

A PETRIFIED *LIVISTONA*-LIKE PALM STEM, *PALMOXYLON*  
*LIVISTONOIDES* SP. NOV. FROM THE DECCAN  
INTERTRAPPEAN BEDS OF INDIA

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ABSTRACT

*Palmoxylon livistonoides* sp. nov., a fossil palm stem showing close affinities with the extant genus *Livistona* is described here from the Deccan Intertrappean beds of Nawargaon in Wardha District, Maharashtra.

*Key-words*— Petrified palm stem, *Palmoxylon*, Eocene, Deccan Intertrappean beds (India).

सारांश

भारत के दक्खन अंतरद्वीपी संस्तरों से लिविस्टोना-सदृश ताड़ का एक अश्मीभूत तना — पामॉक्सिलॉन लिविस्टोनॉयडिस न० जा०—उत्तम प्रकाश एवं कृष्ण अम्ब्वानी

वर्धा जनपद, महाराष्ट्र में नवरगाँव के दक्खन अंतरद्वीपी संस्तरों से प्राप्त तथा वर्तमान प्रजाति लिविस्टोना से घनिष्ठ सजातीयता प्रदर्शित करने वाला ताड़ का एक अश्मीभूत तना, पामॉक्सिलॉन लिविस्टोनॉयडिस न० जा० यहाँ वर्णित किया गया है।

INTRODUCTION

A NEW species of petrified palm stem is described here in detail. The specimen was collected by one of us (K.A.) from the Deccan Intertrappean beds of Nawargaon Village (21°1'N : 78°35'E) in Wardha District, Maharashtra. The palm wood is very well-preserved and shows a lacunar ground tissue towards the centre. It possesses cortical, dermal and subdermal regions together with the roots attached to it indicating a basal region of the stem.

So far only little work has been done on the plant fossils of the Deccan Intertrappean Series of this region; only three fossil woods are known from Nawargaon. Out of these two are palm woods, viz., *Palmoxylon nawargaonensis* Shukla (1941) and *P. sclerodermum* Sahni (Shukla, 1946) while a dicot wood has been described by Kulkarni and Patil (1977a) as *Aristolochioxylon prakashii* of the family Aristolochiaceae. Besides, another palm wood *Palmoxylon deccanense* Sahni (1964) has been reported

from a neighbouring village Maragour, whereas *Palmoxylon intertrappeum* Sahni (1964) is known from Sindhi Vihira. Recently, a fossil palm leaf axis, *Palmocaulon costapalmatum*, has been described by Kulkarni and Patil (1977b) from Maragsur. *Palmoxylon livistonoides* resembling the extant wood of *Livistona* forms an important contribution to our knowledge of the Deccan Intertrappean flora of Wardha District.

MONOCOTYLEDONS

FAMILY — PALMAE

Genus — *Palmoxylon* Schenk, 1882

*Palmoxylon livistonoides* sp. nov.

*Roots* — Small roots measuring 3-5 mm in diameter are present outside the cortical region (Pl. 1, fig. 1). They show the following anatomical characters in transverse section.

*Epiblema* consists of a limiting layer of somewhat thick-walled, rectangular cells. Below this lies *hypodermis* made up of two zones (Pl. 1, fig. 5), the outer consisting of 4-5 layers of thin-walled round cells, while the inner part is composed of several layers of thick-walled cells with small lumen. The *cortex* consists of three distinct regions (Pl. 1, fig. 5; Pl. 2, fig. 12). The outer cortex begins just after the inner hypodermis and is composed of a few layers of thin-walled parenchymatous cells. The middle cortex comprises loosely arranged lamellate parenchymatous cells enclosing air spaces in this region (Pl. 2, fig. 12). These parenchymatous cells are mostly circular in shape. The inner cortex also consists of a few layers of vertically flattened parenchymatous cells in which some thick-walled polygonal cells are scattered here and there (Pl. 2, fig. 12). The *endodermis* and *pericycle* lying below the inner cortex are indistinct. Below this lies the *stele* of the root. Here at the periphery about 14-17 'I'-shaped xylem arches alternate with the phloem strands and lie radially (Pl. 1, fig. 1). These xylem arches have large metaxylem vessels towards the inner side while smaller protoxylem vessels are directed towards the pericycle. Cellular details of the phloem tissue are not clear. *Pith* is composed of slightly lignified cells.

*Cortical Zone* — It is about 1 cm thick and consists of numerous fibrous and a few fibrovascular bundles scattered in the parenchymatous ground tissue (Pl. 1, figs 1, 6). The fibrous bundles are usually round in shape and measure 100-288  $\mu\text{m}$  in size. The fibrovascular bundles are generally slightly circular to oval in shape and measure 150-416  $\mu\text{m}$  (Pl. 1, fig. 6). They consist of mostly reniform dorsal sclerenchymatous sheath and appear to possess usually 1-2 xylem vessels. The ground tissue cells are rod-shaped and are mostly radially elongated (Pl. 1, fig. 6). The stegmata are present both in the fibrous and fibrovascular bundles.

*Dermal Zone* — The fibrovascular bundles in this zone are closely placed, 130-140 per  $\text{cm}^2$  and show regular orientation with xylem facing towards the centre (Pl. 1, fig. 2). They measure 240  $\times$  280-400  $\times$  800  $\mu\text{m}$  in size and are oval in shape. The dorsal sclerenchymatous sheath is prominent, reniform to complanate in shape (Pl. 2, fig. 7). The

f/v ratio of the fibrovascular bundles varies from 1/1-6/1. The auricular sinus is absent but the median sinus is concave, sometimes shallow, and the auricular lobes are usually rounded. Each fibrovascular bundle generally shows one to two xylem vessels which are excluded. Radiating parenchyma is absent in this region but 1-2 layers of tabular parenchyma are present around the fibrous part of the fibrovascular bundles (Pl. 2, fig. 7). Fibrous bundles are rarely seen in this zone. Stegmata are present in the fibrous part of the fibrovascular bundles. Leaf-trace bundles can be seen in this zone.

*Subdermal Zone* — The fibrovascular bundles of this region are bigger in size, sparsely placed 40-60 per  $\text{cm}^2$  and show regular orientation (Pl. 1, figs 3, 4). They are circular to oval in shape and measure 400  $\times$  600-640  $\times$  800  $\mu\text{m}$  in size. The f/v ratio varies from 3/1-7/1. The dorsal sclerenchymatous sheath is mostly reniform with concave median sinus (Pl. 2, fig. 9). The auricular lobes are generally rounded and the auricular sinus is absent. Generally two metaxylem vessels are present in each fibrovascular bundle (Pl. 2, fig. 9); however, sometimes one vessel is also seen in a few bundles. These are excluded. Tabular parenchyma is present around the fibrous part of the fibrovascular bundles in 1-2 layers of cells. The radiating parenchyma is also present in the bundles associated with their vascular part. Leaf-trace bundles are frequently seen in this region. Stegmata are present in the fibrovascular bundles. Fibrous bundles are altogether absent. Phloem is badly preserved but sometimes a few cells can be seen represented by phloem tissue.

*Ground Tissue* — The ground tissue of the present species is characteristic and shows a gradual transformation from compact nature (Pl. 2, fig. 7) in the dermal zone to lacunate tissue towards the centre (Pl. 2, fig. 9). In the dermal zone, the ground tissue is compact, composed of almost round to oval as well as rod-shaped parenchymatous cells which are often tangentially elongated; these cells are usually restricted between the two fibrovascular bundles (Pl. 2, fig. 7). However, in the outer part of the subdermal zone the ground tissue cells are usually rod-shaped with small lacunae appearing at places. Further, going towards the centre the ground tissue becomes more



spongy enclosing larger lacunae of irregular shape (Pl. 2, fig. 11). The parenchymatous cells here are composed mainly of rod to often Y-shaped cells.

**Leaf-trace Bundles**—These are frequently present throughout the stem but less frequent in the subdermal zone (Pl. 1, figs 2-4). They are recognized by protruded tongue-like vascular part with a number of small vessels. The pitting of the metaxylem vessels is scalariform, whereas the protoxylem vessels show annular to spiral thickenings.

**Affinities**—The anatomical characters of the present fossil palm wood are closely comparable with the modern wood of *Livistona* R.Br. especially with *Livistona chinensis* R.Br. in both the dermal and subdermal regions. This study includes the examination of thin sections of a large number of palm woods and their published descriptions. Amongst the species of *Livistona* examined include stem wood sections of *Livistona rotundifolia* Mart., *L. australis* Mart., *L. chinensis* R.Br. and *Livistona* sp. and root wood sections of *L. chinensis* R.Br. The dermal zone, both in the fossil and the living species of *Livistona chinensis*, is about 1.5 cm thick. The fibrovascular bundles are closely placed and regularly oriented in both (Pl. 2, figs 7, 8) and show almost similar shape and size, i.e.  $240 \times 280-400 \times 800 \mu\text{m}$  and  $256 \times 288-640 \times 720 \mu\text{m}$  respectively. The frequency of the fibrovascular bundles in the dermal zone of the fossil is 130-140 per  $\text{cm}^2$  whereas in *Livistona chinensis* it is 115-120 per  $\text{cm}^2$ . The f/v ratio is also closely comparable in both the fossil as well as living; it is 1/1-6/1 in the fossil and 1/1-5/1 in the living species respectively. The number of metaxylem vessels in the fibrovascular bundles, both in the fossil and living species, is one to two. Stegmata are present around the fibrous part of the fibrovascular bundles of both the fossil and the living species. In both, the radiating parenchyma is absent in the dermal zone. The ground tissue of the dermal zone is also similar both in fossil and living (Pl. 2, figs 7, 8). It is compact in nature and composed of circular to oval and tangentially elongated cells.

The subdermal zone of the fossil also resembles closely to that of the living species. The fibrovascular bundles in both show almost similar shape and size (Pl. 2,

figs 9, 10) and measure  $400 \times 600-640 \times 800 \mu\text{m}$  in the fossil, whereas they are  $640 \times 720-800 \times 800 \mu\text{m}$  in the living species. They are almost regularly oriented in both the species. The frequency of the fibrovascular bundles, both in fossil and the living species, is 40-60 per  $\text{cm}^2$  and 50-72 per  $\text{cm}^2$  respectively. The f/v ratio of the fibrovascular bundles in fossil and living is also the same being 3/1-7/1 and the tabular and radiating parenchyma are present in both. Stegmata are also associated with the fibrous part of the fibrovascular bundles. The ground tissue of this zone in both the fossil and living species is also similar. It consists of spongy parenchymatous tissue, the lacunae being bigger towards the centre (Pl. 2, figs 9, 10). The cells are mostly rod-shaped or oval and rarely Y-shaped enclosing irregular air spaces.

Because of a close resemblance of the fossil wood with the modern wood of *Livistona chinensis*, which is indigenous to China and Japan, but cultivated here in gardens, it seems quite likely that a somewhat anatomically similar species of *Livistona* might have been growing in the Deccan Trap country during the Eocene times. The genus *Livistona* R.Br. is represented by about 30 species in the modern flora of tropical Asia and Africa (Willis, 1973). The only species indigenous to India is *Livistona jenkinsiana* Griff. which grows in Upper Assam, but most plentiful in the Nowgong District, Naga Hills and lower hills and outer valleys of Sikkim (Blatter, 1926, pp. 100-115; Brandis, 1971, p. 656).

#### COMPARISON WITH FOSSIL PALM WOODS

Among a large number of Indian fossil palm woods described so far (Sahni, 1964; Prakash & Boureau, 1968), the present fossil is nearly comparable to *Palmoxylon arcotense* Ramanujam (1953) from the Tertiary of Cuddalore Series in South India and *P. khalsa* Sahni (1964) (Table 1).

*Palmoxylon arcotense* although quite distinct from the present species, shows some features similar to this palm. In both, the dorsal sclerenchymatous sheath of the fibrovascular bundles is reniform with concave median sinus whereas auricular sinus is indistinct or absent. The auricular lobes both in *P. arcotense* and the present species are rounded and the xylem vessels are

one to two in each fibrovascular bundle; these are excluded. The tabular parenchyma is also present in the subdermal zone of both the species, although Ramanujam (1953, p. 89) reported it to be absent in *P. arcotense*. However, *Palmoxylon arcotense* differs from *Palmoxylon livistonoides* in the frequency and size of the fibrovascular bundles, in their fibrovascular ratio and in the nature of ground tissue.

The fibrovascular bundles are 50-100  $\mu\text{m}$  in dermal and about 175  $\mu\text{m}$  in subdermal zone of *Palmoxylon arcotense*, whereas they are quite large, 240 $\times$ 280-400 $\times$ 800  $\mu\text{m}$  in dermal and 400 $\times$ 600-640 $\times$ 800  $\mu\text{m}$  in subdermal zone of the present fossil wood. Further the f/v ratio of the bundles in *P. arcotense* is 15/1 in dermal zone and 5/1-8/1 in subdermal zone, whereas these are 1/1-6/1 in dermal and 3/1-7/1 in subdermal zone of this fossil palm stem. The frequency of the fibrovascular bundles is 110/cm<sup>2</sup> in the dermal zone of *P. arcotense* whereas it is slightly more about 130-140/cm<sup>2</sup> in the dermal region of the present fossil palm wood.

The ground tissue also differs in both the species. It is highly lacunar in the subdermal zone of *Palmoxylon arcotense* but slightly lacunar in the subdermal region of the present fossil wood. Besides, the cells are also somewhat different in shape in both the species. Ramanujam (1953, pp. 90, 91) has pointed out that the central part of the stem of *Livistona* especially *L. chinensis* shows a close resemblance with *Palmoxylon arcotense*. According to him there is a layer by layer similarity in both the fossils and *Livistona* (Ramanujam, 1953, p. 91). However, detailed study of the type slides of *Palmoxylon arcotense* and that of *Livistona chinensis* clearly shows that the ground tissue of the central regions has obvious differences between the two, although they are highly lacunar in both. The fossil wood has usually Y-shaped rarely rod-shaped cells enclosing the lacunae, whereas in *Livistona chinensis* the cells are mostly rod-shaped or oval, rarely Y-shaped in nature. Besides, the fibrovascular bundles are also quite small about 100-200  $\mu\text{m}$  in the central region of the fossil wood as compared to the modern wood in which they are about 640 $\times$ 800-800 $\times$ 800  $\mu\text{m}$  in size.

Further, it has also been seen that the ground tissue in *Livistona chinensis* is com-

pact in dermal and somewhat spongy in subdermal zone. Contrary to this the ground tissue of *Palmoxylon arcotense* is somewhat spongy in dermal but becomes quite lacunar in the subdermal region.

Although both *Palmoxylon khalsa* and the present species are somewhat similar, yet they differ from each other in a number of characters. The number of vessels in each fibrovascular bundle is usually 3-4, rarely 2 in *Palmoxylon khalsa* whereas generally two vessels are seen in the present species. Tabular parenchyma is absent in *P. khalsa* while it occurs in the present species. Besides, stigmata are absent in the fibrous part of the fibrovascular bundles of *Palmoxylon khalsa* and the ground tissue is quite lacunar (Sahni, 1964, pl. 7, fig. 51) unlike the present fossil wood where the lacunae when present are quite small. Sahni (1964, p. 58) has also indicated that the form of the fibrovascular bundles and the ground tissue of *Palmoxylon khalsa* is quite similar to that of *Livistona* but this similarity according to him does not imply any affinity with the modern genus.

The present fossil palm wood is also nearly comparable with two fossil palm woods from outside India. These are *Palmoxylon lacunosum* (Ünger) Felix and *Palmoxylon vasculosum* (Stenzel) Schenk described in detail by Stenzel (1904). Apart from the presence of lacunar ground tissue and reniform dorsal sclerenchymatous sheath in both, there are quite marked differences between them.

*P. lacunosum* differs from the present species in having flat median sinus in the fibrovascular bundles; this is concave in the present species. Presence of frequent fibrous bundles is noted in *P. lacunosum* while they may rarely be seen only in the dermal part of the present species.

Similarly, *P. vasculosum* also differs from the present species as the fibrous part of the fibrovascular bundles is much less here as compared to the vascular part. Besides, more than two metaxylem vessels are often present in each fibrovascular bundles of *P. vasculosum* as compared to generally two metaxylem vessels seen in the present species.

As the present fossil palm stem is quite different from all the species of *Palmoxylon* so far known, it is described here as a new species, viz., *Palmoxylon livistonoides*,

TABLE 1

FOSSIL SPECIES	PARTS AVAILABLE	STENZEL'S CLASSIFICATION	FIBROUS BUNDLES; STEGMATA	SIZE OF FIBROVASCULAR BUNDLES	FIBRO-VASCULAR RATIO	DISTRIBUTION OF FIBRO-VASCULAR BUNDLES PER CM <sup>2</sup>	MEDIAN SINUS	AURICULAR SINUS; AURICULAR LOBES	VASCULAR PART OF FIBROVASCULAR BUNDLES WITH NUMBER OF VESSELS
<i>Palmoxylon arcotense</i> Ramanujam	Cortical, dermal, sub-dermal and central	Reniformia	Absent	D. 50-100 $\mu$ m SD. about 175 $\mu$ m C. 100-200 $\mu$ m	D. 15/1 SD. 5/1-8/1 C. 2/1-3/1	D. 110 SD. 50-65 C. 20-25	Concave	Auricular sinus indistinct; auricular lobes rounded	Excluded; one vessel in dermal, two in subdermal and central zones
<i>Palmoxylon khalsa</i> Sahni	Subdermal	Reniformia	Absent	—	—	—	Rounded	—	Excluded; usually 3-4, rarely 2-vessels
<i>Palmoxylon livistonoides</i> sp. nov.	Cortical, dermal and subdermal	Reniformia	Present; Fibrous bundles scanty in dermal, absent in subdermal zone	D. 240 $\times$ 280-400 $\times$ 800 $\mu$ m SD. 400 $\times$ 400-640 $\times$ 800 $\mu$ m	D. 1/1-6/1 SD. 3/1-7/1	D. 130-140 SD. 40-60	Concave	Auricular sinus absent; auricular lobes rounded	Excluded; one vessel in dermal generally two in subdermal

TABLE 1 (contd.)

GENERAL PARENCHYMA	GROUND TISSUE		ANY SPECIAL PECULIARITY	LOCALITY	GEOLOGICAL HORIZON	REFERENCE
	TABULAR PARENCHYMA	RADIATING PARENCHYMA				
Somewhat spongy in dermal, quite lacunar in subdermal and highly lacunar in central zone; cells oval to rectangular in dermal zone, usually Y-shaped, rarely rod-shaped in inner region	Absent (according to Ramanujam), but found present on examination of type slides	Absent (according to Ramanujam), but found present in subdermal zone	—	Near Tiruchitabalam about 8 miles WNW of Pondicherry	Cuddalore Series	Ramanujam, 1953
Lacunar; cells rod-like, sometimes branched	—	Present	—	Unknown	Unknown	Sahni, 1964
Ground parenchyma compact in dermal, slightly lacunar in subdermal zone; cells round to oval and rod-shaped in dermal, mainly rod-shaped often Y-shaped in subdermal zone	Present	Present in subdermal zone	Tangentially elongated parenchymatous cells of ground tissue usually present between the fibrovascular bundles in dermal zone	Nawargaon, Wardha District, Maharashtra	Deccan Intertrappean Series	—



the specific name indicating its resemblance with the modern wood of *Livistona*.

### SPECIFIC DIAGNOSIS

#### *Palmoxylon livistonoides* sp. nov.

Stem small piece with roots attached representing cortical, dermal and subdermal zones. Fibrovascular bundles of cortical zone circular to oval, 150-416  $\mu\text{m}$  in diameter, irregularly oriented; fibrous bundles quite frequent. Fibrovascular bundles of dermal zone regularly oriented with one to two excluded xylem vessels, circular to oval in shape 240 $\times$ 280-400 $\times$ 800  $\mu\text{m}$  in size, 130-140 per  $\text{cm}^2$  with reniform to complanate dorsal sclerenchymatous sheath and 1/1-1/6 f/v ratio; median sinus concave and auricular lobes rounded; tabular parenchyma in 1-2 layers present; radiating parenchyma absent; fibrous bundles scanty; stegmata present. Fibrovascular bundles of subdermal zone mostly regularly oriented with two excluded metaxylem vessels, circular to oval in shape, 400 $\times$ 600-640 $\times$ 800  $\mu\text{m}$  in size, 40-60 per  $\text{cm}^2$  with reniform dorsal sclerenchymatous sheath; f/v ratio 3/1-7/1; median sinus concave and auricular lobes rounded; tabular parenchyma present in 1-2 layers; radiating parenchyma present; fibrous bundles absent but stegmata present round the fibrous part of fibrovascular bundles. Ground tissue of

radially elongated, cylindrical cells in cortical zone, compact composed of round to oval as well as rod-shaped parenchymatous cells in dermal zone but somewhat spongy in subdermal zone often with Y-shaped cells enclosing small lacunae at places. Leaf-trace bundles present throughout but frequent in subdermal zone; metaxylem vessels show scalariform pitting whereas protoxylem with annular to spiral thickenings. Roots small with a layer of somewhat thick-walled rectangular cells of epiblemma; hypodermis of 4-5 layers of thin-walled, round cells in outer region and several layers of thick-walled cells in the inner region; cortex made up of three zones, outer cortex with a few layers of thin-walled parenchymatous cells, middle cortex of lamellate parenchymatous cells enclosing air spaces and inner cortex consisting of vertically flattened parenchymatous cells with thick-walled cells scattered here and there; endodermis and pericycle indistinct; stele with 14-17 'I'-shaped xylem arches alternating with phloem tissue distributed radially; pith composed of slightly lignified cells.

*Material*—A small piece of stem wood measuring 5 cm in length and 5 cm in width.

*Holotype*—B.S.I.P. Museum no. 35318.

*Locality*—Nawargaon, Wardha District, Maharashtra.

*Horizon*—Deccan Intertrappean Series.

*Age*—Eocene.

### REFERENCES

- BLATTER, J. C. (1926). *The Palms of British India and Ceylon*. Oxford University Press, Madras.
- BRANDIS, D. (1971). *Indian Trees*. Dehra Dun.
- KULKARNI, A. R. & PATIL, K. S. (1977a). *Aristolochioxylon prakashii* from the Deccan Intertrappean beds of Wardha District, Maharashtra. *Geophytology*, 7 (1): 44-49.
- KULKARNI, A. R. & PATIL, K. S. (1977b). *Palmocaulon costapalmatum*, a petrified palm leaf axis from the Deccan Intertrappean beds of Wardha District, Maharashtra. *Geophytology*, 7 (2): 208-213.
- PRAKASH, U. & BOUREAU, Ed. (1968). Bois fossiles de Palmiers. *Mem. Sect. Sci. C.T.H.S. Palaeobotanique*, 2: 130-146.
- RAMANUJAM, C. G. K. (1953). *Palmoxylon arcotense* sp. nov. a fossil palm resembling the living genus *Livistona*, from South India. *Palaeobotanist*, 2: 89-91.
- SAHNI, B. (1964). *Revision of Indian Fossil Plants. Part III. Monocotyledons. Monograph no. 1*. Birbal Sahni Institute of Palaeobotany, Lucknow, India.
- SCHENK, A. (1882). Die von den Gebrüdern Schlegelweit in Indien gesammelter fossilen Hölzer. *Bot. Jahrb.*, 3: 353-358.
- SHUKLA, V. B. (1941). Central Provinces (Intertrappean beds). Palaeobotany in India. II. *J. Indian bot. Soc.*, 20 (1 & 2): 1-9.
- SHUKLA, V. B. (1946). *Palmoxylon sclerodermum* Sahni from the Eocene beds of Nawargaon, Wardha District, C.P. *J. Indian bot. Soc.*, 25 (3): 105-116.
- STENZEL, K. G. (1904). Fossile Palmenhölzer. *Beitr. Palaont. Geol. Öst. Ung.*, 16: 107-287.
- WILLIS, J. C. (1973). *A Dictionary of Flowering Plants and Ferns*. Cambridge.

## EXPLANATION OF PLATES

## PLATE 1

*Palmoxylon livistonoides* sp. nov.

1. Cross section in low power showing roots and a part of cortical zone.  $\times 8$ . Slide no. 35318/5892.
2. Cross section of the dermal zone showing regular orientation of fibrovascular bundles. Note closely placed fibrovascular bundles and leaf-traces.  $\times 8$ . Slide no. 35318/5892.
3. Cross section of outer part of the subdermal zone showing sparsely placed, regularly oriented fibrovascular bundles.  $\times 8$ . Slide no. 35318/5892.
4. Cross section of inner part of the subdermal zone showing slightly irregular orientation of the fibrovascular bundles.  $\times 8$ . Slide no. 35318/5893.
5. Cross section of the root magnified to show hypodermis, cortex and the stele.  $\times 40$ . Slide no. 35318/5892.
6. Cortical zone magnified to show fibrous and fibrovascular bundles and vertically elongated parenchymatous cells.  $\times 40$ . Slide no. 35318/5892.
7. Cross section of the dermal zone of *Palmoxylon livistonoides* magnified to show regular orientation of fibrovascular bundles and compact ground tissue. Note tangentially elongated cells between the fibrovascular bundles.  $\times 20$ . Slide no. 35318/5892.
8. Cross section of the dermal zone of *Livistona chinensis* to show similar fibrovascular bundles. Also note compact nature of ground tissue and similar tangentially elongated cells between the fibrovascular bundles.  $\times 20$ .
9. Cross section of the subdermal zone of *Palmoxylon livistonoides* to show fibrovascular bundles and lacunar ground tissue.  $\times 20$ . Slide no. 35318/5893.
10. Cross section of the subdermal zone of *Livistona chinensis* to show similar fibrovascular bundles and ground tissue. Note lacunar ground tissue composed of rod to Y-shaped parenchymatous cells.  $\times 20$ .
11. Cross section of *Palmoxylon livistonoides* magnified to show lacunar ground tissue composed of rod to Y-shaped parenchymatous cells.  $\times 60$ . Slide no. 35318/5893.
12. Cross section of root of *Palmoxylon livistonoides* magnified to show all the three regions of the cortex.  $\times 40$ . Slide no. 35318/5892.

## PLATE 2

7. Cross section of the dermal zone of *Palmoxylon livistonoides* magnified to show regular orientation







