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Palmoxylon phytelephantoides sp.nov.- A New Fossil Palm from the Deccan Intertrappean Beds of Umaria, Madhya Pradesh, India

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Abstract

The present paper deals with a new petrified palm stem having root matrix under the organ genus *Palamoxylon* (*Palmoxylon phytelephantoides* sp. nov.) from Deccan Intertrappean Beds of Umaria, Madhya Pradesh, India with its phytogeographical significance. Detailed anatomical investigations suggest its resemblance with the Phytelephantoid palm, *Phytelephas* Ruiz & Pavon. Occurrence of fossils of *Phytelephas* in the Deccan Intertrappean beds of India and their present distribution in South America and Panama has a phytogeographical significance. Fossil stem of *Phytelephas* (*P. sewardii*) and a seed (*P. olssoni* Brown,) has been reported from Central America where extant *Phytelephas* grows naturally. Occurrence of the present wood from the Deccan Intertrappean beds exposed at Umaria, indicate origin of *Phytelephas* at two places, one in Central America and other in the Indian subcontinent during the Cretaceous time. *Phytelephas* might have become extinct in the later geological period from the Indian subcontinent but continued in Central America.

Keywords:*Phytelephas, Phytelephantoideae, Palmoxylon, Deccan Intertrappean beds*.

1. Introduction

Palms have considerable long geological history right from the early Mesozoic era. 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; 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. Of all monocotyledons, the Arecaceae shows by far the richest fossil record, and there is an extensive literature available. Though, fossil material often lacks sufficient diagnostic detail to allow reasonable association with living palm taxa beyond, or even to, subfamilial level. However, many fossil genera and numerous species have been described.

Umaria is one of the well-known plant fossil locality belongs to Deccan Intertrappean beds which have been dated 65 million years old (Krishnan, 1973). Fossils are scattered and widely spread over in a large area of Umaria, Dindori and Mandla districts of Madhya Pradesh, India. Records of fossils, including a large number of plant organs such as roots, stems, leaves, rhizomes, fruits, seeds, and peduncle, are found abundant in this locality. During Palaeobotanical field expeditions present Sediment was collected, processed and analyzed in the Palaeobotany laboratory of Agharkar Research Institute, Pune.

2. Review of Literature

The large sized monocotyledonous woods are assigned to the organ genus *Palmoxylon* Schenk (1882). 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

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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.

Fossil records show that the continent of Africa and the subcontinent of India once possessed much richer palm floras than at present. Leaves, stems and pollen are particularly abundant in the fossil record, but there are also numerous records of fruits and seeds, rhizomes and roots. Rarely, rachillae, inflorescences or individual flowers are recovered (Harley, 2006).

The species of Pa1moxylon are created on the basis of highly variable characters such as form and distribution of fibrovascular bundles, type of bundle sheath (sclerenchyma), number of metaxylem vessels, structure of vessel endplate, size and shape of phloem, presence of fibre bundles, nature of ground tissue, etc. Moreover, the petrified stem fragments represent to outer or inner region, basal or apical region, exhibit variations in these characters resulting in the creation of a large number of Palmoxylon species (Bonde, 2008).

3. Materials and Methods

The present work is based on a permineralized chert piece collected from Deccan Intertrappean beds exposed at Umaria (23º38' to 24º20' N, 80º28' to 82º12'E), Madhya Pradesh, India, from where quite many angiosperms remains, especially the fossil record of Arecaceae are rich and widespread. Specimen No. U66/97 is a piece of yellowish brown coloured stem axis with root matrix. It is 15.5 cm long and 6.5 cm x 8 cm wide. It has a small stem axis measuring to 5.5 cm in length. The specimen shows a root and stem transition (Fig, a-b). The rooting part is 10 cm long and 8.0cm wide. Sections of the specimens show details of the stem and attached roots lying in various planes, and consequently cut at 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 in the Department of Palaeobiology, Agharkar Research Institute, Pune.

4. Systematics

Order-Arecales
Family-Arecaceae Schultz-Schultzenstein
Genus-Palmoxylon Schenk

***Palmoxylon phytelephantoides* sp.nov.**

(Photo Plates I- III)

Specific Diagnosis- Permineralised monocotyledonous woody axis. Stele atactostele; fibrovascular, leaftrace, diminutive, fibre bundles present. Dorsal sclerenchyma *Reniformia type.* Xylem with large number of trachieds. Roots with velamen tissue, tanniniferous cells and fibres in cortex. Stele with medullary bundles. Vessels long. Ground tissue parenchymatous.

Holotype : U66/97 (Slide Nos. 1-7). Department of Palaeobiology, Agharkar Research Institute, Pune.
Horizon: Deccan Intertrappean Beds of India.
Locality: Umaria, Madhya Pradesh, India.
Age: Upper Cretaceous (Maastrichtian).
Etymology: The specific epithet "*Phytelephantoides*" is after the subfamily Phytelephantoideae of Aracaceae.

5. Figures and Illustrations

Photo Plate-I

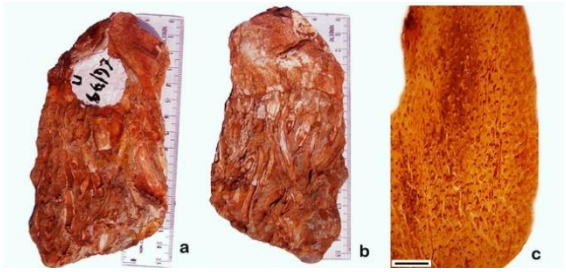

Fig.a *- Entire piece of fossil palm axis showing a transitional zone of stem and rooting region.* ***Fig.b*** *- The same, the opposite side.* ***Fig.c*** *- Transverse section showing distribution of fibrovascular bundles in the stem. Scale bar = 270 µm.*

Photo Plate -II

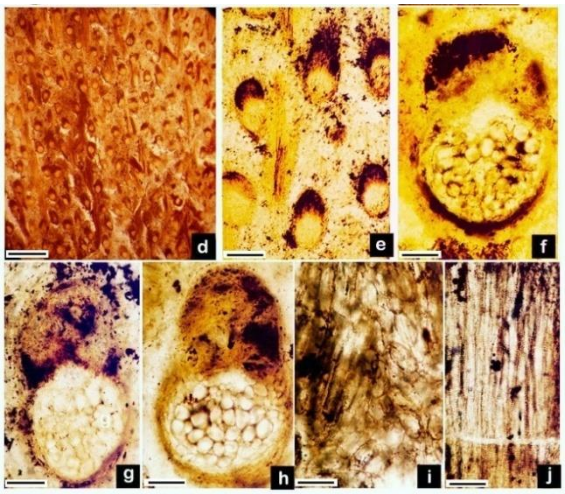

Fig.d *- Dermal region T.S. Scale bar = 135 µm.,* ***Fig.e*** *- The same, showing Fibrovascular bundles. Scale bar = 30 µm.,* ***Figs. f, g, h*** *- Fibrovascular bundles showing reniform dorsal Sclerenchyma , an excluded vascular region with phloem and xylem. Note the large number of*

angular tracheids. Scale bar = 12 µm., ***Fig.i*** *- Ground tissue with Tabular parenchyma. Scale bar = 12 µm. Fig.j - Longitudinal section showing tracheids with pointed ends. Scale bar = 12 µm.*

Photo Plate -III

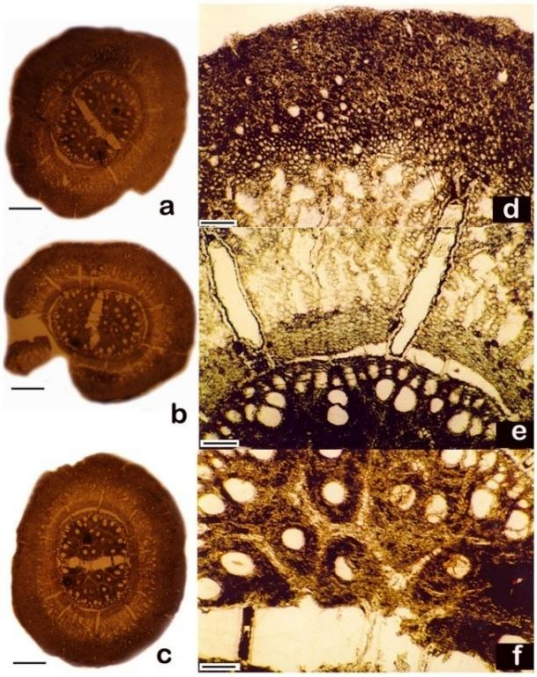

Fig. a, b & c *- T.S. of entire root showing cortical and stellar regions, note the large number of medullary bundles in the pith.Scale bar = 1.6 mm.,* ***Fig. d, e & f*** *- Reconstruction of the T.S.of a root showing cortical and vascular regions,* ***d-*** *Outer cortical region;* ***e****- Middle and Inner cortical region and part of stele showing endodermis, pericycle and xylem and phloem bundles;* ***f****- Pith is showing sclerenchymatous bundle sheath enclosing medullary bundles.* ***Figs.d & e****- Scale bar=45µm; Fig.f Scale bar=60 µm.*

6. Observations and Description

The specimen U66/97 is a yellowish brown coloured small piece measuring 15.5 cm long (the stem part-5.5 cm, rooting region-10cm) and 6.5 cm x 8 cm wide. The specimen shows the basal central part the stem with central rooting system (Pl.I, figs. a, b). The roots are going straight down to the soil. The stem is obconical in cross section showing fibrovascular bundles with *Reniformia* type dorsal sclerenchyma, tangentially elongated phloem and many xylem elements. The roots are the typical adventitious palm type with medullary bundles.

5.1 Stem

The regular orientation and compact arrangement of fibrovascular bundles at the periphery indicate the subdermal zone (Pl. III, figs. c-e).The fibrovascular bundles are regularly oriented and larger in size. Their distribution is 25 to 75/cm². They are slightly oval in shape measuring 0.54 x 0.35-0.60 x 0.34 mm in size. The dorsal sclerenchyma is a *Reniformia* type with rounded angles and rounded sinus. The vascular part is generally excluded consisting of many xylem elements devoid of vessels. Phloem is tangentially elongated measuring 60 x 120 µm in size (Pl. III, figs. f-h). Fibrovascular bundles are covered with 1-2 layered tabular parenchyma. The radiating parenchyma is prominent near the vascular part, though they are present all around the fibrovascular bundle. The leaftrace bundles are not seen. Numerous fibre bundles are present throughout the ground tissue with stegmata. The diminutive bundles are present.The ground parenchyma is thick and compactly arranged. It is composed of horizontally elongated tabular parenchyma cells (Pl. II, fig.i).

5.2 Roots

The roots are adventitious measuring 8-9 mm in diameter (Plate IV, figs.a,b,c,d). *Rhizodermis / Velamen* not preserved. It might have destroyed or removed during the process of making the micropreparations. However, at places it shows the occurrence of unequally thickened cells comparable to the velamen tissue. *Exodermis* is 4-5 layered. Cells are polygonal, compactly arranged without intercellular spaces. *Outer cortex* is single zoned, 200-300 µm wide and made up of compactly arranged polygonal thick walled cells with very small intercellular spaces. Some of the cells show deposition of dark content. These cells are the tanniniferous thick walled cells. *Inner cortex* is very wide, occupying almost two third width of the cortex. It is divisible into three zones. Outer zone is 650-750 µm wide, composed of small, thin walled cells having small intercellular spaces. The cells are 22 x 30 µm in size. Middle zone is 600-750 µm wide. The cells are radially elongated and form large intercellular spaces. Air cavities are radially elongated, arranged in 4-5 radial rows. These air cavities are bounded by one to two layered parenchymatous diaphragms. The inner zone is 7-9 celled (225-300 µm) wide. The cells are smaller in size, measuring 15 x 20 µm and are arranged in 4-9 concentric rings with small intercellular spaces. Fibre cells are frequently present. *Endodermis* is single layered without any passage cells. The cells have strongly thickened inner and radial walls, but the outer walls are thin. *Pericycle* is single layered and made up of tangentially elongated thin walled, 22 x 30 µm cell. Inside the pericycle is a sclerotic zone enclosing 25-30 separate xylem (135 x 150-165 x 195 µm) and phloem (60 x75-60 x 90 µm) bundles in a ring alternate with each other. Protxylem elements are 5-6 in number (Pl. III, figs. d-e). Medullary bundles are very large in number, 15-20, measuring 105 x 120-165 x165 µm. They are spread throughout the pith and also embedded in a sclerotic ring (Pl. III,

fig.f). Vessels in root are 1.5-3.5 mm long and 0.15-0.25 mm in diameter. Inside the sclerotic zone lies wide pith measuring 2-3 mm. The pith is heterocellular with small intercellular spaces. The ground tissue is parenchymatous and longitudinally the cells are arranged in vertical rows (Pl. III, fig. i). Sclerotic cells are abundant in the entire cortex and pith regions. The vessels possess 2-3 bars in the endplate.

7. Comparison and Discussion

Large size of the permineralized wood with roots; stem having fibrovascular bundles with reniform dorsal sclerenchyma; large number of large sized angular xylem elements in the stem; roots with velamen tissue; tanniniferous cells and fibres in the cortex; endodermis with Russow's thickening absence of passage cells; large number of medullary bundles; vessels in the roots are the diagnostic characters of the present fossil wood and indicate its affinity with the axis of the family Aracaceae. The large sized monocotyledonous woods are assigned to the organ genus *Palmoxylon* Schenk (1882).

There are about 200 species throughout the world, including 74 species from India. Large number of species of *Palmoxylon* may be parts belonging to outer or inner, basal or apical region of the stem or sometimes parts of leaf or inflorescence axis established on the basis of anatomical characters such as form and distribution of fibrovascular bundles, type of sclerenchyma, number of metaxylem vessels, size and shape of phloem, presence of fiber bundles, nature of ground tissue, structure of vessel endplate, etc (Stenzel, 1904; Sahni, 1943, 1964; Mahabale, 1958).

6.1 Comparison with extant palms

Aracaceae is a large arborescent monocotyledonous family having 190 genera and 2364 species. It has 5 subfamilies distributed in the tropics and subtropics and has a specific distribution of some genera and species of Old World and New World (Moor, 1973; Uhl & Dransfield, 1987, Govaert & Dransfield, 2005). The present fossil shows its resemblance more with the genus *Phytelephas* Ruiz & Pavon of the subfamily Phytelephantoideae due to the presence of a large number of large sized angular xylem elements. Subfamily Phytelephantoideae has 3 genera *Phytelephas* Ruiz & Pavon, *Palandra* O.F. Cook and *Ammandra* O.F. Cook distributed in South America and Panama. *Phytelephas* has 6 species.

Phytelephas is the only palm genus which is devoid of vessels in the stem, but present in the roots (Tomlinson, 1961; Klotz, 1977, 1978). The outermost layer of the root preserved in places consisting unequally thickened irregular cells comparable to the velamen tissue, thin exodermis, outer cortex with tanniniferous cells, frequent occurrence of fibers in the cortex, emdodermis with Russow's thickening and large number of medullary bundles suggest its resemblance with the Phytelephantoid palm, *Phytelephas* Ruiz & Pavon.

According to Cheadle (1943a,b, 1944) vessel elements have evolved from tracheids. The least specialised types of vessels are like trachieds. They have long, oblique scalariform perforation plate. The metaxylem in monocotyledons are most specialised elements. The protoxylem elements are usually long imperforate tracheids. Vessels appeared first in the roots and only later in the stem and leaf. *Phytelephas* is anomalous because the tracheal elements of the stem are short, irregular and angular tracheids. However, vessels are restricted to the xylem of the root. In the stem vessels are not present, but instead short irregular tracheids with pointed ends and angular cross sectional shape are present.

6.2 Comparison with fossil palms

Phytelephas sewardii Kaul (1943) is a palm stem described from the Miocene sediments of Antigua, West Indies. The present wood resembles with *P. sewardii* in having large numbers of xylem elements (trachieds) and fibre bundles in the ground tissue. However, the present wood is a part of subdermal region. The excluded vascular region and the roots are similar to *Phytelephas*. *P. sewardii* is a small part of the stem having only the central vascular region and in it the roots are not present. Uhl and Dransfield (1987) questioned its affinity with *Phytelephas*.

Mahabalea phytelephantoides Bonde is a juvenile palm axis with condensed stem, rooting region and a crown with trimerous spiral phyllotaxy described from the Deccan Intertrappean Beds of Umaria, District Dindori. The present wood resembles subdermal region of the stem of *M. phytelephantoides*, large number of xylem elements in the fibrovascular bundle, other anatomical characters and also the root characters having vessels. However, the subdermal region of *M. phytelephantoides* shows resemblance with the present stem wood. The present wood may be the well developed stem of *M. phytelephantoides* and well developed and well preserved fibrous roots.

Brown (1956) has reported a sandstone seed cast as *Phytelephas olssoni* Brown from the marine outcrops near Esmeraldas, Quebrada de Camarones, Ecuador of South America belongs to the Punta Gorda Formation of Late Miocene or Early Pliocene age. The seed is 4.5 cm long and 4 cm in diameter showing two flattened faces whose narrowed ends converge toward an apical depression called as a raphe and covered by a thin seed coat. The outer surface is lined by a more or less irregular, shallow, vein-like, interconnecting furrows.

8. Conclusions

Occurrence of fossils of *Phytelephas* in the Deccan Intertrappean beds of India and their present distribution in South America and Panama has a

phytogeographical significance. Fossil stem of *Phytelephas* (*P. sewardii* Kaul, 1943) and a seed (*P. olssoni* Brown, 1956) has been reported from Central America where extant *Phytelephas* grows naturally.

Occurrence of *Mahabalea phytelephantoides* Bonde, the present wood (*Palmoxylon phytelephantoides* sp.nov.), *Mahabalea acaulis* sp. nov. and a seed (*Phytelephasospermum* sp.) from the Deccan Intertrappean beds exposed at Umaria, indicate origin of *Phytelephas* at two places, one in Central America and other in the Indian subcontinent during the Cretaceous time. *Phytelephas* might have become extinct in the later geological period from the Indian subcontinent but continued in Central America.

In order to understand the fossil plant diversification future work is to be concentrated and most care is required to be taken, especially during the field work to look for entire herbaceous plants or woody baby plants comprising roots, stem, leaves, inflorescence, flowers, fruits and seeds in organic connections or the flowering and fruiting organs as they are highly conservative in their characters and hence taxonomically more reliable for phylogenetic assessments. For this in-depth knowledge of morphology and anatomy of comparable extant flora is required for their Phytogeographical and environmental interpretations.

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References

[1] Bonde SD, Indian fossil monocotyledons: Current Status, Recent Developments and Future Directions. The Palaeobotanist, 57:141-164, (2008).

[2] Brown RW, Ivory nut palm from late Tertiary of Equador. Science, 123(Issue 3208): 1131-1132, (1956).

[3] Brown RW, Palm like plants from the Dolores Formation (Triassic) in southwestern Colorado. United States Geological Survey Professional paper, 274: 205-209, (1956).

[4] Cheadle VI, The origin and certain trends of speciahzation of the vessel in the Monocotyledoneae, Amer. J. Bot., 30: 11-17, (1943a).

[5] Cheadle VI, Vessel specialization in the late metaxylem of the various organs in the Monocotyledoneae. Amer. J. Bot., 30: 484-90, (1943b).

[6] Cheadle VI, Specialization of vessels within the xylem of each organ in the Monocotyledoneae. Amer. J. Bot. 31: 81-92, (1944).

[7] Daghlian CP, A review of the fossil record of monocotyledons. Botanical Review 47: 517-555, (1981).

[8] Govaert R and Dransfield J, World Checklist of Palms, 1Edn, Royal Botanic Garden, Kew: 1-235, (2005).

[9] Harley M M, A Summary of Fossil Record of Arecaceae. Botanical Journal of the Linnean Society London, **151**: 39–67(2006).

[10] Kaul KN , A palm stem from the Miocene of Antigua, W.I. – *Phytelephas sewardii*, sp.nov. Proc. Linn. Soc. Lond. Sess,155: 3-4(1943).

[11] Kaul KN, The anatomy of the stem of palms and the problem of the artificial genus Palmoxylon Schenk. Bulletin of the National Botanic Gardens, Lucknow, 51: 1 – 52. (1960)

[12] Klotz LH, A systematic survey of the morphology of tracheary elements in palms. A Ph. D. thesis submitted to the Cornell University, Ithaca, NewYork. (1977).

[13] Klotz, LH, Form of the perforation plates in the wide vessels of metaxylem in Palms. Journal of the Arnold Arboretum, 59:105-128, (1978a).

[14] Klotz, LH , The number of wide vessels in petiolar vascular bundles of palms: an anatomical feature of systematic significance. Principes, 22: 64-69, (1978b).

[15] Krishnan MS 1973. The age of the Deccan Traps. In : Mahabale TS (ed.), Proceedings of the Symposium on Deccan Trap Country, New Delhi, INSA Bulletin No. 45: 87-94.

[16] Mahabale TS, Resolution of the artificial palm genus *Palmoxylon*: a new approach. Palaeobotanist, 7: 76-84, (1958).

[17] Moore HE, The major groups of palms and their distribution. Gentes Herbarum 11: 27–141. (1973).

[18] Sahni B, A new species of petrified palm stems, *Palmoxylon sclerodermum* sp. nov., from the Deccan Intertrappean Series. Journal of the Indian Botanical Society, 22: 209-224. (1943).

[19] Sahni B Revisions of Indian Fossil Plants Part III.Monocotyledons. Monograph No.1, BSIP, Lucknow: 1-89, (1964).

[20] Stenzel KG, Fossile Palmenholzer. Beitrage zur Palaeontologie und Geologie Osterreichungars und des Orients Leipzig: Mitt.d.Geol. u.Pal.Inst.d.Univer.Wien, 16: 107-288, (1904).

[21] Tomlinson PB Anatomy of the Monocotyledons -II Palmae, Clarendon Press, Oxford:1-453, (1961).

[22] Tomlinson PB The Structural Biology of Palms. Clarendon Press, Oxford: 1- 477(1990).

[23] Uhl NW & Dransfield J Genera Palmarum. Allen Press, Lawrence, Kansas: 1- 610 (1987).