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Research Article

Palmoxylon calamoides sp. nov. - a new species of petrified palm stem from the Deccan Intertrappean beds of Umaria, Madhya Pradesh, India

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Abstract

Palms which dominate the woody monocotyledonous flora in fossils are represented by number of organ genera for stem, root, leaf, inflorescence axis, rachilla, flower, fruit, seed and pollen grains. Permineralized woody monocotyledonous stems are generally assigned to the organ genus *Palmoxylon* Schenk (1882) established for woods presumably belonging to the palms. The present petrified palm stem is a part of larger stem and root transition zone. The morphological characters such as stem attached with the roots and its anatomical details (i) Fibrovascular bundles compact; (ii) Dorsal sclerenchyma *Reniformia type,* very large; (iii) Vascular region thin; (iv) Metaxylem vessel single; (v) Phloem groups two on either side of the metaxylem vessel; (vi) Ground tissue compact, parenchymatous; (vii) roots adventitious, polystelic; (viii) Rhizodermis/velamen single layered, cells equally thickened; (ix) Outer cortex wide, compact; (x) Inner cortex aerenchymatous, air cavities in 1-3 rings; (xi) Endodermis devoid of passage cells and (xii) Medullary bundles 1-2 are the diagnostic characters of the present fossil wood and suggests its affinity with family Aracaceae and especially with the Calamoid palms (Subfamily Calamoideae).The specimen was collected from the late Cretaceous sediments of Deccan Intertrappean beds, Umaria, Mandla district, Madhya Pradesh, India. The abundance of costal and mangrove fossil plants such as *Acrostichum* (Mangrove fern), *Nypa* (Mangrove Palm), *Cocos*, *Sonneratia, Phoenix* (Costal Palms) and marine algae from the Deccan Intertrappean beds of this area indicates marine influence and existence of tropical rainforest ecosystem in the vicinity of fossil locality in contrast to the deciduous forests occurring there at present.

INTRODUCTION

Palms have considerable long geological history. Their fossil remains are known in the form of permineralizations, impressions, compressions and casts of almost all organs assigned to

number of organ genera (Daghlian, 1981; Muller, 1981; Harley, 2006). The palms (Family-Arecaceae) constitute a large assemblage of woody monocotyledons distributed naturally in the Oceanic Islands and coastal areas in the tropics between 44º north and south of the equator. They have a very long geological history right from the early Mesozoic era. Of all monocotyledons the Arecaceae displays by far the richest fossil record, and there is an extensive literature available. The records are geographically widespread and comprise a wide range of organs: leaves, cuticles, stems, rhizomes, roots, fruits, seeds, endocarps, rachillae, peduncles, inflorescences, individual flowers and pollen. For some of these organs records are rare while for others, such as leaves, stems and pollen, records are abundant. However, fossil material often lacks sufficient diagnostic detail to allow reasonable association with living palm taxa beyond, or even to, sub familial level. However, many fossil genera and numerous species have been described.

The problem of the artificial genus *Palmoxylon* was addressed by Mahabale (1958) and by Kaul (1960), but little resolution was achieved. Kaul (1960) commented that the comparative anatomy of living palm stems remained little understood and, furthermore, that the situation was becoming more and more problematic because of the increasingly large number of different palm fossils that were being discovered which, 'unfortunately are never found in organic connection [with one another] to give us some clue to their systematic position'. More recently, Tomlinson (1990) offered a concise explanation of the underlying problem: 'developmental features peculiar to the biology of the palm stem tend to transcend systematic differences. There are innumerable records of fossil palm stems, including many from the 19th century that were monographed in 'Fossil Palm Woods of the World' (Stenzel, 1904), in which the 43 species of *Palmoxylon* were divided into four groups: (A) *Mauritia*-like (four species) (B) *Corypha*-like (19 species) (C) *Cocos*-like (18 species) (D) 'Radices Palmarum' (roots; two species) plus a fifth group, *incertae sedis*, of four species.

Umaria is an important north eastern district in shahdol division of Madhya Pradesh state, having a global location between north latitude 23º38' to 24º20' and east longitude 80º28' to 82º12'.It is one of the well-known locality plant fossils which have been dated 65 million years old. These fossils were scattered in a large areas of Umaria, Dindori and Mandla district areas of Madhya Pradesh, India. During palaeobotanical field expeditions present Sediment was collected, processed and analyzed in the Palaeobotany laboratory of Agharkar Research Institute, Pune.

Material and Method

The present work is based on a permineralized piece of stem and root transition zone collected from Deccan Intertrappean beds exposed at Umaria (23º38' to 24º20' N, 80º28' to 82º12'E), Madhya Predesh, India, from where quite many angiosperm remains as well as a mangrove fern *Acrostichum* have been reported (Bonde, 2005; Bonde & Kumaran, 2002, 2005). The specimen U26/97 is a small yellowish brown coloured permineralized piece measuring (9.5 cm rooting region, 6cm stem part) long and 6 x 5.5 cm wide. It exhibits a root stem transition area. It is 15.5 cm long having 9.5 cm long rooting region and 6.0 cm long stem part and 5.5-6.0 cm. wide transverse sectional area (Fig. a).Sections of specimens show details of the stem and attached roots lying in various planes, and consequently cut in different angles. The sections were prepared following the usual ground thin section method employed for silicified material and studied using a Nikon Labophot-2 microscope attached with Fx-35 DX Camera and Leica S6D Microscope along with Canon Powershot S45 Digital Camera. The specimens and micropreparations are deposited at the Department of Palaeobiology, Agharkar Research Institute, Pune.

SYSTEMATICS

Order: Arecales
Family: Arecaceae (Palmae)
Genus: *Palmoxylon* Schenk.
Species: *Palmoxylon calamoides* sp.nov.
(Plate I & II, Figs. a-k).
Specific Diagnosis

***Palmoxylon calamoides* sp.nov.**

Monocotyledonous woody axis with stem and root, Fibrovascular bundles compact. Dorsal sclerenchyma *Reniformia type,* very large. Vascular region thin. Metaxylem vessel single. Phloem groups two on either side of the metaxylem vessel. Ground tissue compact, parenchymatous. Roots adventitious, polystelic. Rhizodermis/ velamen single layered, cells equally thickened. Outer cortex wide, inner cortex compact, aerenchymatous, air cavities in 1-3 rings. Endodermis devoid of passage cells. Pith parenchymatous. Medullary bundles 1-2. Fibre cells abundant in cortex and pith.

Holotype : U26/97 (Slide Nos. 1- 16). Department of Palaeobiology,
Agharkar Research Institute, Pune.
Horizon : Deccan Intertrappean Beds of India.
Locality : Umaria, District Mandla, Madhya Pradesh, India.
Age : Upper Cretaceous (Maastrichtian).
Etmology : The specific epithet "*calamoides*" is after the subfamily Calamoideae.

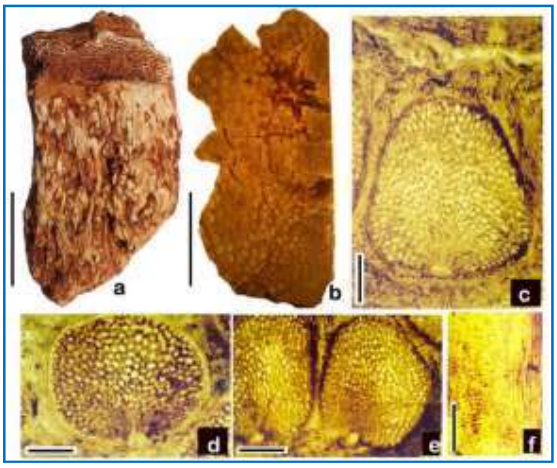
TAXONOMIC DESCRIPION

The specimen U26/97 is a small yellowish brown coloured permineralized piece measuring (9.5 cm rooting region, 6cm stem part) long and 6 x 5.5 cm wide. It exhibits a root stem transition area. It is 15.5 cm long having 9.5 cm long rooting region and 6.0 cm long stem part and 5.5-6.0 cm. wide transverse sectional area (Fig. a).

Stem: The transverse section of the stem exhibits atactostele characteristic of the monocotyledons having separate fibrovascular bundles in the thin walled ground parenchyma. The compact arrangement of fibrovascular bundles and their normal orientation indicate the subdermal zone of the stem. The outermost regions like cortical, dermal and central regions are not present (fig.b).

Subdermal zone: The fibrovascular bundles in this zone are large sized and appears to be more or less round to elongate in shape. They are compactly distributed in the thin walled parenchymatous ground tissue. Stem appears to show atactostele.The frequency of the fibrovascular bundles in this zone varies from 50 to 100/cm².They show normal orientation having xylem pointing towards the centre of the stem. They are 1.56 x 1.2-0.9 x 0.9 mm in size. The fibrovascular ratio ranges from 20/1-42/1. The dorsal sclerenchyma is ***Reniformia type***. The vascular region is generally included and consist single metaxylem vessel and few xylem parenchyma cells and phloem cells which are very difficult to distinguish but may be on the outer side of the vessels. The tabular parenchyma is 1-2 layered and present on the fibrovascular bundle. The fibrous bundles and leaftrace bundle have not been observed. The phloem in all the vascular bundles is not well preserved (Figs. b, c, d, e and f).

Photo Plate-I



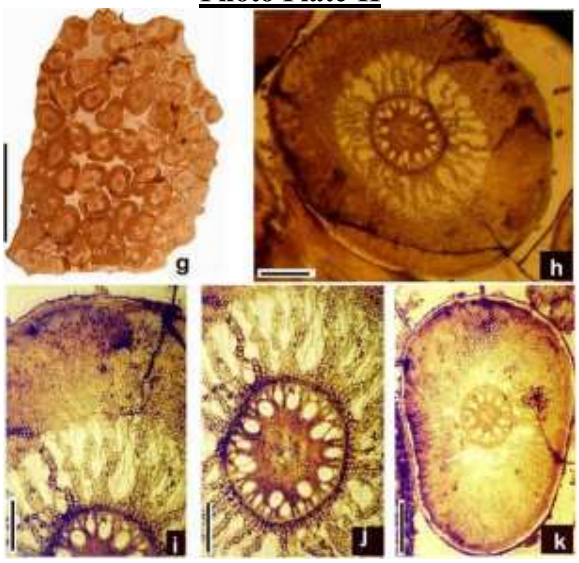
Palmoxylon calamoides sp.nov. (Figs.a-f)

Fig.a - A permineralized specimen of fossil palm axis showing root stem transition. Scale bar = 1.0 cm. Fig.b - T. S through the stem showing distribution of fibrovascular bundles.Scale bar = 1.0 cm. Figs. c, d & e - Fibrovascular bundle showing very large dorsal sclerenchyma and very little vascular region. Scale bar = 250 µm. Fig.f - L.S.of stem showing thick walled ground parenchyma. Scale bar = 250 µm.

Root: The roots appear to make an angle of 60-70 degree with the basal rooting stem region of the plant. They are numerous, adventitious and compact. They are very thin, about 4-5 mm in diameter. The root wood exhibit adventitious roots and rootlets of various sizes and shapes (Fig. g). *Rhizodermis* is single layered without any appendages. It is composed of rectangular thick walled, equally thickened 15 x 15 µm cells comparable to the velamen tissue. *Exodermis* is 2-4 layered, 45-60 µm wide. Cells are polygonal,

compactly arranged without intercellular spaces. *Outer cortex* is single zoned, 90-110 µm wide and made up of compactly arranged polygonal thick walled cells with very small intercellular spaces. *Inner cortex* is very wide occupying almost two third width of the cortex. It is divisible into three zones. Outer zone is 600-850 µm wide, composed of small thin walled cells having small intercellular spaces. The cells are 25 x 35 µm in size. Middle zone is 300-700 µm wide. The cells are radially elongated and form large intercellular spaces. Air cavities are radially elongated, arranged in 1- 4 radial rows. These air cavities are bounded by one to two layered parenchymatous diaphragms. The inner zone is 3-5 celled (60-90 µm) wide. The cells are smaller in size, measuring 22 x 30 µm and are arranged in 3-5 concentric rings with small intercellular spaces. *Endodermis* is single layered without any passage cells. *Pericycle* is single layered and made up of tangentially elongated thin walled, 12 x 22 µm cells. Inside the pericycle is a sclerotic zone enclosing 18-22 separate xylem (70 x 150-110 x 165 µm) and phloem (45 x 60-65 x 75 µm) bundles in a ring alternate to each other. Medullary bundles are 1-2, measuring 90 x 110-90 x 120 µm. They are also embedded in sclerotic ring. Inside the sclerotic zone lies small pith measuring 600-700 µm. The pith is heterocellular with small intercellular spaces. The ground tissue is parenchymatous and longitudinally the cells are arranged in vertical rows. Sclerotic cells are abundant in the entire cortex and pith regions. The vessels possess 0-2 bars in the endplate. Smaller rootlets are abundantly present in root matrix. They are characterized with a rhizodermis without hairs and large air spaces in rings and poorly developed vasculature (Figs. h, i, j, k).

Photo Plate-II



***Palmoxylon calamoides* sp.nov (Figs.g-k)**

Fig.g - T.S through rooting region showing adventitious roots. Scale bar = 1.25 cm. Fig.h - The same, showing Rhizodermis, Exodermis, Outer and inner cortices and the Stele. Note the large radially elongated air cavities in the outer region of inner cortex. Scale bar =825 µm. Fig.i - The same, showing outer and inner cortex. Scale bar =400 µm. Fig.j - The same showing stele. Scale bar = 400 µm. Fig.k - T.S of young root showing developing stele. Scale bar = 400 µm.

Comparison and Discussion

(i) Fibrovascular bundles compact; (ii) Dorsal sclerenchyma *Reniformia type,* very large; (iii) Vascular region thin; (iv) Metaxylem vessel single; (v) Phloem groups two on either side of the metaxylem vessel; (vi) Ground tissue compact, parenchymatous; (vii) roots adventitious, polystelic; (viii) Rhizodermis/velamen single layered, cells equally thickened; (ix) Outer cortex wide, compact; (x) Inner cortex aerenchymatous, air cavities in 1-3 rings; (xi) Endodermis devoid of passage cells and (xii) Medullary bundles 1-2 are the diagnostic characters of the present fossil wood and suggests its affinity with family Aracaceae and especially with the Calamoid palms (Subfamily Calamoideae).

Comparison with extant Calamoid palms

Subfamily Calamoideae have distinct New World and Old World genera. It has 23 genera and 65 species most abundantly occuring in the Eastern Tropics from Sri Lanka, India and China to the Fiji Islands and Western Samoa, but five genera present

in Africa, and three in the Western Hemisphere. *Calamus, Metroxylon, Eugeissona, Raphia, Eremospatha, Laccosperma, Calospatha, Korthalsia, Ceratolobus, Daemonorops, Eleiodoxa, Pogonotium, Retispatha, Salacca, Plectocomia, Plectocomiopsis, Myrialepis, Pigafetta* and *Oncocalamus* are the Old World genera. They have been anatomically investigated in much detail by Pyykko (1985), Liese & Weiner (1989), Weiner & Liese (1991, 1993), Mathew & Bhat (1997), Tomlinson *et al*. (2001), and Quiroz *et al*. (2008). Weiner & Liese (1993) and Mathew & Bhat (1997) have also provided a key for the identification of **Calamoid Palms** on the anatomical charaters. It is very difficult to go the generic level as the specimen is incomplete and some of the characters are not so distinct. However, the wood belongs to the Calamoid palms.

Fossil palm stems

While looking for the affinities with the reported *Palmoxylon* species it was found that *Palmoxylon feistmanteli* Rao and Achutan (1969) and *Palmoxylon ghoshii* Bera & Banerjee (1990, 2001) have been shown their affinities with Calamoid palms. *P. feistmanteli* is compared with the palmate lepidocaryoid palm *Mauritia* due to the gradual reduction of dorsal sclerenchyma in the fibrovascular bundles and also in the gradual change in their distribution. However, the present fossil does not resemble with *P. feistmanteli* as it show only the subdermal zone of the stem so also *P. feistmanteli* when compared with the extant palms do not show its resemblance with *Mauritia*. It needs restudy. *P. ghoshii* resembles *Raphia* due to thick fibrous sheath, tabular parenchyma around the vascular region, two metaxylem vessels and lacunar ground tissue. However, the present fossil differs from *P. ghoshii* due to very thick dorsal sclerenchyma, single metaxylem vessel, two small phloem groups and compact ground tissue. Hence a new species is established as *Palmoxylon calamoides* sp. nov.

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