Scientific Electronic Archives
Issue ID: Sci. Elec. Arch. Vol. 14 (10)
October 2021
DOI: http://dx.doi.org/10.36560/141020211396
Article link: https://sea.ufr.edu.br/SEA/article/view/1396

ISSN 2316-9281

Longitudinal variation of wood basic density and anatomy of *Curatella americana* L.

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Abstract: Studies with *Curatella americana* L wood are justified due to scarce information about this species. In this context, we collected wood samples from six trees (ages varied between 30-40 years old) planted in Selvíria (MS-Brazil). Our objective was to verify longitudinal variation of basic density and wood anatomy. From each sampled tree, 5 cm thick discs were removed, at three different heights: base of the trunk (≈ 15cm from the ground), DBH (diameter at breast height, 1m30cm from the ground), and top of the trunk (commercial height of tree with a minimum diameter of 5 cm). We use standardized methods for basic density and wood anatomy. According to results, we concluded that basic density, fiber length, fiber wall thickness, vessel element length, vessel diameter, and vessel frequency were influenced by different heights. However, in ray percentage, no significant variation was observed. The basic density correlates positively with length and fiber wall thickness, and negatively with vessel frequency.
Keywords: lixeira, native Brazilian wood, sandpaper tree, wood properties.

Introduction

Curatella americana L. (Dilleniaceae), popularly known as "lixeira" or "sandpaper tree" is a native Brazilian species, but not endemic, naturally distributed in the North (Amazonas, Amapá, Pará, Rondônia, Roraima, Tocantins), Northeast (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe), Midwest (Distrito Federal, Goiás, Mato Grosso do Sul, Mato Grosso) and Southeast (Minas Gerais) in the Amazon Forest, Caatinga biomes, Cerrado, Atlantic Forest (Fraga, 2020).

The species frequently occurs in Cerrado and is characterized by being a semi-deciduous, heliophite and selective xerophyte plant. According to Barbosa et al. (2005) *C. americana* is one of the most abundant species in the open Cerrado areas of Roraima, in the northern end of the Brazilian Amazon.

Curatella americana trees can normally have a height of 4-10m, with a short trunk of 40-50 cm of DBH (diameter at breast height, 1m30cm from the ground). The leaves are very resistant and have a very rough surface, hence the popular name, because is like a "sandpaper" being used by local people to sand pots and sand wood (Lorenzi, 2002). Currently, we are not aware of commercialization of *C. americana* wood. However, over the years there are citations of wood use generally by local populations, *e.g.*, Corrêa (1926) mentions that wood is used for internal works in houses, joinery and carpentry. Record and Ress (1943) adds that wood was used as firewood, charcoal and fence posts. More recently, Lorenzi (2002) mentions that wood is practically used in carpentry and joinery. According to Paula and Alves (2007), *C. americana* wood has a low density (0.50 g.cm^{-3}) with thick fibers, making it difficult to work with, however it is very durable under natural conditions, but little used.

For industrial use of wood, it is important to know the variability within the tree, both in the radial direction (pith-bark) and in the longitudinal direction (base-top). In addition, wood properties can be influenced by the characteristics of each species, environmental factors, silvicultural techniques, or forest management (Kollmann and Côté, 1968; Wilkins and Kitahara, 1991; Malan and Hoon, 1992). Research that characterizes *C. americana* wood is justified due to scarce information about this species and its technological properties. One of the only studies we found was that of Araújo and Mattos Filho (1977), which performed the macroscopic anatomical description from samples from States of Pará and Goiás. Therefore, the present study aimed to investigate the longitudinal variation of basic density and wood anatomy of *C. americana* and furthermore to relate these characteristics in samples from trees planted in Selvíria, MS.

Materials and Methods

Study area and sampling

The trees studied occurred naturally in the Fazenda de Ensino Pesquisa e Extensão da Faculdade de Engenharia de Ilha Solteira/UNESP, located in Selvíria municipality, Mato Grosso do Sul State, Brazil (20º 22'S, 51º 24'W, elevation 375 m). The average annual temperature is 23 ºC, average annual rainfall is 1440 mm, and the average annual relative humidity is 67.9% (Flores et. al., 2016). Dystrophic Red Latosol (LVd) is predominant soil type (Santos et al., 2018).

The area originally had vegetation cover of Cerrado in the strict sense, after the construction of Ilha Solteira Hydroelectric Dam at the end of the 1960s, and then ceased to anthropization, began the process of natural regeneration (Calgaro et al., 2015). Thereby, we do not know precisely the age of the trees, but our estimates indicate that these trees should be 30-40 years old.

For wood collection we identified six trees, which were cut and from main trunk we removed three discs of 5 cm thick, at different heights of the tree: base of the trunk (≈ 15cm from the ground), DBH (diameter at breast height, 1m30cm from the ground), and top of the trunk (commercial height of tree with a minimum diameter of 5 cm). Table 1 shows information on the studied trees.

Table 1. Dendrometric data of *Curatella americana* trees. DBH = diameter at breast height e HT= height.

Tree	HT (m)	Base (cm)	DBH (cm)	Bole top (cm)
1	4.6	16.1	14.8	11.5
2	4.8	13.7	12.4	8.9
3	6.7	14.0	12.7	7.3
4	6.8	13.1	11.8	6.3
5	5.9	12.9	11.6	7.0
6	4.5	14.9	13.6	11.4
Mean	5.6	14.1	12.8	8.5

Basic density and wood anatomy

From each disc, we cut two samples (2x2x2cm) close to the bark, one for basic density and another for anatomy. The studied characteristics were: basic density (BD), fiber length (FL), fiber wall thickness (FWT), vessel element length (VEL), vessel diameter (VD), vessel frequency (VF) and ray percentage (RP), ray dimensions and frequency are not measured due the larger size, then we chose to determine the ray percentage.

We used the maximum moisture content method for basic density (Eq. 1) determination (ABNT, 2003).

$$\rho bas = \frac{1}{\left(\frac{m1}{m2}\right) - 0.346} \qquad \text{Eq. 1}$$

For wood anatomy, we cut small pieces from the sample sides and prepared macerations according to the modified Franklin method (Berlyn and Miksche, 1976). Then, samples were boiled in water, glycerin and alcohol (4:1:1) and transverse and tangential longitudinal sections (20 µm in thickness) were obtained with a Reichert sliding microtome. Sections were stained with a 1% solution of safranin and mounted in a solution of water and glycerin (1:1) on slides (Johansen, 1940).

The terminology and characterization of wood followed the IAWA list (IAWA Committee, 1989). All anatomical measurements were obtained from a microscope (Olympus CX 31) equipped with a camera (Olympus Evolt E330) and a computer with image analyzer software (Image-Pro 6.3).

Data analyses

Statistical tests were performed using SAS ® software for Windows (SAS Institute, Inc., 1999). Initially we performed the homogeneity of variance test with Hartley test. Subsequently, we used F test of analysis of variance according to experimental design adopted to study. Then, we applied Tukey test, whenever we observed a significant difference, at the level of 5% probability, of some treatment in F test, we also carried out a correlation study between the variables.

Results and discussion

The analysis of variance summary is presented in table 2. We verified significant variations for basic density, fiber length, fiber wall thickness, vessel diameter and vessel frequency, depending on the tree height. However, we did not observe differences in ray percentage.

The basic density, fiber length, fiber wall thickness and vessel diameter varied significantly between heights, but only the top position differed significantly from the base and DBH positions, and top position presented a lower value for all these characteristics (Table 3).

The vessel frequency showed a significant difference between base and top positions, where the highest value was found at top of trunk, and the lowest value at trunk base (Table 3).

The ray percentage and vessel element length did not differ significantly between the values in the different positions (Table 3).

Table 2. Summary of analysis of variance to basic density (BD), fiber length (FL), fiber wall thickness (FWT), vessel element length (VEL), vessel diameter (VD), vessel frequency (VF), percentage of ray (RP), of *Curatella americana*.

		Mean square						
Cause of variation	Degrees of freedom	BD (g cm^{-3})	FL (mm)	FWT (µm)	VEL (µm)	VD (µm)	VF (nºmm^{-2})	RP (%)
Axial position	2	0.0166	405960	14.53	10078	2961	21.92	82.32
Residual	33	0.0009	37084	1.139	7540.64	698.41	7.32	29.65
Mean		0.55^{**}	1715^{**}	11.16^{**}	$634^{n.s.}$	164.72^{*}	6.50^{**}	$48.84^{n.s.}$
CV_e (%)		5.71	11.22	9.56	13.68	16.04	23.45	11.14

Where: ** significant at level of 1% significance; * significant at level of 5% significance, n.s. = not significant and CVe = coefficient of experimental variation.

Table 3 – Average of basic density (BD), fiber length (FL), fiber wall thickness (FWT), vessel element length (VEL), vessel diameter (VD), vessel frequency (VF), ray percentage (RP), of *Curatella americana.*

Trunk height	BD (g.cm^{-3})	FL (µm)	FWT (µm)	VEL (µm)	VD (µm)	VF (nºmm^{-2})	RP (%)
Base	0.58a	1847a	11.8a	666a	174a	5.4b	51a
DBH	0.56a	1793a	11.7a	628a	173a	6.3ab	48a
Top	0.51b	1505b	9.8b	608a	146b	7.7a	46a

The mean value observed for basic density was 0.55 g.cm^{-3}, a value within the observed interval by Jati et. al. (2014), who found values between 0.48 to 0.60 g.cm^{-3}, however, it is higher than that obtained by Jati and Cavalcante (2020). Jati and Maulaz (2019) studied wood density of *C. americana* in two locations with different characteristics, with average density values ranging from 0.44 - 0.52 g.cm^{-3}, suggesting that differences in density must be related to environmental variations.

The basic density of *C. americana* wood showed a tendency to decrease according to the trunk height, however, only the top position differed significantly from the other positions. Eloy,et. al. (2013) in *Ateleia glazioveana* found a downward trend in density from the base to the top of trees. However, these same authors verified for *Mimosa scabrella* trees, that pattern of variation of basic specific mass, in the longitudinal direction, at 36 months of age showed a decrease from the base to the DBH region, followed by an increase, without a tendency of stabilization. with the height. Valente et al. (2013) also did not observe a characteristic pattern of variation in the longitudinal direction in *Anadenanthera peregrina*, although there was a decrease in top direction for wood density.

The length and fiber wall thickness showed the same trend as basic density, *i.e*, they tend to decrease with tree height. The top position showed the lowest values for these anatomical features. Valente et al. (2013) did not observe differences along the trunk in *A. peregrina* for fiber features.

Vessel diameter tends to decrease with tree height, while vessel frequency increases (Table 3 and Figure 1). However, in 24-year-old *Handroanthus vellosoi* trees, it was found that the diameter of the vessels is smaller at the base of the tree, and greater at the heights of 1 and 2 m according to Longui et al. (2017). Since the presence of narrower vessels at the base of the tree may be an indication of better efficiency in water transport due to pressure differences along the vessel elements (Assad et al., 2016)

In this study, we also carried out correlations between basic density and anatomical features. We found that most important relationships were basic density with fiber wall thickness, fiber length and vessel frequency. The correlations between basic density and fiber length and fiber wall thickness were positive. While the correlation between basic density and vessel frequency was negative (Table 4).

Hoadley (2000) reports that, this is because, in general terms, wood density depends on the size and thickness of the cell walls, and the interrelationship, between these characteristics. Ishiuri et. al. (2009) in a study with *Paraserianthes falcataria*, reported a correlation coefficient (r = 0.87) between fiber wall thickness and basic density. A similar result was observed by Yanchuk and Micko (1990), Butterfield et. al. (1993) and Rocha et. al. (2004) in studies with other species. In several studies with different species, it has been reported that high density is generally associated with an increase in fiber volume, and a decrease in vessel volume (Taylor and Wooten, 1973). In the present study, as shown in Table 4, a negative correlation was found between the percentage of vessels and the basic density.

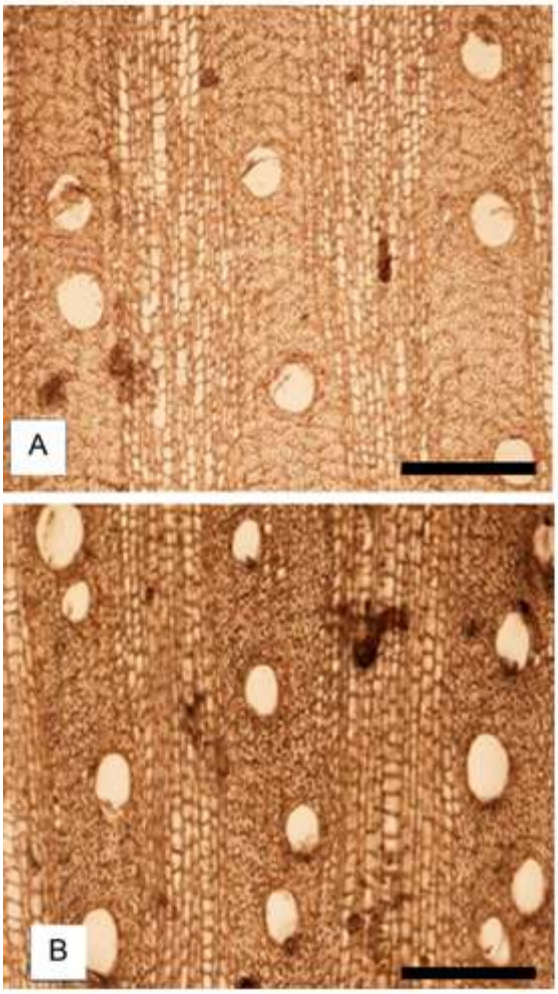

Figure 1. Photomicrographs of *Curatella americana* wood. - A and B. Transverse sections of trunk base and top region respectively. Note increase in vessel frequency (Figures A and B). Scale bar = 500µm.

Table 4. Pearson's correlation among basic density (DB) and anatomical features in *Curatella americana*.

	BD
FL	0.60**
FWT	0.58*
VEL	-0.05 n.s.
VD	0.08 n.s.
VF	-0.59**
RP	0.43 n.s.

Basic density (BD), fiber length (FL), fiber wall thickness (FWT), vessel element length (VEL), vessel diameter (VD), vessel frequency (VF), ray percentage (RP).

Conclusion

The basic density, fiber length, fiber wall thickness and vessel diameter show significant differences that vary significantly with tree height, with the top position having a lower value for these properties.

In vessel frequency there is significant variation only between base and top positions, where top position has the lowest values and the base position the highest.

For vessel element length and ray percentage, there are no differences in relation to the three positions.

The basic density correlates positively with fiber length and fiber wall thickness, and negatively with vessel frequency.

Acknowledgment

The authors thank Sonia Regina Godoi Campião and Juraci Barbosa for laboratory assistance (Forestry Institute - IF). We are grateful to the FUNDAP (Fundação do Desenvolvimento Administrativo) for a grant to Patrícia Vicentin.

References

ARAUJO, P. A. de M., MATTOS FILHO, A. de. Estrutura das madeiras brasileiras de angiospermas dicotiledôneas (XVIII). Dilleniaceae (*Curatella americana* L.). Rodriguésia 29: 233- 245, 1977.

ASSAD, A. APARECIDA. VIANNA., LONGUI, E. L., FLORSHEIM, S. M. B., LIMA, I. L., FREITAS, M. L. M., ZANATTO, A. C. S., ZANATA, MARCELO. Wood axial characterization of 32-year-old *Croton piptFcalyx* Müll. Arg. Euphorbiaceae. Revista do Instituto Florestal 28:69 - 75, 2016.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT. Normas Técnicas. NBR 11941: Densidade básica da madeira. Rio de Janeiro, 6 p. 2003.

BARBOSA, R.I., MOURAO, M., LIMA, G.M., REIS DA SILVA, S.J. Bioecologia do caimbé [*Curatella americana* L. (Dilleniaceae)] II: Estudos fenológicos. Comunicado Tecnico 15. EMBRAPA, Boa Vista Roraima, Brasil,7 p. 2005.

BERLYN, G.P., MIKSCHE, J.P. Botanical microtechnique and cytochemistry. Ames: Iowa State University, 1976.

BUTTERFIELD, R. P., CROOK, R. P., ADANS, R., MORRIS, R. Radial variation in wood specific gravity, fibre length and vessel area for two Central American hardwoods: *Hyeronima alchorneoides* and *Vochysia guatemalensis*: natural and plantation - grown trees. IAWA Journal14: 153-161, 1993.

CALGARO, H.F., BUZETTI, S., SILVA, L.R., STEFANINI, L., MIRANDA, L.P.M., MORARES, M.A., MORAES, M.L.T. Distribuição natural de espécies arbóreas em áreas com diferentes níveis de antropização e relação com os atributos químicos do solo. Revista Árvore 39: 233-243, 2015.

CORRÊA, M.P. Dicionário das plantas úteis do Brasil e das exóticas cultivadas. Rio de Janeiro, Imprensa Nacional, 747 p. 1926.

ELOY, E., CARON, B.O., TREVISAN, R., SCHMIDT, D., ZANON, M.L.B., BEHLING, A., MONTEIRO, G.C. Variação longitudinal e efeito do espaçamento na massa específica básica da madeira de *Mimosa scabrella* e *Ateleia glazioveana*. Floresta 43:327-334, 2013.

FLORES, T. B., ALVARES, C. A., SOUZA, V. C., STAPE, J. L. *Eucalyptus* no Brasil: Zoneamento climático e guia para identificação. Piracicaba: IPEF, 448 p. 2016. .

FRAGA, C.N. Dilleniaceae in Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. Disponível em: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB7337>. Acesso em: 05 Jun. 2020.

HOADLEY, R.B. Understanding Wood: A Craftsman's Guide to Wood Technology. Newtown: Taunton Press, 288 p. 2000.

ISHIGURI, F., HIRAIWA, T., IIZUKA, K., YOKOTA, S., PRIADI, D., SUMIASRI, N., YOSHIZAWA, J. Radial variation of anatomical characteristics in *Paraserianthes falcataria* planted in Indonesia. Iawa Bulletin 30:343-352, 2009.

KOLLMAN, F., COTE, W. Principles of wood science and technology. Berlin (Germany): Springer-Verlag, 419 p. 1968.

IAWA COMMITEE. List microscope features of hardwood identification. IAWA Bulletin 10:221-259, 1989.

JATI, S.R., FEARNSIDE, P.M., BARBOSA, R, I. Densidade da madeira de árvores em savanas do norte da Amazônia brasileira. Acta Amazon 44:79-86.,2014 http://dx.doi.org/10.1590/S0044-59672014000100008.

JATI, S. R., CAVALCANTE, F. F. DENSIDADE DA MADEIRA DE ARBUSTOS DAS SAVANAS ABERTAS NOS ARREDORES DO MUNICÍPIO DE BOA VISTA-RR, NORTE DA AMAZÔNIA BRASILEIRA. Revista Geografica Academica 3:37-47, 2020.

JATI, S. R., MAULAZ, C. DENSITY OF Curatella americana and Byrsonima crassifolia WOOD IN ECOTON AND CENTRAL REGION IN SAVANA ABERTA DE RORAIMA, BRAZIL. Revista Geografica Academica 13: 62-73, 2019.

JOHANSEN, D. A. Plant microtecniques. New York. McGraw-Hill, 523p., 1940.

LONGUI, E. L., OLIVEIRA, I. R. D., GRAEBNER, R. C., FREITAS, M. L. M., FLORSHEIM, S. M. B., GARCIA, J. N. Relationships among wood anatomy, hydraulic conductivity, density and shear parallel to the grain in the wood of 24-year-old Handroanthus vellosoi (Bignoniaceae). Rodriguésia 68:1217-1224, 2017.

LORENZI, H. Árvores Brasileiras - Manual de Identificação e cultivo de plantas arbóreas nativas do Brasil, vol.1. 4ª Edição - Instituto Plantarum, 352 p. 2002.

MALAN, F. S., HOON, M. Effect of initial spacing and thinning on some wood properties of *Eucalyptus grandis*. South African Forestry Journal 163:13-20, 1992.

PAULA, J. E. de; ALVES J. L. de H. 897 Madeiras nativas do Brasil. Porto Alegre, RS. Cinco Continentes Editora LTDA, 279 p. 2007.

RECORD, S.J.; HESS, R.W. Timbers of the New World. Yale University Press, New Haven, 602 p.1943.

ROCHA, F. T.; FLORSHEIM, S. M. B.; COUTO, H. T. Z. Variação das dimensões dos elementos anatômicos da madeira de árvores de *Eucalyptus grandis* Hill ex Maiden aos sete anos. Revista do Instituto Florestal 16:43-55, 2004.

VALENTE, B. M. R. T., EVANGELISTA, W. V., SILVA, J. C., LUCIA, M. D. Variation in the pith-to-bark and in the height directions of the physical and anatomical properties of the wood of angico-vermelho. Scientia Forestalis 41: 485–496, 2013.

SANTOS, H. G.; JACOMINE, P. K. T.; ANJOS, L. H. C.; OLIVEIRA, V. A.; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A.; ARAUJO FILHO, J. C.; OLIVEIRA, J. B.; CUNHA, T. J. F. Sistema brasileiro de classificação de solos. 5. ed. Brasília: Embrapa, 356 p. 2018.

S.A.S. Institute Inc. SAS Procedures Guide. Version 8 (TSMO). SAS Institute Inc. Cary, N.C., 27513, USA, 1999.

TAYLOR, F. W., WOOTEN, T.E. 1973. Wood property variation of Mississippi delta hardwoods. Wood and Fiber 5:2-13,1973.

WILKINS, A.P., KITAHARA, R. Relationship between growth strains and rate of growth in 22-year-old *Eucalyptus grandis*. Aust For, 54:95–98, 1991.

YANCHUK, A.D.; MICKO, M.M. Radial variation of wood density and fiber length in trembling aspen. Iawa Bulletin 11:211-215, 1990.