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Assessment of vessel and fiber characteristics of *Blighia sapida* Konig. and *Lecaniodiscus cupanoides* Planch ex Benth. growing in rainforest and derived savanna areas of Edo state, Nigeria

Okoegwale E. E.[1], Idialu J. E.[2], Ehilen O. E.[3]* and Ogie-Odia E. A.[4]

[1]Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: egiaemmanokoegwale17@gmail.com
[2]Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: impactgroup189@gmail.com
[3]Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: oseghaleehilen@gmail.com
[4]Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: efosa.ogieodia@aauekpoma.edu.ng

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Abstract

This study was carried out to assess the vessel and fiber dimensions and characteristics of *Blighia sapida* Konig. and *Lecaniodiscus cupanoides* Planch ex Benth. growing in the rainforest and derived savanna regions of Edo state, Nigeria. In both taxa, rainforest species possessed wider and longer vessels than the derived savanna species. Also, significant variations were recorded in taxa vessel wall thickness between the two ecozones. The derived savanna plants had thicker vessel wall to counterbalance the water stress prevalent in that environment. In both species, vessel members lacked tails. Also, taxa fibers were of short and medium lengths. Significant variations between fiber lengths of species occurring in both habitats were not encountered. Fiber elements of taxa were of moderately thick wall while fiber / vessel length ratio was greater than 1 in both taxa. Although runkel ratios of both species studied were less than 1, they may however not be suitable for high grade pulp because of their low fiber length values. The study has revealed that the woods are suitable for various end uses because of the presence and distribution of vessels and fiber with thick walls.

Keywords: *Blighia sapida, Derived savanna, Fiber, Lecaniodiscus cupanoides, Rainforest, vessel.*

1. Introduction

As the world supply of non-renewable resources become increasingly critical, wood with its many attributes but also with inherent problems, has the opportunity of playing a more important role in meeting a wide variety of man's needs. Wood plays a significant role in the economy of states in Nigeria, particularly Edo state. Hence, forests and wood industries are of great importance.

Research and development in wood science and utilization of research findings will be more important in determining suitability of wood for various products in the years ahead (Dickinson, 1976; Food and Agricultural Organization, 2013). In the last couple of years, it has become increasingly apparent that the world's supply of non-renewable resources is indeed finite especially in the tropics. As the supply of these resources diminishes and demand becomes high, their market values increase.

* *Corresponding author: Ehilen O. E., Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: oseghaleehilen@gmail.com*

Wood is a heterogenous tissue comprising of different types of cells, some of which function as a mechanical support and others for conduction (Fahn, 1974; and Maiti *et al*., 2016). Wood is the most misunderstood material by man and yet it is his best friend as it accompanies him to his last journey (Gill, 1992).

Histomorphology involves the material composition of wood, their peculiar spatial alignment, and their shapes as they relate to function and use (Gill, 1992). Histomorphological studies therefore provides a thorough anatomical information of woody plants. Tracheary elements are the non-living cells that are principally concerned with the transport of water and which also, to a certain degree, have a supporting function (Fahn, 1974; and Maiti *et al*., 2016). Histomorphological studies of tracheary elements of wood have long been a subject of great interest to both foresters and botanists (Gill and Ogunlowo, 1986 and 1988; and Sano *et al*., 2011). A forester's interest lies primarily in the cellular proportions of different cells of tissue types, like fibers and rays as selection criteria. The botanist interest lies in the ecological trend in the tracheary elements of the wood anatomy in order to understand possible evolutionary mechanisms responsible for the major trends in xylem anatomy and also on phylogenetic trends.

Sanio (1863 cf. Fahn, 1974) was the first person to lay foundation of the study of tracheary elements. He discussed the similarity and differences between the tracheid and the vessel member. Since Sanio's work (cf. Fahn, 1974) much has been devoted to the investigation of different tissue types such as the structure, shape, function, ontogeny and phylogeny of these elements. The components of the tracheary elements include tracheids, vessels and wood rays (Gill, 1992).

World current timber requirement for construction is on continual increase just as the human population is also on continual increase (Ramage *et al*., 2017). In order to meet the requirements for various purposes, it is essential that the available wood resources are tapped more intelligently. Careful selection of problems in this research effort will provide aids and solutions in better meeting man's wood requirement.

Keay *et al.* (1989) reported 900 woody taxa of angiosperms in Nigeria. Unfortunately, only 50 timber species are being commercially exploited. The reason for this low value is that investigation on Nigerian indigenous plants has not attracted the same attention as the temperate plants from wood scientists. Metcalfe and Chalk (1950), stressed the importance of wood anatomy as well as other anatomical data, as wood structure is such a potentially rich source of information. Metcalfe (1972) therefore suggested a thorough investigation of the structure of plants from the tropics. This is due to the fact that not enough information is available on the tracheary elements of tropical woods.

Also, ecological variation in wood anatomy in relation to altitude and environment has been studied by Versteegh (1968) and others, in attempts to answer these problems arising in wood anatomy in their respective localities including Indonesian woody plants. In recent years also, there has been an increased interest in the study of 'ecological wood anatomy' in order to understand possible evolutionary mechanism responsible for major trends in xylem anatomy. It has been assumed in all these studies that most of the variations responsible for the ecological trends observed are the result of selection (Baas *et al*., 1983). On the other hand, it is widely realized through research work that there is also a large component of phenotypic plasticity in wood anatomical feature, part of which may contribute to the observed ecological trends (Gratani, 2014; and Maiti *et al*., 2016).

Blighia sapida Konig. and *Lecaniodiscus cupanoides* Planch ex Benth. were the subjects for this research work. They both belong to the sapindaceae family, also known as the soapberry family. This family contains about 150 genera and some 2,000 species. Its members are mainly tropical and subtropical in origin. In Nigeria it is represented by 13 genera (Keay *et al*., 1989). Previous contributions to hardwood histomorphological studies of this family include Akachuku (1987), Gill and Ogunlowo (1988), Gill and Onuja (1984), Gill, Lamina and Karatela (1985), Metcalfe and Chalk (1950), Okoegwale and Gill (1990), Outer and Van-Veenendal (1976). Available literatures indicate that not much work has been carried out in recent times in the histomorphology of this huge family, particularly those of Nigerian origin.

Generally, what is presently known about the wood anatomy of the rich and diverse flora of Edo state is relatively poorly known. This study therefore focuses on tracheary elements characteristic of *Blighia sapida* and *Lecaniodiscus cupanoides* with the aim of assessing their suitability for pulp, furniture and other uses and to also determine the effects of ecological variations on dimensions, qualities and utilization potentials of their wood.

2. Materials and methods

2.1. Study location

The study sites were in two ecological zones (rainforest and derived savanna) of Edo state, Nigeria. The ecological zones are located between longitude 5°04' East and 6°43' East and latitude 5°44' North and 7°34' North.

2.2. Histological techniques

Wood samples were collected from stem wood at 1.3 meters from the ground level. Wood samples were obtained from trees whose ages could not be ascertained because the collections were made from natural forests. Wood samples collected from the two ecological zones were air dried for 10 days and were made into chips.

Maceration of chips were carried out using modified methods of Thorsch (1999). Wood chips were placed in a test tube containing 10-15 ml of 60% nitric acid and left overnight. The test tube was boiled for 5-10 min. The macerates were washed several times with distilled water. It was then stored in 10% glycerol for subsequent use. Macerates were mounted separately on clean slides. Staining was done by adding a drop of 1% diluted 1:1 glycerol-safranin solution before placing the cover slip. This was to enhance clearer view of the wood features on the microscope. The microscope was calibrated for linear measurements of fiber. Vessel characteristics were also determined. Fiber / vessel diameters were made in radial direction on transverse section. The calibration of the microscope was:

1 unit = 1 / 74 mm

= 0.0135

1 mm = 1000 microns (μm)

Therefore 0.0135 mm = 13.5 μm

This factor was used under x 10 objective in all the measurements taken. Classification into narrow, short, medium, long or large size is according to Metcalfe and Chalk (1950) [See Table A1 in Appendix].

2.3. Statistics

Average values were based on 50 measurements. Mean and standard deviation of the values obtained were calculated. Also, *t*-test distribution was used in comparing vessel lengths, diameters, fiber lengths and wall thickness of trees in rainforest with trees in derived savanna habitat to determine the relationship between the same taxa occurring in the two distinct ecological zones.

2.4. Determination of fiber/vessel length ratio and runkel ratio

Fiber / vessel length ratio was calculated as shown below:

$$\frac{FL}{VL} = \text{Specialization Index}$$

where *FL*= Fiber Length, and *VL*= Vessel Length.

Also, Runkel ratio was estimated using the formula: $\frac{2W}{Ld}$

where *W* = Fiber wall thickness, and

Ld = Fiber lumen diameter.

3. Results and discussion

In the present study, *Blighia sapida* and *Lecaniodiscus cupanoides* occurring in the rainforest and derived savanna habitats were considered. Figures 1-6 show the vessel and fiber characteristics of *Blighia sapida* and *Lecaniodiscus cupanoides* growing in the rainforest and derived savanna regions of Edo state. Results obtained from the study are summarized in Tables 1 and 2.

3.1. Vessel dimensions and characteristics

Taxa vessels are short (<350 μm), with mean ranging from 301.6 + 105.64 μm in *L. cupanoides* to 316.0 + 116.36 μm in *B. sapida* occurring among the rainforest species while mean range of 268.72 + 111.68 μm in *L. cupanoides* and 285.16 + 113.78 μm in *B. sapida* are reported in the derived savanna habitat (Figures 1 and 2). Occurrence of short vessels is in agreement with the previous report by Outer and Van-Veenendaal (1976). Vessel diameters of taxa are of medium (100-200 μm) and large (>200 μm) sizes with mean diameter ranging from 172.3 + 76.16 μm in *B. sapida* to 295.0 +101.19 μm in *L. cupanoides*. In the derived savanna habitat, vessel diameters are of mean range 148.24 + 66.16 μm in *B. sapida* and 182.35 + 75.38 μm in *L. cupanoides*. The presence of medium-sized vessel diameter is in agreement with Outer and Van-Veenendal (1976). Significant variations were only recorded in vessel element diameters of taxa between the two ecozones (Tables 1 and 2). However, Outer and Van-Veenendal (1976) reported non-significant variations in vessel dimensions of *P. pinnata* existing in both the rainforest and savanna areas of Cote'd'voire.

In both taxa studied, wider and longer vessels were found in rainforest species when compared with the derived savanna species (Figures 1 and 2). This relationship agrees with the postulate advanced by Carlquist

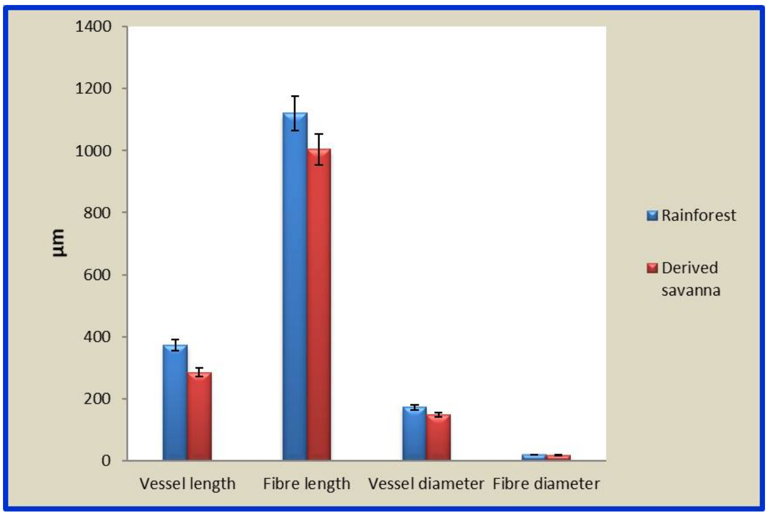

Figure 1: Vessel and fiber lengths and diameters of *B. sapida* growing in the rainforest and derived savanna regions of Edo state

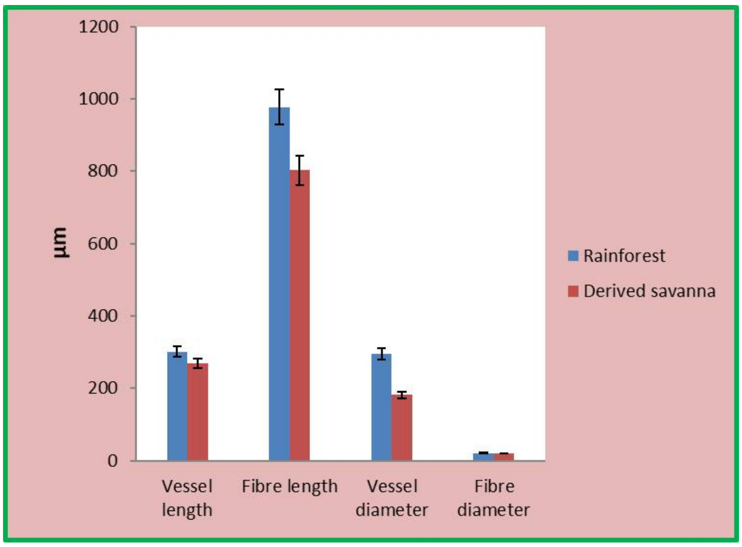

Figure 2: Vessel and fiber lengths and diameters of *L. cupanoides* growing in the rainforest and derived savanna regions of Edo state

(1975) that there are longer and wider vessels elements in species occurring in rainforest habitat than those in the drier areas (derived savanna). Wider vessels offer low friction and deliver larger volumes of water per unit time (Ewers *et al*., 1991; Sperry, 1995; and Yahya, 2014). The morphology and ecological trends of xylem are relevant to efficiency and safety of water conduction. This agrees with the report of Maiti *et al*. (2016) which stated that environments play a great role on wood anatomical characters and that environmental changes have caused modifications or adaptations of structural features in tree-rings.

Taxa vessel walls were of moderately thick types (3.66-5.65 μm); with mean thickness ranging from 3.66 + 1.20 μm in *B. sapida* to 4.08 + 2.01 μm in *L. cupanoides* occurring in the rainforest habitat while mean thickness ranged between 5.20 + 1.88 μm in *B. sapida* and 5.65 + 2.63 μm in *L. cupanoides* in the derived savanna species. Variations in vessel member wall thickness are significantly different among taxa existing in the two ecological zones (Tables 1 and 2). On the average, taxa in the derived savanna locality have shorter but thicker walled vessels than their rainforest counterparts (Figures 3 and 4). Short and thick-walled vessels exhibited by the derived savanna species are relevant for increased safety and efficiency in the habitat where they occur. Vessel wall thickness has been considered functionally significant in offering enough mechanical strength to withstand negative pressure (Carlquist 1975, 1980, and 2001). Maiti *et al*. (2016) stated that species with small narrow vessels have strategy to adapt both to hot and cold climate against cavitation. Hence, the derived savanna plants had higher mean maximum values for vessel wall thickness to counterbalance the water stress prevalent in that environment. Similar findings were reported by Okoegwale *et al*. (2010).

In both species, vessel members lacked tails. Perforation plates are of simple type and transversely situated. Occurrence of simple perforation plate is in agreement with Outer and Van-Veenendaal (1976) on *P. pinnata.* According to Baas (1973), the perforation plates offer potential support and resistance to collapse where negative pressures exist in a vessel. Occurrence of simple perforation plates implies increased efficiency of vessels for water conduction.

The presence of simple pitted-vessels with no definite pattern of arrangement is reported in *B. sapida* while in *L. cupanoides* vessels with simple pits arranged in reticulate pattern is reported (Tables 2 and 3). Outer and Van-Veenendaal (1976) however did not report on this character in *P. pinnata*. Pit membranes affect the penetration of liquids, preservatives and gases in timber (Sano *et al*., 2011). It is important as research on pit membranes provides interesting applications in the field of wood technology, including the paper and pulp industry (Flynn, 1995; Singh *et al*., 1999; and Watanabe *et al*., 1998).

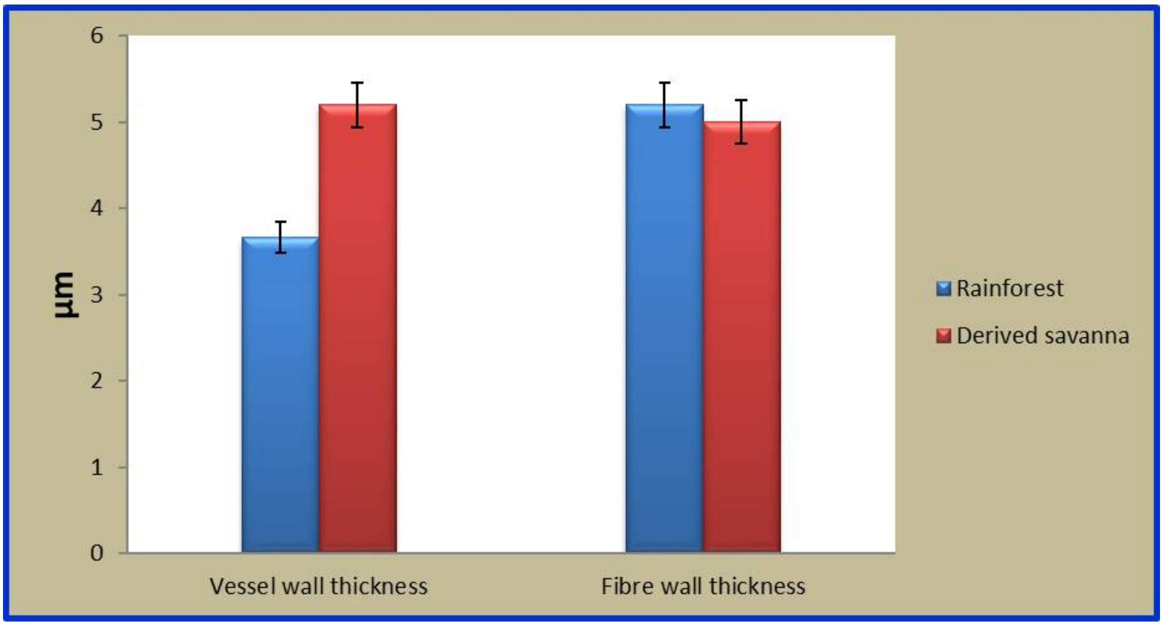

Figure 3: Vessel and fiber wall thickness of *B. sapida* growing in the rainforest and derived savanna regions of Edo state

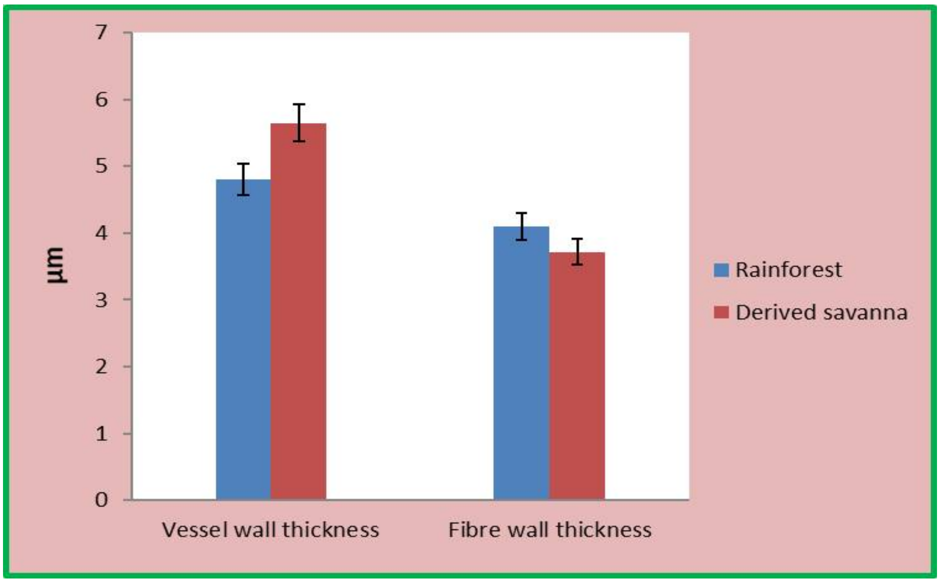

Figure 4: Vessel and fiber wall thickness of *L. cupanoides* growing in the rainforest and derived savanna regions of Edo state

Table 1: Morphological characterization of vessel and fiber elements of *Blighia sapida* growing in rainforest and derived savanna regions of Edo state

Tissue type	Characteristic	Rrainforest	Derived savanna
Vessel	Length	Short; ranging from 157.60-372.82 µm; mean: 316.0 µm	Short; ranging from 131.40 - 328.53 µm; mean: 285.16 µm
	Diameter	Medium sized; Ranging from 98.5-191.10 µm; mean: 172.30 µm.	Medium sized; Ranging from 92.3 - 167.60 µm; mean: 148.24 µm
	Wall thickness	Range of 1.4 - 6.31 µm; mean of 3.66 µm	Range of 2.4-7.44 µm; mean of 5.20 µm
	Tail	Absent	Absent
	Perforation Plates	Simple; located at the transverse end walls.	Simple; transversely located at the end walls.
	Pits	Simple pits with no definite pattern of arrangement.	No definite pattern of arrangement.
Note: Vessel wall thickness vary significantly at $p < 0.01$ between the two vegetation zones.			
Fibre	Length	Medium; ranges from 817.44-1756.21 µm; mean: 1120.63 µm.	Medium; ranges from 800.76-1688.96 µm; mean: 1004.72 µm.
	Diameter	Ranging from 15.08-21.66 µm; mean: 19.62 µm.	Ranging from 15.00-20.52 µm, mean: 18.41 µm.
	Wall thickness	Ranging from 4.61 - 8.50 µm; mean: 5.20 µm.	Ranging from 4.21-8.42 µm; mean: 5.00 µm.
	Lumen Diameter	Ranging from 10.78-18.40 µm; mean: 13.08 µm.	Ranging from 9.4-16.56 µm; mean: 12.11 µm.
	Pits	Absent	Absent
	Septate	Absent	Absent
	Fiber/Vessel length ratio	3.55	3.52
	Runkel ratio	0.80	0.83
Note: Fiber dimensions vary but not significantly between the two vegetation zones.			

Table 2: Morphological characterization of vessel and fiber elements of *Lecaniodiscus cupanoides* growing in the rainforest and derived savanna regions of Edo state

Tissue type	Characteristic	Rrainforest	Derived Savanna
Vessel	Length	Short; ranging from 142.51-346.68 μm; mean: 301.60 μm.	Short; ranging from 134.80-314.32 μm; mean: 268.72 μm.
	Diameter	Large sized; Ranging from 168.4–310.2 μm, mean: 295.0 μm.	Medium sized; Ranging from 100.70–211.50 μm; mean: 182.35 μm.
	Wall thickness	Range of 2.8-14.91 μm; mean: 4.80 μm.	Range of 3.09–15.50 μm; mean: 5.65 μm.
	Tail	Absent	Absent
	Perforation plates	Simple; located at the transverse end walls.	Simple; transversely located at the end walls.
	Pits	Simple pits arranged with reticulate pattern.	Simple pits arranged with reticulate pattern.
Note: Vessel diameter vary significantly at $p < 0.01$ and vessel wall thickness vary significantly at $p < 0.05$ between the two vegetation zones.			
Fiber	Length	Medium; ranges from 755.62-1804.15 μm; mean: 976.72 μm.	Short; ranges from 702.81-1794.60 μm; mean: 802.61 μm.
	Diameter	Ranging from 14.91–28.77 μm; mean: 21.08 μm.	Ranging from 14.62-28.40 μm, mean: 20.14 μm.
	Wall thickness	Ranging from 3.72-6.13 μm; mean: 4.10 μm.	Ranging from 3.40-5.72 μm; mean: 3.72 μm.
	Lumen diameter	Ranging from 10.70-16.22 μm; mean: 12.66 μm.	Ranging from 9.12-18.04 μm; mean: 15.14 μm.
	Pits	Absent	Absent
	Septate	Absent	Absent
	Fiber / Vessel length ratio	3.24	2.99
	Runkel ratio	0.65	0.49
Note: Fiber dimensions vary but not significantly between the two vegetation zones			

3.2. Fiber dimensions and characteristics

Taxa fibers were of short (<900 μm) and medium lengths (900-1600 μm), with mean range of 976.72 + 439.52 μm in *L. cupanoides* and 1120.63 + 504.02 μm in *B. sapida* occurring among the rainforest species. In the derived savanna habitat, average total fiber length ranged from 802.61 + 361.17 μm in *L. cupanoides* to 1004.72 + 452.12 μm in *B. sapida*. Significant variations between fiber lengths of species occurring in the two habitats were not encountered. The fiber length is well-known to influence the physical and mechanical properties of the plant material. According to Espiloy (1987) and Parameswaran and Leslie (1976), the fiber length is associated with plant's toughness, workability and durability. Fiber length is also an important descriptor factor of pulp quality, given its relationship with paper strength properties (Mansfield and Weineisen, 2007; and Ek *et al.*, 2009). According to Ogunleye *et al.* (2017), a greater fiber length corresponds to a higher tearing resistance of the paper produced. This correlation has been ascribed to stress dissipation; the longer the fiber the greater the area over which the stress is disspated (Gallay, 1962).

The average fiber length of both species observed in this study is less than 1290 μm for *Gmelina arborea* reported by Roger *et al*. (2007); 1360 μm for *Ricinodendron heudelotii* (Ogunleye *et al*., 2017) and 1760 μm for

Rhizophora harrisonii (Emerhi, 2012). Since the length of fiber greatly affects the strength of the pulp and the paper made from it, paper made from *L. cupanoides* and *B. sapida*, is likely to have lesser quality than those from woods like *Rhizophora harisonii*, *Ricinodendron heudelotii* and *Gmelina arborea* having longer fibers. Higher fiber length has been reported to result in greater resistance of the paper to tearing (Oluwadare and Sotande, 2007). Ademiluyi and Okeke (1979) reported that the longer the fiber, the higher the tear resistance and the better the quality of the paper produced from it.

Fiber elements of taxa were of moderately thick-walled (3.72-5.20 μm), with mean wall thickness ranging from 4.10 + 1.8 μm in *L. cupanoides* to 5.20 + 2.34 μm in *B. sapida* occurring in the rainforest habitat. In the derived savanna habitat, mean fiber wall thickness ranged from 3.72 + 1.67 μm in *L. cupanoides* to 5.0 + 2.25 μm in *B. sapida*. Variations in fiber wall thickness were however not significant between species occurring in the two habitats. Fiber wall thickness is of relevance in the determination of wood density and its end uses (Fahn, 1974; Okoegwale and Idialu, 1998; and Okoegwale *et al.*, 2010).

3.3. Fiber/vessel length ratio

Fiber / vessel length ratio of *B. sapida* was 3.55 in the rainforest species and 3.52 in the derived savanna species. Similar reduction in the fiber / vessel length ratio was observed in *L. cupanoides* on moving from the rainforest

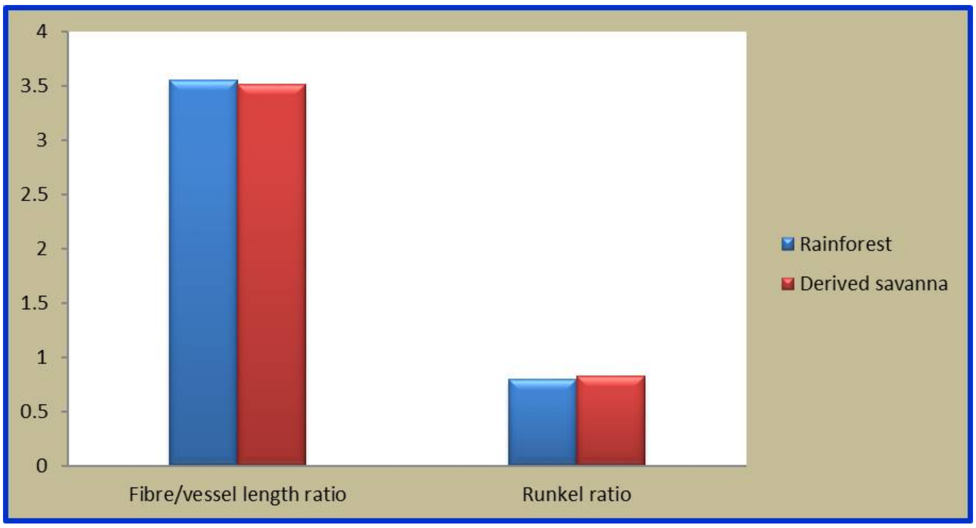

Figure 5: Fiber/vessel length ratio and runkel ratio of *B. sapida* growing in the rainforest and derived savanna regions of Edo state

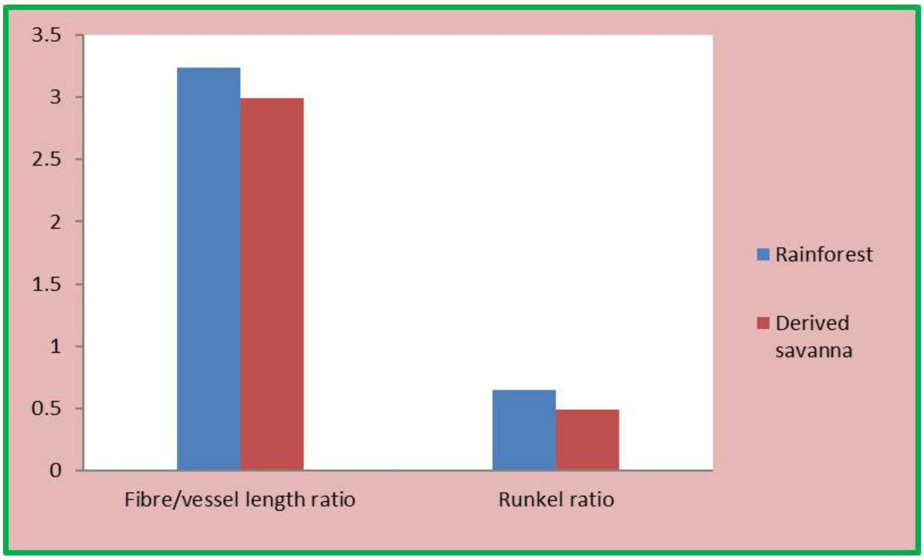

Figure 6: Fiber/vessel length ratio and runkel ratio of *L. cupanoides* growing in the rainforest and derived savanna regions of Edo state

(3.24) to the derived savanna (2.99). Fiber / vessel length ratio was greater than 1 in both taxa indicating that the taxa are phylogenetically advanced and specialized. Fiber / vessel length ratio is considered by many as an important parameter for the assessment of phylogeny of taxa. However, variation in fiber / vessel length ratio between the two ecological zones suggests that ecological zones may affect tracheary element dimensions which influence fiber / vessel length ratio, thus indicating that tracheary elements may be non-plastic. For this reason, it is suggested that much reliance should not be placed on fiber / vessel length ratio for the determination of the phylogeny of a taxa. A similar observation has earlier been made by Bailey (1957) against the use of fiber / vessel length ratio too literarily as indicator of phylogenetic specialization in a species.

3.4. Runkel ratio

Runkel ratio of taxa are below 1 (<1). Runkel ratio of *B. sapida* and *L. cupanoides* ranged from 0.8 and 0.65 respectively in the rainforest species to 0.83 and 0.49 respectively in the derived savanna species (Figures 5 and 6). In papermaking with hardwood fibers, runkel ratio lower than 1.0 is desirable for good conformability and fiber-to-fiber contact in paper (Dean, 1995; and Eroglu, 1980). In hard woods, Bhanadri *et al*. (1988) reported that density and fiber / vessel characteristics (the runkel ratio, fiber / vessel length ratio, vessel dimension, etc.) exhibit marked influence on strength and surface properties of paper.

In line with the reports of Eroglu (1980) and Ekhuemelo and Tor (2013), when Runkel ratio is less than 1, it indicates that the cell wall is thin, and cellulose obtained from these fibers is most suitable for paper production; when the Runkel ratio is equal to 1, it means that the cell wall has medium thickness, and cellulose obtained in such cases is suitable for paper production; and when the Runkel ratio is greater than 1, it indicates that the fiber has thick walls, and cellulose obtained from such fibers is least suitable for paper production.

4. Conclusion

Histomorphological studies of tracheary elements in conjunction with other evidences are important factors in ascertaining the quality of wood and thereby proffer possible end uses as well as promoting information on the position of a taxon. The present study on woods of lesser known plants, viz.,: *Blighia sapida* and *Lecaniodiscus cupanoides* of the sapindacea family growing in the rainforest and derived savanna regions of Edo state, Nigeria has revealed that their woods are specialized and also suitable for various end uses based on Fahn (1974) recommendations which stated that presence and distribution of vessels with thick walls and presence of fiber with thick walls (>3 μm) make wood species suitable for various end uses. However, wood from both tree species investigated may not be very suitable for high grade pulp except for rayon grade pulp because of their low mean fiber length values (Mansfield and Weineisen, 2007; and Ek *et al*., 2009). The study has also shown that ecological zone may have significant effects on vessel elements dimensions.

5. Recommendation

Edo state is blessed with variety of tree species but only little is known of the characteristics, qualities and possible uses to which these tree species can be put. Hence, we are unable to fully utilize and maximize this gift of nature, i.e., the forest trees. The depletion of traditionally economic tree species in the natural forests points to a need to explore alternative sources of raw materials for various uses. Therefore, more histomorphological and histochemical studies are recommended to explore the utilization potentials or attributes possessed by many of the wood taxa in our forest lands.

Conflicts of interest: None.

References

Ademiluyi, E. O. and Okeke, R. E. (1979). Studies on specific gravity and fibre characteristics of *Gmelina arborea* in some Nigerian plantations. *Nigerian Journal of Science*. 13, 231-238.

Akachuku, A. E. (1987). Variation in wood density of dicotyledons as a guide for forest plantations management. *Agricultural Research Bulletin*. 3, 1-8.

Baas, P. (1973). The wood anatomy of Ilex (Aquifoliaceae) and its ecological and phylogenetic significance. *Blumea*. 21, 193-258.

Baas, P., Werker, E. and Fahn, A. (1983). Some ecological trends in vessel characters. *LAWA Bul. Ns*. 4, 141-159.

Bailey, I. W. (1957). The potentialities of wood anatomy in the study of the phylogeny and classification of angiosperms. *J. Arnold Arbo*. 38, 243-254.

Bhanadri, S. S., Singh, S. P., Singh, S.V., Krishan, L. and Sharma, P. (1988). Effect of locality on fibre / vessel characteristics and strength / surface properties of kraft pulps of *Eucalyptus tereticormis*. *J. Timb. Dev. Ass. (India)*. 34, 16-22.

Carlquist, S. (1975). Ecological strategies of Xylem Evolution. University of California Press, Berkeley, 259.

Carlquist, S. (1980). Further concepts in ecological wood anatomy with comments on recent work in wood anatomy. *Aliso*. 9, 453-499.

Carlquist, S. (2001). *Comparative Wood Anatomy*. 2nd Edition. Springer-Verlag, Berlin.

Dean, G. H. (1995). Objectives for wood fibre quality and uniformity. In: CRCTHFIUFRO Conference Eucalypt Plantations: Improving, fibre yield and quality. Hobart, Australia, 76 pp.

Dickinson, F. E. (1976). Scientific and economic aspects of wood research as we look to the future of wood. *Wood Science and Technology*. 10, 73-77.

Ek, M., Gellerstedt, G. and Henriksson, G. (2009). Pulp and paper chemistry and technology. *Pulping Chemistry and Technology*. 2, 484. GmbH & Co. KG, Berlin.

Ekhuemelo, D. O. and Tor, K. (2013). Assessment of fibre characteristics and suitability of maize husk and stalk for pulp and paper production. *Journal of Research in Forestry, Wildlife and Environment*. 5(1), 41-49.

Emerhi, E. A. (2012). Variations in anatomical properties of *Rhizophora racemosa* (Leechm) and *Rhizophora harrisonii* (G. Mey) in a Nigerian mangrove forest ecosystem. *International Journal of Forest, Soil and Erosion*. 2(2), 89-96.

Eroglu, H. (1980). Investigating possibilities of obtaining wood pulp from wheat straw by O2-naoch method. Ph.D Thesis, Karadeniz Technical University.

Espiloy, Z. B. (1987). Physico-mechanical properties and anatomical structure relationships of some Philippines bamboos. *Recent Research on Bamboos. Proceedings of the International Bamboo Workshop.* October 6-14, 185. Hangzhou, China.

Ewers, F. W., Fisher, J. B. and Fichtner, K. (1991). Water flux and xylem structure in vines. In Putz, F. E. and Mooney, H. A. (Eds.), *The Biology of Vines*. Cambridge University Press, Cambridge, pp. 127-160.

Fahn, A. (1974). *Plant Anatomy*. 611. Pergamon Press, Oxford.

Flynn, K. A. (1995). A review of the permeability, fluid flow, and anatomy of spruce (*Picea* spp.). *Wood and Fiber Science*. 27, 278-284.

Food and Agricultural Organisation (2013). Rediscovering wood: the key to a sustainable future. *Proceedings of the International Conference on The Art and Joy of Wood,* 19, October 19-22, 2011, (p21), Bangalore, India.

Gallay, W. (1962). *In:* The Formation and Structure of Paper. Edited by Bolam, F. Technical Section of British Paper and Board Makers' Association, London, pp. 491-535.

Gill, L. S. (1992). *Systematic, Systematist and Society in Nigerian Context*. Idodo-Umeh Publishers Ltd; Benin City. 43p.

Gill, L. S. and Ogunlowo, C. O. (1986). Histomorphology of the tracheary elements of some leguminous woods. *J. Timb. Dev. Assoc. (India)*. 32, 31-39.

Gill, L. S. and Ogunlowo, C. O. (1988). Histomorphology of the tracheary elements of some tropical hardwoods. *J. Timb. Dev. Assoc. (India)*. 34, 42-54.

Gill, L. S. and Onuja, J. E. (1984). A comparative study of the the tracheary elements of some commercial woods of Nigeria. *Feddes Repertorium*. 95, 645-655.

Gill, L. S., Lamina, B. and Karatela, Y. Y. (1985). Histomorphological studies of tracheary elements and the economic potential of tropical hard woods. *Forest Resource Journal*. 2, 121-141.

Gratani, L. (2014). Plant phenotypic plasticity in response to environmental factors. *Advances in Botany*. 2014, 17. http: / / dx.doi.org / 10.1155 / 2014 / 208747

Keay, R. W. J., Onochie, C. F. A. and Stanfield, D. P. (1989). *Trees of Nigeria*. Clarendon Press, Oxford, 476p.

Maiti, R., Rodriguez, H. G., Para, A. C., Kumari, C. H. and Sarkar, N. C. (2016). A comparative wood anatomy of 15 woody species in north-eastern Mexico. *Forest Research*. 5, 166.

Mansfield, S. D. and Weineisen, H. (2007). Wood fiber quality and kraft pulping efficiencies of trembling aspen (*Populus tremuloides* michx.) clones. *J. Wood Chem. Technol*. 27(3-4), 135-151.

Metcalfe, C. R. (1972). Botanical communication with special reference to plant anatomy. In: Ghouse, A. K. M. and Yunus, M. (eds): *Research trends in Plant Anatomy*. Tata McGraw Hill, New Delhi, 7-18.

Metcalfe, C. R. and Chalk, L. (1950). *Anatomy of Dicotyledons*. Clarendon Press, Oxford, 500p.

Ogunleye, B. M., Fuwape, J. A., Oluyege, A.O., Ajayi, B. and Fabiyi, J. S. (2017). Evaluation of fiber characteristics of *Ricinodedron Heudelotii* (Baill, Pierre Ex Pax) for pulp and paper making. *International Journal of Science and Technology*. 6(1), 634-641.

Okoegwale, E. E. and Gill, L. S. (1990). Dimensional variation in fibre and vessel elements of *Lova trichilioides* Harms (Meliaceae). *J. Timb. Dev*. 36, 10-15.

Okoegwale, E. E. and Idialu, J. E. (1998). Trend in histomorphological feature of leguminous woods in rainforest and derived savanna area of Edo State, Nigeria. *Acta Botanica Hungarica.* 41, 159-169.

Okoegwale. E. E, Ogie-Odia, E. and Idialu, J. E. (2010). Tracheary elements characteristics of *Kigelia africana* (Lam) Benth and *Newbouldia laevis* (P. Beauv) Seemann ex. Bureau growing in rainforest and derived savanna regions of Edo State, Nigeria. *Life Science Journal*. **7**(4), 7-13**.**

Oluwadare, A. O. and Sotannde, O. A. (2007). The relationship between fibre characteristics and pulp-sheet properties of *Leucaena leucocephala* (lam.) De Wit. *Middle East Journal of Science Resources*. 2(2), 63-68.

Outer, R. W. Den and Van-Veenendaal, W. I. H. (1976). Variation in wood anatomy of species with a distribution covering both rainforest and savanna areas of the Ivory Coast, West Africa. *Leiden Bot. Series.* 3, 182-195.

Parameswaran and Liese (1976). On the fin structure of bamboo fibres. *Wood Science and Technology.* 10, 231-246.

Ramage, M. H., Burridgeb, H., Busse-Wicherc, M., Fereday, G., Reynolds, T. Shaha, D. U., Wud, G., Yuc, L., Fleming, P., Densley-Tingley, D., Allwood, J., Dupree, P., Linden, P. F. and Scherman, O. (2017). The wood from the trees: The use of timber in construction. *Renewable and Sustainable Energy Reviews*. 68, 333-359.

Roger, M. R., Mario, T. F. and Edwin, C. A. (2007). Fibre morphology in fast growth *Gmelina arborea* plantations. *Madera Bosques,* 13(2), 3-13.

Sano, Y., Morris, H., Shimada, H., Ronse De Craene, L. P. and Jansen, S. (2011). Anatomical features associated with water transport in imperforate tracheary elements of vessel-bearing angiosperms. *Annals of Botany*. 107, 953-964.

Singh, A., Dawson, B., Franich, R., Cowan, F. and Warnes, J. (1999). The relationship between pit membrane ultrastructure and chemical impregnability of wood. *Holzforschung*. 53, 341-346.

Sperry, J. S. (1995). Limitations on stem water transport and their consequences. In: Gartner, B.L. (Ed.), *Plant Stems: Physiology and Functional Morphology*. Academic Press, San Diego, 105-124.

Thorsch, J. (1999). Vessels in Zingiberaceae: a light, scanning and transmission microscope study. *IAWA Journal*. 20(2).

Versteegh, C. (1968). An anatomical study of some woody plants in the mountain flora in the tropics (Indonesia). *Acta Bot. Neerl*. 17, 151-159.

Watanabe, U., Imamura, Y. and Iida, I. (1998). Liquid penetration of precompressed wood. VI: Anatomical characterization of pit fractures. *Journal of Wood Science.* 44, 158-162.

Yahya, S. M. (2014). Ecological significance of wood anatomy in two lianas from arid southwestern Saudi Arabia. *Saudi Journal of Biological Sciences*. 21, 334-341.

APPENDIX

Length measurements of tracheary elements according to Metcalfe and Chalk (1950)	
Long fibers	≥ 1600 μm
Medium length fibers	900-1600 μm
Short length fibers	< 900 μm
Long vessels	> 800 μm
Medium length vessels	350-800 μm
Short length vessels	< 350 μm
Large vessel diameter	≥ 200 μm
Medium vessel diameter	100-200 μm
Small vessel diameter	< 100 μm
Short tracheids	< 100 μm
Medium length tracheid	100-200 μm
Long tracheids	> 200 μm

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