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On the Ecology of the Mangroves with Special Reference to Those in Sunderbans in the Territory of India and Bangladesh

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Abstract Mangroves are communities formed by a relatively limited number of spp. of trees and shrubs representing various related and unrelated taxa. These are distributed in the estuarian intertidal zones with partial fresh water supply specially in the tropics of the new world and also in the vicinity of the Indian Ocean and west Pacific. The mangroves undergo morphological modification to adopt in a unique environment with saline influence and impart a dense forest structure.

The basic points of discussions in this paper would be: (1) mangrove environment vis a vis mangrove in the world; (2) structural modification of parts of mangrove plants; and (3) influence of certain physical factors on the distribution pattern of the mangrove in Sunderbans the largest complex in the world, in the Bengal basin with a reflection of the Quaternary history of vegetation in the basin.

Mangroves, also known as Mangles, are very specialized communities represented by plants of diverse origin but adapted to a unique ecological condition with saline influence; and grow in the interphase of land and the sea, and neither typical marine, nor typical terrestrial. Mangroves have high productivity and are of tremendous importance to the coastal inhabitants of Asia and Oceania. Water system in a mangrove ecosystem is potential fishing grounds. Spent up energies of wave accumulated in the leaf detritus is the major energy input in fisheries. In addition, mangroves protect the coastline by reducing current, and by acting as buffer to oceanic storms. Due to increasing population pressure most of the mangrove belts of Asia, in particular, have been over exploited. Recently it has been felt by the scientists and administrators that more knowledge about the mangroves has to be acquired for their better management. This management has relevance to the restoration of the original landscape in mangrove growing area and optimise sustainable productivity of the ecosystem. The present paper will discuss about some fundamental aspects of the mangrove forests with reference to those growing in Sunderbans in Bengal basin on the Bay of Bengal.

Environmental peculiarities

Mangrove environment of different geographical origin has some basic features in common. Average winter temperature would usually exceed 20 °C and seasonal temperature range would not exceed 5 °C, with some exceptions (Walsh, 1974). Estuaries with soft mud dominated by fine clay perticles are most suitable for the mangroves. Mangrove environment is basically saline but the forest receives influences of both fresh water and saline water which circulate in opposite direction during tide actions. Tidal range (difference between low tide and high tide) in mangrove growing belts are considerably high and this difference in tide level causes more aeration of soil, mineral discharge in the forest floor, and helps to wash down the litters for degradation in water which in turn is recharged in the forest floor. Wave action also cause salinity distribution and influence the mangrove zonation. Finally, geomorphology of the deltaic landmass is usually uneven, and so the landmass receives differential tidal influence and so the salinity distribution pattern is different in forest floor of close proximity. Such differences cause diversification and heterogenity in distribution of forest types.

Adaptation

There are about 80 spp. of mangrove plants of different taxonomic status and those respond to their specialized environment uniquely, and show some morphological (external and internal) and physiological adaptations. The principle of such adoption is related to 1. anchorage of the plants in soft and loose substrate; 2. root resperation in anaerobic soil; 3. dispersal of seeds and establishment of seedlings in the forest; and 4. control of water loss from the leaf surface. Modifications

Fig. 1. Stilt roots of *Rhizophora conjugata*.

Fig. 2. Pneumatophores of *Sonneratia apetala*.

are reflected in the root structure. Root system is relatively shallow with more horizontal spreading and help in anchorage and more absorption from the subsurface soil rich in minerals; anchorage is also provided by prop roots, still roots (Fig. 1) (*e.g., Rhizophora*), or knee roots (*e.g., Bruguiera*)

Fig. 3. Showing germination of seeds and growth of radical still attached in trees of *Bruguiera gymnorhiza*.

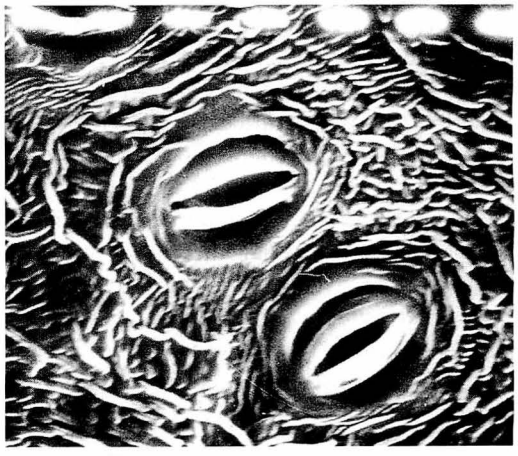

Fig. 4. Showing stomata in stomatal cavities and epidermal deposts in leaf of *Aegialitis rotundifolia*

Horizontal roots occasionally become negatively geotrophic, and stand erect on the soil and breath in air. Erect roots (Fig. 2) are called pneumatophores. Modifications are there in seed germination mechanism. Seeds of most of the mangrove taxa germinate while still attached to the tree. Germinated radical emerges to a considerable length (Fig.3) before the seeds are shed and help attachment of seedlings in the soft substratum. The radical is fleshy with aerenchyma and this structure makes the seed float and disperse. There are modifications in leaves too. Leaves of mangroves are typically thick and leathery, and features of such leaves were studied by Straee (1966). Also, the leaf surface contains enormous quantity of wax (Bagchi, *et al.*, 1988). In a recent

study of leaf surface of some mangrove leaves with SEM indicated that stomatal aperture occurred in cavities over arched by ledge, and thick depositions are prominent (Fig. 4). Such leaves are meant for minimising water loss during transperation as mangrove soil is physiologically dry. The mangrove plants often contain salt glands which either accumulate salts, or secrete excess salt absorbed from the saline environment.

Distribution

Present: Physical factors of the mangrove ecosystem are not uniform throughout the world, and so the distibution pattern and the structure of the forest vary from place to place. World distribution of some important mangroves have been shown in nutshell in Fig. 5. From a critical analysis of this figure it is apparent that (1) *Avicennia* and *Rhizophora* occur round the globe, though different species under these two genera grow in forests of different longitude; (2) the frequency of genera or species are high in Indo Pacific region in comparison to those in the new world; (3) in Indo Pacific region, specifically the forests occurring in longitude between 75°E 150°E incorporate largest number of mangrove species; and (4) some species occur in a very limited geographical region. *Pelliciera rhizophora* for example, is restricted in 95°W 90°W or *Pemphis acedula* occur between 45°E 60°E in Madaguscar and Red Sea, or *Heritiera fomes* grow exclusively in Sunderbans (88°E 90°E) on the Bay of Bengal in association with *Amoora cuculata*. Growth or productivity of different trees in the forest may differ depending on the compatibility of the environment. *Heritiera fomes* forms luxurous forest in Sunderbans in low saline condition (10 12ppt NaCl) (Motilal, *et al.*, 1987). *Kandelia candel* has a wide range of distribution, but growth pattern of this plant is not uniform everywhere. In Sunderbans and allied region (± 90°E) tree height of *K. candel* hardly exceed 1 m, but the same species in forests occurring in longitude between 120°E 135°E e.g. in Japan, becomes a few meters tall.

Past: Mangroaves are known to have a long geologic history. McCoy and Heck (1976) traced the distribution of mangroves in Cretaceous. *Rhizophora* pollen grains were recovered from post Eocene oil bearing strata of Assam (Chakraverty, *et al.*, 1972). History of vegetation of Bengal basin indicated that about 5000 years ago the present day Calcutta was a dense forest dominated by *Heritiera fomes* (Mukherjee, 1972). Since Pleistocene, fresh water distibution pattern of Bengal basin was being shifted towards east due to tendency of eastward tilt of the basin (Morgan and Malntine, 1959); and so in the present day forests of Sunderbans, geographically allied to Calcutta, India, *Heritiera fomes* grow very sportadically with poor growth (Mukherjee and Mukherjee, 1978). We, however, know very little about the geologic history of the mangroves in general.

Succession: Response of different mangrove plants to their physical environment are not identical. Distribution pattern of physical components in a mangrove forest may also vary. Sea level, substrate composition, wave action, etc. may be considered as important environmental factors in this regard (Thom, 1967). In addition, salinity also have a major role in controlling the distribution of mangroves (Mukherjee and Mukherjee 1978; Motila and Mukherjee, 1989; and Karim 1989). Changes in distribution pattern of forest types is directional and follows the environmental gradient, resulting in vegetational zonation. Orientations of different forest zones occur from the proximity of saline water source to the fresh water condition with transitions. But, not necessarily all mangrove forests would follow a uniform type of zonation and succession. For example, the mangroves in Sunderbans are not apparently in zones. But, rather those are in a more mosaic condition when the entire forest is considered. From critical analysis of the salinity distribution pattern in the forests of Sunderbans, now in Bangladesh, it was worked out that there are three categories of salinity zones (low saline, moderately saline, and high saline) and those zones are delimited in certain geographical regions related to the availability of fresh water or brackish water supply (Karim, 1988). Dominance pattern of different forest elements occurring in these zones are different but there are transitory elements in between. Therefore, there is succession of mangrove vegetation in each salinity zone. Each such salinity zone may be treated as a subsystem. The dominant forest type in the low saline zone is *Heritiera fomes*, and that in the high saline zone is *Ceriops decandra*.

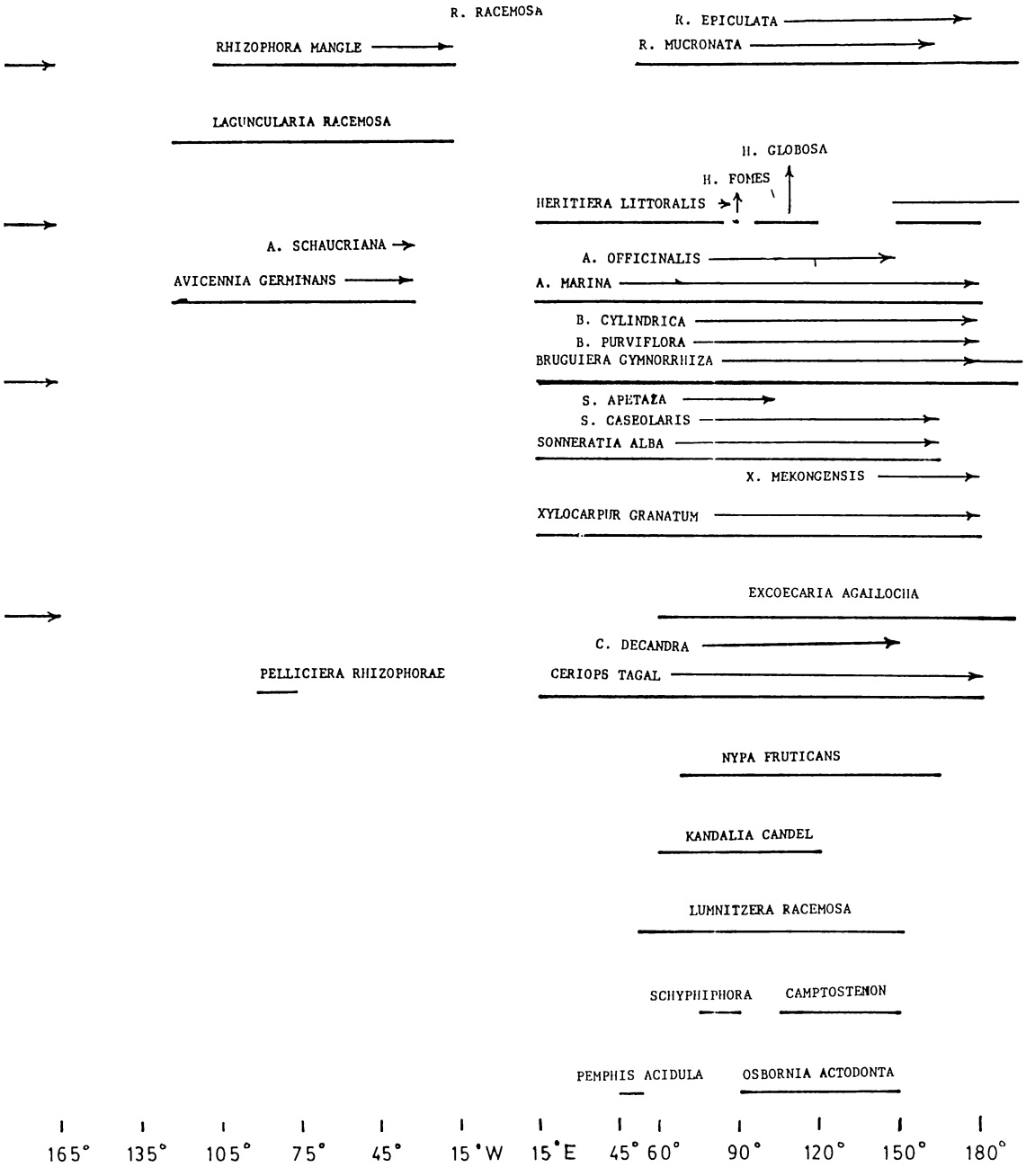

Fig. 5. Showing world distribution of mangroves. '——' indicate the range of longitudinal distribution of genera; and'→' of species.

Execocaria agallocha is dominant in moderate salinity zone. Therefore, there are three separate climax forest types in three subsystems. Lugo (1980) noted that it was difficult to identify subsystems in areas with high species frequency. Sunderban mangroves have a high species frequency and at the same time there were subsystems and it was because only a few species in the forest have dominant status and took part in climax forest formation in subsystems.

Reports of investigations of mangroves of different parts of the world indicated that distribution of plant communities were related to topography, soil, salinity, etc. in a forest. Therefore, it is necessary to gather informations of different environmental factors and the mangrove communities in virgin forests. Such information will be helpful in selecting plant communities suitable for a place for regenration of the ecotonal communities in reclaimed mangrove areas.

References

Bagchi, S., S. Motilal, A. Shaw and B.B. Munkherjee. 1988. Lipids and waxes in leaves of some mangrove plants of Sunderbans, India. Ind. J. Mar. Sci. 17: 150-152.

Chakravorty, A., B.B. Mukherjee, and S. Chanda. 1972. On stratigraphic classification of post Eocene sediments of Garo Hills, Assam J. Palyn. 3: 132-143.

Karim, A. 1988. Environmental factors and the distibution of mangroves in Sunderbans with special reference to *Heritiera fomes*. Ph.D. Thesis, University of Calcutta.

Lugo, A.E. 1980. Mangrove Ecosystem: Succession or steady state. Biotropica 12 (Supplement): 65-72.

McCoy, E.E. and K.L. Heck, Jr. 1976. Biogeography of corals, sea grass, and mangroves. An alternative to the centre of origin concept. Syst. Zool. 25: 201-210.

Morgan, J.P. and W.G. McIntire. 1959. Quaternary geology of the Bengal basin, E. Pakistan and India. Bull. Geol. Soc.America. 70: 319-342.

Motilal, S., B.B. Mukherjee, N. Chatterjee, and M.D. Gupta. 1986. Studies on soil and vegetation of mangrove forests of Sunderbans. Ind. J. Mar. Sci. 15: 181-184.

Motilal, S. and B.B. Mukherjee. 1989. Distribution of mangroves in relation to topography and selection of ecotonal communities for reclaimed areas of Sunderbans. Ind. J. Mar. Sci. 18: 91-94.

Motilal, S. 1990. Studies on mangroves of Sunderbans with special reference to disribution of plants and soil. Ph.D. Thesis, University of Calcutta.

Mukherjee, B.B. 1972. Pollen analysis of a few Quaternary deposits of lower Bengal basin. *In* Ghosh, A.K. (ed.), Proc. Sem. Palaeopalynol. and Ind. stratigraphy, pp.357-374. University of Calcutta.

Mukherjee, B.B. and J. Mukherjee. 1978. Mangroves of Sunderbans, India. Phytomorphology 28 (2): 177-192.

Strace, C.A. 1966. The use of epidermal characters in phylogenetic consideration. New Phytol. 65: 304-318.

Thom, B.G. 1967. Mangrove ecology and deltaic geomorphology, Tabasco, Maxico. J. Ecol. *55*: 301-343.

Walsh, G.E. 1974. Mangroves a review. *In* Reimold, R. J. and W.H. Queen (eds.), Ecology of Halophytes, pp.151-174. Academic Press, New York.