AFFINITIES OF *PALMOXYLON SCLERODERMUM* SAHNI, WITH REFERENCE TO STRUCTURE OF LEAF-SHEATHS

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ABSTRACT

Structurally well-preserved leaf-sheaths of *Palmoxylon sclerodermum* Sahni are described and the affinities of this palm with extant palm groups are discussed.

INTRODUCTION

Of the number of petrified palm stems collected by us from Deccan Intertrappean Beds of Nawargaon Maragasur region (21° 1'N: 78° 35'E) of Wardha District, Maharashtra, one was found to have well-preserved leaf-sheaths.

Observations of thin-ground sections of fossil, cut in various planes, revealed that all the attributes of its stem (Pl. 2, Figs. 7-12) closely agreed with those of *P. sclerodermum* SAHNI (SAHNI, 1943; SHUKLA, 1946; Table 1) which was also described from the Deccan Intertrappean beds of Wardha District, and hence the fossil stem was placed under *P. sclerodermum* SAHNI. So far, only roots and stems of *P. sclerodermum* have been described. An account of leaf-sheaths is given in this communication.

OBSERVATIONS

The leaf-sheaths are arranged one-inside-the-other (Pl. 2, Fig. 7) around the stem. They are thickest in their midrib region and become thinner towards the margins on either side (Pl. 1, Fig. 1; Text-figs. 1-4). In the midrib region they have an average thickness of 0.5 cm while at their extreme margin it is 0.1 cm. They are 0.4 cm thick between the margin and the midrib.

SHEATH STRUCTURE IN THE MIDDLE REGION

Epidermis

Abaxial epidermis has squarish cells with a thick layer of cuticle on their outer face (Pl. 1, Fig. 2). Their inner tangential and radial walls appear thicker than the outer tangential walls. The adaxial epidermis is well-preserved, only at places. It consists of tangentially flattened, rectangular cells with a thin layer of cuticle on its outer face.

Hypodermis

Hypodermis is well differentiated both on abaxial and adaxial surfaces (Pl. 1, Figs. 1, 2; Text-fig. 1, *hyp.*). It can be recognised as a thick-band underlying the epidermis even under the hand lens. The thickness of hypodermis varies from 0.43 mm to 0.46 mm. Usually it is thinner on the adaxial side than on the abaxial. The hypodermis consists of small polygonal, compactly arranged cells. Innermost layers of hypodermal cells have thicker walls than those of the outer layers.

Table 1—Comparative account of *Palmoxylon sclerodermum* (Sahni, 1943; Shukla, 1946) and the *Palmoxylon* attributted here to *P. sclerodermum*.

	Palmoxylon sclerodermum Sahni, 1943; Shukla, 1946	*Palmoxylon sclerodermum*—present fossil
CORTEX		
Fibrovascular bundles	present	poorly preserved
Shape and size	oval in shape with a pointed end, 0.4×0.5 mm	—
Dorsal cap	cordate	—
Xylem	3 to 4 vessels	—
f/v	4/1 to 6/1	—
Fibrous bundles	present	—
Shape and size	rounded, 12-15 fibres	—
Stegmata	present both on the fibrous and fibro-vascular bundles	—
Ground tissue	parenchymatous, cells mostly elongated and rectangular, 0.4×0.4 mm	—
DERMAL		
Fibrovascular bundles		
Distribution	105 cm² (Sahni's type specimen 108)	90–120 cm² mean 105 cm²
Shape and size	elliptic, one or more flat sides, smaller bundles 0.4 mm in diametre, the larger ones twice as thick, 0.9×0.85 mm	elliptic, 1 or more flat sides, 0.850×0.224 mm
Dorsal cap	cordate sinus, auricular lobes mostly rounded	cordate sinus, auricular lobes mostly rounded and angled
Xylem	single large median vessel	single large median vessel
Phloem	badly preserved, lies deep in the angles of cordate sinus	poorly preserved lies deep in the angles or cordate sinus
f/v	9/1 to 18/1 (12/1 to 15/1, Sahni's type specimen)	12/1
Fibrous bundles	present here and there	present
Stegmata	constantly present on the fibrous bundles and also on the fibrovascular bundles	present

Table 1—(*Contd.*)

	Palmoxylon sclerodermum Sahni, 1943; Shukla, 1946	*Palmoxylon sclerodermum*—present fossil
Ground tissue	lacunar and composed of thin-walled isodiametric cells, cells 0.08×0.5 mm (ground tissue badly preserved; Sahni's type specimen)	lacunar and composed of thin-walled isodiametric cells, cells 0.08×0.06 mm, tabular parenchyma present
Leaf trace bundles	present, dorsal sclerenchyma forms the major portion, xylem prominent, vascular part comprises number of vessels of medium size and tongue-like process forms, well-defined acute angled auricular sinus with auricular lobes	present, dorsal sclerenchyma forms the major portion, xylem prominent, vascular part comprises number of vessels of medium size and tongue-like process forms, well-defined acute angled auricular sinuses, auricular lobes 103×207 μm
SUBDERMAL		
Fibrovascular bundles		
Distribution	75 cm² (65 cm² Sahni's type specimen)	60-80 cm², mean 75 cm²
Shabe and size	slightly elliptic, 1×0.75 mm	slightly elliptic, 1.1×0.738 mm
Dorsal cap	dorsal margin of scl. quite round and its base cordate, auricular lobes merge into the sides of xylem; tabular parenchyma present in 1 or 2 layers	dorsal margin of scl. round and its base cordate, auricular lobes merge into sides of xylem
Xylem	the larger 2 elements occurring ventrally and other smaller internally to them, pitting scalariform	2 large metaxylem vessels, protoxylem one or two internally to them
Phloem	poorly preserved	poorly developed
f/v	22/1 (18/1-25/1 Sahni's type specimen)	23/1
Fibrous bundles	present, 12-18 fibres	present
Shape and size	rounded	rounded
Stegmata	present both on the fibrous and the fibrovascular bundles	present
Ground tissue	lacunar and made up of compact, isodiametric cells, cells 0.08×0.06 mm	lacunar and made up of compact, isodiametric cells, cells 0.09×0.08 mm
Leaf trace bundles	as in dermal, radially elongated	as in dermal, radially elongated
CENTRAL	central zone is not present in type specimen	—
Fibrovascular bundles		
Distribution	65-70 cm²	—

Table 1—(*Contd.*)

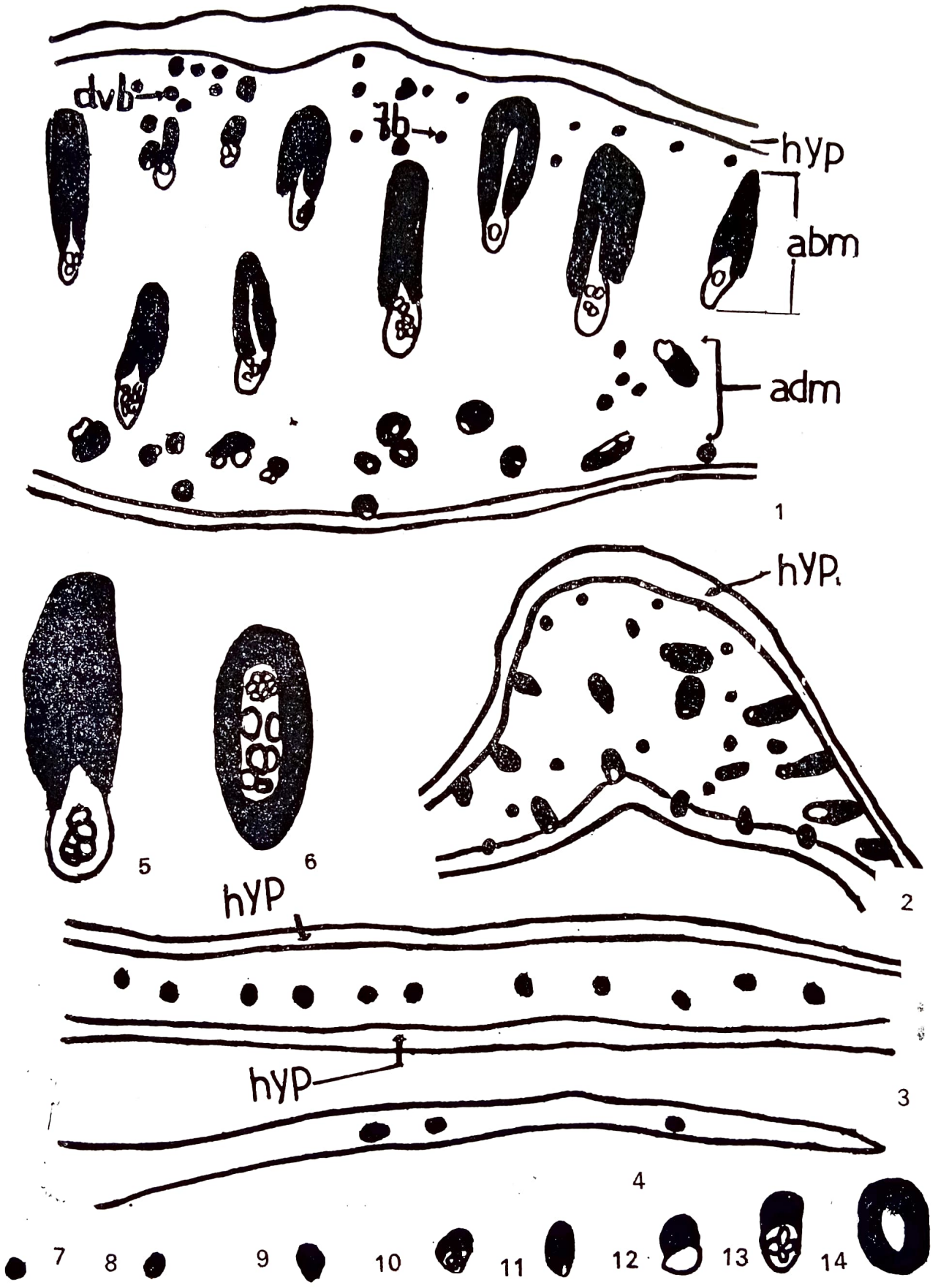
	Palmoxylon sclerodermum Sahni, 1943; Shukla, 1946	*Palmhxylon sclerodermum*—present fossil
Shape and size	slightly elliptic, 1 × 0.85 mm	
Dorsal cap	rounded with its base cordate	
Xylem	tabular parenchyma present-2 large vessels	
Phloem	poorly preserved	—
f/v	23/1	
Fibrous bundles	present, badly preserved	—
Shape and size	10-12 fibres	—
Stegmata	—	—
Ground tissue	parenchymatous, thin-walled cells, cells 0.09 × 0.07 mm	
Leaf trace bundles	—	—

Mesophyll

Between adaxial and abaxial hypodermis the mesophyll region of leaf sheaths is found (Pl. 1 Fig. 2; Text-fig. 1). It consists of fibrovascular bundles, diminutive vascular bundles and fibre bundles distributed in the ground tissue. It can be differentiated into adaxial half with loosely arranged cells having copious inter-cellular spaces and the abaxial-half with somewhat compactly arranged cells.

Abaxial-half has an average thickness of 2.54 mm. Below hypodermis is found a row of small fibre bundles, 72 μm in diameter, each consisting of about 15 fibres. Below this row, one to three rows of diminutive vascular bundles are seen (Pl. 1, Fig. 2; Text-fig. 1; *fb, dvb*). These are mostly circular in outline, 144 μm in diametre and concentric type, consisting of a central strands of xylem and phloem surrounded by a fibrous sheath (Text-figs. 7-9, 14). In a few of them, the vascular tissue is so much reduced that they appear like fibre bundles (Text figs. 7-9). Some of these bundles are collateral (Text-figs. 10-13). They are oval, 216-195μm with well-developed lunate to vaginate dorsal cap, including in the median sinus phloem tissue below which one to two small metaxylem elements are seen. The ground parenchyma in-between the diminutive vascular bundles and the fibre bundles consists of polygonal to squarish, compactly arranged thin-walled cells.

Below the diminutive vascular bundles are seen one to two rows of large elongated fibrovascular bundles (Pl. 1, Fig. 2; Text-fig. 1). These form a distinctive feature of these sheaths. Each vascular bundle is 0.72 to 1.6 mm long and 0.18 to 0.28 mm broad in the middle. It has a massive, radially elongated dorsal fibre-cap, 366 × 1224 μm in size. The median sinus is often deeply angled and fissured enclosing a triangular patch



Text-figs. 1-14. Leaf-sheaths of *Palmoxylon sclerodermum* Sahni, Figs. 1-4. Cross sectional view of leaf-sheaths showing distribution of fibre bundles (*fb*), diminutive vascular bundles (*dvb*) and fibrovascular bundles in the ground tissue, Fig. 1. Median portion ×8 (*hyp*-hypodermis, *abm*-abaxial mesophyll, *adm*-adaxial mesophyll), Fig. 2. Midrib region ×6, Fig. 3. Lateral arm ×8, Fig. 4. Marginal end of the leaf sheath ×8, Figs. 5-14. Fibre and fibrovascular bundles ×40.

of fairly well-preserved phloem tissue. The auricular sinuses are angled to rounded. The xylem tissue is found enclosed in a tongue-shaped protrusion of xylem parenchyma. It consists of 4 to 8 round metaxylem elements, 72 μm in diametre. Protoxylem elements are not conspicuous in transverse sections. Xylem parenchyma is enclosed ventrally by a fibre-cap (Pl. 1, Figs. 3, 4; Text-fig. 5).

The ground parenchyma cells are oval to tubular, 62 × 36 μm in size and rather closely arranged. The parenchyma rows are arranged in tangential pattern on either side of dorsal fibre-caps (Pl. 1, Figs. 3, 4). Many fibro-vascular bundles show radiating strips of parenchyma around their ventral-cap (Pl. 1, Fig. 3).

Adaxial-half of mesophyll (Pl. 1, Fig. 2; Text-fig. 1; *adm*) extends to 1.60 mm in thickness and appears to be radially compressed in almost all leaf sheaths. Numerous fibrovascular bundles, fibre-bundles and diminutive vascular bundles are found irregularly distributed in the ground parenchyma.

The fibrovascular bundles are oval to round, 0.23 × 0.12 mm in size. They have lunate to reniform dorsal fibre-cap and 1-2 metaxylem elements. The diminutive vascular bundles are mostly rounded with a patch of central vascular tissue surrounded by fibrous sheath. The fibre bundles are round, 83 μm in diametre and few in number. The ground parenchyma has loosely arranged, thin-walled cells with copious large intercellular spaces giving lacunar appearence to this part.

Midrib Region

The structure of the leaf-sheath in the midrib region is almost similar to that of the middle region. Midrib region is abadaxially distended and the adaxial mesophyll is more prominent (Pl. 1, Fig. 1; Text-fig. 2). The hypodermis is somewhat massive on the abaxial side. Many of the large fibrovascular bundles on the abaxial half of the mesophyll are obliquely cut and appear to have shifted to the periphery, situated just below the abaxial hypodermis.

Marginal Ends

(Text-figs. 3, 4)

The differentiation of mesophyll tissue into abaxial-and adaxial-half becomes progressively less pronounced towards the marginal ends where the mesophyll tissue appears to be homogeneous with polygonal, compactly arranged cells. A single row of diminutive bundles is seen situated in the middle part of the mesophyll (Text-fig. 3). At extreme tips, the epidermis and the mesophyll tissue consist of somewhat thick-walled cells.

DISCUSSION

Comparison with Fossils

Only one palm stem, *Palmoxylon puratanum* Ramanujam (1958), with structurally preserved leaf-bases has been described from Tertiary of India, from Mortandra, near Pondicherry of Cuddalore Sandstone Series, attributed to middle Miocene period. This leaf sheath has only fibre-bundles scattered in homogeneous ground-tissue consisting of closely packed, angular cells and hence differs in structure from the leaf sheaths described here. The associated stems are structurally different in *P. puratanum* and *Palmoxylon sclerodermum.*

Cyclanthodendron sahnii (Sahni & Surange, 1953; Ramanujam, 1959; Trivedi & Verma, 1976), whose exact affinity with living families of monocotyledons is disputed,

has also structurally different organisation. Prominent air cavities seen in them are not found in leaf sheaths of *Palmoxylon sclerodermum*. Further, the stem structure in both these is radically different.

No other fossil palm stem with leaf sheaths has been described so far and also no detached leaf sheaths are known.

Affinity with Living

The nature of leaf sheath studied here shows that they must be thin because they are not much wider in the midrib region as compared to their lateral arms. The paucity of vascular bundles in the extreme margins of these leaf sheaths also shows that the sheaths must not be marginally fibrous. These two observations preclude the possibility of their comparison with coryphoid, phoenicoid, borassoid, lepidocaryoid, nypoid, caryotoid, ceroxyloid, cocosoid, geonomoid and phytelephantoid palms where the leaf-sheaths are fibrous as well as massive (Moore, 1973; Uhl & Moore, 1973).

The thin leaf-sheaths of this palm are enclosed one-inside-the-other indicating that they must be forming tubular or open sheaths round the stems. Such a situation is characteristic of majority of palm groups of arecoid line of evolution of Palmae (Moore, 1973) found in chamaedoreoid, iriarteoid and most of the genera of arecoid palms. In these palms, leaf-sheaths are thin, non-fibrous, and organize the crown shaft (Bailey, 1946).

Leaf sheaths of commonly available arecoid palms-like, *Chrysalidocarpus, Ptychosperms, Oreodoxa,* etc., were cut and compared for their structural details with the fossil leaf-sheaths (Pl. 1, Figs. 5, 6). None of the living sheaths examined showed the total similarity with the fossil. However, they had some common basic features. In all these genera which were examined, the leaf-sheath is differentiated into abaxial-half with compact ground tissue containing large vascular bundles, and the adaxial-half with loose ground tissue containing smaller vascular bundles, a situation similar to the one found in fossil leaf-sheaths. Further, the arrangement of fibre bundles and diminutive vascular bundles in the abaxial sub-hypodermal region is also similar in some of these genera, viz. *Areca, Ptychosperma,* to that of the fossil leaf-sheaths.

These observations strengthen the belief that the fossil stem with its leaf-sheaths must have belonged to a arecoid stock of palms rather than to *Astrocaryum,* a cocosoid member as previously suggested by Sahni (1946). Four genera, *Areca* (2 species), *Pinanga* (6 species), *Ptychoraphis* (1 species), and *Bentinckia* (2 species), and 11 species of arecoid stock of palms are found in wild conditions in India. Most of them are restricted to Assam Himalayas and Andaman islands—except *Pinanga dicksonii* and *Bentinckia codappanna* distributed in southern part of Western Ghats.

It may be mentioned here that Kulkarni and Mahabale (1971) based upon the reinvestigation of *P. kamalam* Rode collected by them from Kondhali (Maharashtra) suggested its affinity with *Roystonea,* a member of arecoid stock.

Museum No.—N-429, Dept. of Biological Sciences, Ruia College, Matunga, Bombay.

Locality—Nawargaon—Maragsur, Wardha District, Maharashtra.

Horizon—Deccan Intertrappean Beds.

Age—Early Tertiary (Probably Eocene).

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EXPLANATION OF PLATES

PLATE 1

Figs. 1-6. Leaf-sheaths of fossil stem attributed to *Palmoxylon sclerodermum* Sahni, and arecoid palms in T. S. Figs. 1-4. Leaf-sheaths of the fossil, Fig. 1. Cross view of leaf sheaths (*hyp*-hypodermis) ×6, Fig. 2. Middle portion of sheath magnified ×8, Figs. 3-4. Fibrovascular bundles of the abaxial mesophyll and surrounding ground tissue × 120, Figs. 5-6 Larecoid palm sheaths × 72, Fig. 5. *Ptychosperma elegans* Blume, Fig. 6. *Chrysalidocarpus lutescence* Wendl.

PLATE 2

Figs. 7-12. Stem structure of fossil palm referred here to *P. sclerodermum* Sahni, Fig. 7. Transversely cut surface of a sector of the fossil showing peripheral of leaf sheaths ×1.6, Fig. 8. Dermal zone in T.S. ×50, Fig. 9. Subdermal zone in T.S. ×50, Fig. 10. Fibrovascular bundle of the subdermal zone with surrounding ground tissue × 120, Fig. 11. Fibrovascular bundles of the dermal zone with associated ground tissue × 120, Fig. 12. L. S. of stem showing vessel end plate and associated tissue × 140.

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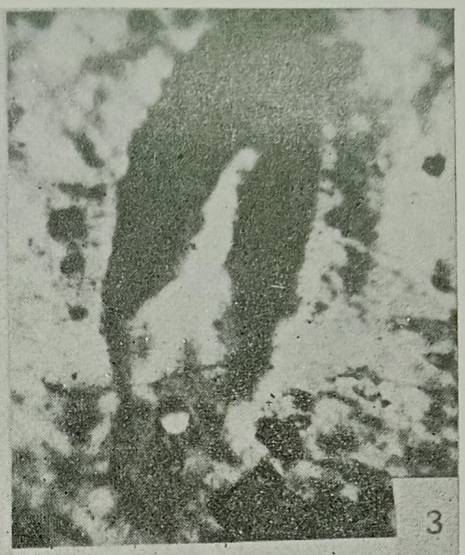

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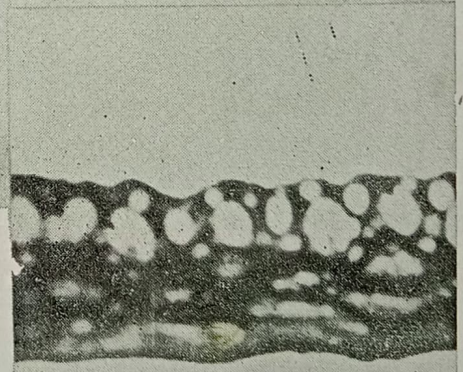

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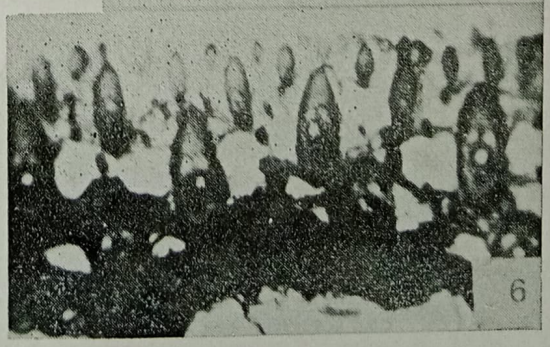

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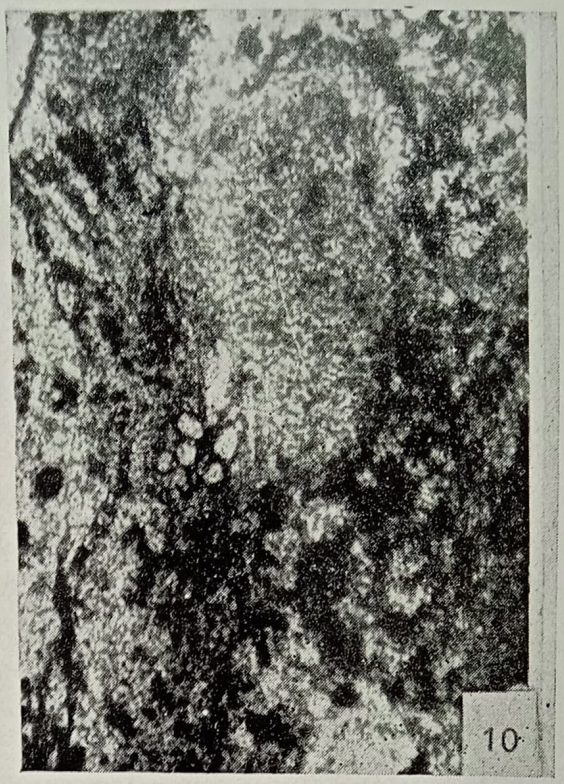

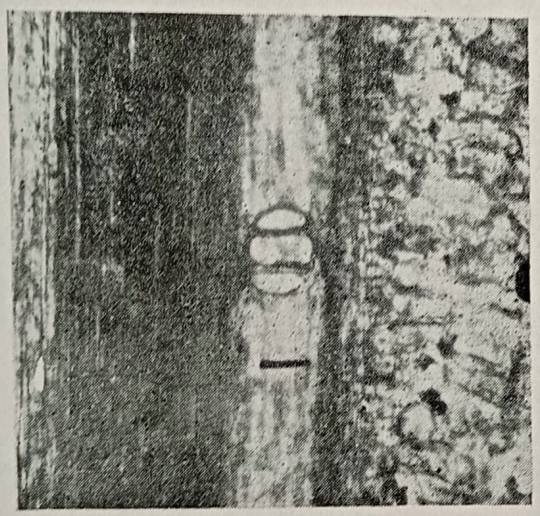

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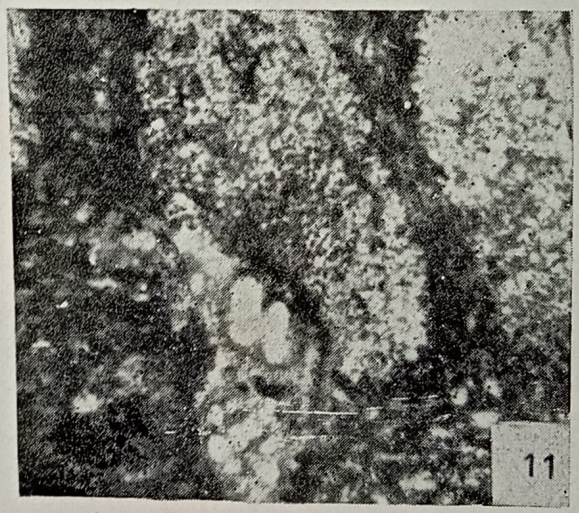

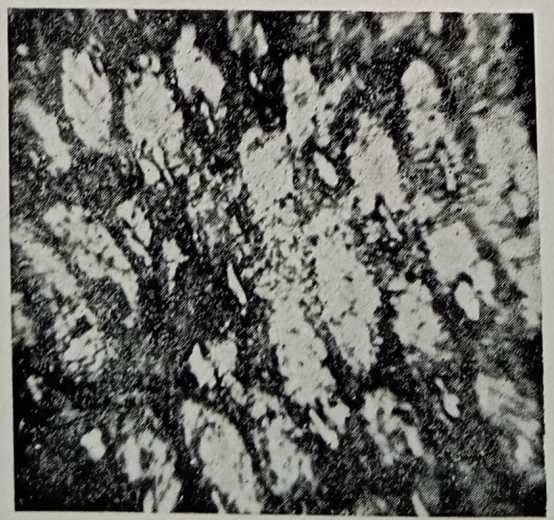

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