CHAPTER 2.5

HOLOCENE VEGETATION AND ENVIRONMENT OF MEENACHIL RIVER BASIN:
AN EVALUATION THROUGH FOSSIL WOODS

2.5.1 INTRODUCTION

In order to understand the distribution of any species in space, one must study its distribution in time. This is because distributions are always changing, sometimes as a response to changing climate and sometimes in response to other changing ecological factors, including the activities of man. The history of a species reveals whether it is on the increase or decrease and its range is expanding or contracting. Such information can often lead us to an understanding of what critical factors underlie the limitation of the range of such species.

Many distribution patterns which appear superficially anomalous can be understood by reference to their histories. An example of this is afforded by species with so-called ‘disjunct distributions’ (Pigott and Walters, 1954). Many species, now rare in Britain, occur as isolated populations in unstable habitats, e.g. marshes, screes, sand dunes, cliffs, etc. Frequently one finds several scarce plants concentrated together in these habitat fragments. Occasionally, a study of the past history of such species has revealed that they were once of more widespread occurrence and have become restricted because of changes in the environment. Often such relict species demand open, unshaded habitats, and hence are able to thrive only where tree growth has been prevented by such factors as soil instability.

Now-a-days, palaeo-environmental interpretation using the fossil remains has attained a worldwide attention and the palaeontological studies coupled with geochronology and stratigraphy could bring many dimensions to certain obstinate facets of biogeography and promote not only the theory of evolution, but the concept of plate tectonics also. The present study is envisaged to evaluate the palaeo-environmental conditions prevailed over the Meenachil river basin through the characteristic features of the fossil woods found embedded in the palaeodeposits of sand.
2.5.2 OBJECTIVES

✧ To identify the species-wise distribution of fossil woods by bringing out their anatomical descriptions

✧ To evaluate the palaeo-environmental conditions prevailed during the Holocene time.

2.5.3 REVIEW OF LITERATURE

The Quaternary period dated back to two million years, also known for the Great Ice Age, was characterised by strong climatic variations. The beginning of the period synchronised with the first major glacial stage, and in the subsequent times it witnessed a succession of alternating glacial and interglacial stages (Merh, 1987). The study carried out by Weingarten et al. (1991) and Rull et al. (2005) showed that the changes in sedimentology and the geochemistry of the sediments could be accounted for the past warm and wet climates. Vishnu-Mittre and Sharma (1966) studied the Haigam Lake post-glacial deposit and suggested that there was a period of cool humid climate, which gradually became warm and dry and ultimately changed to a temperate climate with a trace of early cultivation of crops. Merh (1987) pointed out that almost all over the Indian coastline, features related to Holocene transgressive strandline occur at elevations up to 10 m. above from the present level.

Fossil phytolith assemblages from soils and lake sediments have been used to reconstruct palaeovegetation patterns, especially forest/grassland ecotones (Alexandre et al., 1997). The modern phytolith assemblages enable the differentiation of subdesertic steppe from wooded riparian forest, and characterise the composition of the C₃-grass associations. Moreover they record local as well as regional vegetation (Barboni et al., 1999). Palaeoenvironmental interpretation of foraminifera and ostracod associations was based upon comparison of the analysed micro fauna with recent foraminifers and ostracod described in several studies from the Mediterranean area: Colalongo (1969), Von daniels (1970), Bonaduce et al. (1975), Albani et al. (1990 & 1991) and Belloti et al. (1994). Lucchi et al. (2006) carried out integrated sedimentological and micropalaeontological investigations of two sediment cores from the subsurface of Lesina lagoon area and the study showed a vertical cyclic pattern of facies including continental, paralic and shallow marine deposits. This indicates the mid-Holocene high stand sedimentation and coastal progradation occurred in this region.

Deevey (1939) described that changing combination of temperature and moisture conditions could explain the major changes in vegetation and this interpretation is according to the independent information on water-level changes. Time series of palaeontological data provide a record of regional
and local vegetation development, which means for biostratigraphic correlation and dating and information on changes in water level (Newby et al., 2000). Caratini et al. (1991) analysed a marine core off Karwar, near the estuary of the Kalindi river, have brought out a distinct major vegetational change in the Western Ghats of the Uttara Kannada District from forest to Savanna during 3,500 YBP which pinpoints the commencement of anthropogenic activity in the region. The work done by Hait et al. (1996) on the late Quaternary sediments and their biotic contents proved that climate fluctuation occurred in a short period during a prolonged climatic phase. This was revealed as per the presence of mangrove vegetation noticed by the carbon dating. Chauhan (1996) revealed that the tree savannahs existed in Bastua and Jagmotha region during 6720 to 5000YBP and 6500 to 4250YBP respectively, under cold and dry climate with an ameliorating trend and the formation of Sal dominated tropical deciduous forests commenced simultaneously in Bastua and Amgon regions between 1050 to 1,200YBP as a consequence of a moist climate in the regions.

Rajagopalan et al. (1997) studied the late Quaternary vegetational and climatic changes in southern India. According to them there was a progressively negative trend up to 40,000YBP, indicative of a decrease in the proportion of C₄ plants (tropical grasses and sedges) with increasing moisture conditions. Quaternary climatic changes in the desert regions of Gujarat and Rajasthan, studied by Allchin et al. (1978) and proposed a dry phase prior to 40,000YBP. Similar results were obtained from tropical Africa where high lake levels have been observed prior to 25,000YBP (Butzer et al., 1972).

The study of the fossil remains can give not only the species distribution, but the influence of the past environmental conditions on that particular species also, which ultimately resulted in its bloom or extinction. The study of a fragmentary sample coming from a silicified trunk remain of Lunca formation of Eastern Carpathians led to the identification of a wood structure typical to the Cycadaceae family by Iamandei et al. (2003) and a presence of tropical conditions there. Petrified wood (wood turned to stone) falls into two categories: casts and permineralizations (Smith and Gannon, 1973). The first step in formation of both of these types of fossils involves quick burial in sediment so that fungal and bacterial decay is retarded due to low oxygen levels. A cast is formed as minerals or other sediments fill and harden within the sedimentary cavity formed as the original wood deteriorates. Casts show the external form of the fossil but do not preserve internal cell structure, and consequently cannot be identified to genus or species. Permineralized woods are formed when minerals dissolved in ground waters infiltrate the wood, filling the spaces within and between cells, gradually embedding and preserving the entire tissue. Permineralized woods retain the original cellular structure and therefore can be identified by anatomical study.
Many palaeobotanical studies have dealt with leaf impressions (Lumbert et al., 1984; Ivany et al., 1990), but studies related to fossil woods are few. Fossil woods sometimes retain exquisite details of the original cell structure that can be investigated with the aid of a microscope. Hence the preservation of the tissues has prime importance (Hoffmann and Blanchette, 1997). Such fossils may be identified by comparing their anatomy with that of modern woods or other fossil woods. This method of identification is similar to that used in the identification of timber woods in the forest products industry. Anatomical features such as presence of vessels, vessel size and grouping, distribution of parenchyma, ray size and distribution, are used in wood keys aiding in the determination to family, genus, and in some cases, species. Identification of fossil woods is accomplished through comparison with modern woods and with other known fossil woods. There is enough literature on the anatomy of timbers including keys for quick identification and descriptions and illustrations for thorough comparison (Gregory, 1980; Panshin and de Zeeuw, 1980; Hoadley, 1990; Stewart and Rothwell, 1993). Computerized keys are also available to help in determining modern and fossil woods (Wheeler et al., 1986).

El-Din (2003), by giving detailed wood anatomical descriptions, identified two fossil wood species *Celastrinoxylon celastroides* and *Ficoxylon cretaceum*, which were reported and described for the first time from the Farafra Oasis in Egypt. Anatomical descriptions were used to identify many fossil woods in India also. *Sterculioxylon pondicherriense* was recorded from the Cuddalore Series of the Lower Miocene of eastern peninsular India (Awasthi, 1981), while *Sterculioxylon kalagarhense* was recorded from the Miocene of Uttar Pradesh (Trivedi and Ahuja, 1978). *Sterculioxylon varmahii* was recorded from the Miocene of Assam (Prakash and Tripathi, 1974). Similarly, *Heritieroxylon keralensis* was described from the Middle Miocene of Kerala (Srivastava and Awasthi, 1993) and *Heritieroxylon arunachalensis* was described from the Miocene of Arunachal Pradesh (Lakhanpal et al., 1978). *Sterculioxylon dattai* was recorded from the Tertiary of Assam (Prakash and Tripathi, 1974). Prakash and Dayal (1964) and Srivastava and Guleria (2000) could identify *Grewioxylon indicum* and *Grewioxylon mahurzariense* in the Inter-trappean Beds of the Eocene (?) and Lakhanpal et al. (1976) could describe the anatomical characters of *Sterculioxylon deccanensis* from the Inter-trappean Formation (Palaeocene?) of the Deccan of India.

A. Relevance of the Present Study

Well preserved and submerged wood samples were observed from the palaeodeposits of sand at many regions lying within the lower reaches of the Meenachil River Basin. The Mosco and Ponpally regions of Meenadom Ar sub-watershed of the Meenachil River are presently located at distance of about 15km inland of Vembanad Lake and are remarkably characterised by the presence of carbonized wood.
fragments at certain depth. No carbonized wood has been reported so far from the Meenachil River basin and the present study deals with the identification and significance of these woods.

2.5.4 METHODOLOGY

A. Location

The study area is located in the flood plain regions lying in between Meenachil River and Meenadom Ar (Mosco) and south of Meenadom Ar (Ponpally). The sampling locations are given in Fig. 2.5.1.

Fig. 2.5.1 Sampling sites for carbonized woods
Altogether 9 samples were collected from 4 locations. The samples were packed and marked (Table 2.5.1 and Plate 2.5.1) and sent to Birbal Sahni Institute of Palaeobotany, Lucknow for the analysis.

Table 2.5.1 Details of the sampling locations and the characteristics of the wood samples collected

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>LOCATION NUMBER</th>
<th>NAME OF THE SITE</th>
<th>DESCRIPTION OF THE WOOD SAMPLES</th>
<th>GEOGRAPHICAL POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1</td>
<td>Mosco – I</td>
<td>MIA 90 5.5</td>
<td>09° 36’ 33.7” N 76° 33’ 33.7” E</td>
</tr>
<tr>
<td>2.</td>
<td>1</td>
<td>Mosco – I</td>
<td>MIB 70 5.5</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>2</td>
<td>Mosco – II</td>
<td>MIIA 60 4.3</td>
<td>09° 36’ 33.6” N 76° 33’ 41.3” E</td>
</tr>
<tr>
<td>4.</td>
<td>2</td>
<td>Mosco – II</td>
<td>MIIB 50 5.2</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td>MIIC 80 5.0</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>3</td>
<td>Mosco – III</td>
<td>MIIIA 45 4.3</td>
<td>09° 36’ 28.4” N 76° 33’ 37.2” E</td>
</tr>
<tr>
<td>7.</td>
<td>3</td>
<td>Mosco – III</td>
<td>MIIB 60 4.8</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td>MIIC 50 3.5</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>4</td>
<td>Ponpally – II</td>
<td>PIIA 60 4.4</td>
<td>09° 36’ 17.5” N 76° 32’ 55.4” E</td>
</tr>
</tbody>
</table>

The samples were collected by hand picking and subjected to neither chemical treatment nor artificial preservation methods. For identification of the samples, the transverse, tangential and radial longitudinal sections were prepared. The methodology and the equipments involved in preparation of the slides are as follows.

B. Equipments

1. Microtome, sledge type (Model 860, American Optical)
2. Microtome Blades, disposable type (S35 type, Feather Co)
3. Xylenes (Fisher X-5)
4. Haematoxylin Stain Solution (Fisher SO-H-16)
5. Ethyl Alcohol (95% and 100%)
Chapter 1.1

Introduction

6. Petri dishes (5 are needed - stain, ETOH95%(a), ETOH 95%(b), ETOH 100%, Xylenes)
7. Microscope slides, 22x40 cover slips, labels
8. Permount (Fisher SP15B-100)
9. Small brush, forceps

C. Procedure
A. In order to make a block of the wood of having the size approximately 1cm³, a portion from the best part of the wood available has been taken, by avoiding the branches, etc. The section was cut from the disk by getting as right an angle as possible, preferably using the outside of the section.

B. The wood was clamped in the microtome by allowing the wood specimen to protrude only 1/2 cm.

C. Making of the sections.
   Three types of sections were made for understanding the wood anatomy. Cross sections were made by placing the wood block in such a way that the annual rings were horizontal in the clamp. First few sections were thrown out and kept the block moist to reduce curling. Kept the blade moist with ethyl alcohol (ETOH) and water mixture (½ -½). For preparing the radial section, the annual rings were vertical in the clamp. Since it was the hardest section to do, care was taken to ensure that the rays were properly oriented and the blade was kept moist. In the similar way tangential sections were also prepared. Put a bead of water on the tree section and on the blade, cut several sections and dropped them in a dish of water.

D. Removed the sections from the water with tweezers.

E. Run the sections through the washes
   1. Put in 95% ethyl alcohol. (stirred around a bit; left for about 1 minute).
   2. Put in 95% ETOH.
   3. Put in 100% ETOH.
   4. Put in xylene.

F. Preparation of thin sections
   A drop of permount was placed on the slide. The sections were taken from the xylene, touched them with tissue paper without drawing off all the xylene. The sections were properly oriented, placed a drop of permount on top and then the cover slip. The cover slip was put on before the xylene dried to avoid bubbles. Placed the slides with permount and cover slip, on a hotplate (50°C)
and left overnight. Added a small weight on the cover slip to prevent the sections from curling and lifting the cover slip.

G. Scraped off excess permount, cleaned with xylene and labeled the slides.

The wood structures were studied in detail under the microscope. Anatomical description of each sample was prepared.

2.5.5 RESULTS AND DISCUSSIONS

Palaeodeposits obtained from the sampling locations of Mosco region have special significance as they are located almost middle of an area lying between the Meenadom Ar and Meenachil River, through which no river flows at present (Table 2.5.2). The presence of these palaeo deposits in an area which is not associated with the present orientation of these two rivers (they are neither located in the concave side of a meandering loop to be suggested as point bar deposits, nor along the banks to be suggested as a consequent to the channel shifting) clearly suggested that they are part of a palaeochannel connecting both the rivers.

Table 2.5.2 Proximity of the terrestrial sand mining sites to the adjoining stream segments

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 1</td>
<td>Mosco I. Lies at distance of about 350m from the Meenachil river and 300m from the Meenadom Ar (In between both the streams)</td>
</tr>
<tr>
<td>Location 2</td>
<td>Mosco II. Lies at distance of about 500m from the Meenachil river and 250m from the Meenadom Ar (In between both the streams)</td>
</tr>
<tr>
<td>Location 3</td>
<td>Mosco III. Lies at distance of about 500m from the Meenachil river and 200m from the Meenadom Ar (In between both the streams)</td>
</tr>
<tr>
<td>Location 4</td>
<td>Ponpally II. Lies at a distance of 50m from the Meenadom Ar within its meandering loop.</td>
</tr>
</tbody>
</table>

The thin sections of the wood samples exhibited an interesting pattern. The characteristic features of each wood sample such as distribution, size and shape of vessels, parenchyma, rays and fibres were as given in Figures 2.5.2 to 2.5.7.
## Chapter 1.1 Introduction

Studies on river sinuosity of Meenachil River, with special reference to its palaeochannels, using remote sensing

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Photomicrographs</th>
<th>Characteristic features</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIA</td>
<td><img src="image" alt="Photomicrographs" /></td>
<td>✤ Vessels evenly distributed, small to medium sized, tangential diameter 77-220 µm, radial diameter 55-165 µm; solitary and in radial multiples of 2-3; open or partially filled with tyloses. ✤ Parenchyma abundant, paratracheal vasicentric to aliform forming 3-4 seriate sheath round the vessels which extend laterally to form wings rarely confluent forming 3-4 seriate bands at places. ✤ Rays 1-5 (mostly 3-5) seriate); heterocellular; Gum canals radial, often present in multiseriate rays. ✤ Fibres aligned in radial rows, semilibriform, nonseptate.</td>
</tr>
</tbody>
</table>

Fig. 2.5.2 Characteristic features of the sample MIA revealed in thin sections
### Fig. 2.5.3 Characteristic features of the sample MIB and MIIB revealed in thin sections

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Photomicrographs</th>
<th>Characteristic features</th>
</tr>
</thead>
</table>
| MIB and MIIB | ![Photomicrographs](image) | ✦ Vessels small to medium, tangential diameter 38-93 µm, radial diameter 44-100 µm, solitary and in radial multiples of 2-3, open or filled with brown-black deposits and a few tylosed, inter vessel pits alternate, hexagonal, vestured.  
✦ Parenchyma absent.  
✦ Rays fine, uniseriate, heterocellular; ray cells crystalliferous  
✦ Fibres septate, septa rarely seen. |
### Sample No. | Photomicrographs | Characteristic features
---|---|---
PIIA | ![Photomicrographs](image)

- **Vessels** small to large (mostly medium) sized, tangential diameter 110-225 µm, radial diameter 30-190 µm, solitary and in radial multiples of 2-3, heavily tylosed, inter-vessel pits alternate, large, bordered, hexagonal with linear or lenticular aperture.

- **Parenchyma** scanty, paratracheal, few cells associated with some of the vessels.

- **Rays** 1 - 5 (mostly 2 - 3) seriate, heterocellular, uniseriate rare, short, multiseriate 7-25 cells or 165-1100 µm, long, few with radial gum canals.

- **Fibres** frequently septate.

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**Fig. 2.5.4** Characteristic features of the sample PIIA revealed in thin sections

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Studies on river sinuosity of Meenachil River, with special reference to its palaeochannels, using remote sensing
### Sample No. | Photomicrographs | Characteristic features
--- | --- | ---
MIIC | ![Photomicrographs](image1) | ✦ Vessels mostly small sized, tangential diameter 82.5-177 µm, radial diameter 70-177 µm; solitary as well as in radial multiples of 2-3, open or partially filled with tyloses; inter-vessel pits large.

✦ Parenchyma scanty, paratracheal, few cells associated with vessels, rarely 1-2 seriate sheath round some of the vessels.

✦ Rays 1-5 seriate, uniseriate rare, made up of upright cells only, 8-20 cells or 330-660 µm long, multiseriate 10-30 cells or 275-700 µm long, few with radial gum canals.

✦ Fibres aligned in radial rows, polygonal in cross section, semilibriform, nonseptate.

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**Fig. 2.5.5 Characteristic features of the sample MIIC revealed in thin sections**
### Table: Characteristic features of samples MIIC and MIIIA

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Photomicrographs</th>
<th>Characteristic features</th>
</tr>
</thead>
</table>
| MIIC and MIIIA | ![Photomicrographs](image) | ✤ *Growth rings* indistinct.  
 ✤ *Vessels* almost exclusively solitary, arranged in oblique radial lines; 8-10 per sq. mm; small to large sized, tangential diameter 66-286 µm, radial diameter 100-300 µm; occluded with tyloses; lumen filled with red gummy deposits.  
 ✤ *Parenchyma* abundant, apotracheal, forming 3-6 seriate broken tangential bands; parenchyma cells crystalliferous (single large crystal).  
 ✤ *Rays* exclusively uniseriate, heterocellular single large crystal present in ray cells.  
 ✤ *Fibre tracheids* aligned between two consecutive rays, angular, 11-33 µm in diameter; non septate.  
 ✤ *Vasicentric trachieds* present. |

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Fig. 2.5.6 *Characteristic features of the sample MIIC and MIIIA revealed in thin sections*
### Sample No. | Photomicrographs | Characteristic features
--- | --- | ---
MIIA | ![Photomicrographs](image) | ✦ Vessels small to large (mostly medium) sized, tangential diameter 55-330 µm, radial diameter 50-400 µm; solitary and in radial multiples of 2-3, open or filled with tyloses; inter-vessel pits large with lenticular aperture, 11-12 µm in diameter.

✦ Parenchyma abundant, paratracheal, vasicentric to aliform and aliform-confluent forming 2-4 seriate sheath with wings extending laterally joining 2-3 vessels; cells showing storied tendency at places.

✦ Rays 1-4 seriate, heterocellular, uniseriate rare, short, multiseriate 2-4 seriate, made up of procumbent cells with extensions of 1-3 marginal row of upright cells at one or both the ends; rhomboidal crystals in ray cells.

✦ Fibres libriform, nonseptate.

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**Fig. 2.5.7** Characteristic features of the sample MIIA revealed in thin sections
Based on the characterization of the samples, they were identified as in the Table 2.5.3.

Table 2.5.3 Identified fossil woods of the Meenachil River Basin

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>LOCATION NUMBER</th>
<th>NAME OF THE SITE</th>
<th>SAMPLE NAME</th>
<th>IDENTIFICATION</th>
<th>GENUS</th>
<th>FAMILY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Mosco – I</td>
<td>MIA</td>
<td>Artocarpus</td>
<td>Moraceae</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>MIB</td>
<td>Sonneratia</td>
<td>Sonneratiaceae</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>MIIA</td>
<td>Holigarna</td>
<td>Anacardiaceae</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>Mosco - II</td>
<td>MIIB</td>
<td>Dicot wood, preservation is poor hence the generic identification could not be done.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>MIIC</td>
<td>Calophyllum</td>
<td>Clusiaceae (Guttiferae)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>MIIIA</td>
<td>Calophyllum</td>
<td>Clusiaceae (Guttiferae)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>Mosco - III</td>
<td>MIIIB</td>
<td>Sonneratia</td>
<td>Sonneratiaceae</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>MIIC</td>
<td>Spondias</td>
<td>Anacardiaceae</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>Ponpally - II</td>
<td>PIIA</td>
<td>Canarium</td>
<td>Burseraceae</td>
<td></td>
</tr>
</tbody>
</table>

The assemblage consists of six genera. Two specimens (label no. MIB and MIIIB) represent the same genus (Sonneratia). The other two specimens (MIIC and MIIIA) although represent the same genus (Calophyllum) yet belong to two different species. The genera Calophyllum, Spondias and Sonneratia are inhabitant of coastal area and indicate near shore conditions particularly the Sonneratia. Sonneratia, a mangrove occurs in tidal creeks and in littoral forests. Calophyllum inophyllum is found along the coast above high water mark and in the evergreen forests of Western Ghats and on the bank of rivers. The
rest of the elements like *Artocarpus*, *Holigarna* and *Canarium* are found in evergreen forests of Western Ghats including Kerala.

**2.5.6 ECOLOGY OF THE IDENTIFIED PLANTS** (Gamble, 1915; Gamble, 1928)

**A. Sonneratia**

Glabrous sea-coast trees. Generally as small evergreen tree with large pink petalled flowers and large depressed globose fruits. Wood grey, soft and even grained. Leaves opposite, petaled, coriaceous (leathery), entire. Flowers large, terminal, solitary or 2-3 together. Calyx thickly coriaceous, tube widely campanulate (bell shaped), lobes valvate (opening by valves). Petals 4-8 or zero. Stamens (the floral organ bearing the anther and pollen) numerous, inserted on the circular rim of the calyx-tube, inflexed in bud. Ovary free or adnate (attached by the whole length) at the base to the calyx-tube, many celled; ovules many, ascending, on axile placentas; style long; stigma capitate. Fruit a subglobose, 10-15 celled, many seeded berry, supported by the persistent calyx. Seeds small, curved, angular, embedded in pulp; cotyledons (the leaf or pair of leaves present on the embryonic plant while still in the seed) convolute, radicle (the rudimentary root of the embryo) short, terete (cylindrical and circular in cross section)

**B. Artocarpus**

A very large evergreen tree. Bark grey, smooth, sap-wood white, heart wood yellowish brown, moderately hard durable, does not warp nor crack. Valuable for paneling, flooring and boat building. Leaves alternate, coriaceous, entire, lobed or pinnatifid, pinnerved. Flowers monoecious (with the male and female parts in different flowers but on the same individual plant, crowded on globose, oblong or cylindrical, solitary usually axillary receptacles. Perianth (the flower envelopes of 1 or 2 series, i.e. calyx and corolla; more commonly used when the two series are not differentiated or when only one of them is present) in male 2-4 lobed or partite, in female tubular and confluent below with the receptacle. Stamen 1. Pistillode (a rudimentary female part of a flower) 0. Ovary straight; ovule pendulous; style exserted; stigma undivided. Fruit a large, fleshy, globose, or oblong receptacle covered with the enlarged fleshy anthocarps (false fruit formed by the fusion of the whole or a part of the flower with the fruit itself), which are smooth, tubercled or spiny according as they are completely or partially connate and have flat or attenuate (narrowed) apices. Seed with membranous testa; exalbuminous; embryo straight or incurved. cotyledons fleshy, equal or unequal; radicle short, superior.
C. Holigarna

Lofty trees often with acrid juice. Leaves alternate, simple, entire, coriaceous or sub-coriaceous; petiole with one or two pairs of spur-like deciduous appendages. Flowers small, polygamodioecious, in axillary and terminal racemes or panicles. Calyx superior, shortly 5-toothed, the tube in male flowers cup-shaped or sometimes subcylindric. Petals 5, valvate, cohering at the base and with the edge of the disk, densely villous inside. Disk lining the calyx-tube, obscure in male flowers. Stamens 5, inserted outside the disk; filaments subulate; anthers oblong-cordiform, versatile, dehiscing longitudinally. Ovary in male flowers none, in male flowers inferior, one celled; styles usually 3, divergent, stigmas capitate, ovule pendulous from near the top of the cell. Fruit a resinous, acrid, compressed, ovoid drupe, partly or wholly enclosed in the accrescent calyx and disk (hypocarp). Seed parietal; testa membranous; albumen 0; cotyledons thick, plano-convex; radicle lateral.

D. Spondias

Deciduous glabrous trees. A large tree in good soil with large leaflets. The leaflets have parallel nerves meeting in an intra-marginal nerve. The fruit is eaten. Bark smooth and grey, wood light grey and useless. Leaves usually crowded at the ends of the branches, alternate, imparipinnate (pinnate with an odd terminal member); leaflets subopposite, usually caudate (with a tail like tip) – acuminate; stipules 0. Flowers small, polygamous, in terminal spreading panicles. Calyx small, 4-5 lobed, deciduous; lobes imbricate. Petals 4-5, spreading, valvate. Disk thick, annular. 8-10 crenated. Stamens 8 – 10, inserted below the disk, filaments slender, Ovary shortly ovoid or subglobose, 4-5 celled, immersed in the disk; styles 4-5, conniving above; stigmas spreading; ovule one in each cell, pendulous. Fruit a fleshy drupe with woody endocarp (the inner layer of the wall of a fertilized ovary or a fruit) surrounded by longitudinal interwoven fibres, 1-5 seeded. Seeds pendulous, oblong; testa membranous; albumen 0; cotyledons elongate, plano-convex; radicle short, superior.

E. Calophyllum

Trees. Leaves opposite, coriaceous, with very close numerous parallel nerves at right angles with the midrib. Flowers polygamous, solitary fascicled racemed or panicled, axillary or terminal. Sepals and petals usually 4 each, imbricate. Stamens many, free or connate at base; anthers erect, dehiscence (splitting into definite parts) longitudinal. Ovary 1-celled; style slender; stigma peltate; ovule 1, erect. Drupe (a fruit with a more or less succulent flesh enclosing a single, 1-many-celled stone) with a fleshy or crustaceous pericarp. Seed ovoid or globose.
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E. (i) Calophyllum inophyllum

A littoral species of W. coast of India. Much cultivated and often found run wild, perhaps not truly indigenous in India. The Alexandrian Laurel. A moderate-sized very ornamental tree with a reddish-brown useful wood. The fruits are collected and sold for the extraction of oil.

F. Canarium

Tall trees. Leaves large, alternate, imparipinnate; leaflets usually petiolulate, opposite, often unequal, stipulate or extipulate, Flowers hermaphrodite or polygamous, in terminal or axillary often elongate panicles. Calyx copular or urceolate, 3-lobed, valvate, persistent. Petals 3, imbricate or valvate, ovate or oblong, inserted outside the disk. Disk annular, entire or lobed. Stamens 6, rarely only 3, inserted outside the disk; filaments free or connate at the base; anthers oblong-triangular, dorsifixed, introrse. Ovary ovoid, in male flowers reduced to a pistillode, 2-3 celled; style stout; stigma capitate, 2-3 lobed. Fruit an ovoid or ellipsoid, often trigonous drupe with a 1-3 celled. 1-3 seeded stone. Seed conform to the cell; testa membranous; cotyledons contortuplicate (twisted back upon itself), often divided.

F. (i).Canarium strictum

W. Ghats, common in moist evergreen forests, up to about 5,000ft. A very large, handsome tree with straight white cylindrical stem. The large pinnate leaves, when very young are bright yellow turning velvety crimson, when older they are rusty tomentose and at length subglabrous. The flowers are polygamous and the stamens have the filaments combined in a tube. The wood is soft and of little value. The tree gives a black resin.

2.5.7 CONCLUSION

Among the above genera, Calophyllum, Spondias and Sonneratia are inhabitants of coastal area and indicated near shore conditions particularly the last one. Sonneratia is a mangrove tree that occurs in the tidal creeks and littoral forests. Calophyllum inophyllum, a comparable species is found all along the coast above high water mark and in the evergreen forests of Western Ghats along the river banks. Likewise, Artocarpus (the jack fruit tree), Holigarna and Canarium are found in the evergreen forests of Western Ghats including Kerala. The assemblage indicated that the area was covered by dense forest with high rainfall, which might be turned into warm and humid as revealed from the later deposition of Spondias. The fungal infection in some of the woods further substantiates the existence of warm and humid conditions. So climatically there is no significant difference since the time of deposition of these
woods. However, occurrence of *Sonneratia*, specially indicated the proximity of sea in the area at the time of deposition. Obviously, the sea level was much higher at that time than at present and later it receded. Thus the carbonized woods have thrown light into the palaeoenvironmental conditions and sea level fluctuations in the area. It is suggested that Mosco and Ponpally region, which are located about 15km inland of present Vembanad Lake, had witnessed an episode of marine transgression, regression and contemporaneous geological modifications.
PLATE 2.5.1 Wood samples collected for carbon dating
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2.5.8 REFERENCES


