Nota

CAN Carollia perspicillata (CHIROPTERA: PHYLLOSTOMIDAE) INDUCE SEED GERMINATION OF Cecropia pachystachya?

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ABSTRACT. We tested if seed germination of the tree Cecropia pachystachya is induced after being consumed by the frugivorous bat Carollia perspicillata. We carried out two essays; in the first, we compared germination of seeds from C. perspicillata feces, seeds chemically scarified in acid solutions, and seeds from fresh C. pachystachya infructescences. In the second essay we evaluated seed viability after four months storage. Percentage of seed germination was reduced after C. perspicillata ingestion, but nevertheless remained high (76%). Seeds ingested by this bat also maintain their viability after storage, and C. perspicillata can be considered an effective seed disperser of C. pachystachya seeds.

RESUMO. Carollia perspicillata (Chiroptera: Phyllostomidae) pode induzir a germinação de sementes de Cecropia pachystachya? Desenvolvemos dois experimentos para testar se C. perspicillata pode agir como indutor da germinação de sementes de C. pachystachya. Primeiro comparamos a germinação das sementes retiradas das fezes do morcego, de sementes tratadas em soluções ácidas e sementes retiradas de infrutescências da planta. Avaliamos também a germinação das sementes após 4 meses de armazenamento. A porcentagem de germinação das sementes foi reduzida após a ingestão do morcego, entretanto, ainda com altas taxas de germinação (76%). Sementes ingeridas pelo morcego mantiveram sua viabilidade após o período de armazenamento. C. perspicillata pode ser considerado um dispersor eficiente de sementes de C. pachystachya.

Key words: bats, Cerrado, endozoochory, frugivory, seed dispersal.

Palavras-chaves: Cerrado, dispersão de sementes, endozooocoria, frugivoria, morcegos.

Zoochory is one of the most important dispersal strategies of plants, with about 50 to 90% of trees dispersing their seeds by animals in tropical forests and savannas (Fleming 1987; Vieira et al. 2002; Jordano et al. 2006). Seed dispersal that occurs after passing through the digestive tract of an animal (endozoochory) is an important mutualistic relationship, where animals remove energy from fruits and the plant’s propagules are dispersed (Van Der Pijl 1982; Galetti et al. 2006).

Seeds that pass through the digestive tract of frugivorous may improve their germination rates, due to the removal of germination inhibitors and
the rehydration of tissues by chemical scarification (Traveset & Verdú 2002; Robertson et al. 2006).

Between the frugivorous vertebrates, bats are recognized as one of the most important in the Neotropics (Galetti et al. 2006; Jordano et al. 2006; Muscarella & Fleming 2007; Fleming et al. 2009). They are excellent seed disperser of pioneer and early secondary plant species, making them important for the secondary succession process, allowing the seeds flow from conserved to modified areas (Fleming 1987; Jordano et al. 2006; Galetti et al. 2006; Fleming et al. 2009).

The family Phyllostomidae is widely distributed in the Neotropics with 160 species; and 120 species recorded as frugivorous and/or nectivorous (Simmons 2005). Frugivorous phyllostomids are recognized as efficient seed disperser in tropical forests (Fleming 1987). Between them, Carollia perspicillata (Linnaeus 1758) is one of the most widely distributed bats in the neotropics. It is a medium-sized bat (forearm ± 42.0 mm; weight 10-23 g) (Peracchi et al. 2006) and an important frugivorous generalist, feeding mainly of Cecropia, Ficus, Piper and Solanum species (Garcia et al. 2000; Passos et al. 2003; Carvalho-Ricardo et al. 2014; Parolin et al. 2016).

Bats can maintain mutualistic relationships with these species (Fleming et al. 2009; Parolin et al. 2016), inducing seed germination rate (Heer et al. 2010) or increasing speed of seed germination (Bocchese et al. 2003). But in other cases, there is no effect or even a decrease over seed germination (Tang et al. 2008; Oliveira et al. 2013).

Considering the importance of frugivorous bats for the dispersal of pioneer species and their role in the regeneration of degraded environments, here we investigate if the Neotropical frugivorous bat C. perspicillata can act as a germination inducer of a pioneer tree species, Cecropia pachystachya Trec. (Urticaceae). The species C. pachystachya is a pioneer tree with fast growth, heliophite and selectively hygrophilous. It occurs frequently in disturbed areas or in initial stages of ecological succession (Pott & Pott 1994). We sought to answer the following questions: Are the seed germination induced or reduced after bat digestion? Are the seed viability maintained after storage?

The study was carried out in the Quinta do Sol Privately Owned Nature Reserve (PONR) (Latitude 19°46′34.81″; Longitude 55°14′46.28″), at Taboco region, municipality of Corquirino, Mato Grosso do Sul, Brazil (Fig. 1). The typical native vegetation of the region consists of savanna physiognomies, where...
Fig. 1. Location of Environmental Estancia Quinta do Sol, Taboco region, municipality of Corguinho, Mato Grosso do Sul, Brazil.

1 minute in pH 2 and pH 3 solutions respectively (Bocchese et al. 2007).

All treatments consisted of four replicates with 25 seeds each, which were placed in Petri dishes (seven centimeters in diameter) on two sheets of filter paper and moistened with a 0.2% aqueous solution of Rovral fungida (volume of solution equivalent to 2.5 times the weight of the substrate). The dishes were kept in a germination chamber at a constant temperature of 30°C, with periods of 12 hours of artificial lighting (fluorescent lamps). Germinated seeds, those with a minimum protrusion of two mm of primary root, were counted daily for six consecutive days (Oliveira et al. 2013).

The remained seeds not used in germination tests (fresh seeds and feces seeds) were placed in individual Petri dishes and stored under laboratory conditions (temperature of 28.5°C ± 1.0°C and relative humidity between 60 and 70%). To verify the seed viability (for both fresh seeds and feces seeds) along time, we carried out germination tests every 30 days after seed collection, from November 2010 to February 2011, following the same procedures described above.

For each replicate, in all experiments, we calculated final germination percentage \( G\% = 100 \cdot \sum n_i \cdot N^{-1} \) and mean germination time \( MGT = \sum n_i \cdot t_i \cdot \sum n_i^{-1} \) where \( \sum n_i \) is the amount of germinated seeds in relation to the number of seeds (\( N \)) placed to germinate and \( n_i \) is the number of germinated seeds within the time interval \( t_i - 1 \) and \( t_i \) (Ranal & Santana 2006). The germination percentage and mean germination time data were analyzed with one-way ANOVA and the germination percentage of storage essay was analyzed with two-way ANOVA. The Tukey test (\( p < 0.05 \)) was used to compare means.

There were significant differences between treatments in germination percentage (\( F=99.6; p<0.001 \)), and \( MGT \) (\( F=173.3; p<0.001 \)) (Table 1). Seed germi-
nation from *C. perspicillata* feces was 24% lower than seeds from infructescence. There was no significant difference in germination among seeds from feces and pH 2 treatment. Seed germination from pH 3 treatment differed from feces’ seeds but was statistically equal to pH 2 treatment. *MGT* increased for all treatments in relation to control seeds (Table 1).

**Table 1**

Means (± standard error) of germination percentage (%) and mean germination time (*MGT*) of *Cecropia pachystachya* seeds for fresh seeds (Control), seeds from *Carollia perspicillata* feces (Feces) and chemically scarified seeds (pH 2 and pH 3).

<table>
<thead>
<tr>
<th>Germination (%)</th>
<th>MGT (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100 ± 0.0  a</td>
</tr>
<tr>
<td>Feces</td>
<td>76.0 ± 2.0  b</td>
</tr>
<tr>
<td>pH 2</td>
<td>2 70.0 ± 2.0  bc</td>
</tr>
<tr>
<td>pH 3</td>
<td>3 67 ± 1.0  c</td>
</tr>
</tbody>
</table>

*Different letter in the column indicate significant differences according to Tukey test (p>0.05).*  

There was significant interaction between treatment and storage time (*F*=144.0; *p*=0.001). Storage affected seed germination only in seeds from *C. pachystachya* infructescence, with germination percentage remaining smaller in seeds from feces in relation to seeds from infructescence even after four months of storage (Fig. 2).

Our results indicate that the bat *C. perspicillata* was not a germination inducer of *C. pachystachya* seeds. However, seed germination remained high after bat ingestion (76%). A similar study reported that seed germination percentage of *C. pachystachya* not differed between seeds from infructescence (48%) and from *C. perspicillata* feces (57.5%). However, seed germination of another *Cecropia* species (*C. glaziovii*) was increased after ingestion by *C. perspicillata* (from 51.5 to 98%) (Rossaneis et al. 2015).

Regarding to other bat species, seeds of *C. pachystachya* ingested by *Artibeus lituratus, Platyrrhinus lineatus*, and *Sturnira lilium*, had not their germination percentage changed in relation to seeds from infructescence (Bocchese et al. 2007; Oliveira et al. 2013; Rossaneis et al. 2015).

The *Piper* genus is indicated as the main food item of *C. perspicillata* (Parolin et al. 2016). Seeds of this genus that have been ingested by *C. perspicillata* not changed or increased their germination for *Piper aduncum, P. hispidinervum*, and *P. amalago* (Garcia et al. 2000; Rossaneis et al. 2015). Moreover, the germination percentage of *Solanum americanum, S. mauritianum, S. granuloso-leprosum*, and *Ficus eximia* seeds that are ingested by *C. perspicillata*, also did not differ from seeds extracted from fruits (Rossaneis et al. 2015).

Although *MGT* was in general around four days (Table 1), the slight increase in *MGT* for seeds from feces and pH treatments may indicate some physiological change in the germination process. Similar results were notice in other studies where *C. pachystachya* seeds have *MGT* increased after *P. lineatus* and *S. lilium* ingestion (Oliveira et al. 2013; 2018).

The increase of *MGT* of seeds after bat ingestion has been interpreted for some studies as being a good aspect. Because a longer *MGT* may represent a germination distribution in time (Tang et al. 2008), it may allow seedlings to reach suitable conditions for their establishment in different periods, which increases survival in environments that suffer temporal variations in their abiotic factors (Brancalion & Marcos Filho 2008).

The distinct results of seed germination responses after bat ingestion found here and in other studies may be result of several factors. Such as differences in the pH of the bat species’ digestive system, digestion time, the amount of food consumption, and fruit consumption behavior (e.g. chewing), among others. The statistic similarity of pH 2 treatment and the feces treatment may indicate that the reduction in germination percentage of seeds from *C. perspicillata* feces is a result of stomach acids from digestive tract of bats. In general, the stomach of most mammals has a pH around 2, because the enzyme pepsin, which together with hydrochloric acid-releasing cells, promotes acidification (Schmidt-Nielsen 2002).

Seed storage reduced germination of seeds from *C. pachystachya* fruits, while seeds from *C. perspicillata* feces were not affected by storage period tested. It may indicate that the passage through bat digestive tract affected only seeds that which had low quality. Moreover, the removal of the pulp by passage through digestive tract may also reduce predation risk by insects and/or decrease fungal infection (Tang et al. 2008; Heer et al. 2010).

*Cecropia pachystachya*, a tree characteristic of the early stages of succession is one of the most abundant tree species in soil seed bank (Holthuijzen & Boerboom 1982; Grombone-Guaratini & Rodrigues 2002). Therefore, the large proportion of viable seeds from *C. perspicillata* feces after four months of storage (68%) may indicate that these seeds can
maintain their viability in soil seed bank even after bat dispersion during a period of time.

A recent study reported that *C. perspicillata* consumed 40.7% of plants recorded in that study, and presented the highest value of the dispersion index (DII = 1.536) and the highest abundance of seeds consumed (Casallas-Pabón et al. 2017). Therefore, *C. perspicillata* may be an important seed disperser of *Cecropia* species and another plant species in several areas of the Neotropics. In fact, our results confirm the evidences of Lobova et al. (2003) that the bat dispersal is not necessary for germination of *Cecropia* seeds, but it may increase seed survival. Like other frugivorous bats (Lobova et al. 2003), we conclude that *C. perspicillata* is an effective disperser of *C. pachystachya* seeds.

**Acknowledgments.** The authors are grateful to the Conselho Nacional de Desenvolvimento Científico Tecnológico (CNPq) for providing the Scientific Start-up Grant (PIBIC), present research grant (PQ2) and Regional Development (DCR). We would also like to thank the Conselho Nacional de Desenvolvimento Científico (CNDI = 1.536) and the highest abundance of seeds Tecnológico (CNPq) for providing the Scientific Start-up (p<0.05).

**LITERATURE CITED**


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