Interactions between frugivorous birds and plants in savanna and forest formations of the Cerrado

Keila Nunes Purificação1,2,4, Márcia Cristina Pascotto2, Fernando Pedroni3, Jessiane Mayara Nogueira Pereira2 & Naftali Alves Lima2

1Programa de Pós-graduação em Ecologia e Conservação, Universidade do Estado de Mato Grosso, Nova Xavantina, MT, Brazil.
2Laboratório de Ornitologia, Universidade Federal de Mato Grosso, Barra do Garças, MT, Brazil.
3Universidade Federal de Mato Grosso, Instituto de Ciências Biológicas e da Saúde, Pontal do Araguaia, MT, Brazil.
4Corresponding author: Keila Nunes Purificação, e-mail: keilanunesbio@gmail.com

Abstract: We recorded interactions between frugivorous birds and plants in the Cerrado and we assessed the role and importance of birds as potential seed dispersers. We analyzed the distribution of recorded feeding events, bird-plant interactions, and bird species composition between savanna and forest formations and between the dry and rainy seasons. Samplings were carried out from August 2009 to October 2010 and from November 2011 to August 2012 by means of line transects and focal observations. We recorded 348 feeding events and 187 interactions involving 44 plant species and 60 bird species. Most of the feeding events were observed in the forests and during the dry season ($\chi^2 = 39.529; gl = 1; p < 0.001$). However, no significant difference was found in the number of interactions ($\chi^2 = 15.975; gl = 1; p = 0.06$) between the two vegetation formations and between seasons. The bird species composition differed between savanna and forest formations (ANOSIM, $R = 0.238; p < 0.001$) and between the dry and rainy seasons (ANOSIM, $R = 0.223; p < 0.001$). Most of the potential seed dispersers were generalist birds that preferentially occupy forests during the dry season. Records of feeding events in forest formations increased in the dry season, indicating that birds use these sites as foraging areas during this period. We suggest that the preservation of forests in predominantly savanna-like ecosystems such as the Cerrado is extremely important for frugivorous birds and for frugivore-plant interactions.

Keywords: Mutualistic interactions, Neotropical savanna, seasonality, seed dispersal.

Interações entre aves frugívoras e plantas em formações savanárias e florestais do Cerrado.

Resumo: Registramos interações entre aves frugívoras e plantas no Cerrado e avaliamos o papel e a importância das aves como potenciais dispensadoras de sementes. Observamos como números de registros de alimentação e de interações e composição de espécies de aves se distribuem entre formações savanárias e florestais e entre as estações seca e chuvosa. Realizamos amostragens entre agosto/2009 e outubro/2010 e entre novembro/2011 e agosto/2012 por meio de transecções e observações focais. Observamos 348 registros de alimentação e 187 interações envolvendo 44 espécies de plantas e 60 espécies de aves. A maioria dos registros de alimentação foi observada nas florestas e durante a estação seca ($\chi^2 = 39.529; gl = 1; p < 0.001$). Já em relação ao número de interações não encontramos diferença significativa ($\chi^2 = 15.975; gl = 1; p = 0.06$) entre as duas formações vegetacionais e entre as estações. A composição de espécies de aves diferiu entre formações savanárias e florestais (ANOSIM, $R = 0.238; p < 0.001$) e entre as estações seca e chuvosa (ANOSIM, $R = 0.223; p < 0.001$). A maioria das espécies potencialmente dispersoras foi aves generalistas que ocupam preferencialmente florestas durante a estação seca. Durante a estação seca há aumento de registros de alimentação nas formações florestais, indicativo de que as aves usam estes locais como área de forrageio nesse período. Sugerimos que a manutenção de florestas em ecossistemas predominantemente savanárias como o Cerrado é extremamente importante para a avifauna frugívora e para as interações frugívoro-planta.

Palavras-chave: Interações mutualísticas, savana Neotropical, sazonalidade, dispersão de sementes.
Introduction

One of the main positive interactions between plants and animals is seed dispersal by frugivores. Plants benefit from the dispersal of their propagules away from the parent plant because this reduces competition and predation (Howe & Smallwood 1982) and increases gene flow between populations. In return, animals that consume fruits receive nutritional benefits (Howe & Primack 1975, Snow 1981).

The interactions between fruiting plants and frugivorous birds in a community define a pattern comprising a few bird species that interact with many plant species and a few plants that interact with many birds. This makes the dependence between bird and plants species essential to the stability of the ecological processes of a community (Fadini & De Marco 2004).

Birds stand out as seed dispersers due to the high abundance and frequency with which they feed on fruits and their great ability to move between environments (Jordano 1994). Frugivorous birds represent 56% of the world’s avian families and, in Neotropical forests, 25 to 30% of the avifauna includes fruits in their diet (Pizo & Galetti 2010). According to Jordano (1987), studies of frugivory by birds in tropical forests are relatively well reported (e.g., Snow 1981, Jordano 1987, Galetti & Pizo 1996, Medellı´n & Gaona 1999, Silva & Tabarelli 2000, Bascompte et al. 2003, Saracco et al. 2005, Galetti et al. 2013). It is estimated that 50 to 90% of tree species in tropical forests produce zoothcorous fruit (Howe & Smallwood 1982). In contrast, in tropical savannas, despite the wide geographical distribution and rich biodiversity, few studies have addressed the frugivory and seed dispersal by birds (e.g., Dean et al. 1999, Hovestadt et al. 1999, Wütherich et al. 2001, Faustino & Machado 2006, Christianini & Oliveira 2009, Pascotto et al. 2012, Maruyama et al. 2013).

Savannas are defined primarily by their seasonal climate and fire regime, with vegetation characterized by an herbaceous stratum dominated by grasses and a discontinuous woody shrub stratum (Skarpe 1992). The Brazilian Cerrado, the largest savanna in the world, is represented by a mosaic of phytosociological formations such as Fields, Cerrado sensu stricto, Semideciduous Forests and Gallery Forests (Silva & Bates 2002). The climate is represented by two well-defined seasons (one warm and wet and the other cool and dry), due to the changes in temperature and precipitation over the year (Eiten 1972).

With about 12000 plant species (Mendonça et al. 2008) and 837 bird species (Myers et al. 2000) catalogued, it is estimated that about half of the plant species in the Cerrado need animals to disperse their seeds, and birds are the main group of dispersers (Gottsberger & Silberbauer-Gottsberger 1983, Pinheiro & Ribeiro 2001, Kuhlmann 2012). The proportion of zoothcorous plant species is high in both savanna and forest physiognomies of the Cerrado. In the Cerrado sensu stricto of Central Brazil, for example, the proportion of zoothcorous plant species ranges from 51 to 68% (Vieira et al. 2002). On the other hand, in the Gallery Forests of Central and Southeastern Brazil, 63 to 89% of the plants have zoothcorous dispersion and more than half of them are ornithochorous (Pinheiro & Ribeiro 2001, Motta-Junior & Lombardi 2002).

The fruit production of most Cerrado sensu stricto zoothcorous species follows a seasonal pattern, with a peak in fruit ripening in the rainy season (Silberbauer-Gottsberger 2001, Lenza & Klink 2006, Pirani et al. 2009, Camargo et al. 2013). The same pattern has been observed in Gallery Forests (Oliveira & De Paula 2001). However, the fruit of most abundant species in the two phytosociological formations ripen in the dry season (Gouveia & Felfili 1998).

Knowing that seed dispersal is an important ecological process that acts in the maintenance of diversity and that frugivory is the first step in studying this event (Cordeiro & Howe 2001), our objectives were (i) to identify the interactions between frugivorous birds and plants and the most important species in the community (sensu importance Murray 2000), and (ii) to evaluate the potential of seed dispersal, number of feeding records, number of interactions and composition of frugivorous bird species in savanna and forest formations of the Cerrado, considering the dry and rainy seasons. We tested the hypothesis that forest formations have higher numbers of feeding records and interactions, since most of the zoothcorous plants of the Cerrado are concentrated in forests (Pinheiro & Ribeiro 2001, Kuhlmann 2012), and that the records of feeding and interactions show higher values during the rainy season, because there is greater availability of ripe fruit in the Cerrado during this season (Silberbauer-Gottsberger 2001, Lenza & Klink 2006, Pirani et al. 2009, Camargo et al. 2013). Our second hypothesis is that the composition of frugivorous bird species does not differ between savanna and forest formations or between the dry and rainy seasons, since most of the bird species of the Cerrado occur in both vegetation formations (Silva 1997, Bagno & Marinho-Filho 2001).

Material and Methods

Study area – This study was conducted in Serra Azul State Park (15°52’S and 51°16’W), located in the municipality of Barra do Garcas, in the region of the Araguaia Valley, in the eastern part of the state of Mato Grosso. With an area of about 11,000 ha, this is an important Conservation Unit in the Cerrado containing a variety of phytosociological formations typical to this biome, including savanna and forest formations (Ribeiro & Walter 2008). The average altitudes in the region range from 600 to 700 m and its soils are classified as clayey dystrophic red-yellow latosol (oxisol) (Pirani et al. 2009).

According to the Köppen classification the region has an Aw type climate, hot and humid, with two well-defined seasons, a rainy summer (October to March) and dry winter (April to September). The average annual temperature is 25.5°C and annual average rainfall is 1,528 mm (Pirani et al. 2009).

Data collection – Sampling was conducted from August 2009 to October 2010 (first period) and from November 2011 to August 2012 (second period). In the first period, we used four preestablished trails, each approximately 2 km in length, two of which passed through savanna formations (rocky outcrop Cerrado - Cerrado Rupestre and Typical Cerrado - Cerrado Topico) and two through forest formations (Gallery Forest and Semideciduous Forest). In the second period we sampled the module that follows the RAPELD model (Magnussen et al. 2005), in which two parallel 5-km-long trails, one kilometer apart from each other, pass through different Cerrado phytosociological formations, such as Shrubby Grassland Cerrado (Cerrado Ralo), Typical Cerrado, Semideciduous Forest and Gallery Forest (sensu Ribeiro & Walter 2008).

The interactions were recorded using the line transect method (Bibby et al. 2000), with adaptations for frugivory...
The plant species that interacted with the largest number of plants were Turdus leucotis (Vielliot, 1818) (15 interactions) and Dacnis cayana (Linnæus, 1766) (n = 12), followed by Dacnis cayana (Linnæus, 1766) (n = 9) and Cyanocorax cyanopogon (Wied, 1821) (n = 9). Considering only forest formations, Turdus leucotis (n = 12), Dacnis cayana (n = 8) and Saltator maximus (Statius Muller, 1776) (n = 8) were the bird species that interacted with the largest number of plant species. In the savanna formations, Dacnis cayana and Turdus leucotis (Vielliot, 1818) stood out with five interactions each, and Hemithraupis guira (Linnæus, 1766) and Eulaena chiriquensis Lawrence, 1865, with four interactions each.

The plant species that interacted with the largest number of bird species were Miconia staminea (23 interactions), Cecropia pachystachya (n = 12) and Dilodendron bipinnatum Radl. (n = 12). In the forest formations, 35% of the observed interactions involved Miconia staminea (n = 23), Dilodendron bipinnatum (n = 12) and Schefflera morototoni (n = 10). On the other hand,
about 40% of the interactions in the savanna formations involved *Cecropia pachystachya* (9 interactions), *Curatella americana* L. (n = 9) and *Copaifera langsdorffii* (n = 7).

As for the importance index, *Turdus leucomelas* ($I = 0.107$), *Cyanocorax cyanopogon* ($I = 0.066$) and *Trogon curucui* (Linnaeus, 1766) ($I = 0.054$) were the most important bird species in the entire community (Figure 2A). The most important bird species in the forests were *Turdus leucomelas* ($I = 0.116$), *Trogon curucui* ($I = 0.078$) and *Saltator maximus* ($I = 0.071$). In the savanna formations, the bird species with the highest levels of importance were *Volatinia jacarina* (Linnaeus, 1766) ($I = 0.080$), *Turdus leucomelas* ($I = 0.065$), *Tangara sayaca* ($I = 0.065$) and *Myiodynastes maculatus* (Statius Muller, 1776) ($I = 0.065$).

Among plants, *Miconia staminea* ($I = 0.162$), *Cecropia pachystachya* ($I = 0.083$) and *Rudgea viburnoides* ($I = 0.063$) were the most important in the community (Figure 2B). The plants that stood out in the forest formations were *Miconia staminea* ($I = 0.255$), *Rudgea viburnoides* ($I = 0.089$) and *Xylopia sericea* ($I = 0.084$). The most important plants in the savanna formations were *Cecropia pachystachya* ($I = 0.170$), *Curatella americana* ($I = 0.165$) and *Copaifera langsdorffii* ($I = 0.111$).
Among the observed interactions, 77% showed a potential for dispersal. Of the 60 bird species, 49 (82%) were considered potential dispersers of all the plant species with which they interacted. Seed predators, represented mainly by species of the Psittacidae family, accounted for 12% of the observed bird species. Besides parrots, only *Cyclarhis gujanensis* (Gmelin, 1789), *Nemosia pileata* (Boddaert, 1783), *Neothraupis fasciata* (Lichtenstein, 1823), *Tersina viridis* (Illiger, 1811), *Zonotrichia capensis* (Statius Muller, 1776) and *Gnorimopsar chopi* (Vieillot, 1819) were not considered potential seed dispersers of any plant species (Table 1).

The seeds of nine plant species were not dispersed by any bird species. The seeds of four of these plant species [*Brosimum gaudichaudii* Treécul, *Caryocar brasiliense* Cambess., *Cordia sellowiana* Cham. and *Pseudobombax tomentosum* (Mart. & Zucc.)] were shredded by parrots. Added to these plant species, the fruits of *Mezilaurus crassiramea* (Meisn.) Taub. ex Mez and *Indeterminate 1* were consumed only in the unripe stage. The consumption of pulp was observed only in *Buchenavia tomentosa* Eichler, *Diospyros brasiliensis* Mart. ex Miq. and *Mangifera indica* L. (Table 1).

Most of the feeding events (70% of total) were recorded in forest formations and during the dry season (73%) ($\chi^2 = 39.529; gl= 1; p < 0.001$). As for the number of interactions (consumed/did not consume), about 70% of them were recorded in the forest formations and also during the dry season (75%). However, this result was not significant ($\chi^2 = 15.975; gl= 1; p = 0.06$). Of total number of frugivorous birds recorded, 75% occurred in forest formations and 52% in savanna formations, indicating that the composition of frugivorous bird species differed between the two types of vegetation (ANOSIM, $R = 0.238, p < 0.001$). The bird species composition also differed between seasons (ANOSIM, $R = 0.223, p < 0.001$). About 80% of the species were recorded during the dry season, while approximately 50% were recorded eating fruits in the rainy season. Twenty-nine bird species were recorded consuming fruits exclusively in forests, 15 exclusively in savanna formations, and 16 in both environments (Table 1).

### Discussion

Bird species of the Thraupidae and Tyrannidae families (Passeriformes) were found to be the main potential seed dispersers. In frugivory studies conducted in the Cerrado ([Francisco & Galetti 2002, Cazetta et al. 2002, Melo et al. 2003, Marcondes-Machado & Rosa 2005, Pascotto 2006, 2007, Francisco et al. 2007, Christianini & Oliveira 2009, Allenspach & Dias 2012, Pascotto et al. 2012, Maruyama et al. 2013]), species of the aforementioned families also stood out as the main potential seed dispersers, with *Tangara sayaca*, *Tangara cayana* (Thraupidae), *Pitangus sulphuratus* (Linnaeus, 1766) and *Myiodynastes maculatus* (Tyrannidae) standing out as the most frequently recorded species.

Species of the tanager family are very important to seed dispersal in the Cerrado, as well as throughout the Neotropics (Snow & Snow 1971). According to Francisco & Galetti (2002),

![Figure 2. Indices of importance of the ten avian (A) and plant (B) species that presented the highest values in Serra Azul State Park, Mato Grosso, Brazil. The number of recorded interactions are shown in parentheses.](http://dx.doi.org/10.1590/1676-06032014006814 http://www.scielo.br/bn)
Table 1. Avian species observed consuming fruit during 284 hours of observations in forest and savanna formations in Serra Azul State Park, municipality of Barra do Garcas, Mato Grosso, Brazil.  

| Birds          | Plants                          | DP    | D    | VF   | S   | Portion consumed |
|----------------|---------------------------------|-------|------|------|-----|------------------|
| Red-billed Green Pigeon          | Rudgea viburnoides (Cham.) Benth (Rubiaceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Grey Pigeon                  | Schefflera morototoni (Aubl.) Maguire et al. (Araliaceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Indeterminate Trogosit | Byrsonima sp. (Malpighiaceae) | PD    | Omn  | F    | R   | Whole fruit      |
| Indeterminate Trogosit | Byrsonima sericea DC. (Malpighiaceae) | PD    | F    | R    | D   | Whole fruit      |
| Indeterminate Trogosit | Dilodendron bipinnatum Radlk. (Sapindaceae) | PD    | F    | D    |     | Seeds            |
| Indeterminate Trogosit | Guarea guidonia (L.) Sleumer (Meliaceae) | PD    | F    | D    |     | Seeds            |
| Momotus momota             | Cabralea canjerana (Vell.) Mart. (Meliaceae) | PD    | Omn  | F    | D   | Seeds            |
| Momotus momota             | Xylopia aromatica (Lam.) Mart. (Annonaceae) | PD    | F    | D    |     | Seeds            |
| Dusky Cuckoo                | Cecropia pachystachya Tréc. (Urticaceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Dusky Cuckoo                | Calypranthes cf. lucida Mart. ex DC. (Myrtaceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Dusky Cuckoo                | Campomanesia eugenioides (Cambess.) D.Legrand ex Landrum (Myrtaceae) | PD    | F    | R    |     | Whole fruit      |
| Dusky Cuckoo                | Ocotea corymbosa (Mein.) Mez (Lauraceae) | PD    | F    | R    |     | Whole fruit      |
| Dusky Cuckoo                | Myrsine umbellata Mart. (Primulaceae) | PD    | F    | D    |     | Whole fruit      |
| Celeus flavescens (Gmelin, 1788) | Xylopia aromatica (Lam.) Mart. (Annonaceae) | PD    | Ins  | F    | D   | Seeds            |
| Celeus flavescens (Gmelin, 1788) | Xylopia seirea A.St.-Hil. (Annonaceae) | PD    | F    | D    |     | Seeds            |
| Dryocopus lineatus (Linnaeus, 1766) | Myrcia multiflora (Lam.) D.C. (Myrtaceae) | PD    | Ins  | S    | R   | Whole fruit      |
| Ara chloropterus Gray, 1859  | Caryocar brasiliense Cambess. (Caryocaraceae) | ND    | Fru  | S    | D   | Pulp/Seeds*     |
| Diopsittaca nobilis (Linnaeus, 1758) | Cordia sellowiana Cham. (Boraginaceae) | ND    | Fru  | F    | R   | Pulp/Seeds*     |
| Diopsittaca nobilis (Linnaeus, 1758) | Cordia sellowiana Cham. (Boraginaceae) | ND    | Fru  | S    | R   | Pulp/Seeds*     |
| Diopsittaca nobilis (Linnaeus, 1758) | Brosimum gauchichaudii Tréc (Moraceae) | ND    | Fru  | S    | D   | Pulp/Seeds*     |
| Diopsittaca nobilis (Linnaeus, 1758) | Brosimum gauchichaudii Tréc (Moraceae) | ND    | Fru  | S    | D   | Pulp/Seeds*     |
| Diopsittaca nobilis (Linnaeus, 1758) | Pseudobombax tomentosum (Mart. & Zucc.) A.Robyns (Malvaceae) | ND    | F    | D    |     | Pulp/Seeds*     |
| Pipra fasciicauda Hellmayr, 1906 | Miconia staminea (Desr.) DC. (Melastomataceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Antilophia galeata (Lichtenstein, 1823) | Rudgea viburnoides (Cham.) Benth (Rubiaceae) | PD    | Fru  | F    | D   | Whole fruit      |
| Tityra inquisitor (Lichtenstein, 1823) | Rudgea viburnoides (Cham.) Benth (Rubiaceae) | PD    | Ins  | F    | D   | Whole fruit      |

Continued on next page
Table 1. Continued.

| Birds | Plants | DP | D | VF | S | Portion consumed |
|-------|--------|----|---|----|---|-----------------|
| *Tityra semifasciata* (Spix, 1825) | *Byrsonima sericea* DC. (Malpighiaceae) | PD | Ins | F | R | Whole fruit |
| *Dilodendron bipinnatum* Radlk. (Sapindaceae) | ND | F | D | Whole fruit |
| *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | F | D | Whole fruit |
| *Ocotea corymbosa* (Meisn.) Mez (Lauraceae) | PD | F | D | Whole fruit |
| *Schefflera morototoni* (Aubl.) Maguire *et al.* (Araliaceae) | PD | F | D | Whole fruit |
| *Virola sebifera* Aubl. (Myristicaceae) | PD | F | D | Seeds/Aril |
| *Xylopia aromatica* (Lam.) Mart. (Annonaceae) | PD | F | D | Seeds |
| *Pachyramphus viridis* (Vieillot, 1816) | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | Omn | F | D | Whole fruit |
| **Tyrannidae** |  |  |  |  |  |  |
| *Camptostoma obsoletum* (Temminck, 1824) | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | Ins | F | D | Whole fruit |
| *Elaenia flavogaster* (Thunberg, 1822) | *Byrsonima pachypHYLLA* A.Juss. (Malpighiaceae) | PD | Omn | S | D | Whole fruit |
| *Elaenia mesoleuca* (Deppe, 1830) | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | S | D | Whole fruit |
| *Elaenia chiriquiensis* Lawrence, 1865 | *Xylopia sericea* A.St.-Hil. (Annonaceae) | PD | Omn | F | D | Seeds |
| *Miarychus swainsoni* Cabanis & Heine, 1859 | *Brosimum gauchaudii* Trécul (Moraceae) | ND | Omn | S | D | Pulp |
| *Elaenia chiriquiensis* Lawrence, 1865 | *Byrsonima pachypHYLLA* A.Juss. (Malpighiaceae) | PD | S | D | Whole fruit |
| *Cupania vernalis* Cambess. (Sapindaceae) | ND | F | D | Aril |
| *Miconia albicans* (Sw.) Triana (Melastomataceae) | ND | S | D | Unripe fruit |
| *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | F | D | Whole fruit |
| *Myiarchus swainsoni* Cabanis & Heine, 1859 | *Cabralea canjerana* (Vell.) Mart. (Meliaeaceae) | PD | Ins | F | D | Seeds |
| *Dilodendron bipinnatum* Radlk. (Sapindaceae) | ND | F | D | Aril |
| *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | F | D | Whole fruit |
| *Virola sebifera* Aubl. (Myristicaceae) | PD | F | D | Seeds/Aril |
| *Sirystes sibilator* (Vieillot, 1818) | *Cabralea canjerana* (Vell.) Mart. (Meliaeaceae) | PD | Ins | F | D | Seeds |
| *Pitangus sulphuratus* (Linnaeus, 1766) | *Copaifera langsdorffii* Desf. (Fabaceae) | PD | Omn | F | D | Seeds/Aril |
| *Myiodymanes maculatus* (Statius Muller, 1776) | *Byrsonima sericea* DC. (Malpighiaceae) | PD | Omn | F | R | Whole fruit |
| *Byrsonima* sp. (Malpighiaceae) | PD | F | D | Whole fruit |
| *Cabralea canjerana* (Vell.) Mart. (Meliaeaceae) | PD | F | D | Seeds |
| *Copaifera langsdorffii* Desf. (Fabaceae) | PD | F/S | D | Seeds/Aril |
| *Cupania vernalis* Cambess. (Sapindaceae) | PD | F | D | Seeds/Aril |
| *Curatella americana* L. (Dilleniaceae) | PD | S | D | Seeds/Aril |
| *Davilla elliptica* A.St.-Hil. (Dilleniaceae) | PD | S | D | Seeds/Aril |
| *Dilodendron bipinnatum* Radlk. (Sapindaceae) | ND | F | D | Aril |
| *Megarynchus pitangua* (Linnaeus, 1766) | *Byrsonima* sp. (Malpighiaceae) | PD | Omn | F | R | Whole fruit |
| *Cabralea canjerana* (Vell.) Mart. (Meliaeaceae) | PD | F | D | Seeds |
| *Curatella americana* L. (Dilleniaceae) | PD | S | R | Seeds/Aril |
| *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | F | D | Whole fruit |
| *Empidonax varius* (Vieillot, 1818) | *Byrsonima sericea* DC. (Malpighiaceae) | PD | Ins | F | R | Whole fruit |
| *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD | F | D | Whole fruit |

Continued on next page
Table 1. Continued.

| Birds                  | Plants                                      | DP¹ | D² | VE³ | S⁴     | Portion consumed          |
|------------------------|---------------------------------------------|-----|----|-----|--------|---------------------------|
| *Cnemotriccus fuscatus* (Wied, 1831) | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD  | Ins | F   | D      | Whole fruit               |
| Vireonidae             |                                             |     |    |     |        |                           |
| *Cyclarhis gujanensis* (Gmelin, 1789) | *Cupania vernalis* Cambess. (Sapindaceae) | ND  | Ins | F   | D      | Aril                      |
| *Vireo chivi* (Linnaeus, 1766) | *Cupania vernalis* Cambess. (Sapindaceae) | PD  | Omn | F   | D      | Seeds/Aril                |
|                        | *Dilodendron bipinnatum* Radlk. (Sapindaceae) | ND  | F   | D   |        | Aril                      |
|                        | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Zanthoxylum rhoifolium* Lam. (Rutaceae) | PD  | F   | D   |        | Seeds                     |
| Corvidae               |                                             |     |    |     |        |                           |
| *Cyanocorax cyanopogon* (Wied, 1821) | *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. (Areaceae) | PD$  | Omn | F   | R      | Pulp                      |
|                        | *Buchenavia tomentosa* Eichler (Combretaceae) | ND  | S   | D   |        | Pulp                      |
|                        | *Copaifera langsdorffii* Desf. (Fabaceae) | PD  | S   | D   |        | Seeds/Aril                |
|                        | *Diospyros brasiliensis* Mart. ex Miq. (Ebenaceae) | ND  | F   | D   |        | Pulp                      |
|                        | *Mangifera indica* L. (Anacardiacae) | ND  | F   | R   |        | Pulp                      |
|                        | *Miconia albicans* (Sw.) Triana (Melastomataceae) | PD  | F   | C   |        | Whole fruit               |
|                        | *Miconia macrothyrsa* Benth. (Melastomataceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Tocoynena formosa* (Cham. & Schltdl.) K.Schum. (Rubiaceae) | PD  | S   | D   |        | Seeds/Pulp                |
|                        | *Virola sebifera* Aubl. (Myristicaceae) | PD  | F   | D   |        | Seeds/Aril                |
| Turdidae               |                                             |     |    |     |        |                           |
| *Turdus leucomelas* Vieillot, 1818 | *Byronima sericea* DC. (Malpighiaceae) | PD  | Omn | F   | R      | Whole fruit               |
|                        | *Cabralea canjerana* (Vell.) Mart. (Meliaceae) | PD  | F   | D   |        | Seeds                     |
|                        | *Calyptranthesf. lucida* Mart. ex DC. (Myrtaceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Cecropia pachystachya* Trécul (Urticaceae) | PD  | S   | R/D |        | Pulp/Seeds                |
|                        | *Copaifera langsdorffii* Desf. (Fabaceae) | PD  | S   | D   |        | Seeds/Aril                |
|                        | *Lasiacis iligalata* Hitch. & Chase (Poaceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Miconia staminea* (Desr.) DC. (Melastomataceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Myrcia tomentosa* Aubl. (Myrtaceae) | PD  | S   | R   |        | Whole fruit               |
|                        | Indeterminada 2                             | PD  | F   | D   |        | Whole fruit               |
|                        | *Rudgea viburnoides* (Cham.) Benth. (Rubiaceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Schefflera morototoni* Aubl. Maguire et al. (Araliaceae) | PD  | F   | D   |        | Whole fruit               |
|                        | *Xylopia aromatica* (Lam.) Mart. (Annonaceae) | PD  | F   | D   |        | Seeds                     |
|                        | *Xylopia sericea* A.St.-Hil. (Annonaceae) | PD  | F   | D   |        | Seeds                     |
|                        | *Zanthoxylum rhoifolium* Lam. (Rutaceae) | PD  | F   | D   |        | Seeds                     |
| *Turdus amaurochalinus* Cabanis, 1850 | *Copaifera langsdorffii* Desf. (Fabaceae) | PD  | Omn | S   | D      | Seeds/Aril                |
|                        | *Schefflera morototoni* Aubl. Maguire et al. (Araliaceae) | PD  | F   | D   |        | Whole fruit               |
| *Turdus subalaris* (Seebohm, 1887) | *Cupania vernalis* Cambess. (Sapindaceae) | PD  | Omn | F   | D      | Seeds/Aril                |
|                        | *Dilodendron bipinnatum* Radlk. (Sapindaceae) | ND  | F   | D   |        | Aril                      |
|                        | *Schefflera morototoni* Aubl. Maguire et al. (Araliaceae) | PD  | F   | D   |        | Whole fruit               |
| *Turdus albicollis* Vieillot, 1818 | *Myrsine umbellata* Mart. (Primulaceae) | PD  | Omn | F   | D      | Whole fruit               |
|                        | *Rudgea viburnoides* (Cham.) Benth (Rubieaceae) | PD  | F   | D   |        | Whole fruit               |

Continued on next page
Table 1. Continued.

| Birds              | Plants                                      | DP  | D  | VE | S  | Portion consumed |
|--------------------|---------------------------------------------|-----|----|----|----|------------------|
| Mimidae            | Schellera morototoni (Aubl.) Maguire et al. (Araliaceae) | PD  | F  | D  |    | Whole fruit      |
| Mimus saturninus   | Copaifera langsdorffii Desf. (Fabaceae)     | PD  | Omn| S  | D  | Seeds/Aril       |
| Pasceledida        | Curatella americana L. (Dilleniaceae)        | ND  | Gra| S  | D  | Unripe fruit     |
| Icteridae          | Icterus pyrrhopterus (Vieillot, 1819)        |     |    |    |    |                  |
|                    | Gnorimopsar chopi (Vieillot, 1819)           |     |    |    |    |                  |
| Thraupidae         | Coereba flaveola (Linnaeus, 1758)            |     |    |    |    |                  |
| Saltator maximus   | Copaifera langsdorffii Desf. (Fabaceae)     | PD  | Omn| S  | D  | Pulp/Seeds       |
|                    | Dilodendron bipinnatum Radlk. (Sapindaceae)  | ND  | F  | D  |    | Whole fruit      |
|                    | Lasiacis ligulata Hitchc. & Chase (Poaceae)  | PD  | F  |    |    | Whole fruit      |
|                    | Miconia staminea (Desr.) DC. (Melastomataceae) | PD  | F  | D  |    | Whole fruit      |
|                    | Pterodon pubescens (Benth.) Benth. (Fabaceae) | PD  | F  |    |    | Seeds            |
|                    | Rudgea viburnoides (Cham.) Benth (Rubiacae)  | PD  | F  |    |    | Whole fruit      |
|                    | Schefflera morototoni (Aubl.) Maguire et al. (Araliaceae) | PD  | F  |    |    | Whole fruit      |
| Saltator similis   | Cupania vernalis Cambess. (Sapindaceae)      | PD  | Omn| F  | D  | Seeds/Aril       |
|                    | Miconia staminea (Desr.) DC. (Melastomataceae) | PD  | F  |    |    | Whole fruit      |
|                    | Zanthoxylum rhoifolium Lam. (Rutaceae)       | PD  | F  |    |    | Seeds            |
| Nemosia pileata    | Copaifera langsdorffii Desf. (Fabaceae)     | ND  | Omn| F  | D  | Aril             |
|                    | Davilla elliptica A.St.-Hil. (Dilleniaceae)  | ND  | S  |    |    | Aril             |
|                    | Dilodendron bipinnatum Radlk. (Sapindaceae)  | ND  | F  |    |    | Aril             |
| Tachyphonus rufus  | Byrsonima pachyphylla A.Juss. (Malpighiaceae) | PD  | Omn| S  | D  | Whole fruit      |
|                    | Copaifera pachystachya Tre’cul (Urticaceae)  | PD  | S  |    |    | Pulp/Seeds       |
|                    | Dilodendron bipinnatum Radlk. (Sapindaceae)  | ND  | F  |    |    | Aril             |
|                    | Miconia staminea (Desr.) DC. (Melastomataceae) | PD  | F  |    |    | Whole fruit      |
|                    | Rudgea viburnoides (Cham.) Benth (Rubiacae)  | PD  | F  |    |    | Whole fruit      |
| Ramphocelus carbo  | Cupania vernalis Cambess. (Sapindaceae)      | ND  | Omn| F  | D  | Aril             |
|                    | Miconia staminea (Desr.) DC. (Melastomataceae) | PD  | F  |    |    | Whole fruit      |
|                    | Xylopia aromatica (Lam.) Mart. (Annonaceae)  | PD  | F  |    |    | Seeds            |
| Lanio cristatus    | Miconia staminea (Desr.) DC. (Melastomataceae) | PD  | Omn| F  |    | Whole fruit      |
| Lanio penicillatus | Byrsonima sericea DC. (Malpighiaceae)        | ND  | F  |    |    | Aril             |
|                    | Cupania vernalis Cambess. (Sapindaceae)      | ND  | F  |    |    | Aril             |
|                    | Dilodendron bipinnatum Radlk. (Sapindaceae)  | ND  | F  |    |    | Aril             |
| Tangara sayaca     | Brosimum gaudichaudii Tre’cul (Moraceae)     | ND  | Omn| S  | D  | Pulp             |
|                    | Copaifera pachystachya Tre’cul (Urticaceae)  | PD  | S  |    |    | Pulp/Seeds       |
|                    | Copaifera langsdorffii Desf. (Fabaceae)     | ND  | S  |    |    | Aril             |

Continued on next page
| Birds                    | Plants                          | DP | D² | VF³ | S⁴ | Portion consumed |
|-------------------------|---------------------------------|----|----|-----|----|------------------|
|                         | Norantea guianensis Aubl.       | PD | S  | R   |    | Pulp/Seeds       |
|                         | Psittacanthus robustus Mart.    | PD | S  | D   |    | Whole fruit      |
|                         | Xylopia sericea A.St.-Hil.      | PD | F  | D   |    | Whole fruit      |
|                         | Schefflera morototoni Aubl.     | PD | F  | D   |    | Whole fruit      |
|                         | Miconia staminea (Desr.) DC.    | PD | Fru| F   | R  | Whole fruit      |
|                         | Xylopia sericea A.St.-Hil.      | PD | F  | D   |    | Whole fruit      |
|                         | Miconia staminea (Desr.) DC.    | PD | F  | D   |    | Whole fruit      |
|                         | Xylopia sericea A.St.-Hil.      | PD | F  | D   |    | Whole fruit      |
|                         | Miconia staminea (Desr.) DC.    | PD | F  | D   |    | Whole fruit      |
|                         | Indeterminada 2                 | ND | S  | D   |    | Aril             |
|                         | Norantea guianensis Aubl.       | PD | S  | R   |    | Pulp/Seeds       |
|                         | Rudsea vihurnoides (Cham.) Benth.| PD | F  | D   |    | Whole fruit      |
|                         | Schefflera morototoni Aubl.     | PD | F  | D   |    | Whole fruit      |
|                         | Neothraupis fasciata (Lichtenstein, 1823) | ND | Omn| S   | D  | Pulp             |
|                         | Byrsonima pachyphylla A.Juss.   | ND | Omn| S   | D  | Aril             |
|                         | Davilla elliptica A.St.-Hil.    | ND | Omn| S   | D  | Aril             |
|                         | Byrsonima sericea DC.           | ND | Omn| F   | R  | Whole fruit      |
|                         | Curatella americana L.          | ND | S  | R/D |    | Seeds/Aril       |
|                         | Dilodendron bipinnatum Radlk.   | ND | F  | D   |    | Aril             |
|                         | Ficus sp. (Moraceae)            | PD | F  | D   |    | Whole fruit      |
|                         | Mezilaurus crassiramea (Meisn.) Taub. ex Mez (Lauraceae) | ND | S | R | Unripe fruit |
|                         | Miconia staminea (Desr.) DC.    | PD | F  | D   |    | Whole fruit      |
|                         | Norantea guianensis Aubl.       | PD | S  | R   |    | Pulp/Seeds       |
|                         | Psittacanthus robustus Mart.    | PD | S  | D   |    | Whole fruit      |
|                         | Schefflera morototoni Aubl.     | PD | F  | D   |    | Whole fruit      |
|                         | Xylopia aromatica (Lam.) Mart. (Annonaceae) | PD | F/S| R/D | Seeds |
|                         | Xylopia sericea A.St.-Hil.      | PD | F  | D   |    | Seeds            |
|                         | Zanthoxylum rhoifolium Lam. (Rutaceae) | PD | F  | D   |    | Seeds            |
|                         | Cyanerpes cyaneus (Linnaeus, 1766) | PD | Fru| S   | R/D| Seeds/Aril     |
|                         | Curatella americana L. (Dilleniaceae) | PD | F  | D   |    | Whole fruit      |
|                         | Miconia staminea (Desr.) DC.    | PD | F  | D   |    | Whole fruit      |
|                         | Norantea guianensis Aubl.       | PD | S  | R   |    | Pulp/Seeds       |
|                         | Xylopia sericea A.St.-Hil.      | PD | F  | D   |    | Seeds            |
|                         | Byrsonima pachyphylla A.Juss.   | PD | Omn| S   | D  | Whole fruit      |
|                         | Byrsonima sericea DC.           | PD | F  | R   |    | Whole fruit      |
|                         | Cecropia pachystachya Trécul (Urticaceae) | PD | S | D | Pulp/Seeds |
|                         | Curatella americana L. (Dilleniaceae) | ND | S | R/D | Aril |
|                         | Dilodendron bipinnatum Radlk.    | ND | F  | D   |    | Aril             |
Tanagers stand out especially in the dispersal of seeds from plants with small fruit (< 0.4 cm). In the case of larger fruits, seed dispersal is compromised because the seeds fall under the parent plants (Levey 1987, Sick 1997, Francisco & Galetti 2002). Despite the importance of tanagers as potential seed dispersers in this study, we observed that in the case of larger seeds (> 0.5 cm, personal observation), the potential for seed dispersal was really compromised, confirming the findings of Francisco & Galetti (2002). Tanagers also were less efficient in the dispersal of arilled seeds (Table 1). According to Sick (1997), species of this group commonly eat only the aril and discard the seeds under the plant.

On the other hand, tyrant flycatchers, which are known for their predominantly insectivorous diet, include many species that feed on a mixed diet of insects and fruits (Sick 1997). Some studies have shown that species that supplement their diet with fruits, as in the case of this family, have stood out as major seed dispersers in forest (Melo et al. 2003, Pascotto 2006, 2007) and savanna formations (Faustino & Machado 2006, Pascotto et al. 2012, Maruyama et al. 2013) in the Cerrado. Generally, bird species with non-specialized diets also lack habitat specificity, making them important in seed dispersal among different environments (Melo et al. 2003). Thus, in environments characterized by a mosaic of vegetation types, such as the Cerrado (Silva & Bates 2002), opportunistic frugivores are extremely important from the standpoint of seed dispersal potential, at least with regard to plants that are little specialized and to the quantitative component (Schupp 1993). However, it is worth investigating how seeds are treated after being ingested by these birds.

*Miconia staminea* and *Cecropia pachystachya* stood out as the most important plants. These species are characterized by their abundant production of small fruits and seeds (Kuhlmann 2012). Like most of the plant species observed here, they belong in the low investment model (Howe & Smallwood 1982). In this model, plants produce copious amounts of fruits which are not very nutritious and small seeds, attracting a large variety of opportunistic birds willing to take advantage of a super-abundant resource, but of little nutritional value. Based on the bird species observed consuming fruits (Table 1), we suggest that our results strongly fit this model, since most of the interactions were performed by opportunistic frugivores.

We found that 82% of the frugivorous bird species were considered potential seed dispersers. This was expected, since ornithochory is the main seed dispersal syndrome of tree species in the Brazilian Cerrado, in both forest and savanna environments (Gottsberger & Silberbauer-Gottsberger 1983, Pinheiro & Ribeiro 2001). Species of the Psittacidae family, widely known as predators of seeds, which are usually shredded when ingested, stood out among the bird species that did not act as seed dispersers (Sick 1997). Plants with larger fruits (> 2.5 cm), such as *Buchenavia tomentosa* and *Diospyros brasilensis*, were only visited by pulp-eaters or seed predators (Table 1).

An analysis of the records of feeding events, number of interactions and composition of frugivorous bird species indicated that higher numbers were recorded in forested areas, confirming our hypotheses. A recent study by Kuhlmann (2012) in the central portion of the Cerrado, involving 150 plant species with fruit attractive to fauna, revealed that about 80% were dispersed by birds and about 60% occurred in forested areas. Seed dispersal by animals in forest environments is more advantageous for plants than dispersal by abiotic processes,
since animals, particularly birds, are more likely to disperse seeds over longer distances (Hovestadt et al. 1999).

Kuhlmann (2012) states that the majority of fruiting plants of the Cerrado ripen predominantly in the rainy season. Oliveira & De Paula (2001) reported a similar finding, stating that the fruit of most zoocorous plant species of gallery forests in central Brazil ripen in the rainy season. The same phenomenon has been observed in savanna formations (Silberbauer-Gottsberger 2001, Lenza & Klink 2006, Pirani et al. 2009, Camargo et al. 2013). Based on this information about fruiting phenology, we expected to record more numerous feeding events and interactions during the rainy season since, according to the above cited authors, more fruits ripen during this period. However, our assumption was not confirmed.

We believe that the large number of records of feeding events and of interactions during the dry season stems from the high production of fruits by species such as Rudgdea viburnoides, Schefflera morototoni and Miconia staminea. According to Snow (1981), species of these three genera are very important in the diet of frugivorous birds in the Neotropics, because their fruits are eaten by specialist and generalist frugivores. Firstly, the three species have small fruits (<1 cm), which enables them to be eaten by frugivores of all sizes. Rudgdea viburnoides and Miconia staminea belong to the two most important families of plants for tropical frugivorous birds (Rubiacceae and Melastomataceae, respectively) and, because their fruits are succulent, they are appreciated by a variety of frugivorous birds, especially the small ones that feed in the lower strata of the vegetation (Snow 1981, Maruyama et al. 2013). On the other hand, the fruit of Schefflera morototoni is rich in lipids and proteins (Snow 1971), and therefore also attracts a wide variety of frugivores ranging from the smallest to the largest (Saracco et al. 2005, Parrini et al. 2013).

It should also be noted that highly abundant species such as Turdus leucomelas, which alone accounted for 25% of the recorded feeding events, may have influenced the high number of feeding events recorded in the forests during the dry season, which may explain the fact that we found no difference in the qualitative matrix of interactions. Thus, we emphasize that it is important to consider the abundance of frugivores, as well as the number of recorded feeding events, and not only the presence/absence of interactions. During the dry season, for example, the number of feeding events recorded for Turdus leucomelas in forest areas was about 90% higher than in the rainy season. Most of the species recorded in forests also showed a remarkable increase in recorded feeding events in the dry season. This may be due to temporal and spatial variations in food resources, such as lower abundance of invertebrates and ripe fruits in open areas in the dry season (Macedo 2002). These factors are extremely important and can influence the movement of birds between forest and savanna habitats.

We observed that the composition of frugivorous birds differs between savanna and forest formations. This contradicted our hypothesis since, according to Bagno & Marinho-Filho (2001), most bird species in the Cerrado occur in both savanna and forest formations. However, this does not seem to apply when only frugivorous birds are involved (Vieira et al. 2013), probably due to the dependence of mandatory frugivores [e.g., Ramphastos vitellinus Lichtenstein, 1823 and Antilophia galeata (Lichtenstein, 1823)] on forest environments.

Based on the composition of avian frugivores (Table 1), it was found that the diet of approximately 80% of the recorded bird species is not based on fruits, but that they simply complement their diet with this type of resource. Thus, we believe that during the dry season, when there is a scarcity of other food items [such as small arthropods (Macedo 2002, Manhães 2003)], there is an increase in fruit consumption. Moreover, in situations of water deficit, consuming fruit is one of the main ways to obtain water (Argel-de-Oliveira 1998). Thus, species that do not usually consume fruits begin to use this resource in the dry season, which may explain the increase in the records of feeding events and bird-plant interactions during this period.

Our findings suggest that there is a shift of frugivorous bird species and particularly of individuals between savanna and forest formations in response to fluctuations in food resources, which are influenced by the strong climate seasonality of the Cerrado (Macedo 2002, Manhães 2003). Future studies to evaluate temporal and spatial fluctuations in the composition and abundance of bird species in the different vegetation formations of the Cerrado, as well as the availability of food resources, may complement and strengthen our findings. However, we already have strong evidence that forests represent important foraging areas for frugivorous birds during the dry season. Thus, the conservation of forest areas in predominantly savanna-like ecosystems such as the Cerrado is extremely important for frugivorous birds, thus ensuring the preservation of frugivore-plant interactions.

Acknowledgments

The authors thank the Secretaria de Estado de Meio Ambiente (SEMA-MT) for authorizing the fieldwork in the Parque Estadual da Serra Azul (PESA). We also gratefully acknowledge the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), for granting a master scholarship to the first author; and Fundação de Amparo à Pesquisa do Estado de Mato Grosso (FAPEMAT) (Process Nos. 873/2006 and 738702/2008) and the project SISBIOTA/Rede ComCerrado (Proc. CNpq 563134/2010-0) for their financial support. In addition, we are indebted to the following people for their assistance: the team of the Laboratório de Ornitologia UFM/ CUA for their assistance in the field work; Leandro Maracahipes and Maryland Sanchez for their help in identifying several plant species; Renato Goldenberg for identifying Miconia staminea and M. macrothyrsa; and Dilermando P. Lima Junior and Rudi R. Laps for their insightful suggestions.

References

ALLENSPACH, N. & DIAS, M.M. 2012. Frugivory by birds on Miconia albicans (Melastomataceae), in a fragment of cerrado in São Carlos, southeastern Brazil. Braz. J. Biol. 72(2):407–413, http://dx.doi.org/10.1590/S1519-69842012000200024

ARGEL-DE-Oliveira, M.M. 1998. Aves que plantam: frugivoria e dispersão de sementes por aves. Boletim CEO 13(1):9–21.

BAGNO, M.A. & MARINHO-FILHO, J. 2001. A avifauna do Distrito Federal: uso de ambientes abertos e florestais e ameaças. In Cerrado: caracterização e recuperação de Matas de Galeria (Ribeiro J.F., Fonseca C.E.L. & Sousa-Silva J.C., eds). Embrapa Cerrados, Planaltina, p. 493–528.

BASCOMPTJE, J., JORDANO, P., MELLÁN, J. & OLESEN, J.M. 2003. The nested assembly of plant-animal mutualistic networks. PNAS 100(16):9383–9387, http://dx.doi.org/10.1073/pnas.1633576100

BIBBY, C.J., BURGESS, N.D., HILL, D.A. & MUSTOE, S.H. 2000. Bird census techniques. 2 ed. Academic Press, London.
CAMARGO, M.G.G., CAZETTA, E., SCHAFFER, H.M. & MORELATO, L.P.C. 2013. Fruit color and contrast in seasonal habitats - a case study from a cerrado savanna. Óikos 122(9):1335–1342, http://dx.doi.org/10.1111/j.1600-0706.2013.00328.x

CAZETTA, E., RUBIM, P., LUNARDI, V.O., FRANCISCO, M.R. & GALETTI, M. 2002. Frugivory and dispersal of sementes de Talauma ovata (Magnoliaceae) no sudeste brasileiro. Ararajuba 10(2):199–206.

CHRISTIANINI, A. & OLIVEIRA, P.S. 2009. The relevance of ants as seed dispersers of a primarily bird-dispersed tree in the Neotropical cerrado savanna. Oecologia 160(4):735–745, http://dx.doi.org/10.1007/s00442-009-1349-2

CLARKE, K.R. & GREEN, R.H. 1988. Statistical design and analysis for a ‘biological effects’ study. Mar. Ecol. Prog. Ser. 47:245–263, http://dx.doi.org/10.3354/meps047245

COMITÊ BRASILEIRO DE REGISTROS ORNITOLÓGICOS - CBRO. 2014. Lista das aves do Brasil. 11 ed. http://www.cbro.org.br/CBRO/pdf/AvesBrasil2014.pdf (último acesso em 02/05/2014).

CORDEIRO, N.J. & HOWE, H.F. 2001. Low recruitment of trees

DEAN, W.R.J., MILTON, S.J. & JELTSCH, F. 1999. Large trees,

FRANCISCO, M.R. & GALETTI, M. 2002. Aves como potenciais dispersers. In Monteverde: ecology and conservation of a tropical cloud forest (Nachkarni, N.M. & Wheelwright, N.T. eds) Oxford University Press, New York, p. 294–295.

GALETTI, M.R., GUEVARA, R., CORTE, M.C., FADINI, R., GOTTSBERGER, G. & SILBERBAUER-GOTTSBERGER, I. 1983. DEAN, W.R.J., MILTON, S.J. & JELTSCH, F. 1999. Large trees, FRANCISCO, M.R. & GALETTI, M. 2002. Aves como potenciais dispersers. In Monteverde: ecology and conservation of a tropical cloud forest (Nachkarni, N.M. & Wheelwright, N.T. eds) Oxford University Press, New York, p. 294–295.

GALETTI, M. & PIZO, M.A. 1996. Fruit eating by birds in a forest fragment of a Neotropical savanna (Oliveira, P.S. & Marquis, R.J. eds). Columbia University Press, New York, p. 242–265.

GALETTI, M. & PIZO, M.A. 1996. Fruit eating by birds in a forest fragment of a Neotropical savanna (Oliveira, P.S. & Marquis, R.J. eds). Columbia University Press, New York, p. 242–265.

GOJIZ, E. & KLING, C.A. 2006. Comportamento fenológico de espécies lenhosas em um cerrado sentido restrito de Brasilia. DF. Rev. Bras. Bot. 29(4):627–638, http://dx.doi.org/10.1590/S0100-84042006000400013

HEWET, D. 1987. Seed size and fruit-handling techniques of avian frugivores. Am. Nat. 129(4):471–485, http://dx.doi.org/10.1086/248652

FRANCISCO, M.R., LUNARDI, V.O. & GALETTI, M. 2007. Frugivoria e dispersão de sementes de Prunus mahaleb: patterns and consequences. Óikos 71(3):479–471, http://dx.doi.org/10.2307/5545836

KUHLMANN, M. 2012. Frutos e sementes do Cerrado atrativos para fauna: guia de campo. Rede de Sementes do Cerrado, Brasília.

LEGENDRE, P. & LEGENDRE, E. 1998. Numerical Ecology. Elsevier Science B.V., Amsterdam.

LENZA, E. & KLINK, C.A. 2006. Comportamento fenológico de espécies lenhosas em um cerrado sentido restrito de Brasilia. DF. Rev. Bras. Bot. 29(4):627–638, http://dx.doi.org/10.1590/S0100-84042006000400013

LEVY, D. 1987. Seed size and fruit-handling techniques of avian frugivores. Am. Nat. 129(4):471–485, http://dx.doi.org/10.1086/248652

LISTA DE ESPEÍCIES DA FLORA DO BRASIL. 2014. Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br/ (último acesso em: 02/05/ 2014).

MACEDO, R.H.F. 2002. The avifauna: ecology, biogeography, and behavior. In The Cerrados of Brazil: ecology and natural history of a Neotropical savanna (Oliveira, P.S. & Marquis, R.J. eds). Columbia University Press, New York, p. 242–265.

MACONDES-MACHADO, L.O. & RODRIGUES, R. 2005. Fruitivora por aves em uma área de campo rupestre na Chapada Diamantina, BA. Rev. Bras. Ornitol. 14(2):137–143.

MARTINS, C., BENTO, E.C. & OLIVEIRA, P.E. 2003. Frugivory and seed dispersal mechanisms and the vegetation of forest islands in a West African forest-savanna mosaic (Comon National Park, Ivory Coast). Plant Ecol. 144(1):1– 25, http://dx.doi.org/10.1023/A:1009764031116

MAYR, W.J. & SANTOS, K.C. 1998. Patterns of mutualistic interactions in pollination and seed dispersal: conpectance, dependence asymmetries, and coevolution. An. Nat. 129(5):657–677, http://dx.doi.org/10.1086/284665

MENDONÇA, R.F., FELFI, J.M., WALTER, B.M., SILVA, P.A., BURNS, K.C. & MELO, C. 2013. Avian frugivory in Myrcia (Melastomataceae): contrasting fruting times promote habitat complementary between savanna and palm swamp. J. Trop. Ecol. 29(2):99–109, http://dx.doi.org/10.1111/j.1464-7295.2013.00328.x

MEDELIN, R.A. & GAONA, O. 1999. Seed dispersal by bats and birds in forest and disturbed habitats of Chiapas, Mexico. Biotropica 31(3):478–485, http://dx.doi.org/10.1111/j.1744-7429.1999.tb00390.x

MELO, C., BENTO, E.C. & OLIVEIRA, P.E. 2003. Frugivory and dispersal of Faramea cyanea (Rubiaceae) in cerrado woody plant formations. Braz. J. Biol. 63(1):75–82, http://dx.doi.org/10.1590/S1519-69842003000100010

MOUTA-JUNIOR, J.C. & LOMBARDI, J.A. 2002. Ocorrência de zoocoria em florestas de galeria no Complexo do Cerrado, Brasil. Biotemas 15(1):59–81.
PASCOTTO, M.C. 2007. Rapanea ferruginea PINHEIRO, F. & RIBEIRO, J.F. 2001. Síndromes de dispersão de SARACCO, J.F., COLLAZO, J.A., GROOM, M.J. & CARLO, T.A. PARRINI, R., RAPOSO, M.A., DEL HOYO, J. & SILVA, A.R. 2013. PIZO, M.A. & GALETTI, M. 2010. Métodos e perspectivas do estudo RIBEIRO, J.F. & WALTER, B.M.T. 2008. As principais fitofisionomias do Bioma Cerrado. In Cerrado: caracterização e recuperação de Matas de Galeria (Ribeiro, J.F., Fonseca, C.E.L. & Sousa-Silva, J.C., eds). Embrapa Cerrados, Planaltina, p. 303–332. PARRINI, R., RAPOSO, M.A., DEL HOYO, J. & SILVA, A.R. 2013. Schefflera morototoni (Araliaceae) como importante recurso alimentar para as aves durante a estação seca na Amazônia central. Cotinga 35(1):1–4. PASCOTTO, M.C. 2006. Avifauna dispersora de sementes de PASCOTTO, M.C. 2007. Rapanea ferruginea (Ruiz & Pav.) Mez. (Myrsinaceae) como uma importante fonte alimentar para as aves em uma mata de galeria no interior do Estado de São Paulo. Rev. Bras. Zool. 24(3):735–741. PASCOTTO, M.C., CATEN, H.T. & OLIVEIRA, J.P.F. 2012. Birds as potential seed dispersers of Curatella americana L. in the Brazilian Cerrado. Ornitol. Neotrop. 23(1):583–593. PINHEIRO, F. & RIBEIRO, J.F. 2001. Síndromes de dispersão de sementes em Matas de Galeria do Distrito Federal. In Cerrado: caracterização e recuperação de Matas de Galeria (Ribeiro, J.F., Fonseca, C.E.L. & Sousa-Silva, J.C., eds). Embrapa Cerrados. Planaltina, p. 333–376. PIRANI, F.R., SANCHEZ, M. & PEDRONI, F. 2009. Fenologia de uma comunidade arbórea em cerrado sentido restrito, Barra do Garças, MT, Brasil. Acta Bot. Bras. 23(4):1096–1109, http://dx.doi.org/10.1590/0100-84042009004000019 PIZO, M.A. & GALETTI, M. 2010. Métodos e perspectivas do estudo da frugivoria e dispersão de sementes por aves. In Ornitologia e conservação: ciência aplicada, técnicas de pesquisa e levantamento (Accordi, I., Straube, F.C & Von Matter, S. orgs). Technical Books Rio de Janeiro, p. 492–504. R DEVELOPMENT CORE TEAM. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, ISBN 3-900051-07-0, http://www.R-project.org/. RIBEIRO, J.F. & WALTER, B.M.T. 2008. As principais fitofisionomias do Bioma Cerrado. In Cerrado: ecologia e flora (Sano, S.M., Almeida, S.P. & Ribeiro, J.F., eds). Embrapa Informação Tecnológica, Brasília, p. 151–212. SARACCO, J.F., COLLAZO, J.A., GROOM, M.J. & CARLO, T.A. 2005. Crop size and fruit neighborhood effects on bird visitation to fruiting Schefflera morototoni trees in Puerto Rico. Biotropica 37(1):81–87, http://dx.doi.org/10.1111/j.1744-7429.2005.00404.x SCHUPE, H. 1993. Quantity, quality and the effectiveness of seed dispersal by animals. Vegetatio 107/108(1):15–29. SICK, H. 1997. Ornitologia Brasileira: uma introdução. Nova Fronteira, Rio de Janeiro. SILBERBAUER-GOTTTSBERGER, I. 2001. A hectare of Cerrado. II. Flowering and fruiting of thick-stemmed woody species. Phytom 41(1):129–158. SILVA, J.M.C. & BATES, J.M. 2002. Biogeographic patterns and conservation in the South American Cerrado: a tropical savanna hotspot. BioScience 52(3):225–233, http://dx.doi.org/10.1641/0006-3568(2002)052[0225:BPACIT]2.0.CO;2 SILVA, J.M.C. & TABARELLI, M. 2000. Tree species impoverishment and the future flora of the Atlantic forest of northeast Brazil. Nature 404(6773):72–74, http://dx.doi.org/10.1038/35003563 SILVA, J.M.C. 1997. Endemic bird species and conservation in the Cerrado Region, South America. Biodivers. Conserv. 6(3):435–450, http://dx.doi.org/10.1023/A:1018368809116 SILVA, W.R., DE MARCO, P., HASUI, E. & GOMES, V.S.M. 2002. Patterns of fruit-frugivore interactions in two Atlantic forest bird communities of south-eastern Brazil: implications for conservation. In Seed dispersal and frugivory: ecology, evolution and conservation (Levey, D.J., Silva, W.R. & Galetti, M., eds). CABI Publishing, Oxon, p. 423–436. SKARPE, C. 1992. Dynamics of savanna ecosystems. J. Veg. Sci. 3(3):293–300, http://dx.doi.org/10.2307/3235754 SNOW, B.K. & SNOW, D.W. 1971. The ecology of tanagers and honeyeckers in Trinidad. The Auk 88(2):291–322. SNOW, D.W. 1981. Tropical frugivorous birds and their food plants: a world survey. Biotropica 13(1):1–14. VIEIRA, D.L.M., AQUINO, F.G., BRITO, M.A., FERNANDES-BULHÃO, C. & HENRIQUES, R.P.B. 2002. Síndromes de dispersão de espécies arbustivo-arbóreas em cerrado sensu stricto do Brasil Central e savanas amazônicas. Rev. Bras. Bot. 25(2):215–220, http://dx.doi.org/10.1590/S0100-84042002002000009 VIEIRA, F.M., PURIFICAÇÃO, K.N., CASTILHO, L.S. & PASCOTTO, M.C. 2013. Estrutura trófica da avifauna de quatro fitofisionomias do Cerrado no Parque Estadual da Serra Azul. Ornitolologia 5(2):43–57. WÜTHERICH, D., AZÓCAR, A., GARCÍA-NUÑEZ, C. & SILVA, J.F. 2001. Seed dispersal in Palicourea rigida, a common treetop species from Neotropical savannas. J. Trop. Ecol. 17(3):449–458, http://dx.doi.org/10.1017/S0266647401001304 ZAR, J.H. 1999. Biostatistical analysis. Prentice-Hall, New York.