Phoenicicaulon mahabalei gen. *et* sp. nov., a sheathing leaf base of *Phoenix* from the Deccan Intertrappean beds of India

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Phoenicicaulon mahabalei gen. *et* sp.nov., a permineralized proximal part of the leaf (leaf sheath) of *Phoenix* has been described from the Deccan Intertrappean bed at Umaria, District Mandla, Madhya Pradesh, India. In cross section it appears as a shallow trough; rounded abaxially and lunate on the adaxial side. It is characterized with a central dorsiventral ridge, thin cortex, wide vascular region differentiated into a thin peripheral and wide central vascular regions with compact arrangement of vascular bundles. The petiole exhibits a unique type of vasculature in the central dorsiventral ridge region consisting of highly compact arrangement of fibrovascular bundles. Presence of both dorsal and ventral sclerenchyma, single large phloem, two wide metaxylem vessels in the fibrovascular bundle; abundance of fibre, diminutive and trace bundles suggest its resemblance with the proximal part of the leaf axis (leaf sheath) of a pinnate palm *Phoenix* belonging to a monogeneric tribe Phoeniceae of subfamily Coryphoideae of Palmae (Arecaceae).

Key-words - Palmae, Coryphoideae, Phoeniceae, *Phoenix*, Morpho-Anatomy, Deccan Intertrappeans.

INTRODUCTION

PERMINERALIZED remains belonging to family Palmae (Arecaceae) have been described as stem (*Palmoxylon* Schenk 1882), root (*Rhizopalmoxylon* Felix 1883), petiole (*Sabalocaulon* Trivedi & Verma 1981; *Parapalmocaulon* Bonde 1987),lamina (*Sabalophyllum* Bonde 1986), inflorescence axis (*Palmostroboxylon* Biradar & Bonde 1979), inflorescence (*Arecoideostrobus* Bonde 1996) and fruit and seed (*Palmocarpon* Miquel 1813; *Nypadites* [*Nypa*, *Nipa*] Bowerbank 1840; *Hyphaeneocarpon* Bande *et al.* 1982; *Cocos intertrappensis* Patil & Upadhye 1984; *Areca intertrappea* Senad & Paradkar 1989; *Eugeissonocarpon* Shinde & Kulkarni 1989 and *Arecoidocarpon* Bonde 1990).

The present paper describes the permineralized proximal part of the leaf (leaf sheath) of *Phoenix* from the Deccan Intertrappean bed exposed at Umaria (Lat. 23°05'30"; Long. 80°38'24"), about 3.5 kms SE of the National Fossil Park at Ghughua, District Mandla, Madhya Pradesh.

SYSTEMATIC DESCRIPTION

***Family* : Palmae (Arecaceae)**

***Subfamily* : Coryphoideae**

***Tribe*-Phoeniceae**

Genus : *Phoenicicaulon* gen. nov.

***Phoenicicaulon mahabalei* gen. *et* sp. nov.**

Pl. 1, Figs 1-6; Text-fig 1

The specimen is a permineralized basal part of the leaf (leaf sheath) very close to its attachment to the stem. It is 8.5 cm long and 6.0 x 0.7 cm wide in its tangential and radial direction. It was separated from a large loosely packed chert matrix (Pl. 1, Fig. 1). It is smooth and devoid of appendages like-spines, hooks or serrations on the margin. It is complete, broadly lunate (very shallow trough) in the cross sectional view; concave adaxially and convex on the abaxial side with a dorsiventral ridge in the centre prominent on the adaxial side flanked with long wings on either side (Pl. 1, Figs 2 & 3).

Epidermis is preserved at places. It is single layered having thick cutinized, tangentially elongated,

30 x 15 μm cells. Hypodermis is 2-3 layered made up of 30 x 30 μm; thick-walled compactly arranged cells. The cortex is varying in thickness, 260-624 μm, made up of round to elongated, 45x52 μm loosely arranged thin walled cells forming intercellular spaces.

The vascular region is very wide and show a distinct division into their peripheral and wide central vascular zones. Peripheral vascular zone is 0.52-0.83 mm wide characterized with radial arrangement of fibrovascular bundles merging into the central vascular zone.

The central vascular zone is 5.5-6.0 mm wide with very compact arrangement of bundles. There are five types of bundles, viz. normal fibrovascular bundles, trace, diminutive, fibre and fusion bundles. In the ridge region they are highly compact having 3200-4500 bundles per sq cm area and because of this overcrowding they have become deformed (Pl. 1, Fig. 4). In the wings region they are larger in size, sparsely distributed, 800-1200 per sq cm area and irregularly oriented (Pl. 1, Fig. 5).

Normal fibrovascular bundles are oval, elongated to variously compressed, 468 x 468-750 x 300 mm in size. Each bundle has lunate dorsal and ventral sclerenchyma, tangentially elongated, 365 x 156 μm phloem, two metaxylem vessels 152 x 121 -187 x 136 μm in size, 1-5 protoxylem elements, 30 x 60- 76 x 106 μm in size and their F/V ratio is 0.5/1-0.71/1 (Pl. 1, Fig. 5).

Trace bundles are the large sized fibrovascular bundles with two metaxylem vessels, elongated phloem and 6-11 protoxylem elements. They are generally round to oval in shape but many a times get deformed due to overcrowding in the central vascular region, especially in the ridge area. They are 676 x 468-832 x 572 μm in size and their F/V ratio is 0.5/ 1-0.56/1 (Pl.1, Fig. 6).

Diminutive bundles are the small fibrovascular bundles abundant throughout the vascular region but generally they are associated with the trace bundles. They are 152 x 227-322 x 227 μm in size with vaginate sclerenchyma but their dorsal part is well developed than the ventral one. They have small elongated phloem, two metaxylem vessels and 0-2 protoxylem elements (Pl.1, Fig.4).

Fibre bundles are round or polygonal in shape, 90.6 x 90.6 -175-180 μm in size and are distributed irregularly in the vascular region. However, they are abundant in the ridge area.

Fusion bundles occur mainly in the central vascular region, especially in the ridge area. They are formed by the fusion of normal fibrovascular bundles and /or trace bundles. Their size and shape varies depending upon the number and orientation of fusing bundles.

The ground tissue is parenchymatous. The cells are thin-walled, elongated, 75.5 x 30.3 μm, loosely arranged throughout the vascular region. Tabular and radiating parenchyma are not observed.

AFFINITIES AND DISCUSSION

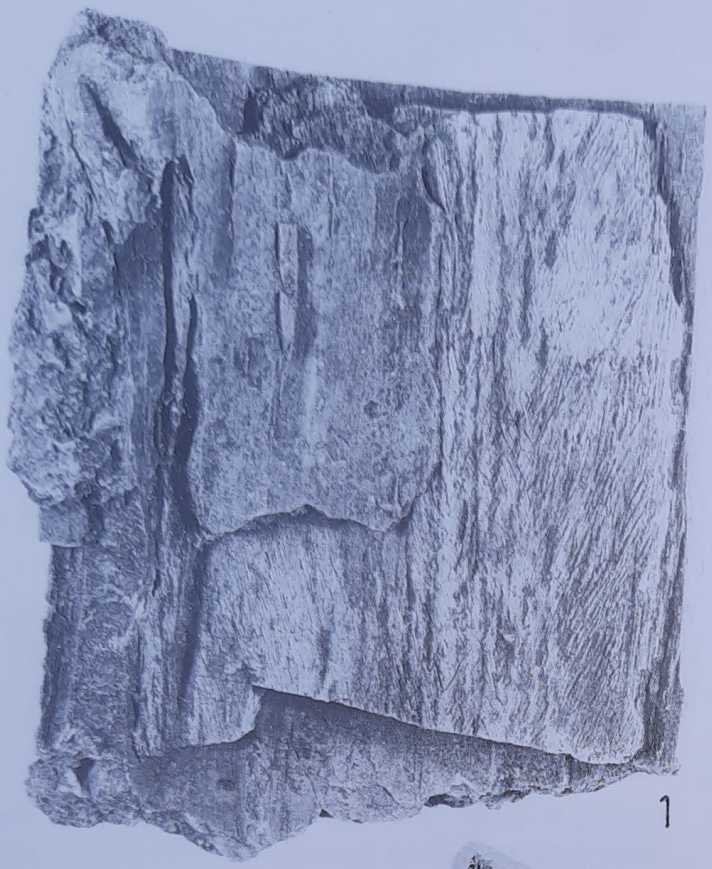
Broadly lunate concavo-convex cross sectional arch with central dorsiventral ridge flanked by two narrow wings; highly compact arrangement of fibrovascular-fibre bundles in the ridge region; vascular bundles with both dorsal and ventral fibrous sclerenchyma, single elongated phloem, two metaxylem vessels and 1-5 protoxylem elements and the xylem and phloem meeting nearly at a straight line are the diagnostic characters of the present specimen and suggest that it is the proximal part of the leaf (leaf sheath) of Palmae (Cheadle & Uhl 1948; Tomlinson 1961, 1990; Klotz 1978; Parthasarathy 1968).

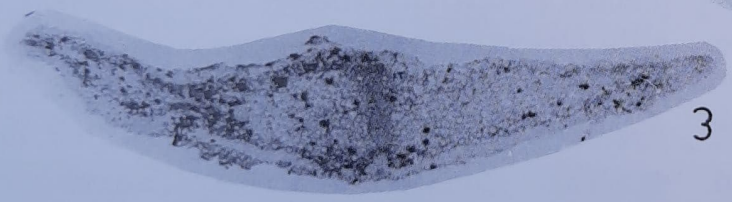
Comparison with the fossil leaf axes

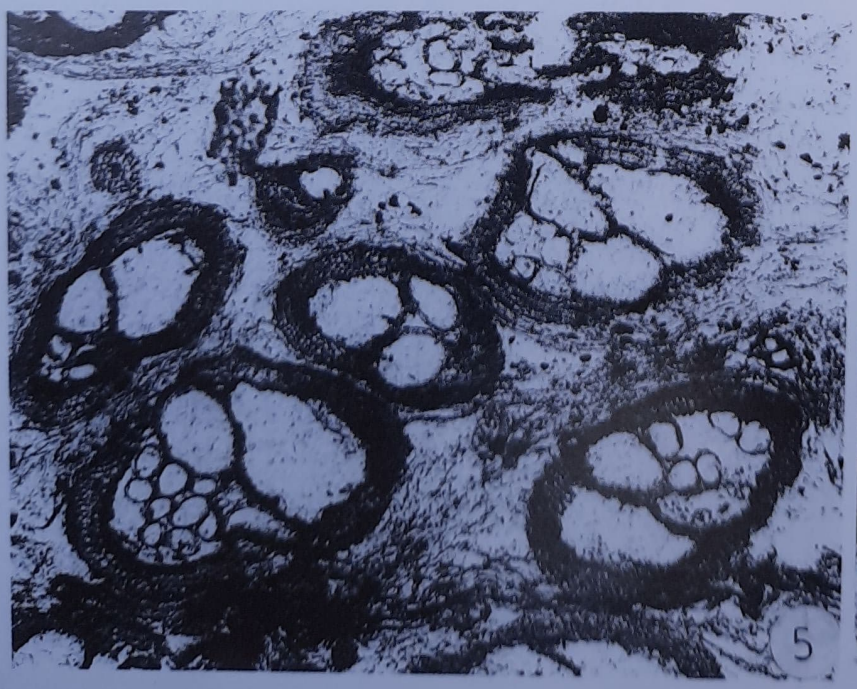
Sabalocaulon intertrappeum Trivedi & Verma (1981), *Parapalmocaulon surangei* Bonde (1987),

PLATE - 1 →

1. Original specimen-viewed from adaxial side x N.S., 2. T.S. of the leaf sheath through proximal region x 2, 3. T.S of the leaf sheath through distal region x 2, 4. T.S. through the ridge area showing highly compact arrangement of fibrovascular-fibre bundles. Note the deformed nature of the vascular bundles due to overcrowding x 20., 5. T.S. of the leaf sheath through the wings showing normal fibrovascular bundles, trace bundles, diminutive bundles and fibre bundles. Note the irregular orientation of the fibrovascular bundles x 25, 6. T.S. showing horseshoe shaped fibrous sheaths meeting at the metaxylem level, single phloem, two large metaxylem vesels and protoxylem elements x 50.







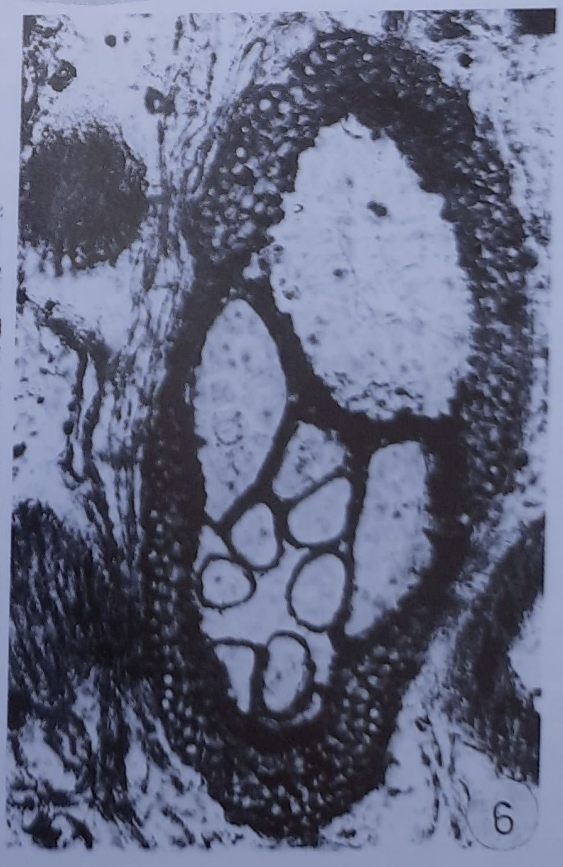


PLATE 1

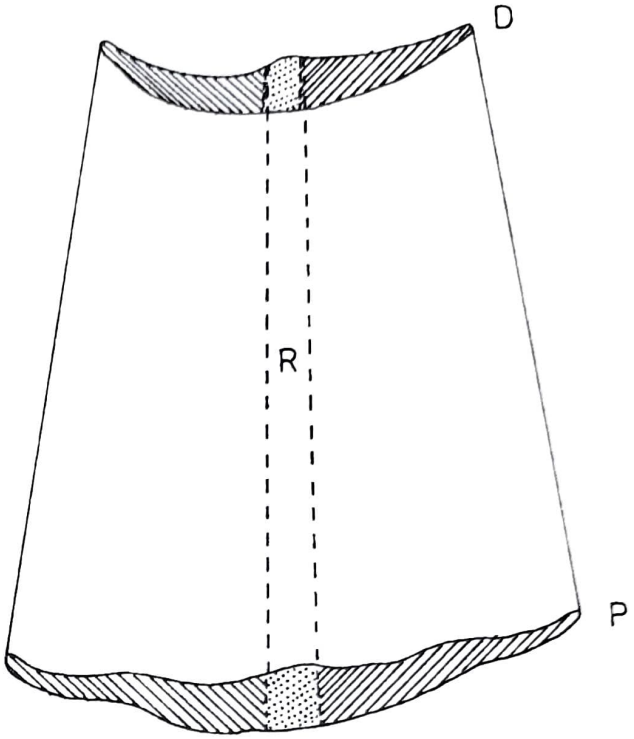
P. monodii (Boureau & Prakash 1968) Bonde (1987), *P. costapalmatum* (Kulkarni & Patil 1977) Bonde (1987) and *P. hyphaeneoides* (Shete & Kulkarni 1980) Bonde (1987) are the palm petioles described so far from different horizons.

The present petiole show some resemblance with *Sabalocaulon intertrappeum* Trivedi & Verma in having a thin flattened cross sectional area becoming gradually thin towards the margins and the ground parenchyma. However, *S. intertrappeum* lacks the dorsiventral ridge and the vascular bundles have only a small dorsal fibrous sheath and one metaxylem vessel.

The present specimen differs from all the species of *Parapalmocaulon*, viz. *P. surangei* Bonde, *P. monodii* (Boureau and Prakash) Bonde, *P. costapalmatum* (Kulkarni & Patil) Bonde and *P. hyphaeneoides* (Shete & Kulkarni) Bonde as there is no central dorsiventral ridge and highly compact arrangement of fibrovascular-fibre bundles in these leaf axes. Moreover, the fibrovascular bundle in *P. surangei* Bonde has a vaginate fibrous sheath, two phloem groups and 1-5 metaxylem vessels. In *P. monodii* Bonde (Boureau & Prakash) the fibrovascular bundles are sparse and fibre bundles are covered with radiating parenchyma. *P. costapalmatum* (Kulkarni & Patil) Bonde and *P. hyphaeneoides* (Shete & Kulkarni) Bonde differ in having undifferentiated vascular region and F/V ratio. The vascular bundles in *P. costapalmatum* in addition, possesses only dorsal fibrous sheath and lack protoxylem elements.

Comparison with the extant palm leaf axes

Moore (1973), Uhl and Dransfield (1987) have studied the morpho-anatomical characters in Palmae. Tomlinson (1961, 1990) has given the most comprehensive account of the anatomy of palms. Mahabale and Udwadia (1953) have investigated the petioles of 35 palms for the distribution of vascular bundles and the ground tissue. However, the detailed account, so far, is not published. The palm petiole exhibit structural variations from base to the apex. Generally, it is flat, winged at the sheathing region and becoming round channelled at the petiole proper region and becoming angular at the rachis region.



Text-fig. 1. The specimen showing outline of the leaf sheath. P–Proximal region, D–Distal region, R–Central dorsiventral ridge x N.S.

Parthasarathy (1968) has investigated the major groups or alliances in Palmae for the character of phloem groups. Accordingly, a single phloem strand in the present fossil indicate its affinity with Coryphoid, Borassoid, Phoenicoid, Nypoid, Caryotoid and Arecoid palms. Klotz (1977, 1978) has made a systematic survey of the tracheary elements in Palmae in which he has also investigated the petiolar anatomy of 213 species belonging to 153 genera and identified the major groups on the character of number of wide metaxylem vessels in the petiolar vascular bundles.

The adaxially channelled and dorsiventrally flattened nature of the leaf axis with central dorsiventral ridge flanked with two long wings, single phloem and two wide metaxylem vessels in the fibrovascular bundle suggest that it is a proximal part of the leaf axis (leaf sheath) of *Phoenix* L. of the tribe Phoeniceae belonging to subfamily Coryphoideae (Klotz 1978, Parthsarathy 1968, Uhl & Dransfield 1987). Compact arrangement of bundles in ridge area gets spreadout in the wings and might have supplied to the spines or pinnae at the petiolar or rachis part of the leaf. The tribe Phoeniceae (Phoenicoid palms) is monogeneric having a wide ranging old world genus *Phoenix* L. with 17 species distributed in Africa, Arabia, India to

Malaya and Sumatra, often in dry regions but usually near water courses, oases or underground sources of water, or in swamps or even among mangroves (Moore 1973, Uhl & Dransfield 1987). Parthasarathy (1957) has investigated 10 species of *Phoenix* for their anatomical characters. The distribution of fibrovascular bundles in the middle vascular region suggests its resemblance with *P. sylvestris* Roxb., *P. robusta* Hook. and *P. acaulis* Buch. However, it differs from these species in one or the other characters. It has been named as *Phoenicicaulon mahabalei* gen. *et* sp. nov. The generic name indicate its affinity with *Phoenix* L. The species is named in honour of Professor T.S. Mahabale.

Diagnosis

***Phoenicicaulon* gen. nov.**

Permineralized leaf axis with broadly concavo-convex flattened cross sectional area with central dorsiventral ridge and long, narrow wings. Compact arrangement of fibrovascular, trace, diminutive and fibre bundles. Highly compact arrangement of fibrovascular-fibre bundles in the ridge region; fibrovascular bundles with both dorsal and ventral fibrous sheaths, broadly elongated phloem and two metaxylem vessels. Ground parenchyma cells thin-walled, elongated with large intercellular spaces.

Genotype - Phoenicicaulon mahabalei gen. *et* sp. nov.

***Phoenicicaulon mahabalei* sp. nov.**

Leaf axis smooth without any appendages. Broadly lunate in cross sectional view; concave adaxially and convex abaxially with central dorsiventral ridge. Cortex thin, 260-624 µm. Vascular region wide. Peripheral vascular zone 0.52-0.83 mm thick with radial arrangement of vascular bundles. Central vascular zone 5.5-6.0 mm thick with compact arrangement of fibrovascular bundles; distribution 800-1200/cm^2; highly compact in the ridge area; distribution 3200-4500/cm^2, consisting of normal fibrovascular, trace, diminutive, fusion and fibre bundles. Fibrovascular bundles oval to elongated or deformed in shape due to overcrowding, 468x468-750x300 µm with both dorsal and ventral horse-shoe shaped sclerenchyma, single elongated phloem, two large metaxylem vessels, 1-5 protoxylem elements. F/V ratio 0.5/1-0.71/1. Ground tissue parenchymatous with thin-walled elongated loosely packed cells.

Holotype - U 35/90, Botany Group, Plant Sciences Division, Agharkar Research Institute, Pune-411004, India.

Locality - Umaria, District Mandla, M.P., India.

Horizon - Deccan Intertrappean Series.

Age - Upper Cretaceous (Maastrichtian).

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