Arecoideostrobus moorei gen. et sp. nov., a palm rachilla from the Deccan Intertrappean beds of India

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A petrified part of a rachilla from an inflorescence of Areaceae has been described from the Deccan Intertrappean beds exposed at Nawargaon-Maragsur area of Wardha District, Maharashtra, India. The inflorescence shows a spiral arrangement of flower triads, each triad in a pit with a central large pistillate flower having a two-whorled perianth and a superior ovary flanked on either side by a small staminate flower. The inflorescence axis exhibits wide variable cortex with fibre bundles and empty sacs, a reduced vascular region with a very compact arrangement of fibrovascular bundles, floral traces and diminutive and fusion bundles enclosing a small pith. Morphological and anatomical characters of the rachilla suggest its affinity with the members of sub-family Arecoideae of the family Areaceae.

Key words—Arecoideostrobus, Rachilla, Areaceae, Deccan Intertrappean beds, Palaeogene (India).

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THE Deccan Intertrappean beds exposed at Nawargaon-Maragsur area (21°01' North; 78°35' East), district Wardha, Maharashtra, are very rich in angiospermic plant fossils. Of them, Palmoxyylon nawargaonensis Shukla 1941, P. sclerodermum Sahni (Shukla, 1946: Shete & Kulkarni, 1983), P. intertrappeum Sahni 1964, P. livistonoides Prakash & Ambwani 1980, P. aruensis Ambwani 1981 and P. hyphaeneoides Rao & Shete 1989 are palm stems; Parapalmocaulon costapalmatum (Kulkarni & Patil, 1977a) Bonde 1987 and P. hyphaeneoides (Shete & Kulkarni, 1980) Bonde 1987 are palm petioles; Sabalophyllumlivistonoides Bonde 1986a is a coryphoid leaf rib; Palmocarpon coryphoidium Shete & Kulkarni 1985 is a coryphoid palm fruit and Culminites eleusineoides Bonde 1986 is a gramineous stem. Besides, a number of dicotyledonous woods have been described from this area by Kulkarni and Patil (1977), Shete and Kulkarni (1982), Bande and Prakash (1984), Prakash et al. (1986) and Bande (1987). Unionaspermum cortnieri Bonde 1993a is the only dicotyledonous seed described from these beds.

Two petrified pieces of a rachilla of an inflorescence were collected from these beds and their transverse and longitudinal sections have been studied. The flower structure was examined in tangential planes of the rachilla. The sections were made by the usual thin ground method and observed under...
light microscope. Both the pieces of rachilla show identical morpho-anatomical characters and hence described here as belonging to the same species.

**SYSTEMATIC DESCRIPTION**

**Family—Arecaceae**

**Genus—Arecoideostrobus gen. nov.**

*Diagnosis*—Rachilla thin with spiral arrangement of flowers in triads in pits. Each triad consisting of a central pistillate flower flanked on either side by a staminate flower. Pistillate flower with a two whorled perianth, each whorl with three lobes and a superior ovary; staminate flower small. Rachilla axis thin, circular in cross section; cortex wide with fibre, fibrovascular bundles and empty sacs. Vascular region reduced with compact arrangement of vascular bundles; diminutive, trace and fusion bundles abundant.

**Type species—Arecoideostrobus moorei** sp. nov.

*Arecoideostrobus moorei* gen. et sp. nov.

*Pl. 1, figs 1-7; Pl. 2, figs 8-12*

*Diagnosis*—Inflorescence rachilla thin, 0.8-1.3 cm. Flower arrangement spiral in triads (short cincinnus) in pits, 1.2 x 1.5 cm in diameter, consisting of a large central pistillate flower flanked by a small staminate flower on either side. Pistillate flower 1.1 x 1.5 cm in diameter. Perianth in two whorls, outer with three thick connate sepals and inner with three petals. Ovary tricarpellary (?), superior. Male flowers 0.63 mm in diameter, sunken in the pit. Rachilla axis thin, circular, 0.8 cm. Periderm thin with fibrous strands. Cortex wide, variable in thickness, 900-2520 μm with fibre, fibrovascular and diminutive bundles. Mucilage sacs abundant, 84 x 110-190 x 230 μm. Fibre bundles round to elongated, 72 x 90-108 x 144 μm. Vascular region reduced, round, 0.44 x 0.44 - 0.5 x 0.5 cm. Fibrovascular bundles compact, more compressed at the periphery; pith small. Fibrovascular bundles oval to elongated, 252 x 216-450 x 342 μm with lunate dorsal sclerenchyma, thin ventral sclerenchyma, elongated phloem, two metaxylem and 0-3 protoxylem vessels; F/V ratio 2.87/1. Floral trace, diminutive and fusion bundles abundant. Distribution 750-1000/cm². Parenchyma cells thin-walled, isodiametric.

*Holotype*—N 90, Department of Botany, Agharkar Research Institute, G.G. Agarkar Road, Pune; Slide nos. N90 (1) to N90 (8).

*Type locality*—Nawargaon, Wardha District, Maharashtra, India.

*Type horizon*—Deccan Intertrappean beds.

*Age*—Palaeocene.

*Description*—Both the pieces of rachilla, one 3.7 cm long and 0.8-1.3 cm in diameter and the other 2.8 cm long and 0.9-1.3 cm in diameter, exhibit similar morphological as well as anatomical characters. These pieces appear to be the flowering parts of a large inflorescence as they show presence of cavities indicating presence of flowers on them. The larger piece of the rachilla shows 8 pits whereas the smaller specimen exhibits 6 pits arranged spirally in 3/8 phylloxy on the peripheral surface (Pl.1, figs 1, 2).

The tangential section of rachilla through pit exhibits flowers in triads (a short cincinnus of three flowers), whereas the cross section suggests their occurrence in pits. Each triad is 1.2 x 1.5 cm in size and consists of a large central pistillate flower flanked by two lateral staminate flowers.

The pistillate flower occupies the central position within the triad, 1.1 x 1.5 cm in diameter with central-gynoecium surrounded by a two whorled perianth (Pl. 1, fig. 3). Outer perianth whorl is incomplete with only one lobe, but its dimensions and shape suggest presence of three thin lobes in the whorl. It is 9.5 mm long and 4.85 mm wide at thickest region. It has epidermis with small cells, broad hypodermis and central parenchymatous region. Number of fibrovascular bundles alongwith few fibre bundles, floral traces and diminutive bundles are present in the central region. The fibrovascular bundle has well-developed dorsal sclerenchyma, elongated phloem and two metaxylem vessels. The inner whorl of perianth shows two lobes, the third one is destroyed during sectioning. Each of them is 9 mm long and 2 mm thick, having an epidermis and inner parenchymatous tissue with a few oblique vascular bundles. The flower has a receptacle having large number of air spaces in it. The section passing through the receptacle shows undifferentiated perianth whorls and a central gynoecium, 3.1 mm in
diameter. Many vascular traces and fibre bundles are present at the base. The vascular bundles have a large oval fibrous sheath. Tannin cells with dark contents are common in the ground tissue. Two male flowers, one on each side of the pistillate flower are present in a triad. They are immature and deeply sunken in the pit. Male flower is small, 0.63 mm in diameter. Number of perianth whors and stamens in a flower could not be seen. An elongated, oval undifferentiated mass probably the sporogenous tissue has also been observed (Pl.1, figs 4, 5). Other structures such as bract, bracteoles or nectaries were not clearly observed.

Anatomy of rachilla axis—The rachilla is entire, thin, 0.8-1.2 cm in diameter. It has thin periderm, wide but variable cortex and reduced central vascular region (Pl.1, figs 6, 7; Pl. 2, fig. 1). Periderm is 540-700 \( \mu m \) wide consisting of thick-walled radially elongated cells arranged in radial rows. Small fibre bundles are also present. Cortex is variable in width, 900-2520 \( \mu m \), widest at the node or at the base of the triad. Fibre bundles, a few fibrovascular and floral trace bundles are present in the thin-walled parenchymatous ground tissue. The parenchyma cells are elongated, 34 x 46 - 60 x 76 \( \mu m \) and present in radial rows. Empty circular to elongated sacs, 84 x 110-190 x 230 \( \mu m \), present throughout the cortical region. Fibrovascular bundles are oval, 215x190-285x265 \( \mu m \) in size. They have a lunate dorsal sclerenchymatous sheath, an elongated phloem, feebly developed ventral sclerenchymatous sheath, two metaxylem vessels and 1-3 protoxylem elements. Fibre bundles are round to elongated, 72 x 90-108 x 144 \( \mu m \). Diminutive bundles are small sized fibrovascular bundles, 130 x 95-170 x 110 \( \mu m \) in size having a small dorsal fibrous cap, a small phloem and 1-2 xylem elements. Most of the fibrovascular and diminutive bundles run obliquely to enter into the cincinnus (Pl. 1, figs 2, 3). Vascular region is reduced, round, 4.4x4.4-5.0x5.0 mm. The vascular bundles do not show a clear distribution into peripheral and central vascular zones. The fibrovascular, floral trace, diminutive and fusion bundles in general are compactly arranged throughout the vascular region but are more compact at the thin peripheral zone. A small pith is present in the centre. Fibrovascular bundles are oval to elongate, 252x216-450x342 \( \mu m \), consisting of both dorsal and ventral sclerenchyma, elongated phloem, two metaxylem vessels and 1-3 protoxylem elements. The dorsal sclerenchyma is well developed, lunate, 250x84-450x105 \( \mu m \), ventral sclerenchyma is poorly developed, lunate, 126x126-294x210 \( \mu m \); phloem is represented by an elongated to squarish cavity, 54x126-105x126 \( \mu m \); metaxylem vessels two, 38x67-63x75 \( \mu m \); and protoxylem elements one to three, 21x29-34x38 \( \mu m \). F/V ratio is 2.87/1 and their distribution is 750-1000 /cm\(^2\). Floral trace bundles are frequent. They are identical in their composition to the normal bundles but larger in size and elongated in shape, 396x360 - 630x450 \( \mu m \) and have two metaxylem and 4-8 protoxylem elements. Diminutive bundles many, 144x108-252x216 \( \mu m \), present throughout the vascular region and are generally associated with the floral trace bundles. They have a small lunate dorsal sclerenchyma, a small phloem cavity and 1-2 xylem elements. Fusion bundles are many and formed by union of 2-3 or more fibrovascular bundles of different orientations. They are 360-540x720-900 \( \mu m \) (Pl. 1, fig. 4). Pith is small and compact. The cells are parenchymatous, isodiametric to elongated, 21x29-65x126 \( \mu m \). The vessels show oblique end plates with 8-12 cross bars (Pl. 1, fig. 5). Tabular and radiating parenchyma and stegota were not observed but tannin cells with dark contents are abundant in both cortical and vascular regions.

**DISCUSSION**

The diagnostic characters of the present inflorescence such as thin but woody nature of the rachilla,

**PLATE 1**

*Arecoides* *strobus* *moorei* gen. et sp. nov.

1, 2. Pieces of rachilla showing floral pits x N.S. (approx).
3. Transverse section of pistillate flower showing central gynoecium surrounded by two perianth whors. Outer perianth —op and inner perianth—ip x 8.
4. Longitudinal section of floral triad showing bases of two staminate flowers deeply embedded in the cortex x 45.
5. Longitudinal section of staminate flowers showing undifferentiated tissue x 45.
6, 7. Transverse section of rachilla showing floral pit - P deep seated in the cortex and central vascular region x 8.
structure of vascular bundles and flower arrangement in triads having central large pistillate flower flanked by a small staminate flower suggest its affinity with sub-family Arecoideae of Arecaceae (Cheadle & Uhl, 1948; Uhl & Dransfield, 1987; Tomlinson, 1990).

Comparison with fossil palms—Mahabale (1950) reported a petrified floral axis of a palm from Mohgaonkalan beds. He compared it with Cyclanthodendron sahni and Carludovicapalmata of Cyclanthaceae. It may be stated here that Cyclanthodendron sahni now has been proved to be a member of Scitamineae (Biradar & Bonde, 1990). In the same year, he (Mahabale, 1950) reported a mould of palm inflorescence comparing it with the inflorescences of Bactris and Hyphaene and proposed the name Palmostrobus for this impression.

Petrified inflorescence axes of Arecaceae have been described under four species of the organ genus Palmostroboxylon Biradar & Bonde. P. indicum Biradar & Bonde 1979 is a primary axis of phoenicoid palms, P. arengoidum Ambwani 1984 resembles Arenga of Caryotoid palms, whereas P. umariense Bonde 1990 and P. sahni Bonde 1995 show their resemblance with Coryphoid palms. All these fossils are the primary axes of the inflorescence described from the Deccan Intertrappean beds of India. The present fossil is a part of rachilla and therefore differs from them.

Monocotylostrobus bracteatus Lakhanpal et al. 1982 is a racemose inflorescence with three whorled trimerous perianth and a subtending bract in each flower. Its affinity has been suggested with Palmae and Liliaceae. The number of perianth whorls in a flower and flower arrangement on the inflorescence axis whether in singles, diads, triads or in cincinnati could be best seen in the cross section of the spikelet or rachilla. A perianth in two whorls is a universal character in Palmae (Tomlinson, 1990) and also in Liliaceae (Dahlgren et al., 1985). The authors have ruled out its affinity with Liliaceae on account of woody nature of the inflorescence. The basal most whorl of perianth (lowermost of three whorls) in M. bracteatus could be a whorl of bracteoles. Presence of well developed bract, bracteoles and flower arrangement in triads on the rachilla are the distinctive features of sub-family Arecoideae (Uhl & Dransfield, 1987). Therefore, M. bracteatus could be a member of Arecoideae of the family Arecaceae.

Comparison with living palms—Arecoideae is the biggest sub-family of Arecaceae comprising about 1500 species belonging to 124 genera and 6 tribes. Each tribe has a characteristic number of peduncular bracts. The present fossil is a part of a rachilla and does not show any peduncular bract. Its resemblance with any tribe or genus could not be traced as the presence of a bract or bracteoles is not clear in the triads. However, the occurrence of three flowers in a pit, structure of perianth lobes and gynoecium suggests its affinity with the tribes Caryoteae, Areceae, Cocoeae and Geonomeae.

Very little work on the anatomy of inflorescence axes and appendages of palms has been done so far. Micheels (1992) studied anatomy of 12 palms in relation to support the fruit loads. Tomlinson and Zimmermann (1968) studied the vascular anatomy of Rhapis excelsa in three dimensional view. Inflorescence and floral anatomy of palms belonging to Arecoideae have been studied by Udawadia (1951), Shirke (1963), Kulkarni (1965), Uhl (1966, 1971, 1976), Uhl and Moore (1977) and Uhl and Dransfield (1984). The fossil material was compared with Archontophoenix cunninghamii, Areca catechu, Asterogyne spinata, Butia yatay, Caryota mitis, C. plumosa, C. rumphiana, C. sobolifera, C. urens, Chrysalidocarpus lutescens, Cocos nucifera, Howea belmoreana, Pinanga kuhlri, Ptychosperma mooreanum, Roystonea regia, Syagrus coronata, S. romanzoffiana and S. schizophylla. Of them, the fossil resembles Caryota plumosa and Caryota urens in having broad cortex with fibre bundles, empty sacs

**PLATE 2**

*Arecoideostrobus moorei gen. et sp. nov.*

1. Transverse section of rachilla showing wide cortex and reduced vascular region x 8.
2. Transverse section showing empty sacs and fibre bundles in cortex x 50.
3. Transverse section showing compact arrangement of vascular bundles in peripheral vascular zone x 60.
4. Transverse section through vascular region showing fusion, floral trace, diminutive and normal vascular bundles x 60.
5. Longitudinal section showing vessel endplate – E x 150.
PLATE 2
(possibly of mucilage), radially elongated parenchyma; a reduced vascular region having round to oval fibrovascular bundles with dorsal and ventral lunate sclerenchyma and compact arrangement of fibrovascular bundles. But differs from them in detailed vascular structure, number of metaxylem vessels, F/V ratio, distribution of vascular bundles and ground parenchyma. Thus more work on the living palms is needed in finding out the affinity of the present fossil material. However, it has been described as *Arecoideostrobus moorei* gen. et sp. nov. The generic name indicates its affinity with sub-family Arecoideae and the specific epithet is after Dr H.E. Moore (Jr.) known for his work on extant palms.

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