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TOCO-TOUCAN (*RAMPHASTOS TOCO*) FEEDING HABITS AT AN URBAN AREA IN CENTRAL BRAZIL

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Resumo. **– Alimentação do Tucano-Toco (*Ramphastos toco*) em uma área urbana. –** A disponibilidade de recurso alimentar é um dos principais fatores relacionados à presença de aves em áreas urbanas. Neste estudo, nós descrevemos as plantas exploradas pelo Tucano Toco (*Ramphastos toco*), a atividade alimentar dessa ave e a relação desses parâmetros com a amplitude do nicho alimentar. Para tanto, estabelecemos quatro trajetos, cada um com 12 km, dispersos na área urbana de Três Lagoas (Mato Grosso do Sul, Brasil). A partir deles amostramos (mensalmente durante 40 h de observação) as espécies vegetais que frutificavam e a atividade alimentar dessa ave em áreas urbanas de Três Lagoas (Mato Grosso do Sul, Brazil). Os Tucanos exploraram frutos em todos os meses do ano e sua atividade alimentar foi influenciada tanto pela riqueza quanto, potencialmente, pela abundância de espécies de plantas disponíveis. Entre as espécies mais exploradas estiveram *Cecropia pachystachya* e *Inga laurina*, que produziram frutos tanto na estação seca quanto chuvosa. A presença de tucanos forrageando todos os meses do ano sugere a adequação da área urbana de Três Lagoas como local de alimentação. A contínua disponibilidade de recursos alimentares ao longo do ano, provavelmente decorreu da combinação da variedade dos padrões de frutificação em espécies vegetais exóticas e nativas que proporcionaram oferta abundante e variada de recurso alimentar.

Abstract. – Food resource availability is an important factor related to bird species presence at urban areas. In this study, we describe the plants exploited by the Toco Toucan (*Ramphastos toco*), its feeding activity, and the relationship between these parameters with feeding niche breadth. We established four transects, each one with 12 km long, to sample fruiting plants, and the feeding habits of this bird (monthly 40 h of observations) at the urban areas of Três Lagoas (Mato Grosso do Sul, Brazil). During all studied months, toucans foraged for fruits and its feeding activity was influenced by the variety and, potential abundance of fruit species available. Among the plant species extensively explored by toucans we highlight *Cecropia pachystachya* and *Inga laurina*, which presented fruits both in the dry and wet season. The year-round feeding activity of toucans suggests Três Lagoas city as an adequate feeding area. The permanent availability of plant food resources probably results from the diverse fruiting patterns of both native and exotic plant species, which provided a variety of suitable and abundant fruit patches. *Accepted 28 February 2013.*

Key words: Toco Toucan, *Ramphastos toco*, Ramphastidae, Central Brazil, Cerrado, feeding ecology, frugivory.

INTRODUCTION

The availability of plant food resources, i.e., flowers and fruits, is variable in Neotropical areas with marked climatic seasonality (van Schaik *et al.* 1993). Consequently, frugivorous/granivorous vertebrates often experience food shortage due to the erratic seasonality in fruit production (Franckie *et al.* 1974, Bullock & Sollis-Magallanes 1990, Ramirez 2002). In this respect, distinct sites of a habitat could be important for frugivores in distinct periods of the year (van Schaik *et al.* 1993, Renton 2001, Ragusa-Netto 2008a, 2010). Then, frugivores often move over large areas searching for suitable fruiting patches (Kinaird *et al.* 1996, Anggraini *et al.* 2000, Renton 2001; Ragusa-Netto 2006a, 2008a, 2008b, 2010). However, during unfavorable feeding periods frugivores may also switch their diet to substitutes, such as flowers, leaves, or even animal items (Terborgh 1986, Galetti 1993, Galetti *et al.* 2000, Solórzano *et al.* 2000; Ragusa-Netto 2004, 2005, 2008a).

The intense anthropization process in urban ecosystems has resulted in highly fragmented habitats comprising a mosaic of agricultural, private, and government preserved natural areas (Gilbert 1989, Marzluff 2001). A number of bird species could adapt to urban areas due to the presence of suitable climate, roosting, breeding and feeding opportunities (Marzluff 2001, Chace & Walsh 2006). In fact, bird abundance and distribution at urban sites may be related to a collection of green areas in which plant species composition influences food resource availability (Rolando *et al.* 1997, Marzluff 2001, Loss *et al.* 2009), specially for frugivorous birds due to adequate fruit supply (Fernández-Juricic 2000, Savard *et al.* 2000, Clergeau *et al.* 2001). Circumstantially, urban areas may exhibit an enhanced food supply in relation to natural areas due to the variety and density of food plant species (Gasperin & Pizo 2009, Philippsen *et al.* 2010), which may provide a frequent availability of dense fruiting patches to frugivorous/granivorous birds (Chace & Walsh 2006, Kark *et al.* 2007).

The Toco Toucan (*Ramphastos toco*) is the largest representative of the Ramphastidae (Sick 1997, Short & Horne 2002). This generalist bird is locally common in Central Brazil (Sick 1997, Short & Horne 2002, Ragusa-Netto 2006b, 2008a, 2010). Its former distribution has been drastically reduced due to the accelerated clearing of Brazilian cerrado for agriculture and pasturelands (Ratter *et al.* 1997, Carvalho *et al.* 2009). However, the Toco Toucan persists in fragmented landscapes (Ragusa-Netto 2006b, 2010), as well as has been recurrently reported from urban areas, mostly in Central Brazil (AAS pers. observ.). In fact, this species has been recorded foraging at modified landscapes within habitat mosaics of natural feeding areas (Graham 2001, Ragusa-Netto 2010). Even then, the factors related to the presence of the Toco Toucan in cities are poorly known. Taking into account the potential use of these sites for feeding purposes, in this study we investigated the exploitation of food resources by the Toco Toucan at the urban area of Três Lagoas (Mato Grosso do Sul, Brasil) to describe its feeding habits at this altered site. Also, we analyzed the relationship between its feeding activity and plant species availability, as well as the relationship between these parameters with feeding niche breadth.

METHODS

Study area. This study was conducted from April 2007 to March 2008 at the municipality of Três Lagoas (Mato Grosso do Sul State,

Brazil; 51°48'W, 20°46'S, 340 m a.s.l.). The climate is seasonal with 1400 mm average annual rainfall (70% falling in wet season). Mean annual temperature lies around 24°C in the wet and 17°C in dry season. The vegetation surrounding the urban area includes a mosaic of pasturelands with remnant cerrado trees, cerrado remnants, and seasonal forest in which the Toco Toucan is apparently common (JRN pers. observ.). The urban vegetation itself is variable, a typical feature of urban areas due to the land use and social context (Pickett *et al.* 2001). In this respect, exotic plant species are often present in central areas, mainly in gardens and squares, whereas native tree species are common in suburban areas in vacant lots and backyards of residences. Common exotic species at Três Lagoas urban area are: *Syzigium cumini*, *Roystonea oleraceae*, *Mangifera indica*, *Persea americana*, *Psidium guajava*, and *Musa paradisiaca*, while common native species are: *Syagrus oleraceae*, *Caryocar brasiliense*, *Anacardium occidentale*, *Cecropia pachystachya*, *Inga laurina*, and *Copaifera langsdorffii.*

Fruit production and feeding habits of toucans. To sample fruit availability and consumption by toucans across Três Lagoas, we included both urban and suburban areas. We established, with the aid of a local map, four 12 km long transects located at least 3 km apart from each other. Such procedure was adopted to sample plants, which were located in public areas like gardens and squares, as well as backyards and residences. We walked each transect for 10 h (see below) monthly searching for fruiting trees and, whenever we spotted a tree bearing fruits we recorded the species, location, and date. However, only those species effectively exploited by Toco Toucans were employed in the statistical analysis comprising the monthly index of diet richness, which consisted of the monthly total species exploited by toucans. We identified plant species by comparison with samples at the herbarium at the Universidade Federal do Mato Grosso do Sul (Campus Três Lagoas); nomenclature follows Lorenzi (1994, 1998).

We observed food consumption by toucans with the aid of an 8x40 binoculars while walking the same transects described above. Also, we used only initial, instead of sequential observations of feeding records to assure the independence among feeding samples, and also because it can be assumed that toucans were equally likely to be seen feeding on any conspicuous food source (Hejl *et al.*1990). To sample feeding birds each one of us monthly walked a different transect by a total of 10 h (40 h of observation every month), from 07:00–10:00 h and from 16:00–18:00 h during the dry season, and from 06:00–09:00 h and from 16:00–18:00 h during the wet season (from April 2007–March 2008), periods of intense activity of this bird (Marsden 1999). Whenever toucans were detected foraging, we recorded: a) number of individuals, b) plant species consumed, c) part eaten, d) date and time.

The Toco Toucan may prey upon invertebrates as well as small vertebrates (Short & Horne 2002, Ragusa-Netto 2008a). Therefore, whenever we observed a toucan capturing a prey we recorded: a) the taxa (usually the family) and b) item type (usually arthropods, eggs, and nestlings). As Toco Toucans were not individually marked, we used the feeding records to avoid pseudo-replication. This conservative data for the analysis consisted only of the number of times a given food item was consumed, regardless of the number of feeding toucans, time they spent feeding and amount of food ingested. We also used the feeding records to calculate the frequency of food species consumed by Toco Toucans (Table 1). However, to improve the analysis on the extent of food source use, we provided the number of feeding toucans together with the proportion of every food item used by them (Table 1). In this respect, the monthly

total of feeding records was taken as an index of feeding activity.

Analysis. We used the non-parametric Spearman Rank Correlation to analyze the relationship between plant species availability and toucan feeding activity, as well as the relationship between these parameters and feeding niche breadth. Taking into account the generalist feeding habits of toucans, we evaluated the range of its diet using Levin's niche breadth index. We adopted this index as it considers only the proportional use of food items without to incorporate food resource abundance, which was not sampled in this study. Hence, values close to zero indicate specialized diet and values closed to one indicate a broad diet. Niche breadth values were calculated monthly. We grouped plant species according to its potential fruiting pattern: asynchronous, when they bore fruits unpredictably during the year; multiple, when they bore fruits more than once in the year and; seasonal, when they bore fruit only once in the year (Milton 1982, Henderson 2002). In seasonal areas fruiting pattern fluctuates exhibiting short periods of pronounced fruit enhancement followed by abrupt declines (Bullock & Solis-Magallanes 1990, Justiniano & Fredericksen 2000, Funch *et al.* 2002, McLaren & McDonald 2005). Hence, in the course of a season fruit production fluctuations have influence on frugivores abundance and feeding activity (van Schaik *et al.* 1993). Then, considering the potential intra-seasonal changes in fruit production (Renton 2001; Ragusa-Netto 2007, 2008a), we divided the year in four distinct periods which were: the late wet season (January–March), the early dry season (April–June), the late dry season (July–September), and the early wet season (October–December; Ragusa-Netto 2008a, 2010). To analyze the proportional use of native or exotic fruits, we compared the number of feeding records on each fruit type using Chi-square test. In this case we expected balanced proportions of both fruit types in the diet of Toco Toucans. As many plant species might produce fruits in more than one season, we used Chi-square contingency analysis to test for differences either in the number of feeding records on native/exotic fruits or fruits with different fruiting patterns during the four periods of the year. In a contingency table rows represent the different states of one nominal variable, columns represent the states of another nominal variable, and cells contain the counts of occurrences of that specific state (row, column) of the two variables. The significance of association between the two variables (based on chi-squared) is then given, with p values from the chi-squared distribution. The contingency table analysis then gives information on whether the two variables are associated. We performed those analysis in order to explore differences in the use of food resources irrespective of their abundance and diversity in the urban area. Then, as these parameters were not assessed comparisons were not intent to infer the Toco Toucan preference. In addition, we crudely grouped plant species according to lipid content: species with fruits composed of more than 10% dry weight lipid were classed lipid-rich, whereas species with lower values were classed as sugar-rich fruits (adapted from Stiles 1993). We used data on fruit pulp nutrient content from Snow (1981), Howe & Smallwood (1982), Wheelwright *et al.* (1984), Moermond & Denslow (1985), Stiles (1993), and Silva *et al.* (2001). If no information was available for a given species, we classed it according to a congener.

RESULTS

Fruit species richness and feeding habits. We recorded a total of 30 fruiting species in the urban area, although toucans made no use of 11 species. The 19 species exploited by Toco

TABLE 1. Plant species, origin, fruiting pattern, and items consumed by Toco-Toucan (*Ramphastos toco*), at the urban area of Três Lagoas (State of Mato Grosso do Sul, Brazil). The number of feeding records and number of toucans ingesting food resources are also provided (n = 171, and n = 387, respectively; A = aril, P = fruit pulp; Sr = sugar rich, Lr = lipid rich, and S = seed; N = native, E = exotic; Se = seasonal fruiting, As = asynchronous, Ml = multiple).

Plant taxon	Origin	Fruiting pattern	Items	Nutrient content	Feeding records (%)	No. of feeding toucans	Months
Araliaceae							
Schefflera sp.	N	Se	P	Lr	5 (2,9)	9	May, Dec
Arecaceae							
Elaeis guineensis	E	As	P	Lr	12 (7)	35	Mar, Apr, May, Jun
Levistonia sp.	E	As	P	Lr	2 (1,1)	4	May
Roystonea oleraceae	E	As	P	Lr	17 (9,9)	29	May, Jun, Jul, Aug
Coccothrinax barbadensis	E	As	P	Lr	4 (2,3)	8	May
Caricaceae							
Carica papaya	E	Se	P	Sr	6 (3,5)	7	May, Aug, Sep
Lauraceae							
Persea americana	E	Se	P	Lr	2 (1,1)	3	Jan, Jun
Leguminosae							
Copaifera langsdorffii	N	Se	A	Lr	19 (11,1)	28	May, Jul, Aug, Sep
Inga laurina	N	Ml	A	Sr	23 (13,4)	68	Apr, May, Jun, Jul, Aug, Sep
Meliaceae							
Melia azedarach	E	Se	P	Lr	7 (4)	23	Apr, May, Jun, Jul, Aug
Moraceae							
Ficus sp.	N	As	P	Sr	4 (2,3)	17	Apr, Jun, Nov, Dec
Morus nigra	E	Se	P	Sr	6 (3,5)	18	May, Jun, Jul, Aug
Musaceae							
Musa sp.	E	Se	P	Sr	1 (0,6)	1	May
Myrtaceae							
Myrcia bella	N	Se	P	Sr	2 (1,1)	4	Feb, Nov
Syzygium cumini	E	Se	P	Sr	2 (1,1)	6	Jan, Jul
Psidium guajava	E	Se	P	Sr	2 (1,1)	6	May, Oct
Sterculiaceae							
Sterculia striata	N	Se	P	Lr	5 (2,9)	13	May, Jun, Aug, Sep
Urticaceae							
Cecropia pachystachya	N	Ml	P	Sr	45 (26,3)	97	Feb, Mar, Apr, May, Jun, Jul, Aug
Aegiphilla lhotzkiana	N	Se	P	Sr	2 (1,1)	4	Mar
Hatchlings					3 (1.7)	5	Oct, Nov, Dec
Eggs					2 (1.1)	2	Aug
Total					**171 (100%)**	**387**	

Toucans belonged to 11 families (Table 1). The number of plant species available for toucans varied seasonally. Important fruits were produced both in the dry and wet season by

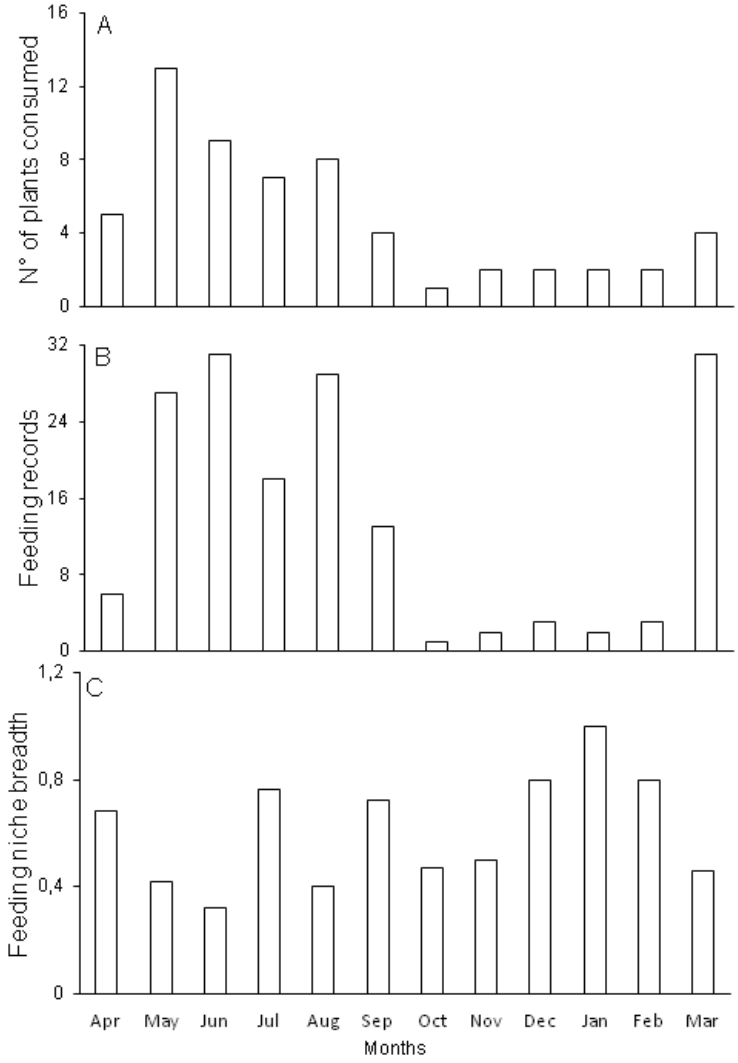

FIG. 1. Number of fruit species monthly available to Toco Toucan (A), number of feeding records (B), and niche breadth fluctuations (C), at the urban area of Três Lagoas (State of Mato Grosso do Sul, Brazil).

trees, such as *Cecropia pachystachya*, *Inga laurina*, *Elaeis guineensis*, and *Roystonea oleracea*. *Copaifera langsdorffii*, *Melia azedarach*, *Coccotrinax barbadensis*, and *Morus nigra* bore fruits during the dry season, while *Psidium guajava*, *Persea americana*, and *Schefflera* sp. fruits were available to toucans in the wet season (Table 1, Fig. 1A).

We documented 171 feeding records in the urban area of Três Lagoas. The Toco Toucan feeding activity fluctuated substantially between seasons exhibiting two major peaks, one during the dry and another at the end of the wet season. Monthly during the dry season, toucans fed on a minimum of four (Sep-

tember) and a maximum of 13 (May) fruit species. They exploited from five to 9 species in the other months. In the dry season, they often fed on *Inga vera* (23 feeding records), *Cecropia pachystachya* (24), *Copaifera langsdorffii* (19), *Roystonea oleracea* (17), *Melia azedarach* (6), and *Morus nigra* fruits (6, Table 1). On the other hand, monthly during the wet season toucans usually exploited only two fruit species, except in October (one), and March (four species, Fig. 1B). Despite of a reduced feeding activity during the wet season, a peak occurred in March, when toucans extensively fed on *Cecropia pachystachya* and *Elaeis guineensis* fruits (Fig. 1B, Table 1). In this season they, in fact, mostly exploited *Cecropia pachystachya* (21 feeding records), *Elaeis guineensis* (7), *Schefflera* sp (5), and *Ficus* sp. (2) fruits (Table 1). Feeding activity fluctuations paralleled the monthly variations in diet richness (r_s = 0.84, P = 0.001; Figs 1A–1B). In fact, fruits comprised much of Toco Toucan diet, while they seldom fed on animal matter (1.5%, Table 1). In the wet season, they preyed upon three hatchlings of Masked Gnatcatcher (*Poleoptila dumicola*, Polioptilidae), Tropical Kingbird (*Tyrannus melancholicus*, Tyrannidae), and Rufous Hornero (*Furnarius rufus*, Furnariidae). In the dry season (August), toucans depredated three nests, one with two eggs and the other with two hatchlings of the Eared Dove (*Zenaida auriculata*, Columbidae, Table 1).

The toucan's feeding niche breadth varied from low (B' = 0.32; June) to high values (B' = 1; January, Fig. 1C). The minor value resulted from the extensive consume of *Inga laurina* fruits (13.4% feeding records, Table 1), while the highest one corresponded to a balanced consumption of only two species (*Persea americana* and *Syzygium cumini*, Table 1). The variations of niche breadth value exhibited an inverse relationship with the monthly fluctuations in diet richness and feeding activity (r_s = -0.59, P = 0.044 and r_s = -0.62, P = 0.031, respectively).

Toucans fed more often on native than on exotic species in urban areas (105 vs 66 feeding records; Chi-square test, χ^2 = 8.89, df = 1, P = 0.003). However, proportionally no significant difference emerged in the use of these fruits in the four periods of the year (Chi-square contingency analysis, χ^2 = 3.47, df = 3, P = 0.324, Fig. 2). Plant species available to toucans exhibited variable fruiting patterns, so that we documented a total of 39 feeding records on asynchronous, 64 on seasonal fruits, and 68 feeding records on plants with multiple fruiting pattern (Table 1). In this respect, the consumption of fruits from plants with variable fruiting pattern (asynchronous + multiple) was twice higher than that of seasonal fruits. Particularly, toucans extensively foraged on asynchronous and multiple fruits both in the early dry and late wet season, while in the late dry and early wet season they consumed balanced proportions of seasonal fruits and those ones with variable fruiting pattern. Therefore, the proportion of asynchronous, seasonal, and multiple fruits highly differed in the toucan's diet during the four periods of the year (Chi-square contingency analysis, χ^2 = 27.85, df = 6, P = 0.0001, Fig. 3).

DISCUSSION

It is well known that landscape structure, plant community composition, and food resources availability could influence bird persistence in urban areas (Marzluff 2001, Luniak 2004). In fact, mobile frugivores often wander over large areas searching for appropriate fruit patches, which availability is variable in time and space (Renton 2001, Moeremburgh & Levey 2003; Ragusa-Netto 2008a, 2010). In this respect, some bird species have persisted in the deforestation process, using vegetation remnants as feeding areas (Graham 2001, Ragusa-Netto 2006b). Potentially, this is also the case in Toco Toucans at the urban area of

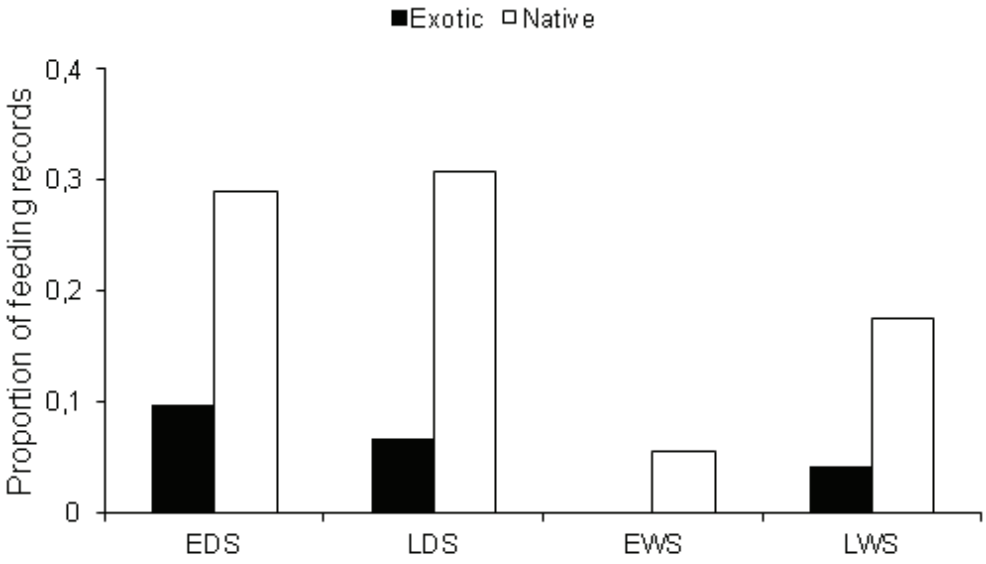

FIG. 2. Proportion of Toco Toucan feeding records on native or exotic fruit species during the four periods of the year at the urban area of Três Lagoas (State of Mato Grosso do Sul, Brazil). (Ed = early dry season, Ld = late dry, Ew = early wet, Lw = late wet)

Três Lagoas exhibiting a generalist diet. Therefore, the presence of Toco Toucan populations in these sites could be explained, at least in part, by the food supply provided by a variety of fruit patches dispersed across the urban area (Møller 2009). Exotic plant species are mainly present in gardens and squares for ornamental purposes at downtown. On the other hand, native trees tend to be common in suburban areas in residence backyards and vacant lots (Pickett *et al.* 2001). As a result, the variety of native and exotic plant species with different fruiting patterns scattered through the year, promotes a permanent food supply favoring the persistence of Toco Toucans at Três Lagoas urban area.

The species with multiple fruit production (*Cecropia pachystachya* and *Inga laurina*), comprised much of the Toco Toucan diet both in the dry and wet season. These pioneering trees are often present in semi-open habitats in early successional stages (Lorenzi 1994, 1998). Not surprisingly, they were often bearing large fruit crops either at central green areas or in suburbs (A. Santos pers. observ.). Due to the high content of soluble carbohydrates (Snow 1981), the diaspores from these species, potentially, quickly provided much of the energy daily required by toucans. The regular presence of *C. pachystachya* and *I. vera* fruits in the toucan's diet in the late dry season, when seasonal nutritive fruits (e.g., *Copaifera langsdorffii* and *Sterculia striata*; Almeida *et al.* 2008) were available and often used, emphasizes the importance of those fruits. Toucans probably use this variety of fruits because when combined might provide important caloric and nutritional reward (Martínez del Rio & Restrepo 1993). Asynchronous food resources, especially palm fruits, were among the major food sources of toucans, mainly during the dry season. These nutritive and, potentially, abundant fruits were available when fleshy fruits often decline in

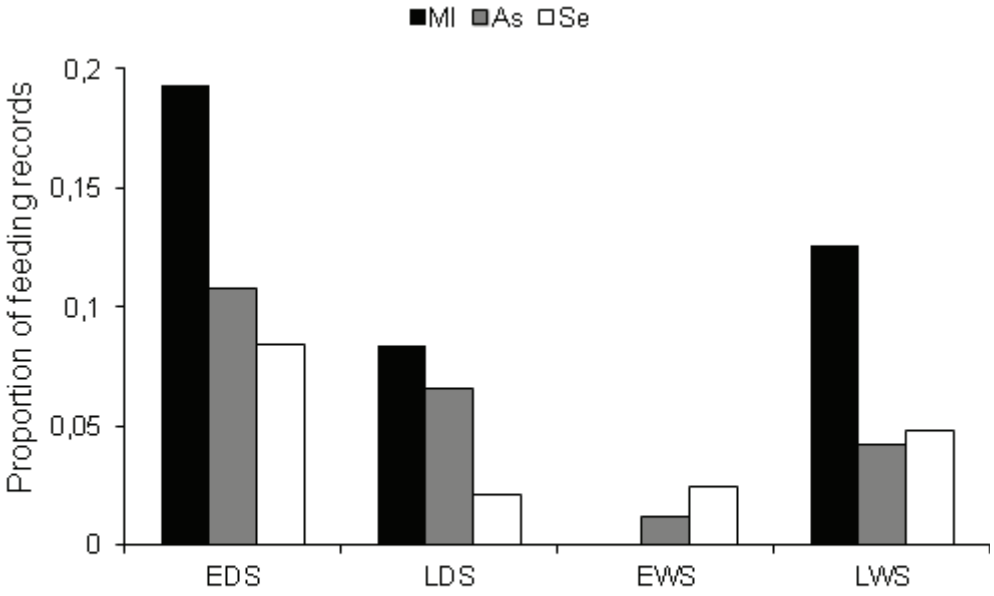

FIG. 3. Proportion of Toco Toucan feeding records on plants with different fruiting patterns during the four periods of the year at the urban area of Três Lagoas (State of Mato Grosso do Sul, Brazil). (Abbreviations for periods as in Fig. 2; Se = seasonal fruiting, As = asynchronous, Ml = multiple).

tropical forests (van Schaik *et al.* 1993). This palm fruiting pattern and respective use by toucans suggests these plants were playing a keystone role as in natural areas (Peres 2000, Genini *et al.* 2009). In fact, the importance of these fruits is particularly pronounced in marked seasonal areas where asynchronous plant species produce all year substantial fruit crops, while seasonal species bore fleshy fruits during limited periods (Peres 2000, Ragusa-Netto 2010). Potentially, this is the case of the studied urban area. When grouped, species exhibiting asynchronous and multiple fruiting patterns were important in providing much of fruits for toucans, especially during the late dry season, a period of minimal rainfall. In this respect, those plants, related to a substantial presence of toucans at the urban area, exhibited an enhanced potential for improving the cities as foraging sites.

The parallel fluctuations of the Toco Toucan feeding activity and the number of fruiting species suggested that toucans have been affected by the variety and potential abundance of available food resources at urban area, inclusively in the case of animal matter since they depredated common bird species (Sick 1997). Frugivores often exhibit fluctuations of niche-breadth values according to the seasonality of food resources (Renton 2001, Ragusa-Netto 2008a). Toco Toucans exhibited fluctuations of niche breadth value, mainly due to the unbalanced consumption of some fruit species at every period of the year. In fact, the factor related to the frequent declines of niche breadth value was the extensive consume of only a fruit type at a given month. This pattern of fruit exploitation may explain the negative relationship between niche breadth value and fruit richness and feeding activity. During much of the wet season, the Toco Toucan exhibited wide niche-breadth values, while this parameter fluctuated abruptly during the dry season, mainly

due to substantial consumption of *C. pachystachya* catkins. Curiously, high niche breadth values during the wet season resulted from the reduced, although balanced, use of few fruit types by only a few toucans present at urban area. Therefore, apparently, Toco Toucans opportunistically switched from a narrow to a broad diet according to the variations in fruit types available at the urban area. Perhaps, few toucans foraged in the city during the wet season as these birds might be foraging more close to their nests while breeding (Holbrook 2001).

In the four seasons of the year, Toco Toucans consumed a variety of native and exotic fruit species. Particularly, exotic fruits comprised a diverse food group including both ornamental (mainly palm species), and fruits used by humans. Based on human preference, exotic species may occur at high densities in the urban areas figuring as advantageous fruit patches to frugivores (Marzluff 2001, Luniak 2004), which often forage in areas of dense fruiting due to better chances of fruit intake (Schupp 1988b, Graham 2001). An additional benefit related to this is the reduced cost of foraging at cities in comparison to natural areas (Chace & Walsh 2006). In cities, the climate changes are milder than in natural areas (Luniak 2004), which could favor food resource availability year-round. In addition, human management often arranges fruit patches close to each other, which could improve foraging efficiency (Chace & Walsh 2006). The versatility of the Toco Toucan to exploit new food sources according to their variable availability stress out the relationship between their opportunist feeding habits and, at least partly, its wide presence in the markedly seasonal and highly diverse central Brazil (Ragusa-Netto 2006b, 2008a, 2010), including human-managed areas.

The Toco Toucan plays an important ecological role as a typical seed disperser (e.g., Howe 1977, 1981, 1993; Howe & Vande Kerckhove 1981, Holbrook & Loiselle 2009), favoring forest regeneration. In spite of this, the species has declined due to the loss and fragmentation of large Cerrado areas (Ratter 1997, Carvalho *et al.* 2009). Although the anthropogenic process has contributed to the local extinction of a substantial proportion of large-bodied birds (Matuzak *et al.* 2008), the urban areas could function as important feeding sites among a collection of native vegetation remnants (Marzluff 2001, Luniak 2004). The adequate management of these areas with an appropriated flora may favor frugivorous birds, such as the Toco Toucan. Hence, increasing the knowledge on plant species explored by toucans might be important for future conservation plans including the design of green areas and respective selection of tree species. Actions of this nature will also help to improve these areas as ecological corridors, an important parameter for animal colonization and its occurrence at cities (Fernandez-Juricic & Jokimäki 2001).

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REFERENCES

Almeida, S. P., T. S. A. Costa, & J. A. Silva. 2008. Frutas nativas do Cerrado: caracterização físico-química e fonte potencial de nutriente. Pp. 351–378 *in* Sano, S. M., S. P. Almeida, & J. F. Ribeiro (eds). Cerrado: Ecologia e flora. Volume 1. Editora Embrapa Informação Tecnológica, Brasília, Brazil.

Anggraini, K., M. Kinnaird, & T. O'Brien. 2000. The effects of fruit availability and habitat disturbances on an assemblage of Sumatran hornbills. Bird. Conserv. Int. 10: 189–202.

Bullock, S. H., & J. A. Sollis-Magallanes. 1990. Phenology of canopy trees of a tropical deciduous forest in Mexico. Biotropica 22: 22–35.

Carvalho F. M. V., P. J. De Marco, & L. G. Ferreira. 2009. The Cerrado into-pieces: habitat fragmentation as a function of landscape use in the savannas of Central Brazil. Biol. Conserv. 142: 1392–1403.

Chace, J. F., & J. J. Walsh. 2006. Urban effects on native avifauna: a review. Landsc. Urban Plann. 74: 46–69.

Clergeau, P., J. Jokimäki, & J. P. L. Savard. 2001. Are urban bird communities influenced by the bird diversity of adjacent landscapes? J. Appl. Ecol. 38: 1122–1134.

Fernández-Juricic, E. 2000. Bird community composition patterns in urban parks of Madrid: the role of age, size, and isolation. Ecol. Res. 15: 373–383.

Fernández-Juricic, E., & J. Jokimaki. 2001. A habitat island approach to conserving birds in urban landscapes case studies from southern and northern Europe. Biodivers. Conserv. 12: 2023–2043.

Frankie, T. H., H. G. Baker, & P. A. Opler. 1974. Comparative phenological studies of trees in tropical wet and dry forest in the lowlands of Costa Rica. J. Ecol. 62: 881–919.

Funch, L. S., R. Funch, & G. M. Barroso. 2002. Phenology of gallery and montane forest in the Chapada Diamantina, Bahia, Brazil. Biotropica 34: 40–50.

Galetti, M. 1993. Diet of Scaly-headed parrot (*Pionus maximiliani*) in a semi-deciduous forest in southeastern Brazil. Biotropica 25: 419–425.

Galetti, M., R. Laps, & M. A. Pizo. 2000. Frugivory by toucans (Ramphastidae) at two altitudes in the Atlantic forest of Brazil. Biotropica 32: 842–850.

Gasperin, P., & M. A. Pizo. 2009. Frugivory and habitat use by thrushes (*Turdus* spp.) in a suburban area in south Brazil. Urban Ecosyst. 12: 425–436.

Genini, J., M. Galetti, & L. P. C. Morellato. 2009. Fruiting phenology of palms and trees in an Atlantic rainforest land-bridge island. Flora 204: 131–145.

Gilbert, O. L. 1989. The ecology of urban habitats. Chapman & Hall, London, U.K.

Graham, C. H. 2001. Factor influencing movement patterns of Keel-billed Toucans in fragmented tropical landscape in southern Mexico. Conserv. Biol. 15: 1789–1798.

Hejl, S. J., J. Verner, & W. Bell. 1990. Sequential versus initial observations in studies of avian foraging. Stud. Avian Biol. 13: 166–173.

Henderson, A. 2002. Evolution and ecology of palms. The New York Botanical Garden Press, New York, USA.

Holbrook, K. M., & B. A. Loiselle. 2009. Dispersal in a Neotropical tree, *Virola flexuosa* (Myristicaceae): does hunting of large vertebrates limit seed removal? Ecology 90: 1449–1455.

Holbrook, K. M. 2011. Home range and movement patterns of toucans: implications for seed dispersal. Biotropica 43: 357–364.

Howe, H. F. 1977. Bird activity and seed dispersal of a tropical wet forest tree. Ecology 58: 539–550.

Howe, H. F. 1981. Dispersal of a Neotropical nutmeg (*Virola sebifera*) by birds. Auk 98: 88–98.

Howe, H. F. 1993. Aspects of variation in a Neotropical seed dispersal system. Vegetatio 107/108: 149–162.

Howe, H. F., & A. G. Vande Kerckhove. 1981. Removal of a wild nutmeg (*Virola sebifera*) crops by birds. Ecology 62: 1093–1106.

Howe, H. F., & J. Smallwood. 1982. Ecology of seed dispersal. Annu. Rev. Ecol. Syst. 13: 201–228.

Justiniano, M. J., & T. S. Fredericksen. 2000. Phenology of tree species in Bolivian dry forests. Biotropica 2: 276–281.

Kark, S., A. Iwaniuk, & A. Schalimtzek, & E. Banker. 2007. Living in the city: can anyone become an 'urban exploiter'? J. Biogeogr. 4: 638–651.

Kinnaird, M. F., T. G. O'Brien, & S. Suryadi. 1996. Population fluctuation in Sulawesi Red-knobbed Hornbills: tracking figs in space and time. Auk 113: 431–440.

Lorenzi, H. 1994. Árvores brasileiras. Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Volume 1. Editora Plantarum, Nova Odessa, São Paulo, Brazil.

Lorenzi, H. 1998. Árvores brasileiras. Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Volume 2. Editora Plantarum,

Nova Odessa, São Paulo, Brazil.

Loss, S. R., M. O. Ruiz, & J. D. Brawn. 2009. Relationships between avian diversity, neighborhood age, income, and environmental characteristics of an urban landscape. Biol. Conserv. 142: 2578–2585.

Luniak, M. 2004. Synurbization: adaptation of animal wildlife to urban development. Pp. 50–55 *in* Shaw, W. W., L. K. Harris, & L. Van Druff (eds). Proc. 4th International Symposium on Urban Wildlife Conservation. Tucson, Arizona, USA.

Martínez del Rio, C. M., & C. Restrepo. 1993. Ecological and behavioral consequences of digestion in frugivorous animals. Vegetatio 108: 205–216.

Marsden, S. J. 1999. Estimation of parrot and hornbill densities using a point count distance sampling method. Ibis 141: 377–390.

Marzluff, J. M. 2001. Worldwide increase in urbanization and its effects on birds. Pp. 19–47 *in* Marzluff, J. M., R. Bowman, & R. Donnelly (eds). Avian ecology and conservation in an urbanizing world. Kluwer Academic Press, Norwell, Massachusetts.

Matuzak, G. D., M. B. Bezy, & D. J. Brightsmith. 2008. Foraging ecology of parrots in a modified landscape: seasonal trends and introduced species. Wilson J. Ornithol. 120: 353–365.

Mclaren, K. P., & M. A. McDonald. 2005. Seasonal patterns of flowering and fruiting in a dry tropical forest in Jamaica. Biotropica 37: 584–590.

Milton, K., D. M. Windsor, D. W. Morrison, & M. A. Estribi. 1982. Fruiting phenologies of two Neotropical *Ficus* species. Ecology 63: 752–762.

Moeremburgh, S. M., & D. Levey. 2003. Do frugivores respond to fruit harvest? An experimental study on short-term responses. Ecology 84: 2600–2612.

Moermond, T. C., & J. S. Denslow. 1985. Neotropical avian frugivores: pattern of behavior, morphology, and nutrition, with consequences of fruit selection. Ornithol. Monogr. 36: 865–897.

Møller, A. P. 2009. Successful city dwellers: a comparative study of the ecological characteristics of urban birds in the Western Palearctic. Oecologia 159: 849–858.

Peres, C. A. 2000. Identifying keystone plant resources in tropical forests: the case of gums from *Parkia* pods. J. Trop. Ecol. 16: 287–317.

Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, C. H. Nilon, & R. V. Pouyat. 2001. Urban ecological systems: linking terrestrial ecological, physical and socioeconomic components of metropolitan areas. Annu. Rev. Ecol. Syst. 32: 127–157.

Ragusa-Netto, J. 2004. Flowers, fruits and the abundance of the Yellow-Chevroned Parakeet (*Brotogeris chiriri*) at a gallery forest in the South Pantanal (Brazil). Braz. J. Biol. 64: 867–877.

Ragusa-Netto, J. 2005. Extensive consumption of *Tabebuia aurea* (Manso) Benth & Hook. (Bignoniaceae) nectar by parrots in a tecoma savanna in the South Pantanal (Brazil). Braz. J. Biol. 65: 339–344.

Ragusa-Netto, J. 2006a. Dry fruits and the abundance of the Blue-and-Yellow Macaw (*Ara ararauna*) at a cerrado remnant in the Central Brazil. Ornitol. Neotrop. 17: 491–500.

Ragusa-Netto, J. 2006b. Frugivory and the abundance of Toco Toucan (*Ramphastos toco*) in a gallery forest in the Pantanal (Brazil). Braz. J. Biol. 66: 133–142.

Ragusa-Netto, J. 2007. Nectar, fleshy fruits and the abundance of parrots at a gallery forest in the southern Pantanal (Brazil). Stud. Neotrop. Fauna Environ. 42: 93–99.

Ragusa-Netto, J. 2008a. Toco Toucan (*Ramphastos toco*) feeding ecology and local abundance in a habitat mosaic in the Brazilian cerrado. Ornitol. Neotrop. 19: 345–359.

Ragusa-Netto, J. 2008b. Yellow-Chevroned Parakeet (*Brotogeris chiriri*) abundance and canopy foraging at a dry forest in western Brazil. Stud. Neotrop. Fauna Environ. 42: 99–105.

Ragusa-Netto, J. 2010. Figs and the persistence of Toco Toucan (*Ramphastos toco*) at dry forests from western Brazil. Ornitol. Neotrop. 21: 59–70.

Ramirez, N. 2002. Reproductive phenology, life forms, and habitats of the Venezuelan Central Plain. Am. J. Bot. 89: 836–842.

Ratter, J. A., J. F. Ribeiro, & S. Bridgewater. 1997. The Brazilian Cerrado vegetation and threats to its biodiversity. Ann. Bot. 80: 223–230.

Renton, K. 2001. Lilac-crowned Parrot diet and food resource availability: resource tracking by a parrot seed predator. Condor 103: 62–69.

Rolando, A., G. Maffei, C. Pulcher, & A. Giuso. 1997. Avian community structure along a urbanization gradient. Ital. J. Zool. 64: 341–349.

Savard, J. P. L., P. Clergeau, & G. Mennechez. 2000. Biodiversity concepts and urban ecosystems. Landsc. Urban Plann. 659: 1–12.