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Avian frugivory in *Miconia* (Melastomataceae): contrasting fruiting times promote habitat complementarity between savanna and palm swamp

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Abstract: Species of *Miconia* are considered keystone plant resources for frugivorous birds in Neotropical forests, but for other ecosystems little of their ecological role is known. The fruiting phenology and the composition of frugivores of four *Miconia* species in savanna and palm swamp from the Brazilian Neotropical savanna were studied in three sites from November 2005 to May 2011. The hypothesis tested was that plants from different habitats share their frugivores and consequently promote links between habitats. Through focal plant observations (30–50 h per species in each site), 668 visits by 47 species of birds were recorded and plants from different habitats shared most of the frugivores (49–97%). The fruiting of *Miconia chamissois* in the palm swamp during the period of fruit scarcity (dry season) was accompanied by an enhancement in the frugivore bird richness and abundance in this habitat, providing indirect evidence of resource tracking. Bird species which primarily dwell in savanna recorded consuming fruits in palm swamps during the resource-scarce season is taken as evidence of landscape supplementation. *Miconia* assemblage studied here seems to promote a link between two adjacent habitats in the Neotropical savanna from Central Brazil, a link which is likely to be common in this naturally patchy ecosystem.

Key Words: keystone plant resource, landscape supplementation, *Miconia chamissois*, Neotropical savanna, null models, phenology

INTRODUCTION

Plants that provide critical resources for frugivores during periods of scarcity are recognized as keystone resources (Bleher *et al.* 2003, Howe 1984, Peres 2000). Several studies point to the importance of zoochorous Melastomataceae for Neotropical bird communities, since these plants provide resources throughout most of the year, during periods of scarcity and/or during breeding seasons for frugivore birds (Galetti & Stotz 1996, Hilty 1980, Kessler-Rios & Kattan 2012, Levey 1990, Poulin *et al.* 1999, Snow 1965). In an attempt to classify such plant resources, Peres (2000) proposed four major parameters to define a keystone plant resource (KPR): low temporal redundancy of the KPR in relation to the combined pool of alternative food resources; low consumer specificity, in the sense that a representative portion of the frugivores assemblage rely on the KPR; high resource reliability, that is, if it will predictably become available through annual periods of scarcity; and KPR abundance.

Considering these parameters proposed, fruiting phenology plays a major role in determining the importance of a plant to frugivorous birds. The phenology of plants is presumed to be shaped by abiotic and biotic factors (Fenner 1998, van Schaik *et al.* 1993). Abiotic factors could impose strong constraints on flowering and fruiting time and duration (Fenner 1998). On the other hand, the interaction with dispersers also has a presumed importance on the fruiting phenology, either promoting co-occurrence of plant species that minimize fruiting overlap, providing fruits sequentially (Hilty 1980, Poulin *et al.* 1999, Snow 1965, Thies & Kalko 2004), or leading to fruiting aggregation (Kessler-Rios & Kattan 2012, Poulin *et al.* 1999). Fruit is a type of resource with strong heterogeneity not only in time, but also over space (García & Ortiz-Pulido 2004, Howe 1984, Levey 1988, Price 2004). In patchy environments like savannas, the seasonal movements of animals among different types of habitats are believed to reflect temporal differences in resource availability (Piratelli & Blake 2006,

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Price 2004, Tubelis *et al.* 2004). In the particular case of the Neotropical savanna, bird movements along adjacent habitats was previously addressed (Piratelli & Blake 2006, Tubelis *et al.* 2004), but resource use across habitats according to seasonality is poorly documented.

In this study, we evaluated the fruiting phenology and the assemblage of frugivorous birds associated with four *Miconia* species from the Neotropical savanna of Central Brazil. *Miconia* is the largest zoochorous genus within Melastomataceae and is associated with frugivorous birds in many Neotropical areas (Galetti & Stotz 1996, Hilty 1980, Kessler-Rios & Kattan 2012, Poulin *et al.* 1999, Manhães *et al.* 2003, Renner 1989). Three of the *Miconia* species studied occur mainly in savanna and fruit during the rainy season whereas *M. chamissois* occurs mostly in adjacent palm swamps and bears fruits during the dry season. After observing a sequential fruiting pattern in these plants, we tested if the observed fruiting phenology was more segregated than expected by chance. The combined results of fruiting phenology and frugivore bird assemblages are used to discuss the role of *M. chamissois* as keystone plant resource, as defined by Peres (2000). For this we also evaluated if the diversity of frugivore birds in the palm swamp is affected by the fruiting of *M. chamissois*, as an indirect support for resource tracking by birds. The primary hypothesis we tested here is that plants from different habitats share their frugivores, thus promoting a link between habitats.

METHODS

Study area and organisms

The Neotropical savanna shows a remarkable physiognomic variation on the vegetation and is characterized by an extremely patchy environment (Oliveira-Filho & Ratter 2002). Our study was mostly carried out in two of these plant physiognomies, savanna (cerrado) and palm swamp (vereda), which are relatively open vegetation areas (Oliveira-Filho & Ratter 2002). We conducted the fieldwork at three sites near Uberlândia city, in the state of Minas Gerais, South-East Brazil. Most of the data were collected in the Clube de Caça e Pesca Itororó de Uberlândia, a private natural reserve (CCPIU – 18°59′21″S, 48°18′06″W) which comprises approximately 400 ha of native vegetation. This area has two major plant physiognomies: savanna and palm swamps, this latter comprising about 100 ha. Complementary observations were conducted in Glória Research Farm (Glória – 18°57′23″S, 48°12′29″W) and Panga Ecological Station (Panga – 19°10′27″S, 48°23′51″W). Glória comprises 685 ha, mostly occupied by experimental crops and with small remnants of savanna, palm swamp and forest formations. Panga presents about 400 ha and includes from grasslands and savanna to dense forest formation. The climate is remarkably seasonal with a warm rainy season (October–March) and a cool dry season (April–September).

We studied the four most abundant species of *Miconia* (Melastomataceae) in the studied region. These species present wide and overlapping distributions, varying from shrubs to treelets (*c.* 1–3 m tall) and are commonly found in sympatry (Martins *et al.* 1996). *Miconia albicans* (Sw.) Triana, *M. fallax* DC. and *M. rubiginosa* (Bonpl.) DC. occur frequently side by side in savanna vegetation while *M. chamissois* Naud. is restricted to humid areas (mostly palm swamps). *Miconia chamissois* is one of the most common and abundant zoochorous species found in the palm swamps of Central Brazil (Araújo *et al.* 2002, Guimarães *et al.* 2002). All species have small fruits (0.5–1.0 cm diameter) which are dark purple or blue (almost black) in *M. fallax*, *M. rubiginosa* and *M. chamissois* or translucent jade green in *M. albicans*. In CCPIU we studied all four *Miconia* species. In Glória we studied *M. albicans* and *M. chamissois* while in Panga only *M. chamissois* was observed. These *Miconia* species are suitable for addressing the importance of dispersers in the phenological pattern since three species from the savanna (*M. albicans*, *M. fallax* and *M. rubiginosa*) are largely independent of pollinators for their reproduction (Goldenberg & Shepherd 1998) and the fruiting pattern observed would be independent of interaction with pollinators.

Fruiting phenology

In CCPIU, we evaluated the phenology from November 2005 to October 2007, monitoring 15 individuals for each *Miconia* species (individuals were at least 5 m away from conspecifics and of similar height). All these individuals were followed weekly counting the number of ripe fruits. In Glória, we carried out fruit counting every other week, in six individuals for each species from January to December in 2009. To evaluate the importance of *Miconia* fruits at community level, we recorded the fruiting of other bird-dispersed plants (with at least 10 individuals in the transect) fortnightly in the CCPIU from May 2008 to May 2011, along a transect of 4.0 km crisscrossing the savanna, the palm swamp and a small fragment of gallery forest (of approximately 1 ha). Plants were followed and fruiting was evaluated with attribution of intensity scores (0 – no fruits; 1 – less than 40% of individuals with fruits; 2 – more than 40 % of individuals with fruits). We also attributed a crop size score to these species according to their crop size per individual during the fruiting peak (1: $\leq$ 50 fruits; 2: $>$ 50 and $\leq$ 150; 3: $>$ 150 and $\leq$ 350; 4: $>$ 350).

Null-models are commonly used to test for phenological patterns (Pleasants 1990), and we used a modified version of the null model used in Marchinko *et al.* (2004) to test for evenly displaced fruiting in *Miconia*. The null-model is based on the index d/w, where d is the difference between peak resource use in two species, and w is the average breadth of resource use of both species. Thus the index was defined as the difference between average fruiting peaks of two adjacent species in the fruiting sequence divided by the average of their fruiting intervals. Analyses were conducted on the CCPIU dataset only, because it was the only site where all four *Miconia* species were studied. Considering the phenology as a circular variable, timing of annual peaks in fruit production was quantified as mean angles (0–360°, roughly equivalent to days in the year, thus each day is equivalent to approximately 0.98°) and fruiting intervals were quantified as circular standard deviations. Each month i = (January, February . . . December) was associated with an angle from the series $\alpha_i = (15°, 45° \ldots 345°)$ and the corresponding number of ripe fruits observed, f_i. The mean angle of fruit production for each species (μ_f, i.e. fruiting peaks), was calculated as:

$$\mu_f = \begin{cases} \text{If } C > 0, S \geq 0 & \mu_f = \arctan\,(S/C) \\ \text{If } C = 0, S > 0 & \pi/2 \\ \text{If } C < 0 & \arctan\,(S/C) + \pi \\ \text{If } C \geq 0, S < 0 & \arctan\,(S/C) + 2\pi \\ \text{Undefined if } C = 0, S = 0 & \end{cases}$$

when

$$C = \frac{\sum_{i=1}^{n} f_i \cos \alpha_i}{n}$$

$$S = \frac{\sum_{i=1}^{n} f_i \sin \alpha_i}{n}$$

n = number of groups (i.e. 12 mo), and α = angle in degrees from zero. Fruiting intervals (w) were calculated as:

$$w = 1 - \sqrt{C^2 + S^2}$$

and the circular distance (d) between any two fruiting peaks (a,b) was calculated as:

$$d(a, b) = 1 - \cos(a - b)$$

The index d/w was calculated for all adjacent species pairs in the annual sequence of fruit availability. The variance of these values was then calculated to obtain a single metric characterizing community-level differentiation in fruit phenologies. To determine whether the observed variance in d/w was lower than what would be expected by chance, the observed variance was compared with the variance calculated for 10 000 simulated assemblages generated in a Monte Carlo simulation. During each iteration of the simulation, the timing of peak fruit production for each species was randomized and the variance in d/w values was recalculated. The fraction of iterations generating values that were less than observed was taken as the probability of obtaining the observed result under the null hypothesis. This fraction was multiplied by two to obtain two-tailed type I error rates (i.e. P values). We used the R statistical framework (R Development Core Team, v. 2.12.2) for the circular null-model analysis.

Frugivorous bird assemblages

Frugivorous birds in *Miconia* were recorded from November 2005 to December 2007 in CCPIU and from January to December 2009 in Glória and Panga. In CCPIU, we conducted 50 h of focal plant observation on each plant species during their respective fruiting peaks. For Glória and Panga each plant species amounted to 30 h of sampling. Observations ranged from 05h00 to 18h00, the maximum length of each observational session was 3 h, and simultaneous observation was limited to three individuals within the same vision field. The following data were recorded: species, number of fruits consumed and consumption strategy. An event of fruit consumption was characterized by a bird starting to consume fruits until it disappeared from the vision field of the observer. We adopted a simple classification of the consumption strategy based on whether birds swallowed the entire fruit or not, regardless of crushing the fruit. As *Miconia* seeds are very small (< 2 mm), we believe that the fruit handling would have less effect than the proportion of fruit consumed or the gut treatment in seed dispersal. The similarity in the frugivores assemblages among *Miconia* species within each site (CCPIU and Glória) was evaluated calculating the abundance-based Sørensen similarity index using SPADE software (http://chao.stat.nthu.edu.tw). This index uses a probabilistic approach that incorporates the estimated effect of unseen shared species, reducing the sample-size bias (Chao *et al.* 2005, 2006).

In order to evaluate the effect of *M. chamissois* on the diversity of birds associated with palm swamp, we estimated bird abundance through the point-count method. This method consists in walking along a path and stopping at pre-determined points where bird incidences are recorded (Bibby *et al.* 2000). In the palm swamp at CCPIU we defined 17 circular points with a radius of 30 m along a path approximately 4.5 km long. Birds were recorded within these points, which were at least 200 m apart.We made observations each month from

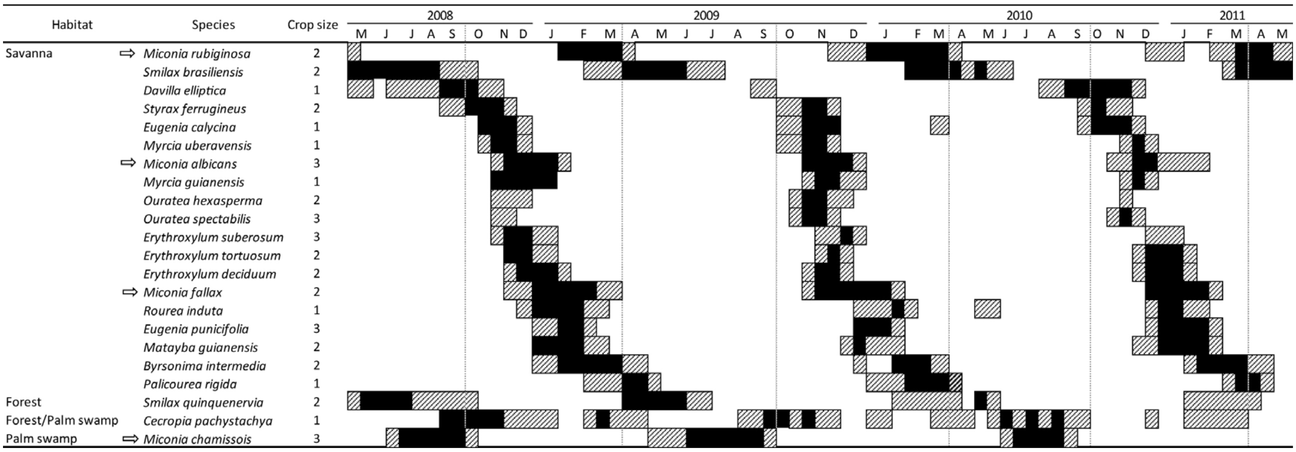

Figure 1. Fruiting phenology of most abundant bird-dispersed plants at CCPIU, Uberlândia, Brazil. The phenology was evaluated with attribution of intensity scores: 0 – no fruits (white); 1 – less than 40% of individuals with fruits (shaded); 2 – more than 40% of individuals with fruits (black). Crop size score attributed according to crop size per individual during the fruiting peak (1 – ≤ 50 fruits; 2 – > 50 and ≤ 150; 3 – > 150 and ≤ 350; 4 – >350). The two seasons of Neotropical savanna (rainy – October to March and dry – April to September) are separated by vertical lines.

November 2007 to October 2008, each starting at 07h30 and finishing at 10h30. Sampling lasted for 10 min at each point with intervals of another 10 min between subsequent points. These samplings were conducted over 4 d with similar weather conditions and each point was sampled twice per month, in inversed sequence. The two samples from the same point in the same month were pooled together, so we had 17 points (samples) with their measure of bird diversity for each month (replicate). The richness and abundance of birds were analysed according to season (rainy and dry) and according to fruiting of *M. chamissois* within the dry season using nested ANOVA after square-root data transformation ($\sqrt{x + 0.5}$) to meet statistical assumptions (Zar 1999). In the first analysis we compared the diversity of birds between seasons (group – fixed-effect factor) with months nested (subgroups – random-effect factor). In the second analysis we compared the diversity of birds according to presence of *M. chamissois* fruits (group – fixed-effect factor) with months nested (subgroups – random-effect factor). Comparisons were made separately for different categories of species: frugivores recorded in *Miconia*; major frugivores recorded in *Miconia,* in other words, species with at least 5% of relative record frequency in the frugivore list and species not recorded in *Miconia*, or non-frugivores.

RESULTS

Fruiting phenology

We found 22 plant species bearing bird-consumed fruits in CCPIU and most of these bore fruits during the rainy season (Figure 1). Most plants were found in savanna, and only three species in palm swamp and forest. In CCPIU the three species from savanna (*M. albicans*, *M. fallax* and *M. rubiginosa*) fruited during the rainy season with some overlapping in fruiting period and *Miconia chamissois* produced fruits during the dry season (Figure 2). The fruiting pattern of *M. albicans* and *M. chamissois* in Glória followed an approximately similar pattern to that found in CCPIU (Figure 2). Despite consistently recording a segregated fruiting pattern over years (Figure 2), approximately 5% of randomized assemblages showed more evenly displaced fruiting than the observed one, not providing support for evenly displaced fruit production ($P = 0.099$).

Frugivorous bird assemblages

We recorded 668 visits by 47 species of birds to *Miconia* (Appendix 1). The feeding behaviour of each species did not vary from plant to plant, probably due to fruit similarity among *Miconia* species, so bird-visit data were pooled across plants. *Miconia chamissois* was most visited in CCPIU and Glória (Appendix 1) and *Miconia* species showed considerable similarity in their frugivore fauna within study sites (Table 1).

In CCPIU, for all four *Miconia* the most frequent visitors were *Elaenia* spp. which were also recorded in Glória. *Elaenia chiriquensis*, *E. cristata* and *E. flavogaster* are commonly found in the study sites (C. Melo, unpubl. data), but we pooled together the data for the genus since specific distinction was difficult while they were feeding on plants. Other species such as *Mimus saturninus*, *Pitangus sulphuratus*, *Tangara*

Table 1. Abundance-based Sørensen similarity index among frugivorous birds feeding on *Miconia* species within two sites in Uberlândia, MG, Brazil.

Site		CCPIU			Glória
		M. albicans	*M. fallax*	*M. rubiginosa*	*M. chamissois*
	M. albicans				
CCPIU	*M. fallax*	0.904			
	M. rubiginosa	0.916	0.890		
	M. chamissois	0.968	0.823	0.782	
Glória	*M. albicans*				0.489

palmarum, *Turdus amaurochalinus* and *Turdus leucomelas* were frequently recorded, depending on the plant species and study site (Appendix 1). Birds usually consumed the fruits entirely, and few species were recorded discarding them (Appendix 1).

Nested ANOVAs showed that bird diversity in palm swamp seems to vary through the year according to month, but not between the rainy and dry seasons (Table 2). The presence of *M. chamissois* fruits affected the diversity of frugivores during the dry season since it was consistently higher during *M. chamissois* fruiting, a pattern not observed for non-frugivores (Figure 3).

DISCUSSION

Miconia species from distinct habitats exhibited contrasting fruiting seasons. The phenological pattern highlights the importance of *M. chamissois* which bears fruits during the dry season, when the overall fruit offer is lower in open habitats of the Neotropical savanna (Batalha & Martins 2004, Oliveira 2008, Piratelli & Pereira 2002). The fact that only *M. chamissois* produces fruits during the dry season may be justified considering the different characteristics between habitats. The soil of the palm swamp keeps some moisture

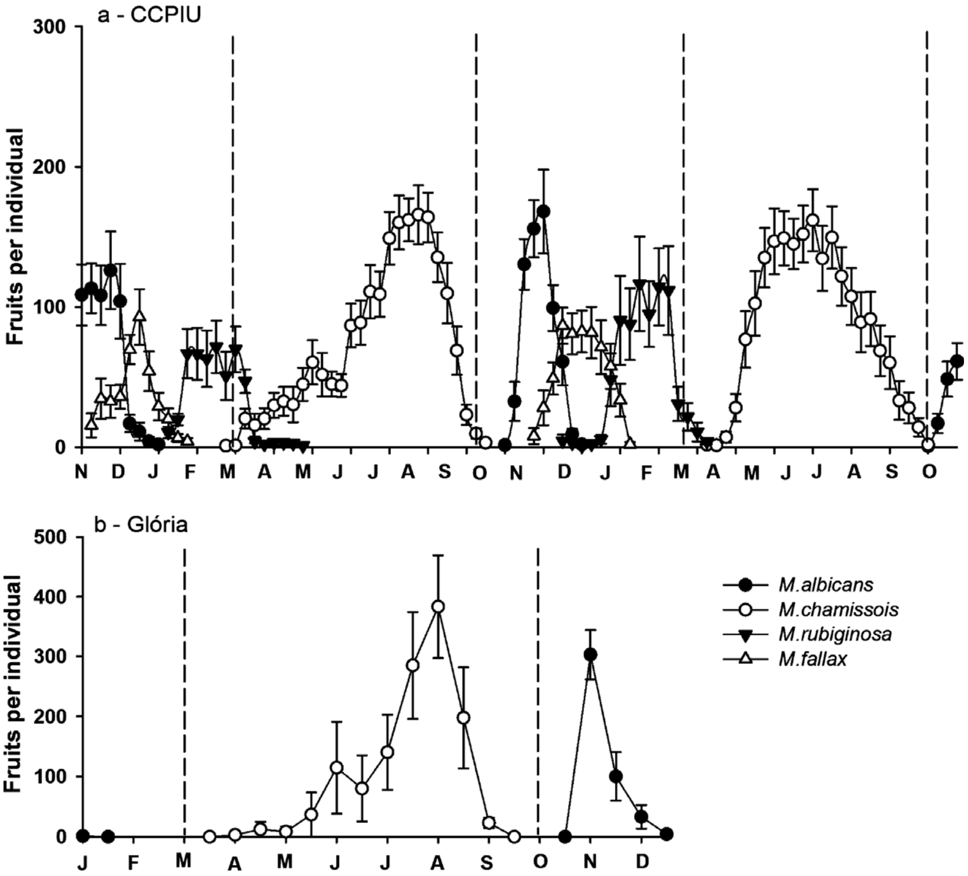

Figure 2. Fruiting phenology of *Miconia* assemblages (number of ripe fruits, mean ± SE) in two different sites near Uberlândia, MG, Brazil. Rainy and dry seasons are separated by dotted lines.

Table 2. Results of nested ANOVAs evaluating the changes in richness and abundance of birds at a palm swamp in Central Brazil. In the first group of analyses we compared the diversity of birds between rainy and dry seasons with months nested. In the second group the diversity of birds was compared according to the presence of *Miconia chamissois* fruits during the dry season, again with months nested as subgroups. Data were analysed after square-root transformation to meet statistical assumptions. *P < 0.05, **P < 0.01, ***P < 0.001.

Birds	Factor	df	*F*	
			Richness	Abundance
Frugivores	Season	1, 10	1.66	0.20
	Month (Season)	10, 192	4.98***	5.63***
Major frugivores	Season	1, 10	0.23	0.06
	Month (Season)	10, 192	2.68**	3.34***
Non-frugivores	Season	1, 10	1.53	1.18
	Month (Season)	10, 192	1.78	2.20*
Frugivores	Fruiting	1, 4	144***	116***
	Month (Fruiting)	4, 96	0.11	0.11
Major frugivores	Fruiting	1, 4	43.9**	43.0**
	Month (Fruiting)	4, 96	0.15	0.17
Non-frugivores	Fruiting	1, 4	1.93	1.22
	Month (Fruiting)	4, 96	0.39	0.43

during the dry season on the superficial layers in contrast with the savanna, allowing for evergreen vegetation (Furley 1999). This soil moisture difference among habitats is often evoked as an explanation for contrasting phenological patterns among different plant physiognomies in the Neotropical savanna (Furley 1999).

Several studies have investigated the existence of non-random phenological patterns in ecological communities (Burns 2005, Pleasants 1990). In some of the most recent studies using the null-model analysis, researchers have found different results either supporting (Kessler-Rios & Kattan 2012, Poulin *et al.* 1999, Thies & Kalko 2004) or not (Burns 2005) the non-random fruiting in plant assemblages. The lack of support for evenly displaced fruiting in this study may be credited to higher overlapping in fruiting among *Miconia* species which occur in savanna, since staggered fruiting could be limited by abiotic constraints, which strongly influence plant phenology (Fenner 1998, van Schaik *et al.* 1993).

Species of different foraging guilds and habits consumed *Miconia* fruits, which characterize their fruit as relatively unspecialized. A large number of species, from specialized frugivores to generalist omnivorous birds consuming fruits of *Miconia* seems to be a general trend, at least for the species in Brazil (Galetti & Stotz 1996, Gridi-Papp *et al.* 2004, Manhães *et al.* 2003) and can be an interesting strategy for pioneer plants like *Miconia*. Because of fruit characteristics (i.e. small and numerous seeds with rigid pericarp), bird pre-ingestion fruit handling probably has little impact on their seed dispersal ability (Levey 1987). Nevertheless, the gut treatment may be important. The majority of birds associated with *Miconia* were omnivorous and compared with specialized frugivores, which seldom destroy seeds in gut passage, they might impair seed germination (Schupp 1993). However, *Miconia* seeds remain intact and successfully germinate even after being defecated by many of the omnivorous species listed here (Manhães *et al.* 2003, Silveira *et al.* 2012).

The high similarity among birds consuming *Miconia* fruits in savanna and palm swamp is evidence of habitat linking and may highlight the importance of landscape supplementation (sensu Dunning *et al.* 1992). In this sense, the higher diversity of frugivores in palm swamp when *M. chamissois* bore fruits indicates an important role of this species and this habitat in maintaining birds which primarily dwell in savanna. The connectivity among different habitats for Neotropical savanna birds is often shown between open and forest habitats (Piratelli & Blake 2006, Tubelis *et al.* 2004), but little is known for palm swamps (Tubelis 2009). Birds are highly mobile animals with the ability to track fruit resources over time and space (Burns 2004, Levey 1988, García & Ortiz-Pulido 2004, Price 2004). The match between bird abundance and fruit abundance in time is dependent on the spatial scale of the observation and particular to each system (Burns 2004, García & Ortiz-Pulido 2004), but the contrast in fruit availability between different patches seems to be determinant (García & Ortiz-Pulido 2004). Considering this, the presence of an abundant fruit resource in the palm swamp during low fruit availability in savanna would generate sufficient contrast at the local scale which birds seem to track seasonally.

Miconia chamissois fruits can be considered a keystone resource (Bleher *et al.* 2003, Howe 1984, Peres 2000) in the study area for three reasons. First, fruits became available consistently throughout the years during the period of lowest fruit availability (dry season). Second, a representative portion of the frugivore birds in savanna consume *M. chamissois* fruits. And third, it is commonly one of the dominant zoochorous species in the palm swamp shrub layer, as shown in studies conducted in the same region and study sites (Araújo *et al.* 2002, Guimarães *et al.* 2002). Species defined as KPR are those with a pervasive influence on community composition (Peres 2000), whose eventual removal would drastically affect the community parameters in the area. Since many birds consuming *M. chamissois* fruits are not specialized frugivores, one may argue that its removal would not drastically affect the bird community. Nevertheless, it has been shown that many birds consuming *Miconia* fruits rely heavily on fruits for their diets, even though belonging to omnivorous or insectivorous groups (Marini & Cavalcanti 1998, Piratelli & Pereira 2002).

Due mostly to their hydrological importance, palm swamps are protected by law in Brazil (Guimarães

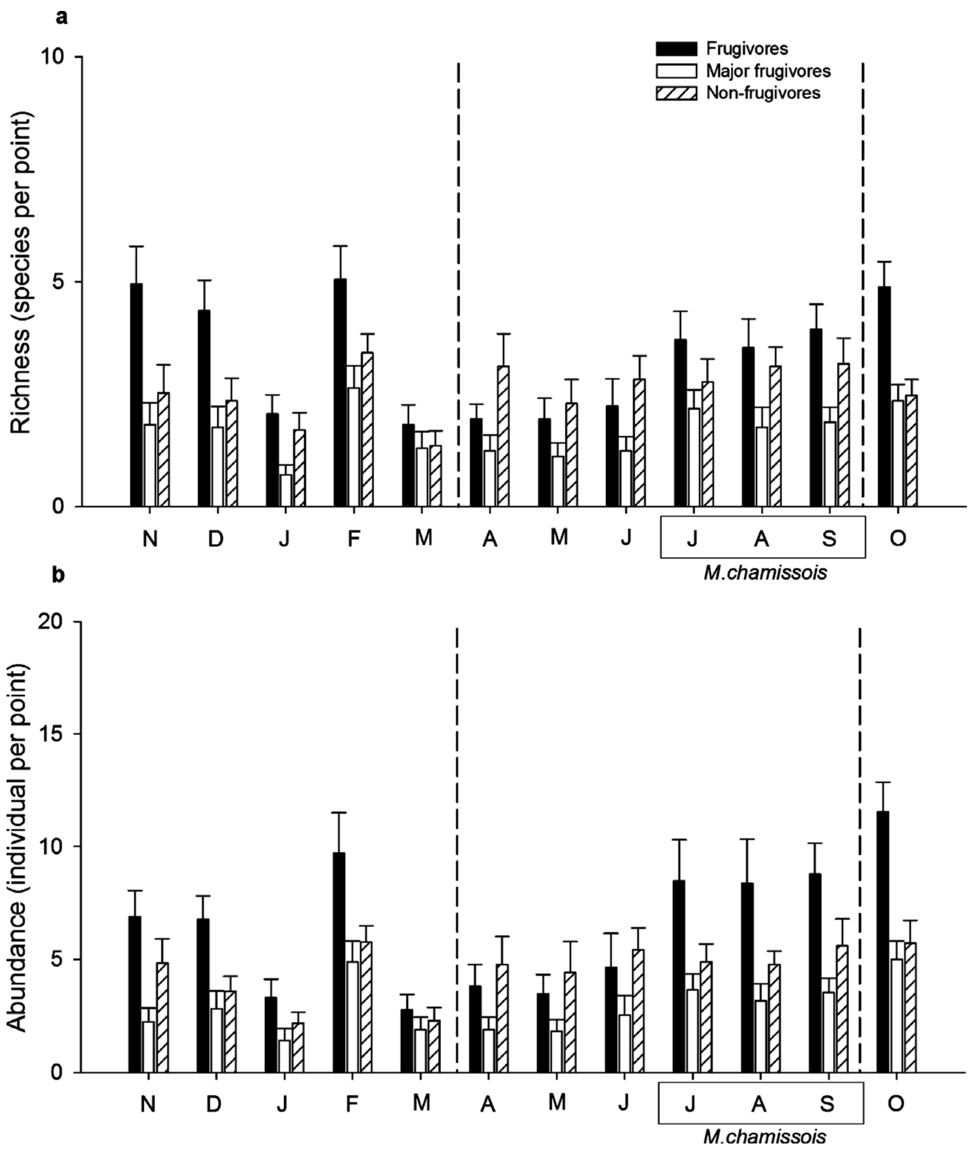

Figure 3. Richness (a) and abundance (b), mean ± SE, of different groups of birds in the vereda at CCPIU. Data were collected by point counting method. Rainy and dry seasons are separated by dotted lines. The frame around July to September indicates *Miconia chamissois* peak fruiting period in 2008.

et al. 2002). At the same time, they are threatened by and very susceptible to human activities which cause sedimentation, soil moisture loss and changes in plant species composition (Guimarães *et al.* 2002, Tubelis 2009). The majority of the birds recorded in this habitat are species that primarily inhabit other plant physiognomies and use it as an additional habitat (Tubelis 2009). Our study adds information about an important plant resource in palm swamp used by birds and reinforces the importance of embedded moister habitats during some periods of the year for birds in the Neotropical savanna. The *Miconia* assemblage studied here seems to promote complementarity between two adjacent habitats for many species of birds in the Neotropical savanna, calling attention to an important process which is likely to be common in this naturally patchy ecosystem.

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Appendix 1. List of frugivorous bird species recorded consuming fruits of *Miconia* (Melastomataceae) in three different sites near Uberlândia, in Central Brazil. *Ma – Miconia albicans; Mf – M. fallax; Mr – M. rubiginosa; Mc – M. chamissois*. Diet is based in major food items consumed by these bird species according to Develey & Endrigo (2004) and Sigrist (2006). *Record based on faecal sample. Diet abbreviations: Fr – Fruits, Ar – Arthropods, Se – Seeds, Sp – Sprouts, Sv – Small vertebrates and Ne – Nectar. *Volatina jacarina* consumed fruits partially, often without removing them from the plant and parakeets grabbed the infructescences with their feet when feeding and dropped many fruits in the process.

Species	Visits							Total	Fruits per visit (mean ± SD)	Fruits consumed (%)		Diet
	CCPIU				Gloria		Panga					
	Ma	*Mf*	*Mr*	*Mc*	*Ma*	*Mc*	*Mc*			Swallowed	Discarded	
Cracidae												
Penelope superciliaris Temminck, 1815	*	1						1*	24.0	100.0		Fr, Ar
Columbidae												
Leptotila sp.	2							2	3.0 ± 1.4	100.0		Fr, Se
Psittacidae												
Amazona aestiva (Linnaeus, 1758)	2							2	> 40	100.0		Fr, Se
Aratinga leucophthalma (Statius Muller, 1776)	2		3					5	> 40	100.0		Fr, Se
Cuculidae												
Crotophaga ani Linnaeus, 1758				4		2		6	11.5 ± 15.0	100.0		Ar, Sv
Furnariidae												
Phacellodomus ruber (Vieillot, 1817)	1	1	1	2				5	2.8 ± 1.5	100.0		Ar
Pipridae												
Antilophia galeata (Lichtenstein, 1823)							5	5	3.6 ± 1.9	100.0		Fr
Rynchocyclidae												
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)			1					1	2.0	100.0		Ar
Tyrannidae												
Elaenia spp.	34	37	46	32	13	3		165	2.7 ± 1.7	100.0		Fr, Ar
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)					4			4	2.8 ± 1.3	100.0		Ar
Gubernetes yetapa (Vieillot, 1818)				9				9	6.0 ± 1.2	100.0		Ar
Knipolegus lophotes Boie, 1828					5			5	1.8 ± 0.8	100.0		Ar
Legatus leucophaius (Vieillot, 1818)					2			2	6.0 ± 4.2	100.0		Ar
Myiophobus fasciatus (Statius Muller, 1776)			2					2	2.0 ± 1.4	100.0		Ar
Myiozetetes spp.						5		5	7.8 ± 2.2	100.0		Ar, Fr
Phyllomyias fasciatus (Thunberg, 1822)			2					2	1.5 ± 0.7	100.0		Ar
Pitangus sulphuratus (Linnaeus, 1766)	5	2		4	2	31		44	8.3 ± 8.0	100.0		Fr, Ar
Tyrannus albogularis Burmeister, 1856	1	5	4	4				14	4.0 ± 1.0	100.0		Fr, Ar
Tyrannus melancholicus Vieillot, 1819	2	3	2	1	4			12	3.2 ± 1.6	100.0		Fr, Ar
Tyrannus savana Vieillot, 1808	1	2		4	4	1		12	3.3 ± 1.4	100.0		Fr, Ar
Corvidae												
Cyanocorax cyanopogon (Wied, 1821)							1	1	26.0	100.0		Ar, Fr
Turdidae												
Turdus amaurochalinus Cabanis, 1850	1	3		8		14		26	9.4 ± 5.7	100.0		Fr, Ar
Turdus leucomelas Vieillot, 1818	2	3	2	11	1	4	4	27	9.3 ± 9.4	100.0		Fr, Ar
Turdus rufiventris Vieillot, 1818						9		9	12.1 ± 6.4	100.0		Fr, Ar

Mimidae											
Mimus saturninus (Lichtenstein, 1823)	5	6	12	10		3		36	6.9 ± 8.3	100.0		Fr, Ar
Coerebidae											
Coereba flaveola (Linnaeus, 1758)	1							1	1.0		100.0	Ne, Ar
Thraupidae											
Cyanerpes cyaneus (Linnaeus, 1766)					1			1	5.0	100.0		Fr, Ar
Dacnis cayana (Linnaeus, 1766)		2		3	5	6	4	20	4.8 ± 1.8	100.0		Fr, Ar
Lanio cucullatus (Statius Muller, 1776)							1	1	5.0	100.0		Se
Neothraupis fasciata (Lichtenstein, 1823)	2	2	3					7	4.4 ± 1.9	87.5	12.5	Fr, Ar
Pipraeidea melanonota (Vieillot, 1819)							1	1	12.0	100.0		Fr, Ar
Ramphocelus carbo (Pallas, 1764)						2	4	6	5.2 ± 2.0	100.0		Fr, Ar
Saltator similis d'Orbigny & Lafresnaye, 1837	2		1	3	1	1	3	11	6.6 ± 4.1	100.0		Se, Sp
Schistochlamys melanopis (Latham, 1790)				6		2	1	9	5.7 ± 2.5	100.0		Fr, Ar
Schistochlamys ruficapillus (Vieillot, 1817)	1	2	4	3				10	5.7 ± 2.1	100.0		Fr, Ar
Tachyphonus rufus (Boddaert, 1783)							3	3	4.7 ± 3.1	100.0		Fr, Ar
Tangara cayana (Linnaeus, 1766)	3		1	6	1	9	2	22	7.4 ± 4.8	98.0	2.0	Fr, Ar
Tangara palmarum (Wied, 1823)	13	8	7	14		7	2	51	4.9 ± 3.3	100.0		Fr, Ar
Tangara sayaca (Linnaeus, 1766)	1			3		12		16	8.8 ± 6.3	92.0	8.0	Fr, Ar
Tersina viridis (Illiger, 1811)						3	1	4	5.8 ± 3.9	100.0		Fr, Ar
Emberizidae											
Sporophila spp.						2		2	5.0 ± 0.0	50.0	50.0	Se
Volatinia jacarina (Linnaeus, 1766)	26	6	4	3	34			73	4.4 ± 3.8	10.1	89.9	Se
Zonotrichia capensis (Statius Muller, 1776)	3							3	2.0 ± 1.7	66.6	33.4	*Se*, *Ar*
Parulidae											
Geothlypis aequinoctialis (Gmelin, 1789)				2		1		3	2.7 ± 1.5	50.0	50.0	Ar
Icteridae											
Gnorimopsar chopi (Vieillot, 1819)	3			1		2		6	6.3 ± 2.2	100.0		Se, Ar
Icterus pyrrhopterus (Vieillot, 1819)	1			4		8		13	8.0 ± 4.8	96.2	3.8	Fr, Ar
Fringillidae											
Euphonia chlorotica (Linnaeus, 1766)				3			1	4	5.0 ± 2.2	100.0		Fr
Total	114	83	95	140	77	127	33	668				