

## Wood anatomy of some members of Euphorbiaceae and Phyllanthaceae from Assam, India

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### Abstract

The wood anatomy of families Euphorbiaceae and Phyllanthaceae was carried out to study the detailed account of both qualitative and quantitative anatomical characteristics in *Macaranga denticulata* (Blume) Müll. Arg., *Balakata baccata* (Roxb.) Esser (Syn: *Sapium baccatum* Roxb.) *Baccaurea ramiflora* Lour., *Bischofia javanica* Blume and *Phyllanthus emblica* L. collected from forests of upper Assam. The common anatomical features among genera were diffuse porous wood, solitary and radial multiple of vessels, vasicentric, diffuse, diffuse in aggregate parenchyma, homocellular and heterocellular rays, alternate intervessel pits and septate fibres. Among genera, growth rings were distinct in *B. ramiflora*. Disjunctive ray parenchyma cells were present in *B. javanica* and *P. emblica*. Vestured pits were present in *M. denticulata* and *P. emblica*. Radial canals were observed in rays of *P. emblica*. Forked fibres, intrusive cavity in parenchyma and fibres, prismatic crystals in chambered axial parenchyma were observed in *B. baccata*. Fibres showed maximum percentage followed by ray, vessel and parenchyma in all genera. Most of the anatomical characteristics showed significant variation within species.

**Key words:** Axial parenchyma; Diffuse porous; Intervessel pitting; Multiseriate rays; Septate fibre

### INTRODUCTION

Euphorbiaceae and Phyllanthaceae are the important families of order Malpighiales. Earlier, the family Phyllanthaceae was considered a tribe of large and heterogenous family Euphorbiaceae. It is segregated from Euphorbiaceae and recognized as a separate family based on the molecular studies using DNA sequence, data of nuclear PHYC, plastid, *atpB*, *mat K* and *rbcL* alongwith morphological characters (Holfman et al 2006). Both the families are of considerable importance and have number of economically important plants like rich source of oil (seeds of *Ricinus communis*, *Croton tiglium*, *Jatropha curcas*, *Vernicia fordii*), vitamin C, protein and iron ((fruits of *Baccaurea ramiflora*), tannins (bark, leaves and fruits of *Phyllanthus emblica*) and rearing silk worms (leaves of *Balakata baccata*). The major commercial product is para-rubber which is a latex obtained from the bark of *Hevea brasiliensis*. In addition, there are a number of timber yielding species. The wood of *Baccaurea ramiflora* is used for making walking sticks, furniture and cabinet works. *Bischofia javanica*, an important avenue tree species is also used for making plywood, packing cases and beams etc. It is also commonly used by tigers to scratch mark territory in the forests of Assam. Its bark is rich source of red dye (Rajbongshi et al. 2014). Orwa et al. (2009) reported the use of wood of *Phyllanthus emblica* for clarification of muddy water of streams. It is also used for making agricultural implements, gunstock, furniture etc. Likewise,

the wood of *Macaranga denticulata* and *Balakata baccata* are used for plywood industries, light packing cases, small turnery articles and general carpentry.

A perusal of literature reveals that Nazma *et al.* (1981) placed *Drypetes roxburghii* in Aprusa type of sub-family Phyllanthoideae due to presence of scalariform perforation plates in ray cells. The detailed wood anatomical studies on seven species of *Amanoa* and 51 genera of 19 tribes of Acalyphoideae were investigated by Hayden *et al.* (1993); Hayden and Hayden (2000). They characterized the wood by simple and scalariform perforation plates, inter vessel pits, types of axial parenchyma and presence of crystals in parenchyma or ray cells. Mennega (2005) observed similarity in vessel arrangements, inter vessel pits, gelatinous fibres and parenchyma type in 82 species of sub-family Euphorboideae and distinguished genera due to presence of either silica or crystals. Wiedenhoef (2008) compared the anatomy of several taxa of Crotonoideae and made the comparison between members of *Celianella* and *Antidesma*. The presence of ray intrusive latifers in *Croton* species of section Cyclostigma were reported by Wiedenhoef *et al.* (2009). Oladipo and Iloh (2012) highlighted significant variation in anatomical characters of *Jatropha* species.

In India, Gamble (1922) listed out only general microscopic features of family Euphorbiaceae. Pearson and Brown (1932) investigated 6 species of the family Euphorbiaceae based on cross section. Raturi *et al.* (2001) mentioned gross features, few microscopic features and general properties of 26 genera of this family. The anatomy of wood specimens of sub families of family Euphorbiaceae available in FRI, Xylarium, Dehradun was performed to reflect their systematic, ecology and evolutionary aspects (Jangid & Gupta 2015, 2016; Jangid *et al.* 2017). However, there is limited report on wood anatomy of different genera available in Assam. Therefore, the aim of the present study is to provide detailed account of both qualitative and quantitative anatomical characteristics of Euphorbiaceae and Phyllanthaceae.

## MATERIALS AND METHODS

### Study site

The wood samples of selected species namely *Baccaurea ramiflora* Lour., *Bischofia javanica* Blume, *Macaranga denticulata* (Blume) Müll. Arg., *Phyllanthus emblica* L. and *Balakata baccata* (Roxb.) Esser [= *Sapium baccatum* Roxb.] were collected from different forest regions of Assam, India (Table 1). For each species, five mature trees with uniform crown and straight boles were selected. Wood sample of 5 cm<sup>3</sup> size was taken from each tree with the help of a chisel and a hammer at breast- height.

### Processing of wood samples

Collected wood samples were trimmed to 2cm<sup>3</sup> size and were fixed in FAA for 24 – 48 hours. The samples were preserved in 50 % alcohol for further studies.

### Preparation of permanent slides

Wood sections of about 15 – 25 microns thickness were cut in three planes (cross, tangential longitudinal and radial longitudinal) with the help of a sliding microtome. Permanent slides were prepared by following standard laboratory protocol.

### Study of anatomical characteristics

The anatomical features of selected woods in three planes were studied under light microscope at different magnification. Also, parameters like fibre diameter, fibre wall thickness, vessel

**Table 1.** Dimensions and location of selected species.

Sl. No.	Species name	Height (m) Mean±SD	Diameter (cm) Mean±SD	Geographical co-ordinates		Place
				Latitude	Longitude	
1.	<i>B. ramiflora</i>	15±0.38	57±0.89	25°35'N 26°19'N	94°54'E 91°40'E	Gali Lekhapani
2.	<i>B. javanica</i>	20±1.29	316±1.82	27°41'N 27°33'N	94°53'E 94°17'E	Simen Jiadhal
3.	<i>M. denticulata</i>	10±1.25	86±1.29	27°23'N 27°21'N	95°52'E 95°43'E	Katha Digboi
4.	<i>P. emblica</i>	15±1.28	126±1.29	26°29'N 27°36'N	94°36'E 94°35'E	Jiadhal Simen
5.	<i>B. baccata</i>	30±1.26	116±1.28	26°14'N 27°21'N	91°40'E 95°43'E	Lekhapani Digboi

diameter, vessel frequency and tissue proportion were determined from cross sections. Ray height, ray width and parenchyma strand from tangential longitudinal sections and inter-vessel pits from radial longitudinal sections were measured. The IAWA list of anatomical features (Wheeler *et al.* 1989) was followed for terminology, measurements and anatomical features.

#### Preparation of temporary slides

Small match sized splinters from radial sides were taken and macerated with Franklin's solution in an oven at 60°C for 24 hours. Temporary slides were prepared in 50 % glycerol for measurements of fibre length, vessel length, vessel shapes and fibre tips.

#### Statistical analysis

The data were analysed using SPSS 16.0 software.

## RESULTS

The photomicrographs and quantitative features of selected species are presented in Figures 1-3 and Table 1.

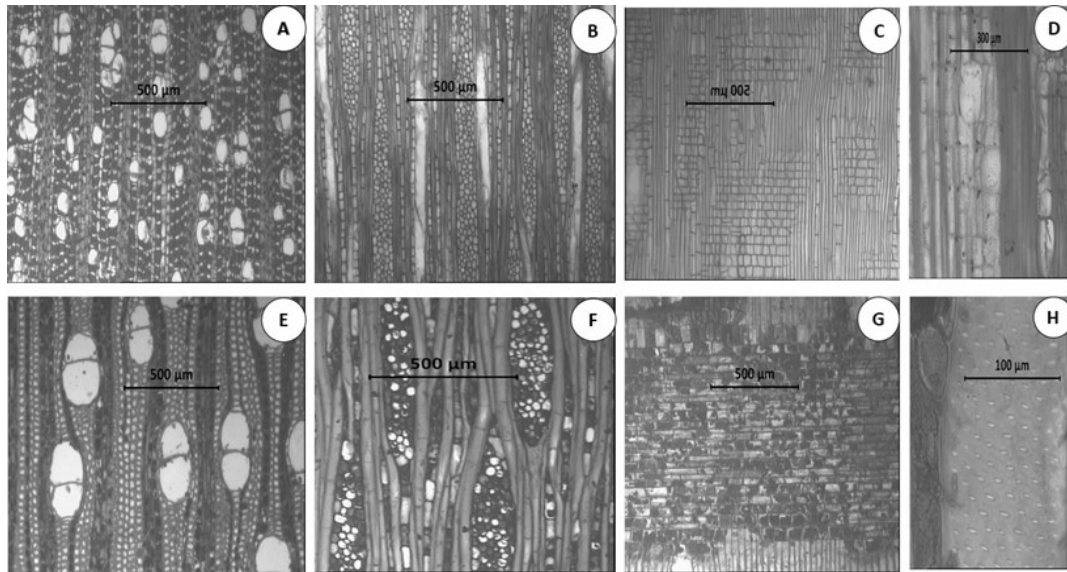
### EUPHORBIACEAE

*Macaranga denticulata* [Figures 2A - D; 3G]

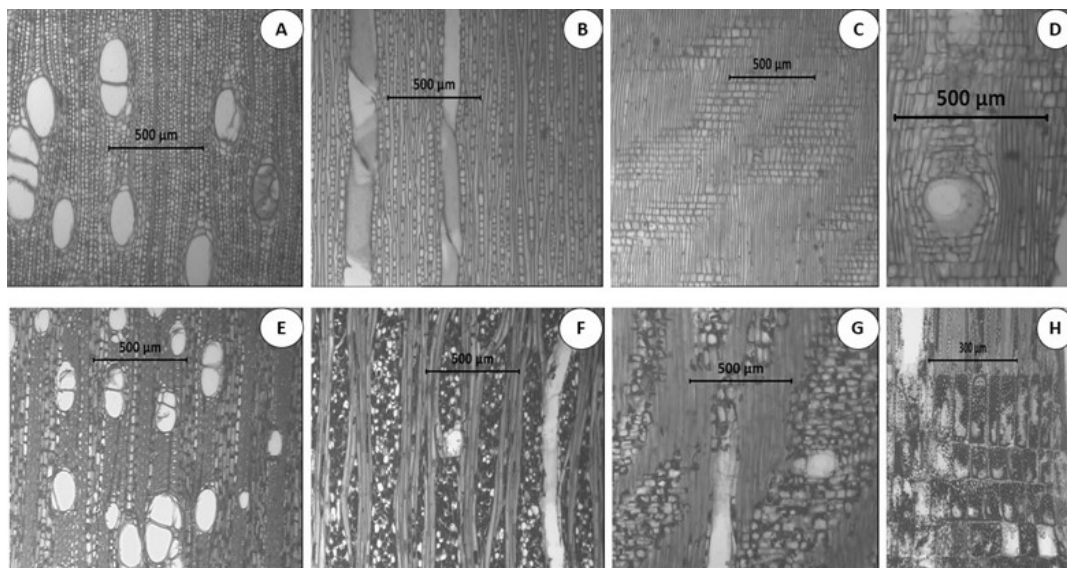
**Growth rings:** indistinct.

**Vessels:** diffuse-porous, vessels mostly solitary, in radial multiples of 2-6, oval in outline, 125.1-1075.86µm (Mean 482.18±196.81µm) in length, 93.78-276.13µm (Mean 165.13±36.22µm) in diameter, vessel frequency 2-10 (Mean 4.56±1.97) per mm<sup>2</sup>, simple perforation plate, intervessel pits alternate, vestured, medium to large, 5.20-18.20 µm (Mean 8.27±1.78µm) in size, vessel - ray pits with much reduced borders to apparently simple: pits rounded or angular, tyloses present.

**Fibres:** thin walled, 450.36-1551.24µm (Mean 1089.47±236.66µm) long, 13-46.8µm (Mean 26.68±6.21µm) and 7.8-31.2 µm (Mean 16.61±4.69µm) in diameter and lumen diameter, 1.3-16.9µm (Mean 5.10±2.89µm) in wall thickness, septate fibres present.



**Figure 1: *Baccurea ramiflora*:** **A** Cross-section showing diffuse-porous wood, vessel solitary and in radial multiple of 2-4, parenchyma vascentric and diffuse in aggregates. **B** Tangential longitudinal section showing multiseriate rays and parenchyma strand **C-D** Radial longitudinal sections showing heterocellular rays (**C**) and perforated ray cell with simple perforation (**D**). *Bischofia javanica*: **E** Cross-sections showing diffuse-porous wood, vessels in radial multiple of 2, parenchyma vascentric. **F** Tangential longitudinal section showing uniseriate, multiseriate rays and parenchyma strand. **G** Radial longitudinal sections showing heterocellular rays and **H** vestured intervessel pits



**Figure 2: *Macaranga denticulata*:** **A** Cross-section showing diffuse-porous wood, vessel solitary and in radial multiples of 2-3, vascentric, diffuse and diffuse in aggregate parenchyma. **B** Tangential longitudinal section showing uniseriate rays, intervessel pits and parenchyma strand **C-D** Radial longitudinal sections showing homocellular rays (**C**) and perforated ray cell with simple perforation (**D**). *Phyllanthus emblica*: **E** Cross-section showing diffuse-porous wood, vessel solitary, in radial multiples of 2-3, vascentric and scanty paratracheal parenchyma. **F** Tangential longitudinal section showing multiseriate rays, parenchyma strand and radial canal in ray. **G** Radial longitudinal sections showing heterocellular rays; perforated ray cell with simple perforation. **H** disjunctive ray parenchyma cells.

**Parenchyma:** vasicentric, diffuse and diffuse in aggregate, 2-8 cells per strand, prismatic crystals present in axial parenchyma.

**Rays:** mostly uniseriate, rarely biseriate, ray height and ray width 31.26-875.28 $\mu\text{m}$  (Mean 404.46 $\pm$ 167.39 $\mu\text{m}$ ) and ray width 10.42-41.68 $\mu\text{m}$  (Mean 10.75 $\pm$ 2.94 $\mu\text{m}$ ), rays homocellular and heterocellular, all ray cells upright in homocellular ray and body ray cells procumbent with two rows of upright and/or square marginal cells in heterocellular ray. Rays 7-21 (Mean 13.48 $\pm$ 2.64) per mm, perforated ray cells with simple perforation present, Prismatic crystals present.

***Balakata baccata*** [Figures 3A - D, I]

**Growth ring:** indistinct.

**Vessels:** diffuse-porous, mostly solitary, in radial multiples of 2, oval in outline, 175.14-950.76 $\mu\text{m}$  (Mean 540.03 $\pm$ 188.20 $\mu\text{m}$ ) in length, 93.78-291.76 $\mu\text{m}$  (Mean 178.18 $\pm$ 40.93 $\mu\text{m}$ ) in diameter, vessel frequency 3-14 (Mean 8.46 $\pm$ 2.77) per mm<sup>2</sup>, simple perforation plate, intervessel pits alternate, medium, 5.20-23.40 $\mu\text{m}$  (Mean 9.06 $\pm$ 2.63 $\mu\text{m}$ ) in size, vessel ray pits with much reduced borders to apparently simple, tyloses present.

**Fibres:** thin to thick walled, 375.30-1851.48 $\mu\text{m}$  (Mean 1142.51 $\pm$ 280.73 $\mu\text{m}$ ) long, 15.6-52  $\mu\text{m}$  (Mean 29.12 $\pm$ 6.76 $\mu\text{m}$ ) and 7.8-28.6 $\mu\text{m}$  (Mean 17.86 $\pm$ 4.96 $\mu\text{m}$ ) in diameter and lumen diameter, 1.3-15.6 $\mu\text{m}$  (Mean 5.62 $\pm$ 3.44 $\mu\text{m}$ ) in wall thickness, intrusive cavity, septate and bifurcated fibres present.

**Parenchyma:** diffuse, diffuse-in-aggregates, 2-10 cells per parenchyma strand, intrusive cavity present, prismatic crystals in chambered axial parenchyma.

**Rays:** mostly uniseriate, rarely biseriate, ray height 72.94-1250.40 $\mu\text{m}$  (Mean 398.04 $\pm$ 199.23 $\mu\text{m}$ ) and ray width 10.4-52.1 $\mu\text{m}$  (Mean 12.08 $\pm$ 5.19 $\mu\text{m}$ ), rays both homocellular and heterocellular. In homocellular rays, all ray cells procumbent and body ray cells procumbent with two rows of upright and/or square marginal cells in heterocellular rays, rays 3-7 (Mean 4.98 $\pm$ 1.02) per mm, radial canals and pith flecks present.

## PHYLLANTHACEAE:

***Baccaurea ramiflora*** [Figures 1A-D; 3E]

**Growth rings:** both indistinct and distinct and marked by radially flattened thick walled fibres if distinct.

**Vessels:** diffuse-porous, mostly solitary, in radial multiples of 2-4, oval in outline, 325.26-1626.3 $\mu\text{m}$  (Mean 800.43 $\pm$ 249.05 $\mu\text{m}$ ) in length, 52.10-166.72 $\mu\text{m}$  (Mean 94.61 $\pm$ 24.00 $\mu\text{m}$ ) in diameter, vessel frequency 16-30 (Mean 22.5 $\pm$ 3.21) per mm<sup>2</sup>, scalariform perforation plate with e"10 bars, intervessel pits alternate, medium to large, 5.2-26  $\mu\text{m}$  (Mean 8.71 $\pm$ 3.82  $\mu\text{m}$ ) in size, vessel- ray pits with much reduced borders to apparently simple: pits rounded or angular.

**Fibres:** thick walled, 300.24-3002.40 $\mu\text{m}$  (Mean 1384.90 $\pm$ 498.73 $\mu\text{m}$ ) long, 10.4-52  $\mu\text{m}$  (Mean 28.18 $\pm$ 6.89 $\mu\text{m}$ ) and 7.8-36.4 $\mu\text{m}$  (Mean 24.93 $\pm$ 8.14 $\mu\text{m}$ ) in diameter and lumen diameter, 13-37.7 $\mu\text{m}$  (Mean 23.14 $\pm$ 4.58 $\mu\text{m}$ ) in wall thickness, septate fibres present.

**Parenchyma:** vasicentric and also diffuse-in-aggregate. 2 -12 cells per strand.

**Rays:** uniseriate, biseriate, multiseriate, ray height 62.52-1302.50 $\mu\text{m}$  (Mean 534.75 $\pm$ 380.05 $\mu\text{m}$ ) and ray width 31.26-135.46 $\mu\text{m}$  (Mean 81.77 $\pm$ 21.82 $\mu\text{m}$ ), rays homocellular and heterocellular.

In homocellular rays, all ray cells either procumbent or square or upright. In heterocellular rays, body ray cells procumbent with two rows of upright and/or square marginal cells. Rays 3-13 (Mean  $7.58 \pm 2.15$ ) per mm, perforated ray cells with scalariform perforation present. Prismatic crystals present in procumbent ray cells.

***Bischofia javanica*** [Figures 1E-H; 3F]

**Growth rings:** Indistinct.

**Vessels:** diffuse-porous, mostly solitary, in radial multiples of 2-3, oval in outline, 250.2-950.76 $\mu\text{m}$  (Mean  $532.62 \pm 161.42\mu\text{m}$ ) in length, 98.88-234.45 $\mu\text{m}$  (Mean  $162.71 \pm 28.15\mu\text{m}$ ) in diameter, vessel frequency 4-20 (Mean  $11.06 \pm 3.62$ ) per  $\text{mm}^2$ , both simple and scalariform perforation plate, intervessel pits alternate, vestured, medium to large, 5.20-23.40 $\mu\text{m}$  (Mean  $11.56 \pm 3.59\mu\text{m}$ ) in size, vessel ray pits with much reduced border to apparently simple, pits rounded, tyloses present.

**Fibres:** thick walled, 500.4-2251.8 $\mu\text{m}$  (Mean  $1252.80 \pm 370.37\mu\text{m}$ ) long, 20.8-72.8 $\mu\text{m}$  (Mean  $45.53 \pm 9.18\mu\text{m}$ ) and 7.8-52 $\mu\text{m}$  (Mean  $24.93 \pm 8.14\mu\text{m}$ ) in diameter and lumen diameter, 1.3-27.3 $\mu\text{m}$  (Mean  $10.29 \pm 4.76\mu\text{m}$ ) in wall thickness, septate fibres present, Laticifers (black streaks) present among fibres.

**Parenchyma:** vasicentric, diffuse. 2-6 cells per strand.

**Rays:** uniseriate, biseriate, multiseriate, ray height 166.72 - 1114.94 $\mu\text{m}$  (Mean  $527.33 \pm 207.92\mu\text{m}$ ) and ray width 10.42-135.46 $\mu\text{m}$  (Mean  $76.60 \pm 29.06\mu\text{m}$ ), rays heterocellular, body ray cells procumbent with two rows of upright and/or square marginal cells. Rays 3-11 (Mean  $6.32 \pm 2.06$ ) per mm, disjunctive ray parenchyma walls present.

***Phyllanthus emblica*** [Figures 2E-H; 3H]

**Growth rings:** indistinct.

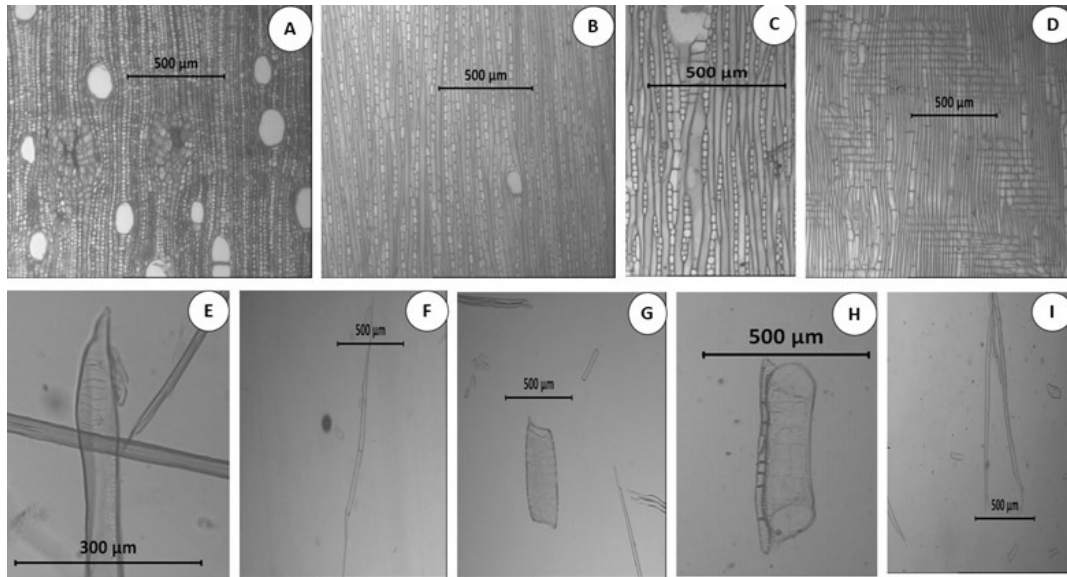
**Vessels:** diffuse-porous, vessels mostly solitary, in radial multiples of 2-5, oval in outline, 125.1-1251 $\mu\text{m}$  (Mean  $531.62 \pm 232.90\mu\text{m}$ ) in length, 88.57-224.03 $\mu\text{m}$  (Mean  $149.25 \pm 27.39\mu\text{m}$ ) in diameter, vessel frequency 11-32 (Mean  $18.18 \pm 4.22$ ) per  $\text{mm}^2$ , simple perforation plate, intervessel pits alternate, vestured, medium to large, 5.20-18.20 $\mu\text{m}$  (Mean  $8.17 \pm 1.82\mu\text{m}$ ) in size, vessel ray pits with much reduced borders to apparently simple, pits horizontal, scalariform.

**Fibres:** thin to thick walled, 200.16-2001.6 $\mu\text{m}$  (Mean  $1377.70 \pm 1331.06\mu\text{m}$ ) long, 18.2 - 52 $\mu\text{m}$  (Mean  $30.95 \pm 6.89\mu\text{m}$ ) and 7.8-31.2 $\mu\text{m}$  (Mean  $17.38 \pm 4.85\mu\text{m}$ ) in diameter and lumen diameter, 1.3-15.6 $\mu\text{m}$  (Mean  $6.78 \pm 3.08\mu\text{m}$ ) in wall thickness, septate fibres present, prismatic crystals present.

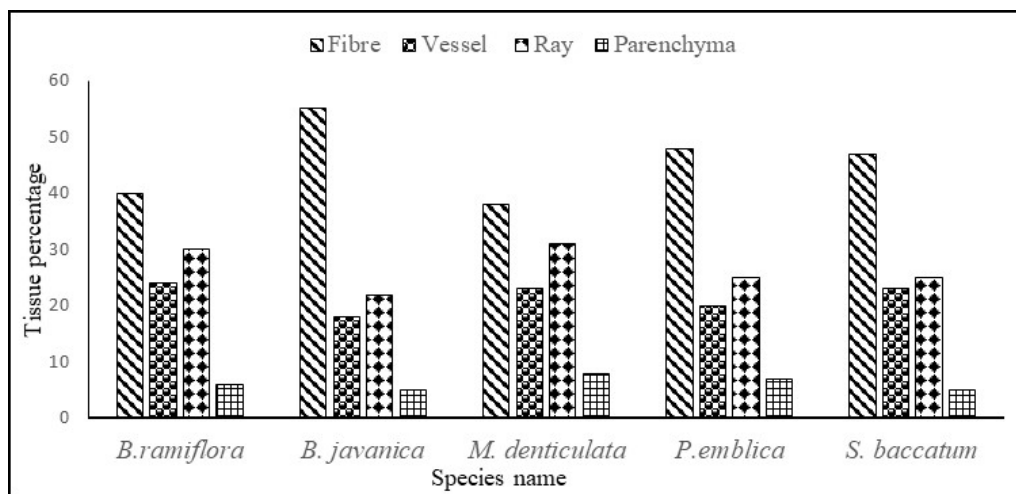
**Parenchyma:** vasicentric and scanty paratracheal. 2-9 cells per strand.

**Rays:** multiseriate, ray height 364.70-5543.44 $\mu\text{m}$  (Mean  $1222.30 \pm 806.99\mu\text{m}$ ) and ray width 41.68-229.24 $\mu\text{m}$  (Mean  $114.28 \pm 40.15\mu\text{m}$ ), rays heterocellular, body ray cells procumbent with two rows of upright and/or square marginal cells. Rays 3-8 (Mean  $5.36 \pm 1.24$ ) per mm, disjunctive ray parenchyma cells, perforated ray cells with simple perforation present, latex canal present in ray, prismatic crystals present in procumbent cells of ray.

Tissue percentage varied among species. *B. javanica* had maximum fibre percentage followed by *P. emblica*, *B. baccata*, *B. ramiflora* and *M. denticulata*. There was maximum vessel and ray percentage *B. ramiflora*. *M. denticulata* had also maximum percentage of ray and parenchyma. On the other hand minimum vessel and ray percentage in *B. javanica*



**Figure 3:** *Sapium baccatum*: **A** Cross-sections showing diffuse-porous wood, vessel solitary and in radial multiple of 2, diffuse and diffuse in aggregates parenchyma and pith flecks. **B-C** Tangential longitudinal sections showing uniseriate rays, parenchyma strand, radial canal (B) intrusive cavity in fibre (C). **D** Radial longitudinal section showing heterocellular rays. **E-I** Macerated wood elements showing scalariform perforation in *B. ramiflora* (E), septate fibre in *B. javanica* (F), vessel barrel shaped with short tails and simple perforations in *M. denticulata* and *P. emblica* (G-H), parenchyma strand (H) and forked fibre in *S. baccatum* (I).



**Figure 4:** Tissue proportion of selected species of family Euphorbiaceae and Phyllanthaceae

and parenchyma percentage in *B. javanica* and *B. baccata* were observed (Figure 4). The result presented in Table 3 showed that fibre length and fibre diameter existed statistically significant variation in all species except *B. javanica* and. There was a statistically significant variation in fibre lumen diameter in *M. denticulata* and *B. baccata*. The vessel parameters namely vessel length, vessel diameter and intervessel pits exhibited statistically significant differences in all species except vessel length in *B. javanica*, inter vessel pits in *P. emblica*

and *M. denticulata*. Vessel frequency and axial parenchyma strand were non-significant for all species except *B. ramiflora*. Ray height and ray width were significant for all species except *M. denticulata*. Fibre wall thickness was non-significant for all species except *B. ramiflora*. Ray frequency was significant in *M. denticulata* and *B. baccata*.

**Table 2.** Quantitative features of selected species of Euphorbiaceae and Phyllanthaceae

Parameters	<i>B. ramiflora</i>	<i>B. javanica</i>	<i>M. denticulata</i>	<i>P. emblica</i>	<i>B. baccata</i>
FL(μm) (Mean±SD)	300.24-3002.40 (1384.90±498.73)	500.40-2251.80 (1252.80±370.37)	450.36-1551.24 (1089.47±236.66)	200.16-2001.60 (1377.70±1331.06)	375.3-1851.48 (1142.51±280.73)
FD(μm) (Mean±SD)	10.40-52 (28.18±6.89)	20.80-72.80 (45.53±9.18)	13-46.80 (26.68±6.21)	18.20-52 (30.95±6.89)	15.60-52 (29.12±6.76)
FLD(μm) (Mean±SD)	7.80-36.40 (24.93±8.14)	7.80-52 (24.93±8.14)	7.80-31.20 (16.61±4.69)	7.80-31.20 (17.38±4.85)	7.80-28.60 (17.86±4.96)
FWT (μm) (Mean±SD)	13-37.70 (23.14±4.58)	1.30-27.30 (10.29±4.76)	1.30-16.90 (5.10±2.89)	1.30-15.60 (6.78±3.08)	1.30-15.60 (5.62±3.44)
VL (μm) (Mean±SD)	325.26-1626.3 (800.43±249.05)	250.20-950.76 (532.62±161.42)	125.10-1075.86 (482.18±196.81)	125.10-1251 (531.62±232.90)	175.14-950.76 (540.03±188.20)
VD(μm) (Mean±SD)	52.1-166.72 (94.61±24.00)	98.88-234.45 (162.71±28.15)	93.78-276.13 (165.13±36.22)	88.57-224.03 (149.25±27.39)	93.78-291.76 (178.18±40.93)
IVP(μm) (Mean±SD)	5.20-26 (8.71±3.82)	5.20-23.40 (11.56±3.59)	5.20-18.20 (8.27±1.78)	5.20-18.20 (8.17±1.82)	5.20-23.40 (9.06±2.63)
VF/mm <sup>2</sup> (Mean±SD)	16-30 (22.5±3.21)	4-20 (11.06±3.62)	2-10 (4.56±1.97)	11-32 (18.18±4.22)	3-14 (8.46±2.77)
APS (Mean±SD)	2-12 (3.52±1.61)	2-6 (2.94±1.15)	2-8 (3.86±1.42)	2-9 (3.70±1.65)	2-10 (4.66±2.07)
RH(μm) (Mean±SD)	62.52-1302.50 (534.75±380.05)	166.72-1114.94 (527.33±207.92)	31.26-875.28 (404.46±167.39)	364.70-5543.44 (1222.30±806.99)	72.94-1250.40 (398.04±199.23)
RW(μm) (Mean±SD)	31.26-135.46 (81.77±21.82)	10.42-135.46 (76.60±29.06)	10.42-41.68 (10.75±2.94)	41.68-229.24 (114.28±40.15)	10.4-52.10 (12.08±5.19)
RF/mm (Mean±SD)	3-13 (7.58±2.15)	3-11 (6.32±2.06)	7-21 (13.48±2.64)	3-8 (5.36±1.24)	3-7 (4.98±1.02)

## DISCUSSION

The present study shows that all selected genera of families Euphorbiaceae and Phyllanthaceae were diffuse-porous with indistinct rings. Distinct rings were also observed in *Baccaurea ramiflora*. Vessels were mostly solitary, in short radial multiple of 2-3 in *B. ramiflora* and *Bischofia javanica* and in long radial multiples of 2-6 in *Macaranga denticulata* and *Phyllanthus emblica*. Barrel, oblong and linear shapes of vessels were present in all genera. In addition, drum shaped vessels were present in *Balakata baccata* and *P. emblica*. Simple perforation plates were present in *M. denticulata*, *P. emblica* and *B. baccata*, scalariform perforation plates with 10-20 bars in *B. ramiflora* and both simple and scalariform perforation plates were present in *B. javanica*. Intervessel pits were alternate, medium except *B. ramiflora*. Vestured pits were seen in *B. javanica* and *P. emblica*. Vessel ray pits were with much reduced borders to apparently simple, pits rounded, horizontal and scalariform. Porosity, vessel grouping, perforation plates, intervessel pits arrangement and vessel ray pitting in the present investigation are in confirmation with the findings of other workers (Mennega 1984, 2005; Hayden *et al.*, 1993; Hayden & Hayden, 2000; Jangid & Gupta, 2015). Nair (1998) identified small branched or unbranched vestures distributed randomly on pit chamber away from aperture in *Phyllanthus acidus* and branched or unbranched vesture aggregations near the pit aperture in *Bridelia retusa* and *Bridelia squamosa*. In the present



**Table 3.** Analysis of variance for quantitative characteristics within selected species (n=5)

Sl. No.	Species	F values												
		FL	FD	FLD	FWT	VL	VD	IVP	VF	APS	RH	RW	RF	
1	<i>B. ramiflora</i>	5.91**	2.93*	.908 <sup>ns</sup>	2.85*	4.08**	21.79**	12.18**	1.33 <sup>ns</sup>	.57 <sup>ns</sup>	63.56**	5.80**	1.20 <sup>ns</sup>	
2	<i>B. javanica</i>	1.80 <sup>ns</sup>	2.73*	1.80 <sup>ns</sup>	.23 <sup>ns</sup>	1.10 <sup>ns</sup>	5.29**	15.30**	10.58**	4.99**	11.40**	21.07**	0.61 <sup>ns</sup>	
3	<i>M. denticulata</i>	4.87**	4.81**	2.76*	1.79 <sup>ns</sup>	3.67**	25.61**	0.35 <sup>ns</sup>	0.11 <sup>ns</sup>	0.49 <sup>ns</sup>	1.13 <sup>ns</sup>	1.39 <sup>ns</sup>	10.19**	
4	<i>P. emblica</i>	13.15**	1.36 <sup>ns</sup>	1.10 <sup>ns</sup>	0.40 <sup>ns</sup>	15.45**	13.21**	0.66 <sup>ns</sup>	0.26 <sup>ns</sup>	1.23 <sup>ns</sup>	4.76**	16.88**	1.65 <sup>ns</sup>	
5	<i>B. baccata</i>	14.01**	2.72*	7.74**	.383 <sup>ns</sup>	2.91*	24.06**	8.44**	1.50 <sup>ns</sup>	0.31 <sup>ns</sup>	2.28 <sup>ns</sup>	4.58**	3.72**	

[The level of significance used are ns = non-significant; \* = significant at Pd<sup>0.05</sup> level; \*\* = significant at Pd<sup>0.01</sup> level. FL - Fibre Length; FD - Fibre Diameter; FLD - Fibre Lumen Diameter; FWT - Fibre Wall Thickness; VL - Vessel Length; VD - Vessel Diameter; IVP - Intervessel Pitting; VF - Vessel Frequency; APS - Axial Parenchyma Strand; RH - Ray Height; RW - Ray Width; RF - Ray Frequency]

study vestured pits were present in *B. javanica* and *P. emblica*, but branching of vesture was not clear. It may be due to observation of pits under light microscope. Tyloses were common in *B. javanica*, *M. denticulata* and *B. baccata*.

Fibres were thin to thick-walled. However, highly thick walled fibres with narrow lumen were observed in *B. ramiflora*. Septate fibres were present in all the species. There were several septa per cell but a single septum dividing the fibre lumen into two parts was present in *B. javanica*. Such types of fibres are reported in *Clusia abyssinica* (Hayden & Hayden 2000). In *B. baccata*, fibres with forking and intrusive cavities were recorded. Such fibres are also reported in *Croton floribundus* and *Sapium glandulosum* of Euphorbiaceae by Dias-Leme and Angyalossy-Alfonso (1998) and confirm the present investigation.

In the present investigation, the axial parenchyma were diffuse and diffuse in aggregate in *B. javanica*, *M. denticulata* and *B. baccata*, narrow bands in *B. ramiflora*, with some scanty parenchyma cells in *B. baccata* and *P. emblica*. Vascentric parenchyma was also present in *B. javanica*, *M. denticulata* and *P. emblica*. The present investigations are in agreement with the findings of Hayden and Hayden 2000; Hayden *et al.*, 1993; Mennega 2005; Jangid and Gupta, 2015. Prismatic crystals in parenchyma cells of *M. denticulata* and crystals bearing chambered parenchyma cells in *B. baccata* are in agreement with the investigation of Hayden *et al.* (1993) and Hayden and Hayden (2000). Intrusive cavities were found rarely in axial parenchyma cells of *B. baccata* and corroborate findings of Dias-Leme and Angyalossy-Alfonso (1998).

Rays were uniseriate, biseriate and multiseriate in *B. javanica* and *B. ramiflora*, multiseriate only in *P. emblica* and mostly uniseriate and rarely biseriate in *M. denticulata* and *B. baccata*. Rays were both homocellular and heterocellular in all selected members. The homocellular rays of *B.*

*ramiflora* were composed of either procumbent cells or upright cells or square cells. Heterocellular rays in all genera consisted of body ray cells procumbent with two rows of upright and/or square marginal cells. Perforated ray cells with simple perforation in *P. emblica* and *M. denticulata* and scalariform perforations in *B. ramiflora* were observed. Disjunctive walls were present in upright cells of *P. emblica* and square cells of *B. javanica*. Similar conclusions are drawn by Mennega 1984; Hayden and Hayden 2000 and Jangid and Gupta 2015. However, these workers did not report the type of perforations in perforated ray cells.

Laticifers are present in secondary xylem and in rays (Rudall 1987; Carlquist 2001). Hayden and Hayden (2000) observed lysigenous radial canals devoid of any secretion in larger rays of some genera of family Euphorbiaceae while Wiedenhoef *et al.* (2009) recorded ray intrusive laticifers in *Croton* species. In the present investigations, some long, dark coloured streaks were recorded among fibres in tangential and radial sections of *B. javanica*. On the other hand, radial canals in rays of *P. emblica* and *B. baccata* were also recorded. Prismatic crystals were present in *B. ramiflora*, *P. emblica* and *M. denticulata* and are in agreement with the findings of Hayden and Hayden (2000) and Jangid and Gupta (2015).

Most of the anatomical characteristics were significant within the species and contrary to the findings of Pande *et al.* (2005, 2008).

## Conclusions

The present study revealed that wood structure was homogeneous among genera of families Euphorbiaceae and Phyllanthaceae. Growth rings were indistinct in all genera except *B. ramiflora*. Disjunctive ray parenchyma cells were present in both *B. javanica* and *P. emblica*. Vestured pits were present in *M. denticulata* and *P. emblica*. Anatomically, *P. emblica* could be differentiated from *B. javanica* by presence of exclusively multiseriate rays and radial canal in rays. The presence of uniseriate rays and perforated ray cells with simple perforation were the features to distinguish *M. denticulata* from *P. emblica*. The forked fibres, intrusive cavity in fibre and parenchyma, pith flecks and prismatic crystals in chambered axial parenchyma were the diagnostic features to distinguish *B. baccata* from other genera.

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