STUDIES IN MUSACEAE—2. *MUSOCAULON INDICUM* GEN. ET SP. NOV., A PETRIFIED PSEUDOSTEM FROM THE DECCAN INTERTRAPPEAN SERIES, INDIA

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ABSTRACT

The present paper deals with a petrified pseudostem of Musaceae discovered from the Deccan Intertrappean beds of Mohgaon Kalan (22°1′N; 79°11′E) in district Chhindwara, M.P., India. It is the first fossil record of a pseudostem from India or elsewhere. It has been referred to Musaceae. But it could not be identified with certainty with any living genus.

INTRODUCTION

THE present paper deals with a petrified pseudostem of Musaceae discovered from Mohgaon Kalan beds of the Deccan Intertrappean Series. This study is based on a solitary specimen discovered partly embedded in chert. There is no earlier record of a fossil pseudostem from these beds or any other formations of India or elsewhere. All the earlier fossil records of Musaceae are in the form of leaf fragments with the exceptions of some carbonized seeds of *Ensete berryi* from the Tertiary of Colombia, S. America (BERRY, 1925; JAIN, 1960). A petrified fruit of banana (*Musa cardiosperma* Jain) from the Deccan Intertrappean Series of India has also been described (JAIN, 1963).

DESCRIPTION

The specimen (PL. 1, FIG. 1) measured about 35 cm. in length. It was somewhat compressed, perhaps during preservation, becoming oval in cross section (PL. 1, FIG. 2) and measuring about 4 cm. in longer diameter and about 1·5 cm. in the shorter diameter.

It is made up of a few open concentric leaf sheaths (PL. 1, FIG. 2). The space enclosed by these leaf sheaths is filled with a non-cellular (rock) matrix. Each leaf sheath is about 2 mm. wide in the middle, gradually narrowing towards the margins. The outer surface of each leaf sheath is somewhat uneven or more or less undulated, while the inner surface is smooth or plain (PL. 1, FIG. 3). It is made up of parenchymatous ground tissue enclosing a large number of tannin cells and vascular and fibrous bundles (PL. 1, FIGS. 3; TEXT-FIG. 1). There are no air canals or intercellular spaces.

Each sheath is bound by a thick cuticle on either side (TEXT-FIGS. 2-3). The outer epidermis consists of highly thick-walled and somewhat radially elongated cells (TEXT-FIG. 2). The cells of the ground tissue are generally polygonal to circular in cross section and vertically elongated as seen in longitudinal section. The cells of the ground tissue towards the outer periphery are polygonal to oval and somewhat radially elongated (TEXT-FIG. 2); those in the middle region are oval to circular and the ones close to the inner surface are more or less tangentially flattened (TEXT-FIG. 3). The lower epidermis consists of moderately thick-walled tangentially flattened cells (TEXT-FIG. 3). The latter gradually merge into the cells of the ground tissue.

No articulated laticifers have been recognized. However, the tannin cells are easily recognized by their dark contents (PL. 1, FIG. 3; TEXT-FIGS. 2-3). These cells are also vertically elongated like the cells of the ground tissue. The tannin fills the whole intracellular space.

The vascular and fibrous bundles are distributed in a definite manner. They are arranged in a number of, rather ill-defined, arcs. In description, the arcs have been numbered as I-IV (PL. 1, FIG. 3; TEXT-FIG. 1). The main arc of large vascular bundles (Arc — I) is close to the adaxial surface (PL. 1, FIG. 3; TEXT-FIG. 1). The arcs II and III of progressively smaller

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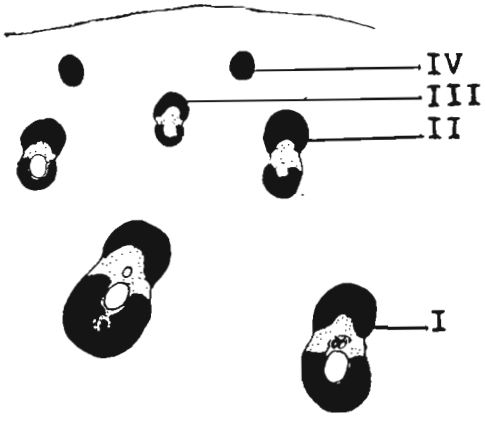

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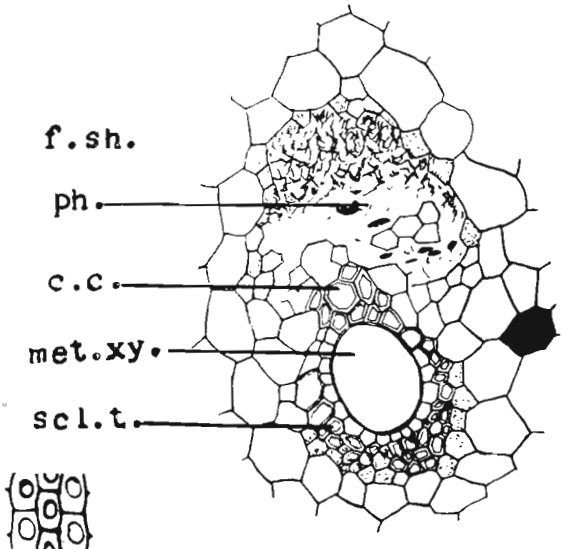

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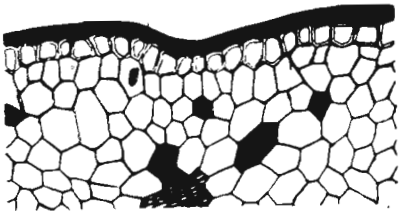

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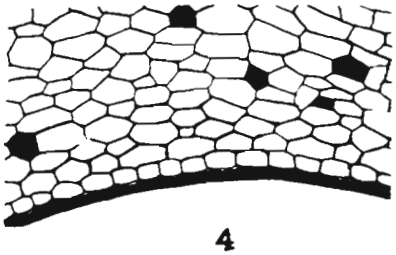

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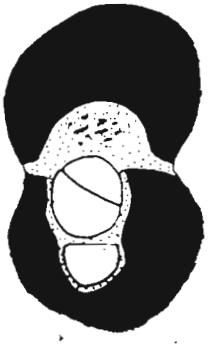

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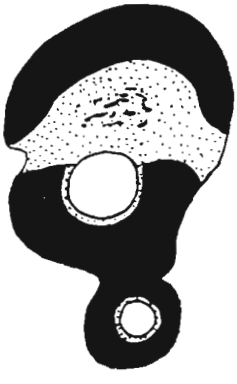

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TEXT-FIGS. 1-8

vascular bundles lie abaxial to the main arc. Arc IV consists of fibrous bundles and is quite close to the abaxial surface. Some fibrous bundles are also present between arcs III and IV. Some of the vascular bundles of arc I appear to be abnormal in structure owing to their branching off smaller vascular bundles towards the adaxial side (PL. 1, FIGS. 1, 6-7). This probably indicates that there may be another arc of smaller bundles close to adaxial surface. This also indicates that this pseudostem is not fully mature or it is the young top of a mature plant.

A typical vascular bundle (PL. 1, FIG. 4; TEXT-FIG. 4), is of a kind usually termed as "Scitaminean" or "*Musa*-type" by Futterer (1896) and Solereder and Meyer (1930) respectively. Each vascular bundle is elliptical to dumbbell-shaped in cross section, being constricted near the junction between the xylem and the phloem. The inner half of each bundle is slightly wider than the outer. There is a considerable variation in the size of the bundles, varying from 150 μ to 400 μ in radial diameter and 150 μ to 350 μ in tangential diameter at the widest part. The size of the vascular bundles gradually decreases towards the outer periphery of each sheath where they measure about 150 μ in either diameter.

The dominant feature of the vascular bundles is a single conspicuously large conducting element in the metaxylem (PL. 1, FIG. 4; TEXT-FIG. 4). Sometimes, two such elements are seen due to overlapping end walls cut together. Whether these elements had perforated end walls or not could not be determined due to unsatisfactory preservation. And, therefore, the usage of any of term such as 'tracheids' or 'vessels' has been avoided in preference to the term "conducting element".

This conducting element is surrounded by an ill-preserved layer of xylem parenchyma. Between this and the phloem are found a few small thick-walled elements. Such elements have been described as "Commissural connectives" by Tomlinson (1955). In the present specimen, however, such elements are often laterally extended and behave as "Commissural connectives". No protoxylem elements on the inner side of the metaxylem have been seen.

No phloem is preserved. However, it is represented by a shapeless tissue of crushed cells, some of which appear to be filled with a dark substance (PL. 1, FIG. 4; TEXT-FIG. 4). They probably represent the laticifers associated with phloem.

The bundles are sheathed laterally by 1-2 layers of parenchymatous cells. The sheaths are completed on the xylem and phloem poles by sclerenchymatous tissue. The outer sheath, i.e., the one on the phloem pole is usually more developed than the one on the xylem pole. In the peripheral layer of the sheaths are some cells filled with a dark brown substance (PL. 1, FIGS. 3-4). Sometimes the sheath on the xylem pole is replaced by many layers of vertically aligned small thick-walled isodiametric cells (TEXT-FIG. 5). The sheaths consist of fibrous cells. The latter are not well preserved and as such no histological details are available.

Some of the vascular bundles of arc I are seen to possess another conspicuous, though smaller, conducting element between the main conducting element and the sheath on the xylem pole (PL. 1, FIGS. 5-6; TEXT-FIGS. 6-8). These, however, represent no abnormality but show that either these bundles are cutting off smaller bundles towards the adaxial side, which would eventually constitute the fifth arc of vascular bundles or some smaller bundles

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TEXT-FIGS. 1-8 — 1, diagrammatic cross-section of the leaf sheath showing the distribution of fibrous (arc IV) and vascular (arcs I-III) bundles. × 34. 2, cross-section of the outer region of the leaf sheath. × 100. 3, cross-section of the inner region of the leaf sheath. × 100. 4, cross-section of a vascular bundle. c.c. = "Commissural connective" or "Late metaxylem"; f.sh. = fibrous sheath (of ill-preserved cells); ph. = phloem; met. xy. = metaxylem; sel-tis. = sclerenchymatous tissue. × 200. 5, sclerenchymatous cells as seen in a longitudinal section of the xylem pole of vascular bundles. × 300. 6-8, diagrammatic cross-sections of some vascular bundles from arc I showing the intermediate stages, either in the process of branching off of the smaller bundles, or their fusion with the latter. × 100.

(which must have already been there between the main arc of vascular bundles and adaxial surface of the sheath) are fusing with these bundles. The latter condition seems to be more probable, because fusion of vascular bundles is a common phenomenon in many monocotyledons. But, in any case, it is necessary to postulate the presence of the fifth arc of smaller vascular bundles which was either present or going to develop in between the adaxial surface of the sheath and the bundles of arc I. This also indicates that this pseudostem is not fully mature.

The elements of the vascular bundles are not well-preserved. However, the spiral thickening on the conducting elements is sometimes seen.

The fibrous bundles (Arc IV) are not well-preserved (PL. 1, FIG. 7). There are some variation in the size of the fibrous bundles, measuring about 50 to 100 μ in diameter. Their structure is essentially similar to that of the sclerenchymatous sheath of the vascular bundles.

DISCUSSION

Affinities with Modern Plants

The pseudostem of the type described above, with characteristic "Scitaminean type" of vascular bundles, at once suggests that it belongs to Scitamineae. In Scitamineae, the plants are mostly rhizomatous herbs, forming pseudostems in some genera of Zingiberaceae and Musaceae.

Zingiberaceae is usually divided into two sub-families—(i) Costoideae and (ii) Zingiberoideae. In the former sub-family the plants develop a real aerial shoot, while in the latter (Zingiberoideae) the aerial shoot is either absent or represented by a short pseudostem. Rarely the pseudostem may attain a height as long as 5 metre (WINKLER, 1930; HOLTTUM, 1950).

As regards the anatomy of this family, it has been recently studied by Tomlinson (1955). According to Tomlinson (loc. cit.) in Zingiberoideae, the main arc of vascular bundles is close to the abaxial surface, whereas in the present specimen it is close to the adaxial surface. Further, the presence of fibrous bundles close to the abaxial surface in the present fossil is unknown in Zingiberaceae. Therefore, on anatomical grounds this pseudostem cannot be referred to Zingiberaceae.

On the other hand the adaxial position of the main arc of vascular bundles and the presence of fibrous bundles close to the abaxial surface are characteristic feature in the anatomy of the leaf sheath of Musaceae (TOMLINSON, 1959).

Musaceae is a family of controversial circumscription. According to some authors it has only two genera *Musa* L. and *Ensete* Horan., while others also include *Ravenala* (including *Phenacospermum*) *Strelitzia*, *Heliconia* and *Lowia* or *Orchidantha* (WINKLER, 1930; NAKAI, 1948; LAWRERNCE, 1951; LANE, 1955; HUTCHINSON, 1959). Here the family is treated in its widest sense comprising all the genera mentioned above. Among these *Ravenala* (including *Phenacospermum*) and some species of *Strelitzia*, have woody aerial shoots, while *Lowia* or *Orchidantha* and most of the species of *Heliconia* are rhizomatous herbs without forming pseudostems. *Musa*, *Ensete* and some species of *Heliconia* have pseudostems of variable heights. Thus, the closest relatives of the present fossil must be in *Musa*, *Ensete* or *Heliconia*. All the genera of Musaceae have longitudinal air canals divided at intervals by horizontal septa of thin parenchymatous tissue in the leaf sheaths and the presence of articulated laticifers in the ground tissue and the phloem of *Musa* and *Ensete*.

As regards the present fossil, no air canals are present and no articulated laticifers have been recognized. However, the presence of a dark substance in the ill-preserved tissue of the phloem is interesting which may or may not represent the laticifers. Also it is interesting to note that it is usually difficult to recognize laticifers even in the living material. Therefore, we have no means to ascertain whether or not the laticifers were present in the present fossil. In view of these circumstances it would seem appropriate to assign the present fossil to a new form genus in Musaceae as *Musocaulon indicum*.

Comparison and Relationship with Other Fossils of Musaceae

No other fossil pseudostem of this family has been described so far. Among the fossil records of Musaceae from the Deccan Intertrappean Series are some petrified

fruits known as *Musa cardiosperma* Jain and a Musaceous petiole described by Mahabale (MS). All the three organs, viz., the fruit, the petiole and the pseudostem, come from the same locality. As such it is possible that all these organs belong to plants of the same species or at least to one genus. However, it is quite risky to pronounce any judgement as yet on the relationship of these dispersed organs.

GENERIC DIAGNOSIS

Genus: *Musocaulon* gen. nov.

Pl. 1, Figs. 1-7; Text-figs. 1-8

Pseudostem of open concentric leaf sheaths; sheaths thicker in the middle, narrowing towards the margins; air canals absent; ground tissue parenchymatous; tannin cells abundant; vascular and fibrous bundles numerous, arranged in ill-defined arcs, the arc of main vascular bundles close to the adaxial surface and the arc of fibrous bundles close to the abaxial surface; vascular bundles dumbbell-shaped, typically with a conspicuous solitary metaxylem conducting element in the centre, some thick-walled elements between the latter and the phloem representing the "Commissural connectives", a fibrous sheath on either (xylem and phloem) pole and parenchymatous cells completing it laterally.

Genotype — *Musocaulon indicum* sp. nov.

SPECIFIC DIAGNOSIS

Species: *Musocaulon iudicum* sp. nov.

Pl. 1, Figs. 1-7; Text-figs. 1-8

Leaf sheaths with distinct abaxial hypodermis of radially elongated thick-walled cells, the cells of the ground tissue vertically elongated, those close to the abaxial surface oval to polygonal with radial axis longer than the horizontal, those in the middle region more or less circular and those close to the adaxial surface more or less flattened as seen in cross-section; the adaxial hypodermis of tangentially flattened thick-walled cells; tannin cells mostly angular in cross-section, elongated vertically; a single layer of small thick-walled isodiametric cells all round the sheaths of each vascular bundle; the conducting elements spirally thickened.

Holotype — B.S.I.P. Museum No. 31657.

Locality — Mohgaon Kalan, Distt. Chhindwara, M.P. India.

Horizon — Deccan Intertrappean Series.

Age — Lower Eocene.

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EXPLANATION OF PLATE 1

1. A part of the specimen (pseudostem) as seen from outside. × 1.

2. Cross-section of the pseudostem showing concentric leaf sheaths. × 1.

3. Cross-section of a portion of a leaf sheath showing the distribution of tannin cells (t.c.) fibrous (f.b.) and vascular bundles (v.b.). × 52.

4. A typical vascular bundle as seen in cross-section. × 110.

5-6. Cross-sections of two vascular bundles of arc I showing intermediate stages, either in the process of branching off of the smaller bundles, or their fusion with the latter. × 110.

7. Cross-section of a fibrous bundles. × 380.

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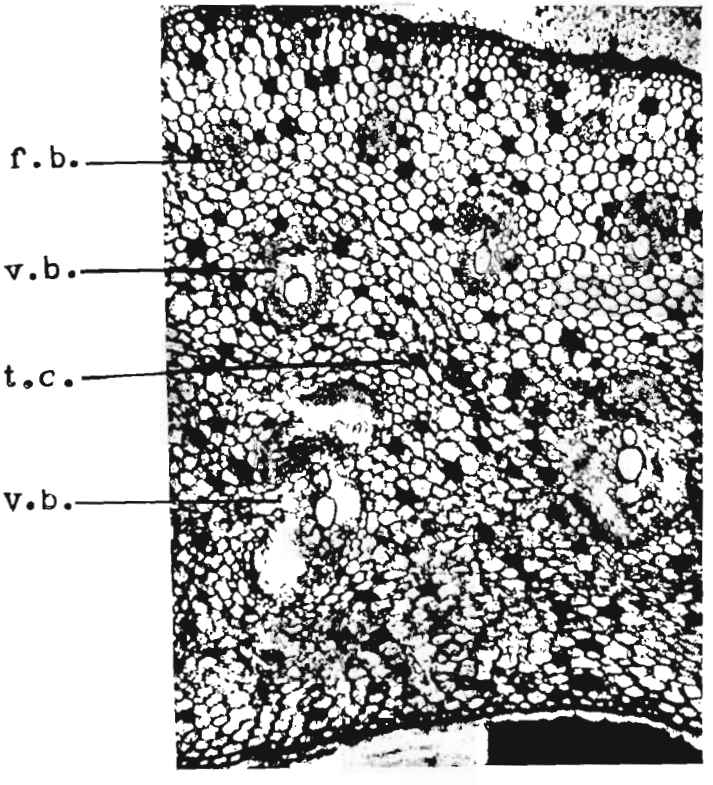

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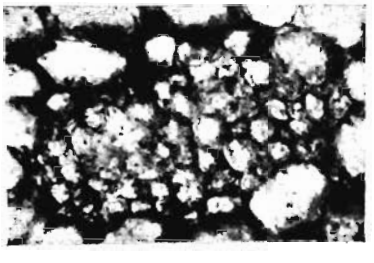

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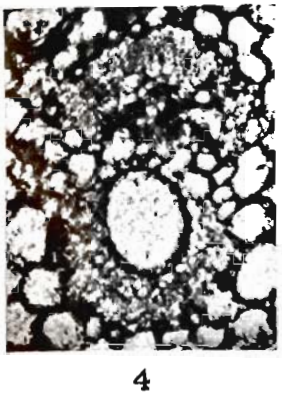

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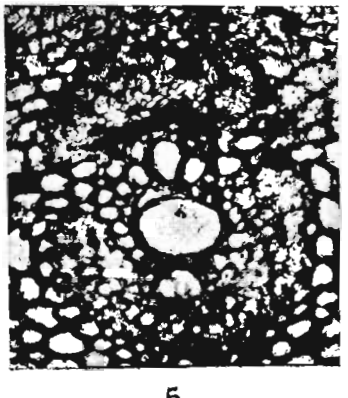

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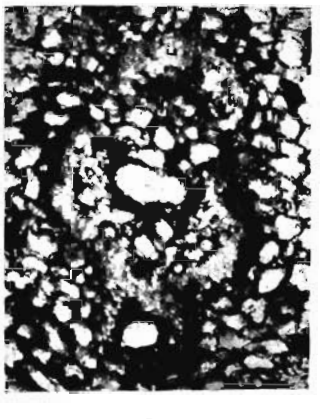

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