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Effects of gut passage on the germination of seeds ingested by didelphid marsupials in a neotropical savanna

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ABSTRACT

We analyzed the effects that passage through the guts of seven didelphid species had on the seed germination of 10 plant species. This study was conducted in an area of riparian woodland in a *cerrado* (savanna) reserve in southeastern Brazil. We found seeds of 23 angiosperm species in 427 fecal samples obtained from seven didelphid species. The plant families most often represented by the seeds found in the fecal samples were Melastomataceae (5 species) and Rubiaceae (4 species) . Most gut-passed seeds showed no significant difference in germinability when compared with the hand-extracted seeds. Among the ingested seeds, only those of *Clidemia urceolata* DC. (Melastomataceae) and *Myrcia* sp. (Myrtaceae) showed an increase in germinability (final proportion of germinated seeds), indicating that didelphid gut passage does not always benefit seed germination. The average germination time of consumed seeds ranged from 12 days (*Cipocereus minensis* (Werderm.) Ritter) to 171 days (*Cordiera sessilis* (Vell.) Kuntze). The small number of seeds destroyed after gut passage and the results obtained during the germination experiments underscore the importance of didelphid marsupials to the dynamics of plant reproduction, especially those of small-seeded *cerrado* species.

Key words: Cerrado, frugivory, scarification, seed dispersal, zoochory

Introduction

Endozoochorous seed dispersal results from a mutualistic interaction between plants and the animals that feed on ripe and nutritious fleshy fruits containing one or several seeds (Howe & Smallwood 1982; Galetti 2002; Cáceres & Lessa 2012). In this interaction, animals tend to consume fruits from various species and the fruits tend to be consumed by a wide range of animals (Charles Dominique 1993; Lord *et al*. 2002). For the plant, seed dispersal by animals increases the likelihood of offspring survival by facilitating the removal of the seeds away from the zone of high mortality near the parent plant as well as conquering new environments potentially favorable for seed germination and seedling development (Janzen 1970; Howe *et al.* 1985; Howe 1993). One of the apparent advantages of seed dispersal is the increase in the rate of germination of the seeds ingested by vertebrate dispersers (Traveset & Verdú 2002). However, recent studies have shown that this increase is not universal and that a myriad of factors intrinsic to the plant or the type of seed disperser may influence the outcome after seed passage through the digestive tract of the disperser (Traveset & Verdú 2002; Cantor *et al.* 2010).

Didelphid marsupials are small, solitary nocturnal mammals (Gardner 2008), featuring a generalist diet that varies from the consumption of invertebrates and small vertebrates to flowers and fruits in different proportions (Lessa & Geise 2010; Santori *et al.* 2012). In the neotropics, the role of didelphids as potential seed dispersers is usually related to the consumption of a wide variety of fruits and the presence of intact seeds in their feces with generally increased germinability (Cáceres & Monteiro-Filho 2007; Raíces & Bergallo 2008; Lessa & Costa 2010; Cáceres & Lessa 2012). However, the process of gut scarification of the seed coat by passage through the digestive tract of didelphid dispersers does not always have positive effects on the germinability and germination time of the ingested seeds (see Cantor *et al*. 2010; Camargo *et al*. 2011; Cáceres & Lessa 2012).

The present study examined the effects of gut passage on seed germination (germinability and mean germination time) of fruit consumed by seven didelphid species in an area of riparian forest in the *cerrado* (savanna) of southeastern Brazil: *Gracilinanus agilis* (Burmeinster 1854), *G. microtarsus* (Wagner 1842), *Marmosops incanus* (Lund 1840), *Caluromys philander* (Linnaeus 1758), *Marmosa*

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paraguayana (Tate 1931), *Metachirus nudicaudatus* (Desmarest 1817) and *Didelphis albiventris* (Lund 1758). We chose these species because they were the most abundant marsupial species in the study area (see Lessa & Costa 2010).

Materials and methods

Study Area

We conducted the study in an area of riparian forest within the *cerrado* in Rio Preto State Park (RPSP: 18°05'20"S; 43°20'25"W), located in the municipality of São Gonçalo do Rio Preto, in the state of Minas Gerais, Brazil (Fig. 1). With an area of 12,000 hectares, the RPSP is located in the southern area of the Espinhaço Range, with a mosaic of vegetation physiognomies, which includes *campos rupestres* (dry, rocky grasslands), *cerrado* (*stricto sensu*), *cerradão* (woodland savanna) and riparian woodlands along the banks of the Rio Preto River. The climate is type Cwb, according to the Köppen classification. The annual rainfall ranges from 223 to 1,550 mm, rains occurring mainly in the wet season (October-March), although some rain may occur during the dry season (April-September). The average annual temperature ranges from 17°C to 19°C (Neves *et al*. 2005; Lessa & Costa 2010).

Sample design and data collection

We captured seven species of marsupials from November 2009 to October 2011 using the capture-mark-recapture method. We used 96 galvanized wire traps (300 × 160 × 160 mm) arranged in four 180 m long parallel transects, 50 m apart. In each transect, were installed 12 capture stations, 15 m apart. At each capture station, we laid two traps, one on the soil and the other in the understory (approximately 2 m above the ground). As bait, we used fruit (orange or pineapple), cotton balls soaked in Scott's emulsion and bacon bits. Captured animals were identified, marked with numbered ear tags (Zootech, Curitiba, Brazil) and released at the site of capture.

We collected the feces of captured individuals directly from the traps or during handling. Each sample was placed in a labeled plastic container and kept refrigerated for a maximum period of seven days to prevent deterioration. In the laboratory, the material was washed with a metal mesh sieve (0.1 mm), separated and identified with the aid of a stereomicroscope. The seeds were counted, measured (maximum length) and identified by comparison with a reference collection of fruits and seeds collected at the same study site and deposited in the herbarium of the Federal University of the Jequitinhonha and Mucuri Valleys (code, DIAM). We used the relative frequency of occurrence expressed as the number of samples in which an item was found (n), divided by the total number of samples and multiplied by 100, to determine the contribution of each item (seeds) to the diet of the marsupial species (Korschgen 1987).

Germination tests

We separated the seeds found in the samples and set them to germinate in sterilized Petri dishes containing a double layer of moistened filter paper. To create a control group, we manually removed the seeds from mature fruits of the same species consumed and set them to germinate. The seeds were exposed to room temperature. Dishes were moistened regularly with distilled water and monitored daily for seed germination, defined as when protrusion of the hypocotyl-root axis was detected. Seedling emergence was recorded weekly for a total of 24 months. The maximum germination period was evaluated for eight of the ten species: *Cipocereus minensis*, *Clidemia urceolata*, *Miconia*

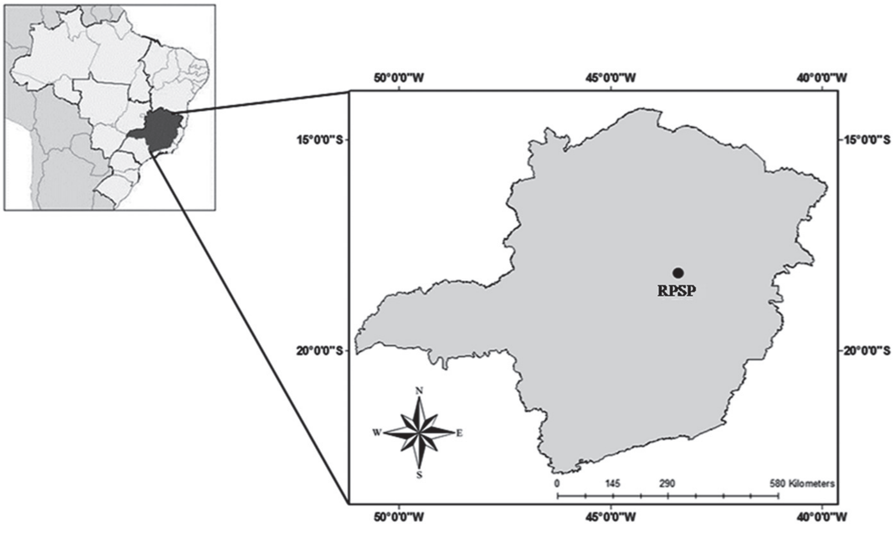

Figure 1. Geographic location of Rio Preto State Park (RPSP), a Brazilian reserve.

holosericea, *Myrcia* sp., *Psidium* sp., *Cordiera sessilis*, *Psychotria capitata* and *Phoradendron crassifolium*. To test for differences in germination percentage and germination time between the control group *versus* seeds found in the samples, we used the chi-square test (Zar 2010). For all analyzes, we excluded the feces samples from recaptures of the same individuals, thus avoiding pseudo-replicates (Hurlbert 1984). We used the terms germinability (the final proportion of germinated seeds) and mean germination time (the mean time of germination of the faster seeds) to examine seed germination (Ranal & Santana 2006; Robertson *et al*. 2006).

Results

Germinability

We found seeds of 23 different taxa of angiosperms in a total of 427 fecal samples analyzed: *Gracilinanus agilis* (n = 144), *G. microtarsus* (n = 118), *Marmosops incanus* (n = 72), *Caluromys philander* (n = 33), *Metachirus nudicaudatus* (n = 22), *Didelphis albiventris* (n = 22) and *Marmosa paraguayana* (n = 16). Overall, the seeds most frequently found in the feces samples were small seeds of pioneer species, which were indentified in 68% of the samples (Tab. 1). The germination experiments revealed that for smaller didelphids, such as *G. agilis* (mean weight±SD = 17.2±4.9 g), *G. microtarsus* (24.5±8.8 g) and *M. incanus* (47.9±27.8 g), the seeds that remained viable (undamaged) after gut passage measured 0.6-2.0 mm in length (*C. minensis*, *C. urceolata* and *P. capitata*). For larger didelphids, such as *M. paraguayana* (104±8.48 g), *C. philander* (128±49.6 g), *M. nudicaudatus* (273.5±98.3 g) and *D. albiventris* (513.5±298.2 g), the larger intact seeds were 3.0-5.0 mm long (*C. sessilis*, *Myrcia* sp. and *Psidium* sp.). Large seeds (> 6.0 mm), such as *E. hyemalis* (7.0 mm), *Campomanesia* sp. (6.0 mm), *A. guianensis* (8.0 mm) and *Mimosoideae* sp.1 and sp.2 (9.0 mm and 11.0 mm, respectively) were found damaged (Tab. 1).

Seeds that remained intact after gut passage showed no significant differences in their germinability when compared with the seeds from the control group (Tab. 2). However, seeds of *C. minensis*, *Psidium* sp., *C. sessilis* and *P. hoffmannseggiana* showed significantly lower germinability compared with the control group, regardless of the didelphid species. In turn, germinability of *C. urceolata* (Melastomataceae) seeds, consumed in large proportions by most species, was significantly higher than that of control group seeds in *G. agilis* (χ^2=12.35, d.f.=1, p=0.007), *G. microtarsus* (χ^2=10.15, d.f.=1, p=0.002), *M. incanus* (χ^2=11.00, d.f.=1, p=0.001), *C. philander* (χ^2=9.69, d.f.=1, p=0.001), *M. nudicaudatus* (χ^2=9.95, d.f.=1, p=0.002) and *M. paraguayana* (χ^2=8.10, d.f.=1, p=0.004) but not in *D. albiventris* (χ^2=0.58, d.f.=1, p=0.512). A similar pattern, with higher germinability of seeds found in the feces, was also observed for *Myrcia* sp. after passage by *C. philander* (χ^2=5.49, d.f.=1, p=0.019), *M. paraguayana* (χ^2=4.59, d.f.=1. p=0.032) and *D. albiventris* (χ^2=5.77, d.f.=1, p=0.016) (Tab. 2).

Germination time

The mean germination time of seeds consumed by didelphids ranged from 12 days (*C. minensis*) to 171 days (*C. sessilis*) (Tab. 3). Most seeds (62.5%) had a germination time of less than 2 months, and only 27.5% had a germination time of greater than 4 months. In comparison with the control group seeds, germination times of the gut-passed seeds were significantly shorter for small seeds (0.6-1.0 mm), such as those of *C. minensis* and *P. crassifolium*. Regarding *C. minensis* seeds, the difference was significant for the samples taken from the feces of *M. incanus* (χ^2=7.43, d.f.=1, p<0.001) and *M. nudicaudatus* (χ^2=3.87, d.f.=1, p=0.041). For *P. crassifolium*, there was also a decrease in the germination time for *G. agilis* (χ^2=46.40, d.f.=1, p=0.041), *G. microtarsus* (χ^2=3.87, d.f.=1, p=0.049) and *M. incanus* (χ^2=4.02, d.f.=1, p=0.041). However, no significant difference in germination time was observed for *P. crassifolium* after gut passage by *D. albiventris* (χ^2=0.03, d.f.=1, p=0.851), nor was any significant effect of gut passage on germination time observed for the other species (Tab. 3).

Discussion

Germinability

Our results show that the seven didelphid species studied in RPSP consume fruits from 10 plant families, from different life-forms and with different phenologies, acting as potential seed dispersers (especially of pioneer species) in the riparian forest of the *cerrado*. Fruit consumption and seed dispersal by neotropical didelphid marsupials have previously been observed in areas of the Atlantic Forest (Cáceres & Monteiro-Filho 2000; Cáceres 2002; Cáceres & Monteiro-Filho 2007; Pinheiro *et al*. 2002) and in different vegetation types of the *cerrado* (Lessa & Costa 2010; Camargo *et al*. 2011). With regards to fruit consumption, Melastomataceae fruits, mainly those belonging to the genera *Clidemia* and *Miconia*, stand out as an important food resource in *cerrado* areas (Lessa & Costa 2010; Camargo *et al*. 2011), being present in the diet of all seven studied didelphids.

It has been assumed that seeds ingested by didelphids germinate in higher proportions or more quickly than non-ingested seeds (Cáceres 2002; Cáceres & Monteiro-Filho 2007; Lessa & Costa 2010). However, despite the fact that changes in the probabilities of seed germination after gut passage comprise an important component of seed dispersal and effectiveness (Traveset & Verdu 2002; Silveira *et al*. 2012b), increased germination is not a general rule for seeds consumed by didelphid dispersers (Cáceres & Lessa 2012, present study). Recent studies indicate that the passage of seeds through the digestive tract of *D. albiventris* and *G. agilis* does not always improve seed germinability (see Cantor *et al*. 2010; Camargo *et al*. 2011, respectively). Our germination experiments revealed that, although the

Table 1. Seed size, number of occurrences and relative frequency of occurrence (in %) of seeds in the feces of seven didelphid species found in a riparian forest within the *cerrado* (savanna) in Rio Preto State Park, in the municipality of São Gonçalo do Rio Preto, in the state of Minas Gerais, Brazil.

FAMILY Species	Seed size (mm)	*Gracilinanus agilis* (n = 144)	*Gracilinanus microtarsus* (n = 118)	*Marmosops incanus* (n = 72)	*Caluromys philander* (n = 33)	*Metachirus nudicaudatus* (n = 22)	*Marmosa paraguayana* (n = 16)	*Didelphis albiventris* (n = 22)
ANACARDIACEAE								
Tapirira obtusa (Benth) J.D.	7	-	-	-	1 (1.4)	-	2 (12.5)	-
CACTACEAE								
Cipocereus minensis (Werderm.) Ritter	0.6	-	-	1 (1.4)	-	3 (13.6)	-	-
CHRYSOBALANACEAE								
Hirtella gracilipes (Hook.f.) Prance	9	-	-	-	-	-	-	2 (9.0)
LAURACEAE								
Ocotea lancifolia (Schott) Mez*	3	-	-	-	2 (6.0)	-	1 (6.2)	-
FABACEAE								
Mimosoideae sp.1*	9	-	-	-	-	-	-	1 (4.5)
Mimosoideae sp.2*	11	-	-	-	-	-	-	2 (9.0)
MELASTOMATACEAE								
Clidemia urceolata DC.*	1	21 (14.6)	6 (5.0)	11 (15.2)	3 (9.0)	6 (27.2)	2 (12.5)	3 (13.6)
Miconia holosericea (L.) DC.*	1	2 (1.4)	8 (6.8)	1 (1.4)	2 (6.0)	1 (4.5)	1 (6.2)	2 (9.0)
Miconia pepericarpa DC.*	1	3 (2.0)	5 (4.2)	2 (2.8)				
Miconia stenostachya DC.*	2	2 (1.4)	2 (1.7)		-	-	2 (12.5)	1 (4.5)
Miconia sp.*	0.8	2 (1.4)	4 (3.4)	3 (4.2)	-	-	-	1 (4.5)
MYRTACEAE								
Eugenia hyemalis A.St.-Hill & Naudin	7	-	-	-	2 (6.0)	-	1 (6.2)	1 (4.5)
Campomanesia sp.	6	-	-	-	2 (6.0)	-		2 (9.0)
Myrcia sp.*	5	-	-	-	5 (15.1)	-	1 (6.2)	2 (9.0)
Psidium sp.*	4	-	-	-	3 (9.0)	-	-	3 (13.6)
Myrtaceae sp.1	2	1 (0.7)	2 (1.7)	-	-	-	-	-
RUBIACEAE								
Cordiera sessilis (Vell.) Kuntze*	5	-	-	1 (1.4)	2 (6.0)	1 (4.5)	3 (18.8)	4 (18.2)
Amaioua guianensis Aubl.	8	-	-	-	-	-	-	1 (4.5)
Psychotria capitata Ruiz & Pav.*	2	8 (5.6)	-	3 (4.2)	6 (18.2)	4 (18.2)	-	2 (9.0)
Psychotria hoffmannseggiana (Wild. ex Shult.) Mull. Arg.*	4	-	-	1 (1.4)	-	1 (4.5)	1 (6.2)	1 (4.5)
SANTALACEAE								
Phoradendron crassifolium (Pohl ex DC.) Eichler	1	7 (4.9)	2 (1.7)	4 (5.6)	-	-	1 (6.2)	3 (13.6)
SMILACACEAE								
Smilax sp.*	0.5	-	-	-	-	-	-	2 (9.0)
Smilacaceae sp.1*	0.5	-	1 (0.8)	2 (2.8)	-	1 (4.5)	3 (18.8)	2 (9.0)
Seeds (total)		43 (29.8)	29 (24.5)	27 (37.5)	23 (69.6)	13 (59.0)	14 (87.5)	18 (81.8)

n – number of samples.
*Pioneer plants

Table 2. Results of the germination tests in the control group seeds and the seeds collected from the feces of seven didelphid species found in a riparian forest within the *cerrado* (savanna) in Rio Preto State Park, in the municipality of São Gonçalo do Rio Preto, in the state of Minas Gerais, Brazil.*

FAMILY Species	CG	*Gracilinanus agilis*	*Gracilinanus microtarsus*	*Marmosops incanus*	*Caluromys philander*	*Metachirus nudicaudatus*	*Marmosa paraguayana*	*Didelphis albiventris*
CACTACEAE								
Cipocereus minensis	230 (38.6)**	-	-	133 (6.2)	-	155 (11.4)	-	-
MELASTOMATACEAE								
Clidemia urceolata	800 (37.1)	230 (73.6)**	153 (70.1)**	350 (71.7)**	220 (69.2)**	350 (69.0)**	200 (66.0)**	220 (44.0)
Miconia holosericea	500 (33.1)	133 (49.6)	210 (46.6)	152 (45.3)	130 (42.3)	140 (42.1)	230 (41.1)	350 (39.2)
MYRTACEAE								
Myrcia sp.	168 (41.2)	-	-	-	37 (65.4)***	-	30 (63.1)***	12 (66.1)***
Psidium sp.	331 (71.2)***	-	-	-	22 (38.9)	-	-	34 (38.3)
RUBIACEAE								
Cordiera sessilis	121 (68.3)***	-	-	-	17 (47.8)	-	27 (44.4)	51 (43.1)
Psychotria hoffmannseggiana	300 (77.6)**	-	-	09 (22.2)	-	11 (27.3)	05 (20.0)	34 (23.5)
Psychotria capitata	127 (40.1)	30 (42.3)	-	123 (41.4)	154 (42.5)	330 (37.5)	-	291 (39.3)
SANTALACEAE								
Phoradendron crassifolium	335 (45.0)	87 (44.5)	53 (43.1)	91 (42.3)	-	-	-	430 (40.1)
SMILACACEAE								
Smilax sp.	207 (5.7)	-	-	50 (5.1)	-	-	-	121 (4.7)

CG – control group.
*Results expressed as total number of seeds tested (germinability, in %); **p<0.01; ***p<0.05.

Table 3. Mean germination time in the control group seeds and the seeds collected from the feces of seven didelphid species found in a riparian forest within the *cerrado* (savanna) in Rio Preto State Park, in the municipality of São Gonçalo do Rio Preto, in the state of Minas Gerais, Brazil. CG – control group.

FAMILY	Seed size	Germination period (days) mean±SD							
Species	(mm)	CG	*Gracilinanus agilis*	*Gracilinanus microtarsus*	*Marmosops incanus*	*Caluromys philander*	*Metachirus nudicaudatus*	*Marmosa paraguayana*	*Didelphis albiventris*
CACTACEAE									
Cipocereus minensis	0.6	30±2	-	-	12±3*	-	17±8*	-	-
MELASTOMATACEAE									
Clidemia urceolata	1.0	32±2	30±6	31±3	31±4	31±3	33±4	29.2±6	33±3
Miconia holosericea	1.0	31±2	31±5	31±5	33±4	32±7	32±7	30.8±4	33±6
MYRTACEAE									
Myrcia sp.	5.0	162±7	-	-	-	170±14	-	159.8±8	160±9
Psidium sp.	4.0	138±23	-	-	-	137±7	-	-	135±10
RUBIACEAE									
Cordiera sessilis	5.0	175±14	-	-	-	157±21	-	164±14	171±8
Psychotria capitata	2.0	43±7	41.2±4	-	43±4	-	44±5	-	40±7
SANTALACEAE									
Phoradendron crassifolium	1.0	46±6	29±1*	30±2*	29±5*	-	-	-	45±9

*$p<0.05$.

seeds remain viable (undamaged) after passage through the digestive tract, nearly all showed moderate germination rates (33-66%) and only one species (*C. urceolata*) showed high germinability (> 66%) compared with the control group seeds. When didelphids accelerate seed germination (as in the case of *C. urceolata*), ingested seeds germinate in higher proportions than do non-ingested seeds, probably as a result of seed coat scarification (Robertson *et al.* 2006; Lessa & Cáceres 2012).

Many factors related both to the intrinsic plant and disperser traits may influence the outcomes of seed passage through the digestive tract of potential vertebrate dispersers (Traveset & Verdú 2002; Rodrigues-Peréz *et al.* 2005), such as seed size, fruit color, experimental conditions, disperser taxon, habitat structure and vegetation composition, or a combination of such factors (Traveset & Verdu 2002; Cantor *et al.* 2010; Cáceres & Lessa 2012). All these factors, together or alone, can explain the differences observed between the germination of seeds found in the samples and the control group. Didelphids are nocturnal animals that forage using the sense of smell, primarily attracted to fleshy, sweet fruits with attractive smell and cryptic coloration (Atramentowicz 1988; Cáceres & Lessa 2012), as observed in the present study for the high consumption of Melastomaceae fruits (*C. urceolata* and *Miconia* spp.). However, brightly colored fruits (typically ornithochoric), which are characteristic of Rubiaceae and Melastomataceae, can also be consumed occasionally (Lessa & Costa 2010; Cáceres & Lessa 2012). In general, most seeds dispersed by didelphids show that endozoochorous dispersal syndrome and gut scarification do not seem to affect their viability (Cáceres & Monteiro-Filho 2007). However, considering the relationship between seed size and disperser size (Casella & Cáceres 2006; Lessa & Costa 2010), it has been observed that smaller seeds remain trapped in the digestive system for a longer period of time than do larger seeds (Jordano 1992). A longer seed retention period reduces germinability (Murray 1994) or germination time, which may explain differences in germinability and germination time of very small seeds, such as *C. urceolata* (~ 1.0 mm) and *P. crassifolium* (~ 0.6 mm) eaten by larger species, such as *D. albiventris*. Therefore, the simple passage through the digestive tract of the disperser is not a prerequisite for increasing the germination of gut-passed seeds (Cantor *et al.* 2010). Finally, it is also important to consider the group of dispersers involved, because small gut-passed seeds are more likely to be eaten and dispersed by a wide range of vertebrates (Fleming & Sosa 1994). Therefore, birds may be linked to more successful and effective seed dispersion of colorful fruits (Staggemeier & Galetti 2007), as in the case of *C. sessilis* and *P. hoffmannseggiana* (Rubiaceae), species whose fruit is consumed by didelphids in low proportions and presented a reduction in germinability after gut passage.

Germination time

The effects of frugivores on plants go beyond the increase in seed germination time, because they can exert multiple effects (that are not always immediate) on the performance of seeds and seedlings (Jordano 1992; Staggemeier & Galetti 2007). Frugivores may contribute to the maintenance of plant populations by carrying the seeds away from the zone of high mortality near the parent plant and depositing them in microhabitats favorable for germination and seedling establishment (Janzen 1970; Howe *et al.* 1985). Even when the deposition occurs in microhabitats unfavorable for germination, didelphids contribute effectively by increasing the seed rain, a vital process to maintaining the soil seed bank (Cantor *et al.* 2010). The variation in germination time observed in seeds consumed by didelphids in the study area suggests the identification of two strategies (according to Garwood 1983, cited in Cáceres 2002): seeds that germinate quickly (~ 12 days) during the same rainy season (*C. minensis*, *C. urceolata*, *M. holosericea*, *P. capitata* and *P. crassifolium*) and seeds which will germinate only in the next rainy season (*C. sessilis*, *Myrcia* sp. and *Psidium* sp.). These germination strategies were also observed for other seeds dispersed by didelphids in the neotropical region (Cáceres 2002; Cáceres & Monteiro-Filho 2007; Cantor *et al*. 2010; Cáceres & Lessa 2012) and reinforce the importance of seasonal soil water deficits in determining the probability of germination (Cáceres & Monteiro-Filho 2007) in environments such as the *cerrado*. The consumed seeds showed different germination times and, in a general way, germination was delayed until periods of more favorable environmental conditions (see Cáceres 2002; Thompson & Ooi 2010; Silveira *et al*. 2012a).

The didelphid species studied here can be considered important seed dispersers of riparian forest species in the *cerrado* for the following reasons: fruits are consumed year round; a significant proportion of ingested seeds remain viable after being defecated; they act as effective seed dispersers of small seeds (0.6-5.0 mm); they contribute to increasing germinability and hastening seed germination for some plant species, especially pioneer plants with small seeds; they contribute to seed germination by isolating the seeds, given that seeds remaining within intact fruits may not germinate (Silveira *et al*. 2012b); and even when seed germination of ingested seeds is not significantly higher than that of non-ingested seeds, the species studied may have a positive impact by increasing the seed dispersal distance and contributing to the maintenance of the soil seed bank. We do recognize, however, that experimental conditions for seed germination may have affected our results because the disinhibition effect was not measured (Robertson *et al*. 2006).

In conclusion, the small number of seeds destroyed after gut passage and the results obtained during the germination experiments underscore the importance of didelphid marsupials to the dynamics of plant reproduction. However, due to the complex nature of didelphid-fruit interactions, the benefits of gut passage and the effects of digestive retention on the germination dynamics (germinability and mean germination time) may be better understood with further study. Additional studies are needed in order to clarify the contribution of didelphids as seed dispersers in the *cerrado* biome.

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