

DENSITY AND SELECTED STRENGTH PROPERTIES OF *Laccosperma secundiflorum* (P. BEAUV.) RATTAN FROM TWO DIFFERENT ECOLOGICAL ZONES IN NIGERIA

Samson Oluwaseun OGUTUGA *

Research Fellow I – Forestry Research Institute of Nigeria
Address: Forestry Research Institute of Nigeria. P.M.B. 5054, Jericho, Ibadan, Oyo State, Nigeria
Tel: 00234 805 8507670, E-mail: tugalord001@yahoo.com

Adedeji Robert OJO

Principal Research Fellow, Forestry Research Institute of Nigeria
Address: Forestry Research Institute of Nigeria. P.M.B. 5054, Jericho Hill, Ibadan. Oyo state, Nigeria
E-mail: djofafrica2001@yahoo.com

Sylvester Ehiagwinah AREGHAN

Principal Research Fellow, Forestry Research Institute of Nigeria
Address: Forestry Research Institute of Nigeria. P.M.B. 5054, Jericho Hill, Ibadan. Oyo state, Nigeria
E-mail: sylvesterareghan@gmail.com

Lawrence Olanipekun AGUDA

Senior Research Fellow, Forestry Research Institute of Nigeria
Address: Forestry Research Institute of Nigeria. P.M.B. 5054, Jericho Hill, Ibadan. Oyo state, Nigeria
E-mail: agudaola@gmail.com

Abstract:

*The suitability of rattan canes as structural material for appropriate utilization is demonstrated by its properties. Thus, in order to satisfactorily use the canes of rattan as a raw-material for structural purpose, the properties must be studied. This study therefore investigated the density and some strength properties of *Laccosperma secundiflorum* from two different ecological zones. Three matured wild *Laccosperma secundiflorum* were obtained each from fresh water swamp and Rain forest. Samples were collected along the sampling height: base, middle and top. Density and selected strength properties test; Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and Maximum Compressive Strength Parallel to Grain (MCS_{//}) were carried out on the *L. secundiflorum* samples from the two ecological zones and data were analysed using descriptive statistics and ANOVA at $P < 0.05$. From the results, density ranged from 407.21 ± 55.65 to $485.39 \pm 32.25 \text{ kg/m}^3$. MOR and MOE varied from 41.75 ± 3.88 to $57.39 \pm 4.17 \text{ N/mm}^2$; 438.50 ± 48.14 to $711.34 \pm 249.02 \text{ N/mm}^2$ respectively. While, MCS_{//} increased from 24.72 ± 1.50 to $34.15 \pm 1.90 \text{ N/mm}^2$. Results further showed that density and strength properties decrease along the axial direction from base to top. While, the samples of *L. secundiflorum* sourced from rain forest had higher density and strength properties values compared to samples from fresh water swamp. Based on the result obtained, *L. secundiflorum* samples obtained the base and from rain forest were denser and the strongest in terms of strength.*

Key words: density; ecological variation; *Laccosperma secundiflorum*; sampling height; strength properties.

INTRODUCTION

Rattans are one of the most important non-timber forest products that come from tropical forests. About 600 species of rattan belonging to 13 genera have been known to exist (Sunderland 2001), the majority of which are native to South and Southeast Asia. In West and Central Africa, 20 species of rattan from 4 genera have been identified (Sunderland 2001). Sunderland (2001) stated further that the four genera of African rattan are easy to distinguish, mainly through the morphology of their climbing organs. Rattan stem diameter varies considerably, from 2mm to 3mm among the smallest species to 100mm in extremely large species (Dransfield 2001). Stem of rattans with diameter of 18mm and above are classified as large-diameter canes, while those below 18mm are small-diameter canes. Rattans have been established to attain great heights; usually about 46m, but may attain as much as 150m (Strausbaugh 1997).

Rattan canes are essential natural biomass used for furniture making and other products, such as traditional items like sport equipment, fish traps, handbags and crossbow strings (Olorunnisola and Adefisan 2002). Rattan canes, when soaked in water (depending on the temperature of the water) for a day or two, becomes more pliable and a softer material that can be easily bent into twisted curved shapes (Rao and Lal

*Corresponding author

1968). Olubanjo (2002) and Dahunsi (2000) reported that rattan canes are used for general construction works and building in Western and Southern parts of Nigeria. The areas of application comprise frames, partitions, rafters, walls as well as ceilings of mud houses. They have been utilized in the construction of articles such as fishing traps, granaries, sieves and winnowers, mats, barn and trays, as well as reinforcement for wall partitions and frames of structures used as market stalls, stores and residential residences of forest communities. Burkill (1966) conclude that there is no natural product that would be able to contend with rattan if sufficient supply can be assured at a reasonable price based on the exceptional performance of some rattan canes under stress.

In Nigeria, majority of the research carried out on rattan canes has been on its utilization and trade, especially for furniture (Komolafe 1992, Morakinyo 1995, Olubanjo 2002). Limited information on the physical and strength properties of Nigerian rattan canes appear in published works. Sunderland (2001) reported that current and new research on African rattan has focused on providing information on the utilization, ecology and taxonomy. Kadir (2001) stated that there is a scarceness of information on the properties of rattan species. Hence, some of them have remained un-utilized or inappropriately utilized. Further research is needed to determine the properties and also the appropriate utilization technology of Nigeria rattan species.

Rattan is a very good material because it is suitable for outdoor use, light in weight, durable and flexible to a certain extent.

The selection and preparation of rattan either for processing or manufacturing are dictated by its basic characteristics such as anatomical features, physical properties, chemical constituents (Abd. Latif 1991, Abd. Latif 1992) and mechanical properties. Since there is limited information on such properties and many rattan species remain un-utilized in Nigeria, research is therefore needed to determine the properties of rattan species.

The aim of this research is to investigate the density and selected strength properties of *Laccosperma secundiflorum* rattan from different ecological zones with a view to developing its appropriate utilization technology.

MATERIALS AND METHODS

Three matured wild *Laccosperma secundiflorum* each were obtained from fresh water swamp- Arapagi Village, Ibeju-Lekki Local Government Area, Lagos State, Nigeria and Rain forest- Nicholas Village, Ovia North-East Local Government Area, Edo State, Nigeria. The rattan samples were collected and their morphological features like stem height (with an average height of 10.37m for fresh water swamp and 10.98m for rain forest), internodes (with an average of 52 for fresh water swamp and 55 for rain forest), stem diameter, leave and fruit were examined for the purpose of accurate identification with references made to the stocks of rattan samples kept in the Herbarium of the Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria, Ibadan, Oyo State, Nigeria.

The samples were collected along the sampling height for base, middle and top.

Preparation and Testing of Samples

Samples for density and Strength properties (Modulus of Rupture, Modulus of Elasticity and Maximum Compressive Strength Parallel to Grain) were collected from base, middle and top of each of the rattan stems of the two ecological zones (Table 2) following ASTM D143-52 (ASTM 1972) with modification due to the peculiarities of rattan species (Fig. 1). Each treatment combination (Rattan location: Fresh water swamp and Rain forest; Sampling height: Base, middle and top) was replicated five times (i.e. five samples for each sampling height and rattan location) and 30 samples were obtained for each of the variables tested (Table 2).

The method used for the determination of Density of rattan species of the two ecological zones is in accordance with ASTM D 2395-17 (ASTM 2017) while, Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and Maximum Compressive Strength Parallel to Grain (MCS_{//}) test of the rattan species of the two ecological zones were in accordance with ASTM D1037-94 (ASTM 1994). Samples for MOR, MOE and MCS_{//} were tested using Universal Testing Machine (Jinan Hensgrand Instrument, Model: WDW-50).

Table 1

<i>The size and number of the samples for density and selected strength properties</i>						
Test	Fresh Water Swamp			Number of samples	Rain Forest	
	Base	Middle	Top		Base	Middle
Density	Base	26.68 ± 1.02 x 60	5	Base	28.75 ± 0.95 x 60	5
	Middle	29.69 ± 1.02 x 60	5	Middle	30.57 ± 0.95 x 60	5
	Top	31.49 ± 1.02 x 60	5	Top	32.70 ± 0.95 x 60	5

MOR	Base	26.68 ± 1.02 x 300	5	Base	28.75 ± 0.95 x 300	5
	Middle	29.69 ± 1.02 x 300	5	Middle	30.57 ± 0.95 x 300	5
	Top	31.49 ± 1.02 x 300	5	Top	32.70 ± 0.95 x 300	5
MOE	Base	26.68 ± 1.02 x 300	5	Base	28.75 ± 0.95 x 300	5
	Middle	29.69 ± 1.02 x 300	5	Middle	30.57 ± 0.95 x 300	5
	Top	31.49 ± 1.02 x 300	5	Top	32.70 ± 0.95 x 300	5
MCS _{II}	Base	26.68 ± 1.02 x 60	5	Base	28.75 ± 0.95 x 60	5
	Middle	29.69 ± 1.02 x 60	5	Middle	30.57 ± 0.95 x 60	5
	Top	31.49 ± 1.02 x 60	5	Top	32.70 ± 0.95 x 60	5



Fig. 1.
***Laccosperma secundiflorum* samples.**

Data Analysis

Analysis of variance in 2 x 3 factorial experiment in a Completely Randomized Design (CRD) was carried out to determine if the rattan location and sampling height had significant effects on the density and strength properties of the *Laccosperma secundiflorum*. Duncan Multiple Range Test (DMRT) at $p < 0.05$ was also used to compare means.

RESULTS AND DISCUSSION

Density

The result of density conducted on *L. secundiflorum* rattan samples of the two different ecological zones are presented in Fig. 2 with a mean density value of $443.39 \pm 52.63 \text{ kg/m}^3$. It was observed that the density of *L. secundiflorum* samples decreased from base to top of the rattan stem. This is in line with the trend found by Abd. Raza *et al.* (1995) for *Calamus manan*, *Calamus scipionum*, *Calamus palustris*, *Korthalsia rigida* and *Plectomiopsis griffithii*. Thicker fibre wall and bigger concentration of vascular bundles within the matured tissues of the basal region may contribute to this (Abd. Latif and Norralakman 1993). Similarly, Ojo *et al.* (2014) and Areghan *et al.* (2018) observed the same trend for *Borassus aethiopicum* and raw specimens of *Bambusa vulgaris* respectively. This means that samples obtained from the base were denser compared to the ones obtained from the middle and top. Among the rattan location, density of *L. secundiflorum* rattan samples sourced from rain forest was higher than those sourced from fresh water swamp (Fig. 2).

Lucas and Dahunsi (2004) gave the density of green samples of *Calamus deerratus*, *Laccosperma secundiflorum* and *Eremospatha macrocarpa* to be 648 kg/m^3 , 573 kg/m^3 and 539 kg/m^3 respectively which are slightly higher than the mean density ($443.39 \pm 52.63 \text{ kg/m}^3$) reported for *L. secundiflorum* in this current research. Abd Razak *et al.* (1995) recorded an oven-dry density range of $0.41\text{-}0.45 \text{ g/cm}^3$ for *Calamus scipionum* and $0.33\text{-}0.36 \text{ g/cm}^3$ for *Plectomiopsis griffithii*.

According to Ahmad (2000), density is the most important factor that determines strength properties, and it is closely linked to the proportion of vascular bundles. Kubler (1980) also stated that density is a measure of strength properties such as bending and is the simplest and most accurate indication of wood quality.

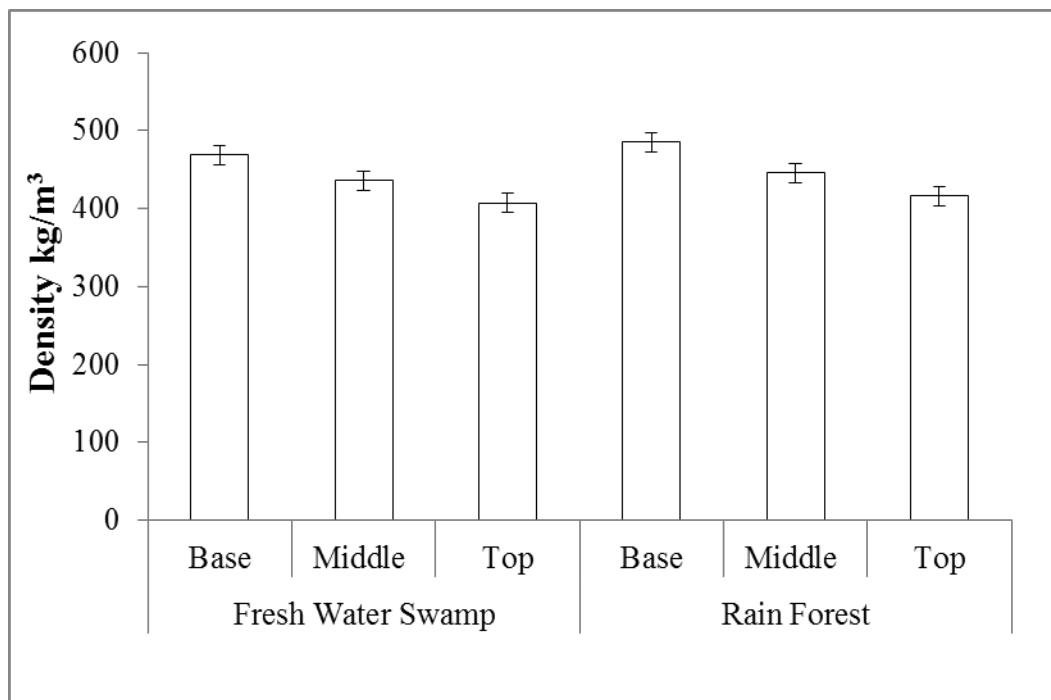


Fig. 2.
Density of *Laccosperma secundiflorum* Rattan Samples.

Statistically, there is significant difference in the density of *L. secundiflorum* rattan along the sampling height (Table 2) at $p < 0.05$ while, rattan location and their level of interaction had no significant effect on density (Table 2).

Table 2

Source of variation	df	SS	MS	F-cal	Sig.
Rattan Location	1	1067.079	1067.079	0.443 ^{ns}	0.512
Sampling Height	2	21401.934	10700.967	4.445*	0.023
Rattan Location * Sampling Height	2	76.436	38.218	0.016 ^{ns}	0.984
Error	24	57778.817	2407.451		
Total	29	80324.266			

* Significant at $p < 0.05$ and **ns**= not significant at $p > 0.05$

The follow up test as presented in Table 3 showed that sampling height was different from one another with the samples obtained at the base having the highest density but, not significantly different from the density of samples obtained at the middle. While, the density of samples obtained at the middle and top were also not significantly different from each other.

Table 3

Sampling Height	Density Mean±SDV
Base	477.18 ^a ±28.64
Middle	441.11 ^{ab} ±56.11
Top	411.87 ^b ±50.78

Mean with the same alphabet in the same column are not significantly different ($p < 0.05$) from one another

Modulus of Rupture, MOR

The result of MOR as presented in Fig. 3 conducted on *L. secundiflorum* rattan samples of the two different ecological zones showed that MOR decreased from base to top of the stem of *L. secundiflorum* samples. This means that samples obtained from the base were the strongest of all the other samples

obtained from the middle and top. The trend of variations in MOR from base to top might be as a result of the decrease in fibre length (Rulliaty and America 1995).

It was also observed that *L. secundiflorum* samples sourced from rain forest had an MOR which is higher but, not significantly different from the MOR of samples sourced from fresh water swamp (Fig. 3). Bhat *et al.* (1991) reported the mean MOR of *Calamus gamble*, *Calamus hootwrianus*, *Calamus psetidotenuis* and *Calamus metzianus* as 71.5N/mm², 52.7N/mm², 69.8N/mm² and 37.0N/mm² respectively which are higher than the mean MOR (49.06±6.87 N/mm²) obtained in this study except, 37.0N/mm² recorded for *Calamus metzianus*. The variations observed in MOR could be as a result of the differences in species as well as the effect of climate and soil condition.

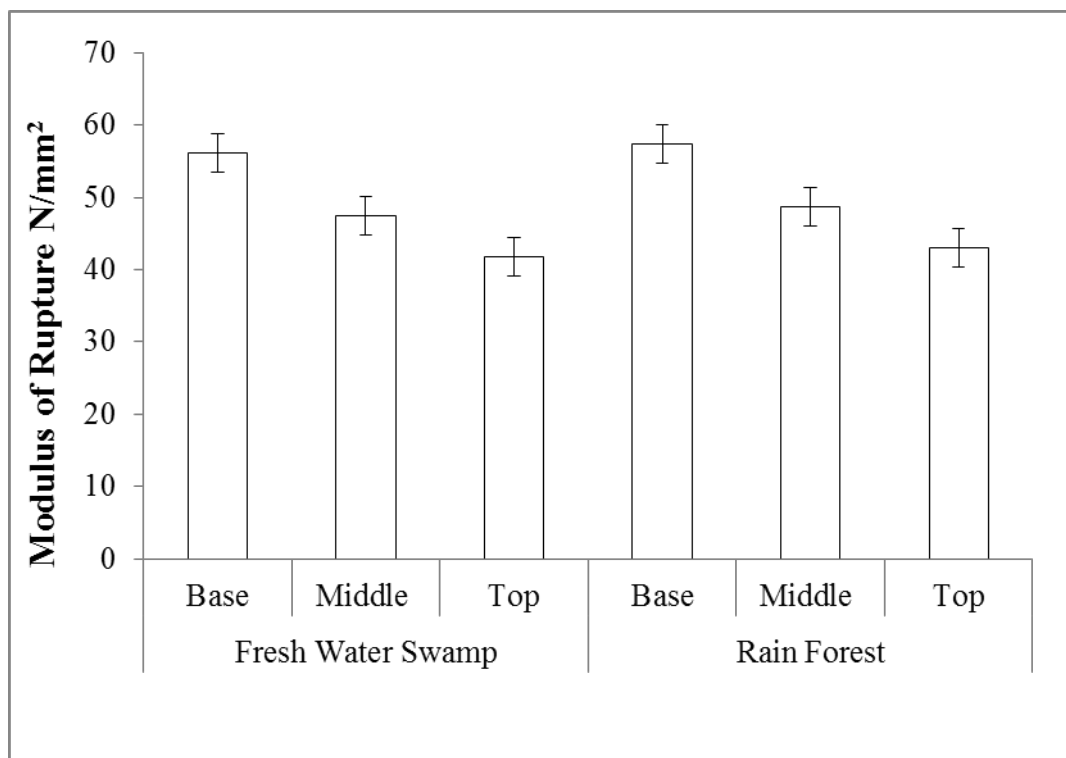


Fig. 3.
Modulus of Rupture of *Laccosperma secundiflorum* Rattan Samples.

Meanwhile, the result of analysis of variance carried out shows that there is significant difference in the MOR of *L. secundiflorum* rattan along the sampling height (Table 4) at $p < 0.05$ while, rattan location and their level of interaction had no significant effect on MOR (Table 4).

Table 4

Analysis of Variance for Modulus of Rupture					
Source of variation	df	SS	MS	F-cal	Sig.
Rattan Location	1	11.017	11.017	0.852 ^{ns}	0.365
Sampling Height	2	1048.490	524.245	40.534*	0.000
Rattan Location * Sampling Height	2	0.035	0.018	0.001 ^{ns}	0.999
Error	24	310.407	12.934		
Total	29	1369.949			

* Significant at $p < 0.05$ and **ns**= not significant at $p > 0.05$

The follow up test as presented in Table 5 showed that samples obtained at the base were significantly different from those obtained at the middle and top, thus signifying that samples from the base were the strongest and the most preferred.

Table 5

Follow-up Test for Sampling Height

Sampling Height	MOR Mean±SDV
Base	56.75 ^a ±4.02
Middle	48.07 ^b ±2.80
Top	42.37 ^c ±3.42

Mean with the same alphabet in the same column are not significantly different ($p < 0.05$) from one another

Modulus of Elasticity, MOE

As presented in Fig. 4, the MOE of *L. secundiflorum* rattan samples of the two ecological zones decreased from base to top of the stem. This is in line with the trend found by Kadir (2001) for *Calamus scipionum* and *Daemonorops angustifolia*.

Fig. 4 also showed that the samples of *L. secundiflorum* rattan sourced from rain forest had an MOE value which is higher than those sourced from fresh water swamp. A mean MOE of 1666N/mm², 1666N/mm², 1754N/mm² were reported for *Calamus rotang*, *Calamus metzianus* and *Calamus hootwrianus* respectively by Bhat *et al.* (1991). The reported MOE values for the three rattan species were higher than the mean MOE (532.24±174.21N/mm²) reported in this study which could be as a result of the differences in species as well as the effect of location, climate and soil condition.

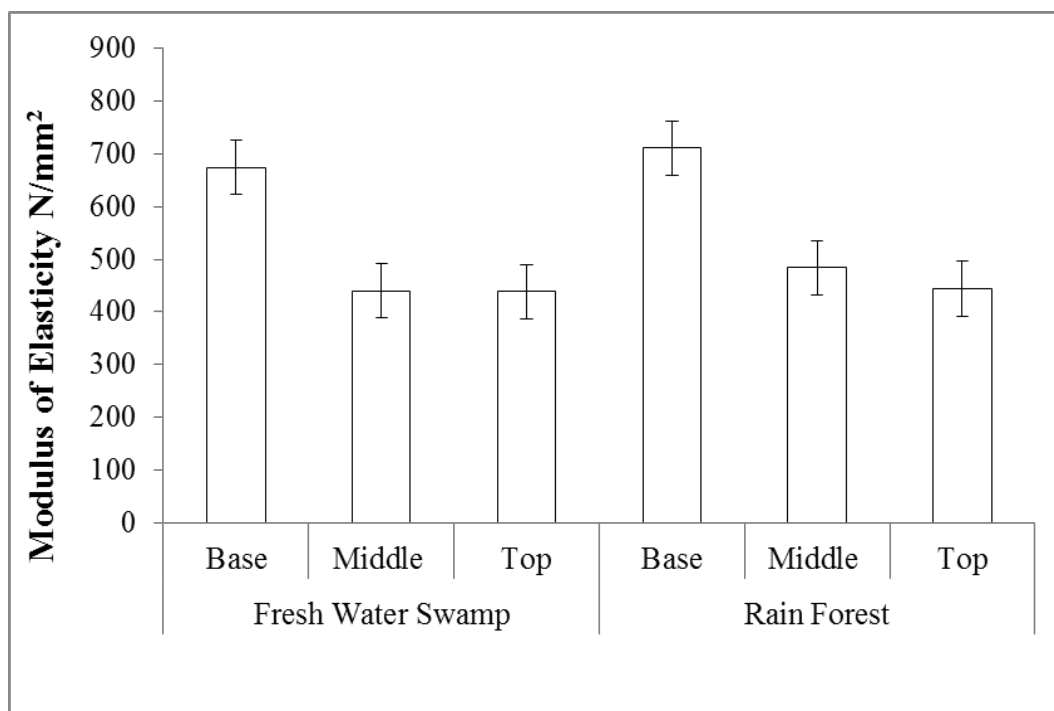


Fig. 4.
Modulus of elasticity of *Laccosperma secundiflorum* Rattan Samples.

Statistically, there is significant difference in the MOE of *L. secundiflorum* rattan along the sampling height (Table 6) at $p < 0.05$ while, rattan location and their level of interaction had no significant effect on MOE (Table 6).

Table 6

Analysis of Variance for Modulus of Elasticity

Source of variation	df	SS	MS	F-cal	Sig.
Rattan Location	1	6256.852	6256.852	0.311 ^{ns}	0.582
Sampling Height	2	389699.632	194849.816	9.700*	0.001
Rattan Location * Sampling Height	2	2095.611	1047.806	0.052 ^{ns}	0.949
Error	24	482108.082	20087.837		
Total	29	880160.177			

* Significant at $p < 0.05$ and ^{ns}= not significant at $p > 0.05$

The follow up test presented in Table 7 showed that sampling height were different from one another with *L. secundiflorum* rattan samples obtained at the base being the stiffest. While, the MOE of samples obtained at the middle and top were not significantly different from each other.

Table 7

Follow-up Test for Sampling Height

Sampling Height	MOE Mean±SDV
Base	692.96 ^a ±223.91
Middle	462.44 ^b ±53.16
Top	441.32 ^b ±39.16

Mean with the same alphabet in the same column are not significantly different ($p < 0.05$) from one another

Maximum Compressive Strength Parallel to Grain, MCS_{//}

The result of MCS_{//} as presented in Fig. 5 conducted on *L. secundiflorum* rattan samples of the two ecological zones showed that MCS_{//} also decreases from base to top of the *L. secundiflorum* stem as observed in MOR and MOE. This means that samples obtained from the base were the strongest of all the other samples obtained from the middle and top.

It was also observed that *L. secundiflorum* samples sourced from rain forest had an MCS_{//} value which is higher but, not significantly different from the MCS_{//} value of the samples sourced from fresh water swamp (Fig. 5). Bhat *et al.* (1991) gave the mean Maximum Compressive Strength values for *Calamus nagbettai*, *Calamus thwaitesii* and *Calamus gamblei* to be 33.6N/mm², 29.2N/mm² and 29.9N/mm² respectively which are similar to the mean MCS_{//} (28.08±4.27N/mm²) reported in this study.

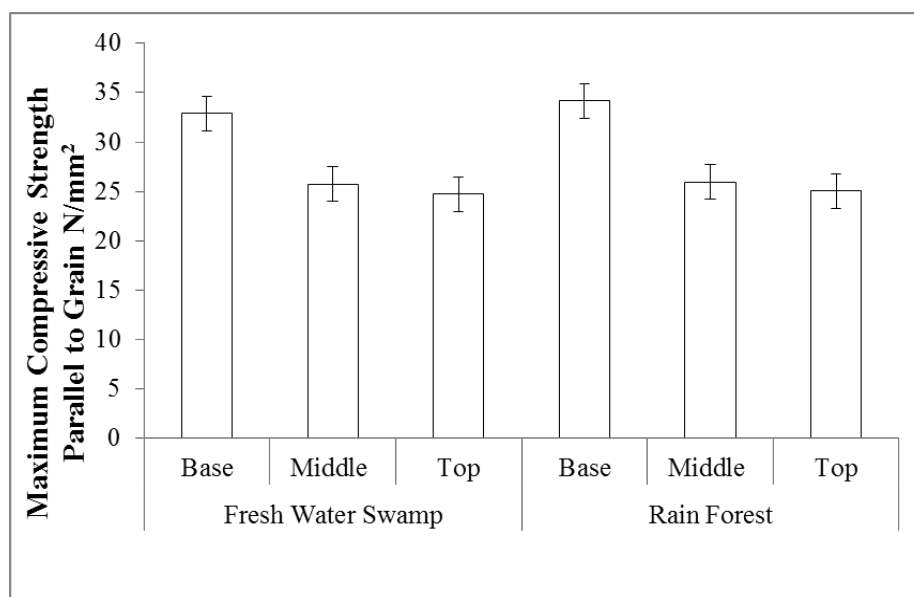


Fig. 5.

Maximum Compressive Strength Parallel to Grain of Laccosperma secundiflorum Rattan Samples.

Meanwhile, the result of analysis of variance carried out shows that there is significant difference in the MCS_{//} of *L. secundiflorum* rattan along the sampling height (Table 8) at $p < 0.05$ while, rattan location and their level of interaction had no significant effect on MCS_{//} (Table 8).

Table 8

Analysis of Variance for Maximum Compressive Strength Parallel to Grain					
Source of variation	df	SS	MS	F-cal	Sig.
Rattan Location	1	2.552	2.552	0.826 ^{ns}	0.372
Sampling Height	2	449.915	224.958	72.811*	0.000
Rattan Location * Sampling Height	2	1.641	0.821	0.266 ^{ns}	0.769
Error	24	74.151	3.090		
Total	29	528.259			

* Significant at $p < 0.05$ and ns= not significant at $p > 0.05$

The follow up test as presented in Table 9 also showed that samples obtained at the base were significantly different from those obtained at the middle and top, therefore indicating that samples obtained at the base are preferred. While, the MCS_{II} of samples obtained at the middle and top were not significantly different from each other.

Table 9

Follow-up Test for Sampling Height

Sampling Height	MCS_{II} Mean±SDV
Base	33.53 ^a ±2.01
Middle	25.84 ^b ±1.59
Top	24.87 ^b ±1.45

Mean with the same alphabet in the same column are not significantly different ($p < 0.05$) from one another

CONCLUSION

The study showed that density and strength properties were influenced by sampling height and rattan location. The study revealed that density decreased from base to top of the *L. secundiflorum* stems of the two ecological zones. The study further revealed that along the axial direction from base to top, modulus of rupture, modulus of elasticity and maximum compressive strength parallel to grain decreases. The study showed that samples obtained at the base were denser and the strongest in terms of strength compared to samples obtained at the middle and top portion of the *L. secundiflorum* stems of the two ecological zones.

The study also showed that *L. secundiflorum* samples sourced from rain forest were denser and had better strength (but, not significantly different) compared to those sourced from fresh water swamp.

REFERENCES

- Abd. Latif M (1991) Guidelines for the Selection and Preparation of Rattan for Industrial Use. Rattan Information Centre Handbook 2:1-27.
- Abd. Latif M (1992) Processing of Rattans. In: W.M. Wan Razali, J. Dransfield & N. Manokaran (eds.). Guide to the Cultivation of Rattan, pp. 239-260. Malayan Forest Record 35. Forest Research Institute of Malaysia.
- Abd. Latif M, Norralakman YS (1993) Anatomical Characteristics of Five Malaysian Canes and its Relationship with Physical and Mechanical Properties. In: S. Chand Basha and K.M. Bhat (eds.). Rattan Management and Utilization, pp. 207-213. Proceedings of the Rattan (Cane) Seminar India. January 29-31, 1992. Trissur, Kerala, India.
- Abd. Razak MA, Abd. Latif M, Khoo KC, Kasim J (1995) Physical Properties, Fibre Dimensions and Proximate Chemical Analysis of Malaysian Rattans. *Thailand Journal of Forestry*. Vol. 14:59 – 70.
- Ahmad M (2000) Analysis of Calcutta bamboo for structural Composite materials. A Ph.D thesis in Wood Science and Forest Products, Virginia Polytechnic Institute and State University. August 11, 2000, Blacksburg, Virginia. Pp. 210.
- ASTM D143-52 (1972) Standard methods of testing small clear specimens of timber, West Conshohocken.
- ASTM D1037-94 (1994) Standard methods of evaluating the properties of wood based fibre and particle panel materials. ASTM, Philadelphia, Pa.
- ASTM D 2395-17 (2017) Standard Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials, ASTM International, West Conshohocken, PA, 2017.
- Areghan SE, Ojo AR, Ogutuga SO (2018) Density Evaluation of Raw and Laminated *Bambusa vulgaris* Schrad. with a view to Assess its Structural Application Potentials. *Journal of Forestry Research and Management*. Vol. 15(3):57-70.
- Bhat KM, Thulasidas PK, Mohamed CP (1991) Strength Properties of Ten South Indian Canes. *Journal of Tropical Forest Science* 5(1): 26-34.
- Burger LM, Ritcher HG (1991) Anatomia Da Madeira. Nobel Press, Brasil, pp. 97-105.
- Burkill IH (1966) In: *A Dictionary of the Economic Products of the Malay Peninsula*, pp. 1869–1885. HorticulturalBooks (Ed.).
- Dahunsi BIO (2000) The properties and potential application of rattan canes as reinforcement material in concrete, PhD Thesis, Faculty of Technology, University of Ibadan, Nigeria.
- Dransfield J (2001) Taxonomy, Biology and Ecology of Rattan, *Unasylva* 52(205):11–13.

- Kadir RA (2001) Variation of Strength Properties of Locally Grown *Calamus scipionum* and *Daemonorops angustifolia*. *Journal of the Institute of Wood Science*. Vol 15(6):289–296.
- Kitin P, Funada R, Sano Y, Ohtani J (2000) Analysis by confocal microscopy of the structure of cambium in the hardwood *Kalopanax pictus*. *Ann. Bot.* 86:1109–1117.
- Komolafe D (1992) Cane Makers Face Raw Material Scarcity. *Daily Times (Nigeria)* 5th August, 30pp.
- Kubler H (1980) *Wood as a Building and Hobby Material*. John Wiley and Sons, New York. 245 pp.
- Lucas EB, Dahunsi BIO (2004) Characteristics of three Western Nigerian Rattan Species in Relation to their Utilisation as Construction Material. *Journal of Bamboo and Rattan*. Vol. 3(1):45 – 56.
- Morakinyo AB (1995) The Commercial Rattan Trade in Nigeria. *Forest, Trees and People Newsletter*, Vol. 25:22–30.
- Ojo AR, Adebayo SO, Ogutuga SO (2014) Site Factor and Intra-tree Variations in the Density of *Borassus aethiopum* mart. Woods in Savannah Zones of Nigeria. *Journal of Forestry Research and Management*. Vol.11:99 – 111; 2014. ISSN: 0189-8418 available at: www.jfrm.org
- Olorunnisola AO, Adefisan OO (2002) Trial Production and Testing of Cement-Bonded Particle Board from Rattan Furniture Waste. *Wood and Fiber Science* 34(1):116-124.
- Olubanjo OO (2002) *Extensive Rattan Production-To-Consumption System in Southern Nigeria: A Case Study*. International Network for Bamboo and Rattan (INBAR), Beijing.
- Rao HS, Lal B (1968) Modelling with Cane, *The Indian Forester*. Vol. 94(8):630 – 634.
- Rulliaty S, America WA (1995) Natural variation in wood quality indicators of Indonesia big leaf Mahogany (*Swietenia macrophylla*) King. XX IUFRO. World Congress Proceeding. Tempere Finland. Pp. 220
- Strausbaugh PO (1997) Rattan, In: *Encyclopedia Americana*, Vol. 23, M. Cumming (Grolier, Danbury, CT – Ed.), pp. 269.
- Sunderland TCH (2001) Rattan Resources and Use in West and Central Africa, *Unasyiva* Vol. 52(205):18-23.