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Diversity and Morphological distinctiveness of *Avicennia Marina* in the Sundarbans in India

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Abstract:

Many factors contribute to the morphological variations in the members of a species of the plants grown in different areas and ecosystems. In such a way, *Avicennia* is woody trees or shrubs which grow near the coastal areas. Scientists Moldenke 1975 & Tomlinson 1986 recorded the considerable morphological differences in the leaves and flowers of Mangroves. The objective of the present work is to find out the complete morphological variations among the members of *Avicennia* grown in inland and marine systems.

Keywords: Mangroves, Morphological niches, Diversity, Distribution

Introduction:

Mangroves were quite old and it might have possibly risen after the first angiosperms, around 114 million years ago [3]. *Avicennia* and *Rhizophora* were probably the first genera to evolve and it appeared near the end of the Cretaceous period [4]. Pollen records provide vital information about the subsequent radiation. Fossil pollen from sediments in Liuzhou Peninsula &China suggests that mangroves expanded from south to north. After reaching their northern limit on the Changjiang Delta by mid-Holocene, a similar study about pollen from the late Holocene samples in Bermuda suggests that mangroves were established before 3000 years and the sea level rise decreased from 26 to 7 cm per century [5].

Mangrove distributions within their ranges were strongly affected by temperature [6] and moisture [7]. Large-scale currents may also influence distributions by preventing propagates from reaching some areas [8]. Individual mangrove species differ in length along with their establishment in success, growth rate and their tolerance limits.

Indian Species Composition:

A total of 70 varieties of true mangroves are recorded across the globe while India represents a total of 125 species including 39 species of true mangroves and 86 species of acquaintances. The highest species diversity is recorded from Odisha with a total of 101 species while Gujarat shorelines 40 species. Three types of mangrove arrangement can be seen such as deltaic, backwater-estuarine and insular. The deltaic mangroves occur mainly along the east coast, the backwater-estuarine type along the west coast and the insular type in the Andaman and Nicobar Islands.

Indian Mangrove Cover: Total area under mangrove cover is 4921 kilometer square, which contributes 3.3% to the global mangrove cover.

Sundarbans: The Sundarbans in the Gangas-Brahmputra delta extend from the Hooghly river in West Bengal to the Baleswar river in Bangladesh. This area comprises closed and open mangrove forests, agriculturally used land, mudflats and barren land. It is the largest mangrove region and the largest single block of tidal halophytic mangrove forest in the world. This region is part of the Great Sundarbans and covers a National Park, Tiger reserve and a Biosphere Reserve. This region is also UNESCO world heritage site and Ramsar wetland site. India's mangrove forests are habitat for salt water crocodiles (Crocodylus porosus), turtles, and snakes.

Bhitarkanika: India's second largest mangrove forest, located in the state of Odisha. Bhitarkanika is created by the two river deltas of Brahmani and Baitarani river and one of the important Ramsar Wetland in India. It is also the home of saltwater crocodiles and nesting olive ridley sea turtles.

Godavari-Krishna: Mangroves ecoregion is under protection for Calimere Wildlife and Pulicat lake Bird Sanctuary.

Pichavaram: It is situated at Pichavaram near Chidambaram in the state of Tamil Nadu.

Mumbai: Mumbai's single largest mangrove belt is the western bank of Thane creek.

Baratang Island: It is located within the Andman and Nicobar islands.

Causes of Depletion:

Over harvesting of the forest for various purpose, creation of big dams and extensive irrigation are continue reducing the amount of water reaching to the mangrove which will result in increasing salinity and the mangroves can't survive. Overfishing in the mangrove areas, coral reefs provide the first barrier current and strong waves. But if they are destroyed, the strong and destructive waves directly reach to mangroves and wash away the essential nutrients. Fertilizers, pesticides, and other toxic man-made chemicals carried by river systems from sources upstream can kill animals living in mangrove forests. Mangrove forests require stable sea levels for long-term survival. They are therefore extremely sensitive to current rising sea levels caused by global warming and climate change.

Mangroves are important because of many factors, It is found in one satellite based study of NASA that Mangrove forests move carbon dioxide "from the atmosphere into long-term storage" in greater quantities than other forests, making them "among the planet's best carbon scrubbers". Other Importance of Mangroves are, as they protect shorelines from damaging storm and hurricane winds, waves, and floods. Mangroves also help prevent erosion by stabilizing sediments with their tangled root systems. They maintain water quality and clarity, filtering pollutants and trapping sediments originating from land. Mangroves serve as valuable nursery areas for fish and invertebrates. In addition to commercially important species, mangroves also support a number of threatened and endangered species. Mangroves are utilized in many parts of the world as a renewable resource and also used in building houses, boats, pilings, and furniture.

Though mangroves were evolved in the tropics, one species, *Avicennia marina*, is found in temperate latitudes and it is particularly found in the southern hemisphere [10]. This genus is of a western Gondwanan origin with the subsequent radiation of several taxa facilitated by tectonic dispersal of continental fragments in southern region [11].Fossils of Mangroves had provided valuable information about the pre historical evolution of mangrove and its dispersal.

Chronological changes in mangrove distributions can reveal the detail about paleo climates and sea-level changes [12]. For example, in the equatorial Pacific Ocean, there are alternating reef and mangrove fossils in upper Miocene and lower Pliocene deposits [13].Similarly, Holocene sediments from the Maya Wetland of Belize indicate that mangrove peat had filled the lagoon before 4800 [14]. These patterns may reflect the fluctuating sea levels or large-scale climatic shifts. In Poverty Bay, New Zealand, the presence of *Avicennia marina* suggests that the area had a frost-free climate [15]. The mangrove fossil record is clearly an area where a continued research has the potential for providing significant information about the history of these unique plants.

Materials and Methods:

A survey has been conducted recently to study the mangrove vegetation in India in the sundarbans with great diversity. We studied the morphology and anatomy of few mangroves species in relation to their adaptation to saline habitat. Leaves, stems, roots from different families of mangrove, materials were collected from those areas during 2017 and they were placed in a polythene bag containing water. Thin sections and cross sections were cut by using a sharp razor blade. The sections were immersed in water to avoid the formation of air bubbles. Sections were stained with Safranine. Excess of stain was washed with water. Then, the sections were stained with fast green solution and the excess of stain was washed with water. Thereafter, sections were mounted in Glycerol and covered with cover slip and observed under microscope.

Results and Discussion:

There were a significant amount of inter- and intra specific variability among mangroves. For example, physiological differences had been identified between West African and Western Atlantic species of *Avicennia germinans* [16] and distinct chemotypes have been described for *A. germinans* and *Rhizophora* [17]. Variability may result from genotypic differences or phenotypic responses to local environments. Mean leaf area of *Rhizophora mangle* in Mexico is positively correlated with annual precipitation and negatively correlated with latitude. This morphological response to local conditions may allow the trees to maximize their photosynthetic efficiency [18].Similarly in southeast Florida, leaf area indices can be used to differentiate *Rhizophora mangle* from basin and dwarf forest types. In contrast, variation in *Rhizophora mangle* flower morphology appears to have a genetic basis.

Changes in gene frequency, such as those species produced by inbreeding, can lead to genetic differentiation. If inbreeding is prevalent, a mangrove forest may be a virtually mono specific stand with little genetic diversity. Pollination by bees produces geitonogamous selfing in *Kandelia candel*. However, a little genetic differentiation is seen among 13 populations along

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the coastlines of Hong Kong, indicate the fact that the dispersion of propagates is sufficient to maintain high levels of gene flow in this species [19]. In contrast, the concept of genetic differentiation, has led to sub speciation in *Avicennia marina* [20]. It has been assumed that the propagates of *Avicennia* commonly move long distances. However, all studies suggest that *Avicennia* species in the Indo-West Pacific and eastern North America have limited gene flow. This may indicate that the true dispersal distances are much shorter than it has been commonly believed [21].

Root Anatomy:

Mangroves were highly adapted to the coastal environment, with exposed breathing roots, extensive support roots and buttresses. Salt-excreting leaves and viviparous water dispersed propagules. These adaptations vary among taxa and with respect to their physico-chemical nature of the habitat [20]. Perhaps the most remarkable adaptations of the mangroves were seen at the stilt roots of *Rhizophora*, the pneumatophores of *Avicennia*,*Sonneratia* and *Lumnitzera*, the root knees of *Bruguiera*, C*eriops* and *Xylocarpus* and the buttress roots of *Xylocarpus* and *Heritiera.* The roots of many mangroves do not penetrate far into the anaerobic substrata. Instead, the trees produce profuse lateral roots for their support.Their effectiveness is well illustrated by the tallest mangrove trees, found in Ecuador, which attain heights of more than 60 m and may be 100 years old [23].

Picture 1: Normal Short Roots

Picture 2: Long Adapted Roots

The specialized roots of mangroves were important sites of gas exchange for living in anaerobic substrata. The exposed surfaces may have numerous lenticels [3]. *Avicennia* possesses lenticel-equipped pneumatophores (upward directed roots) through which passive diffusion of oxygen is feasible [5]. The lenticels may be closed or partially opened or fully opened on the basis of environmental conditions [6]. The spongy pneumatophores are generally short (< 30 cm), but they grow much larger and become more numerous in *Avicennia marina* in anaerobic and oil-polluted conditions. These phenotypic responses were increased in surface area for gas exchange [7].

Wood Anatomy:

Mangrove wood has certain special features that enable the trees to overcome the high osmotic potential of seawater and the transpiration caused due to the effect of high temperatures. There are numerous narrow vessels running through the wood. These range in density from 32 mm^{-2} in *Excoecaria* to 270 mm^{-2} in *Aegiceras* [8]. The vessels helpcreate high tensions in the xylem due to a slight decrease in vessel diameter to produce a disproportionally large increase in flow resistance [9-11]. The vessel elements to form these vessels normally have simple perforation of plates [4]. However, mangroves in the family Rhizophoraceae (except *Kandelia candel*) have scalar form perforation plates.

Seed and Seedling Anatomy:

Avicennia marina forms endosperm haustoria during early embryonic histo differentiation. Once the growth phase is initiated, subsequent embryonic development is extra-ovular. The mature seed, therefore, is enclosed by a pericarp that originates entirely from the ovary wall. From the end of histo differentiation until the mature seeds are abscised, cotyledon cells become highly vacuolated and contain large amounts of soluble sugars, which constitute the major nutrient reserves of the mature seed [23].

Table 2: Leaf Characteristics of Avicenniaceae

Avicennia marina	Leaves are leathery, Medium size leaves. Opposite. Ovate shape, Lamina. Elliptic oblong. Somewhat rounded apex. Upper surface is glabrous. Midrib is prominent. Small petiole with estipulate

Picture 1 Healthy leaves

Picture 2

Leaf thickness differs from species to species within the members of Avicenniaceae and the range is 327.83 µm to 666.60 µm. Mostly stomata are preset on lower surface, but in case of Sonneratiaceae, stomata were seen on both surfaces of the lamina. The average number of stomata per given area and the average leaf area was differs from species to species.

Conclusion:

Nature has provided us many useful resources which is essential for human survival and we as a generation has responsibility to use them wisely and protect them from all kind of adversities. Mangrove forest is one of them and very important for maintaining coastal ecology. Mangrove ecosystems are receiving an increasing attention in the recent times but still we lack a much more amount of basic information about their structure and function. There are still gaps in fundamental aspects in our knowledge of the reproductive biology among mangroves and the evolution of mangrove is poorly understood. We are still far from understanding the energy flow and the dynamics involved in the food web in mangrove environments and their connection with other ecosystems. There is a great need to understand the effects of environmental change and pollution on the flora and fauna of mangrove. Still, studies are required to understand the animals that are highly dependent on mangroves, particularly with respect to their larval supply.

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