
Arecoideostrobis 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 Arecaceae 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 Arecaceae.

Key-words—*Arecoideostrobis*, Rachilla, Arecaceae, Deccan Intertrappean beds, Palaeogene (India).

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सारांश

भारत के दक्खन अन्तर्द्वीपी संस्तरों से ताड़ का एक रैकिला—*अरेकॉयडिओस्ट्रोबिस मूराई* नव प्रजाति व जाति
एस० डी० बोंडे

महाराष्ट्र में वर्धा जनपद के नवरगाँव-मोरगसुर क्षेत्र में अनावरित दक्खन अन्तर्द्वीपी संस्तरों से अरेकेसी कुल के पुष्पविन्यास के एक अश्मीभूत रैकिला का वर्णन किया गया है। इस पुष्पविन्यास में त्रिफलकी पुष्प चक्रीय रूप में विन्यस्त हैं। पुष्पक्रम अक्ष में कोर्टेक्स में तन्तु बंडल, रिक्तिकायें, सघन तन्तुवाही बंडलों से युक्त एक हासित वाहिनीकीय क्षेत्र आदि मज्जा को चारों ओर से घेरे हुए हैं। आकारिकीय एवं शारीरीय लक्षणों के आधार पर यह रैकिला अरेकेसी कुल के उपकुल अरेकॉयडी के सदस्यों से सजातीयता व्यक्त करता है।

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, *Palmoxylon nawargaonensis* Shukla 1941, *P. sclerodermum* Sahnii (Shukla, 1946; Shete & Kulkarni, 1983), *P. intertrappeum* Sahnii 1964, *P. livistonoides* Prakash & Ambwani 1980, *P. arviensis* 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; *Sabalophyllum livistonoides* Bonde 1986a is a coryphoid leaf rib; *Palmocarpon coryphoidium*

Shete & Kulkarni 1985 is a coryphoid palm fruit and *Culmites 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). *Unonasperrum corneri* Bonde 1993a is the only dicotyledonous seed described from these beds.

Two silicified 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—*Arecoideostrobis* 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—*Arecoideostrobis moorei* sp. nov.

Arecoideostrobis 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 tricarpeal (?), 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 μ m with fibre, fibrovascular and diminutive bundles. Mucilage sacs abundant, 84 x 110 - 190 x 230 μ m. Fibre bundles round to elongated, 72 x 90 - 108 x 144 μ m. 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 μ m 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. Dis-

tribution 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 phyllotaxy 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 along with 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 either 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 whorls 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 μm 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 μm , 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 μm and present in radial rows. Empty circular to elongated sacs, 84 x 110-190 x 230 μm , present throughout the cortical region. Fibrovascular bundles are oval, 215x190-285x265 μm 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 μm . Diminutive bundles are small sized fibrovascular bundles, 130 x 95-170 x 110 μm 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. 2, 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 μm , 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 μm , ventral sclerenchyma is poorly developed, lunate, 126x126-294x210 μm ; phloem is represented by an elongated to squarish cavity, 54x126-105x126 μm ; metaxylem vessels two, 38x67-63x75 μm ; and protoxylem elements one to three, 21x29-34x38 μm . 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 μm and have two metaxylem and 4-8 protoxylem elements. Diminutive bundles many, 144x108-252x216 μm , 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 μm (Pl. 2, fig. 4). Pith is small and compact. The cells are parenchymatous, isodiametric to elongated, 21x29-63x126 μm . The vessels show oblique end plates with 8-12 cross bars (Pl. 2, fig. 5). Tabular and radiating parenchyma and stegmata 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

Arecoideostrobus moorei gen. et sp. nov.

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| 1, 2. Pieces of rachillae showing floral pits x N.S. (approx). | flowers deeply embedded in the cortex x 45. |
| 3. Transverse section of pistillate flower showing central gynoecium surrounded by two perianth whorls. Outer perianth — <i>op</i> and inner perianth— <i>ip</i> x 8. | 5. Longitudinal section of staminate flower showing undifferentiated tissue x 45. |
| 4. Longitudinal section of floral triad showing bases of two staminate | 6, 7. Transverse section of rachilla showing floral pit - <i>P</i> deep seated in the cortex and central vascular region x 8. |



PLATE 1

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 sabnii* and *Carludovica palmata* of Cyclanthaceae. It may be stated here that *Cyclanthodendron sabnii* 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. sabnii* 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 cincinni 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 gynoeceum suggests its affinity with the tribes Caryoteae, Arecaceae, 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 Udwardia (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 spicata*, *Butia yatay*, *Caryota mitis*, *C. plumosa*, *C. rumphiana*, *C. sobolifera*, *C. urens*, *Chrysalidocarpus lutescens*, *Cocos nucifera*, *Howea belmoreana*, *Pinanga kublii*, *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 60.
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.

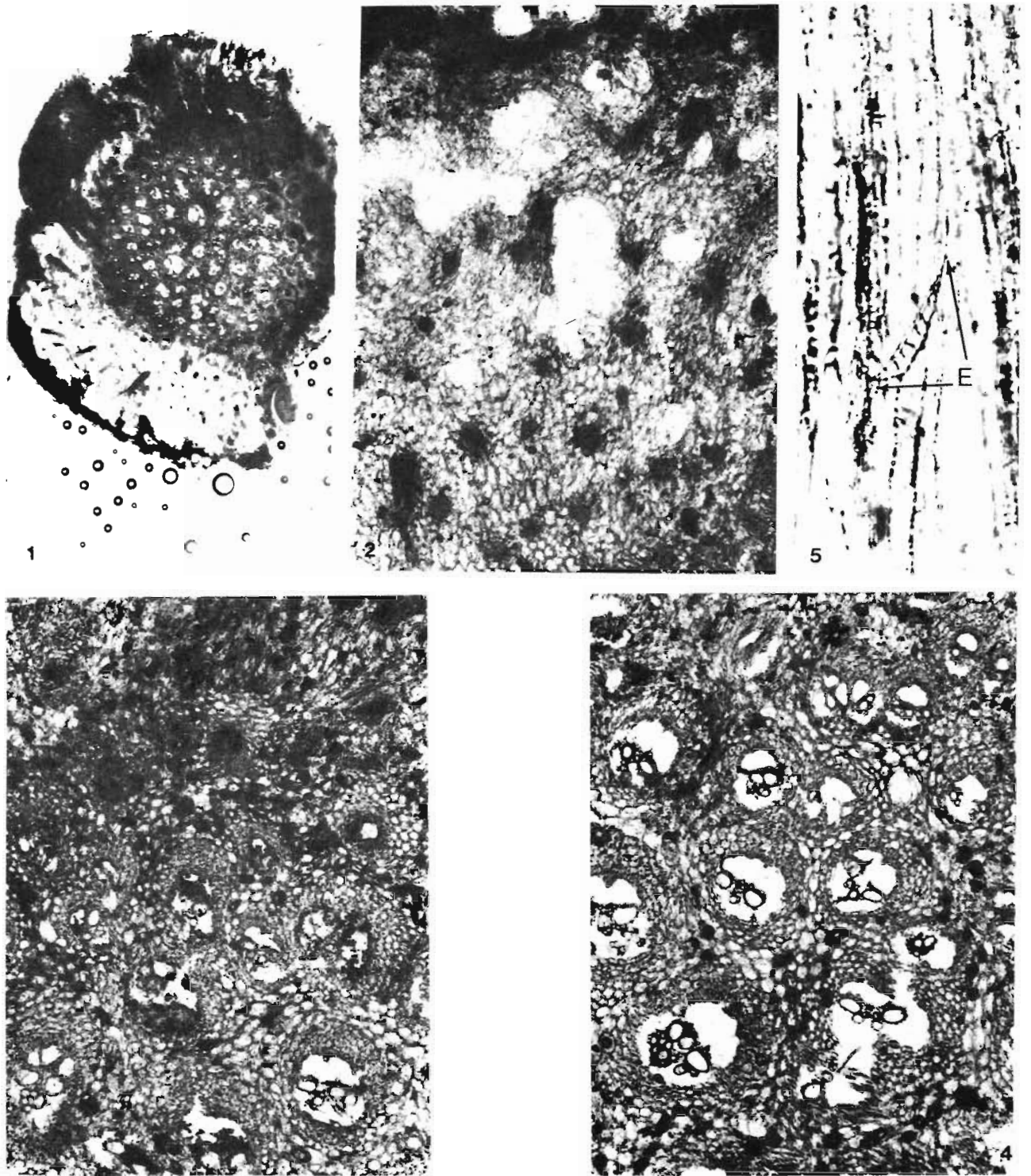


PLATE 2

(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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