

Carbonised woods of Sterculiaceae and Sapindaceae from Middle Miocene sediments of Kerala Coast

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Two carbonised woods from Warkalli sediments (Middle Miocene) of Kerala Coast have been described. One of them belongs to the genus *Heritiera* Dryand of the family Sterculiaceae and the other to xylogenically allied genera—*Euphoria*, *Litchi* and *Otonephelium* complex of the family Sapindaceae. Occurrence of the wood of *Heritiera* resembling *H. fomes* and *H. littoralis*, provides evidence that the Warkalli beds at Meenkunnu in Kannur District were laid down in coastal environment. These taxa also provide further evidence of the prevalence of tropical warm and humid climate in the area during deposition.

Key-words—Carbonised woods, Sterculiaceae, Sapindaceae, Middle Miocene, Kerala.

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सारांश

केरल तट के मध्य मध्यनूतन अवसादों से स्टर्कुलिएसी एवं सेपिन्डेसी कुलों की कार्बनमय काष्ठ

रश्मि श्रीवास्तव एवं नीलाम्बर अवस्थी

केरल तट के वरकली अवसादों (मध्य मध्यनूतन) से प्राप्त कार्बनी काष्ठों का वर्णन किया गया है। इनमें से एक स्टर्कुलिएसी कुल की हेरिटियेरा ड्राएण्ड प्रजाति तथा दूसरी सेपिन्डेसी कुल की शारीरीय सम्बद्ध प्रजातियों—यूफोरिया, लिची एवं आटोनिफेलियम सम्मिश्र से सम्बन्धित हैं। हे० फोम्स एवं हे० लिटोरालिस से मिलती-जुलती हेरिटियेरा की काष्ठ की उपस्थिति से यह प्रमाणित होता है कि कन्नूर जनपद में मीनकुन्नु के आसपास वरकली संस्तर तटीय वातावरण में निक्षेपित हुए थे। इस क्षेत्र में इन वर्गों की अशिमल काष्ठ मिलने से यह भी इंगित होता है कि निक्षेपण के समय यहाँ उष्णकटिबन्धीय उष्ण एवं आर्द्र जलवायु विद्यमान थी।

THE Neogene sequence along Kerala Coast contains rich deposits of carbonised woods in Warkalli sediments. These sediments are of Middle Miocene age (Ramanujam, 1982; Ramanujam & Rao, 1977). Anatomical studies of carbonised woods carried out from Varkala and Payangadi by Awasthi and his co-workers (Awasthi & Ahuja, 1982; Awasthi & Panjwani, 1984; Awasthi & Srivastava, 1989, 1990, 1992a, 1992b) have revealed a rich flora consisting of dicotyledonous genera which are the main constituents of tropical wet evergreen vegetation distributed at present in the forests of Western Ghats and Malaya Peninsula. One of the woods resembling that of *Heritiera* was found in the carbonaceous clays overlain by variegated clays and sandstones from Meenkunnu cliff section in Kannur District. This particular site is often inundated by high tide sea water. The other

sapindaceous wood was collected from a clay pit in Padappakara Village near Ashtamudi Lake in Kollam District.

Genus—*Heritieroxylon* Lakhanpal et al. 1981

H. keralaensis sp. nov.

Pl. 1, figs 1-3, 6, 8

Description—Wood diffuse porous. Growth rings indistinct. Vessels small to medium-sized, t.d. 80-160 μ m, r.d. 50-190 μ m, circular to oval when solitary and flattened at the place of contact when in multiples; filled with dark contents; evenly distributed, 8-10 vessels per sq mm; vessel members short, 160-300 μ m long with truncate or tailed ends; perforation simple; intervessel pits minute, bordered, alternate, hexagonal or circular in shape with lenticular apertures, 4-5 μ m in diameter. Parenchyma paratracheal and apotracheal;

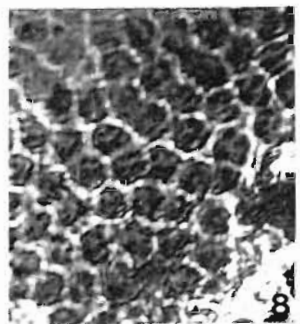
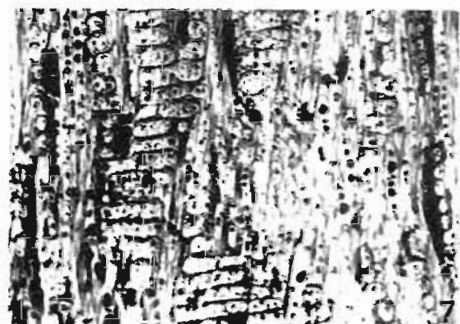
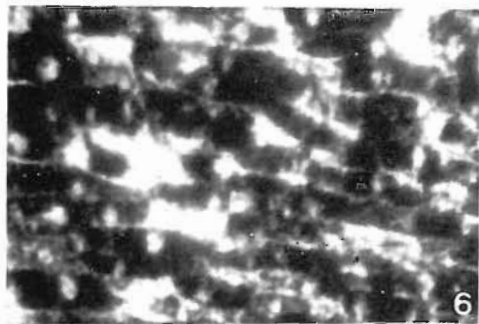
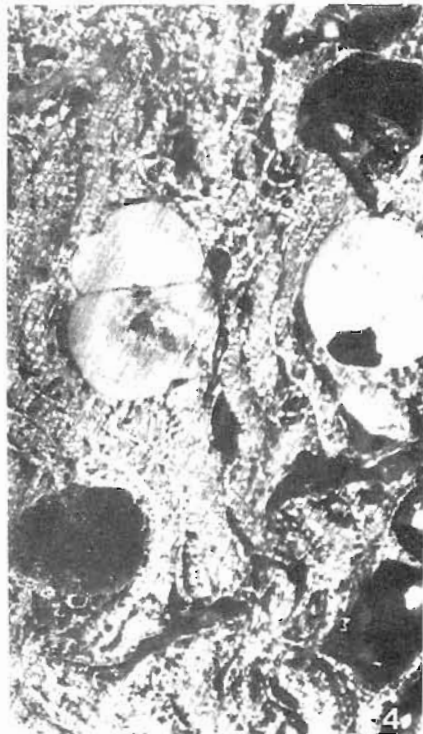


PLATE I

paratracheal forming a sheath of 1-2 cells around some of the vessels and sometimes few cells touching them; apotracheal parenchyma diffuse to diffuse-in-aggregate, forming 1-2 seriate broken lines, few cells also seen scattered among fibres; parenchyma cells 16-20 μm in diameter and 64-80 μm in length; parenchyma strands showing storied tendency at places. *Rays* 1-8 (mostly 4-6) seriate, weakly heterocellular, made up of procumbent cells with few square cells at one or both the ends; sheath cells absent; uniseriate rays few, short, 3-12 cells or 160-360 μm long; ray cells thin-walled, some are filled with dark contents; procumbent cells 24-32 μm in tangential height and 10-16 μm in radial length; upright or square cells 32-48 μm both in tangential height and radial length. *Fibres* aligned in radial rows between two consecutive rays, semilibriform, nonseptate, 16-20 μm in diameter.

Comparison with extant species—The important features of the fossil wood are small to medium-sized vessels, 1-8 seriate xylem rays, parenchyma paratracheal as well as apotracheal, diffuse to diffuse-in-aggregate and nonseptate fibres. These features indicate its affinities with the members of Sterculiaceae and *Barringtonia* of Lecythidaceae. However, *Barringtonia* having relatively longer vessel-members, larger inter-vessel pits (8-12 μm), non-storied parenchyma strands and heterogeneous rays, differs strikingly from the present fossil wood. Among sterculiaceae genera, *Sterculias* of Group A (Chattaway, 1937) can be compared in the nature and distribution of parenchyma. However, they too differ in other characters, such as longer vessel-members and very high multiseriate rays with prominent sheath cells at the flanks. Among other members of Sterculiaceae, *Heritiera* Dryand is the only genus with which our fossil shows closest resemblance. The similarities can be observed in the length of vessel-members, absence of sheath cells and in almost homogeneous multiseriate rays with only 1-2 square cells at the ends (Chattaway, 1937; Metcalfe & Chalk, 1950). Thin sections as well as published descriptions and photographs of the woods of *Heritiera fomes* Buch. (*H. minor* Roxb.), *H. javanica* Bl., *H. littoralis* Dryand and *H. simplicifolia* (Mast.) Kosterm (after Chowdhury & Ghosh, 1958; Desch, 1954; Hayashi *et al.*, 1973; Pearson

& Brown, 1932), further confirm the affinities of our carbonised wood with those of *H. fomes* and *H. littoralis*. The only difference between the carbonised wood and *Heritiera fomes* is that in the former the sheath cells are absent and the rays are composed of procumbent cells with occasionally 1-2 square cells at one or both the ends. This type of ray tissue is found in *H. littoralis* but the rays are 1-7 (mostly 3-5) seriate and the vessels are also larger (up to 235 μm).

Comparison with fossil species—So far, there is only one record of the fossil wood of *Heritiera* from India. Lakhanpal *et al.* (1981) described a petrified fossil wood of *Heritiera* as *Heritieroxydon arunachalensis*, resembling extant *H. fomes*, from the Tertiary of Deomali, Arunachal Pradesh. It differs from present fossil wood in having larger vessels which often form long chain of radial multiples, longer vessel-members, absence of paratracheal parenchyma and 1-5 (mostly 1-4) seriate xylem rays with few sheath cells at the flanks. In view of these differences the present carbonised wood has been named as *Heritieroxydon keralaensis* sp. nov., indicating its occurrence in Kerala Coast.

Holotype—Specimen no. BSIP 37034.

Locality—Meenkunnu Cliff section (Middle Miocene), Kannur District, Kerala.

Family—Sapindaceae

Genus—*Euphorioxydon* Awasthi *et al.* 1982

Euphorioxydon indicum Awasthi *et al.* 1982

Pl. 1, figs 4, 5, 7

Description—Wood diffuse porous. *Growth rings* indistinct. *Vessels* small to medium-sized, t.d. 80-200 μm , r.d. 80-220 μm , solitary and in multiples of 2-3; round to oval when solitary and flattened at the places of contact when in multiples; often filled with brown deposits; tyloses absent; 8-20 vessels per sq mm, vessel-members 129-500 μm long; inter-vessel pits small, alternate, 4-5 μm in diameter. *Parenchyma* scanty paratracheal, a few cells around some vessels; parenchyma cells 18-24 μm in diameter. *Rays* mostly



PLATE 1

Heritieroxydon keralaensis sp. nov.

1. Cross section showing nature and distribution of vessels and parenchyma, $\times 40$; Slide no. BSIP 37034-1.
2. Same section magnified to show apotracheal and paratracheal parenchyma, $\times 100$; Slide no. BSIP 37034-1.
3. Tangential longitudinal section showing multiseriate xylem rays, $\times 40$; Slide no. BSIP 37034-2.
6. Radial longitudinal section showing almost homocellular xylem rays, $\times 150$; Slide no. BSIP 37034-3.

8. Inter-vessel pits, $\times 800$; Slide no. BSIP 37034-4.

Euphorioxydon indicum Awasthi *et al.*

4. Cross section showing distribution of vessels and parenchyma, $\times 150$; Block no. BSIP 37035.
5. Tangential longitudinal section showing uniseriate xylem rays, $\times 150$; Block no. BSIP 37035.
7. Radial longitudinal section showing homocellular xylem rays made up of procumbent cells, $\times 150$; Block no. BSIP 37035.

uniseriate, occasionally biseriate due to pairing of cells, ray tissue homogeneous, rays homocellular. made up of procumbent cells only, 7-15 cells or 80-480 μm long; cells 16-20 μm in tangential height and 20-32 μm in radial length. *Fibres* aligned in radial rows between two consecutive rays, nonseptate to occasionally septate, 16-20 μm in diameter.

Affinities—On the anatomical grounds the carbonised wood shows affinities with *Euphoria*, *Litchi* and *Otonephelium* of the family Sapindaceae. These genera are indistinguishable xylotomically from each other (Ramesh Rao, 1963). For naming such fossil woods Awasthi *et al.* (1982) instituted the genus *Euphorioxylon*. So far, two species of this genus are reported from India, viz., *Euphorioxylon indicum* Awasthi *et al.* 1982 from the Neogene sediments of Kutch, Pondicherry, Kalagarh and Arunachal Pradesh (Awasthi *et al.*, 1982; Awasthi & Mehrotra, 1993; Prasad, 1993), respectively and *Euphorioxylon deccanensis* Mehrotra from the Palaeogene (Deccan Intertrappean Series) of Mandla District, Madhya Pradesh (Mehrotra, 1987). The present fossil, in general, is comparable to both the species. However, in having ray tissue homocellular and nonseptate to septate fibres, it is closer to *Euphorioxylon indicum* than to *E. deccanensis* in which a single row of upright or square cells at one or both the ends of rays is often seen and fibres are nonseptate.

DISCUSSION

The occurrence of woods resembling *Heritiera* and *Euphoria-Otonephelium-Litchi* complex in the Middle Miocene sediments of Kerala are quite significant for further interpreting the palaeoclimate and depositional environment of Warkalli beds. The genus *Heritiera* consists of 35 species distributed in tropical Asia, Africa and Australia (Willis, 1973). About five species of this genus are known to occur in the Indian sub-continent. *H. fomes* and *H. littoralis*, the modern comparable species with the fossil, are littoral as well as inland, while the rest are inland (Chowdhury & Ghosh, 1958; Hooker, 1872). *H. fomes* is found gregariously in Sunderbans and Bangla Desh but reaches its best development in Myanmar where it occurs throughout tidal forests from Arakan to Tenasserim. *H. littoralis* grows in tidal forests all along sea shore from Chittagong to Tenasserim, Andmans and also on the West Coast. But it is not found in Sunderbans. It is also distributed in tropical Asia, Africa, Australia and particularly in Malaysian region (Chowdhury & Ghosh, 1958). Of the family Sapindaceae, *Euphoria longan* (Laur.) Steud. is distributed in wet evergreen forests of Western Ghats from Konkan southward extending to Sri Lanka and ascending up to 900 m in Assam, south China, Myanmar and Malaysia. *Otonephelium stipulaceum*

is also confined to Western Ghats from Nilgiris southwards ascending up to 900 m. *Litchi chinensis* is a native of China and cultivated in India (Ramesh Rao, 1963).

Recently, the leaves and a fruit resembling those of *Euphoria* have been described from the Siwalik beds of Nepal and West Bengal (Prasad, 1994; Antal & Awasthi, 1994). Thus the fossil records which include woods, leaves and fruits, indicate that the genus *Euphoria* was widely distributed in the Indian sub-continent during Tertiary period

Occurrence of littoral species of *Heritiera* indicates that the Warkalli clays and lignites at Meenkunnu Coast were laid down in mangrove and swampy environment. This is also supported by palynological assemblage recovered from Warkalli beds of Kerala (Ramanujam, 1982), which includes both mangrove and back mangrove elements, viz., *Rhizophora* (*Zonocostites*), *Avicennia* (*Retitricolpites*) and *Sonneratia* (*Florscheutzia*).

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