Frugivory and seed dispersal of *Miconia theaezans* (Bonpl.) Cogniaux (Melastomataceae) by birds in a transition palm swamp - gallery forest in Central Brazil

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Abstract

The objective of this study was to evaluate potential avian dispersers of *Miconia theaezans* by dietary habits in the Cerrado of Central Brazil. Forty-two hours and 40 minutes of focal tree observation were conducted between 7:00 AM and 5:00 PM. For each bird species that consumed the fruit, we registered: the time they remained on the plant, the total amount of fruit they consumed, foraging tactics and strategies to consume the fruit. Five-hundred and fifty-nine units of fruit were consumed in 47 visits by seven bird species. Thraupidae was the most frequent and representative family and *Tangara cayana* was the main consumer. The *Tachyphonus rufus* had the highest rate of intake of the entire fruit, however the rates were not significantly different among the visitors. The most-used foraging tactic by all species was to consume the fruit while "perched" (95.74% of the visits). The most commonly-used consumption strategy was to mandibulate the fruit and swallow all the contents (65.12%). Omnivores were the predominant visitors (71.43%) and made most of the visits (89.36%). All visiting species could act as potential dispersers of *M. theaezans*, which demonstrates the low selectiveness of this pioneer plant towards its frugivorous.

Keywords: fruits, pioneer species, birds, cerrado.

Frugivoria e dispersão de sementes de *Miconia theaezans* (Bonpl.) Cogniaux (Melastomataceae) por aves em uma transição Vereda – Mata de galeria no Brasil Central

Resumo

O objetivo deste trabalho foi avaliar, através do comportamento alimentar, as aves potencialmente dispersoras de *Miconia theaezans* no Cerrado do Brasil Central. Foram realizadas 42 horas e 40 minutos de observações árvore-focal, entre 07:00 e 17:00 horas. Foram registrados para cada espécie de ave consumidora de frutos: tempo de permanência na planta, total de frutos consumidos, tática de forrageio e estratégia de consumo dos frutos. Foram consumidos 559 frutos em 47 visitas, por sete espécies de aves. Thraupidae foi a família mais representativa e frequente e *Tangara cayana* foi o principal consumidor. A maior taxa de consumo de frutos inteiros foi encontrada para *Tachyphonus rufus*, porém não foi significativamente diferente entre os visitantes. A tática de forrageamento mais utilizada no consumo dos frutos de todas as espécies foi "empoleirado" (95,74% das visitas). A estratégia de consumo mais utilizada foi mandibular o fruto e engolir todo o conteúdo (65,12%). Houve predominância de onívoros em termos de visitantes (71,43%) e visitas (89,36%). Todas as espécies visitantes podem atuar como potenciais dispersoras de *M. theaezans*, demonstrando a baixa seletividade desta planta pioneira em relação aos seus frugívoros.

Palavras-chave: frutos, espécies pioneiras, aves, cerrado.

1. Introduction

Seed dispersal is an important stage in the reproductive cycle of most plants because it can affect their demography and survival (Howe and Smallwood, 1982; Herrera et al., 1994). Consequently, it is a fundamental process in the maintenance and recovery of biodiversity in degraded areas (Wunderle-Junior, 1997; Hardwick et al., 2004; Trakhtenbrot et al., 2005) such as the Cerrado biome, one of the biodiversity hotspots of the planet (Myers et al., 2000).

In this biome, various plant species present fruit with attractive characteristics for animal consumption, and constitute an important food source, especially for frugivorous birds (Francisco and Galetti, 2001; Francisco and Galetti, 2002a,b; Marcondes-Machado, 2002; Melo et al., 2003; Francisco et al., 2007; Melo and Oliveira, 2009), a group that stands out when compared to other vertebrate dispersers due to its mobility and diversity of species (Scherer et al., 2007).

Pioneer plant species present characteristics (e.g. small fruit with numerous small seeds) that do not restrict their consumption (Wheelwright, 1985) and increase the chances of dispersal (Swaine and Whitmore, 1988), even if by opportunistic dispersers (Marcondes-Machado, 2002). One example is the Melastomataceae family, which is considered important for the maintenance of frugivorous diversity because most of its species present zoochoric dispersion (Stiles and Rosselli, 1993). Fruit from the *Miconia* genus are particularly and frequently mentioned as important food resources for frugivorous birds (Snow, 1965; Alves, 1991; Stiles and Rosselli, 1993; Galetti and Stotz, 1996; Marcondes-Machado, 2002; Manhães, 2003; Fadini and De Marco Júnior, 2004). The *Miconia* species fructify asynchronously in a complementary form (Snow, 1965; Maruyama et al., 2007; Borges, 2010; Leiner et al., 2010), presenting small fruit, a kind of berry, generally with numerous small seeds. This genus can be found in the Cerrado with several phytophysiognomies (Weiser and Godoy, 2001; Araújo et al., 2002; Cardoso et al., 2002; Guimarães et al., 2002; Assunção and Felfili, 2004; Gomes et al., 2004; Campos et al., 2006; Silva-Júnior and Sarmento 2009), being common in secondary vegetation (Araújo et al., 1997; Silva-Júnior and Sarmento 2009).

Miconia theaezans (Bonpl.) Cogn. is a species of shrub (2 to 3 m high), whose unripe berries are pinkish, becoming whitish-grey when ripened (personal observation). The fruit of *M. theaezans* can be a key resource for maintaining potential avian seed dispersers because it is produced throughout the entire dry season (from the end of March until September) (Borges, 2010), a period when food resources are scarce for Cerrado fauna (Develey and Peres, 2000; Batalha and Martins, 2004; Tannus et al., 2006; Silva et al., 2009).

The objective of this study was to register the species of frugivorous birds that visited the *Miconia theaezans* in a transition area between permanent swamps dominated by palm trees (palm swamp) and gallery forests in the Cerrado (*sensu lato*) and to evaluate the importance of these birds in the seed dispersal of this Melastomataceae species, based on their eating habits.

2. Material and Methods

2.1. Study area

The birds visiting *Miconia theaezans* were registered in the Panga Ecological Station (PES), which is a Private Natural Patrimony Reserve having an area of 409.5 ha (Cardoso and Schiavini, 2002). The PES is in Uberlândia, Minas Gerais, Brazil (19° 10' 27" S and 48° 23' 51" O). Until 1984, this area was used for agricultural and animal husbandry activities (Ranal, 2003). After it was transformed into a conservation area, the local vegetation recovered naturally, and today this area is considered representative of Central Brazilian Cerrado (Ranal, 2003; Cardoso et al., 2009), where various kinds of phytophysiognomies can be found, such as gallery forests, cerradão, cerrado *sensu stricto*, cerrado field, dirty field, humid fields and palm swamp (Schiavini and Araújo, 1989; Cardoso et al., 2009).

The climate in the region is seasonal, designated as Aw in Köppen climate classification, having two well defined seasons: a rainy season (from October to March) and a dry season (from April to September) (Rosa et al., 1991). The total precipitation in the city of Uberlândia in 2009, the year of this study, was 1313.4 mm; the mean in the rainy season months was 174.4 mm, and 44.5 mm during the dry season. The mean temperature in 2009 was 24.0 °C; the lowest mean temperature was registered in the month of June (20.9 °C), and the highest was registered in November (25.8 °C) (Data from the Laboratory of Climatology of UFU).

2.2. Methods

From the end of April to mid-May 2009, focal tree observations were carried out with four *Miconia theaezans* individuals to determine which species were consuming their fruit. Forty-two hours and 40 minutes of focal observation were conducted between 7:00 AM and 5:00 PM; daylight saving time was not considered.

During the observation sessions, the following information was registered: species of bird consuming the fruit, time of arrival and departure from the plant, number of units consumed, foraging tactics and consumption strategies (Melo et al., 2003; Melo and Oliveira, 2009). Taxonomic classification was in accordance with CBRO (2009). When the observed plant was visited by a group of individuals simultaneously, either monospecific or not, the number of units consumed and the time of permanence on the plant were registered only for one randomly-chosen individual (Cazetta et al., 2002). In order to determine the feeding guild of each bird, data from the literature (Table 1) and field observation were used, and the predominant diet of the species was considered in every possible case. When no data was found for the species, the predominant diet of the family was utilized (Sick, 1997).

Foraging tactics were classified according to Argel-de-Oliveira et al. (1996), as "perched" or "in flight". The

tactic was defined as "perching" when the bird remained on the plant while collecting and consuming the fruit. The tactic was considered "in flight" when the bird came to the plant, collected the fruit and landed somewhere else to consume it.

The observed birds were classified according to the consumption strategies described in Argel-de-Oliveira et al. (1996) and Marcondes-Machado (2002). The birds that swallowed the fruit whole without mandibulating it were considered "swallowers". Birds that mandibulate the fruit before ingesting it were considered "mandibulate"; they used their beaks to macerate the pulp, and afterwards swallowed either the entire pulp or just the juice, discarding the rest of the fruit with its seeds. Fruits were considered "swallowed whole" when the fruit was ingested without mandibulating, or when there was mandibulation, but the pulp and the seeds were swallowed afterwards.

2.3. Data analysis

The Spearman correlation was used for the number of units consumed and the time the birds remained on the *Miconia theaezans*. The test was processed with Systat v10.2 (Systat, 2002). The dispersal potential was calculated using the quotient of the number of units swallowed whole by the time spent by the bird on the plant (in minutes). The number of fruits swallowed whole, regardless of having been mandibulated or not, was considered to calculate the dispersal potential.

3. Results

Forty-seven visits by seven bird species were registered. Thraupidae was the most representative (five species) and the most frequent family (41 visits, 87.23%). The main visiting species was *Tangara cayana* (28 visits, 59.57%) (Table 1). Among the species registered, omnivorous birds predominated (five species, 71.43%) over frugivores (two species, 28.57%) (Table 1).

Five-hundred and fifty-nine units of *M. theaezans* were consumed. *Tangara cayana* was the main consumer (340 units, 60.52%), and the species that consumed the least was *Antilophia galeata* (six units, 1.07%). The mean time spent per visit varied from 1.25 ± 1.06 minutes (*A. galeata*) to 5.00 ± 1.41 minutes (*Schistochlamys melanopis*) (Table 2). Except for the *Saltator similis*, whose consumption strategy was not identified, the other species can be considered potential dispersers of *M. theaezans* due to the high number of units consumed whole per minute. The rate of whole fruit consumption varied from 2.40 (*A. galeata*) to 4.20 units/minutes (*Tachyphonus rufus*) (Table 2), and there was no significant difference between species ($t = 13.41$, $gl = 5$, $p < 0.01$). The number of units consumed was correlated with the visitor's time of permanence on the plant ($rs = 0.77$, $n = 47$, $p < 0.05$).

The "perched" foraging tactic was more common (45 visits, 95.74%) than the "in flight" tactic. Mandibulate and swallowing was the most-used consumption strategy (364 units, 65.12%), followed by mandibulate and disposal (121 units, 21.64%) (Table 1).

4. Discussion

The main consumer and potential disperser of *Miconia theaezans* fruit was *Tangara cayana*. This Thraupidae, like other representatives of this family, mandibulates the fruit before ingestion (Gridi-Papp et al., 2004), and can swallow the whole fruit (with the seeds) or part of it (Argel-de-Oliveira et al., 1996; Sick, 1997; Marcondes-Machado, 2002; Manhães, 2003). Those portions of fruit and seeds that fall on the ground during mandibulation can be used by other animals, such as ants, that can act

Table 1. Characteristics of bird visitation, with fruit consumption, on *Miconia theaezans.*

Family/species	Feeding guild	Visits	Fruit consumption			
			Swallower n (%)	"Mandibulator" n (%)		Not identified n (%)
				Swallows	Despises	
TYRANNIDAE						
Elaenia spp.*[I, II, III, VI]	ONI[1,2]	4 (8.51)	30 (5.37)			
PIPRIDAE						
Antilophia galeata (Lichtenstein)*[IV]	FRU[1,3]	2 (4.26)	6 (1.07)			
THRAUPIDAE						
Saltator similis (d'Orbigny & Lafresnaye)	ONI[1,5]	1 (2.13)				7 (1.25)
Schistochlamys melanopis (Latham)*[V]	FRU[8]	2 (4.26)		33 (5.90)		
Tachyphonus rufus (Boddaert)*[III]	ONI[1,5,6]	4 (8.51)		21 (3.76)	61 (10.91)	
Tangara cayana (Linnaeus)*[VI, VII]	ONI[1,4,6,7]	28 (59.57)		280 (50.09)	60 (10.73)	
Dacnis cayana (Linnaeus)*[VI, VIII]	ONI[1,4,6,7]	6 (12.77)	31 (5.55)	30 (5.37)		
Total		47 (100)	67 (11.99)	364 (65.12)	121 (21.64)	7 (1.25)

[1]Sick (1997); [2]Marini and Cavalcanti (1998); [3]Marini (1992); [4]Argel-de-Oliveira (1999); [5]Piratelli and Pereira (2002); [6]Melo (2001); [7]Manhães (2003); [8]Personal observation. *Other records of birds consuming fruits of *Miconia*. [I]Antas (2004); [II]Faustino and Machado (2006); [III]Luck and Daily (2003); [IV]Guaraldo et al. (2008); [V]Magnuss and Sanaiotti (1987); [VI]Tubelis (2004); [VII]Parrini et al. (2008); [VIII]Cymerys (1991).

Table 2. Consumption rates of the *Miconia theaezans* fruits.

Family/species	Fruits consumption		Time spent on the plant (minutes) Mean ± SD (n)	Consumption rate (entire fruits/ minutes)
	Total n (%)	By visit Mean ± SD		
TYRANNIDAE				
Elaenia spp.	30 (5.37)	7.50 ± 9.15	2.88 ± 2.95 (4)	2.93
PIPRIDAE				
Antilophia galeata	6 (1.07)	3.00 ± 2.83	1.25 ± 1.06 (2)	2.40
THRAUPIDAE				
Saltator similis	7 (1.25)	7	1	--
Schistochlamys melanopis	33 (5.90)	16.50 ± 13.44	5.00 ± 1.41 (2)	3.30
Tachyphonus rufus	82 (14.67)	20.50 ± 9.18	3.88 ± 2.25 (4)	4.20
Tangara cayana	340 (60.82)	12.14 ± 11.79	3.45 ± 2.97 (28)	3.94
Dacnis cayana	61 (10.91)	10.17 ± 5.67	2.92 ± 2.62 (6)	3.49
Total	559 (100)			

as secondary dispersers (Francisco and Galetti, 2002a; Christianini and Oliveira, 2009).

However, mandibulating the fruit does not eliminate the possibility of seed ingestion and dispersal because according to Levey (1987), small seeds are not easily separated from the pulp, and can be ingested after mandibulation. This was proved by Manhães (2003) when some *Leandra aurea* (Melastomataceae) seeds were found in the excrement of the *Tangara desmaresti*, a bird presenting mandibulation behavior. Therefore, the different consumption strategies used by the birds lead to a range of possibilities regarding seed ingestion and dispersal. In situations where the whole fruit is consumed, all the seeds are ingested. However, when there is mandibulation and posterior ingestion of the content, some seeds may be lost, but most are still swallowed with the fruit. The smallest, yet not null, chance of ingestion occurs when part of the fruit is discarded after mandibulation.

Except for *Saltator similis*, for whom the fruit consumption strategy was not identified, all species presented similar rates of consumption of the entire fruit in spite of the low number of visits compared to the *Tangara cayana*. Even though the *Antilophia galeata* consumed the whole fruit with no mandibulation and was mentioned by Marini (1992) as "highly frugivorous", it should not be considered a good disperser of this *Miconia*. Godoi and Takaki (2007) found that the germination of the *M. theaezans* depends considerably on the amount of light, and because the *Antilophia galeata* depends on a forest environment (Bagno and Marinho-Filho, 2001), most of the seeds ingested are defecated inside the gallery forest, which does not propitiate the germination of this *Miconia* species due to low environmental luminosity.

Pioneer species are, by definition, the first ones that colonize degraded areas, and due to this fact their main reproductive investment is to offer high numbers of seeds, increasing the chances of establishing a population in an area (Swaine and Whitmore, 1988). Considering this, the number of visits made by a certain species may not be the most important factor in the dispersal of the *Miconia*, but the number of units consumed and the place where they are later deposited.

The most commonly-used foraging technique (collecting the fruit while perched) is advantageous for the bird because it demands a lower energy cost and allows an increase in the rate of fruit consumption per minute (Melo et al., 2003). However, when the fruit is collected by the bird in flight, the visits are shorter and the frugivore tends to move more, which increases the chances of dispersing the seeds farther from the mother plant (Melo and Oliveira, 2009); this is favorable for plant fitness, but results in greater energy loss for the consumer (Melo and Oliveira, 2009).

According to Jordano and Schupp (2000), the amount of time visitors remained on *Miconia theaezans* can be considered short (less than 2 minutes). The fact that the number of units ingested by the birds is positively correlated with the time they remained indicates that the visits lasted just enough time for the bird to feed (Francisco and Galetti, 2002a), which reduces the possibility of the seeds being deposited on the mother plant.

Considering the results of this study, all the bird species that visited the *Miconia theaezans* can act as dispersers because they presented high rates of fruit consumption, which increases the chances of seed dispersal in places favorable to the establishment of new populations.

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