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QUALITATIVE AND QUANTITATIVE ASSESSMENT OF AFFORESTATION IN THE FLAMBOYANT NEIGHBORHOOD IN CHAPADÃO DO SUL, MATO GROSSO DO SUL – BRAZIL

Edmara Aparecida Lourenço Pelegrim[1]; Ana Paula Leite de Lima[2]; Sebastião Ferreira de Lima[3]

ABSTRACT

Aiming to quantify and qualify trees and shrubs in the Flamboyant neighborhood in the city of Chapadão do Sul – Mato Grosso state – Brazil –, we carried out a survey to analyze all individuals (trees, shrubs and palm trees) found on the streets of this neighborhood. A total of 1,228 individuals from 31 species and 18 botanical families were identified, and *Licania tomentosa* was the most predominant species (32.33%). From the total, 48.4% and 51.6% were native and exotic, respectively. We found an average of 106.6 trees per kilometer of sidewalk, a value considered appropriate for urban afforestation. From the total plants surveyed, 43.16% presented the first fork below of 1.80 m and 54.56% was in current or potential contact with electric wiring. We also observed that 25.32% showed root outcropping and/or damage to sidewalks and 60.91% was planted in paved floors. Regarding management actions implemented, 86.34% was control actions and 12.46% was light pruning, whilst heavy pruning had no significant occurrence. Although no major problems related to the quality of plants was detected, a better planning for tree planting is required, involving the choice for appropriate species for each site, species management in plant nurseries and on the public streets of the Flamboyant neighborhood.

Keywords: Plants inventory; Urban trees; Planning.

AVALIAÇÃO QUALITATIVA E QUANTITATIVA DA ARBORIZAÇÃO NO BAIRRO FLAMBOYANT EM CHAPADÃO DO SUL, MS

Edmara Aparecida Lourenço Pelegrim[4]; Ana Paula Leite de Lima[5]; Sebastião Ferreira de Lima[6]

RESUMO

Com o objetivo de quantificar e qualificar a arborização do bairro Flamboyant, no município de Chapadão do Sul, MS, foi realizado um censo, analisando-se todos os indivíduos (árvores, arbustos e palmeiras) encontrados nas ruas desse bairro. Foram inventariados 1228 indivíduos distribuídos em 31 espécies e 18 famílias botânicas, sendo *Licania tomentosa* a espécie mais freqüente (32,33 %). Dessas espécies, 48,4 % eram nativas e 51,6 % exóticas. Foi obtido um número médio de 106,6 árvores por quilômetro de calçada, valor esse considerado adequado para a arborização urbana. Dos indivíduos mensurados, 43,16 % apresentaram a primeira bifurcação abaixo de 1,80 m e 54,56 % encontrava-se em contato atual ou potencial com a fiação. Observou-se ainda que 25,32 % apresentaram afloramento de raiz e ou danos à calçada e 60,91 % tinham colo pavimentado. Quanto às ações de manejo executadas, 86,34 % tratava de ações de controle e 12,46 % de poda leve. A poda pesada não teve ocorrência expressiva. Embora não tenham sido detectados grandes problemas relacionados à qualidade dos indivíduos, é necessário um melhor planejamento da arborização, que envolva a escolha da espécie adequada para cada local, o manejo das espécies, no viveiro e nas vias públicas deste bairro.

Palavras-chave: Inventário; Árvores urbanas; Planejamento.

[1] Graduanda em Licenciatura de Biologia a Distância da UFMS, Pólo Chapadão do Sul, MS, edmaraaplp@hotmail.com
[2] Dra. em Ciências Florestais, Professora da UFMS, campus de Chapadão do Sul, MS**,** paula.leite@ufms.br
[3] Dr. em Fitotecnia, UFMS, campus Chapadão do Sul, MS, sebastiao.lima@ufms.br.
[4] Graduanda em Licenciatura de Biologia a Distância da UFMS, Pólo Chapadão do Sul, MS, edmaraaplp@hotmail.com
[5] Dra. em Ciências Florestais, Professora da UFMS, campus de Chapadão do Sul, MS**,** paula.leite@ufms.br
[6] Dr. em Fitotecnia, UFMS, campus Chapadão do Sul, MS, sebastiao.lima@ufms.br.

INTRODUCTION

Urban afforestation can be defined as a set of natural or cropped tree vegetation that a city has, which is represented in private areas, such as squares, parks, public roads and in other green spaces (GONÇALVES; ROCHA, 2003).

The first trees planted on public roads were registered in Persia, Egypt and India, however, Paris – France – was the first city (1660) to present an afforested street to beautify the city, protect from military moves acting as material for barricades (TAKAHASHI, 1992).

In Brazil, according to Dantas and Souza (2004), urban afforestation started a little over than 120 years ago, which is a relatively new practice in comparison to European countries. According to Toledo (1993), 73% of the Brazilian population dwells in cities, and it justifies, therefore, the concern for adequate planning and management of the urban environment, among which, urban afforestation.

Among the numerous benefits that urban afforestation provide, we underscore the lessening of sonic, visual and air pollutions through the purification of air; the absorption of carbon dioxide and the retention of solid particles suspended in the air; protection against winds and rains; partial absorption of solar rays providing shades; increase of areas for water infiltration; soil protection against erosion; the maintenance of microclimate balance through the reduction of temperature range and increase of relative humidity in the air; aesthetic and landscape enhancement and attraction of local fauna. All of these factors combined provide welfare to the population and increase physical and mental health of the residents (ROCHA; LELES; OLIVEIRA NETO, 2004).

However, it is required an adequate planning for urban afforestation to provide these benefits, which encompasses lengthy knowledge of the qualitative and quantitative tree species used in urban afforestation that allows interventions with greater chances for success. A sine qua non condition for planning is a survey of urban trees to provide basis for a diagnosis of the actual afforestation in a city (RACHID; COUTO, 1999).

The choice for the species to be planted is of extreme importance so that the trees provide the expected benefits to the cities. According to Paiva (2009), this choice should be based on their structural and aesthetical characteristics (size, crown volume, physical characteristics of wood, morphology and color of leaves, color of flowers, texture, ratio between BHD and size, structure and deepness of roots and trunk aspects) as well as ecological features (phenology, life cycle, climate adaptability, resistance to pests and diseases, tolerance to urban stress, shade, physical damages and pruning). We should also consider the chemical characteristics of the trees, such as their allergenic and toxic principles.

Regarding the planting design of tree species on public roads, Santos and Teixeira (2001) does not recommend the planting of a variety of tree species in one block, given that this procedure hinders the management of trees, besides the use of different species does not characterize the landscape and generates visual confusion once different species have distinct behaviors. According to COELBA (2002), some authors suggest that each street have a given species. Others also suggest that different species can be used; however, one species should prevail on each side of the street.

The most common problems involving road afforestation without a previous planning is the planting of large-sized species in inadequate sites. This is a common procedure in cities in Brazil and causes serious damages to electric wiring, interruptions of power supply, clogging of sewers, obstacles to passersby and accidents involving pedestrians, vehicles or constructions (TAKAHASHI, 1992).

Qualitative and quantitative studies carried out in some cities in Brazil, e.g., Nova Iguaçu, Rio de Janeiro state (ROCHA; LELES; OLIVEIRA NETO, 2004), Franca, São Paulo state (SILVA; SILVEIRA; TEIXEIRA, 2008), Cosmópolis, São Paulo state (PAIVA, 2009) and Colorado, Rio Grande do Sul state (RABER;

REBELATO, 2010) showed situations that jeopardize the desirable growth of the tree species, including inadequate species for the space and urban use. In light of this reality, it is critical to have planning and to perform a survey on the tree assets of cities.

According to Souza et al. (1996), the objectives to carry out a survey on urban forests are: to know the tree asset, define a long-term policy for administration, establish budget previsions, prepare a management program for urban trees, identify the needs for maintenance, define intervention priorities, locate areas for planting, identify trees that require treatment or removal and use the a communication vector.

Therefore, the objective of this study was to characterize, qualitatively and quantitatively, road afforestation of the Flamboyant neighborhood in the city of Chapadão do Sul – Mato Grosso do Sul state – Brazil – to provide basis for the planning and application of mitigating actions.

MATERIALS AND METHODS

The municipality of Chapadão do Sul is situated in the microregion of Cassilândia and mesoregion of East Mato Grosso do Sul state, distant 330 km from the capital city of Campo Grande. It is located at 820 m above sea level at 18º47'39" S and 52º37'22" W with a total area of 3,850.693 km². The population consists of 19,163 inhabitants (IBGE, 2010).

The study was carried out in the neighborhood of Flamboyant, which comprises 30 blocks and 23 streets, bordering the neighborhoods of Flamboyant II and Sibipiruna.

We performed a qualitative/quantitative survey to evaluate all individuals (trees, shrubs and palm trees) planted on sidewalks, parking lots and median strips of the neighborhood. The data were collected between April 2010 and July 2010, using in a specific form, adapted from Silva Filho et al. (2002), where we collected data regarding:

a) Location and identification of the tree: collection date, name and length of the street, and name of the species (popular and scientific).

b) Dimensions of individuals: total height (m); height of the first fork (m) and BHD (cm).

c) Biology: we evaluated the general condition of the tree, crown and trunk balance, the sanitary condition and occurrence of damages.

d) Surroundings and interferences: we collected information about the tree location, street paving, root cropping, presence of aerial wiring, conflict with wiring, light poles, lighting, street signs and construction walls.

e) Definition of actions executed.

The variables "total height", and "height of the first fork" were dimensioned using a telescopic stick and the BHD was measured with a tape measure.

The other data were collected by direct observation *in loco*.

For the location of public streets, as well as their length, we carried out a planialtimetric survey of the municipality at 1:5,000 scale.

Based on the data obtained, we calculated the number of individuals per kilometer of sidewalk. This index was calculated for each street where the trees were planted.

The data were, then, processed to obtain the descriptive analysis.

RESULTS AND DISCUSSION

On the public streets of the Flamboyant neighborhood of the Chapadão do Sul municipality, we identified 1,228 individuals (trees, shrubs and palm trees) belonging to 31 different species distributed into 18 botanical families. From this total, the ten most frequent species account for 94% of the plants surveyed (Table 1).

According to Grey and Deneke (1986), the minimum number of species to homogenously compose urban afforestation of a city should be between seven and ten.

However, for a good planning of urban afforestation, Milano and Dalcin (2000) recommend that each species should not surpass 10-15% of the total individuals of a tree population. In this aspect, the species that predominate in the Flamboyant neighborhood were *Licania tomentosa* (Benth.) Fritsch. (oiti) with 32.33%, *Sapindus saponaria* L. (saboneteira) with 16.78 % and *Murraya paniculata* (L.) Jacq. (murta de cheiro) with 15.55 %, surpassing the recommendations.

From the 31 species surveyed, we verified that 48.4% were native and 51.6%, exotic. Similar to the results found by Paiva (2009) in Cosmópolis city, São Paulo state – Brazil –, where 57.7% of the species found were exotic. The author points out that this condition is common in most cities in Brazil. The author also emphasizes that it is not necessary to exclude exotic species from urban afforestation projects, however, these projects should play, in addition to the aesthetic function, a functional role, promoting environmental services and interactions with the native fauna, which in many cases is affected by the use of exotic species.

Table 1 – Frequency of occurrence of species found in urban afforestation in the neighborhood Flamboyant, Chapadão do Sul city, Mato Grosso do Sul state - Brazil.

Popular name	Scientific name	Family	O	NI	F(%)
Oiti	*Licania tomentosa* (Benth.)Fritsch.	Chrysobalanaceae	N	397	32.33
Saboneteira	*Sapindus saponaria* L.	Sapindaceae	N	206	16.78
Murta de cheiro	*Murraya paniculata* (L.)Jacq.	Rutaceae	E	191	15.56
Ipê	*Tabebuia* spp.	Bignoniaceae	N	124	10.10
Chorão	*Schinus molle* L.	Anacardiaceae	N	77	6.27
Flor da China	*Koelreuteria paniculata* Laxm.	Sapindaceae	E	52	4.23
Alfeneiro	*Ligustrum lucidum* W.T.Aiton	Oleaceae	E	41	3.34
Flamboyant	*Delonix regia* (Bojer ex Hook.) Raf.	Fabaceae	E	28	2.29
Fenix	*Phoenix roebelenii* O' Brien	Arecaceae	E	20	1.63
Espirradeira	*Nerium oleander* L.	Apocynaceae	E	19	1.55
Quaresmeira	*Tibouchina granulosa* (Desr.) Cogn.	Melastomataceae	N	11	0.90
Palmeira Imperial	*Roystonea oleracea* (Jacq.)O.F.Cook	Arecaceae	E	09	0.73
Resedá	*Lagerstroemia indica* Lam.	Lythraceae	E	09	0.73
Chapéu de Napoleão	*Thevetia peruviana* Schum.	Apocynaceae	N	07	0.57
Sibipiruna	*Caesalpinia pluviosa* DC.	Fabaceae	N	06	0.49
Canelinha	*Nectandra megapotamica* (Spreng.) Mez	Lauraceae	N	05	0.41
Cipreste	*Cupressus lusitanica* Miller	Cupressaceae	E	04	0.33
Hibisco	*Hibiscus rosa-sinensis* L.	Malvaceae	N	03	0.24
Flor da Rainha	*Lagerstroemia speciosa* Pers.	Lythraceae	E	03	0.24
Mangueira	*Mangifera indica* L.	Anacardiaceae	E	03	0.24
Gueirova	*Syagrus oleracea* (Mart.) Becc.	Arecaceae	N	02	0.16
Munguba	*Pachira aquatica* Aubl.	Malvaceae	N	02	0.16
Atemóia	*Annona cherimola* Mill.x *A. squamosa* L.	Annonaceae	E	01	0.08
Cróton	*Codiaeum variegatum* (L.) A.Juss.	Euphorbiaceae	E	01	0.08
Ingá	*Inga edulis* Mart.	Fabaceae	N	01	0.08
Pata de vaca	*Bauhinia forficata* Link	Fabaceae	N	01	0.08
Pau-Brasil	*Caesalpinia echinata* Lam.	Fabaceae	N	01	0.08
Pitanga	*Eugenia uniflora* L.	Myrtaceae	N	01	0.08
Tamarindeiro	*Tamarindus indica* L.	Fabaceae	E	01	0.08
Ficus-benjamim	*Ficus benjamina* L.	Moraceae	E	01	0.08
Ficus-benjamim rajado	*Ficus benjamina* L. var.*variegata* Blume	Moraceae	E	01	0.08
Total	**31 species**	**18 families**		**1,228**	**100**

O: origin of species; E: exotic species; N: native species; NI: number of individuals of one species found in the public streets of Chapadão do Sul, Mato Grosso do Sul; F(%): Relative frequency of occurrence, data in percentage.

Regarding the total height of the trees (Chart 1), we observed the 176 individuals (14.33%) showed height below 2 meters; 311 (25.33%) had height ranging from 2 to 4 meters; 579 individuals (47.15%) showed variable height from 4 to 6 meters, while 138 (11.24%) displayed

height between 6 and 8 meters and 24 (1.95%) above 8 meters.

The tree planting process implemented in this neighborhood, as well as in the entire city, in the last years, explains the fact that 39.66% of the individuals were represented in the first two classes of height. Furthermore, Chapadão do Sul is a young city (a little over 20 after foundation) and, therefore, most trees planted on public roads have not reached their full development yet.

Circa 32.0% of the trees (393 individuals) had BHD of 10 cm, confirming that this parcel is a result of a recent urban afforestation program (Chart 2). Trees with 10-15 cm of BHD corresponded to 22.4% (275 individuals) and between 15 and 20, accounted for 12.8% of the population. We observed that 54.4% of the individuals displayed BHD lower than 15 cm, which shows that the trees planted on the streets of this neighborhood are still in the developmental stage.

Chart 1. Height classes of individuals found in urban afforestation in the Flamboyant neighborhood, Chapadão do Sul city, Mato Grosso do Sul state – Brazil.

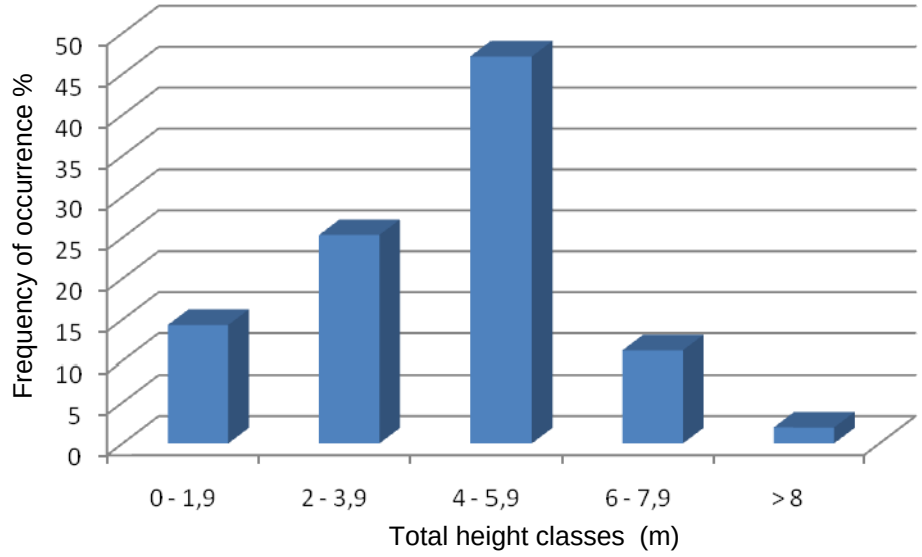
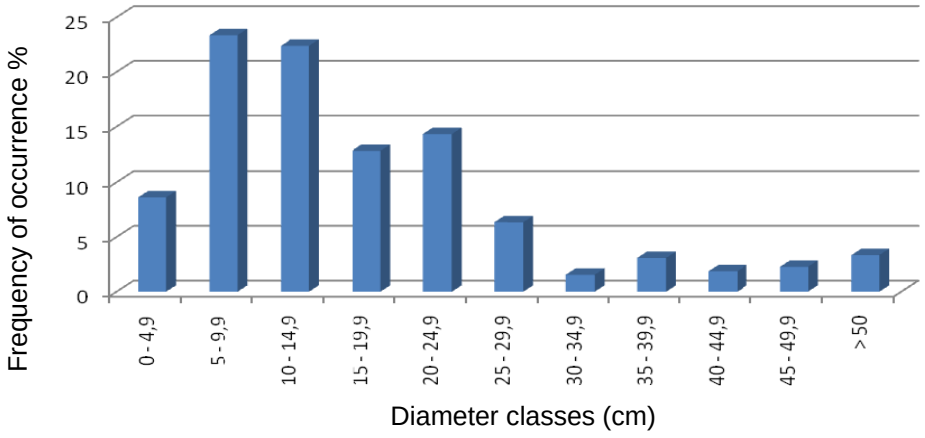


Chart 2. Distribution of individuals in urban afforestation of the Flamboyant neighborhood, Chapadão do Sul city, Mato do Gross do Sul – Brazil.

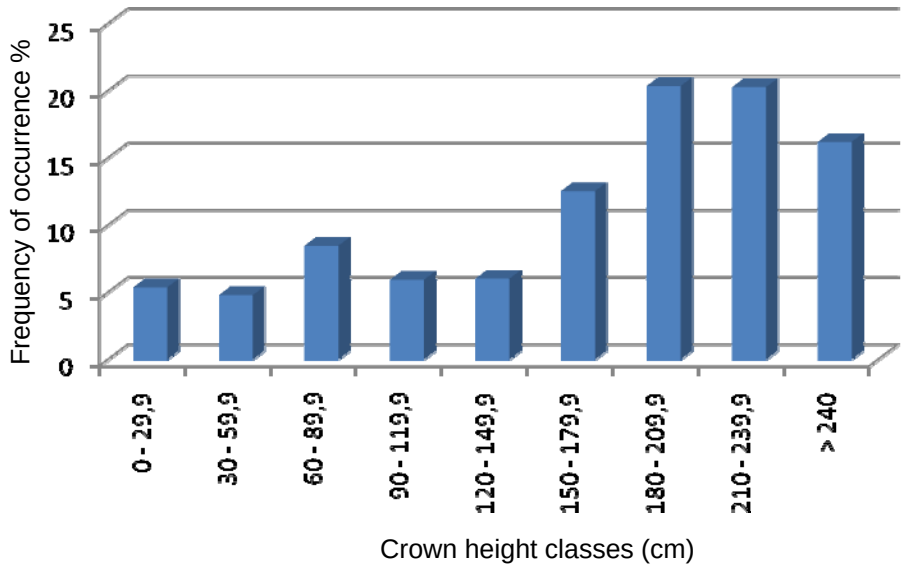


At first fork height (Chart 1), we observed that 43.16% of the trees showed the first fork below 1.80 meters. According to Silva, Paiva and Gonçalves (2007), the height of the first fork should be at least 1.80 meters, at

the planting time of the seedlings. This minimum was established to avoid, in general terms, conflicts with pedestrians and vehicles under the reach of the crown.

This result points to the need for seedlings to remain longer in nurseries, to perform the pruning for transport, for crown formation, or even, for the periodical management of plants already planted on the streets, in order to adequate the trees to recommended standards.

Chart 3. Canopy height classes of individuals from the urban forest of the Flamboyant neighborhood, Chapadão do Sul city, Mato Grosso do Sul state – Brazil.



We also observed the presence of fruit species, with little representation in relation to the total species surveyed, such as *Mangifera indica* (mangueira) with three individuals, *Annona* sp. (atemóia), *Inga edulis* (ingá), *Eugenia uniflora* (pitanga) and *Tamarindus indica* (tamarindeiro) with one individual for each species.

The presence of this type of trees, as well as other species with few occurrences in this neighborhood (Table 1), shows the unplanned spontaneous participation of the population in the composition of urban forest. The lack of planning is observed in most cities in Brazil, where the population itself performs the tree planting on public streets, which results in irregular and inadequate afforestation for most cities (SILVA; SILVEIRA; TEIXEIRA, 2008; SUCOMINE; SALES, 2010), causing inconveniences and damages to the population and municipal government.

Regarding the number of trees per kilometers of sidewalk, in our study, we surveyed 11.53 km in the 23 streets, avenues and median strips, and identified 1,228 individuals, with an average number of 106.6 trees per Km of sidewalk. The result can be considered adequate, given that the Brazilian Society of Urban Afforestation prescribes a number of 107 individuals per Km of sidewalk as ideal (PAIVA, 2009).

In comparison to results found for other cities in Brazil, although below those found by Bortoleto et al. (2007), who obtained 130 trees/Km of sidewalk in the municipality of Águas de São Pedro, São Paulo state, it is far above the results for other cities like Alta Floresta, Mato Grosso state, with 47.7 trees/Km; Nova Monte Verde, Mato Grosso state, with 52.3 trees/Km and Carlinda, Mato Grosso, with 56.0 trees/Km (ALMEIDA; RONDON NETO, 2010); São Carlos, São Paulo state, with 30.1 trees/Km of sidewalk (RACHID; COUTO, 1999) and Colorado, Rio Grande do Sul state, with 43 trees/Km of sidewalk (RABER; REBELATO, 2010).

As for the general condition of the trees surveyed, we observed that, from the 1,228 individuals identified, 88.4% showed balanced crowns and 82.90% had balanced trunks (Table 2). These aspects provide better stability to the trees and reduce risks of falling down, besides reducing the chances for conflicting with the flow of pedestrians and vehicles.

Table 2. Evaluation of general condition of trees, balance of canopy and trunk, injury severity, plant phytosanity, severity and location of pest attack in urban forest in the neighborhood of Flamboyant, Chapadão do Sul city, Mato Grosso do Sul state – Brazil.

Parameters assessed	Level		NI	F (%)
General condition of trees	Optimal		343	27.93
	Good		850	69.22
	Regular		24	1.95
	Poor		11	0.90
	Total		1228	100
Balance	**Crown**	Yes	1091	88.84
		No	137	11.16
	Total		1228	100
	Trunk	Yes	1018	82.90
		No	210	17.10
	Total		1228	100
Injuries	Absent		668	54.40
	Light		501	40.80
	Average		54	4.40
	Serious		05	0.40
	Total		1228	100
Phytosanity/ Severity	Absent		18	1.46
	Light		1200	97.72
	Average		10	0.82
	Serious		0	0
	Total		1228	100
Location of attack	Trunk		1155	94.05
	Trunk/Leaves		64	5.21
	Leaves		09	0.74
	Total		1228	100

NI: number of individuals of a species found in public streets of the city of Chapadão do Sul, Mato Grosso do Sul state; F(%): relative frequency of occurrence in percentage.

In assessing the occurrence of injuries and phytosanitary problems, we observed that more than half of the individuals (54.40%) do not show any type of mechanical injury; 40.80% has light injuries and less than 5% of the trees presented serious injuries (Table 2). Regarding phytosanitary problems, 97.72% of the 1,228 individuals showed light injuries and 94% of them were found in the trunk, which evidences the need for preventive and corrective actions to control the occurrence and aggravation of these injuries.

Urban afforestation undergoes several changes caused by anthropogenic actions and plant development. In the period of data collection, 21.25% of the total trees showed conflict with electric wiring and 33.31% had potential for conflict (Table 3), totaling 54.56% of individuals that require adequate handling, such as corrective pruning to prevent future problems. However, the pruning carried out at the tree crowns that conflict with electric wiring are, in most cases, drastic pruning, which cause irreversible damages to the plant (PAIVA,

2009), besides conflicts between the population and municipal government.

Table 3. Conflict of the urban forest with the elements in the public streets of the neighborhood Flamboyant, Chapadão do Sul city, Mato Grosso do Sul state, Brazil.

Conflicts		NI	F (%)
Wall/Construction	Absent	989	80.53
	Current	17	1.39
	Potential	222	18.08
	Total	1228	100
Street signs	Absent	1214	98.86
	Current	03	0.24
	Potential	11	0.90
	Total	1228	100
Lighting	Absent	1189	96.82
	Current	03	0.25
	Potential	36	2.93
	Total	1228	100
Street poles	Absent	1110	90.39
	Current	12	0.98
	Potential	106	8.63
	Total	1228	100
Wiring	Absent	558	45.44
	Current	261	21.25
	Potential	409	33.31
	Total	1228	100

NI: number of individuals of a species found on public streets of the city of Chapadão do Sul, Mato Grosso do Sul state, Brazil; F(%): relative frequency of occurrence, data in percentage.

Cerezo and Martins (1994) suggest alternative solutions to these facts, such as the insulation or protection of electric wiring, changes in the way the wiring and poles are fixed and replacement of aerial by underground wiring. However, Yamamoto et al. (2004) state that the ideal action is to plan urban afforestation in accordance to the other elements found in the site.

Regarding the other elements found on the public streets, the conflict with the trees was not significant (Table 3).

We also observed that 25.32% of the individuals studied showed root outcropping and/or damages to sidewalks (Table 4), and the species that showed the highest occurrence were *Licania tomentosa* with 71.70 %, *Delonix regia* with 10.28 %, *Ligustrum lucidum* with 8.68 % and *Schinus molle* with 5.80 %. According to Ferreira, Gasparotto, and Lima (2001), the species *Licania tomentosa* (oiti) has been largely used in urban afforestation because it does not cause damages and has expressive and perennial crown. Lorenzi (2002), however, highlights that due to its large size, *Licania tomentosa* is reported in the literature as one of the species that most damages sidewalks, clogging drains and gutters.

In our study, 60.91% of the individuals are planted in paved floors and their trunks are surrounded by cemented or ceramic areas, which, for Silva, Paiva and Gonçalves (2007) is the main cause for cracks and breaks in sidewalks, because these problems are tied to lack of free areas for plant growth. In addition, Raber and Rabelato (2010) report that the lack of free space does not allow infiltration of rainwater and plant nutrients, which hinder their growth.

Table 4. Distribution of species of more occurrences with root outcropping, found in the urban forest of the neighborhood Flamboyant, Chapadão do Sul city, Mato Grosso do Sul state, Brazil.

Outcropping/Sidewalk damages	NI	F(%)
Licania tomentosa (Benth.) Fritsch.	223	71.70
Delonix regia (Bojer ex Hook.) Raf.	32	10.28
Ligustrum lucidum W. T. Aiton	27	8.68
Schinus molle L.	18	5.80
Tibouchina granulosa (Desr.) Cogn.	04	1.29
Roystonea oleracea (Jacq.) O.F. Cook.	04	1.29
Pachira aquatica Aubl.	02	0.64
Mangifera indica L.	01	0.32
Total	311	100.00

NI: number of individuals of a species found on public streets of the city of Chapadão do Sul, Mato Grosso do Sul state, Brazil; F(%): frequency of occurrence, data in percentage.

During the survey period, management actions performed by responsible bodies, in most cases, comprised control actions (86.32%) and light pruning (12.46%) (Table 5). Heavy and drastic pruning was not significant in this neighborhood (0.81%) because the pruning of trees in city starts in September and October with the beginning of the rainy period. Regarding the quality of the pruning, 75.65% of the actions were considered optimal (17.02%) or good (58.63%) and in 24.35% of the cases, the actions were regular (0.07%) or poor (24.28%). Therefore, the responsible bodies should invest in training their employees in order to qualify them to adequately manage urban trees.

Table 5. Actions taken on urban forest in the neighborhood Flamboyant, Chapadão do Sul city, Mato Grosso do Sul state, Brazil

Actions	NI	F(%)
Control	1060	86.32
Light pruning	153	12.46
Heavy pruning	10	0.81
Planting	02	0.16
Repairs	03	0.25
Total	**1228**	**100.00**

NI: number of individuals of a species found on public streets of the city of Chapadão do Sul, Mato Grosso do Sul state, Brazil; F(%): frequency of occurrence, data in percentage.

CONCLUSIONS

The survey allowed to identify the existence of 106.6 trees per kilometer of sidewalk, which is considered adequate for road afforestation, providing benefits to the environment and aesthetics ensuring better life quality in cities. However, it is necessary to adequate the species to the site.

Although there was a significant number of species that comprise urban afforestation, we observed that species such as *Licania tomentosa* (oiti), *Sapindus saponaria* (saboneteira) and *Murraya paniculata* (murta de cheiro) predominate and therefore, we suggest investments to plant other species.

We observed the need for technical assistance in the planting of adequate seedlings for urban afforestation, as well as for the effective management of the trees in the public streets of this neighborhood. We highlight the need for alternative initiatives to mitigate the conflict between urban elements and urban afforestation.

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