PALMOXYLON KAMALAM RODE FROM KONDHALI, DISTRICT NAGPUR, M.S., AND ITS RESEMBLANCE WITH OTHER PALMS

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ABSTRACT

The Paper gives an account of *Palmoxylon kamalam* Rode described from a new locality in the Deccan Intertrappean Series at Kondhali, near Nagpur. This is the largest and complete specimen of the tree trunk of *Palmoxylon kamalam* described so far. It shows transitional zone between dermal and subdermal zone, the subdermal zone and the central zone. This makes it possible to compare it with the entire T.S. of the stem of living palms. It was found that it greatly resembles with the stem of *Roystonea regia*. The sparse distribution of the fibrovascular bundles, their complanate dorsal caps and highly lacunar ground parenchyma bear a very close similarity with those in *Roystonea*. This genus is of South American origin and grows in marshy area or near lake. Looking to the fact that palms occur in such diverse areas they seem to have had more than one centre of origin.

INTRODUCTION

PALMOXYLON Kamalam Rode was found near Kondhali buried in a nalla. It is a much larger specimen than any hitherto described, measuring 36×24 cm and is an entire part of a whole tree-trunk. Its external surface is eroded and smooth and has no periderm or leaf scars (Pl. 1, Fig. 1). It was collected by one of us (T.S.M.) at Kondhali, 35 miles west of Nagpur from a nalla close to the intertrappean beds. It was not found *in situ* in the beds but drifted and buried in earth a little farther at another place.

DESCRIPTION

A cross-section shows sparsely distributed fibrovascular bundles and mesh-like ground parenchyma, typical of the species apparent even with the naked eye. The orientation and distribution of fibrovascular bundles indicate that the specimen (stem) has three zones: (A) transitional zone between the dermal and subdermal zone, (B) subdermal zone, and (C) central zone (Text-fig. 40, Pl. 1, Fig. 1).

(A) *Transitional zone between dermal and subdermal zones* — Fibrovascular bundles are sparsely distributed, oval, 376×264μ-364×260μ, regularly oriented 40-50 per cm.^{2} lying at a minimum distance of 520 μ. F/V ratio 1·5/0:5-2/0·5. Dorsal caps complanate, vascular part extruded with a single metaxylem element 36-80 μ (Text-fig. 2, Pl. 1, Fig. 4).

(B) *Subdermal zone* — This is 2·4 cm broad. Fibrovascular bundles circular to oval, 360×320μ-420×380μ, irregularly oriented and sparsely distributed, 20-24 per cm.^{2} lying at a minimum distance of 600 μ (Text-fig. 3, Pl. 1, Fig. 5). F/V ratio 2/1-2·2/1. Dorsal caps complanate, median sinus very shallow, vascular part extruded mostly with two metaxylem elements, 85 μ, rarely one. Phloem is poorly preserved as a single patch (Text-figs. 7-9, Pl. 2, Fig. 11).

Ground tissue is highly lacunar, its cells, 120×64μ-188×64μ, variously shaped — elongated, rectangular, rod-like and some 'V-' or T-shaped. The ground parenchyma cells around the fibrovascular bundles have more or less oval, large, intercellular spaces 144×80μ-168×176μ. The inter-cellular spaces in parenchyma increase as one goes towards the centre. They are separated by 1-2 cells thick trabeculae, which overlap and form typical petaloid arrangement of cells around the fibrovascular bundles in this species (Text-figs. 3, 15; Pl. 1, Figs. 6, 7; Pl. 2, Fig. 11).

(C) *Central zone* — Fibrovascular bundles are more or less oval, 504×424μ-400×352μ, irregularly oriented and sparsely distributed. They are 12-16 per cm.^{2} and lie at a minimum distance of 1040 μ (Text-fig. 4, Pl. 1, Fig. 6). Dorsal caps are complanate. Their auricular lobes are poorly developed. Median sinus is shallow enclosing a small patch of phloem. Vascular part extruded with 1-2 metaxylem elements 60-80 μ. F/V ratio 2/1-2·5/1 (Text-figs. 5, 11-13).

Ground tissue is highly lacunar, loose and mesh-like. Its cells 196×60μ-264×68μ are rectangular elongated, ' V '- or T-shaped. They are arranged around the fibrovascular bundles in such a way as to enclose oval to variously shaped intercellular spaces, 160×136μ-320×240μ. Their size increases progressively as they lie farther away from the fibrovascular bundles. The trabeculae in between the intercellular spaces are 1-2 cells broad. Such a distribution of the intercellular spaces around the fibrovascular bundles makes for the petaloid arrangement of a lotus flower which prompted Dr. K. P. Rode to name this species as *kamalam* which means lotus (Text-figs. 4, 18; Pl. 1, Fig. 6, Pl. 2, Fig. 13).

Leaf-trace bundles — These are present in the subdermal and central zones. They are 520×384μ-640×600μ. Dorsal caps are complanate, median sinus shallow, auricular lobes poorly developed. Phloem is rarely preserved. Vascular part is extruded with two metaxylem elements, 82-85μ and 3-4 protoxylem elements 35-42μ. Radiating parenchyma lies in 2-3 tiers around the vascular part of leaf-trace bundles (Text-figs. 6, 10, 14; Pl. 2, Fig. 12).

In longitudinal sections the ground parenchyma cells are horizontally elongated and disposed in vertical rows (Text-fig. 17, Pl. 1, Fig. 3). Xylem is very poorly preserved. Highly lacunar nature of the parenchyma, poor development and preservation of xylem suggest that this palm might have been growing in marshes or near ample source of water such as a lake.

IDENTIFICATION

There are no fibre bundles in the ground tissue of the present *Palmoxylon*. The dorsal caps of the fibrovascular bundles are complanate. According to Ünger's classification (1850) it is a soft palm and falls under the *Complanata* group of Stenzel (1904).

It shows some resemblance with *P. blanfordi* Schenk (1882), *P. mathuri* Sahni (1931), *P. geometricum* Sahni (1931), *P. edwardsi* Sahni (1931), *P. jammuense* Sahni (1932), *P. kamalam* Rode (1933), *P. hislopi* Rode (1933), *P. arcotense* Ramanujam (1953) and *P. chhindwarense* Prakash (1958) in having lacunar ground tissue. *P. mathuri* however is a hard palm. Likewise it differs much from *P. blanfordi*, *P. hislopi*, *P. arcotense*, *P. chhindwarense*, *P. geometricum* and *P. jammuense* as they all have reniform, lunate or cordate dorsal caps, whereas this palm has complanate dorsal caps. All these palms have lacunar ground parenchyma with large intercellular spaces, but they do not have regular rosette pattern of intercellular spaces around the fibrovascular bundles.

It rather shows closer resemblance with *P. edwardsi* in the nature of its ground tissue and disposition of intercellular spaces around the fibrovascular bundles and in the shape of dorsal caps. But it differs from it, as *P. edwardsi* is a hard palm. The present palm, therefore, is undoubtedly *P. kamalam* Rode. However, it is being recorded from a new locality (see Table). Besides this, the specimen is a large entire stem, and some new features of it, not previously recorded have been brought out. They are as follows:

Rode (1933) and Shukla (1939) pointed out that rosette arrangement of highly lacunar tissue around the vascular bundles in this palm is characteristic. They based their accounts of it on the specimens which were fragments from different parts of stem. The present specimen however, is important, in as much as, it is entire and is the largest piece of stem having a diameter 24 cm. showing all regions, viz. transitional zone between dermal and subdermal, subdermal and central zones. These were not known before, though many pieces of central zone were obtained and described by previous workers like Rode (1933), Shukla (1939), Sahni (1964), etc. They were also collected from far off locality in a reserved forest area between Pulpuldoh and Paraspani in the District Chhindwara. But none of them was entire piece of trunk showing all the regions together as described here. To this extent it is an addition to our knowledge of this palm, and its diagnosis, therefore, needs to be emended.

Emended Diagnosis of P. KAMALAM Rode:

A petrified piece of tree trunk 36×24 cm diameter, having transitional zone between dermal and subdermal zones, subdermal and central zones.

Transitional zone — 2 cm broad, fibrovascular bundles 376×264 μ oval, regular in orientation, but they are sparse in distribution, 40-50 per cm². Dorsal caps complanate, median sinus very shallow, vascular part extruded with a single metaxylem element 36-80 μ. F/V ratio 1·5/0·5-2/0·5. Ground tissue lacunar, cells having various shapes.

Subdermal zone — 2·5 cm broad. Fibrovascular bundles 360×320μ-420×380μ, oval to circular, sparse in distribution 20-24 per cm², irregular in orientation. Dorsal caps complanate, median sinus shallow, vascular part extruded with 1-2 metaxylem elements 85μ. Phloem rarely preserved. F/V ratio 2/1 : 2·2/1. Ground tissue highly lacunar, cells rectangular, elongated, ' V '- or 'Y'-shaped, intercellular spaces more or less oval, disposed around the fibrovascular bundles in the manner of petals of a lotus flower. Leaf-trace bundles rarely present.

Central zone— Fibrovascular bundles more or less oval, 504×424μ-400×352μ, very sparse in distribution, 12-16 per cm². Orientation irregular. Dorsal caps complanate, median sinus shallow, vascular part extruded with 1-2 metaxylem elements 60-80 μ. Phloem is a single patch, rarely preserved. F/V ratio 2/1-2·5/1. Ground tissue or pith highly lacunar.

Isotype — Specimen No. 234/TSM/KNDL. Museum, Department of Botany, University of Poona, Poona.

Locality — Kondhali, 40 miles west of Nagpur, in District Nagpur (Maharashtra State).

Horizon — Deccan Intertrappean Series.

Age — Eocene.

DISCUSSION

Among living palms *Palmoxylon kamalam* shows considerable resemblance with the genus *Roystonea* because of its ground tissue and fibrovascular bundles.

In the classification of palm stems Von Möhl (1845), Stenzel (1904) and Sahni (1938) utilized the shape of dorsal cap as a

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TEXT-FIG. 1 — T.S. of stem showing transitional zone between dermal and subdermal zones, subdermal and central zone × N.S.

TEXT-FIG. 2 — T.S. of transitional zone showing fibrovascular bundles — *fvb* with regular orientation and lacunar ground tissue *gt*. Note the complanate dorsal cap × 8.

TEXT-FIG. 3 — T.S. of subdermal zone showing two irregularly oriented fibrovascular bundles — *fvb*. Note the rosette disposition of the intercellular spaces around the fibrovascular bundles × 8.

TEXT-FIG. 4 — T.S. central zone showing two irregulary oriented fibrovascular bundles. Note the complanate dorsal cap and rosette disposition of intercellular spaces around the fibrovascular bundles × 8.

TEXT-FIG. 5 — A typical fibrovascular bundle from the central zone with complanate dorsal cap — *dc* and vascular part extruded with single metaxylem element — *mx* × 25.

TEXT-FIG. 6 — A leaf-trace bundle from the central zone with complanate dorsal cap and vascular part extruded with two metaxylem elements — *mx* and four protoxylem elements — *px*. Note the radiating parenchyma *rp* around the vascular part × 25.

TEXT-FIGS. 7-9 — Fibrovascular bundles from subdermal zone with 1-2 metaxylem elements × 8.

TEXT-FIG. 10 — A leaf-trace bundle from the subdermal zone × 8.

TEXT-FIGS. 11-13 — Fibrovascular bundles from the central zone with 1-2 metaxylem elements × 8.

TEXT-FIG. 14 — A leaf-trace bundle from the central zone × 8.

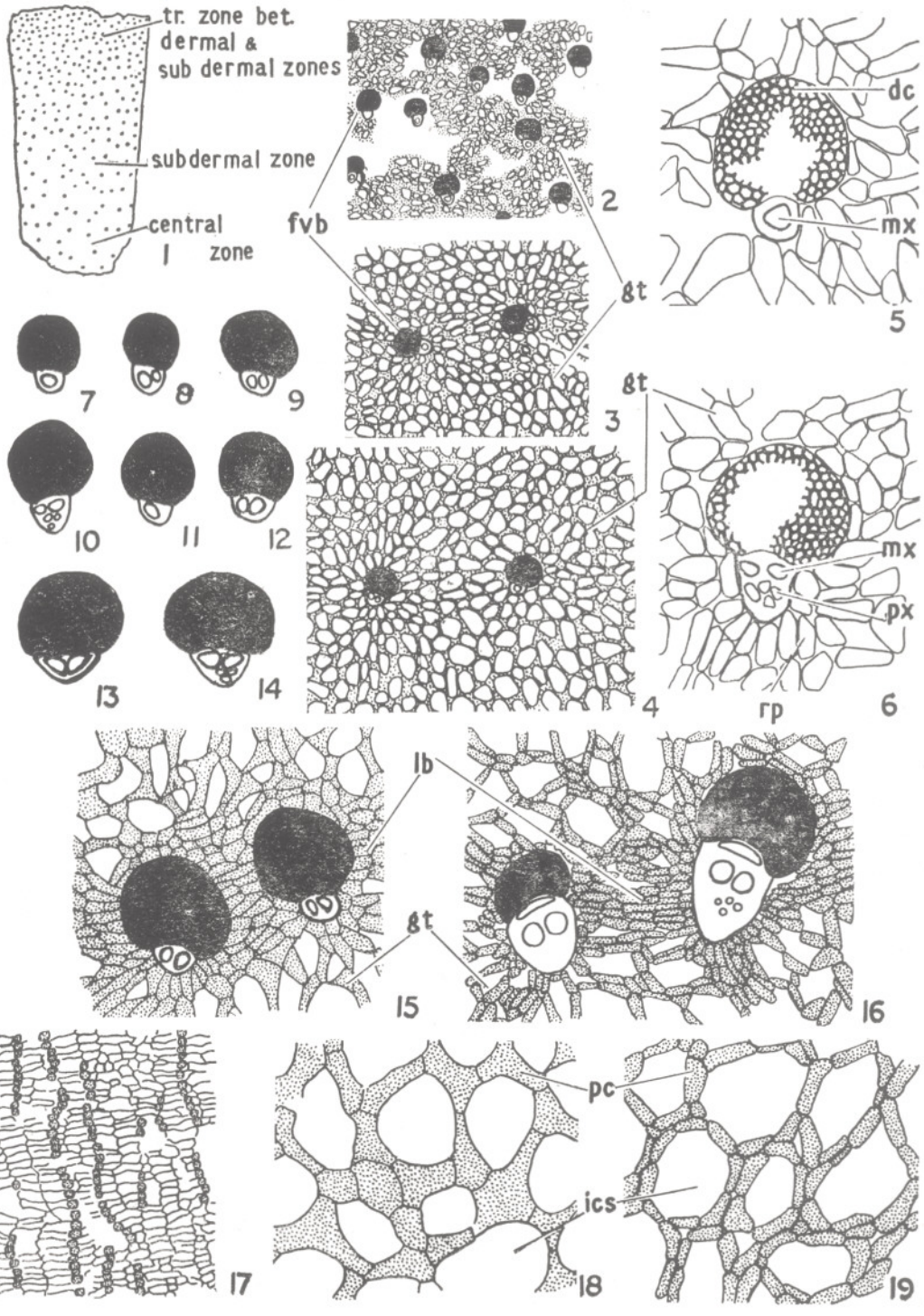
TEXT-FIG. 15 — T.S. of subdermal zone showing two fibrovascular bundles connected by a band of ground tissue — *lb* Note the highly lacunar ground tissue — *gt* × 25.

TEXT-FIG. 16 — *Roystonea regia* O.F. Cook. T.S of stem showing a leaf-trace bundle and a fibro. vascular bundle in subdermal zone. Note highly lacunar ground tissue — *gt* and a band of ground tissue connecting the fibrovascular bundle and the leaf-trace bundle X 25.

TEXT-FIG. 17 — *P. kamalam* Rode. L.S. showing vertical rows of horizontally elongated ground parenchyma cells × 16.

TEXT-FIG. 18 — T.S. of ground tissue in the central zone showing 1-2 cells thick trabeculae between intercellular spaces — *ics*. Parenchyma cells — *pc* × 33.

TEXF-GIG. 19 — *Roystonea regia* O.F. Cook. T.S. of ground tissue from the central zone in the stem. Note 1-2 cells thick trabeculae between the intercellular spaces — *ics* and variously shaped ground parenchyma cells — *pc* × 33.



Palmoxylon kamalam Rode
Text-figs. 1-19

distinguishing character to resolve the artificial genus *Palmoxylon* Schenk. Kaul (1935, 1938, 1960) utilized the structure of ground tissue in addition. On that basis he identified *Palmoxylon sundaram* as a species of *Cocos*, *P. coronatum* as a species of *Borassus* and *P. mathuri* as a species of *Bactris*. Ramanujam (1953) has compared *P. arcotense* with *Livistona chinensis*.

In the opinion of senior author (T.S.M.) all the characters of stem, petiole and penduncle should be utilized to decipher fossil palm woods lumped together under the artificial genus *Palmoxylon*.

He also suggested that a detailed study of metaxylem elements helps in resolving it into its natural components, rather than on the basis of a single character, because in the living palms one can assign different genera like *Arenga*, *Areca*, *Borassus*, *Corypha*, *Cocos*, *Caryota* and their species with the help of metaxylem elements (Mahabale, 1958, p. 82, 1965).

Therefore, while comparing an unknown fossil palm stem with that of a living one, one should first take into account overall characters such as distribution of fibrovascular bundles, shape of the dorsal cap, nature of the ground tissue, number of metaxylem elements in the vascular part, their appearance in L.S. and determine first what part the fossil piece represents. *Palmoxylon kamalam* from Kondhali is a piece of entire tree trunk that must have grown above the soil showing all regions. The account of this species given by Rode (*l.c.*) is from a piece possibly from the peripheral region and that given by Shukla (1936) from a piece of central region. Sahni's (1964) description of it is based on a piece from the subdermal zone. Since the present material contains all these three zones, it is possible now to compare the entire transverse section of its stem with that of *Roystonea regia* with which it seems to show a close resemblance rather than with any other palm. It will be seen from Text-figs. 1-19 and Plates 1 and 2 and the Table that all three regions in the fossil specimen fully agree with the corresponding ones in *Roystonea regia*.

It would be interesting, therefore, to compare in detail *Palmoxylon kamalam* described here with the entire transverse section of the stem of *Roystonea regia*. In both distribution of fibrovascular bundles in different zones is sparse. They are regularly oriented in the transitional zone but irregular in subdermal and central zones. Shape of the dorsal cap is also similar, viz. complanate, with a shallow median sinus, the vascular part being completely extruded with 1-2 metaxylem elements (Text-figs. 2-9, 11-13; Pl. 1, Figs. 2, 4-10; Pl. 2, Figs. 11, 12, 14-17, 39). The ground tissue in this fossil as well as in the living genus *Roystonea* is highly lacunar and netted. The intercellular spaces are more or less oval and disposed around the fibrovascular bundles in a petaloid fashion as in a lotus flower. The trabeculae around the intercellular spaces are 1-2 cells thick (Text-figs. 3, 4, 18, 19; Pl. 1, Figs. 4-7, 10; Pl. 2, Figs. 13, 14, 18, 19). Lateral bands of parenchyma connecting the fibrovascular bundles to each other are also seen both in the fossil as well as in the living *Roystonea* stem (Text-figs. 15, 16; Pl. 1, Fig. 7).

The present stump of *Palmoxylon* has a diameter of 24 cm. Its periphery commences from the transitional zone between the dermal and subdermal zones. Making an allowance for the breadth of a part of the transitional zone between dermal and subdermal zone, the dermal zone and the cortical zone, the girth of the present *Palmoxylon* should nearly be equal to that of *Roystonea regia*, about 50 cm. in the lower part of the tree trunk. This is significant.

However, there are a few minor differences also between them. For example, the number of metaxylem elements in the vascular part of the fibrovascular bundles is different. In both these palms metaxylem elements are 1 or 2, but in fossil stem they are mostly two. In the living palm in many fibrovascular bundles there is one metaxylem element and two in some. But on the whole, *P. kamalam* seems to be closely comparable with *Roystonea* and some past species of that genus, as we would refrain from saying that this fossil palm is *Roystonea regia* O. F. Cook. More likely it represents an extinct species of that genus or of a closer ally of it.

The genus *Roystonea* is South American in origin and has four species in Cuba, Puerto Rico. They grow in the low ground and swamps in Florida and South America. It is a curious thing though well known, that several plants from Deccan Intertrappean Series show affinities with plants

TABLE 1 — COMPARISON OF *PALMOXYLON KAMALAM* RODE FROM KONDHALI WITH OTHER SPECIES OF *PALMOXYLON* AND *ROYSTONEA REGIA* O.F. COOK

1	2	3	4	5	6	7	8	9	10	11	12	13
CHARACTERS	*P. Blanfordi* SCHENK (1882)	*P. mathuri* SAHNI (1931)	*P. geometricum* SAHNI (1931)	*P. Edwardsi* SAHNI (1931)	*P. jammuense* SAHNI (1931)	*P. Hislopi* SAHNI (1931)	*P. kamalam* RODE (1933) SHUKLA (1939)	*P. arcotense* RAMANUJAM (1953)	*P. chhindwarense* PRAKASH (1958)	*P. dakshinense* PRAKASH (1958)	*P. kamalam* RODE FROM KONDHALI	*Roystenea regia* O.F. COOK
1. Regions	Central	Central	Central	Dermal-Subdermal	Subdermal	Subdermal	Subdermal	Dermal-Subdermal-Central	Dermal-Subdermal-Central	Dermal-Subdermal-Central	Subdermal Central	All regions
2. Shape of the dorsal cap	Reniform	Reniform	Cordate	Cordate Complanate	Lunate	Lunate	Complanate	Orbicular-Reniform	Reniform	Reniform	Complanate	Complanate
3. Fibre bundles	Absent	Present	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
4. Stegmata	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent	Present
5. Radiating parenchyma	All around the fibro-vascular bundle	Absent	Present around the vascular part of leaf trace bundle	Absent	2-3 layers around the vascular part	Absent	Present around the vascular part of the leaf-trace bundle	Absent	Absent	Present only in dermal zone	Present around the vascular part of leaf trace bundle	Present around the vascular part of leaf trace bundle
6. Tabular parenchyma	1-2 layers around the whole bundle	Absent	1-2 layers	Absent	2-3 layers over the dorsal cap	Single layer around the dorsal cap	Absent	Absent	1-2 layers around the dorsal cap	Present only in dermal zone	Absent	Absent
7. Ground tissue	Lacunar cells cylindrical with slight stellate tendency	Markedly trabecular with large intercellular spaces	Very lacunar cells of various geometrical shapes	Lacunar, mesh-like cells of various shapes	Very lacunar, cells cylindrical or more or less stellate	Lacunar, cells rod-like or slightly branched air-spaces about equal in area to the cells	Markedly trabecular with very large inter-cellular spaces	Narrow, rectangular cells of various shapes forming loosely fitted meshes with conspicuous intercellular spaces	Dermal-compact Subdermal-lacunar Central-lacunar cells thin-walled	Compact in dermal zone, slightly lacunar in subdermal zone, Central zone consists of cells of various shapes with large intercellular spaces	Markedly trabecular with very large intercellular air-spaces	Markedly trabecular with very large intercellular spaces in the subdermal and central zones
8. Special character		Ground tissue markedly trabecular	Cells in ground tissue are of regular geometric forms Y-shaped & rod-shaped	Sclerotic nests present in ground tissue in subdermal zone	Fibrovascular bundles very large, intercellular spaces large and of various shapes	—	Intercellular spaces around the f.v.b. similar to petaloid arrangement of a lotus flower	Intercellular spaces large	Highly lacunar ground tissue consisting of more or less rectangular cells forming loose large meshes	Cells of various shapes forming loose meshes with large intercellular spaces	Intercellular sapces around the fibrovascular bundles similar to petaloid arrangement of a lotus flower	Intercellular spaces around the fibrovascular bundles similar to petaloid arrangement of a lotus flower
9. Locality	Near Jhansi	Lackopoor	Sindh	Jubblepore	Jammu	Mohgaon Kalan	Mohgaon Kalan	South Arcot	Chhindwara	South Arcot	Kondhali	
10. Geological horizon	Unknown	Bhuj series	Tertiary	Either Nermada Alluvium or Deccan trap	Upper Siwalik Conglomerate	Base of the Deccan Intertrappean	Deccan Intertrappean series	Cuddalore sandstone series	Deccan Intertrappean series	Tertiary	Deccan Intertrappean series	Native of South America

living today in South America, e.g. *Regnellidium* and *Rodeites*, etc. The present palm provides one more link between the present day flora of South America and the Tertiary flora of the Deccan Intertrappean Series that flourished 70 million years ago. How this must have happened is an enigma of the Tertiary Palaeobotany of India. Possibly, Palms as a group have had had more than one centre of origin.

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EXPLANATION OF PLATES

PLATE 1

Palmoxylon kamalam Rode

1. Isotype specimen No. 234 × 1/5 N.S.

2. T.S. of stem showing transitional zone between dermal and subdermal zones — *tz*, subdermal zone — *sd*, and central zone — *C* × 2.

3. L.S. of ground tissue to show vertical rows of thin-walled cells × 50.

4. T.S. of transitional zone between dermal and subdermal zones. Note the sparse distribution of the fibrovascular bundles — *fvb* and highly lacunar ground tissue *gt*. × 9.

5. T.S. Subdermal zone showing sparsely distributed fibrovascular bundles *fvb* and lacunar ground tissue-*gt*. Note the intercellular spaces arranged in a petaloid manner of a lotus flower around the fibrovascular bundles × 9.

6. T.S. of central zone showing the sparsely distributed fibrovascular bundles × 12.

7. T.S. of subdermal zone showing lateral bands of parenchyma cells — *lb* connecting fibrovascular bundles — *fvb* × 10.

Roystonea regia

8. T.S. of stem showing cortical, dermal and subdermal zones × 1/2 N.S.

9. T.S. of stem showing transitional zone between subdermal and central zones and the central zone × N.S.

10. T.S. of stem, central zone × 5.

PLATE 2

Palmoxylon kamalam Rode

11. *P. kamalam* Rode. A. fibrovascular bundle from the subdermal zone, with complanate dorsal cap — *dc*, extruded vascular part with two metaxylem elements — *mx*. Note the intercellular spaces — *ics* around the fibrovascular bundle × 45.

12. A leaf-trace bundle from the central zone. Dorsal cap — *dc*, vascular part — *vp* × 45.

13. T.S. of central zone showing ground tissue with large intercellular spaces — *ics* × 40.

14. T.S. of subdermal zone showing the distribution of fibrovascular bundles — *fvb* and highly lacunar ground tissue — *gt*. Note the intercellular spaces around the fibrovascular bundles disposed in a petaloid manner of a lotus flower × 15.

Roystonea regia

15 — A fibrovascular bundle from the central zone of the stem with complanate dorsal cap — *dc*, vascular part extruded with two metaxylem elements — *mx* × 40

16 — A fibrovascular bundle from the central zone with one metaxylem element in the vascular part × 40

17 — A leaf-trace bundle from the central zone × 40

18 — T.S. of central zone showing ground tissue with large intercellular spaces × 40

19 — T.S. of subdermal zone in the stem. Note the distribution of fibrovascular bundles and highly lacunar ground tissue × 15

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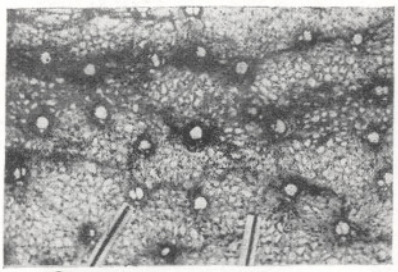

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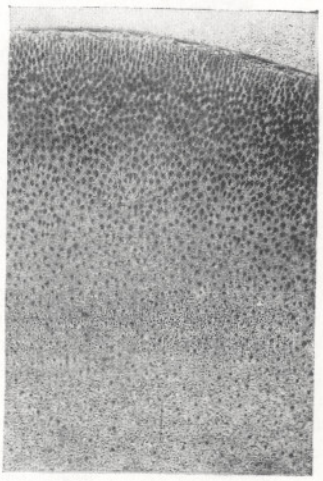

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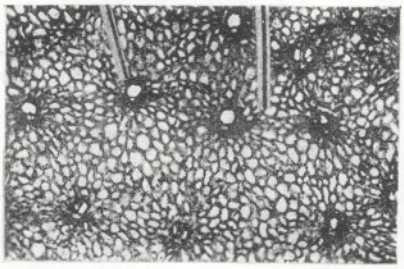

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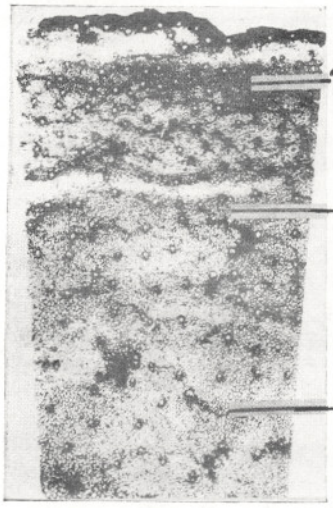

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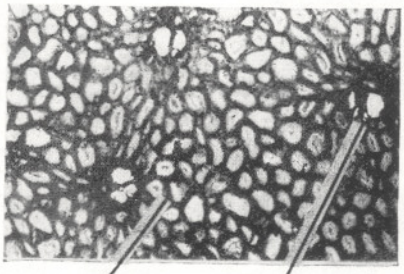

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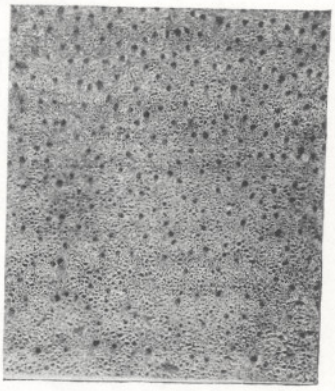

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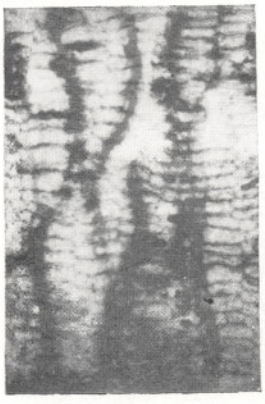

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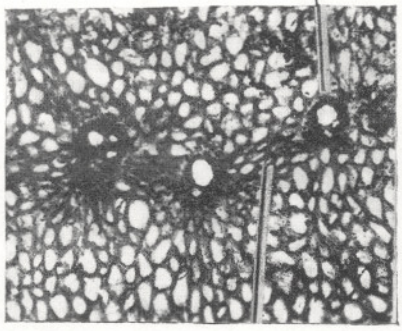

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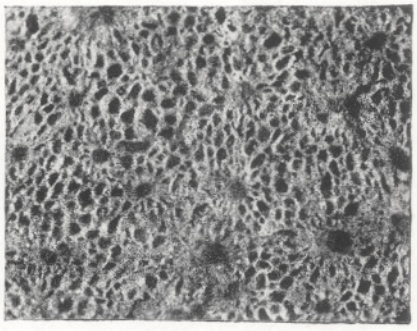

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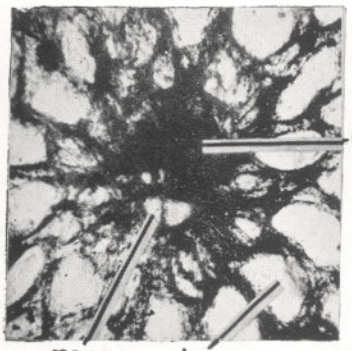

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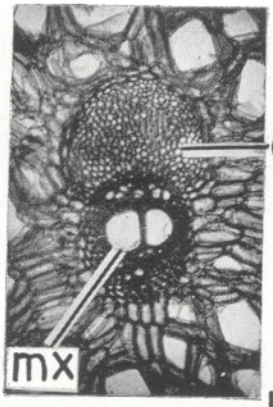

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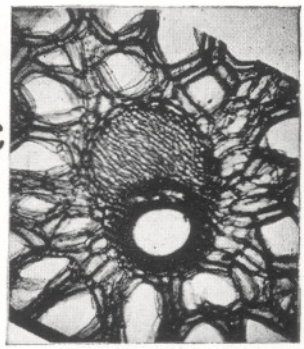

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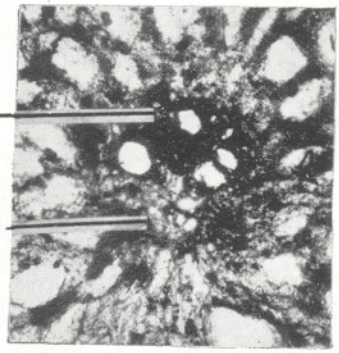

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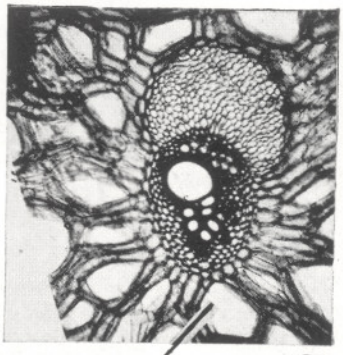

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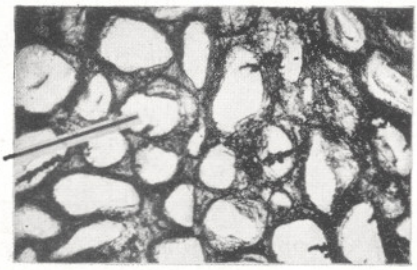

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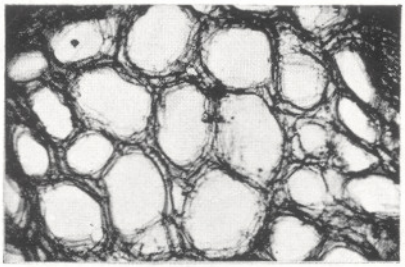

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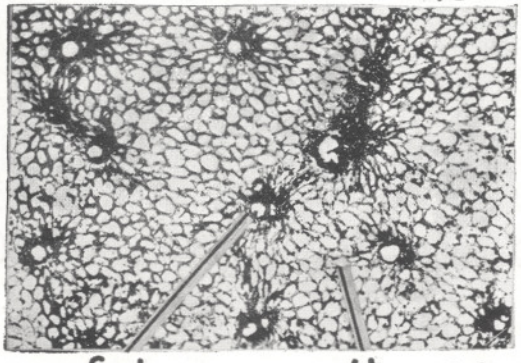

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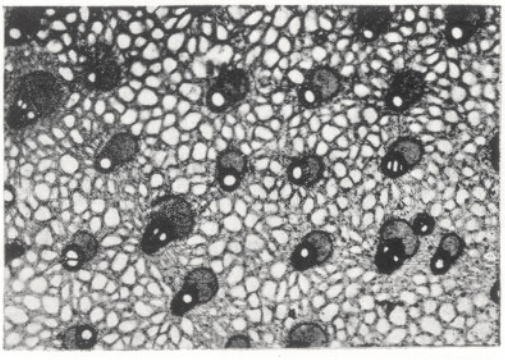

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