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.

Okoegwale. E.E, Ogie-Odia E and Idialu J.E

Department of Botany, Ambrose Alli University, P.M.B 14, Ekpoma, Edo state
effexing@yahoo.com

ABSTRACT: Variations in dimensions of tracheary elements of *Kigelia africana* (Lam) Benth. and *Newbouldia laevis* (P.Beauv.) Seemann ex Bureau growing in the rainforest and derived savanna areas of Edo State are reported. Both taxa exhibit short vessel lengths (<350µm), with medium-sized (100-200µm) diameters in the two vegetation zones. Vessels are thick-walled (>3.0µm) and decrease in wall thickness from derived savanna to the rainforest area. Taxa vessels are tailless having simple perforation with simple pits arranged in rows. Fibres are long (1600 µm), medium (900-1600µm) except in *K. africana* growing in the derived savanna areas where short lengths (<900µm) were encountered. Variations in fibre dimensions were significant at 1% and 5% probability levels between *K. africana* growing in the two ecological zones but were only significant at 5% probability level in fibre diameter of *N. laevis* growing in the two ecological zones. Taxa fibres were non-pitted and septations were only encountered in species found in the rainforest zone. Fibre /vessel length ratio in both taxa is greater than 1 and ratios approaching 10 are phylogenetically more advanced and specialized. Higher mean maximum values were obtained in vessel element lengths of *K. africana* and *N. laevis* growing in the rain forest zone. *N. laevis* from the derived savanna had thicker fibre walls than its counterpart in rain forest. Both species are suitable for various end-uses but are however not suitable for high grade pulp because of their relative low fibre length and runkel ratio (<1) which was low.
[Okoegwale. E.E, Ogie-Odia E and Idialu J.E. 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 2010;7(4):7-13]. (ISSN: 1097-8135).

Key words: Tracheary elements, *Kigelia africana, Newbouldia laevis*, rainforest, derived savanna, ecological zones.

INTRODUCTION

Kigelia africana (Lam) Benth. and *Newbouldia laevis* (P.Beauv.) Seemann ex Bureau belong to the Bignoniaceae family which has world distribution of 120 genera and 800 species and is primarily tropical in distribution. In West Africa it contains 17 genera and 20 species (Gill 1988). According to Gill (1992), only 50 timber species are being coµmercially exploited. The possible reason for this low value is that not enough is known about the characteristics, qualities and the uses to which the others could be put. An important characteristic which determines the end use of timber species is the tracheary element. Previous contributions to the tracheary elements characteristics of hard wood include Akachuku (1987), Baas (1973, 1976), Baas *et al*. (1983), Gill and Okoegwale (1990), Gill *et al*. (1985), Okoegwale and Idialu (1998), Outer and Van-Veenendaal (1976). Baas *et al*. (1983) reported almost consistent trend for vessel member to be shorter in arid region species and longer in the hygrophylic regions of Isreal and adjacent regions. They also reported higher maximum vessel diameter in hygrophylic regions and higher vessel wall thickness in the arid flora.

Gill and Onuja (1982) reported medium (100-200µm) to large – sized (>200µm) vessel diameters in the family Bignoniaceae but Gill *et al*. (1985) reported short vessels with extremely narrow diameter (mean 30.43µm) and medium length (mean 1519.88µm) in *Jacaranda acutifolia*. Okoegwale and Idialu (1998) reported higher maximum and minimum values for vessels and fibre lengths of woody leguminous plants in rain forest than in derived savanna counterparts, and these are important parameters for the determination of strength qualities and end-uses of wood. They also reported significant variations in fibre wall thickness in the same plant found in the rainforest and derived savanna areas which according to them are of relevance in comparing density or strength qualities. According to Akachuku (1987), density is largely determined by diameter and wall thickness of cells and the proportion of thick-walled tissues (vessels and fibres) and is the best singular indication of wood quality and its suitability for various purposes.

Outer and Van-Veenendaal (1976) reported short vessel (>350µm) of medium sized diameter (100-200µm) in *Kigelia africana* in the rainforest and savanna areas of Cote d' Voire. They however reported non-significant variations in vessel lengths between *K. africana* in rainforest and savanna areas.

The purpose of this study was to ascertain the level of plasticity of the dimensions of tracheary elements (fibres and vessels) of both *Kigelia africana* (Lam). Benth and *Newbouldia laevis (*P. Beauv) Seemann ex Bureau growing naturally in the rainforest and derived savanna areas of Edo State, Nigeria. It was also to assess the effects of ecological variations on the dimensions of their tracheary elements on qualities and potentialities of their wood for various uses and to ascertain their phylogenetic trend.

METHODOLOGY.

Wood samples from *Kigelia africana* and *Newbouldia laevis* growing naturally in two ecological zones (rain forest and derived savanna) of Edo State Nigeria and whose ages were not ascertained were obtained. The ecological zones are located between longitude 5°04' East and 6°43' East and latitude 5°44' North and 7°34' North. Wood samples were collected from plants whose girths ranged from 9.0-11.0 centimeters at 1.3 meters above ground level i.e. 1.3 meters diameter at breast height (d.b.h).Wood samples were air-dried for 10 days before they were made into chips. Maceration of chips was carried out using the procedures of Gill *et al.* (1983) and Okoegwale and Gill (1990). Wood chips obtained, were placed in a test tube containing 10-15ml of 60% nitric acid and left overnight. It was then boiled for 5-10 minutes. The macerated materials were washed several times with distilled water. By modification, macerated materials were not centrifuged as described by Okoegwale and Gill (1990). A diluted (1%) drop of 1:1 glycerol-safranin solution was added before placing a cover slip. Linear measurements (length, diameter, lumen diameter and wall thickness) of vessels and fibres were made on calibrated microscope. Average values were based on 100 measurements. A t-test distribution was used to analyze the data.

RESULTS

Table 1. Morphological characteristics of vessels and fibres of *K. africana* (Lam) Benth growing in rainforest and derived savanna regions of Edo State.

	RAINFOREST	**DERIVED SAVANNA**
Plant tissue type	**Morphological characteristics**	**Morphological characteristics**
VESSELS		
Length	Short, ranging from 104.3-316.8µm mean 245.0µm	Short, ranging from 100.0-304.70µm. mean 200.0µm.
Diameter	Medium-sized, ranging from 75.66-177.8µm mean 126.0µm	Medium-sized, ranging from 62.68-141.60µm. mean 118.40µm.
Wall thickness	Thick-walled, ranging from 2.90-9.50µm mean 5.42µm.	Thick. Ranges from 3.14-11.70µm. mean 7.0µm.
Tail	Absent	Absent
Perforation plate	Simple and obliquely located at the end walls	Simple, obliquely located at the end walls.
Pit	Simple, round, arranged in rows	Simple, round, arranged in rows.
FIBRE		
Length	Medium, ranging from 1018.61-1640.11µm. mean 1450.15µm.	Short, ranges from 11.01-18.66µm. mean 13.71µm.
Diameter	Ranging from 11.4-31.11µm. mean 26.0µm.	-
Lumen diameter	Ranging from 11.46-21.70µm. mean 19.04µm.	-
Wall thickness	Moderate, ranging from 3.61-6.0µm. mean 4.10µm.	-
Pit	Absent	Absent
Septae	Present	-
Fibre vessel: Length ratio	5.92	3.55
Runkle ratio	0.43	0.50

Table 2. Morphological characteristics of vessel and fibres of *Newbouldia laevis* (P. Beauv) Seemann ex Bureau growing in rainforest and derived savannah regions of Edo State.

	RAINFOREST	**DERIVED SAVANNAH**
Plant tissue type	**Morphological characteristics**	**Morphological Characteristics**
VESSELS		
Length	Short, ranging from 212.60-441.20µm mean 320.50µm	Short, ranges from 210.4- 356.0µm mean 292.0µm
Diameter	Medium-sized, ranging from 61.40-216.40µm mean 130.0µm	Medium size, ranges from 55.8-194.3µm mean 123.10µm
Wall thickness	Thick-walled, ranging from 2.82-11.10µm mean 6.40µm.	Thick. Ranges from 3.60-12.60µm. mean 8.0µm.
Tail	Absent	Absent
perforation plate	Simple, obliquely located at the end walls	Simple, obliquely located at the end walls.
Pit	Simple, round, arranged in rows	Simple, round, arranged in rows.
FIBRE		
Length	Long, ranging from 1178.13-1660.40µm. mean 1620.22µm.	Medium, ranges from 1105.10-1630.90µm. mean 1596.78µm
Diameter	Ranging from 10.55-23.16µm. mean 21.48µm.	Ranges from 9.82-18.92µm mean 16.61µm
Lumen diameter	Ranging from 9.88-14.71µm. mean 12.58µm.	Ranges from 9.22-13.98µm mean 10.11µm
Wall thickness	Moderate, ranging from 3.11-6.44µm. mean 4.18µm.	Moderate, ranges from 3.0-6.05µm mean 5.0µm
Pit	Absent	Absent
Septae	Present	Absent
Fibre Vessel	Length ratio = 5.06	Length ratio = 5.47
Runkle ratio	0.67	0.99

DISCUSSION

In the presently investigated plants, vessel members are of medium lengths (350-800µm), medium- sized diameter (100-200µm), thick-walled (>3.0µm), tailless with simple perforation plates obliquely situated and simple round pits arranged in rows (Table 1)

Mean length of vessel members ranged from 245.0±102.08µm in *Kigelia africana* to 320.50±133.3µm in *Newbouldia laevis* growing in the rain forest area. In the derived savanna habitats, mean length ranged from 200.0±83.3µm in *K. africana* to 292.0±121.67µm in *N. laevis*.

Diameter was of the mean range 126.0±72.5µm in *K. africana* to 130.0± 54.17µm in *N. laevis* growing in the rain forest habitat while it ranged from 118.40±69.3µm in *K. africana* to 123.10+51.25µm in *N. laevis* growing in the derived savanna area. The presence of short vessels in the presently investigated species is in line with Gill *et al* (1985) and Outer and Van-Veenendaal (1976) who reported similar trends in *J. acutifolia* and *K. africana* respectively. Occurrence of medium sized vessel diameter is also in agreement with Outer and Van-Veenendaal (1976). Gill *et al* (1985), however, reported extremely small-sized diameter (mean 30.45µm) in *J. acutifolia*.

Vessel wall thickness ranged from 5.42±2.95µm in *K. africana* to 6.40±2.14µm in *N. laevis* growing in the rain forest habitat; it ranged from 7.01±4.93µm in *K. africana* to 8.0±3.34µm in *N. laevis* in the derived savanna area. Variations in vessel element wall thickness between *N. laevis* obtained from the two ecological zones were significant at 1% and 5% probability levels. The derived savanna plants have higher mean maximum vessel dimensions to counterbalance the water stress prevalent in that environment.

Taxa investigated possessed vessels with simple perforation plates confirming the previous report by Gill *et al*. (1985). The presence of simple round pits arranged in rows is also reported in the vessels of the taxa under study. Gill *et al* (1985) however reported simple pits of no definite pattern of arrangement in *J. acutifolia*, while Outer and Van-Veenendanl (1976) neither reported the presence nor absence of this feature nor the pitting pattern in *K. africana*. Pit membranes affect the penetration of liquids, preservatives and gases in timber. It is important as research on pit membranes provides interesting applications in the field of wood technology, including the paper and pulp industry (Watanabe *et al.*, 1999, Singh *et al.*, 1999 and Flynn 1995). Taxa fibres are of short (>900µm) medium (900-1600µm) and long (>1600µm) types. Moderately thick-walled (3-5µm), septate; non-septate and non-pitted Fibre mean length ranged from 1450.15±534.0µm to 1620.22±611.0µm in *N. laevis* growing in the rain forest zone. In the derived savanna habitat, it ranged from 710.0±344.11µm in *K. africana* to 1595.78±543.16µm in *N. laevis.* Fibre mean diameters in the rain forest zone range from 21.48±9.36µm in *N. laevis* to 26.0±12.55µm in *K. africana*. Average fibre diameters in the derived savanna habitat ranged from 16.61±7.31µm in *N. laevis* to 18.0±7.99µm in *K. africana*.

Fibre mean lumen diameter ranged from 12.58±5.0µm in *N. laevis* to 19.04± 7.10µm in *K. africana* growing in the rainforest zone while it ranged from 10.11 ±4.77µm in *N. laevis* to 13.71±7.11µm in *K. africana* growing in the derived savanna area. Occurrence of medium –sized fibres ?is in line with Gill *et al*. (1985) on *J. acutifolia*. Variations in fibre length of taxa are not however significant. Higher mean maximum values in fibre element length were obtained in *N. laevis* occurring in the rain forest area, thus justifying the assumption of Okoegwale and Idialu (1998) on fibre lengths of some leguminous woody plants.

The thickness of the fibre walls ranged from 4.10±2.11µm in *K. africana* to 4.18±2.15µm in *N. laevis* obtained from the rain forest habitat. In the derived savanna habitat, fibre wall thickness ranged from 3.40±1.30µm in *K. africana* to 5.0±2.33µm in *N. laevis*. However, Gill *et al*. (1985) reported very thin-walled fibres in *J. acutifolia*, but Outer and Van-Veenendaal (1976) gave no description on the fibres of *K. africana*. On comparison, *N. laevis* of the derived savanna habitat has thicker fibre walls than its counterpart in the rain forest. Fibre wall thickness is of relevance in the determination of wood density and its end-uses (Okoegwale and Idialu, 1998).

In this investigation only *K. africana* and *N. laevis* growing in the rain forest habitat had septate fibre. Taxa fibres were non-pitted but Gill *et al.* (1985) reported simple pits with a row-like pattern of arrangement in *J. acutifolia.* Fibre vessel length ratio of taxa investigated ranges from 3.55 to 5.92µm in *K. africana* growing in the derived savanna and rain forest area respectively. Although the species growing in the rain forest area has higher ratio than its derived savanna counterpart, presence of septate may be an indication that such species has not lost all its primitive traits. The fibre/vessel length ratio of *K. africana* and *N. laevis* growing in the two ecological zones are presented in Fig 1. This ratio is an important parameter for the assessment of phylogeny of taxa. The ratio of taxa approaching 10 is more advanced and specialized and suitable for different uses as timber.

There were no significant variations in vessel element lengths and diameters (P<0.05) of these species growing in the two ecological zones. However, on comparison higher mean maximum value were obtained in vessel element lengths of *K. africana* and *N. laevis* growing in the rain forest zone. This is in agreement with Okoegwale and Idialu (1998) who reported similar trends in some leguminous woody taxa occurring in two different ecological zones. According to Baas *et al*. (1983), the advantage of high mean maximum length is for increased efficiency for water conduction.

CONCLUSION

From a technology point of view, the shape of the vessel and fibre cells, their lengths and wall thickness are some important parameters for the determination of wood properties. The present investigation on woods of lesser known plants viz: *Kigelia africana* and *Newbouldia laevis* growing in the rain forest and derived savanna area of Edo State, Nigeria indicated that vessel and fibre dimensions show plasticity and so these plants are suitable for various end-uses but are however not suitable for high grade pulp because of their relatively low fibre length and runkel ratio (<1). Plasticity in the tracheary elements had hitherto not been reported in these species.

Table 3: Vessel and fibre characteristics of *Kigelia africana* and *Newbouldia laevis*

Plant species	Habitat	d.b.h.(cm)	Vessel means length ±SD (µm)	Level of significance	Vessel mean diameter ± SD (µm)	Level of significance	Vessel wall thickness ± SD(µm)	Level of significance	Vessel tail length (µm)	Vessel perforation type	Pits/pattern of arrangement	Fibre mean length ±SD(µm)	Level of significance	Fibre mean diameter ±SD(µm)	Level of significance	Fibre mean lumen diameter ±SD(µm)	Fibre mean wall thickness ± SDµm)	Level of significance	Pits	Septate	F/v length ratio	Runkel ratio
Kigelia africana (Lam) Benth	F	10	245.0±10 2.8	NS 1.82	126.0 ±72.5	Ns 0.41	5.42±2. 95	NS 1.51	-	SIMPLE / OBLIQUE	Simple round in rows	1450. 15±5 3.4.0	** 6. 38	26.0± 12.55	2.94	19.04 ±7.10	4.10±2.1 1	Ns 0.91	-	+	5.92	0.43
	DS	11	200.0±83. 3		118.4 0±69. 3		7.0±4.9 3		-		Simple round in rows	710.0 ±344. 11		18.0± 7.99		13.71 ±7.11	3.40±1.3 0		-	-	3.55	0.50
Newbouldia laevis (p. Beau(Seemann ex Bureau	F	10	32.0.5±13 3.3	NS 1.28	130.0 ±54.1 7	Ns 0.34	6.40±2. 14	**3.0	-		Simple round in rows	1620. 22±6 11.0	N S 0. 16	21.48 ±9.63	2.24	12.58 ±5.0	4.18±2.1 5	NS 1.56	-	+	5.06	0.67
	DS	9	292.0±12 1.67		123.1 ±51.2 5		8.0±3.3 4		-		Simple round in rows	1596. 78±5 43.16		16.61 ±7.31		10.11 ±4.77	5.0±2.32		-	-	5.47	0.99

F - rainforest habitat
DS - derived savanna habitat
d.b.h. - diameter at breast height
M(µm - microns
\+ - present
\- - absent
NS - Not significant
SD - Standard deviation

* Significant at 5% probability level
** Significant at 1% probability level

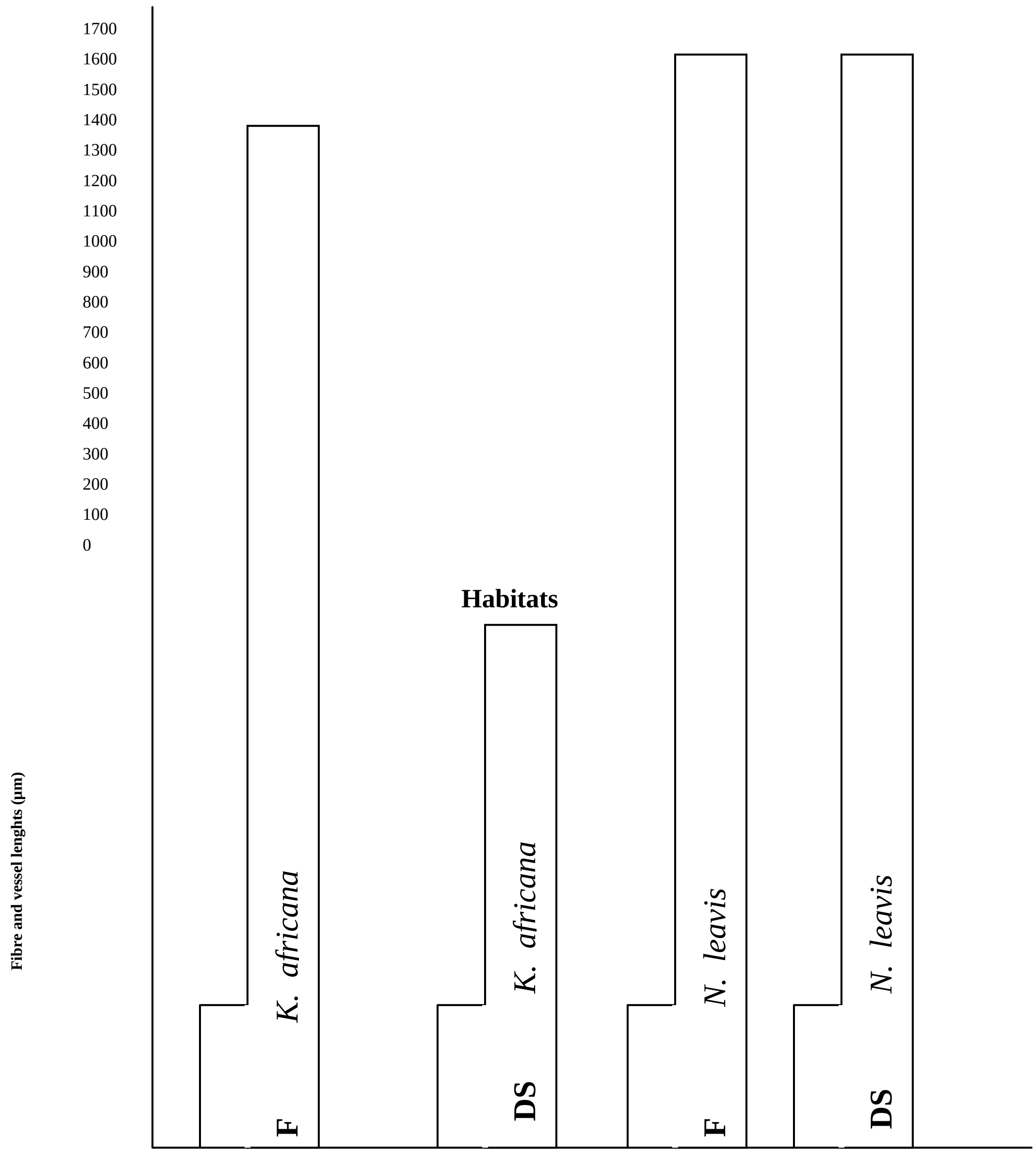

Fig. 1. Fibre/vessel length ratio of *Kigelia africana* and *Newbouldia laevis* in rainforest and derived savannah habitat

REFERENCES

1. Akachuku A. E. (1987) Variation in wood density of dicotyledons as a guide for forest plantations management. *Agricultural Research Bul* **3**: 1-8.
2. Baas, P. (1973) The wood anatomy of llex (Aquifoliaceae) and its ecological and phylogenetic significance. *Blumea* **21**: 193-258.
3. Baas, P. (1976). Some functional and adaptive aspects of vessel member morphology, In: wood structure in Biological and technological Research (eds: P. Baas, A.J. Bolton and D.M. Catling) Leiden Bot series No 3:157-181 Leiden University Press The Hague.
4. Baas, P; Werker, Eand Fahn, A (1983). Some ecological trends in vessel characters *LAWA bul. Ns* **4**: 141-159.
5. Flynn KA. (1995) A review of the permeability, fluid flow, and anatomy of spruce (*Picea* spp.). *Wood and Fiber Science* **27:** 278–284

6. Gill, L. S. (1988) Taxonomy of flowering plants Africana Fep Publishers Ltd, Akwa. P. 237.
7. Gill L.S. (1992) Systematic, systematist and society in Nigerian Context. Idodo-Umeh Publishers Ltd; Benin City. p 43.
8. Gill, L. S. and Okoegwale. E.E. (1990). Variation in some wood properties of two species of Entandrophrgema C.D.C. in Nigeria. *Discovery and Innovation* **2**: 83-88
9. Gill, L. S. and Onuja, J.E. (1982) Characteristics of two woods of Nigeria (Bignoniacea). *Nig. Jour. Forestry* **12**: 40-43.
10. Gill L.S. Lamina, B.L. and Husaini S.W.H. (1983). Observation on the tracheary element of some Nigerian Leguminous woods. *Legume Research* **6**: 9-17.
11. Gill L. S.Lamina, B.l, and Karatela Y. Y. (1985) Histomorphological studies of tracheary elements and the economic potential of tropical hard woods. *Forest Resource journal*. **2**: 121 – 141.
12. 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.
13. 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
14. 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.
15. Singh A, Dawson B, Franich R, Cowan F, Warnes J. (1999) The relationship between pit membrane ultrastructure and chemical impregnability of wood. *Holzforschung* **53:** 341–346
16. Watanabe U, Imamura Y, Iida I. (1998) Liquid penetration of precompressed wood. VI. Anatomical characterization of pit fractures. *Journal of Wood Science* **44:**158–162

8/8/2009