

*PALMOXYLON SHAHPURAENSIS* SP. NOV., A FOSSIL PALM  
RESEMBLING *LICUALA* FROM THE DECCAN INTERTRAPPEAN  
BEDS OF MANDLA DISTRICT, MADHYA PRADESH

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ABSTRACT

*Palmoxylon shahpuraensis* sp. nov., a petrified palm wood showing close resemblance with the extant *Licuala* belonging to sabaloid group of Palmae, has been described here. The specimen was collected from the Deccan Intertrappean beds near the village Ghugua in Mandla District. It shows compact to spongy nature of the ground tissue with usually one to two metaxylem vessels in dermal, two in subdermal and central zones and the absence of the fibrous bundles in the stem.

*Key-words* — Xylotomy, *Palmoxylon*, *Licuala*, Deccan Intertrappean Series, Early Eocene, India.

सारांश

मध्य प्रदेश में मांडला जनपद की दक्खिन अन्तर्द्वीपी संस्तरों से लिक्वुआला से मिलता-जुलता एक ताड़-काष्ठाशम: पाल्मॉक्सिलॉन शाहपुरायेन्सिस नव जाति - कृष्ण अम्बवानी

पाल्मी कुल के सैबॅलॉयड समूह से सम्बन्धित एवं वर्तमान लिक्वुआला से घनिष्ठ सजातीयता व्यक्त करने वाला एक अश्मीभूत ताड़ काष्ठाशम - पाल्मॉक्सिलॉन शाहपुरायेन्सिस नव जाति - का वर्णन किया गया है। यह प्रादर्श मांडला जनपद में घुगुआ गाँव के समीपस्थ दक्खिन अन्तर्द्वीपी संस्तरों से एकत्र किया गया था। यह काष्ठाशम तने में रेशेदार बंडलों की अनुपस्थिति तथा त्वचीय, उपत्वचीय एवं केन्द्रीय खंडों में प्रायः एक से दो तक अनुदारु वाहिनियों के साथ-साथ संहत से स्पंजी भरण ऊतक प्रदर्शित करता है।

INTRODUCTION

ONLY a few fossil dicotyledonous woods (Ingle, 1972, 1973; Bande, 1973, 1974; Lakhanpal, Prakash & Bande, 1978; Lakhanpal, Prakash & Ambwani, 1980; Bande & Khatri, 1980; Bande & Prakash, 1981) and a petrified palm fruit resembling the modern genus *Hyphaene* (Bande, Prakash & Ambwani, 1981) as well as a fossil palm wood resembling the extant genus *Chrysalidocarpus* Ambwani & Prakash (1983) have so far been described from the Mandla District.

SYSTEMATIC DESCRIPTION

FAMILY — PALMAE

Genus — *Palmoxylon* Schenk, 1882

*Palmoxylon shahpuraensis* sp. nov.

The present specimen is well-preserved to reveal all the structural details. It is a

triangular piece measuring 10×18×4.5 cm in size with a radius of 9 cm, having well preserved dermal, subdermal and central zones.

*Dermal Zone* — The fibrovascular bundles in this zone are not conjoined but regularly oriented (Pl. 1, fig. 1). They are generally oval in shape with their xylem facing towards the centre. The frequency of the fibrovascular bundles in this zone ranges from 140-150 per cm<sup>2</sup> and the size of the bundles varies from 720×400-1000×720 μm. The f/v ratio is 4/1-6/1. The dorsal sclerenchymatous sheath is prominent and is usually reniform to cordate and the cells of this sheath are thick-walled with very narrow lumen (Pl. 1, fig. 1). The median sinus is concave to angular and the auricular lobes are round while the auricular sinus is indistinct. Generally one to two excluded metaxylem vessels are present in each fibrovascular bundle (Pl. 1, fig. 1). Tabular parenchyma is indistinct and the radiating parenchyma is absent. Stegmata are present

around the fibrous part of the fibrovascular bundles. Phloem is not preserved and is represented by a cavity. The diminutive fibrovascular bundles are sometimes seen in this zone. The leaf-trace bundles are frequently visible but the fibrous bundles are absent.

*Subdermal Zone* — The fibrovascular bundles in this zone are sparsely placed and regularly oriented; sometimes a few deflected bundles may also be seen among the regularly oriented ones (Pl. 1, fig. 2). They are comparatively bigger in size than those of the dermal zone. Their frequency varies from 65-70 per cm<sup>2</sup>. The shape of the bundles varies from round to oval. They vary from 800×800-1200×800 μm in size. The f/v ratio varies from 2/1-4/1. The dorsal sclerenchymatous sheath is reniform to cordate and the cells of this sheath are thick-walled having small lumen (Pl. 1, fig. 2). Median sinus is concave to angular and the auricular sinus is indistinct while the auricular lobes are round (Pl. 1, fig. 2). One to three excluded metaxylem vessels may be seen in each fibrovascular bundle but the vessels in pairs are frequently seen (Pl. 1, fig. 2). Tabular parenchyma generally indistinct, sometimes a layer may be observed around the fibrous part of the fibrovascular bundles. Stegmata are present in the fibrous part of the fibrovascular bundles. Phloem is badly preserved to indicate cellular details and is generally represented by a lacuna.

*Central Zone* — The fibrovascular bundles are sparsely placed and irregularly oriented in the ground mass (Pl. 1, fig. 3). They are usually round to oval in shape. Their frequency ranges from 40-50 per cm<sup>2</sup>. They vary from 800×800-1000×800 μm and the f/v ratio ranges from 1/1 to 2/1. The dorsal sclerenchymatous sheath is prominent and usually reniform to cordate in shape. Cells of this sheath are thick-walled with comparatively larger lumen than those of the dermal and subdermal zones. Generally two sometimes three, rarely four excluded metaxylem vessels may be seen in each fibrovascular bundle (Pl. 1, fig. 3). Tabular and radiating parenchyma are absent. Stegmata are present in the fibrous portion of the fibrovascular bundles. Phloem is mostly represented by a lacuna. The diminutive fibrovascular bundles are absent and the leaf-trace bundles are frequent in this zone.

*Diminutive Fibrovascular Bundles* — These bundles are restricted only to the dermal and the subdermal zones of the present specimen. They measure about 320×400 μm in size and exhibit similar structure to that of the larger bundles. They are irregularly oriented in the ground tissue but less frequent.

*Leaf-trace Bundles* — These are frequently present throughout the stem and can be easily distinguished by their protruded tongue-like vascular part with a number of smaller vessels (Pl. 1, figs 1, 2).

*Ground Tissue* — The ground tissue in the dermal zone is compact in nature while in subdermal and central zones, it becomes spongy having small intercellular spaces. Thus showing a gradual change from compact to spongy texture. The parenchymatous cells in the dermal zone vary from round, oval to sometimes slightly elongated in shape (Pl. 1, fig. 1). In the subdermal zone also these cells are round to oval as well as elongated in shape with very small intercellular spaces having spongy nature while in the central zone the cells are more or less similar in nature to those in subdermal zone but the intercellular spaces are slightly larger (Pl. 1, figs 2, 3).

*Vessel Elements* — Metaxylem vessels of the fibrovascular bundles measure 100-120 μm in diameter and 1.5-2 mm long. Their perforation plates are oblique with 3-8 perforation bars and usually with scalariform thickenings on their walls. Whereas the protoxylem vessels are 60-80 μm in diameter and are usually longer, measuring 2-2.5 mm. Their perforation plates are oblique with 2-4 perforation bars and they have annular to spiral thickenings.

#### SPECIFIC DIAGNOSIS

##### *Palmoxylon shahpuraensis* sp. nov.

The fossil palm stem shows well preserved dermal, subdermal and central zones. Fibrovascular bundles of dermal zone regularly oriented, 720×400-1000×720 μm size; frequency 140-150 per cm<sup>2</sup>; f/v ratio 4/1-6/1. Shape of fibrovascular bundles round, oval to elongated; metaxylem vessels one to two, excluded. Dorsal sclerenchymatous sheath reniform to cordate; median sinus concave to angular, auricular

sinus indistinct, auricular lobes round. Tabular and radiating parenchyma absent. Stegmata present, fibrous bundles absent. Diminutive fibrovascular bundles scanty, leaf-trace bundles present.

Fibrovascular bundles of subdermal zone mostly regularly oriented,  $800 \times 800$ - $1200 \times 800$   $\mu\text{m}$  in size. Frequency varies from 65-70 per  $\text{cm}^2$ ; f/v ratio 2/1-4/1. Shape of fibrovascular bundles usually round to oval; generally with two excluded metaxylem vessels, some times three may be seen. Dorsal sclerenchymatous sheath reniform to cordate; median sinus usually concave to angular, auricular sinus indistinct to absent, auricular lobes round. Tabular and radiating parenchyma absent. Stegmata present, fibrous bundles absent, diminutive fibrovascular bundles present.

Fibrovascular bundles of central zone irregularly oriented,  $800 \times 800$ - $1000 \times 800$   $\mu\text{m}$  size; frequency 40-45 per  $\text{cm}^2$ ; f/v ratio 1/1-2/1. Shape of bundles round to oval; usually two sometimes three to four metaxylem vessels in each bundle; dorsal sclerenchymatous sheath reniform to cordate, median sinus concave to angular, auricular sinus absent, auricular lobes round. Tabular and radiating parenchyma absent, stegmata present. Fibrous and diminutive fibrovascular bundles absent.

Metaxylem vessels 100-120  $\mu\text{m}$  in diameter, 1.5-2.0 mm long; perforation plates oblique, 3-8 bars; scalariform thickenings. Protoxylem vessels 60-80  $\mu\text{m}$  in diameter, 2.0-2.5 mm long; perforation plates oblique, 2-4 bars; annular to spiral thickenings.

Ground tissue shows gradual transformation from compact in dermal to spongy towards central zone. The cells are round, oval to slightly elongated with prominent intercellular spaces in the central zone.

*Holotype* — B.S.I.P. Museum no. 35980.

*Locality* — Ghugua Village near Shahpura, Mandla District, Madhya Pradesh.

*Horizon* — Deccan Intertrappean Series.

*Age* — Probably Early Eocene.

*Affinities* — The anatomical features of the present fossil palm wood closely resemble the modern sabaloid palm wood of *Licuala* Thunb., especially with *Licuala peltata* Roxb. (Tomlinson, 1961). The species of *Licuala* examined for comparison include the stem sections of *L. peltata* Roxb., *L. rumphiana* Bl., *L. grandis* H. Wendl. and *L. spinosa* Roxb. The dermal zone, both in the present fossil

and in the stem of *Licuala peltata*, is very narrow and fibrovascular bundles in this zone are not very densely arranged and show regular orientation (Pl. 1, figs 1, 4). They are more or less similar in shape and size and measure  $380 \times 250$ - $880 \times 800$   $\mu\text{m}$  in the living species. The shape of the dorsal sclerenchymatous sheath is usually reniform to cordate having thick-walled cells with narrow lumen both in the fossil as well as living specimens. Median sinus is concave to angular and the auricular lobes are rounded in both. However, the frequency of the fibrovascular bundles in the dermal zone of *Licuala peltata* is 150-180 per  $\text{cm}^2$ . The f/v ratio is also closely comparable both in the fossil as well as in living species up to 4/1-6/1 in the dermal zone of living species and slightly greater in the fossil. The number of metaxylem vessels in each fibrovascular bundle of fossil as well as living species is one to two (Pl. 1, figs 1, 4) though vessels in *L. peltata* are slightly smaller. Stegmata are present around the fibrous portion of the fibrovascular bundles while tabular and radiating parenchyma are absent in both. The ground tissue in the dermal zone of fossil and living species is compact and the cells are generally round, oval to slightly elongated in shape but the tangential pattern of arrangement of cells seen in *L. peltata* is not evident in the fossil specimen.

The subdermal zone of the present fossil species also resembles that of the living species. The fibrovascular bundles of this zone also show similar shape and size, measuring  $900 \times 400$ - $1000 \times 600$   $\mu\text{m}$  in the living species. They are more or less regularly oriented. The dorsal sclerenchymatous sheath is usually reniform to cordate and the cells of this sheath are less thickened in the outer part in the fossil and living species. Median sinus is concave to angular, the auricular sinus is indistinct and auricular lobes are rounded in both. The frequency of the fibrovascular bundles both in the fossil and living species is nearly same, being 50-60 per  $\text{cm}^2$  in the living species. F/v ratio is similar in both the species, being 2/1-4/1 (Table 1). The number of metaxylem vessels in each fibrovascular bundle is two to three, usually two and they are excluded in both (Pl. 1, figs 2, 5). Stegmata are present around the fibrous part of the fibrovascular bundles while tabular

TABLE 1

GENUS/ SPECIES	STENZEL'S CLASSIFICATION	FIBROUS BUNDLES AND STEGMATA	SIZE OF FIBROVASCULAR BUNDLES IN $\mu\text{m}$	F/V RATIO	DISTRIBUTION OF FIBROVASCULAR BUNDLES/ $\text{cm}^2$	MEDIAN SINUS	AURICULAR SINUS/ AURICULAR LOBES	VASCULAR PART OF FIBROVASCULAR BUNDLES WITH NUMBER OF METAXYLEM VESSELS IN EACH FIBROVASCULAR BUNDLE	GROUND TISSUE			NATURE OF THE CELLS OF FIBROUS SHEATH OF FIBROVASCULAR BUNDLES
									GENERAL PARENCHYMA	TABULAR PARENCHYMA	RADIATING PARENCHYMA	
<i>Licuala peltata</i>	Cordata to Reniformia	Fibrous bundles absent; stigmata present	D=380×250–880×800	D=3/1-4/1	D=150–180	Angular to concave	D=Auricular sinus indistinct, auricular lobes rounded	D=Excluded; usually one to two vessels in each fibrovascular bundle	D=Compact, cells round, oval and horizontally elongated	Indistinct or absent	Absent	D=Thick-walled with narrow lumen
			SD=900×480–1000×600	SD=2/1-4/1	SD=50-60		SD=Auricular sinus indistinct, auricular lobes rounded	SD=Excluded; two to three vessels in each fibrovascular bundle	SD=Compact, cells round, oval to slightly elongated with small intercellular spaces	Indistinct or absent	Absent	SD=Lignified, more lignification towards inner side, outer cells with larger lumen, inner cells with narrow lumen
			C=400×600–1000×800	C=1/1-2/1	C=40-50		C=Auricular sinus indistinct, auricular lobes rounded	C=Excluded; two to three vessels in each fibrovascular bundle	C=Slightly lacunar, cells round, oval to angular	Indistinct or absent	Absent	C=Outer cells with larger lumen, inner cells with narrow lumen
<i>L. rumphiana</i>	Cordata to Reniformia	Fibrous bundles absent; stigmata present	D=200×200–320×560	D=1/1-6/1	D=250–280	Concave to angular	D=Auricular sinus present, auricular lobes rounded	D=Excluded; usually one sometimes two vessels	D=Compact	Absent	Absent	D=Thick-walled with narrow lumen
			SD=480×400–800×400	D=1/1-3/1	SD=140–150		SD=Auricular sinus present, lobes rounded	SD=Excluded; one to two sometimes three small vessels	SD=Slightly lacunar	Absent	Absent	SD=Less thickened with wider lumen
			C=720×600–800×480	C=1/1-2/1	C=60-65		C=Auricular sinus present, lobes rounded	C=Excluded, one to two small vessels	C=Lacunar with bigger intercellular spaces	Absent	Absent	C=Less thick with wider lumen
<i>L. spinosa</i>	Cordata to Reniformia	Fibrous bundles absent; stigmata present	D=320×200–800×600	D=3/1-5/1	D=200–215	Concave to angular	D=Auricular sinus indistinct or absent, auricular lobes round	D=Excluded; usually one sometimes two vessels	D=Compact, cells usually round to oval	Indistinct or absent	Absent	D=Thick-walled with narrow lumen
			SD=480×400–800×480	SD=2/1-3/1	SD=60–70		SD=Auricular sinus indistinct or absent, auricular lobes round	SD=Excluded; usually two sometimes three rarely four vessels	SD=Compact with tiny air spaces, cells round, oval to elongated	Indistinct or absent	Absent	SD=Thick-walled with narrow lumen
			C=600×480–800×600	C=usually 1/1	C=30–40		C=Auricular sinus indistinct or absent, auricular lobes round	C=Excluded; usually two sometimes three to four	C=Lacunar, cells elongated to variously shaped	Indistinct or absent	Absent	C=Thick-walled with narrow lumen
<i>L. grandis</i>	Cordata to Reniformia	Fibrous bundles absent; stigmata present	D=200×200–600×520	D=4/1-6/1	D=200-150	Concave to angular	D=Auricular sinus indistinct; auricular lobes round	D=Excluded; one to two vessels	D=Compact, cells round, oval to angular	Indistinct or absent	Absent	D=Thick-walled with narrow lumen
			SD=600×480–800×480	SD=2/1-4/1	SD=65–70		SD=Auricular sinus indistinct, auricular lobes round	SD=Excluded; usually two vessels	SD=Spongy with small air spaces, cells variously shaped	Indistinct or absent	Absent	SD=Thick-walled with narrow lumen
			C=600×800–600×480	C=1/1-2/1	C=40-45		C=Auricular sinus indistinct, auricular lobes round	C=Excluded; usually two vessels	C=Lacunar cells variously shaped	Indistinct or absent	Absent	C=Thick-walled with narrow lumen
<i>Palmoxydon shahpuransis</i> sp. nov	Cordata to Reniformia	Fibrous bundles absent; stigmata present	D=720×400–1000×720	D=4/1-6/1	D=140–150	Concave to angular	D=Auricular sinus indistinct; auricular lobes rounded	D=Excluded; one to two vessels, usually two	D=Compact, cells usually round oval to elongated	Indistinct	Absent	D=Usually all the cells thick-walled with narrow lumen
			SD=800×800–1200×800	SD=2/1-4/1	SD=65–70		SD=Auricular sinus indistinct; auricular lobes rounded	SD=Excluded; usually two sometimes three vessels	SD=Compact, cells usually round oval to slightly elongated with small air spaces	Indistinct	Absent	SD=Cells thick-walled with narrow lumen
			C=800×800–1000×800	C=1/1-2/1	C=40–45		C=Auricular sinus indistinct, auricular lobes rounded	C=Excluded, usually two sometimes three, rarely four vessels	C=Cells loosely placed with slightly bigger intercellular spaces	Indistinct	Absent	C=Cells thick-walled with narrow lumen towards the inner side

and the radiating parenchyma are absent in both. Ground tissue has small intercellular spaces in the fossil and living species and the cells are round, oval to slightly elongated in shape.

Similarly the central zone of both the fossil and living specimens is also closely comparable. The fibrovascular bundles of fossil and living species are almost of similar size and shape. They range  $400 \times 600$ – $1000 \times 800 \mu\text{m}$  in *Licuala peltata* (Table 1), usually irregularly oriented. The dorsal sclerenchymatous sheath is generally reniform to cordate and the cells of outer portion of the sheath have larger lumen as compared to those of inner ones, both in the fossil as well as living specimens (Pl. 1, figs 3, 6). Median sinus is concave to angular and the auricular sinus is indistinct whereas the auricular lobes are round in both. The frequency of the fibrovascular bundles in the central zone of fossil as well as *Licuala peltata* is  $40$ – $50 \text{ cm}^2$  while the f/v ratio is 1/1–2/1 in both (Table 1). The number of the metaxylem vessels in each fibrovascular bundles is usually two sometimes three and they are excluded in both. Stigmata are present around the fibrous part of the fibrovascular bundles and the tabular parenchyma is indistinct whereas radiating parenchyma is absent both in the fossil and the living species. Ground tissue has slightly larger intercellular spaces in both (Pl. 1, figs 3, 6), the cells are round to oval sometimes angular.

Although the present fossil specimen also shows similarities with other species of *Licuala*, viz., *Licuala rumphiana*, *L. spinosa*

and *L. grandis* (amongst wood specimens available for comparison), it differs from them in size, frequency of the fibrovascular bundles, f/v ratio as well as in the nature of parenchymatous cells of the ground tissue. The ground tissue is much lacunar in *L. rumphiana*, *L. spinosa* and *L. grandis*. Also the cells of the dorsal sclerenchymatous sheath are thicker-walled with narrow lumen throughout the stem (Table 1).

Among the different species of *Licuala*, *L. peltata* attains a height of 8–15 ft (Blatter, 1926, pl. 23) and it also appears from the photograph that the mature stem of this species attains a girth of about 20–25 cm, which agrees with the present fossil palm stem being 18 cm in diameter.

The species of the genus *Licuala* are distributed in tropical Asia, Australia and Pacific islands (Blatter, 1926, p. 88; Brandis, 1971, p. 656; Willis, 1973, p. 651). At present *L. peltata* occurs in Sikkim, deep hot valleys near the Teesta River, Assam, Khasia Hills, Cachar, woody mountainous country to the coast and near Chitagon, Burma in damp ravines of the Pegu Yoma and Andaman islands. Present finding of fossil stem resembling *Licuala* suggests that the sabaloid palms similar to *Licuala* were also existing during the Early Eocene time in central India. Further, occurrence of sabaloid palm petiole, *Palmocaulon costapalmatum* Kulkarni & Patil (1977) from Wardha District and a fossil palm wood, *Palmoxylon livistonoides* Prakash & Ambwani (1980) also support the presence of sabaloid palms during the Early Eocene in the Deccan Intertrappean beds of India.

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## EXPLANATION OF PLATE

*Palmoxylon shahpuraensis* sp. nov.

1. Cross section of the dermal zone of the fossil showing regular orientation of the fibrovascular bundles. × 25. Slide no. 6617.
2. Cross section of the subdermal zone of the fossil showing regular orientation of the fibrovascular bundles with usually two metaxylem vessels. × 25. Slide no. 6617.
3. Cross section of the central zone of the fossil showing irregular orientation of the bundles and spongy ground tissue. × 25. Slide no. 6618.
4. Cross section of the stem of *Licuala peltata* showing regularly oriented fibrovascular bundles with compact ground tissue. × 25. B.S.I.P. Herbarium slide no. 48.
5. Cross section of subdermal zone of *L. peltata* showing fibrovascular bundles usually with two metaxylem vessels. × 25. B.S.I.P. Herbarium slide no. 48.
6. Cross section of *L. peltata* showing irregularly oriented fibrovascular bundles and spongy nature of the ground tissue in the central zone. × 25. B.S.I.P. Herbarium slide no. 48.

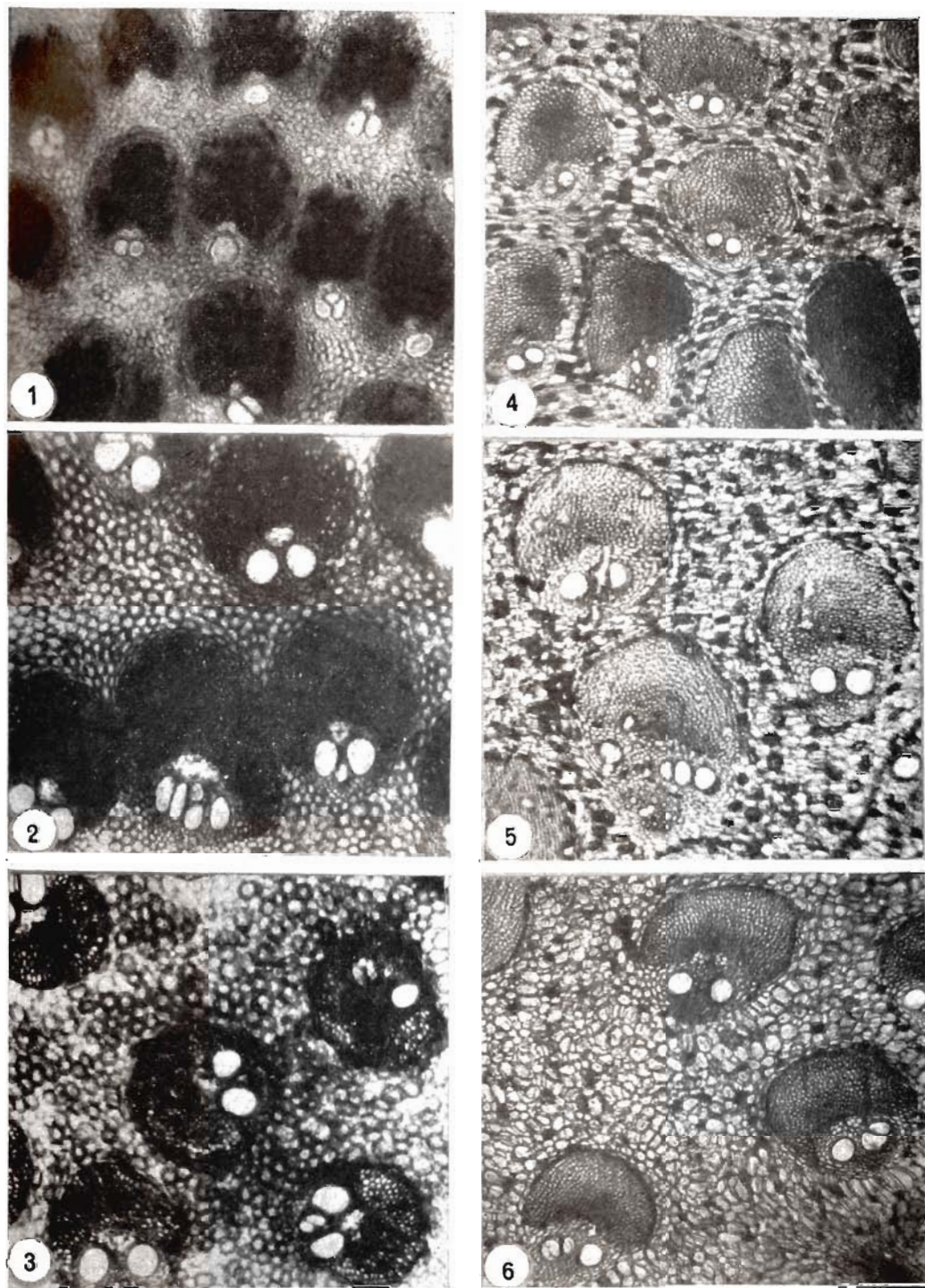


PLATE 1