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GROWTH DYNAMICS OF *Anadenanthera colubrina* var. *cebil* AND *Tabebuia impetiginosa* FROM PANTANAL MATO-GROSSENSE, BRAZIL

DINÂMICA DE CRESCIMENTO DE *Anadenanthera colubrina* var. *cebil* E *Tabebuia impetiginosa* DO PANTANAL MATO-GROSSENSE, BRASIL

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ABSTRACT

There is a great demand for wood within tropical natural forests and a scarcity of available data to carry out a management program. It is of great importance, therefore, that growth ring information is being enhanced. The Pantanal of Nhecolândia, sub-region of Pantanal Mato-grossense, may be viewed as one of these regions. Its natural forests are systematically cut to be used as solid wood or fuel, or replaced by cultivated pastures. Peculiar climatic and soil factors of Nhecolandia induce the formation of annual growth rings. This work aims at determining the radial increments of *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa* by growth ring analysis. Disks from eight trees of *Anadenanthera colubrina* var. *cebil* and six of *Tabebuia impetiginosa* were collected, in July 1996, in Nhumirim Farm, *Embrapa Pantanal*, located in Nhecolandia sub-region. The trees of *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa* were 14 to 30 and 15 to 30 years old, respectively. Diameter increment varied from 5.4 to 8.0 mm/year for *Anadenanthera colubrina* var. *cebil* and from 4.8 to 11.6 mm/year for *Tabebuia impetiginosa*. The average estimated time for both species to reach a diameter of 40 cm was 55 years.

Keywords: dendrochronology; tropical trees; diameter increment; growth rings.

RESUMO

O uso de informações obtidas por estudos com anéis de crescimento é cada vez mais freqüente e são muito importantes para florestas naturais tropicais onde a demanda por madeira é grande, mas geralmente não existem dados disponíveis sobre o crescimento das espécies arbóreas para a estruturação de programas de manejo. O Pantanal da Nhecolândia, sub-região do Pantanal Mato-Grossense, pode ser visto como uma dessas regiões onde as florestas naturais são sistematicamente cortadas para extração de madeira, ou para implantação de pastagens cultivadas. Fatores climáticos e edáficos, característicos do Pantanal, sub-região da Nhecolândia, induzem a formação de anéis anuais de crescimento. Objetivou-se, com este trabalho, determinar a idade e os incrementos radiais de *Anadenanthera colubrina* var. *cebil* e *Tabebuia impetiginosa*, pela análise dos anéis de crescimento. Discos de oito árvores de *Anadenanthera colubrina* var. *cebil* e seis de *Tabebuia impetiginosa* foram coletados em julho de 1996, na fazenda Nhumirim, de propriedade da *Embrapa Pantanal*, localizada na sub-região da Nhecolândia. As árvores de *Anadenanthera colubrina* var. *cebil* e *Tabebuia impetiginosa* apresentavam 14 a 30 e 15 a 30 anos respectivamente, com crescimento anual médio, em diâmetro a 1,3 m do solo, variando de 5,4 a 8,0 mm em *Anadenanthera colubrina* var. *cebil* e de 4,8 a 11,6 mm em *Tabebuia impetiginosa*. O tempo médio para *Anadenanthera colubrina* var. *cebil* e *Tabebuia impetiginosa* atingirem 40 cm de diâmetro foi estimado em, no mínimo, 55 anos.

Palavras-chave: dendrocronologia; árvores tropicais; incremento diamétrico; anéis de crescimento.

INTRODUCTION

Studies of growth rings in tropical trees are becoming more frequent. Their importance is related to the knowledge of the environmental factors that influence the growth rates, the wood production and its quality, the rotation period and the replacement rates. That information is of great relevance for management plans or even for the maintenance of natural forests, as pointed out by Jacoby (1989).

In tropical regions where there is not a defined, non-growing season, the tendency to produce an anatomical cycle in cellular structures is greatly reduced because the formation of the growth rings depends on the occurrence of limiting factors to the growth of the trees and the genetic characteristics of each species.

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However, tropical regions may present annual growth rings when there is a seasonal variation marked by dry annual seasons, by flood periods (WORBES, 1989), or in environments with moderate dry seasons, but with well drained soils, where the trees go through a dormancy period (JACOBY, 1989; SEGUIERI *et al.*, 1995).

The sub-area of Nhecolândia, Pantanal Mato-grossense, presents seasonal climatic conditions with 80% of the rains concentrated in the summer (CADAVID GARCIA, 1984). It also presents Ferrocarbic Hidromorfic Arenic Espodossoil soils (Embrapa, 1999), with low water retention (CUNHA, 1980). Phenological studies in Nhumirim farm show total or partial loss of the leaves in *Anadenanthera colubrina* var. *cebil* (Vell.) Bren. and *Tabebuia impetiginosa* (Mart. Et DC.) Tol. during the dry season, between June and August (MATTOS *et al.*, 2003), reflecting the growth rhythm of these species (MATTOS *et al.*, 1999). The dynamics of individual growth of those species is still basically unknown.

This work was based on the hypothesis that the time for the trees from Pantanal to achieve commercial diameter is longer than the average cutting cycle established in the legislation for management of natural forests. The objective of this paper is to estimate age and average radial increment of the individuals in order to understand the dynamics of the species, thus providing basic information for the management of tropical natural forests of Pantanal.

MATERIAL AND METHODS

The disks of the stem of the trees were collected in the Nhumirim farm, located in the sub-area of Nhecolândia, district of Corumbá, Mato Grosso do Sul, property of *Embrapa Pantanal*. This sub-area shows a very typical physiognomy, with “cordilheiras” - alluvial paleodiques covered by savanna, forested savannas, semi-deciduous and gallery forested areas that are not subject to flood (RATTER *et al.*, 1988). The floods in the areas of the Pantanal out of the rivers domain are limited to the portions of low land named “baías” (RIZZINI, 1979). The Pantanal forest areas are occasionally submitted to selective cuts, fire hazards and are also used by cattle as shelter and browsing.

The trees were chosen at the forested area of the Nhumirim farm, from Embrapa Pantanal, as an exploratory selection, by its trunk and canopy formation. *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa* were selected due to the possibility to visualize the growth rings and also because these species present economic value and they are very common in the region.

The height of the trees was measured after they fell down, before taking sample disks. Information about the trees is presented in Table 1. Cross sections were collected from eight trees of *Anadenanthera colubrina* var. *cebil* and six of *Tabebuia impetiginosa* at 1.3 m (Diameter at Breast Height – DBH) and at 0.3, 2.5; 5.0; and 7.5 m height. After drying at air temperature, each disk was sanded progressively with sandpaper of granulation 40, 80, 120 and 220.

The growth rings in the collected disks were counted and measured with a stereoscopic microscope. Due to the shape irregularities, eight rays were measured on each disk. The growth rings were measured with accuracy of 0.01 mm. The data were processed with the program *Time Series Analysis and Presentation*– TSAP (RINN, 1996). The average annual increment of the rays was calculated using the quadratic average.

The age of the trees was estimated, considering the annual formation of the growth rings for these species (MATTOS *et al.*, 1999), counting the number of growth rings in the lowest disk (0.30 m of height from the soil). The age of the trees at different heights was estimated by the difference between the number of growth rings of the lowest disk and the one at the considered height.

RESULTS AND DISCUSSION

The estimated average age of *Anadenanthera colubrina* var. *cebil* trees was 20 years, with a minimum of 14 and maximum of 30 years of age. The average height of the trees was 11 m, with minimum of 8.5 m and maximum of 16 m (Table 2).

TABLE 1: Total height, DBH, total volume, stem form of *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa*, in the sub-area of the Nhecolândia, MS.

TABELA 1: Altura total, DAP, volume total, forma de tronco de *Anadenanthera colubrina* var. *cebil* e *Tabebuia impetiginosa*, na sub-região da Nhecolândia, MS.

Tree	Total height	Estimated merchantable height	DBH	Merchantable volume (m^3)	Merchantable form factor
Anadenanthera-7	11.0	8.0	10.4	0.042	0.62
Anadenanthera-8	13.5	12.5	14.2	0.115	0.58
Anadenanthera-2*	16.0	12.5	14.1	0.147	0.75
Anadenanthera-10	10,0	6.0	8.4	0.023	0.69
Anadenanthera-4*	13.0	10.0	16.7	0.157	0.72
Anadenanthera-5	9.5	7.5	8.9	0.035	0.75
Anadenanthera-9	8.5	7.5	8.8	0.030	0.66
Anadenanthera-6	10.0	7.5	14.2	0.087	0.73
Tabebuia-1	10.0	7.5	12.7	0.039	0.41
Tabebuia-9	11.0	7.5	10.7	0.036	0.53
Tabebuia-5	8.5	4.5	7.7	0.018	0.86
Tabebuia-6	10.5	8.5	12.5	0.055	0.53
Tabebuia-8	9.0	7.5	9.2	0.022	0.44
Mean	10.8	8.2	11.4	0.060	0.64
CV%	20.2	27.6	25.2	80.600	20.40

TABLE 2: Age, age at DBH, diameter and mean diameter increment, minimum, maximum and average diameter increment of the last five growth rings, at DBH of *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa,* in the sub-area of the Nhecolândia, MS.

TABELA 2: Idade, idade à altura do peito, diâmetro e incremento médio, mínimo, máximo e incremento médio do diâmetro dos últimos cinco anéis de crescimento, à altura do peito, de *Anadenanthera colubrina* var. *cebil* e *Tabebuia impetiginosa*, na sub-região da Nhecolândia, MS.

Tree	Age (years)	Age at DBH (years)	Diameter (cm)	Diameter increment			
				Mean (mm)	Minimum (mm)	Maximum (mm)	Average of the last five years (mm)
Anadenanthera-7	14	13	10.4	8.0	3.2	13.8	10.6
Anadenanthera-8	19	18	14.2	8.0	2.8	16.0	10.4
Anadenanthera-2*	30	20	14.1	7.0	3.6	10.4	7.0
Anadenanthera-10	14	12	8.4	7.0	3.6	10.8	7.0
Anadenanthera-4*	26	24	16.7	7.0	3.2	12.2	7.8
Anadenanthera-5	14	14	8.9	6.4	2.2	11.6	6.6
Anadenanthera-9	15	15	8.8	5.8	2.0	13.4	8.8
Anadenanthera-6	27	26	14.2	5.4	2.0	8.8	4.2
Tabebuia-1	16	11	12.7	11.6	2.4	21.8	11.0
Tabebuia-1	16	11	12.7	11.6	2.4	21.8	11.0
Tabebuia-9	17	15	10.7	7.2	4.4	12.6	6.6
Tabebuia-5	30	11	7.7	7.0	3.8	13.2	7.6
Tabebuia-6	15	15	12.5	5.0	2.2	8.0	6.0
Tabebuia-7	-	22	10.8	5.0	1.6	11.0	6.0
Tabebuia-8	20	19	9.2	4.8	2.2	9.2	6.2

In that: * = Samples taken at 2.5 m height.

The age of *Anadenanthera colubrina* var. *cebil* trees in different heights is represented in Figure 1a. The growth, up to 6 m, was similar in six trees reaching this height in approximately seven years. Two trees presented slow initial growth in height. However, they recovered the vigor after ten years, one of them reaching 16 m in thirty years (Tree-2) and the other reaching 10 m height at 27 years (Tree-6).

The diameter growth was slow in the first five years, as measured in the base disks. The mean annual increment in diameter at breast height was 4.6 mm, with minimum of 2.8 and maximum of 7.0 mm (Table 2). The trees with the slowest diameters growth increment (Tree-6 AND 9) did not correspond to the trees with the lowest heights increment (Figure 1a). The initial growth in height was very slow in Tree-2 similar to what was observed in the diameter increment (3.1mm). Trees with increment near or above the average diameter increment rates were the ones that presented better initial height increment.

The volume equations for both species were estimated (Table 3), but they must be considered with restrictions, as the number of trees used to generate these equations was very small.

TABLE 3: Volume equation fitted for *Anadenanthera colubrina* var. *cebil* and *Tabebuia impetiginosa*, in the sub-area of Nhecolândia, MS.

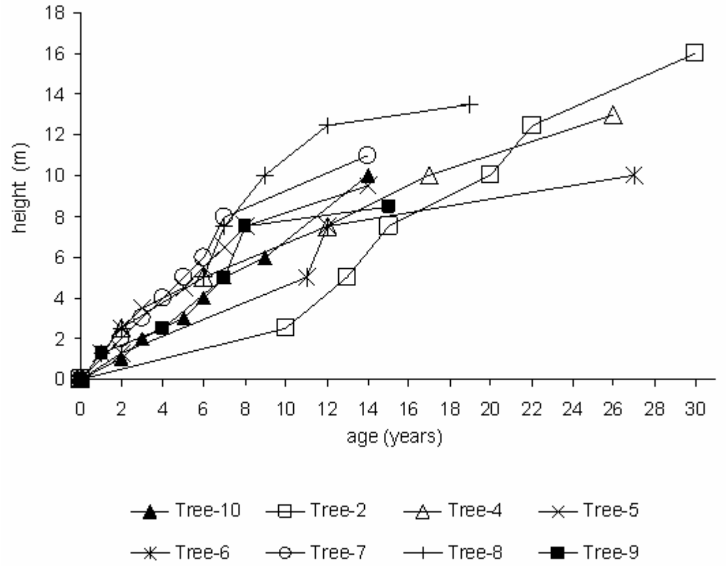
TABELA 3: Equações de volume ajustadas para *Anadenanthera colubrina* var. c*ebil* e *Tabebuia impetiginosa*, na sub-região da Nhecolândia, MS.

Species	Linear equation	R²	CV %
Anadenanthera colubrina var. *cebil*	y = - 0.0001 + 0.00005D	0.97	13.7
Tabebuia impetiginosa	y = 0.0065 + 0.005D	0.87	17.9

In that: y = volume; x = squared diameter at breast height times merchantable height.

At breast height, in spite of the great variation of age (12 to 20 years) and diameters (8.4 to 16.7 cm), there was an average diameter increment of 6.5 mm, with minimum of 5.4 cm and maximum of 8.0 cm (Table 2). Tree-6 presented the lowest increment in height and also presented the lowest mean diameter increment (5.4 mm). Nevertheless, the secondary diameter growth at breast height among the trees showed differences after the fifth to seventh year of age, as it can be verified for the transversal area of the stem at DBH (Figure 1b). The data in Table 2 indicate that Tree-6 and Tree-9 presented similar mean diameter increment; however, Tree-9 presented average growth in the last five years, higher than the average growth of the studied population. This was probably due to local environmental variation, as opening of a forest gap.

The estimated average age of *Tabebuia impetiginosa* trees was 20 years, with a minimum of 15 and maximum of 30 years. The average height of the trees was 10 m, with minimum of 8.5 and maximum of 11 m (Table 2).



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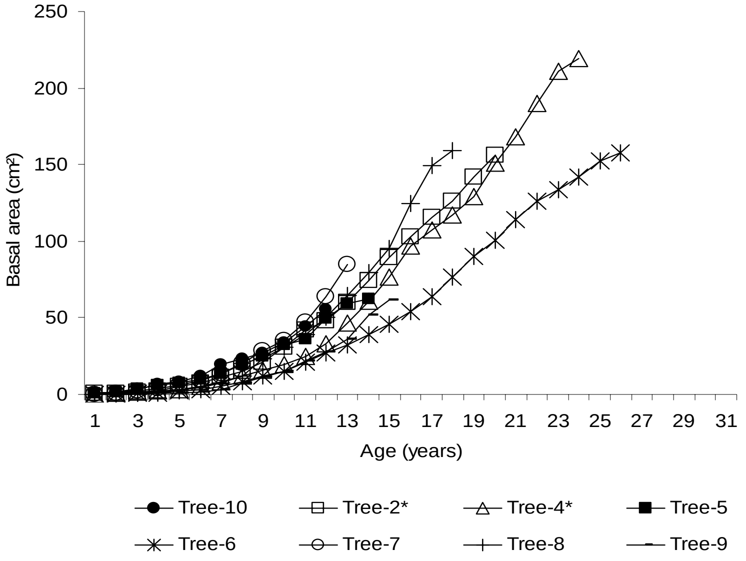
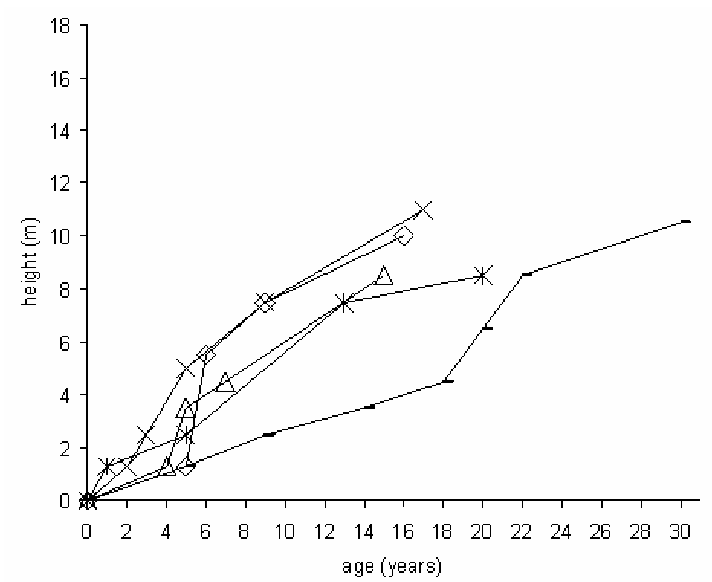


b

FIGURE 1: Evolution of height and basal area (cm^2) according to age in disks taken at DBH of *Anadenanthera colubrina* var. *cebil.*

FIGURA 1: Evolução em altura e área basal (cm^2) de acordo com a idade nos discos retirados a altura do peito de *Anadenanthera colubrina* var. *cebil.*

The ages of *Tabebuia impetiginosa* trees in different heights are represented in Figure 2a. Although six trees of this species were collected, only five were considered for the discussion of height increment compared to age, because the age estimate of Tree-7 was harmed due to damages presented in the basal disk. Four trees reached four meters in height in seven years. However, Tree-5 presented very slow initial height growth, and it only reached 4 m in height after 15 years.



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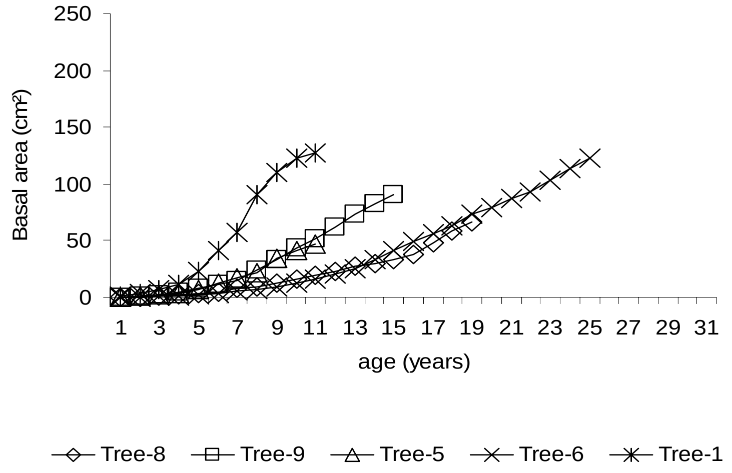

b

FIGURE 2: Evolution of height and basal area (cm^2) according to the age in disks taken at DBH of *Tabebuia impetiginosa*.

FIGURA 2: Evolução em altura e área basal (cm^2) de acordo com a idade nos discos retirados a altura do peito de *Tabebuia impetiginosa.*

The mean annual diameter increment was 5.5 mm/year, with minimum of 2.9 mm and maximum of 9.5 mm. The slowest diameter growth (Tree-6) did not correspond to the lowest initial height development (Tree-5), as presented in Figure 2a.

There was a great variation in the mean annual diameter increment at DBH for this species, with an average of 6.8 mm, varying from a minimum of 4.8 to a maximum of 11.6 mm (Table 2). The tree with the highest diameter was Tree-1, the same tree which presented the highest initial growth in diameter and which is also among the best according to the height growth. The sectional area accumulated at 1.3 m showed differences from the second year on, with TREE-1 presenting the best development (Figure 2b). The growth rhythm of Trees-7, 8 and 6 is lower, increasing only after the 15th year. The other trees (Trees-5 and 9) presented intermediary growth. Tree-1 presented higher mean increment in the last years (11.0 mm); the others reached around 6.0 and 7.6 mm in mean diameter increment in the last five years (Table 2).

The annual variation of diameter increment found among trees of the same species as in *Anadenanthera colubrina* var. cebil (0.54 to 0.80 cm) and *Tabebuia impetiginosa* (0.48 to 1.16 cm) was expected, as described in similar situations as mentioned by Worbes (1989) for *Tabebuia barbata* (E.Mey.) Sandwith, which varied from 0.20 cm to 0.94 cm annual increment, in trees of 18 to 94 years-old.

Considering the average increment of the last five years (Table 2), it was possible to estimate the age that each tree of *Anadenanthera colubrina* var. *cebil* would reach 40 cm diameter at DBH, in case it maintained the same increment tendency. Except for Tree-6, whose development was visibly slower, the trees of this species would take on average 55 years, varying from 44 to 63 years, to reach this diameter. The same was estimated for *Tabebuia impetiginosa*, where the same average was verified (55 years). In this case, Tree-1 would reach 40 cm faster, in 36 years, and the others would take from 45 to 80 years (Trees-5, 6, 8, 9). So, it is possible to estimate the minimum period of rotation necessary to manage these species in natural forests, without endangering the continuous use of those resources.

Despite several works having focused on the existence of annual growth rings in native species, information on annual increment in the environment of natural tropical forests is very scarce. Growth data observed in plantations of native species are more frequent. In plantations tests, in different areas of Brazil, it was observed that growth in height and diameter was above those of the sampled trees in the Pantanal area for *Anadenanthera colubrina* (CARVALHO, 1994; SILVA and TORRES, 1992) and *Tabebuia impetiginosa* (CARVALHO, 1994; GARRIDO *et al.*, 1990; LIMA *et al.*, 1982; SANTARELLI, 1990; SILVA and

TORRES, 1992; TOLEDO FILHO, 1988). However, different growing rates of the same species are expected when one moves from natural forests to planted conditions (GOURLAY, 1995).

Under current conditions of the sub-area of Nhecolandia, a minimum period of a 55-year-cycle for the exploitation of *Tabebuia impetiginosa* and *Anadenanthera colubrina* var. *cebil* is suggested and, also, the implementation of silvicultural practices in order to stimulate greater growth on the trees. According to Rizzini (1970), the increasing yield in areas of Savanna (Cerrado) can only be achieved by adopting appropriate silvicultural practices.

CONCLUSIONS

The trees of *Anadenanthera colubrina* var. *cebil* were from 14 to 30 years-old, with mean annual diameter increment varying from 5.4 mm to 8.0 mm, at DBH.

The trees of *Tabebuia impetiginosa* were from 15 to 30 years-old, with mean annual diameter increment varying from 4.8 mm to 11.6 mm, at DBH.

The estimated average time for trees of *Anadenanthera colubrina* var. *cebil* and of *Tabebuia impetiginosa* to reach stem with 40 cm of diameter was a minimum of 55 years.

REFERÊNCIAS BIBLIOGRÁFICAS

CADAVID GARCÍA, E. A. **O clima no Pantanal Mato-grossense**. Corumbá: EMBRAPA-UEPAE de Corumbá, 1984. 39p. (EMBRAPA-UEPAE de Corumbá. Circular técnica, 14).

CARVALHO, P. E. R. **Espécies florestais brasileiras**: recomendações silviculturais, potencialidades e uso da madeira. Colombo: EMBRAPA-CNPF. Brasília: EMBRAPA-SPI, 1994. 639p.

EMBRAPA. **Sistema brasileiro de classificação de solos**. Brasília: Embrapa Solos, Rio de Janeiro & Embrapa Produção de Informação, 1999.

CUNHA, N. G. **Considerações sobre os solos da sub-região da Nhecolândia, Pantanal Mato-grossense**. Corumbá: EMBRAPA-UEPAE de Corumbá, 1980. 45p. (EMBRAPA-UEPAE de Corumbá. Circular técnica, 1).

GARRIDO, M. A. de O. *et al.* Pesquisa e experimentação com cinco espécies nativas. In: CONGRESSO FLORESTAL BRASILEIRO, 6., 1990, Campos de Jordão. **Anais**. São Paulo: Sociedade Brasileira de Silvicultura, 1991, v. 3, p. 602-610.

GOURLAY, I. D. Growth ring characteristics of some African *Acacia* species. **Journal of Tropical Ecology**, New York, v. 11, p. 121-140, 1995.

JACOBY, G. C. Overview of tree-ring analysis in tropical regions. **IAWA Journal**, Utrecht, v. 10, n. 2, p. 99-108, 1989.

LIMA, P. C. F.; SOUZA, S. M. de; DRUMOND, M. A. Competição de espécies florestais nativas em Petrolina, PE. **Silvicultura em São Paulo**, São Paulo, v. 16A, pt. 2, p. 1139-1148, 1982. Edição dos Anais do 1º Congresso Nacional sobre Essências Nativas, Campos do Jordão, 1982.

LORENZI, H. **Árvores brasileiras**: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Nova Odessa: Plantarum, 1992. 352p.

MATTOS, P. P. de; SEITZ, R. A.; BOLZON de MUNIZ, G. I. Identification of annual growth rings based on periodical shoot growth. In: WIMMER, R; VETTER, R. E. (Org.). **Tree ring analysis**. Wallingford: CAB Publ., 1999. v. 1, p. 139-145.

MATTOS, P. P. de; TEIXEIRA, L. L.; SEITZ, R. A.; SALIS, S. M. de; BOTOSSO, P. C. **Anatomia de madeiras do Pantanal Mato-grossense (Características microscópicas) = Anatomy of Pantanal Mato-Grossense woods (Microscopic features) = Anatomie des bois du Pantanal Mato-Grossense (Caractéristiques microscopiques).** Colombo: Embrapa Florestas; Corumbá, Embrapa Pantanal, 2003. 182p.

POTT, A.; POTT, V. J. **Plantas do Pantanal**. Brasília: EMBRAPA, 1994. 320p.

RATTER, J. A.; POTT, A; POTT, V. J.; CUNHA, C. N.; HARIDASAN, M. Observations on woody vegetation types in the Pantanal and at Corumbá, Brazil. **Notes RBG**, Edingurgh, v. 45, n. 3, p. 503-525, 1988.

RINN, F. **TSAP, version 3.0, reference manual**: computer program for tree ring analysis and presentation. Heidelberg: Dipl.-Phys., 1996. 263p.

RIZZINI, C. T. Sobre alguns aspectos do Cerrado. **Brasil Florestal**. Rio de Janeiro, v. 1, n. 1, p. 20-34, 1970.

RIZZINI, C. T. **Tratado de fitogeografia do Brasil**. São Paulo: Ed. da USP, 1979. v. 2. 374p.

SANTARELLI, E. G. Comportamento de algumas espécies vegetais na recomposição de matas nativas. In: CONGRESSO FLORESTAL BRASILEIRO, 6., 1990, Campos de Jordão. **Anais**. São Paulo: Sociedade Brasileira de

Silvicultura, 1991. v. 3, p. 232-235.

SILVA, L. B. X.; TORRES, M. A. V. Espécies florestais cultivadas pela COPEL – PR (1974-1988). **Revista do Instituto Florestal**, v. 4, pt. 2, p. 585-594. 1992. Edição dos Anais do 2º Congresso Nacional sobre Essências Nativas, 1992, São Paulo. Edição especial.

TOLEDO FILHO, D. V. de. Competição de espécies arbóreas de cerrado. **Boletim Técnico do Instituto Florestal**, São Paulo, n. 42, p. 61-70, 1988.

VELOSO, H. P.; RANGEL FILHO, A. L. R.; LIMA, J. C. A. **Classificação da vegetação brasileira, adaptada a um sistema universal**. Rio de Janeiro: IBGE. Departamento de Recursos Naturais e Estudos Ambientais, 1991. 123p.

WORBES, M. Growth rings, increment and age of trees in inundation forests, savannas and a mountain forest in the neotropics. **IAWA Journal**, Utrecht, v. 10, n. 2, p. 109-122, 1989.