from tropical areas to warm temperate. The temperature, mean number of annual rain days, seepage of water from the land surface influenced the occurrence of macrolichens in the mangrove. The distribution of 105 macrolichens indicated that a replacement of species takes place (to a greater or lesser extent within different genera) with change in latitude. Nakanishi (1964) studied epiphytic community growing on a mangrove tree *Kandelia candel* and described several lichens and bryophytes. According to Savillo (2009) lichens favourably grow on mangrove trees in inland streams compared to those growing near the river mouths and open seas. Trees in bays or in island partly surrounded by islets were seen to harbor lichen growth.

## Lichen study in Indian mangroves

As mentioned above though India has large coastal area under mangrove vegetation under 10 states and Union Territories exclusive studies on lichens are rare in these areas. Roychowdhury (1985) studied the lichen flora of 24-Paragans in West Bengal which also included a part of Sundarbans and Parmadan Forest. According to their study the district possessed about 160 lichen taxa which suggested the presence of diverse lichen flora in Sundarbans mangroves.

Table 2: **Some new species and new distribution records reported by Jagadeesh Ram *et al.* from Sundarbans Biosphere Reserve, West Bengal**

| | Taxa | Status | Publication |
|---|---|---|---|
| 1. | *Amandinea insperata* (Nyl.) H. Mayrhofer & Ropin | New Record | Jagadeesh Ram et al. (2007a) |
| 2. | *Anisomeridium leptospermum* (Zahlbr.) R.C. Harris | New Record | Jagadeesh Ram et al. (2005b) |
| 3. | *Anisomeridium tamarindi* (Fée) R.C. Harris | New Record | Jagadeesh Ram et al. (2007a) |
| 4. | *Anthostomella zongluensis* K.D. Hyde | New Record | Jagadeesh Ram et al. (2005b) |
| 5. | *Arthonia dispersula* Nyl. | New Record | Jagadeesh Ram and Sinha (2003) |
| 6. | *Arthonia obesa* (Müll. Arg.) R. Sant. | New Record | Jagadeesh Ram and Sinha (2003) |
| 7. | *Astrosphaeriella sundarbanensis* Jagadeesh Ram & Aptroot | New Species | Jagadeesh Ram et al. (2005b) |
| 8. | *Chrysothrix septemseptata* Jagadeesh Ram, Lumbsch, Lücking & Sinha | New Species | Jagadeesh Ram et al. (2006) |
| 9. | *Cryptothecia alboglauca* Jagadeesh Ram, G.P. Sinha & Kr.P. Singh | New Species | Jagadeesh Ram et al. (2009) |
| 10. | *Cryptothecia bengalensis* Jagadeesh Ram, G.P. Sinha & Kr.P. Singh | New Species | Jagadeesh Ram et al. (2009) |
| 11. | *Cryptothecia multipunctata* Jagadeesh Ram, G.P. Sinha & Kr.P. Singh | New Species | Jagadeesh Ram et al. (2009) |
| 12. | *Dirinaria leopoldii* (Stein) D.D. Awasthi | New Record | Jagadeesh Ram and Sinha (2003) |
| 13. | *Encephalographa anthracothecii* Diederich | New Record | Jagadeesh Ram et al. (2007a) |
| 14. | *Enterographa anguinella* (Nyl.) Redinger | New Record | Jagadeesh Ram et al. (2008) |
| 15. | *Enterographa bengalensis* Jagadeesh Ram, G.P. Sinha & Kr.P. Singh | New Species | Jagadeesh Ram et al. (2008) |
| 16. | *Enterographa divergens* (Müll. Arg.) Redinger | New Record | Jagadeesh Ram et al. (2008) |
| 17. | *Enterographa mesomela* Sparrius, Saipunkaew & Wolseley | New Record | Jagadeesh Ram et al. (2007a) |
| 18. | *Enterographa multiseptata* R. Sant. | New Record | Jagadeesh Ram et al. (2008) |
| 19. | *Glonium caucasicum* (Rehm) H. Zogg | New Record | Jagadeesh Ram et al. (2007a) |
| 20. | *Graphis sundarbanensis* Jagadeesh Ram & G.P. Sinha | New Species | Jagadeesh Ram et al. (2007b) |
| 21. | *Hysterographium mori* (Schwein.) Rehm | New Record | Jagadeesh Ram et al. (2007a) |
| 22. | *Julella geminella* (Nyl.) R.C. Harris | New Record | Jagadeesh Ram et al. (2005b) |
| 23. | *Megalaria bengalensis* Jagadeesh Ram, Aptroot, G.P. Sinha & Kr.P. Singh | New Species | Jagadeesh Ram et al. (2007a) |
| 24. | *Opegrapha rubefacta* Räsänen | New Record | Jagadeesh Ram et al. (2007a) |
| 25. | *Parmotrema overeemii* (Zalhbr.) Elix | New Record | Jagadeesh Ram and Sinha (2003) |
| 26. | *Polymeridium proponens* (Nyl.) R.C. Harris | New Record | Jagadeesh Ram et al. (2005b) |
| 27. | *Pseudopyrenula subnudata* Müll. Arg. | New Record | Jagadeesh Ram et al. (2005b) |
| 28. | *Pyrenula acutalis* R.C. Harris | New Record | Jagadeesh Ram and Sinha (2010) |
| 29. | *Pyrenula subcylindrica* Jagadeesh Ram & Upreti | New Species | Jagadeesh Ram et al. (2005a) |
| 30. | *Pyrenula thelemorpha* Tuck. | New Record | Jagadeesh Ram and Sinha (2010) |
| 31. | *Sarcographa subtricosa* (Leight.) Müll. Arg. | New Record | Jagadeesh Ram and Sinha (2005) |
| 32. | *Strigula hypothallina* R.C. Harris | New Record | Jagadeesh Ram et al. (2007a) |
| 33. | *Trypethelium subeluteriae* Makhija & Patw. | New Record | Jagadeesh Ram and Sinha (2005) |

Jagadeesh Ram (2006) carried out extensive exploration on lichens growing in Indian part of Sundarbans Biosphere Reserve for his Ph.D. degree. In his initial study he collected 550 specimens which resulted in 72 species belonging to 28 genera and 15 families. This study also yielded 25 species new to West Bengal region (Jagadeesh Ram and Sinha 2002). By the end of his studies he recorded a total of 165 species of which 9 were new to science and 24 were new records for India. He also encountered 28 endemic lichen species which is a clear evidence for lichen uniqueness in mangrove forests. The new taxa so far described by Jagadeesh Ram are given in Table 2, while many are still being described by him. Lichenological Laboratory at CSIR-NBRI frequently receives the lichen samples collected by botanists of Gujarat from Marine National Park, Jamnagar and Pirotan Island. These samples belong to Graphidaceous, Pyrenocarpous, Roccellaceae groups and are interesting, either hitherto undescribed or new to Indian lichen flora. Recently, Nayaka *et al.* (2010) reported five new records of lichens from Gujarat area and mostly they belong to family Roccellaceae (*Cresponea flava* (Vain.) Egea and Torrente, *Dirina paradoxa* subsp. *africana* (Fée) Tehler, *Enterographa*

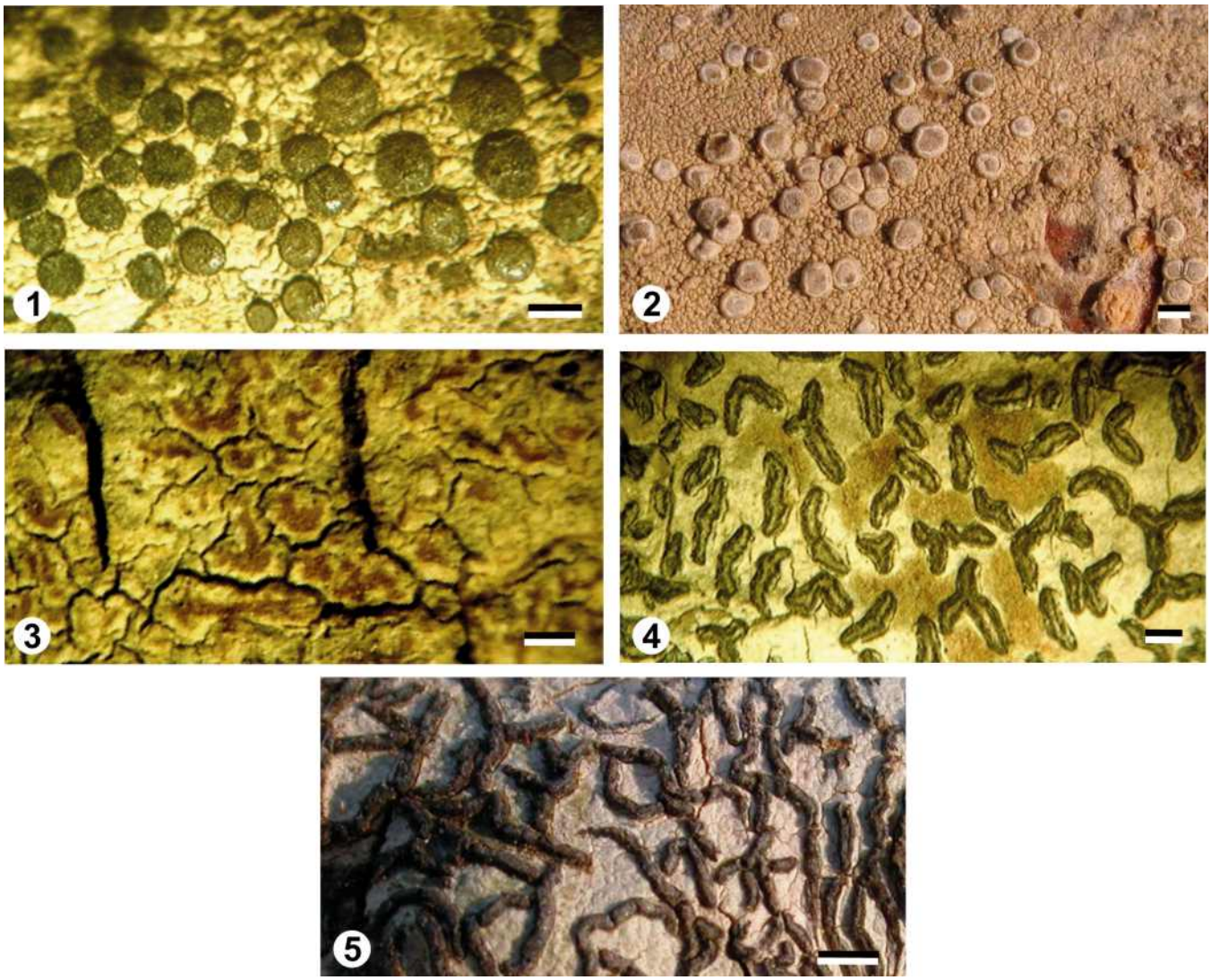


**Figure 1 - 5:** Some members of lichen family Roccellacae recently being reported as new records for India from Gujarat mangroves (Nayaka *et al.* 2010). 1. *Cresponea flava*, 2. *Dirina paradoxa* subsp. *africana*, 3. *Enterographa pallidella*, 4. *Opegrapha arabica*, and 5. *O. varians (Scale bars*, 1 - 3 = 0.5 mm, 5 - 5 = 1 mm).

*pallidella* (Nyl.) Renger, *Opegrapha arabica* (Müll. Arg.) Vain., O. varians (Müll. Arg.) Vain. Figure 1 - 5). Mohan and Hariharan (1999) studied the distribution pattern of lichens in Pichavaram mangroves in Tamil Nadu and reported 10 species of lichens and most of them are partially identified (*Buellia* sp., *B. montana Magnusson, Dirinaria confluens* (Fr.) D. D. Awasthi, *D. consimilis* (Stirton) D.D. Awasthi, *Graphis* sp., *G. scripta* (L.) Ach., *Lecanora* sp., *Pyrenula* sp1, *Pyrenula* sp2, *Roccella montagnei* Bél.). The study showed the dominance of crustose lichens in the forest and two tree species *Avicennia marina* and *A. officinalis* did not host any lichen species. In their study the sites exposed to heavy anthropogenic disturbances favoured luxuriant growth of lichens due to increased availability of light and moisture from sea breeze.

Above studies clearly indicate that mangroves have rich diversity of unique lichens dominated by crustose growth forms. The members of Arthonioid, Pyrenocarpous group, family Roccellaceae and to some extent Graphidaceae are most common inhabitants of mangrove forests. This indicates the smoothness of the

tree barks in mangrove as these lichens prefer such barks. The Arthonoid and Roccellacean lichens are sometimes referred as primitive lichens as they do not form definite fruiting bodies. Here the fertile ascigerous hyphae gather together in the form of apothecia or perithecia. Among the foliose lichens members of *Dirinaria* and *Pyxine* are most common encounters in mangrove forest. *Roccella montagnei* Bél is probably the only fruticose lichen that is commonly found in mangrove forests with their abundance in south India than in West Bengal region. Occasionally, few species of Ramalina also occur in mangroves. Among the other lichens some of the common representatives of mangrove forest are *Bacidia*, *Buellia*, *Lecanora*, *Physcia* and *Rinodina*. The species of *Parmelioid* and *Physcioid* (except for *Dirinaria* and *Pyxine*) lichens are rare in mangroves.

The lichen communities that occur in mangroves indicate their tolerance to hot, humid and saline breeze environmental conditions prevailing in mangrove. It would be an interesting aspect to study in detail the environmental factors and the physiology of these lichens enabling them for the successful colonization in mangrove forests. Morphologically, these lichens have very less visible adaptation.

## Lichenogeographic regions of India and mangroves

Singh and Sinha (1997) divided India in to eight lichenogeographical regions based on the 10 dominant families and genera in the region which is followed till date. These regions included mostly all parts under political boundary of India, except for Lakshadweep Islands. At that time a total of 2021 species within 248 genera were known and the country was not explored completely. However, there is a scope for further fine division of the country into more lichenogeographic regions. Among the other potential habitats coastal area and mangrove vegetation can be considered for making lichenogeographic region. It is now established that mangrove forest posses a unique lichen vegetation dominated by members of family Graphidaceae, Roccellaceae, pyrenocarpous and foliicolous groups. However, literature review revealed that only Sundarbans has been extensively studied and very few reports of lichens are available for Gujarat and Tamil Nadu. Further, India possesses a long coast line but littoral rocky areas are few but coconut trees (*Cocos nucifera*) are the most common substratum for lichens. Except casual collections, comprehensive or even representative collections have not been made from this region (Awasthi 2000). In case of west coast it is difficult to demarcate it from Western Ghats in most of the places. The forested area of Western Ghats many a times ended directly in to the sea and there do not exist any coast (www.westernghatsindia.org). Consequently, idea of recognizing coastal area and mangrove vegetation as separate biogeographic regions may be dropped for the time being. However, in future two possible licheno-geographic regions that can be recognized are 1. 'Western mangrove and coastal region' including the west coast and mangrove, and similarly 2. 'Eastern mangrove and coastal region'. The former region may also include Lakshadweep islands as it is located in the Arabian Sea, also has common pantropical lichen species composition (Makhija & Adawadkar 2001), similar to those occur in coastal areas and growing over coconut trees.

## Conclusion

The coastal areas are also the place where natural disasters are experienced. The entire coast of India face frequent cyclone which sometimes cause large scale destruction of life and property. There were 366 cyclones, out of which 133 were severe along the Bay of Bengal between 1891-1970; but only 98 cyclones in the Arabian Sea, of which 55 were of sever nature (Koteswaram 1984). Apart from natural calamities anthropogenic threats are severe throughout the coastal belt. Kathiresan (2003) has listed 16 threat factors in different maritime states of India. According to him three problems that are most common in most of the mangrove ecosystem are; (a) over exploitation of fishery resources, hampering regeneration of mangrove seedlings and unnecessary cutting of trees, (b) damage of trees for firewood, cattle feed, rehabilitation, reclamation and conversion activities, and (c) lack of peoples awareness and participation in conservation activities.

In the past, mangroves are viewed as economically

unproductive areas and as a consequence they were felled to get timber, fuel wood and fodder. In recent time the urbanization, pollution, oil spills, expansion of harbors, mining, salt industries, mericulture and agriculture are causing further damage. Experts have their opinion that mangroves continue to disappear all over the world at a faster rate and the rate of loss has already reached to an alarming stage. It is a general opinion that the world lost its 50% mangrove after 1960 and India alone lost about 60% (Singh 2006). The global annual loss of mangroves has been estimated about 70,000 sq. km. In Gujarat, apart form natural disaster and felling about 150 $km^2$ mangrove area was leased out to salt industries before commencement of Forest (Conservation) Act 1980.

Taking into consideration the ecological and economic significance of mangroves India has taken efforts and launched scheme for conservation of management of mangroves through Ministry of Environment and Forests. The National Committee of the scheme has identified several thrust area for management related research activities for funding. Under this activity CSIR-National Botanical Research Institute, Lucknow has bagged a project to study the lichen diversity of Gujarat State which possesses a large area (about 25,083 $km^2$) as wetland which is highest (62.3%) amongst all the states of the country. Gujarat coast measures about 1,650 km, which is longest coastline amongst the maritime states of India. Among the states in the west coast of India, extent of the mangrove cover is highest in Gujarat. It supports the second largest block of tidal forests after Sundarbans in term of area coverage. Mangroves in Gujarat are called as 'cher' and 'cheradi' which is addressed to *Avicinnia* constituting ove 99% of the total mangrove vegetation.

It is also notable that mangrove cover in Gujarat is consistently improving as against general trend of decline in other states. Because Gujarat has taken a lead in the afforestation of mangrove since the beginning of mangrove conservation programme. However, with new policy of economic liberalization and encouragement of privatization, the Government of Gujarat has been evolving an ambitious plan for the development of its vast coastal zone for new ports, harbours, jetties, industries etc. This may result into high environmental burden on the coastal wetlands of the State. To avoid such scenario environmental safeguard measures and conservation of marine ecosystem, including mangrove development have to be initiated. Our aim under the said project is to document the lichen wealth of the state before they are vanished due to natural disasters, anthropogenic pressure and global warming.

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