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RAY PATTERNS IN SELECTED WOOD SPECIES OF NIGERIAN GENERA OF STERCULIACEAE

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ABSTRACT: Patterns of rays in *Mansonia altissima*, *Sterculia rhinopetala*, *Pterygota macrocarpa*, *Triplochiton scleroxylon*, *Hildergardia bateri*, *Cola lateritia*, *Cola glabra* and *Nesogordonia papaverifera* of sterculiaceae family were investigated in this study. Transverse and longitudinal sections of about 20 micrometers thick were prepared on a Reichert microtome. Slides were examined under a Zeiss microscope (Standard 25) ×80 magnification to which a digital camera (SVP DC-12DX) was attached. The results showed that all rays were heterocellular; sheath cells were present in all the wood species except in *Mansonia altissima*, *Cola glabra* and *Nesogordonia papaverifera*. Pattern of rays was similar in *Sterculia rhinopetala*, *Pterygota macrocarpa*, *Hildergardia bateri*, *Cola lateritia* and *Cola glabra* in which rays were mostly multi seriate and more than 1 mm in height. Pattern of rays was also found to be the same in *Mansonia altissima*, *Triplochyton* and *Nesogordonia papaverifera* on the account of short and storied rays. Crystals /silica bodies were present in all the wood species except in *Hildergardia bateri*. The patterns of rays were also related to utilization of these wood species while photo-micrographs from a digital camera mounted on a light microscope were presented. Anatomical descriptions were based on International Association Wood Anatomists (IAWA) codes. In spite of the patterns of rays which can influence wood utilization, the presence and absence of inclusions, sheath cells and ray height in these wood species are important diagnostic features in the family.

Keywords: Rays, cells, width, Sheath, crystals, gum

1. INTRODUCTION

Rays are part of the traits by which wood species maybe distinguished or separated, and their patterns or changes in dimension can be influenced by injuries (Arbellay, et al, 2012) as well as transition from juvenile to adult wood in some wood species (Prمود and Karumanchi, 2012). They are ribbon-like strands or strips of cells extending radially within a tree to connect the various layers from pith to bark. Wood rays vary in height from several cells to over 1mm in some wood species. It has been reported that dimensions of multiseriate rays in 5-yr-old trunk wood can be similar to those of 15-yr-old trees (Prمود and Karumanchi, 2012). In softwood, rays constitute about 8% of the volume, and an average of about 17% in the hardwood xylem, and sometimes it may be more than 30% (Haygreen and Bowyer 1982). In teak, ray percentages

were 20.3% in fast-grown trees and 18.7% in slow-grown trees (Bhat et al., 2001).

Wood rays in softwood species are one cell wide and as a result are hard to see in macro identification. Hardwoods on the other hand show great variation from broad to invisible rays with the naked eye. In a few hardwoods rays are only one cell wide and comparatively few cells high, and in most cases they are many cells wide and extend vertically some distance in the wood while some species have both narrow and wide rays. The practical implications of rays in wood anatomy include its influence on wood during drying and painting. Wood drying takes place faster on the flat grain (tangential section) than on the edge grain (radial section). This is due to the fact that moisture movement that occurs during drying comes from deep within the piece and depends on ray cells

which act as conduits. Yet, paint penetration is very shallow at flat grain (Jozsa and Middleton, 1994). Relationships between ray proportion and strength properties including shrinkage values have been reported by several authors (Schniewind 1959; Kennedy 1968; Beery *et al.*, 1983; Mattheck and Kubler 1997; Schniewind 1959). Taylor (1969a,b) and Boyce *et al.* (1970) also indicated that ray proportion was positively correlated with specific gravity in hardwoods. But they can be responsible for some physical phenomena in wood. For instance, surface checking in oak has been attributed mainly to wide wood rays that create spots of surface weakness (Zhang, 2003) as broad rays contribute to poor radial cleavability. Most cracks occurred within a ray or were initiated near a ray in some Oak specimens (Zink-Sharp, *et al.*, 1999). The large, multiseriate rays of oak represent a plane of weakness or potential stress concentrator. Meanwhile rays form part of figure in wood.; Rahman *et al.*, 2005 considered it advisable to breed teak with a high ray proportion as selection for a high ray proportion may result in selection for high quality wood with a higher wood density. Red oak, which is a ring-porous species, has large conspicuous rays, and is highly variable in structure; maple, however, is diffuse-porous, has smaller rays, and is quite uniform in structure (Zink-Sharp, *et al.*, 1999).

Wood being anisotropic, shrinkage is unequal in its three axial directions. In normal wood, radial and tangential shrinkage is appreciable (on average 4% and 8%, respectively), owing to the fact that reinforcing effect of the rays on the radial plane tends to retard shrinkage (Jozsa and Middleton, 1994).

Ray pattern in *Scaphium macropodum* (Sterculiaceae) has been studied by Dickson (1972) and International Association of Wood Anatomists (IAWA, 1989); Metcalfe and Chalk, 1989 also carried out some research studies on Sterculiaceae family especially on taxonomic significance of tyloses in vessels, but studies on patterns of rays among the members of this family are rare. Therefore, the present study is undertaken to investigate the patterns of rays in the Sterculiaceae family which is of tropical and sub-tropical plants, comprising of 48 genera and about 600 species, of which many are trees. Apart from being used as moulding, veneer, furniture or furniture components, boxes and crates, sculpture, matches, pencils, ship building, shingles, flooring and tool

handles; notable wood species within the family have been widely used for roofing in Nigeria include *Nesogordonia papaverifera*, *Pterygota macrocarpa* and *Steculia rhinopetala* (Arowosoge, 2015). Some other members of the family that are economically important are *Theobroma cacao*, *Mansonia altissima*, *Hildegardia*, *Scaphopetalum*, *Leptonychia*, *Dombeya*, *Octolobus* and *Cola*. This study intends to investigate the patterns of rays among the members of this family with a view to distinguishing them based on their microscopic features.

2. MATERIALS AND METHODS

Wood samples from *Mansonia altissima*, *Steculia rhinopetala*, *Pterygota macrocarpa*, *Triplochiton scleroxylon*, *Hildegardia bateri*, *Cola lateritia*, *Cola glabra* and *Nesogordonia papaverifera* were collected from matured trees at breast height using an increment borer. Wood samples were sectioned into transverse, tangential and radial sections of about 20 microns using a sliding microme. Staining was done by covering the sections with safranin red solution dehydrated in increasing concentrations of ethanol, while clearing was done using coconut oil (Adeniyi *et al.*, 2016) and mounted on a slide using a Canadian balsam. Wood cells were observed under a light microscope 80 ×. A digital camera on a light microscope was used to photograph anatomical features. Nomenclature and cell sizes were determined following microscopic terminology for hardwood identification (IAWA Committee 1989).

3. RESULTS

Generally, rays in all the wood species were more than one-cell wide; about 2-3 cell wide in *Nesogordonia papaverifera*; 1-3 cells wide *Mansonia altissima*; 1-5 cells wide in *Triplochiton scleroxylon*; 1-8 cells wide in *Steculia rhinopetala*; 1-12 cell wide in *Pterygota macrocarpa*; 1-7 cells wide in *Hildegardia bateri*; 1-11 in *Cola lateritia*; 1-10 in *Cola glabra*. All rays are heterocellular; sheath cells are present in all the wood species except in *Mansonia altissima*, *Cola glabra* and *Nesogordonia papaverifera* (Table 1). Crystals /silica bodies were present in all the wood species except in *Hildegardia bateri*. All the wood species in which rays were less than 1 mm were storied.

Table 1: Wood species and some present features in rays

Name of Species	Sheath cells	Multiseriate	Crystals, Silica bodies etc	Ray > 1 mm	Storied Rays
<i>Mansonia altissima</i>	-	+	+	-	+
<i>Sterculia rhinopetala</i>	+	+	+	+	-
<i>Pterygota macrocarpa</i>	+	+	+	+	-
<i>Triplochiton scleroxylon</i>	+	+	+	-	+
<i>Hildergardia bateri</i>	+	+	-	+	-
<i>Cola lateritia</i>	+	+	+	+	-
<i>Cola glabra</i>	-	+	+	+	-
<i>Nesogordonia papaverifera</i>	-	+	+	-	+

+ means present; - means absent

Nesogordonia papaverifera

Rays were multiseriate (about 2–3 cells wide), heterocellular with square and upright cells restricted to marginal rows. The rays were storied and mostly filled with gum deposits.

Mansonia altissima

Rays were multiseriate (1–3 cells wide), heterocellular with square and upright cells restricted to marginal rows, mostly 1 marginal row of upright or square cells to mostly 2–4 marginal rows of upright or square cells, and storied. Silica aggregate present, crystals present in ray cells

Triplochiton scleroxylon

Rays were multiseriate (about 1–5 cells wide), heterocellular with tile cells, procumbent, square and upright cells mixed throughout the ray. Sheath cells present. Storied rays were present. Prismatic crystals present in ray cells.

Sterculia rhinopetala,

Rays were multiseriate (about 1–8 cells wide), heterocellular with tile cells, procumbent, square and upright cells mixed throughout the ray. Sheath cells present. Rays were mostly more than 1 mm high.

Storied rays were present. Crystals and silica aggregate present. Gum deposits in ray cells.

Pterygota macrocarpa

Rays were multiseriate (about 1–12 cells wide), mostly more than 1 mm, heterocellular with procumbent, square and upright cells mixed throughout the ray. Crystals found in some rays. Sheath cells present.

Hildergardia bateri

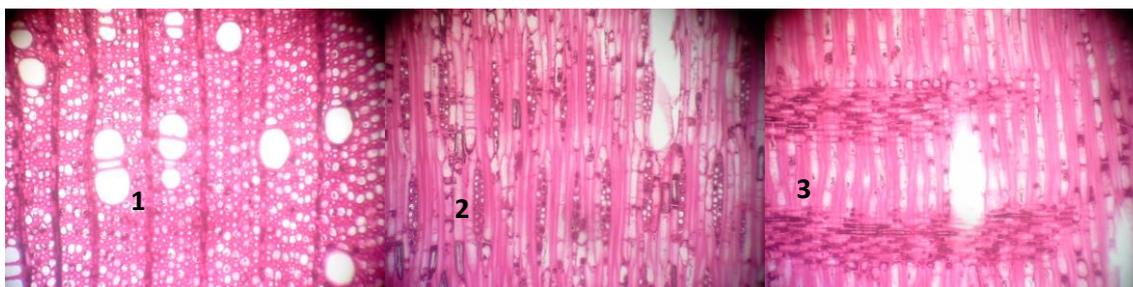
Rays were multiseriate (about 1–7 cells wide), mostly more than 1 mm, heterocellular with procumbent, and upright cells mixed throughout the ray. Sheath cells present.

Cola lateritia

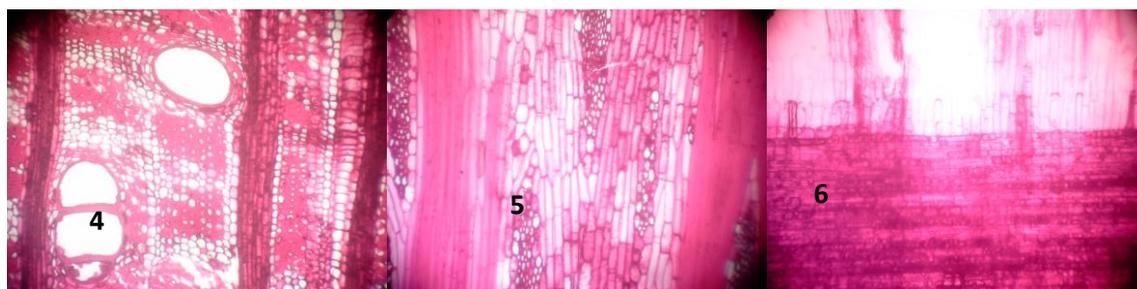
Rays were multiseriate (about 1–11 cells wide), mostly 1 mm, heterocellular with square, procumbent, and upright cells mixed throughout the ray. Sheath cells present. Silica bodies in rays.

Cola glabra

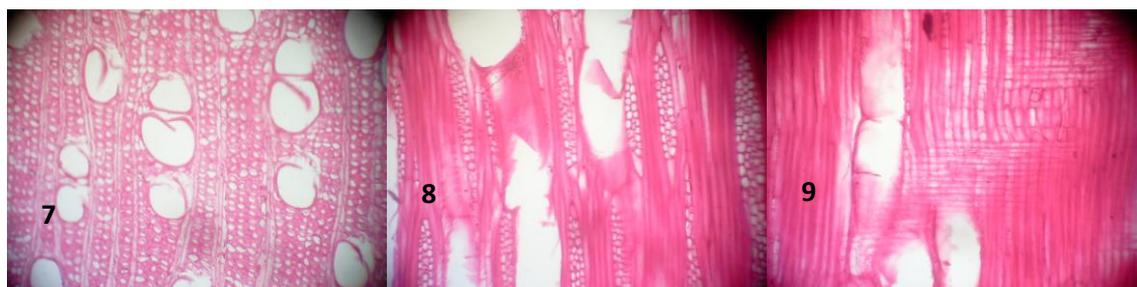
Rays were multiseriate (about 1–10 cells wide), mostly 1 mm, heterocellular with procumbent, and upright cells mixed throughout the ray. Silica bodies in rays.



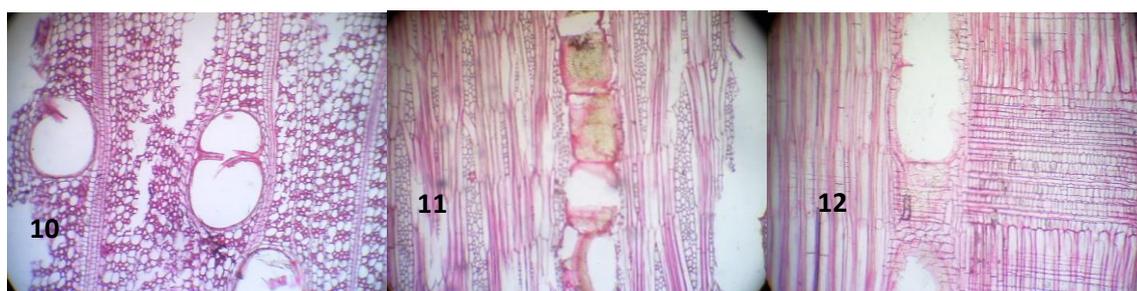
Plates 1-3: *Nesogordonia papaverifera*. 1-Transverse section; 2-Tangential longitudinal section; 3- Radial longitudinal section



Plates 4-6: *Sterculia rhinopetala*. 4-Transverse section; 5-Tangential longitudinal section; 6- Radial longitudinal section



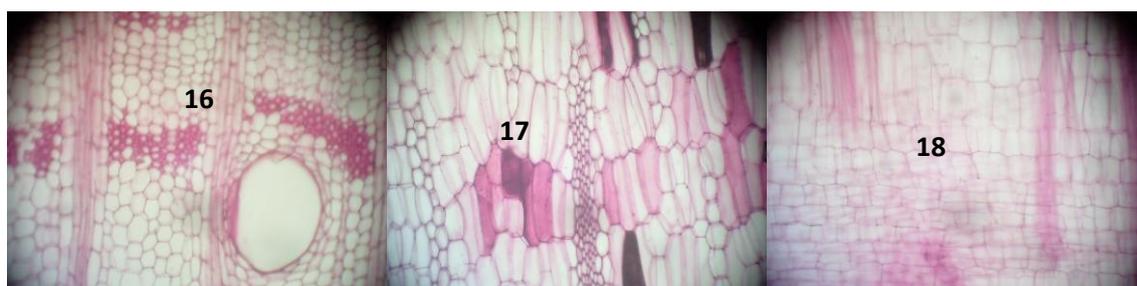
Plates 7-9: *Mansonia altissima*. 7-Transverse section; 8-Tangential longitudinal section; 9- Radial longitudinal section.



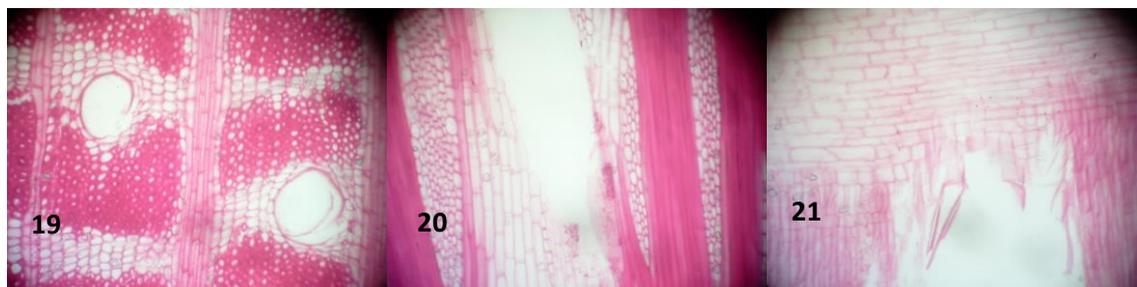
Plates 10-12: *Triplochyton scleroxylon*. 10-Transverse section; 11-Tangential longitudinal section; 12- Radial longitudinal section



Plates 13-15: *Pterygota macrocarpa*. 13-Transverse section; 14-Tangential longitudinal section; 15- Radial longitudinal section



Plates 16-18: *Hildergardia barteri*. 16-Transverse section; 17-Tangential longitudinal section; 18- Radial longitudinal section



Plates 19-21: *Cola lateritia*. 19-Transverse section; 20-Tangential longitudinal section; 21- Radial longitudinal section



Plates 22-24: *Cola glabra*. 22-Transverse section; 23-Tangential longitudinal section; 24- Radial longitudinal section

4. DISCUSSION

Pattern of rays in the wood species investigated in this study were similar in *Sterculia*, *Pterygota*, *Hildergardia*, *Cola lateritia* and *Cola glabra*. It is noteworthy that the type of rays in *C. lateritia* and *C. glabra* can be separated on the basis of sheath cells (Plates 19 to 24) which can be used as a diagnostic feature that is absent in *Cola glabra*. Pattern of rays was the same in *Mansonia altissima*, *Triplochyton* and *Nesogordomia papaverfera* (Plates 1, 3 and 4) in which storied and short rays (less than 1mm) were present.

Short and small rays as observed in *Mansonia altissima*, *Triplochyton* and *Nesogordomia* perhaps explains why some wood species season fairly rapidly well with little or no distortion and with a low tendency to split when nailed or screwed, while others with considerably large rays (*Sterculia rhinopetala*, *Pterygota macrocarpa*, *Hildergardia bateri*, *Cola lateritia* and *Cola glabra*) tend to season slowly and with a marked tendency toward surface checking (Okeke, 1975, Adeniyi et al., 2013). Large rays in such woods also influence failure mode during bolt loading (Zink-sharp *et al.*, 1999) and are not easily nailed at their ends without splitting. In most cases, they are pre-bored before nailing as also witnessed in *sterculia rhinopetala* (Okeke, 1975). Perhaps, owing to the nature of rays in *Mansonia altissima*, *Triplochyton* and *Nesogordomia papaverfera*, they can be suggested for sculpturing and tool handles as seen in woods like

Jelutong (*Dyera costulata*) and Basswood (*Tilia americana*) which have small rays and are mostly used for sculpturing and other related purposes. Large rays wood species (i.e. *Sterculia rhinopetala*, *Pterygota macrocarpa*, *Hildergardia bateri*, *Cola lateritia* and *Cola glabra*) on the other hand, when quarter-sawn, will exhibit figure and add a lot of beauty to their timber. Such wood species will be good for furniture items such as cabinet, and surface veneers.

5. CONCLUSION

The following conclusions are drawn from this study

1. Ray patterns in the selected wood species investigated within the Sterculiaceae family fell between long and short rays.
2. The wood of *Sterculia rhinopetala*, *Pterygota macrocarpa*, *Hildergardia bateri*, *Cola lateritia* and *Cola glabra* are characterized with long rays, ray pattern among *Mansonia altissima*, *Triplochyton* and *Nesogordomia papaverfera* is essentially short and storied.
3. Apart from the fact that these two categories of ray patterns can influence wood utilization, the presence and absence of inclusions, sheath cells and ray height in these wood species are important diagnostic features during wood identification.

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