**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 (*Conderea sessilis* (Vell.) Kantze). 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*...
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...
Results

Germinability

We found seeds of 23 different taxa of angiosperms in a total of 427 fecal samples analyzed: Gracillanum 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 (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 ($\chi^2$=12.35, d.f.=1, p=0.007), G. microtarsus ($\chi^2$=10.15, d.f.=1, p=0.002), M. incanus ($\chi^2$=11.00, d.f.=1, p=0.001), C. philander ($\chi^2$=9.69, d.f.=1, p=0.001), M. nudicaudatus ($\chi^2$=9.95, d.f.=1, p=0.002) and M. paraguayana ($\chi^2$=8.10, d.f.=1, p=0.004) but not in D. albiventris ($\chi^2$=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 ($\chi^2$=5.49, d.f.=1, p=0.019), M. paraguayana ($\chi^2$=4.59, d.f.=1, p=0.032) and D. albiventris ($\chi^2$=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 M. incanus and P. crassifolium. Regarding C. minensis seeds, the difference was significant for the samples taken from the feces of M. incanus ($\chi^2$=7.43, d.f.=1, p<0.001) and M. nudicaudatus ($\chi^2$=3.87, d.f.=1, p=0.041). For P. crassifolium, there was also a decrease in the germination time for G. agilis ($\chi^2$=46.40, d.f.=1, p=0.041), G. microtarsus ($\chi^2$=3.87, d.f.=1, p=0.049) and M. incanus ($\chi^2$=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 ($\chi^2$=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 paraguayaensis (n = 16) | Didelphis albiventris (n = 22) |
|----------------------|------------------|----------------|-------------------------------|-----------------------------------|---------------------------|-------------------------------|---------------------------------|---------------------------------|---------------------------------|
| ANACARDIACEAE        |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Tapirira obtusa      |                  | 7              | -                             | -                                 | 1 (1.4)                   | 2 (12.5)                     |                                 |                                  |                                  |
| CACTACEAE            |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Cephalocereus minensis | (Werderm.) Ritter | 0.6            | -                             | -                                 | 1 (1.4)                   | 3 (13.6)                     | -                               | -                               | -                               |
| CHRYSOBALANACEAE     |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Hirtella gracilipes  | (Hook.f.) Prance | 9              | -                             | -                                 | -                         | -                             | -                               | -                               | 2 (9.0)                         |
| LAURACEAE            |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Octoea lancifolia    | (Schott) Mez*    | 3              | -                             | -                                 | 2 (6.0)                   | 1 (6.2)                      | -                               | -                               | -                               |
| FABACEAE             |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Mimosaideae sp. 1*   |                  | 9              | -                             | -                                 | -                         | -                             | -                               | -                               | 1 (4.5)                         |
| Mimosaideae sp. 2*   |                  | 11             | -                             | -                                 | -                         | -                             | -                               | -                               | 2 (9.0)                         |
| MELASTOMATACEAE      |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Clidemia urecolata   | 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)                   | -                            | -                               | -                               | 2 (12.5)                       |
| 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     |                  | 7              | -                             | -                                 | 2 (6.0)                   | -                            | 1 (6.2)                        | 1 (4.5)                         |                                  |
| A.S.- Hill & Naudin  |                  | 6              | -                             | -                                 | 2 (6.0)                   | -                            | 2 (9.0)                        |                                  |                                  |
| Myrcia sp.*          |                  | 5              | -                             | -                                 | 5 (15.1)                 | -                            | 1 (6.2)                        | 2 (9.0)                         |                                  |
| Pidium sp.*          |                  | 4              | -                             | -                                 | 3 (9.0)                   | -                            | -                               | 3 (13.6)                       |                                  |
| Myrtaceae sp. 1      |                  | 2              | 1 (0.7)                       | 2 (1.7)                           | -                         | -                            | -                               | -                               | -                               |
| RUBIACEAE            |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Cordiera sessilis    | (Vell.) Kantare* | 5              | -                             | -                                 | 1 (1.4)                   | 2 (6.0)                      | 1 (4.5)                        | 3 (18.8)                       | 4 (18.2)                       |
| Acalypha viridiiiana | 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 |            | 4              | -                             | -                                 | 1 (1.4)                   | 1 (4.5)                      | 1 (6.2)                        | 1 (4.5)                         |                                  |
| (Wild. ex Shult.) Mull. Arg.* |        | 1              | 7 (4.9)                       | 2 (1.7)                           | 4 (5.6)                   | -                            | 1 (6.2)                        | 1 (4.5)                         | 3 (13.6)                       |
| SANTALACEAE          |                  |                |                               |                                   |                           |                               |                                 |                                  |                                  |
| Phoradendron crassifolium |            | 0.5            | -                             | -                                 | -                         | -                            | -                               | -                               | 2 (9.0)                         |
| Smilax sp.*          |                  | 1              | 1 (0.8)                       | 2 (2.8)                           | 1 (4.5)                   | 3 (18.8)                     | 2 (9.0)                        |                                  |                                  |
| Seeds (total)        |                  | 43             | 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 paraguayaensis | Didelphis albiventris |
|----------------------|------------------|-----------------|---------------------|-------------------------|------------------|---------------------|------------------------|------------------------|----------------------|
| CACTACEAE            |                  | 230 (38.6)**    | -                   | -                       | 133 (6.2)        | -                   | -                      | -                      | -                    |
| MELASTOMATACEAE      |                  | 800 (37.1)**    | 230 (73.6)**        | 153 (70.1)**           | 350 (71.7)**     | 220 (69.2)**        | 350 (69.0)**           | 200 (66.0)**           | 220 (44.0)           |
| MYRTACEAE            |                  | 500 (33.1)      | 133 (49.6)          | 210 (46.6)              | 152 (45.3)       | 130 (42.3)          | 140 (42.1)             | 230 (41.1)             | 350 (39.2)           |
| RUBIACEAE            |                  | 331 (71.2)**    | -                   | -                       | 37 (65.4)**      | -                   | 30 (63.1)**            | 12 (66.1)**            | -                    |
| SANTALACEAE          |                  | 121 (68.3)**    | -                   | -                       | 17 (47.8)        | -                   | 27 (44.4)              | 51 (43.1)              | -                    |
| SMILOLACEAE          |                  | 300 (77.6)**    | -                   | -                       | 09 (22.2)        | -                   | 11 (27.3)              | 05 (20.0)              | 34 (23.5)            |
| Seeds (total)        |                  | 127 (40.1)      | 30 (42.3)           | -                       | 123 (41.4)       | 154 (42.5)          | 330 (37.5)             | -                      | 291 (39.3)           |

CG – control group.
*Results expressed as total number of seeds tested (germinability, in %); **p<0.01; ***p<0.05.
Effects of gut passage on the germination of seeds ingested by didelphid marsupials in a neotropical savanna

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            | Species                     | Seed size (mm) | Germination period (days) | Mean±SD               |
|-------------------|-----------------------------|----------------|---------------------------|-----------------------|
|                   |                             |                | CG Gracillanrus agilis Gracillanrus microtarsus Marmosops incanus Calomys philander Metachirus nudicaudatus Marmosa paraguayanus Didelphis albiventris |                      |
| CACTACEAE         | Cepocereus minensis         | 0.6            | 30±2                      | 12±3*                 | 17±8*                 |                      |                      |                      |
| MELASTOMATACEAE   | Chilemias urceolata         | 1.0            | 32±2                      | 31±3                  | 33±4                  | 32±7                 | 29±6                 | 33±3                 |
|                   | Miconia holosericea         | 1.0            | 31±2                      | 31±5                  | 31±5                  | 32±7                 | 30±8                 | 33±6                 |
| MYRTACEAE         | Myrcia sp.                  | 5.0            | 162±7                     |                      | 170±14                | 159±8                 | 160±9                 |                      |
|                   | Psidium sp.                 | 4.0            | 138±23                    |                      | 137±7                 |                      | 135±10                |                      |
| RUBIACEAE         | Cordyera sessilis           | 5.0            | 175±14                    |                      | 157±21                | 164±14                | 171±8                 |                      |
|                   | Psychotria capitata         | 2.0            | 43±7                      | 41±4                  | 43±4                  | 44±5                 | 40±7                 |                      |
| SANTALACEAE       | Phoradendron crusfillium    | 1.0            | 46±6                      | 29±1*                 | 30±2*                 | 29±5*                |                      | 45±9                 |

*p<0.05.

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-Pérez 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 & Verdú 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 Melastomaceae, can also be consumed occasionally (Lessa & Costa 2010; Cáceres & Lessa 2012). In general, most seeds dispersed by didelphids show that endozoocorous 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. crusfillium (~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...
Biodiversity Conservation) for issuing the license to capture the animals, via the Sistema de Autorização e Informação em Biodiversidade (SISBIO, System for Biodiversity Authorization and Data Access; License no. 19790-1); and to the Instituto Estadual de Florestas de Minas Gerais (IEFMG, Minas Gerais State Forestry Institute), for allowing access to RPS. In addition, we thank the two anonymous reviewers for their helpful comments on an earlier draft of the manuscript. Financial support was provided by the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG, Foundation for the Support of Research in the State of Minas Gerais; Grant no. APQ 01034-09), the Brazilian Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES, Office for the Advancement of Higher Education; scholarship grant to LGL), the Brazilian Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, National Council for Scientific and Technological Development; research grant to LG) and the Universidade do Estado do Rio de Janeiro (UERJ, Rio de Janeiro State University) Prociência (“Prosciência”) Program (additional research grant to LG).

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