

ANATOMICAL PROPERTIES OF NINE INDIGENOUS RATTAN SPECIES OF JAMBI, INDONESIA

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Received: 16 June 2017, Revised: 31 October 2018, Accepted: 31 October 2018

ANATOMICAL PROPERTIES OF NINE INDIGENOUS RATTAN SPECIES OF JAMBI, INDONESIA. Various rattan species grow naturally in Jambi, Indonesia, i.e. opon (*Plectocomiopsis geminiflora* (Griff.) Beccari), udang (*Korthalsia flagelaris* Miquel), getah (*Daemonorops micracantha* (Griff.) Beccari), duduk (*D. didymophylla* Beccari), tunggal (*Calamus laevigatus* Martius), sijau (*C. tumidus* Furtado), buruk ati (*C. insignis* Griff. var. *longispinosus* Dransfield), batu (*C. zonatus* Beccari), and paku (*C. exillis* Griff.). The rattan species are classified as lesser known species, which its properties are unknown to rattan supplier and consumers. This paper observes the anatomical properties of nine indigeneous rattan species of Jambi. Anatomical observations were conducted from solid, sectioned and macerated samples. Results show that anatomical properties become a diagnostic characteristic for rattan species identification and specific characteristic has been developed for key species determination. Vascular bundles in the outer part of the stem of opon and udang rattans are yellow-capped. Width and length ratio of vascular bundle in the outer part is more than 1, oval shape was found in sijau rattan, while elongated shape vascular bundle with the ratio less than 1 was found in buruk ati. Fiber bundles separated from vessels are found in central ground parenchymatous tissue of rattan tunggal. In the peripheral area, fiber bundle forms one or two lines with no specific pattern found in rattan paku, while fiber bundles in one line with alternate pattern found in rattan duduk. Single resin canals are found both in center part and peripheral area is found in batu rattan and mostly single. Resin canals are found in pair at getah rattan stem. Tentative identification key to rattan species has been developed for nine species investigated, then the key should be developed for further genera identification among rattan species in Indonesia.

Keywords: Anatomical properties, nine indigenous rattan species, Jambi, identification key

*SIFAT ANATOMI SEMBILAN JENIS ROTAN ASLI JAMBI, INDONESIA. Beberapa jenis rotan tumbuh secara alami di wilayah Jambi, Indonesia, yaitu opon (*Plectocomiopsis geminiflora* (Griff.) Beccari), udang (*Korthalsia flagelaris* Miquel), getah (*Daemonorops micracantha* (Griff.) Beccari), duduk (*D. didymophylla* Beccari), tunggal (*Calamus laevigatus* Martius), sijau (*C. tumidus* Furtado), buruk ati (*C. insignis* Griff. var. *longispinosus* Dransfield), batu (*C. zonatus* Beccari), dan paku (*C. exillis* Griff.). Rotan tersebut termasuk rotan yang kurang dikenal, karena sifat dan karakteristiknya belum diketahui oleh konsumen dan penyuplai rotan. Tulisan ini mempelajari sifat anatomi sembilan jenis rotan yang tumbuh secara alami di Jambi. Observasi karakteristik anatomi batang rotan dilakukan dari contoh utuh, preparat sayatan, dan preparat maserasi. Hasil penelitian menunjukkan bahwa sifat dan karakteristik anatomi batang rotan dapat dijadikan karakteristik diagnostik untuk identifikasi jenis rotan. Berkas pembuluh pada bagian luar rotan opon dan udang memiliki lapisan berwarna kuning pada ujungnya (yellow capped). Perbandingan lebar dan tinggi berkas pembuluh bagian luar lebih dari satu, bentuk oval dijumpai pada rotan sijau, sementara bentuk lonjong memanjang dengan rasio lebar dan panjang kurang dari satu dijumpai pada rotan buruk ati. Berkas serat yang terpisah dari berkas pembuluh di bagian tengah dari parenkima dasar dijumpai pada rotan tunggal. Pada bagian luar batang, berkas serat membentuk satu atau dua garis dengan pola tidak beraturan terlihat pada rotan paku, sementara berkas serat dengan pola membentuk satu garis tampak pada rotan duduk. Saluran getah di bagian tengah dan luar bertipe tunggal dijumpai pada rotan batu, sedangkan pada rotan getah saluran getah berpasangan. Sifat anatomi batang rotan selanjutnya disusun dalam bentuk kunci determinasi untuk identifikasi jenis rotan. Untuk sembilan jenis rotan dari Jambi, kunci determinasi telah dikembangkan dan disarankan untuk dikembangkan untuk identifikasi genus untuk seluruh jenis rotan yang tumbuh di Indonesia.*

Kata kunci: Sifat anatomi, sembilan jenis rotan asli, Jambi, kunci identifikasi

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I. INTRODUCTION

Rattan is a group of spiny and climbing palms which is classified into Monocotyledons, Palmae family. Botanically, it is about 600 rattan species grouped into 13 genera grows around the world (Zehui, 2007). Among 13 genera, there are only four genera are traded commercially, i.e. Calamus, Daemonorops, Korthalsia, and Plectocomia. From 600 rattan species, it was recorded about 312 rattan species grown in Indonesian forest and 51 species of them has been traded commercially (Sumarna, 1996 in Rachman & Jasni, 2013).

Currently, rattan resources are available to support Indonesian rattan industry. Although rattans are recognized and utilized for centuries, rattan resources were not depleting until the 1970s when the demand for rattan cane was increasing rapidly (Zehui, 2007). Since 2012, Indonesian rattan export has been banned through the Indonesian Ministry of Trade Regulation No.35, 36, 37/2011. The export ban is aiming to support local industries, however the ban policy has been impeding the livelihood of rattan farmers and entrepreneurs (Otniel, 2013). One possible reason, the current traded rattan species is exclusively for those of commercial rattan species but the lesser known rattan species.

Referring to lesser known timber species defined by (Sosef, Hong, & Prawirohatmodjo, 1998), lesser known rattan species is defined as those rattan species which are little known or known only locally and are not marketed or are marketed on small scale only. Lesser known rattan species fall into one of the lesser known criteria that rattan species existence and its properties are largely unknown to rattan supplier and consumers. The species is ignored because more commercial rattan species predominate the forest and better known. Lesser known rattan species could be assumed that public is unfamiliar with these species, then the need for more research. The term lesser known species is similar with those of less used species which suggests a lack of market acceptance and utilization (Sosef et al., 1998).

Prior to rattan utilization, species identification is one important process to determine its use. In general, rattan species is accurately identified based on its taxonomic characteristics such as habitus, leafs, climbing organ, inflorescens and flower type (Abasolo, 2015). However, once rattan stems are cut and leaf sheaths removed, species identification becomes difficult (Ebanyenle & Oteng-Amoako, 2003).

Currently, rattan collectors harvest rattan stem based on the local name and stem diameter irrespective its botanical name. The local names often vary from one locality to another and sometimes the same name is given to more than one species. Jambi is an area where rattan grows naturally. There is various rattan species grows in Jambi's forest and has not been commercially utilized. Rattan species identification would support rattan genetic conservation and led to efficient rattan utilization. Weiner and Liese (1990) and (Astuti (1990) stated that the anatomical properties of rattan stem cross section could become a diagnostic characteristic for rattan species identification. This paper studies the anatomical properties of nine rattan species grown in Jambi's forest. The anatomical data is described for rattan species identification purposes.

II. MATERIAL AND METHOD

Nine rattan species are collected from Marangin-Bangko forest, Jambi Province, where nine indigenous rattan species grows naturally in the area. Nine matured stems were collected randomly from different growing clumps for each species. Herbarium samples were collected for species identification purposes in the Botany Research Group, Forest Research and Development Center (P3H), while rattan stem were collected for macroscopic, microscopic, and fiber dimension assessments. Macroscopically, solid rattan stem was cut using sharp knife and was observed under stereomicroscope. Microscopically, cross-sectional rattan stems were sliced into 35 – 45 μm using a microtome. These sectioned were then red-

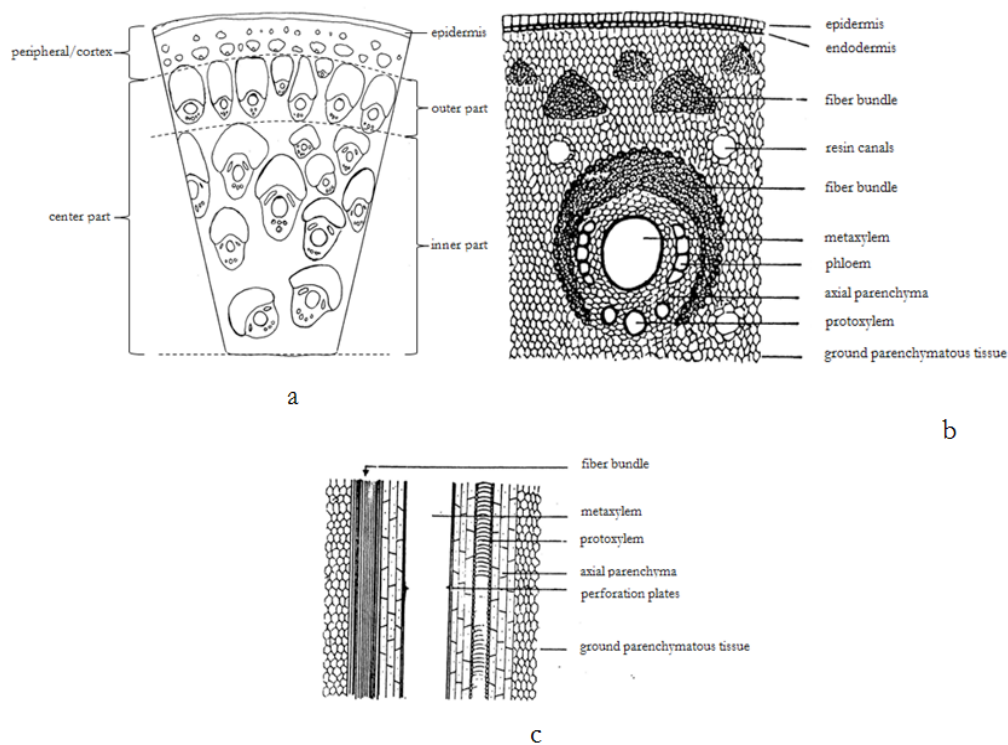


Figure 1. General structure and observation area (a), transversal section (b), lateral section (c)

Source: Astuti (1990); Krisdianto and Jasni (2005); Mandang and Rulliaty (2004)

stained using safranin, dehydrated in ethanol sequence (35–100%) prior to mount it in object glass with entellan. (Sass, 1961 as cited by Rulliaty, 2014). Two millimetre by two millimetre transversal stem in two centimetres length stem was macerated according to modified Forest Products Laboratory method as mentioned by Rulliaty (2014).

Rattan stem observation area is modified based on Astuti (1990), Krisdianto and Jasni (2005), and Jasni, Krisdianto, Kalima, and Abdurachman, (2012). Rattan stem anatomical properties is observed based on Mandang and Rulliaty (2004), Weiner and Liese (1990) and Krisdianto and Jasni (2005). The schematic observation is shown in Figure 1a, and anatomical rattan stem properties is shown in Figure 1b and 1c.

III. RESULT AND DISCUSSION

Anatomical properties of nine rattan species are described as follows:

A. Batu (*Calamus zonatus* Beccari)

Single layer epidermis consisting of unligified parenchyma cells and covered by siliceous layer interspersed with few stomata cells. The epidermis layer is about $19.01 \pm 1.92 \mu\text{m}$ and the endodermis layer is about $4.6 \pm 0.75 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one to two layers with resin canals found in the peripheral area (Figure 2b). The peripheral area is about $136.81 \pm 9.26 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 12–13 per mm^2 , with the width and length (W/L) ratio is 0.9 ± 0.3 , which means vascular bundle's width is approximately similar with vascular bundle's length. Yellow cap is absent, and metaxylem vessel diameter is $99.27 \pm 27.22 \mu\text{m}$.

As commonly found in monocotyledonous stem structure, vascular bundle in the inner part is greater in diameter than those of the outer part. The ellipse to oblique vascular bundle length and width is $448.4 \pm 53.6 \mu\text{m}$ and 359.75

$\pm 43.04 \mu\text{m}$, respectively. The vascular bundle in the inner part is 6–8 per mm^2 , with the width and length (W/L) ratio is 0.81 ± 0.08 . Metaxylem vessels are mostly single, sometime found in pair, with diameter of $211.35 \pm 26.65 \mu\text{m}$. Protoxylem consists of a cluster 2–6 cells, with single cell diameter of $40.61 \pm 10.65 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 2c). Individual phloem cell diameter is about $27.89 \pm 6.17 \mu\text{m}$. Resin canals are diffusely distributed in the inner, outer and peripheral areas. Resin canal diameter is $68.81 \pm 10.23 \mu\text{m}$.

Fiber sheath is extensively broader in vascular bundle of peripheral area and normal 'horse-shoe shaped' in vascular bundle of inner part. Fiber length is $1,821.16 \pm 169 \mu\text{m}$, width

$20.4 \pm 3.21 \mu\text{m}$, lumen $11.76 \pm 2.57 \mu\text{m}$ and wall thickness $4.31 \pm 0.71 \mu\text{m}$. Ground parenchyma round to oval with varying sizes, type A.

B. Buruk ati (*Calamus insignis* Griff. var. *longispinosus* Dransfield)

Epidermis is a single layer of unligified parenchyma cells covered by siliceous interspersed with stomata cells. The epidermis layer is about $32.9 \pm 3.78 \mu\text{m}$ and the endodermis layer is about $10.23 \pm 2.23 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 3b). The peripheral area is about $352.48 \pm 61.66 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 7–8 per mm^2 , with the width and length (W/L) ratio is 0.9 ± 0.2 , which means vascular bundle's width is approximately

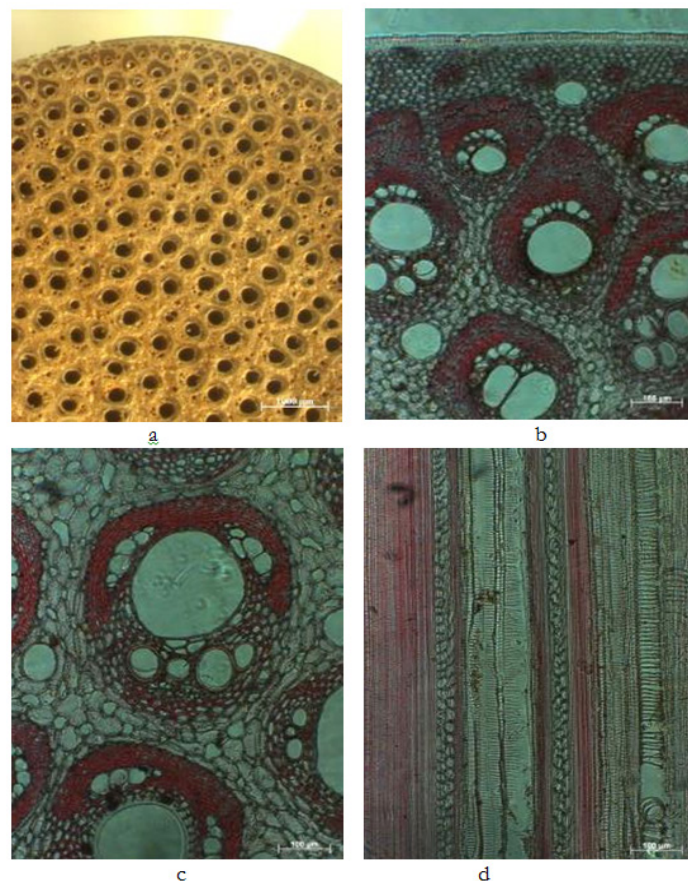


Figure 2. Anatomical structure of batu rattan stem (*Calamus zonatus* Beccari)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

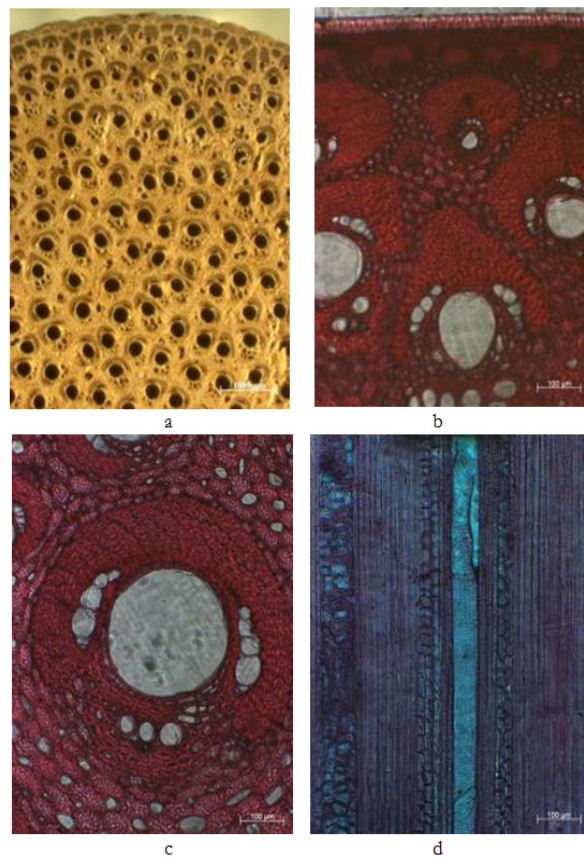


Figure 3. Anatomical structure of buruk ati rattan stem (*Calamus insignis* Griff. var. *longispinosus* Dransfield)

Remarks: a. Stem cross section, scale 1000 μm; b. Stem cross section, scale 100 μm; c. Single vascular bundle, scale 100 μm; d. Lateral section, scale 100 μm

similar with vascular bundle's length. Yellow cap is absent, and metaxylem vessel diameter is $107.42 \pm 31.83 \mu\text{m}$.

Similar with those of monocotyledonous stem structure, vascular bundle in the inner part is greater in diameter than those of the outer part. The round to oblique vascular bundle length and width is $338.35 \pm 68.49 \mu\text{m}$ and $296.59 \pm 52.32 \mu\text{m}$, respectively. The vascular bundle in the inner part is only 2–4 per mm^2 , with the width and length (W/L) ratio is 1.05 ± 0.14 . Metaxylem vessels are single, with diameter of $295.1 \pm 8.47 \mu\text{m}$. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of $37.9 \pm 8.04 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 3c). Individual

phloem cell diameter is about $46.83 \pm 8.73 \mu\text{m}$. Resin canals are not found, intercellular spaces found in ground parenchyma tissue.

Fiber sheath is extensively longer in vascular bundle of peripheral area and normal 'horse-shoe shaped' in vascular bundle of inner part. Fiber length is $2,381.07 \pm 246.98 \mu\text{m}$, width $22 \pm 2.52 \mu\text{m}$, lumen $12.09 \pm 2.73 \mu\text{m}$ and wall thickness $4.95 \pm 0.66 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type A.

C. Duduk (*Daemonorops didymophylla* Beccari)

A single layer of unligified parenchyma cells of epidermis layer covered by siliceous interspersed with few stomata cells. The

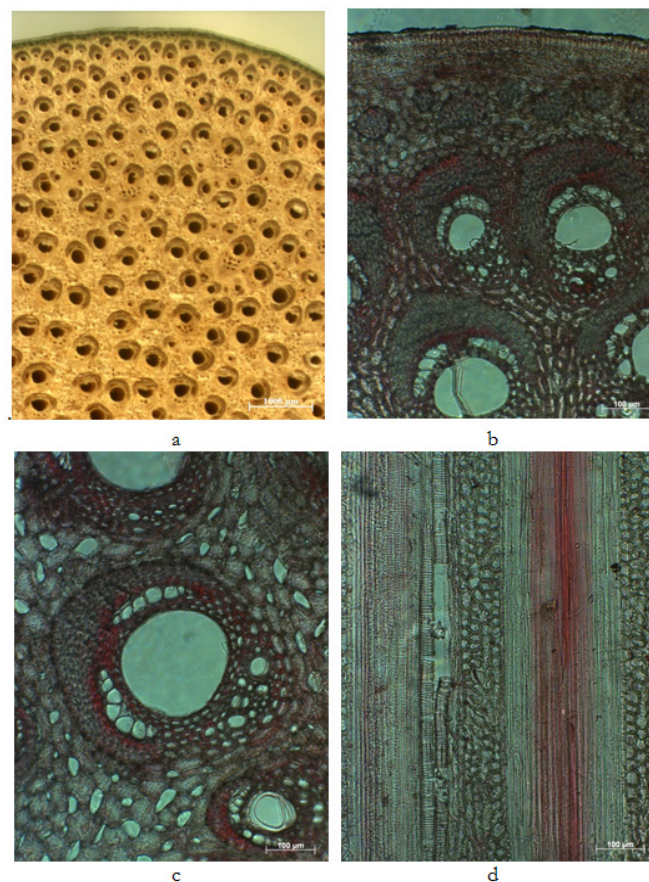


Figure 4. Anatomical structure of duduk rattan stem (*Daemonorops didymophylla* Beccari)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

epidermis layer is about $30.67 \pm 2.77 \mu\text{m}$ and the endodermis layer is about $6.83 \pm 1.59 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer in alternate pattern, smaller and greater fiber bundles one after another (Figure 4b). The peripheral area is about $237.93 \pm 18.62 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 9–11 per mm^2 , with the width and length (W/L) ratio is 0.72 ± 0.09 , which means vascular bundle is approximately oval. Yellow cap is absent, and metaxylem vessel diameter is $104.76 \pm 28.5 \mu\text{m}$.

Vascular bundle in the inner part is greater in diameter than those of the outer part as commonly found in monocotyledonous stem. The oblique vascular bundle length is $451.18 \pm 24.15 \mu\text{m}$ and width is $339.09 \pm 57.24 \mu\text{m}$. The vascular bundle in the inner part is 4–6 per

mm^2 , with the width and length (W/L) ratio is 0.75 ± 0.11 . Metaxylem vessels are single, with diameter of $176.16 \pm 25.62 \mu\text{m}$. Protoxylem consists of a cluster 2–5 cells, with single cell diameter of $26.51 \pm 3.66 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 4c). Individual phloem cell diameter is about $26.61 \pm 3.5 \mu\text{m}$. Resin canal diameter is $36.19 \pm 10.01 \mu\text{m}$.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and some tapering in the outer part. Fiber length is $1,790.55 \pm 228.42 \mu\text{m}$, width $20.8 \pm 1.17 \mu\text{m}$, lumen $13.15 \pm 0.99 \mu\text{m}$ and wall thickness $3.82 \pm 0.37 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type B.

D. Getah (*Daemonorops micracantha* (Griff.) Beccari)

Single layer epidermis consisting of unligified parenchyma cells and covered by siliceous layer. The epidermis layer is about $29.93 \pm 3.11 \mu\text{m}$ and the endodermis layer is about $12.84 \pm 3.38 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 5b). The peripheral area is about $208.74 \pm 24.27 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 8–11 per mm^2 , with the width and length (W/L) ratio is 0.73 ± 0.11 , which means vascular bundle is approximately oval. Yellow cap is absent, and metaxylem vessel diameter is $66.32 \pm 12.26 \mu\text{m}$.

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The oval vascular bundle length and width is 533.25 ± 31.18 and $438.46 \pm 74.25 \mu\text{m}$, respectively. The vascular bundle in the inner part is 4–6 per mm^2 , with the width and length (W/L) ratio is 0.83 ± 0.18 . Metaxylem vessels are single, with diameter of $250.88 \pm 13.05 \mu\text{m}$. Protoxylem consists of a cluster 4–6 cells, with single cell diameter of $57.78 \pm 9.42 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells (Figure 5c). Individual phloem cell diameter is about $50.31 \pm 9.07 \mu\text{m}$. Resin canal diameter is $100.23 \pm 22.71 \mu\text{m}$.

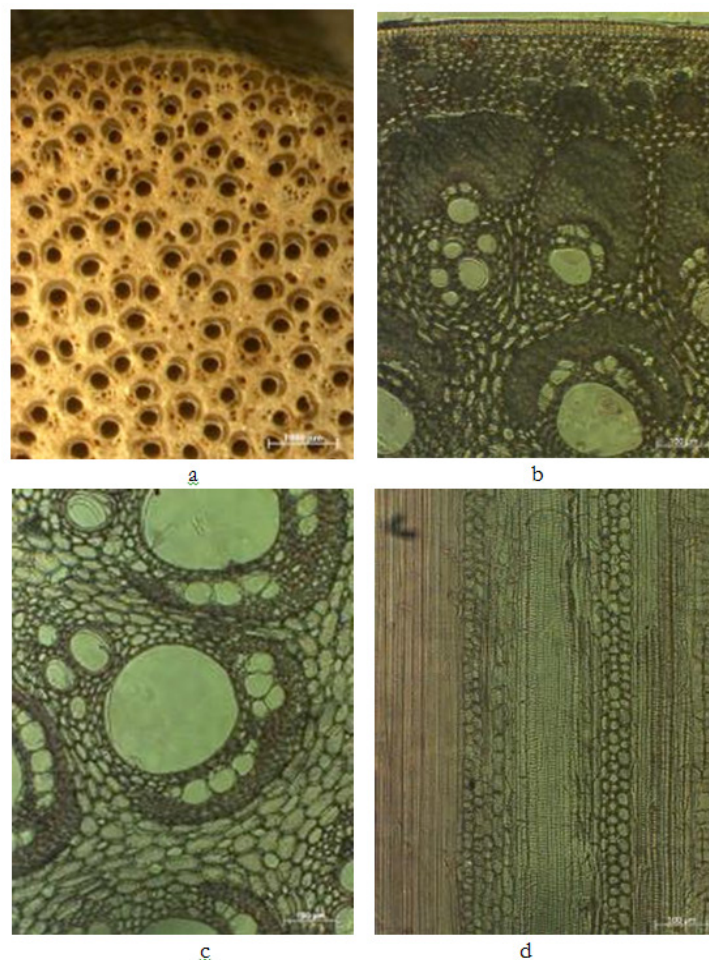


Figure 5. Anatomical structure of getah rattan stem (*Daemonorops micracantha* (Griff.) Beccari)
 Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ;
 d. Lateral section, scale 100 μm

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and tapering in the outer part. Fiber length is $2,254.43 \pm 292.55 \mu\text{m}$, width $20.3 \pm 2.54 \mu\text{m}$, lumen $13.15 \pm 2.74 \mu\text{m}$ and wall thickness $3.41 \pm 0.47 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type B.

E. Opon (*Plectocomiopsis geminiflora* (Griff.) Beccari)

Epidermis is a single layer of un lignified parenchyma cells covered by siliceous interspersed with few stomata cells. The epidermis layer is about $30.93 \pm 6.24 \mu\text{m}$ and the endodermis layer is about $4.81 \pm 0.96 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 6b). The peripheral area is about $145.67 \pm 18.4 \mu\text{m}$ from the outer bark. Vascular bundle in the

outer part is about 7–9 per mm^2 , with the width and length (W/L) ratio is 0.98 ± 0.39 , which means vascular bundle is approximately round. Yellow cap is found on the top of outer fiber bundle. Metaxylem vessel diameter is $192.59 \pm 77.84 \mu\text{m}$.

Vascular bundle in the outer part is extensively longer and narrower in the outer part than those in the inner part. In the inner part, vascular bundle is $479.49 \pm 87.28 \mu\text{m}$ length and $438.46 \pm 74.25 \mu\text{m}$ width. The vascular bundle in the inner part is 6–8 per mm^2 , with the width and length (W/L) ratio is 0.88 ± 0.16 . Metaxylem vessels are mostly single in the outer part, while pair metaxylem vessels are found in the inner part with diameter of $313.2 \pm 18.13 \mu\text{m}$. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of $35.81 \pm 11.97 \mu\text{m}$. Phloem double stranded fields lying laterally to

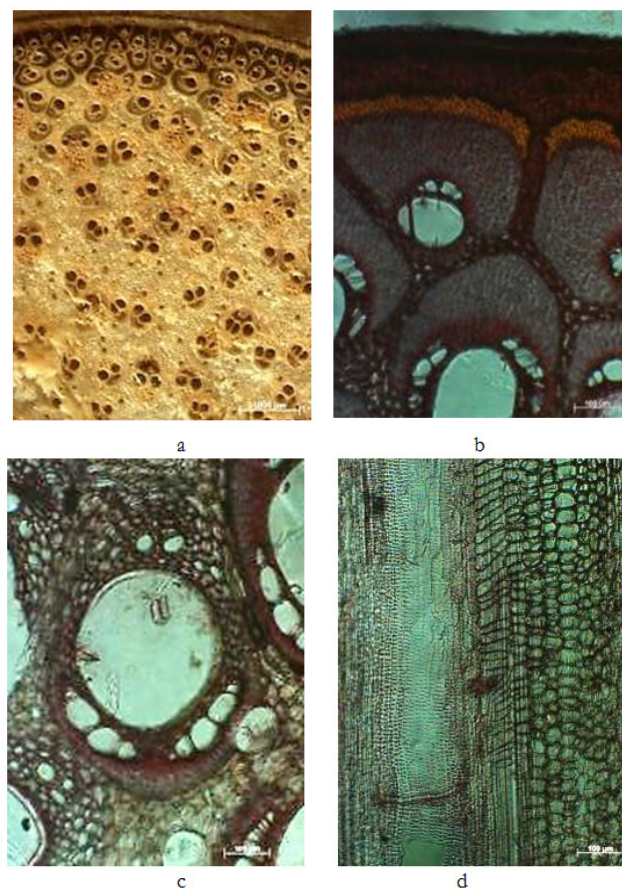


Figure 6. Anatomical structure of opon rattan stem (*Plectocomiopsis geminiflora* (Griff.) Beccari)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

the metaxylem vessels and every field contains of 3–6 cells (Figure 6c). Individual phloem cell diameter is about $43.43 \pm 6.9 \mu\text{m}$. Resin canal diameter is $86.8 \pm 20.4 \mu\text{m}$.

Fiber sheath is mostly normal ‘horse-shoe shaped’ in inner part’s vascular bundle and tapering in the outer part. Fiber length is $3,518.51 \pm 474.51 \mu\text{m}$, width $18.1 \pm 2.9 \mu\text{m}$, lumen $12 \pm 2.19 \mu\text{m}$ and wall thickness $3.05 \pm 0.69 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type B.

F. Paku (*Calamus exillis* Griff.)

Single layer epidermis consisting of un lignified parenchyma cells and covered by siliceous layer interspersed with few stomata cells. The epidermis layer is about $33.84 \pm 2.27 \mu\text{m}$ and the endodermis layer is about $9.82 \pm 0.97 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one to two layers with no specific pattern (Figure 7b). The peripheral area is about $173.07 \pm 15.46 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 14–15 per mm^2 , with the width and length (W/L) ratio is 1.05 ± 0.24 , which means vascular bundle is approximately round with length and width ratio is about 1. Yellow cap is absent. Metaxylem vessel diameter is $48.69 \pm 13.2 \mu\text{m}$.

Vascular bundle’s shape in the outer part is approximately similar with those in the inner part. In the inner part, vascular bundle is $393.36 \pm 35.71 \mu\text{m}$ length and $336.01 \pm 49.33 \mu\text{m}$ width. The vascular bundle in the inner part is 7–11 per mm^2 , with the width and length (W/L) ratio is 0.86 ± 0.12 . Metaxylem vessels are mostly single in the inner part, while pair metaxylem vessels sometime are found in the inner part. Vessel’s diameter is $167.31 \pm 14.44 \mu\text{m}$. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of $33.54 \pm 5.94 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells (Figure 7c). Individual phloem cell diameter is about $26.22 \pm 4.7 \mu\text{m}$. Resin canal diameter is $34.51 \pm 8.14 \mu\text{m}$.

Fiber sheath is in ‘horse-shoe shaped’ and elongated both in inner and outer parts. Fiber

length is $1,367.21 \pm 199.23 \mu\text{m}$, width $19.8 \pm 2.48 \mu\text{m}$, lumen $13.03 \pm 2.08 \mu\text{m}$ and wall thickness $3.39 \pm 0.64 \mu\text{m}$. Ground parenchyma round to oval with varying sizes, type B.

G. Sijau (*Calamus exillis* Griff.)

A single layer of un lignified parenchyma cells of epidermis layer covered by siliceous interspersed with few stomata cells. The epidermis layer is about $55.35 \pm 1.33 \mu\text{m}$ and the endodermis layer is about $10.67 \pm 0.8 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer pattern (Figure 8b). The peripheral area is about $259.48 \pm 51.42 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 4–5 per mm^2 , with the width and length (W/L) ratio is 1.2 ± 0.38 , which means vascular bundle is oblique widely. Yellow cap is absent, and metaxylem vessel diameter is $138.9 \pm 38.13 \mu\text{m}$.

Vascular bundle in the inner part is greater in diameter than those of the outer part as commonly found in monocotyledonous stem. In the inner part, the vascular bundle length is $590.82 \pm 66.57 \mu\text{m}$ and width is $518.52 \pm 56.19 \mu\text{m}$. The vascular bundle in the inner part is 3–4 per mm^2 , with the width and length (W/L) ratio is 0.88 ± 0.11 . Metaxylem vessels are single, with diameter of $255.54 \pm 49.19 \mu\text{m}$. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of $40.88 \pm 14.5 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 8c). Individual phloem cell diameter is about $41.88 \pm 6.82 \mu\text{m}$. Resin canal is distributed evenly in the ground parenchymatous tissue together with intercellular spaces.

Fiber sheath is mostly elongated in outer part and normal ‘horse-shoe shaped’ in inner part’s vascular bundle. Fiber length is $1,958.94 \pm 177.12 \mu\text{m}$, width $21.9 \pm 3.39 \mu\text{m}$, lumen $12.92 \pm 2.75 \mu\text{m}$ and wall thickness $4.49 \pm 0.74 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type B.

H. Tunggal (*Calamus laevigatus* Martius)

Single layer epidermis consisting of un lignified parenchyma cells and covered by

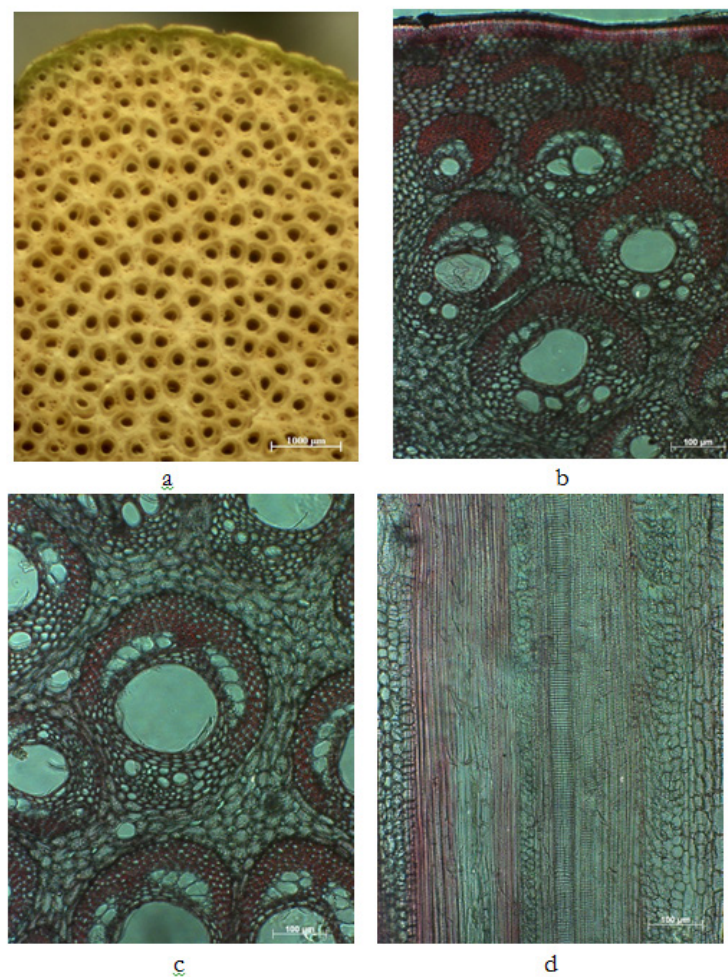


Figure 7. Anatomical structure of paku rattan stem (*Calamus exillis* Griff.).

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm

siliceous layer. The epidermis layer is about 36.89 ± 4.06 µm and the endodermis layer is about 6.42 ± 1.1 µm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 9b). The peripheral area is about 117.94 ± 13.3 µm from the outer bark. Vascular bundle in the outer part is about 4–5 per mm², with the width and length (W/L) ratio is 0.95 ± 0.17 , which means vascular bundle is approximately round. Yellow cap is absent, and metaxylem vessel diameter is 114.49 ± 30.84 µm.

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The round vascular bundle length and width is 443.7

± 27.06 and 436.3 ± 29.32 µm, respectively. The vascular bundle in the inner part is 4–5 per mm², with the width and length (W/L) ratio is 0.99 ± 0.09 . Metaxylem vessels are single, with diameter of 226.76 ± 28.46 µm. Protoxylem consists of a cluster 3–5 cells, with single cell diameter of 37.96 ± 5.17 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells (Figure 9c). Individual phloem cell diameter is about 49.62 ± 7.21 µm. Resin canal is distributed evenly in the ground parenchymatous tissue together with intercellular spaces.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner and outer parts. Fiber length is $2,126.57 \pm 252.84$ µm, width 19 ± 2.89 µm,

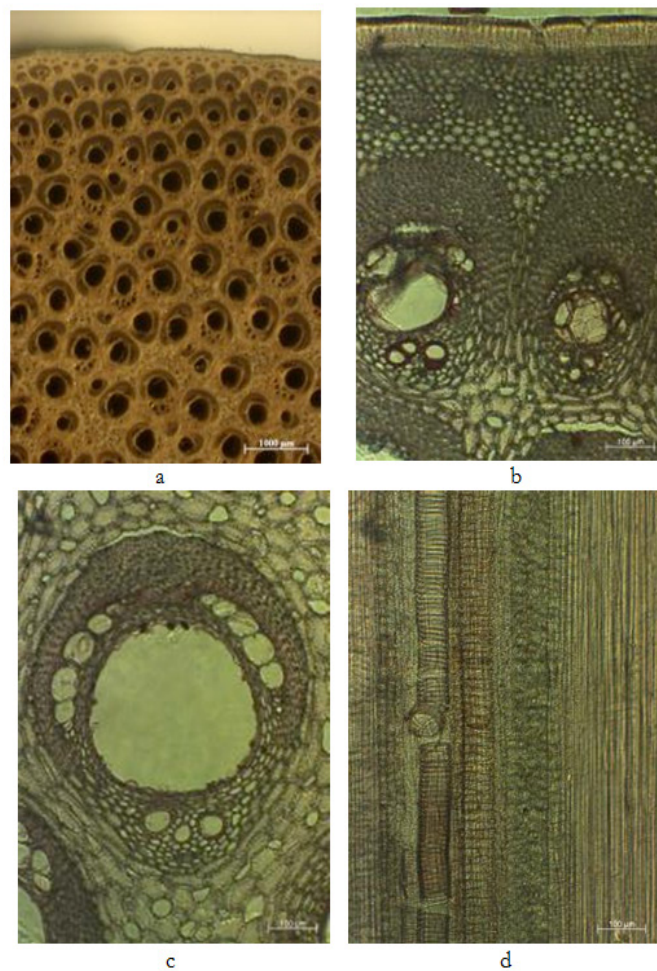


Figure 8. Anatomical structure of sijau rattan stem (*Calamus laevigatus* Martius)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

lumen $10.59 \pm 2.69 \mu\text{m}$ and wall thickness $4.2 \pm 0.71 \mu\text{m}$. Ground parenchyma cells are round to oval with varying sizes, type A.

I. Udang (*Korthalsia flagellaris* Miquel)

Single layer epidermis consisting of unligified parenchyma cells and covered by siliceous layer. The epidermis layer is about $63.39 \pm 6.25 \mu\text{m}$ and the endodermis layer is about $10.34 \pm 4.43 \mu\text{m}$. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern. The peripheral area is about $208.67 \pm 12.77 \mu\text{m}$ from the outer bark. Vascular bundle in the outer part is about 7–8 per mm^2 , with the width and length (W/L) ratio is 0.97 ± 0.41 , which means vascular bundle is

approximately oval. Yellow cap is found in the top of outer vascular bundle, metaxylem vessel diameter is $142.81 \pm 35.79 \mu\text{m}$.

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The oval vascular bundle length and width is 673.72 ± 76.96 and $480.26 \pm 68.17 \mu\text{m}$, respectively. The vascular bundle in the inner part is 6–7 per mm^2 , with the width and length (W/L) ratio is 0.73 ± 0.18 . Metaxylem vessels are single, with diameter of $319.02 \pm 33.74 \mu\text{m}$. Protoxylem consists of a cluster 4–6 cells, with single cell diameter of $57.05 \pm 5.81 \mu\text{m}$. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells

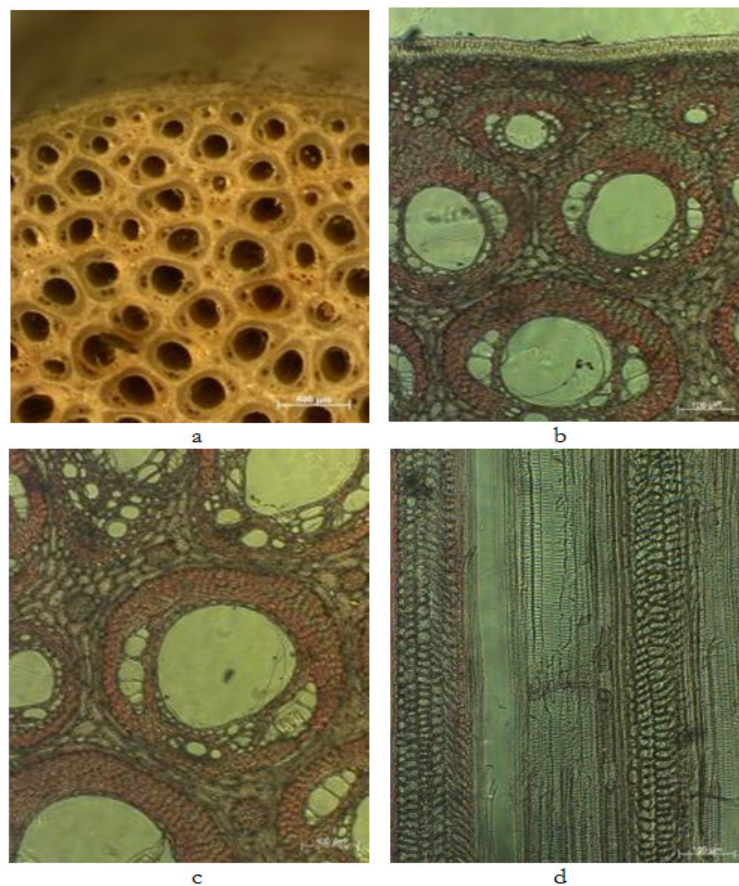


Figure 9. Anatomical structure of tunggal rattan stem (*Calamus laevigatus* Martius)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

(Figure 10c). Individual phloem cell diameter is about $51.52 \pm 8.87 \mu\text{m}$. Resin canal diameter is $100.43 \pm 15.84 \mu\text{m}$.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and elongated in the outer part. Fiber length is $2,476.86 \pm 332.08 \mu\text{m}$, width $23.3 \pm 2.8 \mu\text{m}$, lumen $13.57 \pm 1.94 \mu\text{m}$ and wall thickness $4.86 \pm 1.05 \mu\text{m}$. Ground parenchyma round to oval with varying sizes, type B.

As generally found in monocotyledonous, stem comprise a large central core of primary vascular bundles embedded in parenchymatous ground tissue, surrounded by peripheral area (cortex) (Butterfield & Meylan, 1980). The general stem anatomy of species investigated is similar with some Indonesian rattan species described by Jasni, Damayanti, and Kalima,

(2012); Jasni, Damayanti, Kalima, Malik, and Abdurachman, (2010); Jasni, Krisdianto, Kalima, and Abdurachman (2012). All species investigated were distinctly made up of epidermis, cortex and central cylinder. All species exhibited a single layer epidermis consisting of un lignified parenchyma cells. The epidermis was covered with siliceous layer interspersed with few stomata cells. The cortex or known as peripheral area consisted of fiber bands, undeveloped vascular bundles embedded in parenchyma cells of varying shapes and sizes structured ring-like in the outer part. Yellow cap which covers the top part of outer vascular bundle is found in *Plectocomiopsis geminiflora* (Griff.) Beccari (Figure 6b) and *udang* (*Korthalsia flagelaris* Miquel) (Figure 10b).

The central cylinder of all species was

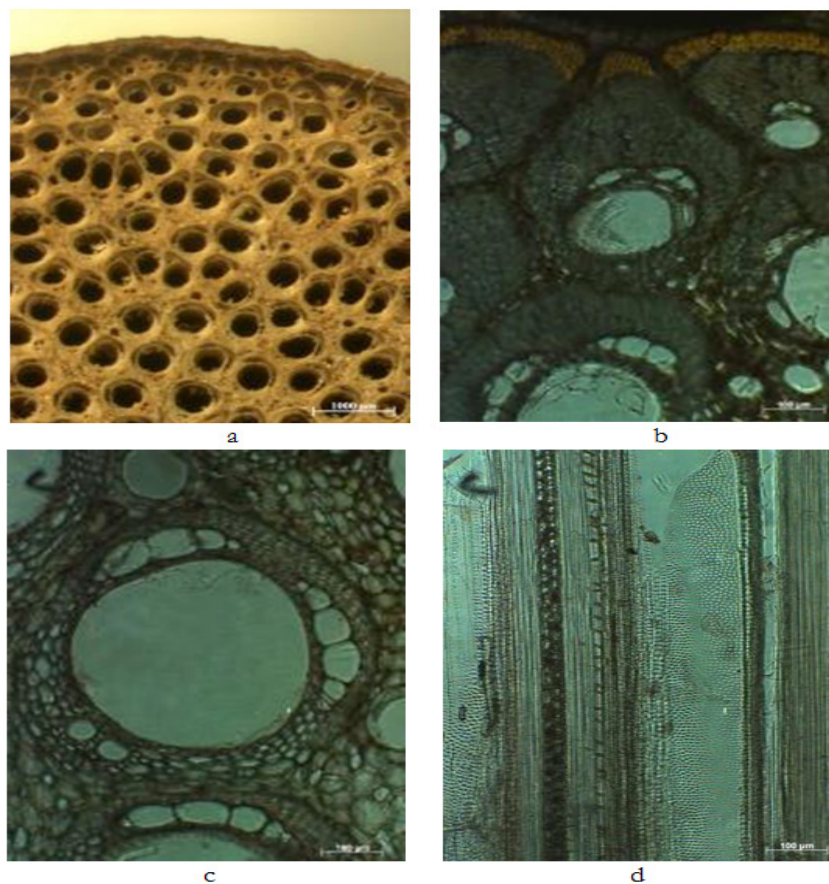


Figure 10. Anatomical structure of udang rattan stem (*Korthalsia flagelaris* Miquel)

Remarks: a. Stem cross section, scale 1000 μm ; b. Stem cross section, scale 100 μm ; c. Single vascular bundle, scale 100 μm ; d. Lateral section, scale 100 μm

generally composed of vascular bundles of varying sizes and structure embedded in ground parenchyma. The vascular bundle consisted of conducting tissue (xylem and phloem), which was surrounded by fiber sheath and parenchyma. The xylem was mostly composed of one large metaxylem-vessel and a cluster of protoxylem-vessels. In some species investigated, tyloses-like was found in few metaxylem-vessels. The phloem consisted of different number of sieve tubes with companion cells. Ground parenchyma cells are round to oval with varying sizes, type A and B, as shown in longitudinal section appear like ‘stacks of coins’. Tentative identification key to rattan species originated from Jambi is shown below.

Tentative identification key to rattan species above has been developed for nine species

investigated from Jambi area, then the key should be developed for further genera identification among rattan species in Indonesia.

IV. CONCLUSION

Nine rattan species originated from Jambi were anatomically described for species identification purposes. The anatomical properties could become a diagnostic characteristic for rattan species identification and specific characteristic has been developed for key species determination. Vascular bundles in the outer part of the stem of opon and udang rattans are yellow-capped. Width and length ratio of vascular bundle in the outer part is less than 1, oval shape was found in sijau rattan, while elongated shape with the ratio less than 1 was found in buruk ati. Fiber bundles

1. Vascular bundles in the outer part of the stem
 - a. yellow capped 2
 - b. yellow cap absent 3
2. Metaxylem vessels in the inner part
 - a. mostly in pair.....opon (*Plectocomiopsis geminiflora* (Griff.) Beccari).
 - b. mostly singleudang (*Korthalsia flagelaris* Miquel).
3. Circle resin canals
 - a. found in ground parenchymatous tissue 4
 - b. not found 7
4. Resin canals
 - a. in some area are found in pairgetah (*Daemonorops micracantha* (Griff.) Beccari)
 - b. exclusively single 5
5. Single resin canals
 - a. are found in center part and in cortex/peripheral areabatu (*Calamus zonatus* Beccari)
 - b. are found in center part 6
6. Fiber bundles in the peripheral area
 - a. is structured in one to two lines with no specific patternpaku (*Calamus exillis* Griff.)
 - b. is structured in one line with alternate patternduduk (*Daemonorops didymophylla* Beccari)
7. Fiber bundles in the central part
 - a. are embedded in the ground parenchymatous tissue in between vascular bundle ..
..... tunggal (*Calamus laevigatus* Martius)
 - b. are not found separately from vascular bundle 8
8. Vascular bundles in the outer part
 - a. are round to oval with W/L ratio is more than 1 sijau (*Calamus laevigatus* Martius)
 - b. are oval to elongated with W/L ratio is less than 1 buruk
ati (*Calamus insignis* Griff. var. *longispinosus* Dransfield)

separated from vessels are found in central ground parenchymatous tissue of rattan tunggal. In the peripheral area, fiber bundles forms one or two lines with no specific pattern found in paku rattan, while fiber bundles in one line with alternate pattern found in duduk rattan. Single resin canals are found both in center part and peripheral area is found in batu rattan and mostly single. Resin canals are found in pair at getah rattan stem. Tentative identification key to rattan species has been developed for nine species investigated, then the key should be developed for further genera identification among rattan species in Indonesia.

ACKNOWLEDGEMENT

The author would like to thank Forest Products Research and Development Center, Indonesian Ministry of Environment and Forestry for funding this study. The author would also send their gratitude to Sali Yulianto for his effort in collecting samples.

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