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# *Palmostroboxylon deotamuraensis* sp. nov., a new cocoid fossil palm peduncle from the Tipam Sandstone (Late Miocene) of Tripura, North-East India

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## ABSTRACT

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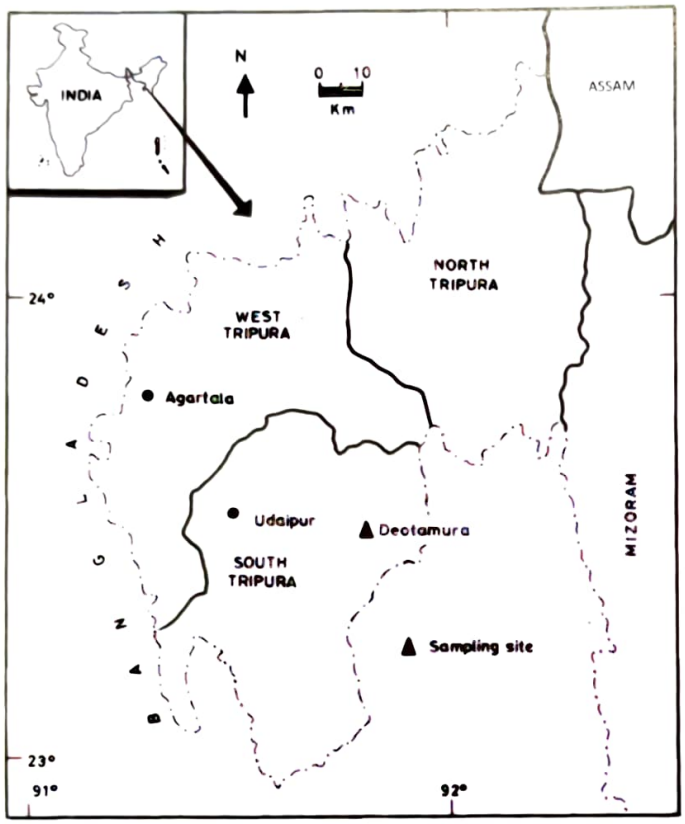
A new species of fossil palm peduncle, *Palmostroboxylon deotamuraensis* sp. nov., belonging to cocoid group of family Arecaceae, has been described from the Tipam Sandstone (Late Miocene) of Deotamura, Amarpur District, South Tripura, India. The fossil peduncle is characterized by presence of fibrovascular bundles with two metaxylem vessels. The ground tissue gradually tends to become slightly spongy towards inner zone and encompasses the fibrovascular bundles, diminutive as well as fused bundles. Leaf trace bundles are present in both inner and outer parts of the axis. Stegmata (phytoliths) are noted in the fibrovascular bundles. Fibrous bundles are profusely present throughout the ground tissue.

**Key-words:** Fossil cocoid palm peduncle, *Palmostroboxylon deotamuraensis* sp. nov., Tipam Sandstone, Late Miocene, Deotamura, Tripura, India.

## INTRODUCTION

A large number of fossil palms have been reported from different parts of India (Sahni 1931, 1943, 1944, 1946, 1964, Kaul 1933, Rode 1933, Shukla 1939, 1946, Trivedi & Verma 1971a, b, Awasthi 1974, Chitaley 1974, Prakash 1974, Lakhanpal et al. 1979, Ambwani & Prakash 1983, Ambwani 1983, 1984a, b, c, Bonde 1987, 1990, 1995, Bonde et al. 2004, Mandaokar et al. 2012). In addition, petiole and peduncle have been reported from Dongargaon, Chanda district, Maharashtra by Biradar and Bonde (1979). The specimen described here constitutes the first record of fossil palm peduncle from the Late Miocene sediments of Tripura, North-East India (Text-figure 1).

A large number of dicotyledonous fossil woods are also found in Tipam Sandstone (Late Miocene) of Deotamura, Tripura. Only a few fossil woods have been recorded from near Khowai bridge, Telimura near Agartala in the West Tripura and Dumbur near Amarpur in the South Tripura. Taxa reported from the Miocene sediments are *Gluta* (Ghosh & Taneja 1961), *Afzelia intsia* (Ghosh & Kazmi 1961), *Cassia* and *Millettia* (Acharya & Roy 1986) and *Cynometra* (Awasthi et al. 1994). These belong to Fabaceae and Dipterocarpaceae (Mehrotra & Bhattacharyya 2002, Mehrotra et al. 2006). There is no published record of plant megafossils from Deotamura area. The authors collected, for the first time, several fragmentary woods from the area.




**Text-figure 1.** Map of Tripura, showing fossil locality.

## GEOLOGICAL SETTING

The oldest stratigraphic unit in Tripura is represented by Surma Group. It is divided into Bhuban (Early Miocene) and Bokabil (Middle Miocene). The Surma is conformably overlain by Tipam Group. The latter is differentiated from Bokabil by the common occurrence of arenaceous sediments. This group is divided into lower Tipam Sandstone, comprising mainly coarse grained massive sandstone, and upper Girujan Clay, consisting of mottled clays with subordinate argillaceous sandstone. The overlying Dupitila Formation consists of coarse grained, poorly consolidated ferruginous sandstones intercalated with brown mottled clays. This is unconformably overlain by the Dihing Formation (Late Pliocene-Early Pleistocene) and consists essentially of conglomerates with thin bands of sandstones and clays. The generalized geological succession of Tripura is given in Table 1.

**Table 1. Generalized stratigraphic succession in Tripura (After Director General, Geological Survey of India 1974).**

| Group | Formation | Lithology |
|---|---|---|
| Recent | Recent | Alluvium represented by unconsolidated, pale to dirty grey silt, sand, clay, silty clay, sandy clay, sometimes with decomposed vegetable matters and yellowish brown coarse river sand, gravels and concretions. |
| | | ---------- Unconformity ---------- |
| Dupitila | Dupitila | Earthy- brown to buff sandy clays with greyish brown to reddish brown sand loam, mottled sandy clays, clayey sandstone, coarse to gritty ferruginous sandstone including lenticular bands, and pockets of bluish to grey plastic clays, white silica sand and laterites. |
| | | ---------- Unconformity ---------- |
| Tipam | Champanagar | Massive, medium to coarse, friable, sub-arkosic sandstone with occasional laminae of sandy shale and abundant lumps of silicified fossil woods. |
| | | ---------- Contact gradational ---------- |
| | Manu Bazar | Fairly bedded, fine to medium, sub-arkosic sandstone, including laminated layers and thick lenticular bands of sandy shale, siltstone and sandy mudstone. |
| | | ---------- Contact transitional ---------- |
| Surma | Bokabil | Thinly laminated and thinly bedded repetition of sandstone, siltstone/ shale alternation, shales, mudstone and ferruginous sandstone with irregular partings of fine to coarse sand and interstratified thick, occasionally lenticular horizon of medium to coarse, micaceous sandstone with mudstone. |
| | | ---------- Contact gradational to transitional ---------- |
| | Bhuban | Indurated, hard, compact, both massive and well bedded sandstones, dark to olive shale, sandy shale and siltstone repeatedly occurring in space. |
| | | ---------- Base not seen ---------- |

## MATERIAL AND METHOD

The fossil specimen, collected from Deotamura area of South Tripura, is cylindrical in shape, about 5 cm long and 4 cm in diameter, and shows a complete cross section. The epidermal and cortex parts are not preserved. Anatomically, it can be divided into two main parts, the outer and the inner zones. For detailed anatomical study, the specimen was cut into thin sections along transverse and longitudinal planes (TS and LS). These sections were ground and polished using carborundum powder of different grades. All the slides and specimens are stored in the museum of the Birbal Sahni Institute of Palaeobotany, Lucknow.

## SYSTEMATIC DESCRIPTION

**Monocotyledonae**

**Family: Arecaceae**

**Genus: *Palmostroboxylon* Biradar & Bonde 1979**

***Palmostroboxylon deotamuraensis***
**B. D. Mandaokar & K. Ambwani, sp. nov.**

Plate 1, figures 1-14

**Specific diagnosis**: Specimen complete, 5 cm long, 4 cm in diameter, divisible into two zones, outer (1.5 cm thick) and inner (2.5 cm thick). Fibrovascular bundles irregular, 100 x 150 to 130 x 180 µm, 120-150 per cm², f/v ratio 2:1-1:1 to 1:1-1:3. Dorsal sclerenchymatous sheath, reniform-type, median sinus concave, auricular sinus indistinct, 1-2 metaxylem vessels present in a bundle. Tabular parenchyma, stegmata (phytoliths), diminutive bundles, fusion and leaf trace bundles present. Fibrous bundle profuse in outer zone but less frequent in inner zone; ground tissue compact to spongy.

**Description: Outer zone**: The fossil palm peduncle has a narrow zone, about 1.5 cm thick. The fibrovascular bundles are generally irregularly oriented, mostly oval in shape; 100 x 150 - 130 x 180 µm in size; their frequency varies from 150 - 200 per cm². The fibrovascular ratio ranges from 2:1 to 1:1. The dorsal sclerenchymatous sheath is generally thick walled and the cells are weakly preserved to show details, however when suitably preserved, show sclereids with very thick walls (Plate 1, figures 1-5). The dorsal sclerenchymatous sheath is well developed and reniform-type. The median sinus is concave and the auricular sinus is indistinct or absent. Mostly two metaxylem vessels are present in each fibrovascular bundle, sometimes a single vessel can be seen in a vascular bundle (Plate 1, figure 3). The number of protoxylem vessels may extend up to eight (Plate 1, figure 6). A single cell layer of tabular parenchyma may be seen around the fibrous sheath of the bundle. Stegmata (phytoliths) may be seen in this zone. Phloem is moderately preserved and is seen in a single patch enclosed between xylem and sclerenchymatous sheath. The diminutive and leaf -trace bundles are frequent. Fusion bundles are also present in this zone. The fibrous bundles are abundantly present in the ground tissue (Plate 1, figures 2, 10). **Inner zone**: This zone is wider than the outer zone and measures about 2.5 cm thick. The shape of these bundles is generally oval. The fibrovascular bundles in this zone are 100 x 150 - 130 x 150 µm in size and their frequency varies from 120 to 150 per cm². The f/v ratio is generally 1:1 to 1:3. The dorsal sclerenchymatous sheath is generally thick walled and the cells are poorly preserved to show details, however when suitably preserved, show sclereids with very thick cell wall. The dorsal sclerenchymatous sheath is well developed and reniform-type. The median sinus is concave and the auricular sinus is indistinct or absent. Mostly, two metaxylem vessels are present in each fibrovascular bundle, sometimes only a single vessel can be seen (Plate 1, figure 11). The number of protoxylem vessels may extend up to ten. A single cell layer of tabular parenchyma may be seen around the fibrous sheath of the bundle. Stegmata (phytoliths) may be seen in this zone. Phloem parenchyma is moderately preserved forming single patch. These sclerenchyma cells have comparatively small lumen. The diminutive and leaf- trace bundles are present. Fusion bundles are also present in this zone, while the fibrous

bundles are abundantly present in the partially lacunar ground tissue. Leaf-trace bundles are present with 6-8 xylem vessels (Plate 1, figures 8-9). The metaxylem vessels possess scalariform thickenings while protoxylem shows spiral to annular thickenings and the perforation plates have 4-6 bars (Plate 1, figure 13). **Ground tissue**: Ground tissue in the outer zone is composed of compact parenchymatous cells. The cells of this zone are isodiametric. Sometimes, some cells of variable shapes may be present while those of inner zone are slightly lacunar showing the intercellular spaces. At places, the cells are stretched forming a rosette like glandular appearance (Plate 1, figures 2, 11). **Diminutive fibrovascular bundles:** The diminutive fibrovascular bundles are frequently distributed throughout the ground mass. These are distinguished in having smaller size as compared to the normal fibrovascular bundles. They show irregular orientation. Each diminutive bundle reveals similar structure to that of normal bundles. The size of these bundles ranges from 120 x 80 to 100 x 70 μm having only single metaxylem vessel. (Plate 1, figures 2, 11). **Leaf-trace bundles**: The Trace-bundles can be seen sometimes scattered in the outer zone only. These bundles can be recognized by their enlarged vascular structure to that of the normal fibrovascular bundles, these can be as large as up to 1 mm in size (Plate 1, figures 6, 8). **Fibrous bundles**: Fibrous bundles are profusely seen throughout both in the outer and inner zones. Each fibrous bundle is comprised of 10 to 20 small cells ranging from 70 to 80 μm in diameter (Plate 1, figures 10, 12).

**Holotype:** BSIP Specimen No. 40108/1-3, stored in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow, Plate 1, figures 1-14.

**Type locality:** Deotamura, South Tripura. India.

**Horizon and age:** Tipam Sandstone Formation, Late Miocene.

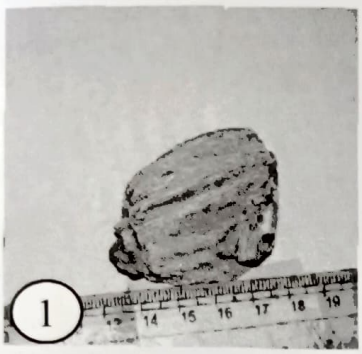
## COMPARISON

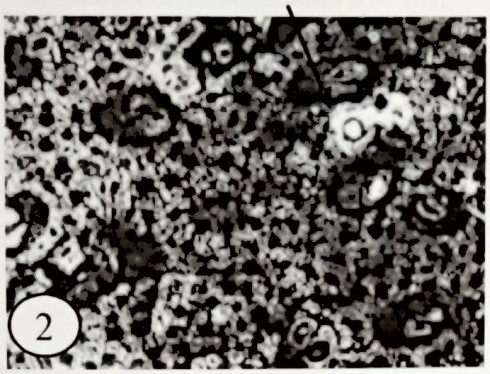
**Comparison with other species of *Palmostroboxylon*:** *Palmostroboxylon deotamuraensis* differs from *P. indicum* in having greater frequency of the fibrovascular bundles, both in outer and inner zones. The size of the fibrovascular bundles is much smaller in the present species and the ground tissue gradually becomes spongy towards the inner zone, while in *P. indicum* it is compact and the cells are isodiametric. The present species also shows differences from *P. arengoidum* because it has smaller size of fibrovascular bundles with less frequency. The f/v ratio is slightly higher while the ground tissue tends to be lacunar, it is also compact in *P. arengoidum*. *P. deotamuraensis* differs from *P. umariense* in having greater number of fibrovascular bundles whereas the f/v ratio is less and the ground tissue is compact with isodiametric cells in *P. umariense*. *P. sahnii* shows anatomical differences in having very small number of fibrovascular bundles per $cm^2$ and greater f/v ratio while the ground tissue is also compact. It is also noted that the ground parenchyma in *P. umariense* is scanty and the end plate perforation bars are greater in number than those in the above mentioned species (Table 2).

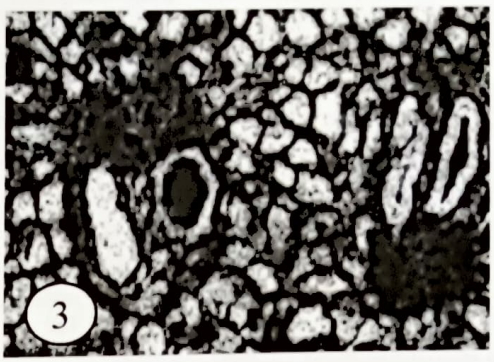
→

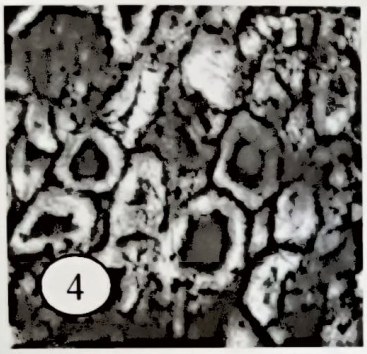
## Plate 1

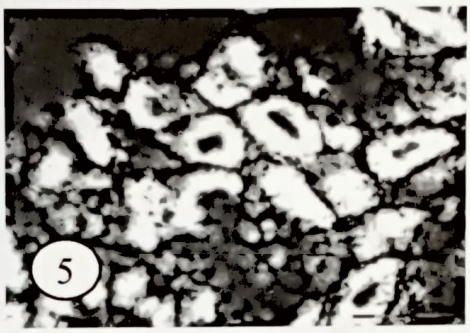
1-14. *Palmostroboxylon deotamuraensis* sp. nov. 1. Fossil specimen. 2. Cross section of outer zone (indicated by arrow), showing distribution of fibrovascular bundles and compact ground tissue with profusely fibrous and diminutive bundles. 3. Fibrovascular bundles with two metaxylem vessels and compact ground tissue. 4. Cells of dorsal sheath of fibrovascular bundles. 5. Cells of fibrous sheath, showing small lumens. 6. Leaf-trace bundles of outer zone, showing multiple number of protoxylem vessels and leaf traces. 7. Stegmata (phytolith), shown by arrow, in the fibrous sheath of the fibrovascular bundles. 8. Inner zone, showing six to eight xylem vessels forming leaf-trace bundles. 9. Fibrovascular bundles of inner zone, showing two metaxylem vessels and slightly spongy ground tissue. 10. Part of outer zone, showing fibrous bundles with fibre cells. 11. Cross section of inner zone (shown by arrow), showing distribution of fibrovascular bundles dispersed in slightly spongy ground tissue with fibrous bundles and diminutive bundles. 12. Fibrous bundles of inner zone, showing large number of fibrous cells. 13-14. Metaxylem vessels, showing scalariform thickening and four to six oblique bars in perforation plates.

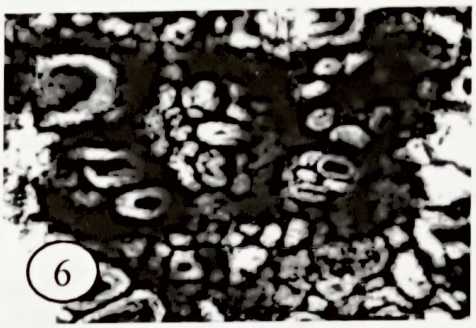


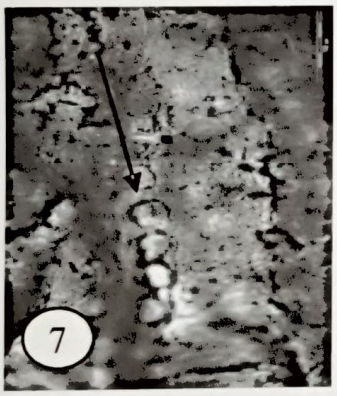



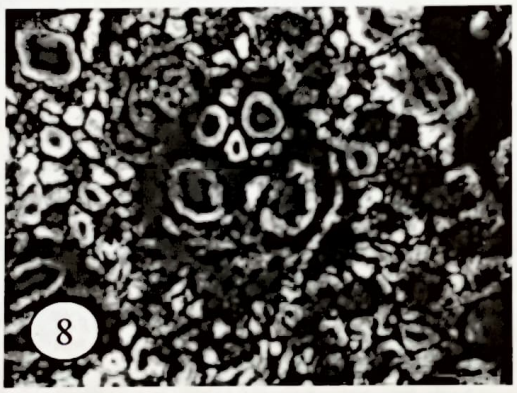



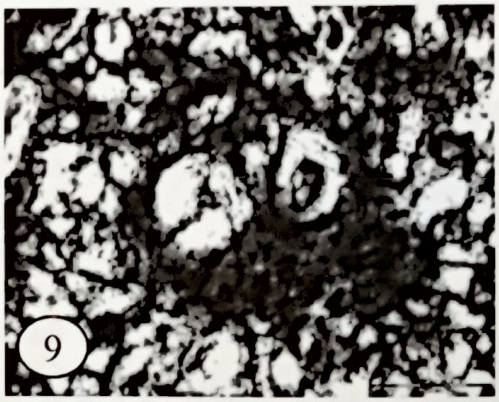



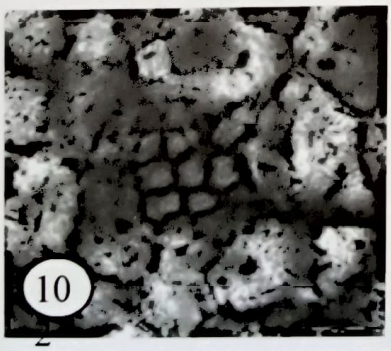



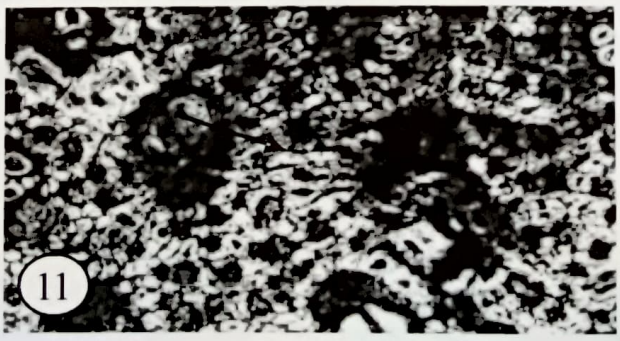



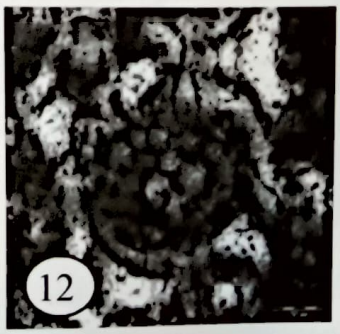





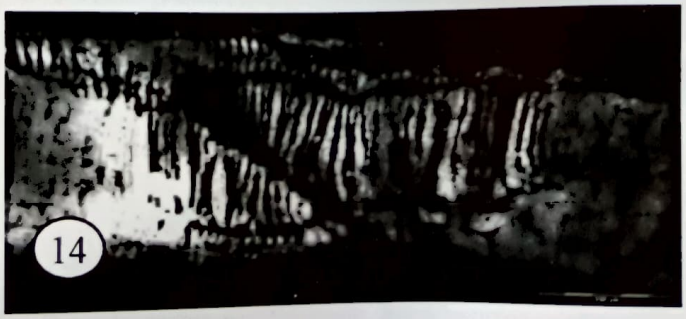



**Plate 1**

**Table 2. Comparison of *Palmostroboxylon deotamuraensis* sp. nov. with other species of *Palmostroboxylon*.**

| Genus/ species | Stenzel's cassification (1904) | Frequency of FVBs/cm | Size of FVBs (µm) | FVB Ratio | Fibrous bundles and stegmata | Ground Tissue | Affinities |
|---|---|---|---|---|---|---|---|
| *Palmostroboxylon indicum* Biradar & Bonde 1979 | Reniform to lunate | O = 100-125<br>I = 85-140 | O = 430x280<br>I = 88 x 90-111 x 87 | O = 2:03/1<br>I = 0.96/1 | absent | Compact, thin walled | Phoenicoid |
| *Palmostroboxylon arengoidum* Ambwani 1984 | Lunaria | O = 200-250<br>I =150-200 | O = 200x200-300x400<br>I = 400x400-400x600 | O= 1:1<br>I= 1:1 or less | Both absent | Compact throughout | Caryotoid |
| *Palmostroboxylon umariense* Bonde1990 | Lunaria | O= 117-160<br>I=107-115 | - | O=1.4/1<br>I=1.7/1 | Not known | Compact cells isodiametric | - |
| *Palmostroboxylon sahnii* Bonde1995 | Lunaria | O=2125-2375<br>I=1326-1600 | O=216x180-390x216<br>I=360x234-468x306 | O=1.147/1<br>I=0.35/1 | Not known | Compact with elongate cells | (Palmae) Arecaceae |
| *Palmostroboxylon deotamuraensis* sp. nov. | Lunaria Reniformia | O=150-200<br>I=120-150 | O= 100x150µm<br>I=120x100µm | O= 1: 2:1<br>I= 1:1 | Both Present | O= compact<br>I= Slightly spongy | Arecoid |
| *Cocos nucifera* L. | Reniform to Sagittata | O=less than 50<br>I= 20-30 | O = Larger than 1000 µm<br>I = more than 1600 µm | O= usually1:1<br>I= 1:2 | Fibres absent, stegmata present | Compact cells isodiametric | Cocoid |
| *Elaeis guineensis* L. | Reniform | O=200-240<br>I=160-170 | O=380-400µm<br>I=250-300µm | O= 2:1<br>I= 1:1 | Both present | Compact, cells round sometimes slightly spongy | Cocoid |
| *Borassus flabellifer* L. | Reniform | O = 300-350<br>I = 250-275 | O = 1200-1600 µm<br>I = 900-12000 µm | O = 3:1<br>I = 2:1 | Both present | Compact to slightly spongy | Borassoid |
| *Sabal palmetto* Lodd. | Reniform | O = 130-210<br>I = 110-120 | O = 150 x 120 µm<br>I = 170 x 140 µm | O = 1:0.6<br>I = 1:1 | Both present | Generally compact | Sabaloid |

**Comparison with the extant palms:** The bactroid, borassoid, coryphoid and cocoid groups of family Arecaceae were considered for comparison with *Palmostroboxylon deotamuraensis*. These groups generally show two metaxylem vessels and reniform fibrous sheath in fibrovascular bundles, presence of fibrous bundles and stegmata (phytoliths). The vessel end plates have more than one septum and the ground tissue tends to be slightly spongy. It has been observed that *P. deotamuraensis* shows close relationship with the cocoid group of plants (*Elaeis*) and has been compared with *Elaeis guineensis*. Both, *P. deotamuraensis* and *Elaeis guineensis*, fall under Reniformia group and the frequency of the fibrovascular bundles is also similar in outer and inner zones. However, the size of the fibrovascular bundles slightly vary (may be due to more girth of the peduncle). The f/v ratio in both species is nearly the same whereas the ground tissue is slightly spongy in nature. It includes diminutive, fused and leaf-trace bundles. The metaxylem vessel ends show oblique perforation plates with multiple transverse bars. Presence of fibre bundles and phytoliths are noted in both the species (Table 2). Based on the above mentioned characters, it is surmised that the plants similar to *Elaeis guineensis* might have been growing around Deotamura area of Tripura. The plants of *Elaeis guineensis* grow in swamps and low land throughout tropical Africa, even Madagascar (Corner 1966) but it does not have preference for light coastal soils. Geologically, Upper Tipam Formation, as mentioned by Roy (1969), is deposited under near-shore conditions, which further supports the ecology and growth of these plants that were later fossilized in the area.

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