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STEM ANATOMY AND NODAL ANATOMY OF THE GENUS *KNEMA**

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Abstract

The anatomy of the young stem and node was investigated in ten species of the genus *Knema*. The young stem is covered by trichomes. Secretory cells, canals, acicular crystals and druses are found in the parenchymatous tissue. The stem has a periderm of superficial origin, cortical sclerieds, plates of sclerieds in the pith and a pseudo-siphonostelic primary vascular system capped on the outside by groups of seperate extraxylary fibers. The phloem is made up of primitive sieve tube elements with a large number of unspecialized sieve areas and oblique end-walls. All species show a unilacunar three-trace node.

Introduction

Myristicaceae in the order Ranales is a medium sized tropical family with about 400 species (Bessey, 1897). There are fifteen genera included four of which are Asian, six African and five American. *Knema* is the third largest Asian genus of Myristicaceae with 37 species (Sinclair, 1961). The plants of this genus are medium sized deciduous trees. There does not appear to be any report on the stem and nodal anatomy of the genus *Knema*. An account of this study will help in discerning the probable relationships of genera in the family Myristicaceae and the relationships of this family with other related families.

Materials and Methods

Specimens of various species of the genus *Knema* present at the Botany Department, Miami University, Oxford, Ohio, U.S.A. were used in this study (Table 1). Some specimens were preserved in formaldehyde-acetic acid-ethanol, while others were taken from herbarium sheets. The preserved specimens were easily handled by standard paraffin techniques. The intervals for dehydration and infiltration were greatly cut down using a vacuum oven with a vacuum of 600 mm. of mercury (Wittlake, 1942). Dried herbarium material was restored in a weak potassium hydroxide solution followed by chloral hydrate (Wilson, 1965).

Observations

Epidermis.—The epidermis consists of a single layer of cells. These cells are rectangular (Figure 1-B). There is a thick cuticle on the exterior periclinal

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TABLE 1. Stem specimens of *Knema* spp. examined.

Name	Locality	Collector and/or source
Knema furfuracea	Singapore	*Canright*, 189
	Malaya	*Canright*, 1102
K. glomerata	Philippines	*Lagrimas*, 222
	Philippines	*Lagrimas*, 223
K. hookeriana	Singapore	*Canright*, 961
K. latericia	Singapore	*Canright*, 192
	Singapore	*Canright*, 950
	Singapore	*Canright*, 996
K. intermedia	Singapore	*Canright*, 187
	Singapore	*Canright*, 198
	Singapore	*Canright*, 1008
K. laurina	Singapore	*Canright*, 194
	Singapore	*Canright*, 200
	Malaya	*Canright*, 937
K. communis	Malaya	*Canright*, 1134
K. conferata	Singapore	*Canright*, 1120
K. tomentella	Java	*Canright*, 843
K. sp.	Borneo	SAN, 205
	Borneo	SAN, 206

walls. Very young stems are heavily tomentose, but in older twigs there are few hairs and in still older, there are no hairs. The hairs are of different size and shapes. Basically each hair has a uniseriate axis 200-350 µm long. On this axis are 7-12 lateral branches, 50-80 µm in length (Figure 1-I). When seen above they give the appearance of stellate hairs.

Periderm.—The periderm on the stem develops early. A phellogen arises by periclinal divisions from the first or second layers of cells beneath epidermis (Figure 1-B). Soon a phellem is formed unevenly around the stem. A number of lenticels can be seen protruding above the surface of the periderm (Figure 1-A). These lenticels arise almost simultaneously with the initiation of the periderm. The tissue of the lenticels consists of compact cells with few air spaces. The filling cells of the lenticels are suberized.

Ground Tissues—The cortex is mainly made up of parenchyma cells. The cells forming the outermost layers are oval or polygonal in shape. They are slightly more elongated vertically. In most of the specimens the cells of the inner cortex are dilated and give the appearance of sacs (Figure 1-E). These cells are usually the extensions of dilated cells of the phloem rays. In older specimens many of the parenchyma cells in the cortex develop secondary walls and become sclerotic (Figure 1-F). This sclerotic parenchyma (Bailey & Swamy, 1949) is abundant in *K. glomerata* and *K. latericia*. Interestingly in these species there are few sclereids, compared to other species.

The pith parenchyma cells are polygonal. Vertically they are more elongated (Figure 1-G). The pith parenchyma cells are much larger in size than the cortical parenchyma cells (see table 2). There is an abundance of sclerieds in the pith. In some species there are scattered sclereids but mostly there are big masses of sclerieds occupying most of the area of the pith. In the median, longitudinal section in the internodal regions, pith diaphragms are also observed. They consist of transversely oriented brachy-sclereids (Figure 1-C). In some cases as in *K. latericia* the parenchyma cells become sclerotic. Tannin canals are found in the pith of *K. glomerata*, *K. intermedia* and *K. furfuracea* (Figure 1-G).

Idioblasts.—Secretery cells are present in all the specimens examined. They are observed in the cortex in all the specimens examined, and in the pith in *K. latericia* and in *K. laurina*. Secretory cells are more abundant in the outer cortex of *K. glomerata*, K. *laurina* and *K. tomentella* (Figure 2-H). One can easily recognize these cells from neighboring cortical parenchyma cells by their large size. Table 2 gives the size of these secretory cells and cortical parenchyma cells. They can also be recognized by their spherical shape and by their contents. Some of these secretory

TABLE 2. Measurements* of Oil Cells and Cortical and Pith Parenhyma Cells in the Species of the Genus *Knema*.

Species	Cortical parenchyma cells		Oil cells in cortex		Pith parenchyma cells	
	Range um	Mean um	Range um	Mean um	Range um	Mean um
K. furfuracea	18—42	29.0	45—75	67.0	55—87	72.0
K. glomerata	20—40	27.1	40—70	50.19	50—90	75.0
K. hookeriana	22—46	28.5	40—75	53.5	54—89	74.6
K. latericia	15—30	25.0	30—60	47.1	40—80	52.2
K. intermedia	20—35	25.7	40—80	58.0	40—90	59.0
K. laurina	15—30	23.7	30—70	46.7	50—100	70.0
K. communis	25—33	26.0	40—80	50.0	40—70	57.0
K. conferata	26—60	31.0	50—80	65.0	62—84	72.0
K. tomentella	20—40	27.4	30—70	52.3	40—60	50.0
K. sp.	22—41	26.5	33—65	54.0	45—64	55.0

*All measurements taken from cross sections.

Fig. 1. Stem Features:

A. *Knema furfuracea.* Transverse section showing the general anatomy of the stem. X18.

B. *Knema intermedia.* Showing periderm characteristics in transverse section of the stem. X444.

C. *Knema furfuracea.* Longitudinal section of the stem showing sclereid plates in the pith. X29.

D. *Knema intermedia.* Showing extraxylary fibers in the transverse section of the stem. X500.

E. *Knema intermedia.* Transverse section of the stem showing cortical cells. DP—dilated parenchyma. X433.

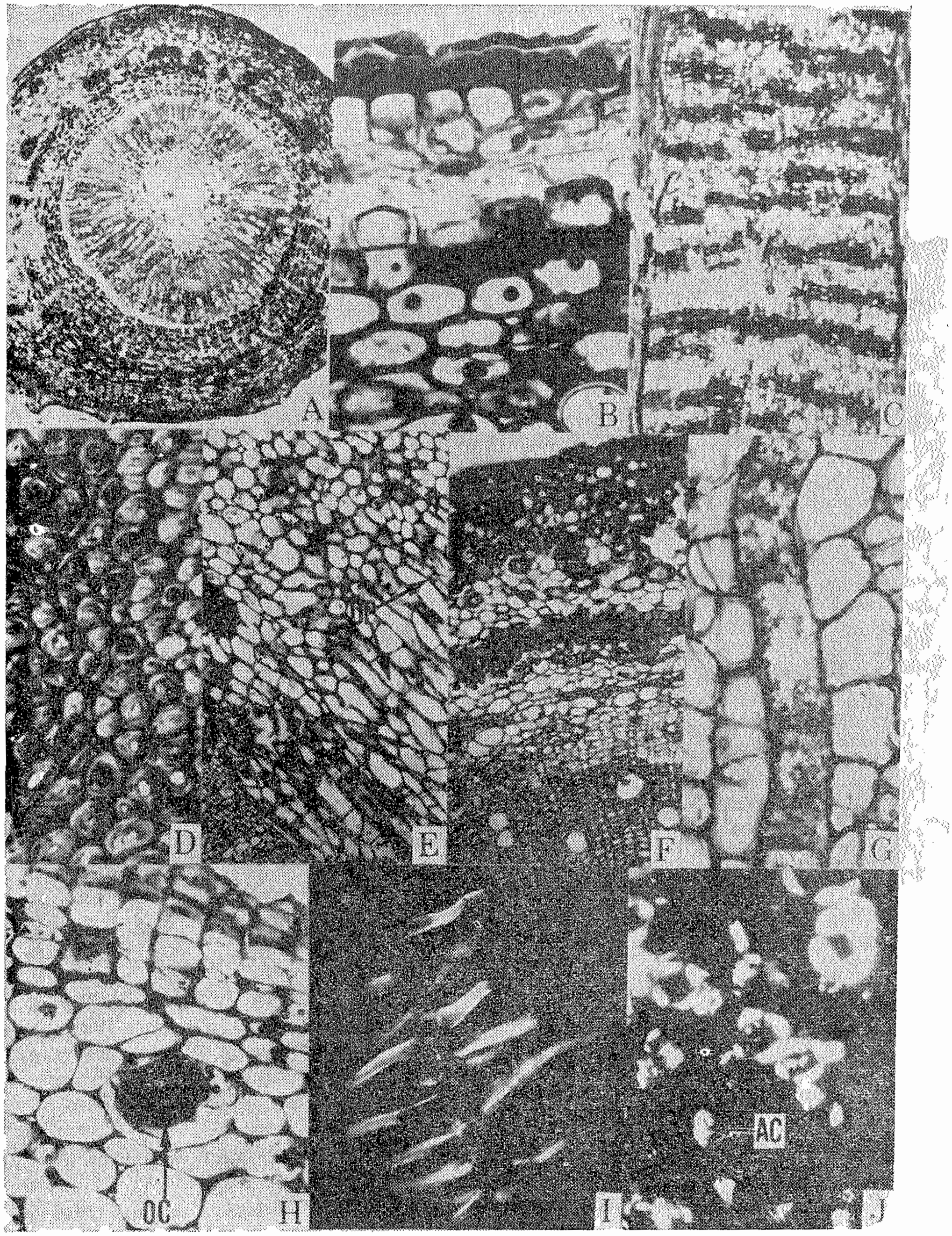
F. *K. latericia.* Showing extraxylary fibers, sclerotic parenchyma in cortex and xylem characteristics in the transverse section. X200.

G. *Knema furfuracea.* Longitudinal section showing a secretory canal in the pith. X550.

H. *Knema laurina.* Showing oil cell in the cortex of the stem. OC—oil cell. X380.

I. *Knema latericia.* A single hair under polarized light showing the branching pattern. X300.

J. *Knema intermedia.* Acicular crystals in the cortical cells under polarized light. AC—acicular crystal. X1333.


A
B
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cells are empty, others have orange or green vesicles or drops. Whether these are the developmental stages of the same kind of secretory cells or are diff rent kinds of cells is not certain.

Brachysclerieds are very prominent in the cortex and pith of all the specimens. Sometimes they are found as isolated cells while in other cases they form nests of sclerieds (Figure 1-A) of varying size. When there is an abundance of sclerotic parenchyma in the cortex, there are fewer sclerieds as can be seen in *K. latericia* and *K. tomentella*.

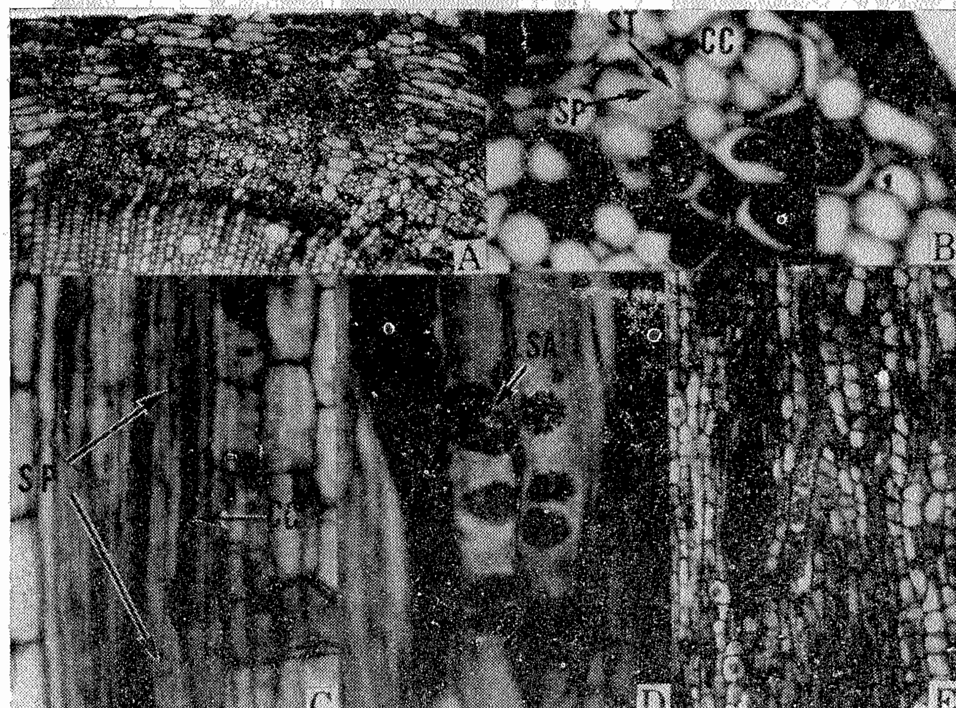

Fig. 2. Phloem features:

A. *Knema laurina*. Transverse section of the young stem from the phloem to the outer cortex. X200.

B. *Knema furfuracea*. Transverse section of the stem showing sieve elements. CC—companion cell: SP—sieve plate: ST—sieve tube element. X1625.

C. *Knema furfuracea*. Longitudinal section of the stem showing sieve tube. CC—companion cell: SP—sieve plate. X150.

D. *Knema glomerata*. Longitudinal section of the stem showing lateral sieve areas on the sieve tube element. ISA—lateral sieve area. X1250.

E. *Knema latericia*. Longitudinal section of the stem showing branched secretory canal in the phloem. X200.

Crystals of calcium oxalate are seen in all the specimens examined. They are present in the cortex, phloem parenchyma, ray parenchyma cells and the pith. There are more crystals in the cortex than in other regions. Mostly these crystals are acicular and are found isolated or in groups (Figure 1-J). Druses are present in the cortex or pith.

Extraxylary Fibers.—The hard bast is made up of extraxylary fibers. These fibers form bundles and are present in the form of caps. The fiber bundles remain seperate even after secondary growth. In no case is a ring of fiber bundle formed, although the bundles are close to one another. The fiber bundles are very prominent in *K. glomerata*, *K. tomentella* and *K. intermedia* (Figure, 1-D, 1-F).

Vascular Tissues.—The primary vascular system is pseudo-siphonostelic. Due to early development of secondary tissues the arrangement of primary tissue is obscured and vascular tissue then appears as a continuous cylinder of xylem and phloem. The xylem consists of vessels, fiber tracheids and parenchyma. The vessels are fewer in number than those seen in the mature wood. They are found mostly in small chains or in radial pairs. Most of the vessels are angular in outline. The vessels are long (510-1850 um), and of medium diameter (40-180 um). The vessel has scalariform perforation plate with 2-9 bars. Thin walled fiber trachieds with pits with reduced borders are present. Uniseriate and biseriate heterocellular rays are found. Oil cells and tanniniferous tubes were observed in most specimens. The xylem of young stems of *Knema* is not basically different from that of older stems (Siddiqi, 1968). The phloem is composed of sieve tubes, companion cells, rays and parenchyma. The phloem is capped on the outside by a number of primary phloem fibers. These fiber bundles are very well developed and are 7-18 cell deep (Figure 2-A). The fiber bundles are separated from one another by phloem parenchyma cells. The sieve tube elements have a length of 250-800um. The sieve plates are compound with a large number of sieve areas. In all the specimens examined The end walls of the sieve tube elements is oblique (Figure 2-C). These sieve tube elements conform to Zahur's (1959) type I. There is a large number of sieve areas on the side walls. These sieve areas are well organized and are arranged in circular masses (Figure 2-D). The companion cells are densely stained. These companion cells occur singly on the side of the sieve tube elements (Figure 2-D). The phloem rays are uniseriate and multiseriate. Some of the rays are wedge shaped (Figure 2-A) with radially elongated cells. The phloem parenchyma is scattered among the sieve tube groups and is also present in the form of bands between the caps of vascular bundles (Figure 2-A). A large number of acicular crystals are present in the phloem parenchyma cells. Some branched or unbranched secretory canals are also present in the phloem (Figure 2-E).

Nodal Anatomy.—In all the species of the genus *Knema* studied, a strikingly similar kind of node is found. The node is trilacunar i.e., three distinct traces are associated with three gaps (Figure 3, A-E). The median trace is little bigger in size than the two lateral traces. In all cases the two lateral traces diverge into the cortex before the median trace (Figure 3-C). Once the three traces are in the cortex the lateral traces gradually bend toward the median but remain seperate. The lateral traces diverge into the cortex at an angle of 45-70° from the median trace.

In the base of the petiole the three traces can be seen distinctly separate from one another. Later the three traces converge and finally there is a fusion of bundles and an arc is formed.

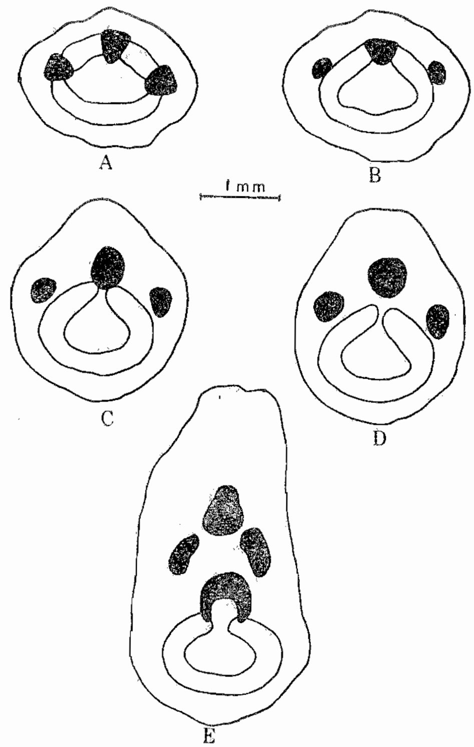

Fig. 3. Diagrams of the nodal anatomy:

A-E. Sections through the mature node. Scale represents 1 mm.

Discussion

The investigation shows that the young stem of the genus *Knema* is characterized by the following features:

1. Characteristic hairs on the epidermis;
2. Superficial origin of periderm ;
3. Cortical sclerieds;
4. Nests and transversely oriented plates of medullary sclerieds;
5. Secretory cells;
6. Crystals of calcium oxalate.

7. Hard bast of extraxylary fibers, bundles of which remain seperate even after secondary growth.

8. A pseudo-siphonostelic primary vascular system.

9. Long vessels, with medium diameter and a scalariform perforation plate.

10. Primitive sieve tube elements with a large number of unspecialized sieve areas and oblique end walls.

11. Trilacunar node.

With few minor differences like the relative abundance of oil cells, sclerieds and crystals, all species show similar anatomical features in the stem.

Very little is known about the stem anatomy of the other genera of the family Myristicaceae. This makes it difficult to compare the stem anatomy of the genus *Knema* with other genera of the family. The secretory cells, secretory canals, sclerieds and Scicular canals reported here are also reported by Solereder (1908) and Metcalfe & Chalk (1950) in *Myristica* and *Virola*. The phloem of one species of Myristica has been described by Zahur (1959). When the phloem of *Knema* is compared with that of *Myristica*, a number of similarities can be noted. In both genera sieve tubes show similar characteristics. The acicular crystals present in the phloem parenchyma cells of *Knema* are absent in *Myristica*.

There are similarities between *Knema* stem and the stem of Canellaceae (Wilson, 1965). Both have superficial origin of periderm, a continuous cylinder of primary vascular tissue and sclerotic parenchyma. There is also a similarity in the shape, distribution and contents of secretory cells found here and those reported in Canellaceae.

The nodal anatomy of *Knema* does not show much variation, amongst its species. According to Canright (1955) the trilacunar node is not primitive but considerably specialized. But Benzing (1967), has pointed out that this trilacunar node is more likely to be primitive in angiosperms. Little is known about the nodal anatomy of other genera of Myristicaceae. Benzing (1967) has described the node of *Myristica fragrans* as trilacunar three trace. Money, Bailey & Swamy (1950) have placed the family Myristicaceae in the second group of Ranalian families with trilacunar nodes. Wilson (1965) observed a trilacunar three trace node in all members of family Canellaceae. He also found some variations in the origin of lateral and median traces in the nodes of Canellaceae. No such variation was noted in the node of *Knema*.

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