Mangrove Plant Diversity in Bay Islands, India and its Significance

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Introduction

Mangroves are specialized marine ecosystem of a group of salt tolerant plants found in tropical and subtropical intertidal regions of the world. It is consisting of a low diversity forests with complex webs and ecosystem dynamics (Macnaw 1968 & Tomlinson 1986). Mangrove vegetation covers roughly 170,000 sq. km. of the earth surface (Spalding *et al.,* 1997, Valiela *et al.,* 2001), but the exact area of mangroves in the world is not well known. Analysis of species composition show that about 60 species of mangroves occur in two distinct biogeographically regions; the Indo-west Pacific which includes Asia, Austria, Oceana and the eastern coast of Africa and the Atlantics- Caribbean East Pacific region which covers the Americas and Western coast of Africa (Fao 1982, Jayawardene 1984, Duke 1992). Asia is the richest regions of mangrove species diversity with 44 species, Balsco (1975) stated that India is one of the most important mangrove areas of the world. In India, the phytodiversity of Bay Islands is one of the unique and richest in the country in terms of biodiversity with remarkable degree of genetic variations. It is a group of 572 Islands and Islets in the Bay of Bengal. Its irregular and deeply indented coast line results in innumerable creeks, bays and estuaries which facilitate the development of rich, extensive and luxuriant growth of mangrove forests with high degree of biodiversity. The mangrove vegetation of these Islands constitute 9.4% of land area and has many functions such as coastal stabilization, prevention of erosion, pollution trapping, the provision of spawning grounds, the production of foods, timbers, thatches, firewoods, etc and serve as habitat for wild animals. However, the mangrove plant diversity in many areas of Bay Islands has not drawn much attention. In addition, the total mangrove area in Bay Islands has not been assessed correctly, although several attempts have been made earlier to survey the mangrove areas by various authors like Mathuda (1957), Sahni (1957), Waheed Khan (1959), Sidhu (1963), Blased (1977), Mall *et al.* (1982) and Forest Department of Andaman-Nicobar Islands (1989). The present study deals with mangrove plant diversity in Bay Islands and its significance.

Material and Methods

The present study records the mangrove plant

diversity based on several intensive and extensive field surveys in various parts of Bay Islands with relevant details about the topography, geomorphology, climate, soil and tidal inundation. Perusal of literatures *viz.* Prain1903, Waisel 1972; Dagar 1982; Mall *et al.*, 1982; Saenger *et al.,* 1983; Teas 1983; Singh & Mongia 1985; Dagar & Dagar 1986; Rajgopalan 1987; Singh *et al.,* 1987; Banerjee *et al.,* 1989 & 1998; Dagar & Sharma 1989; Dagar *et al.,* 1991; Mongia *et al.,* 1992; Spalding *et al.,* 1997; Balachandra 1998; Kothari & Singh 1998; Naskar & Mandal 1999; Saenge 2002; Debnath 2004; Giesen *et al.,* 2007; Dam Roy *et al.,* 2009) the following details are provided here.

Geography

Bay Islands a group of 572 Islands and islets is located in the Bay of Bengal. They constitute a biogeographically distinct province located between 6°45' - 13°40' N latitudes and 92°12' E longitudes. The Andaman group of Islands are located further away from the equator and are lying close to Myanmar (Burma), with a few exceptions, the bulk of the Islands are continuous, whereas Nicobars lie close to the equator, and are disjunctive. The Bay Islands covers an area of 8293 sq. km, which is 0.25% of total landmass of the Indian Union. The contribution of these Islands to the Mangrove vegetation exceeds 22.5%. The rainforests of the Islands constitute 0.3% of the Asian forests and 0.07% of the global tropical rain forests. The 1986 Km long coastline of the Bay islands represents one fourth of the Indian coastline. The Exclusive Economic Zone (E.E.Z.) is approximately 6,00,000 Sq. Km which is roughly 30% of that of India.

Topography

The hypothesis is that the Islands are emergent peaks of a submerged mountain related to the Arakan Yoma range.

The geographical formation in the Islands is mainly of thick Eocene sediments deposited on pretertiary fine grey sand stone, silt stones and shoals in which the basic and ultra basic igneous rocks are intrusive. The calcareous sand stones and sand rocks occur frequently interspersed with conglomerates and intercalated clays.

Soil

Mangrove soils are generally distinctive. They are poorly drained, saline, anoxic and rich in organic matter. The primary constituents of the soils range from compact fine-grained clay containing little or no organic matter in the more recent deposits at the sea front and riverbanks to comparatively friable brownish-black mud containing sand and a high percentage of organic matter in the middle of Islands and towards the hinterland. In areas subject to daily tidal flushing, mangrove soils are often ill consolidated and semi fluid in nature. Under the anaerobic conditions below the soil surface, sulphate-reducing bacteria produce hydrogen sulphide through reduction of organic sulphate from the soils. Emission of this gas gives mangrove soils their pungent odour. The characteristic gray or black colour of mangrove soils is due to reduction of ferric compounds to various sulphide by the gas.

In general, soils of the territory are acidic in nature. Soil showed a mean value of 4.5 to 6.0 pH, 0.25 to 1.54 per cent for organic carbon and 0.02 to 0.27 per cent for P_2O_3 (Singh and Mongia, 1985).

Climate

Proximity to the equator and to the sea ensures a hot, humid, uniform climate with day temperature around 30 degrees Celsius in Andaman-Nicobar Islands. There is little variation in mean monthly temperature with the values between 15-33 degrees Celsius. The mean relative humidity is about 82% and the average annual rainfall varies between 300-380 cm. The Islands are subjected to the southwest and northeast monsoon, the former from May to September and the later from November to March. The cyclonic winds are also frequent. The months of January to March, remain relatively drier.

Following main physical factors controlling to the distribution of mangrove and determine the extent of mangrove ecosystem development.

Temperature

Globally, mangroves are limited in distribution by temperature. They are tropical species and do not develop satisfactorily in regions where the annual average temperature is below 19 degrees Celsius (Waisel (1972), Walsh (1974) and Chapman (1975, 1977) suggested that extensive mangrove development was

only possible in areas where the average air temperature of the coldest north exceeds 20 degrees Celsius and where the seasonal range does not exceed 10 degrees Celsius or temperature below freezing for any length of time.

It plays an important role in photosynthetic activity, water loss and stomata opening, transpiration and salt loss. Consequently, since mangroves occur in a high salinity environment in tropical regions they show xeromorphic adaptations. Moore *et al.* (1972, 1973) and Clough *et al.* (1982) showed that for most mangrove species photosynthesis declines sharply above 35° C with little or none occurring above 40 ° C.

High water temperature can also be limiting. McMillan (1971) reported that seedlings of *Avicennia* were killed by temperature of 39 to 40 °C, although established seedlings and trees are not damaged.

Salinity

Mangroves are facultative halophytes *i.e.* salt water is not a physical requirement (Bowman, 1917; Egler, 1948). In fact, most mangroves are capable of growing quite well in fresh water (Teas, 1979). It is important to note, however, that mangrove ecosystems do not develop in strictly freshwater environments. This is probable due to the fact that they are not good competitors and the salinity is important in reducing competition from freshwater and terrestrial vascular plant.

Tidal Inundation

Mangrove forests develop only in shallow water and intertidal area and are thus strongly influenced by the tides. Whereas according to Odum & Heald 1972, tidal influence is not a direct physiological requirement for mangroves, it is important indirectly in a number of ways.

First of all, tidal stress in combination with salinity helps exclude other competitively superior vascular plant permitting mangroves to exist. Secondly, tides bring salt-water upto estuaries permitting mangroves to become established well in land. Thirdly, tides may transport nutrients and relatively clean water into mangrove ecosystem and export accumulation of organic carbon and reduced sulphur compounds. Fourthly, in areas with high evaporation rates, the action of the tides helps to prevent soil salinities from reaching concentration which might be lethal to mangroves. Fifthly, tides aid in the dispersal of mangrove propagules and detritus.

Perhaps, these are factors, termed tidal subsides that mangrove communities reach their greatest development where there are large tidal fluctuation (Odum (1971).

Result

On the basis of their habitats the Bay Islands mangroves can be classified into two groups: exclusive group and fringe group. Exclusive group consists of 33 species under 19 genera (Table-1) and Fringe group of 22 species in 17 genera (Table-2) have been recorded from various areas of North Andaman, Middle Andaman, South Andaman, Little Andaman, Nicobar and Great Nicobar of Bay Islands. However, about 33 species of mangrove belonging to 15 genera and 12 families have been treated as true mangroves. Luxuriant growth of mangroves can be seen in Shoal Bay of South Andaman, Yerrata Jetty of Middle Andaman, Austin Creek of North Andaman.

Adaptations

The mangrove ecosystem is highly fragile subjected to long duration of intrusion as well as incessant physiological and morphological stresses, salinity effect, aeration and on slough of wave action which have series of markable adaptations (Macnaw 1968, Chapman 1976, Duke 1992,Hogarth 1999.) each species has its own solutions of these problems and require a number of physiological adaption to over cum the problems. This may be the primary reason why on some shore lines, mangrove tree species show distinct conation. In connection to adaption, mangroves are characterized by development of stilt and negatively geotropic aerial roots with plenty of lenticels has function of stability, anchorage and gaseous exchange or aerating organ respectively (Gill and Tomlinson 1975, Misra & Singh 2000 a, b, 2004 a,b, Singh 2002) and vivipary. (Macnaw 1968, Gill & Tomlinson 1969).

Typically, they produce tangled masses of arching roots that are exposed during low tides and aerial roots

Table 1. **List of Mangrove species in Andaman - Nicobar Islands**

OBLIGATE OR EXCLUSIVE GROUP:
(Plants are absolutely bound to salty or brackish water)

Family	Scientific Name
Arecaceae (Palmae)	*Nypa fruticans* Wurmb. *Phoenix paludosa* Roxb.
Asclepiadaceae	*Sarcolobus globosus* Wall.
Avicenniaceae	*Avicennia marina* (Forsk.) Vierh. *A. officinalis* Linn.
Combretaceae	*Lumnitzera littorea* (Jack.) Voigt *L. racemosa* Willd.
Euphorbiaceae	*Excoecaria agallocha* Linn.
Fabaceae	*Derris trifoliata* Lour.
Meliaceae	*Aglaia cucullata* (Roxb.) Pellegrin *Xylocarpus gangeticus* (Prain) C.E. Parkinson *X. granatum* Koen. *X. mekongensis* Pierre *X. moluccensis* (Lamk.) Roem.
Myrsinaceae	*Aegiceras corniculatum* (Linn.) Blanco
Plumbaginaceae	*Aegialitis rotundifolia* Roxb.
Rhizophoraceae	*Bruguiera cylindrica* (Linn.) Bl. *B. gymnorrhiza* (Linn.) Savigny *B. parviflora* (Roxb.) Wt. & Arn. ex Griff. *B. sexangula* (Lour.) Poir. *Ceriops decandra* (Griff.) Ding Hou *C. tagal* (Perr.) C. B. Rob. *Kandelia candel* (Linn.) Druce *Rhizophora apiculata* Blume *R. lamarckii* Montr. *R. mucronata* Lamk. *R. stylosa* Griff.
Rubiacea	*Scyphiphora hydrophyllacea* Gaertn. f.
Sonneratiaceae	*Sonneratia alba* J. Smith *S. caseolaris* (Linn.) Engl. *S. griffithii* Kurz *S. ovata*
Sterculiaceae	*Heritiera littoralis* Dryand
Tiliaceae	*Brownlowia tersa* (Linn.) Kosterm.

Table 2. **Facultative or Fringe or Back Mangrove**

(Plants belonging to the littoral vegetation regularly make their appearances in the back mangroves)

Family	Scientific Name
Acanthaceae	*A. canthus ebracteatus* Vahl *A. illicifolius* Linn. *A. volubilis* Wall.
Apocynaceae	*Cerbera manghas* Linn. *C. odollum* Gaertn.
Asclepiadaceae	*Finlaysonia obovata* Wall. Tylophora tenuissima (Roxb.) W. & A. ex W.
Asteraceae	*Pluchea indica* (Linn.) Less.
Caesalpiniaceae	*Caesalpinia bonduc* (Linn.) Roxb. *C. crista* Linn.
Cyperaceae	*Fimbristylis ferruginea* (Linn.) Vahl.
Fabaceae	*Cynometra iripa* Kosteletzky *C. ramiflora* Linn. *Dalbergia candenatensis* (Dinnst.) Prain.
Flagellariaceae	*Flagellaria indica* Linn.
Hippocrateaceae	*Salacia chinensis* Linn.
Lecythidaceae	*Barringtonia racemosa* (Linn.) Spreng.
Lythraceae	*Pemphis acidula* J.R. & G. Forst.
Malvaceae	*Hibiscus tiliaceous* Linn.
Myrsinaceae	*Ardisia solanacea* Roxb.
Pandanaceae	*Pandanus odoratissimus* Linn.f.
Verbenaceae	*Clerodendrum inerme* (Linn.) Gaertn.

extend above the water or mud and act as aerating organs called pneumatophores or respiratory roots. (Scholander *et al.,* 1955, Waisel 1972, Singh 2002). Many of the root types are distinctive to the species of mangrove. So the plant genus can be identified some times by the roots types. Vivipary is one of the most important adaptive reproductive strategies. Since there is uninterrupted development of the embryo following fertilization to seedling (Propagule) without any resting viable for extended period of time.

Significance

Mangroves admittedly are not only important but

crucial for the coastal areas and play vital role in stabilizing these areas. It has been cited that mangroves can help buffer against Tsunami, cyclones and other storms. (Danielsen *et al.,* 2005). Some area in Tamil Nadu (Calimere, Muthupettai and Pitchavaram), India were protected from tsunami destruction. When tsunami struck much of the land around the village areas were flooded but these areas itself did not cause any serious damages because of the dense and luxuriant mangrove cover.

In the recent ,tsunami struck Bay islands on 26th Dec. 2004, much of the densely and luxuriantly mangrove covered areas of middle and North Andaman were flooded but itself not severely damage.

Mangroves are an important part of the food chain for a number of animal species. The fruit and nectar of same plants like *Nypha* palm can be eaten after preparation. It serves as an important habitat for birds, mammals, crustaceans, fish and other wild animals by providing a breeding place and by giving protection. The best honey is considered to be that produced by bees feeding in mangroves. Many traditional medicines are made from mangroves including those for treating skin diseases, headaches, rheumatism, snakebite, ulcers and many more. The leaves are crushed and floated on the water and stunned fish float to the surface.

Some mangrove trees are prized for their hard wood and were traditionally by local peoples. *Nypha* palm founds are used for thatching and basket weaving, some barks are used for tanning and fishing float.

Conservation

Despite well known ecologically and biologically significance, most of the challenges to mangrove ecosystem observe in Bay Islands for conservation. However, it may be due to global climatic change by natural and human induced stressers. (Edwards 1995, Lovelock *et al.,* 1992, Isaksen 1989, Milliman 1989, Pernetta & Elder 1992,).

Coastal retro-gradation process, cyclones, tsunami etc are significant natural factors which are destroying natural mangroves vegetation. More recently when tsunami struck, Bay Islands on 26th Dec. 2004 have got affected maximum areas and destroying the ca 80% mangrove vegetation in particular area of South Andaman. In addition, human induced stresses like over exploitation, agriculture, settlement, urbanization, urban infrastructural development, deforestation are major cause of threats due to which mangrove ecosystems are in jeopardy in many more areas of the Bay Islands from last past decades. However, destruction and depletion of Mangrove ecosystems now is one of the most serious global problems.

The best practice for mangrove ecosystem of Bay Islands is preservation because the preservation of adjacent ecosystem that are linked significantly by functional process. In the past, the mangrove forests were worked for extraction of fuel wood around Port Blair to meet the domestic requirement of the people. The Andaman Timber Industry and Chatham Power House were also using mangrove fuel wood for running their boilers. However, the mangrove fuel wood extraction and sale of mangrove has been totally stopped in the Islands.

Summary and Discussion

Mangrove ecosystems are very unique and complex kind of coastal wetland which exist in a constantly changing environment. They are highly specialized plants that have developed unusual adaptations to the unique environmental conditions in which they are found and exhibit remarkable capacity for salt water tolerance that inhibit the upper intertidal zones, primarily in tropical regions with in 30 of the equator (Tomlinson 1986, Hutchings & Saenger 1987).

In Bay Islands, three conspicuous zones of mangroves are identified; proximal, middle and distal zones. The species *Rhizophora apiculata* and *R. mucronata* are major representative of the proximal zone, whereas *Bruquiera gymmorrhiza, B. cylindrica, Lumnitzera racemosa, L. littoralis* of middle zone and *Excoecaria agallocha, Heritiera littoralis* of distal zone are specially adapted with stilt roots, prop roots, pneumatophores and vivipary for survival of the fittest.

Besides, Bay Islands mangrove areas in India along the east coast are found in the Gangetic Sunderban Complex, Mahanadi deltaic complex, the Godavari Krishna deltas, the Cauvery estuarine system and along

Bruguieria gymnorrhiza

Bruguieria parviflora

Ceriopsis taga

Excoecaria agallacha

the west coast mangroves are confined to the back water system, innumerable inter connecting canals, lakes and creeks in Maharashtra, Karnataka and Kerala and salt marsh dominated mangrove areas of Kutch and Saurashtra of Gujrat. (Chaudhari & Chaudhari 1994).

Change in mangrove distribution over evolutionary time, expected that Pleistocene epoach (Ricklefs *et al.,* 2006) event did affect global climate and sea level, ultimately modifying present mangrove distri-bution in different regions of the world (Woodroffe & Grindrod 1991). Ellison (1994) stated that global climate change is expected to increase the average temperature and spatial-temporal variability precipitation, as well as cause a rise in sea level.

Approximately, 35% of mangrove area was lost during the last several decades of the twentieth century which encompass about half of the area of mangrove (Millennium Ecosystem Assessment 2005). The United Nations Environment Program also estimated Shrimp farming causes a quarter of the destruction of mangrove diversity (Borkin & Kelter 2003). Likewise the world mangrove Atlas 2010 (WMA) indicated a fifth of the world ecosystems have been lost since 1980 (TNC 2010a). Globally, mangrove ecosystem continues to disappear which is becoming threatened. Like relevant parts of the world, Bay Islands also include such problems by natural and human induced stresses. In the absence of proper management and conservation plan and local awareness, mangrove of these Islands has reached an alarming stage. However, the gravity of the problems varies from area to area. Hence, it is essential to systematically conserve the biodiversity in the mangrove ecosystem for the significance of mankind as well as nature.

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References

Balachandra, L. (1988) A comprehensive account of the mangrove vegetation of Andaman & Nicobar Islands Indian For. 114 : 741-751.

Balsco, F. (1975) The Mangroves in India (Translated by Mrs. K. Thanikaimoni from LES MANGROVES DE L' INDE) Institute Francais de Pondicherry, India, Shri Aurbindo Ashram Pondicherry, India.

Banerjee, L. K., Sastry, A. R. K. & Nayar, M. P. (1989) Mangroves in India, Identification Manual. Botanical Survey India. Calcutta.

Banerjee, L. K., Ghosh, D. & Sastry, A.R.K. (1998) Mangroves, Associates and Salt Marshes of the Godavari and Krishna Delta, A.P. India, Bot. Surv. India.

Borkin, D. & Kelter, E. (2003) Environmental Science: Earth as a living Planet, John Wiley & Sons.

Bowman, H. H. M. (1917) Ecology and Physiology of the red mangrove Proc. Amer. Philos. Soc. 56 : 589-672.

Chapman, V. J. (1976) Mangrove vegetation Vaduz : Cramer 447.

Chapman, V. J. (1975) Mangrove Biogeography. In Walsh, G.E.S.C. Snedaker and H. J. Teas, Proceedings of the International Symposium on Biology and Management of Mangroves, Uni. Florida Gainesville 1: 3-22.

Chapman, V. J. (1977) Introduction. In Ecosystems of the world 1. Wet Coastal ecosystems Elseview, Amsterdam, 1-29.

Chandhuri, A. B. & Choudhury, A (1994) Mangroves of the Sunderban, Vol. 1. India. The IUCN Wetlands Programme Bangkok, Thailand.

Clough, B.F., Andrews, T. J. & Cowan, I. R. (1982) Primary Productivity in Mangroves. In Clough, B. F. (ed.) Mangroves Ecosystems in Australia, Structure, Function and Management. AIMS with ANU Press, Canberra, Australia.

Danielsen, F., Sorensen, M. K. Olwing M. F., Parish N D (2005). The Asian Tsumani; a protective role for Coastal Vegetation. Science 310 : 643.

Dagar, J. C. (1982) Some Ecological Aspects of Mangrove vegetation of the Andaman & Nicobar Islands in India. Sylvastrop Philipp. For. Res. J. 7 : 177-216.

Dagar, J. C. & Dagar, H. S. (1986) Mangroves and some Coastal plants in ethno-botany of tribals of Andaman & Nicobar Islands. J. Andaman Sci. Assoc. 2 (2) : 33-36

Dagar, J. C. & Sharma,A. K.(1989) Impact of developmental activities on litterfall and mangal formation in the Andamans. Paper presented in Sym. Dev. Vis - a vis Ecology INTACH Forest Deptt. PBL..

Dagar, J. C., Mongia, A. D. & Bandyopodhyay, A. K. (1991) Mangroves of Andaman Islands, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi 19.

Dam Roy, S.,Krishnan, George,G., Kaliyamoorthy & Goutham Bharathi (2009) Mangroves of Andaman and Nicobar Islands.CARI, Port Blair.

Debnath, H.S. (2004) Mangroves of Andaman & Nicobar Islands; Taxonomy & Ecology. Bishen Singh Mahender Pal Singh, Dehra Dun, India.

Duke, N. C. (1992), Mangrove floristics and biogeography, in Tropical Mangrove Ecosystem, Coastal Estuarine Blud., Vol. 41, edited by A. I. Robertson and D. M. Alongi, pp. 63-100, AGU, Washington, D. C.

Edwards, A. J (1995) Impact of Climatic change on Coral Reefs, Mangroves and Tropical Seagrass Ecosystem. In Eisma, Docka (ed.) Climate change Impact on Coastal Habitation. Florida Lew is Publishers 224.

Egler, F. E. (1948) The dispersal and establishment of red mangroves, Rhizophora in Florida Caribb For. 9(4) : 299-319.

Ellison, J. C. (1994) Climate change and sea level rise impacts on mangrove ecosystems. In J. Pernetta. R. Leemans, D. Elder & S. Humphrey (eds.), Impact of climate change on Ecosystems and species; Marine & Coastal Ecosystems IUCN Gland. 11-30.

FAO (1982) Management and utilization of mangroves in Asia and the Pacific, Rome.

Giesen, W.,Wulffraat, S.,Zieren,M.& Scholten L.(2007)Mangrov Guidebook for Southeast Asia, RAP Publication.

Gill, A. M and Tomlin, P. B. (1969) Studies on the growth of red mangrove (Rhizophora mangle L.) I, Habit and general morphology, Biotropica 1(1) : 1- 9.

Gill, A. M & Tomlinson, P. B. (1975) Aerial roots : An Any of Forms and Function in third Cabot Symposium. The development & Function of roots. 237-260.

Hogarth P. J. (1999) The Biology of Mangroves, Oxford University Press Oxford.

Hutchings, P. & Saenger, P. (1987) Ecology of Mangroves, University of Queensland Press, St. Lucia, Australia 1-388.

Jayawardene,R.P.(1984) Mangroves of Asia and the Pacific: Present Status and Multiple Practices;Srilanka country Report, Paper Presented for Second Regional Task Force Meeting, Borong, India.

Kothari, M. J. & Singh, N. P. (1998) Mangrove diversity along the North West Coast of India, J. Econ. Tax. Bot. 22 (3) : 571-585.

Isaksen, I.S.A. (1989) The beginnings of a problem in Ozone Depletion; Health and Environmental consequences, Jones R. R. and Wigley, T. Eds (Chichester; John Wiley & Sons 1989) 15-25.

Lovelock, C. E., Clough, B.F & Woo drow, I.E. (1992) Distribution and accumulation of ultraviolet radiation absorbing compounds in leaves of tropical mangroves Planta 188 : 143-154.

Macnaw, W. (1968). A general account of the fauna and flora of

mangrove swamps and forests in the Indo-West Pacific region. Adv. Mar. Bio. 6 : 73-270.

Mathauda, G.S. (1957) The Mangroves of India, Proc. Mangr. Symp. Culcutta:31.

Mcmillan, C. (1971) Environmental factors affecting seedling establishment of the black mangrove on the central Taxa Coast. Ecology 52 : 927-930.

Mall, L. P., Billore, S. K. & Amritphale, D. (1982) Certain Ecological Observations on mangroves of Andaman Islands Trop. Ecol. 23 : 225-233.

Millennium Ecosystem Assessment (MCA) (2005) Ecosystem and Human Well being; Synthesis, Islands Press, Washington.

Milliman, J. D., Broadus, J. M. & Gable, F. (1989) Environmental and economic implications of rising sea level and subsidizing deltas; The Nile and Bengal examples Ambio 18 : 340-345.

Misra, D. R. & Singh, Lal Ji (2000a) The Morphology and Anatomy of aerial and terrestrial roots of Justicia gendarussa. Recent Trends In. Bot. Res. Prof. D. D. Nautiyal Comm. Vol. (ed. Chauhan, D. K.) University of Allahabad : 189-202.

Misra, D. R. & Singh, Lal Ji (2000b) Anatomical diversity of Sansevieria suffruticosa, Bionature 20 : 23-45.

Misra, Dharam Raj & Singh, Lal Ji (2004a) Morphology Anatomy of aerial and terrestrial roots of Petrea volubilis, Geophytology 32 (1 & 2) : 107-113.

Misra, Dharam Raj & Singh, Lal Ji (2004b) On the Morphology and anatomy of aerial and terrestrial roots of Pseuderanthemum reticulatum and Sanchezia nobilis Vitas in Palaeobotany and Plant morphology; Evolutionary and Environmental Perspectives Prof. DD Pant Memorial Volume (ed. Srivastava, P.C.) U. P. Offset, Lucknow, India 395-407.

Mongia, A. D., Dagar, J. C. & Bandyopadhya, A. k. (1992) Potential of degraded mangrove areas of Andaman and Nicobar Islands for Agriculture and other altermative uses, Agrochimica 36 (4-5) : 312-323.

Moore, R. T., Miller, P. C., Albright, D. & Tiezen, L. L. (1972) Comparative gas exchange characteristics of the mangrove species during the winter. Photogynthetica 6 : 387-394.

Moore, R. T., Miller, P. C., Ehleringer, J. & Lawrence, W. (1973) Seasonal trends in gas exchange characteristics of three mangrove species. Photosynthetica 7 : 387-394.

Naskar, K. R. & Mandal, R. N. (1999) Ecology and Biodiversity of Indian Mangroves Milton Book company, Dehra Dun, India, 1 : 3 - 348.

Odum, E. P. (1971) Fundamentals of Ecology, Philadelphia W. B. Saunders.

Odum, W. E. & Heald (1972) Trophic Analysis of an estarine mangrove community Bull. Mar. Sci. 22 : 671 - 738.

Prain, D.(1903) Flora of the Sunderbans. Rec. Bot. Surv. India 2: 231-370.

Pornetta, J. C. and Eder, D. L. (1992) Climate, sea level rise and the coastal zone L: Management and Planning for global changes Ocean and Coastal Management 18 : 113-160.

Rajagopalan, M. S. (1987) Mangrove as component of coastal ecosystems of the Andamans. In Proc. Sym. Manag. Coastal Ecosystems and Oceanic Resources of Andamans Sci. Assoc. Port Blair 1-7.

Ricklefs, R. E. Schwarzbach, A & Renner, S. S. (2006) Rate of lineage origin explains the diversity anomy in the world's mangrove vegetation, American Naturalist 168 : 805-810.

Saenger, P. (2002) Mangrove Ecology Silviculture and Conservation. Kluwer Academic Publishers Dordrecht.

Saenger, P., Hegerl, E. J. & Davie, J. D. S. (1983) Global Status of Mangrove Ecosytems, commission Ecology Papers 3 : Gland, Switzerland, IUCN 88.

Sahni,K. C. (1957) Mangrove Forests in the Andaman & Nicobar In Mangrove Symposium 16-19 Oct.1957 Culcutta, India.

Scholander, P. F., Van Dam, L. & Scholander, S. I. (1955) Gas Exchange in the roots of Mangroves. Am. J. Bot. 42 : 92-98.

Sindhu, S. S.(1963) Studies on Mangroves. Proc. Indian Acad Sci. 33(8): 129-136.

Singh, Lal Ji (2002) Studies in Plant Morphology; Aerial and Terrestrial Roots in some vascular Plants. D. Phil Thesis University of Allahabad.

Singh, N.T. & Mongia, A. D. (1985) Soils of the Andaman & Nicobar Islands J. Andaman Sci. Assoc. 1(1) : 28-34.

Singh, V. P., Garge, Pathak, S. M . & Mall, L. P. (1987) Pattern and Process in Mangrove forests of the Andaman Islands. Vegetation 21 : 185-188.

Spalding, M. D., Blasco, F. & Field, C. D. (1997) World Mangrove Atlas, The Internal Society for Mangrove Ecosystem, Okinawa Japan.

Teas, H. J. (1979) Silviculture with Saline Water. Biosaline Concept 1974 : 117-161.

Teas, H. J. (1983) Biology and Ecology of Mangroves, W. Junk Publishers, Hague.

The Nature Conservancy (TNC) 2010a "World Atlas of Mangroves". Highlights the Importance of and Threats to Mangroves. Mangroves among World Most Valuable Ecosystems Arlington, Virginia.

Tomlinson, P. B. (1986) The Botany of Mangroves Cambridge University Press, Cambridge.

Valiela, I, Bowen, J. L. & York, J. K. 2001. Mangrove forests : One of the world's threatened major tropical environments, Bioscience 51 : 807-815.

Waheedkhan, M. A. (1959) Ecological Studies of the Mangrove Forests In India. In Proc. Mangs. Symp. Faridabad. 97-113.

Waisel,Y (1972) Biology of Halophytes, Academic Press, New York.

Walsh, G. E. (1974) Mangroves : A review; In Reimhold, R. J. and Queen, W. H. (eds) Ecology of Halophytes, Academic Press, New York 51-174.

Woodroffe, C. D. & Grindrod, J. (1991) Mangrove Biogeography; The Role of Quaternary Environmental and Sea Level change J. of Biogeography 18(5) 479-492.