OBSERVATIONS ON THE ANATOMY OF THE STEM OF *TRACHYCARPUS MARTIANA* H. WENDL.

K. AMBWANI

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, (India)

Abstract

The present paper deals with the stem anatomy of *Trachycarpus martiana* H. Wendl. The structural variations in the stem have also been recorded, which could be helpful in resolving the artificial genus *Palmoxylon* because the petrified fragments of this genus might represent parts of the same palm. Besides, among the 'species' referred to its artificial 'genus', many natural genera are represented.

Introduction

Anatomy of *Trachycarpus martiana* H. Wendl. has been undertaken keeping in view that a large number of petrified fragments of palm woods are known from different parts of the world belonging to Cretaceous and onwards. So far any detailed work on the anatomy of modern palm stems has not been taken up and with the result the problem of identifying these species of fossil palms has gained universal importance. In the absence of a satisfactory criterion for a natural classification of these fossil fragments, they have been assigned to the artificial genus *Palmoxylon* schenk (1882). This genus constitutes a large number of species described by Sahni (1964) and Prakash and Boureau (1968). Most of these species are assignable to palms but among the true palms referred to this 'genus' many natural genera are represented. Besides, a number of these 'species' might also belong to one and the same palm or parts of the same organ.

In order to assign these artificial species to their natural genera and to identify the isolated fragments of fossil palms from the Deccan Intertrappean beds, one of which appeared to resemble *Trachycarpus* and the other to *Hyphaene*. Hence the detailed anatomy of the stem wood of one of these two genera, *Trachycarpus* has been undertaken and *Trachycarpus martiana* H. Wendl. has been selected for this purpose. It was collected from Nongnah in Meghalaya during the year 1982. This genus belongs to Sabaloid group of plams (Tomlinson, 1961). The stem of the present species under study measures 6 ft. in length. It is simple with distinct internodes and fairly narrow clothed by permanent very fibrous leaf bases especially at the upper portion.

Fossil palms, belonging to Sabaloid group, have been reported from the Deccan Intertrappean beds of India, viz., *Palmoxylon livistonoides* Prakash & Ambwani (1980) resembles *Livistona*; *Sabalocaulon intertrappeum* Trivedi & Verma (1981) resembles *Sabal* petiole as well as *Palmoxylon shahpuraensis* Ambwani (1983) compares to modern *Licuala*. Apart from this, fossil leaf impression belonging to *Sabal* has been described by Sahni (1964) from the Deccan Intertrappean Series of India and to *Trachycarpus* by Lakhanpal *et al.* (1983) from the Lyan Formation of Ladakh. Recently a leaf impression of *Livistona* has been recorded from the Hemis conglomerate Horizon of Ladakh by Lakhanpal *et al.* (1985).

Anatomy of modern palms has been an attraction of early workers like Van Mohl (1824, 1849), Karsten (1847), Branner (1884) and Shoute (1912). They emphasized much

Geophytology, **15**(2) : 199—205, 1985.

on the course of vascular bundles and mode of secondary growth in different palm stems. Later workers like Monoyer (1925), Ball (1941), Zimmermann and Tomlinson (1965), Kaul (1941, 1942, 1960) and Tomlinson (1961) delt in detail the significance of the criteria like distribution of the fibrovascular bundles per square unit area, shape of the fibrous sheath of the fibrovascular bundles, fibrovascular ratio, number of metaxylem elements, nature of perforation plates in them as well as the nature of ground tissue. Kaul (1935) based his results in the anatomy of palms with emphasis on the ground tissue. These characters together were employed to distinguish the different species of *Palmoxylon* by Stenzel (1904), Sahni (1931, 1934, 1964) and other workers in this field. It was Swamy and Govindrajalu (1961) who traced the variability of different tissues and cell types occurring in the stem of *Phoenix sylvestris*. Ambwani and Prakash (1979-80) made a detailed study of the anatomical variability in the stem of *Caryota sobolifera* Wall. and its significance in the identification of the genus *Palmoxylon*. Reddy and Kulkarni (1981) described the systematic anatomy of *Chrysalidocarpus lutescens* H. Wendl. and discussed its anatomical variations throughout the stem length. Apart from this, anatomical studies of petioles of different species of *Livistona* have been carried out by Mahabale and Kulkarni (1972) and Kulkarni and Mahabale (1979) giving a range of anatomical variations throughout the length.

Material and Methods

The palm stem selected for the present studies was collected from Nongnah about 5000 ft. high hill-top in Meghalaya. The whole plant was uprooted measuring 6 feet in height. Four discs of about 1 inch thickness were cut at the intervals of every two feet from the base to the apex, i. e. these discs were obtained at the base, 2 feet, 4 feet and 6 feet levels. From each disc a sector was cut along its radius which contained all the regions from centre to the periphery. Each sector, so obtained, was further divided having cortical, dermal, subdermal and central zones. These blocks were then subjected to the microtome directly or whenever necessary they were embeded in paraffin wax. Sometimes the material, especially in the peripheral part, was quite hard to be worked out by microtome directly; it was first boiled under pressure and then waxed to obtain the thin sections. A series of transverse and longitudinal sections from each block was obtained from base to apex of the stem.

Description

Cortical zone—It is about 0.5 cm thick throughout the stem length composed mainly of larger fibrovascular bundles alongwith rarely seen smaller fibrous bundles. The outermost layer is mainly composed of suberised cells of comparatively thicker walls to that of the parenchymatous cells in the inner side of this zone. The parenchymatous cells in the inner part are thin-walled ranging in shape and size. The cells between two adjoining fibrovascular bundles become laterally elongated and are arranged in tiers (Pl. 1, fig. 1). The size of these bundles ranges from 640 $\times$800-1440 $\times$800 μm but they become smaller at the lavel of 6 feet and measure 320$\times$400-480$\times$320 μm (Pl. 2, fig. 12). The apical portion is especially dominated by fibrous bundles of comparatively larger size which range from 50-160 μm (Pl. 2, fig. 12). It has been observed that the frequency of fibrous bundles in this zone increases from base to apex. The fibrovascular bundles are irregularly distributed (Pl. 1, fig. 1, 8 and Pl. 2, fig. 12). The dorsal sclerenchymatous sheath is prominent, mostly reniform. The f/v ratio varies from 4/1-6/1 at the base whereas it is 1/1-3/1 at the apex. Generally two small metaxylem vessels, sometimes three are seen at the base while this number may be 4 at the apex, usually these vessels are associated with smaller protoxylem elements and their number may exceed up to 8 in a fibrovascular bundle. The ground tissue cells are of various shapes, laterally elongated in between two fibrovascular bundles. They are also arranged in vertical files which run irregularly through this zone and extend into dermal zone; these files are absent in the apical region (Pl. 2, fig. 12). The ground tissue is compact without any intercellular spaces. Stegmata are present profusely in the fibrous portion of the fibrovascular bundles.

Dermal Zone—This zone extends about 1 to 1.2 cm just after the cortical zone and is mainly composed of fibrovascular bundles. These bundles in the basal part are fairly apart and regularly oriented (Pl. 1, fig. 1). They gradually come closer with the increase of stem height as seen in apical part (Pl. 2, fig. 12)). Their shape ranges from round to oval sometimes elongated. Dorsal sclerenchymatous sheath is reniform. The size of the bundles in this zone at the basal part ranges from 1280×800-1440×640 and 960×860-1440×800 μm at the level of 2 feet whereas they are 800×640-1280×800 μm at 4 feet and 480×400-1120×640 μm at 6 feet level. This indicates that the bundles of larger size are frequent at the base and smaller ones at the apical portion (Pl. 1, figs. 2, 5, 8; Pl. 2, fig. 12). The frequency of the fibrovascular bundles shows an increasing trend at different levels of the stem, i.e. they are 35-40/cm^2 at the base, 40-45/cm^2 at 2 feet, whereas 65-70/cm^2 and 130-140/cm^2 at 4 feet and 6 feet respectively meaning thereby a gradual concentration of the fibrovascular bundles occuring in the apical portion of the stem. The f/v ratio of the bundles is 3/1-5/1 at the base and 9/1-10/1 in rest of length of the stem. The median sinus is usually concave and the auricular sinus indistinct or absent. The auricular lobes are usually rounded (Pl. 2, fig. 11). Each fibrovascular bundle has generally two metaxylem vessels with 2-4 protoxylem vessels at the basal portion while this number increases up to 4 or more towards the apex of the stem. Stegmata and a layer of tabular parenchyma are present around the fibrous part of the fibrovascular bundles. The radiating parenchyma are absent. Leaf-trace bundles are frequently present throughout this zone. Phloem is present in the cavity between the xylem and dorsal sheath of the bundle and comprises of sieve tube elements and companion cells, supported by a few phloem parencyma. The ground tissue is compact throughout this zone (Pl. 1, figs. 2, 5, 8; and Pl. 2, fig. 12). Diminutive fibrovascular bundles are frequently present in the upper portion of the stem.

Subdermal Zone—The fibrovascular bundles are almost equally distant from each other throughout this zone. Generally the larger bundles are at the basal part and range from 1280×960-1440×960 μm and gradually decrease in size towards the apex and range from 960×640-1120×960 μm at 2 feet level. They further decrease in size 960×800-1120×640 μm and 960×640-830×640 μm at 4 feet and 6 feet distance from the base but here the larger bundles are fewer. The majority of the bundles fall under the range 830×640 μm (Pl. 1 figs. 3, 6, 9; Pl. 2 fig. 13). The frequency of the fibrovascular bundles is 25-30, 35-40, 45-50 and 85-90 per cm^2 at base, 2 feet, 4 feet and 6 feet respectively. The fibrovascular ratio in this zone varies from 3/1-4/1 at base, 5/1-6/1 at 2 feet, 6/1-7/1 at 4 feet and 6 feet levels. The dorsal sclerenchymatous sheath is usually reniform. The median sinus is usually concave and the auricular sinus indistinct whereas the auricular lobes are rounded. Each fibrovascular bundle usually has 2-5 metaxylem vessels associated with a few protoxylem elements. Stegmata are profusely present throughout the fibrous part of the fibrovascular bundles. A layer of tabular parenchyma is present around the fibrovascular bundles whereas radiating parenchyma is absent. Phloem is composed of sieve tube elements, companion cells and phloem parenchyma. Sometimes the phloem is seen divided into two parts due to further extension of sclerenchymatous cells of the sheath (Pl. 2, fig. 11). The ground tissue is compact and fibrous bundles are absent throughout this zone of the stem.

Central Zone—Fibrovascular bundles in this zone are irregularly oriented and widely placed, their size ranges from 1120×960-1280×960 μm at the basal region, 830×800-1120×800 μm at 2 feet, 960×830-1120×830 μm at 4 feet while 640×400-960×480 μm at 6 feet level, meaning thereby the size of these bundles decreases with the increase in the stem height (Pl. 1, figs. 4, 7; Pl. 2, figs. 10, 14).

The frequency of these bundles varies from 6-10/cm³ at the base, 25-30/cm² at 2 feet height, 35-40/cm² at 4 feet level while 60-65/cm² at the level of 6 feet and the fibrovascular ratio varies from 3/1-4/1 at the base, 4/1-5/1 at 2 feet, 2/1-3/1 at 4 feet and usually 2/1 at 6 feet level. Dorsal sclerenchymatous sheath is usually reniform. The median sinus concave and the auricular sinus is indistinct (Pl. 1, figs. 4, 7; Pl. 2, figs. 10, 14). Each fibrovascular bundle has usually 3-5 metaxylem vessels but this number increases 8-9 throughout the stem length. There may be as many as 15 protoxylem elements in a bundle. Stegmata are profusely present in the fibrous part of the fibrovascular bundles (Pl. 2, fig. 15). A layer of tabular parenchyma may also be seen around the fibrovascular bundles. Fibrous bundles frequently present in the basal portion whereas they are absent in the upper part of the stem (Pl. 1, figs. 4, 7; Pl. 2. figs, 10, 14). Radiating parenchyma are absent throughout this zone. Phloem is composed of sieve tube elements, companion cells and phloem parenchyma. It is also seen divided into two parts due to the extension of sclerenchymatous cells of the sheath. The ground tissue is compact throughout this zone but sometimes a few smaller intercellular spaces may be present in the basal part of the stem (Pl. 1, figs. 2, 3, 4).

Diminutive Fibrovascular Bundles—The diminutive fibrovascular bundles are frequently present in the dermal zone throughout the stem. In the subdermal and central zone their frequency decreases, i. e. their number is inversely proportional to the stem height. These bundles usually measure up to 200×180 μm and exhibit similar construction as the larger fibrovascular bundles and show irregular orientation.

Leaf-Trace Bundles—Leaf trace bundles are present throughout the stem and can easily be distinguished by their extended vascular part with many smaller xylem vessels. They are slightly larger than the normal fibrovascular bundles (Pl. 1, figs. 2, 3, 4; Pl. 2, figs. 10, 13, 14).

Fibrous Bundles—Fibrous bundles are profusely seen in the cortical zone and very rarely in the dermal zone while they are absent in subdermal zone. Further, their appearance in the central zone is noteworthy (Pl. 1, figs 3, 5; Pl. 2, figs. 12, 13, 14).

Ground Tissue—The ground tissue is compact throughout the stem and does not show secondary expansion of the parenchymatous cells. These cells indicate variation in shape and size in the dermal zone up to 2 feet height, and vary from round, oval to angular. Sometimes the angular cells are highly inflated (Pl. 1, figs. 1, 2, 3). The vertical files of the cells may be seen running between the fibrovascular bundles (Pl. 1, fig. 5). These files run irregularly throughout this zone whereas in the subdermal and central zone of the stem the cells become more compact and smaller which at the apical part become isodiametric in shape (Pl. 1, figs 6, 7, 9; Pl. 2, fig. 13).

Vessel Elements—Metaxylem vessels in dermal zone are usually narrow, round to oval (in T. S.) in the basal part while their number increases in the apical part as many as 8-9 per vascular bundle. They measure 80×40-96×40 μm in cross section and 160×60-560×64 μm in length. The end plates are oblique with 2-8 perforation bars, sometimes simple perforations are also present (Pl. 2, figs. 15, 16). These vessels have densely scalariform to reticulate thickenings on their walls. Protoxylem elements measure 32-80 µm in cross section while they are larger than metaxylem elements being 130-960 µm, usually possessing annular to spiral thickening on their walls (Pl. 2, figs. 15, 16, 17, 18).

The larger size vessels generally occur in the upper portion of the stem indicating their positive relationship with the height of the stem (also see Reddy & Kulkarni, 1982).

Discussion

Generally the anatomical characters exhibited by the present palm stem such as: the nature of the fibrovascular bundles, their frequency per unit square area, f/v ratio, shape of the dorsal sclerenchymatous sheath, vessel elements as well as the nature of the ground tissue, do not show stability throughout the stem length (Tomlinson, 1961; Sawant & Mahabale, 1980; Ambwani & Prakash, 1981; Reddy & Kulkarni, 1981) but some of the characters like nature of the dorsal sclerenchymatous sheath, the ground tissue as well as presence of stegmata etc. appear to be stable characters throughout the stem. The features of variable behaviour can be summarised as follows:

The maximum size of the fibrovascular bundles in the dermal zone at the base being 1200×800-1440×640 µm gradually decreases up to 480×400-1440×640 µm towards the apical part. In the subdermal zone these bundles also show same size but at the level of 4 feet they become smaller and range 830×640-960×640 µm whereas in the central zone their size varies 1220×960-1280×960 µm at base which are reduced to 640×400-960×480 µm towards the apical region meaning there by the size of the fibrovascular bundles is inversely proportional to the height of the stem. The number of the metaxylem vassels per vascular bundle in the dermal zone is usually 2, sometimes 3 to 4 may also be seen; in the subdermal zone they range from 3-5 and exceed to 9 in the central zone (Pl. 1, figs. 1-9; Pl. 2, figs 10-14). The number of the fibrovascular bundles per unit square area in the dermal zone ranges from 35-40 at the base which increases up to 130-140 at the apex while in the subdermal zone they become lesser to 26-30 at the base and 85-90 at the apical region. This number still decreases from 6-10 in the central zone at the base and extends to 60-65 at the apex showing their direct relationship with the height of the stem. According to Tomlinson (1961, pp. 18) "the number of vascular bundles per unit area of stem is aproximately the same at all the heights. This is true even where the stem tapers or becomes swollen." But this does not hold good in case of *Trachycarpus martiana*, as the number of fibrovascular bundles in the stem increases with the increase in the stem height (see text). The f/v ratio in the dermal zone of the basal part ranges from 3/1-5/1 and beyond the level of 2 feet to the apical region, it remains constant between 9/1-10/1. This ratio in the subdermal zone is 3/1-/1 and 6/1-7/1 whereas in the central zone it is 4/1-5/1 at the base and usually 2/1 at the apical portion. As regards the number of metaxylem vessels per bundle, it extends up to 4 at the base whereas 8 to 9 at the upper portion and their length increases from 160 to 560 µm. The protoxylem elements are longer than the metaxylem elements and range up to 960 µm. The longer vessels usually occur in the apical part of the stem, showing a direct relationship with the stem height.

The ground tissue in the present species does not seem to undergo secondary expansion and is usually compact throughout the stem. The parenchymatous cells in the lower part of the stem are usually larger and variously shaped. It is notable that the fibrous bundles, which show their appearance in the basal part, disappear as the height of the stem increases.

Generally the lacunar condition of the ground tissue is exhibited in the central zone of Sabaloid palm stems (Tomlinson, 1961; Sawant & Mahabale, 1980). It has been observed that the ground tissue in *Trachycarpus martiana* does not show any lacunar condition except a few small intercellular spaces at the basal region which are formed due to the irregular shapes of the parenchymatous cells. This further does not agree the work of Tomlinson (1961) in the case of *Trachycarpus* and indicates that even the girth of the stems in sabaloid plams does not necessarily become a factor for lacunarization of the ground tissue.

References

AMBWANI, K. (1983). *Palmoxylon shahpuraensis* sp. nov. resembling *Licuala* from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. *Pelaeobotanist*, **31**(1) : 52-57.

AMBWANI, K. & PRAKASH, U. (1979-80). Anatomical variability in the stem wood of *Caryota sobolifera* Wall. and its significance in the identification of the genus *Palmoxylon*. *Phyta*, **2 & 3** : 11-25.

BELL, E. (1941). The development of the shoot apex and the primary thickening meristem in *Phoenix canariensis* with comparison to *Washingtonia filifera*. *Amer. J. Bot.*, **28** : 820-832.

BRANNER, J. C. (1884). The course and growth of fibrovascular bundles in palms. *Proc. Amer. Phil. Soc.*, **21** : 459-483.

KARSTEN, G. K. W. H. (1847). Die Vegetationsorgane der Palmen. *Abh. Akad. Berlin Physik.*, 1847 : 73-236.

KAUL, K. N. (1935). A classification of palms based upon the ground-tissue of the stem. *Proc. 22nd Indian Sci. Congr. Calcutta*: 285-286 (Abst.).

KAUL, K.N. (1941-42). The anatomy of the stem of palms and the problem of the artificial genus *Palmoxylon*. *Proc. Linn. Soc.*, **754** : 66-68.

KAUL, K. N. (1960). Anatomy of plants. "Palms". *Bull. natn. Bot. Gdn. Lucknow*, **57** : 1-52.

KULKARNI, K. M. & MAHABALE, T. S. (1979). Studies on palms : I. Anatomical studies on the petioles, lamina and ribs in the genus *Livistona R. Br. J. Univ. Poona Sci. each.*, **52** : 377-399.

LAKHANPAL, R. N. (1983). A fossil fan palm from the Liyan formation of Ladakh (J. & K.) *Palaeobotanist*, **32**(3) : 201-207.

LAKHANPAL, R. N., SAH, S. C. D., SHARMA, K. K. & GULERIA, J. S. (1985). Occurrence of *Livistona* in the Hemis conglomerate horizon of Ladakh. (in press).

MAHABALE, T. S. & KULKARNI, K. M. (1972). Studies on palms : fruits, seeds and their germination in *Livistona chinensis* R. Br. *J. Bombay Nat. Hist. Soc.*, **72**(2) : 655-661.

M NOYE , A. (1925). Anatomy du Cocos botryophora Mart. *Mem. Acad.R. Belg. el. Sci.*, **2** : 1-43.

PRAKASH, U. & AMBWANI, K. (1980). A petrified *Livistona*-like palm stem, *Palmoxylon livistonoides* sp. nov. from the Deccan Intertrappean beds of India. *Palaeobotanist*, **26**(3) : 297-306.

PRAKASH, U. & BOUREAU Ed. (1968). Bios fossiles de Palmiers. *Mem dela section de sci. du C. J. H. S.*, **2** : 130-146.

REDDY, G. N. & KULKARNI, A. R. (1981). Anatomy of palm stems : I, *Chrysalidocarpus lutescens* Wendl. *Geophytology*, **77**(2) : 165-172.

SAHNI, B. (1931). Materials for a monograph of the Indian petrified palms. *Proc. Acad. Sci.* U.P. I : 140-144

SAHNI, B. (1964). *Revision of Indian fossil plants-part III. Monocotyledons. Monograph*, No. 1. Birbal Sahni Institute of Palaeobotany, Lucknow, India.

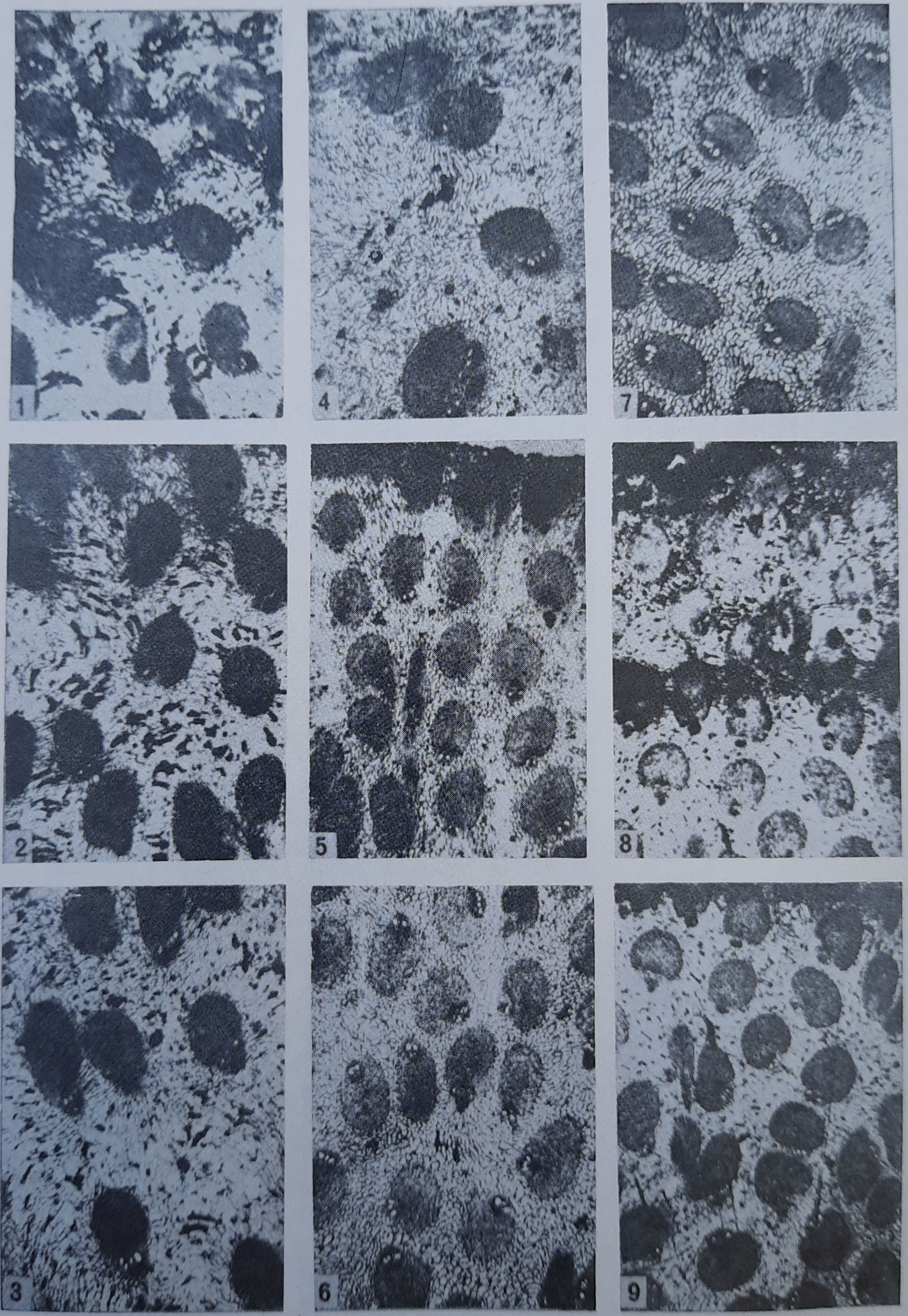
SAWANT, N. & MAHABALE, T.S. (1980). Studies on Palms : Anatomy of stem and root in the Genus *Caryota* in India. *Biovigyanam*, **6** : 135-149.

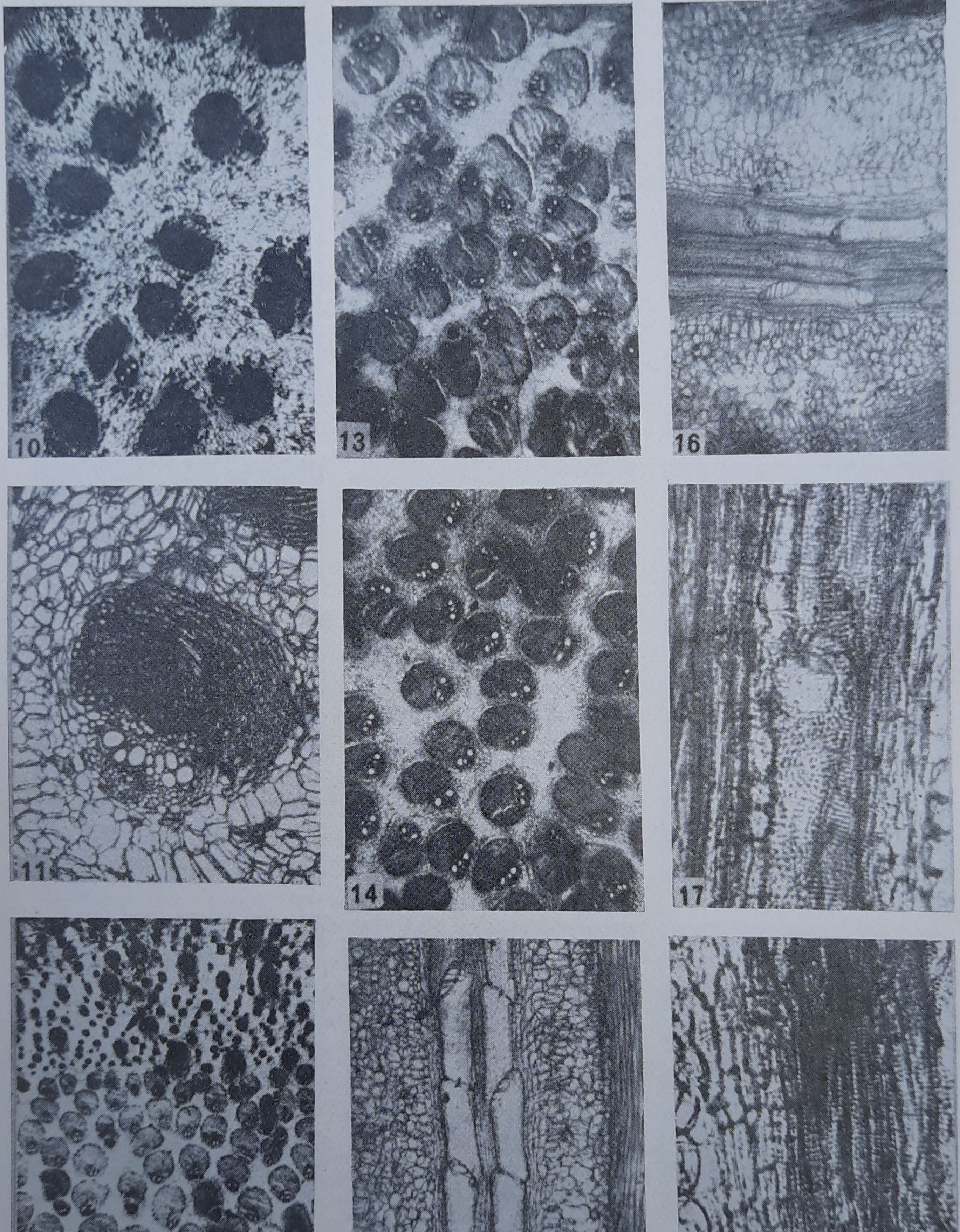
SCHENK, A. (1882). Die von Gebru ern Schlegintweit in Indian gessammelten fossilen Hol er. *Engl. Bot. Jahrb*, **3**(4) : 353-358.

SCHOUTE, J. C. (1912). Uber das di Inwastum der palmen *Ann. Jard. bot. Buiten II Ser.*, **2**(26) : 1-209.

STENZEL, K. G. (1904). Die fossile Palmen holzer. Beitrage zur Palaontologie und Geologie, Oesterreichungiras und des Orients. *Mitt dss. Geol. U. Pal. Ins. der Universitat Wien*, **76** : 107-287.

SWAMY, B.G. L. & GOVINDRAJULU, E. (1961). Studies on the anatomical variability in the stem of *Phoenix sylvestris* 1. Trends in the behaviour of certain cells and tissue. *J. Indian bot. Soc.*, **45** : 14-23.


1
4
7
2
5
8
3
6
9


10
11
12
13
14
15
16
17
18

TOMLINSON, P. B. (1961). *Anatomy of the monocotyledons*—vol. II. Palmae. Oxford Univ. Press London.
TRIVEDI, B. S. & VARMA, C. L. (1981). *Sabalocaulon intertrappeum* gen. et sp. nov. from the Deccan Intertrappean beds of Madhya Pradesh, India. *Palaeobotanist*, **22-23** : 329-337.
MOHL, H. VON (1824) 'Destructure Palmarum' in von Martius. *Historia Naturalis Palmarum* 1.
MOHL, H. VON (1848). On the structure of palm stem. *Req. Ray. Soc.* **7243** : 1-92.
ZIMMERMANN, M. H.& TOMLINSON, P. B. (1965). Anatomy of the palms, *Rhapis excelsa* 1. Mature vegetative axis. *J. Arnoid Arb.*, **46** : 160-180.

Explanation of Plates

Plate 1

Trachycarpus martiana H. Wendl.

1. Transverse section of stem at the base showing cortical and a part of dermal zone ×10.
2. Transverse section of the stem at the base showing fibrovascular bundles of subdermal zone. Note the presence of fibrous bundles ×10.
3. Transverse section of stem at the base showing fibrovascular bundles of subdermal zone. Note the presence of fibrous bundles ×10.
4. Transverse section of stem at the base showing the irregular orientation of the fibrovascular bundles in the central zone. ×10.
5. Transverse section of the stem at 2 feet level passing through the dermal zone indicating compact nature of the fibrovascular bundles. ×10.
6. Transverse section of stem at 2 feet level showing the orientation of the subdermal fibrovascular bundles. ×10.
7. Transverse section of stem at 2 feet level showing irregular orientation of the fibrovascular bundles and the absence of fibrous bundles in the central zone. ×10.
8. Transverse section of stem at 4 feet level showing cortical and a part of dermal zones. ×10.
9. Transverse section of stem at 4 feet level passing through subdermal zone. ×10.

Plate 2

10. Transverse section of stem at 4 feet level showing central zone. Note the compact nature of the ground tissue. × 10.
11. A single magnified fibrovascular bundle showing increased number of xylem vessels and phloem divided into two parts. ×10.
12. Transverse section of the stem at 6 feet level showing cortical and dermal zones. Note the presence of profuse fibrous and fibrovascular bundles in the cortical zone and diminutive bundles in the dermal zone. × 10.
13. Transverse section of the same level passing through subdermal zone showing compact ground tissue composed mostly of isodiametric parenchymatous cells. × 10.
14. Transverse section of stem showing central zone at 6 feet level. Note the presence of multiple number of metaxylem vessels. × 10.

15, 16. Longitudinal section of stem to show nature of the metaxylem vessels. Note the scalariform perforation of end wells and oblique perforation plates × 120.

17. Longitudinal section showing perforation plate having simple perforation. × 120.
18. Longitudinal section to show the stegmata. × 120.