EFFECTS OF FIG SEEDS INGESTION BY *ALOUATTA CARAYA*: DOES PASSAGE THROUGH THE GUT AFFECTS GERMINATION?

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INTRODUCTION

The unidirectional movement of an organism away from its place of birth is defined as dispersal. In plants, dispersal is reserved to a short stage of the life cycle and, in higher plants, individuals move in space mostly as seeds (Levin *et al.*, 2003). The usual classification of dispersal syndrome is based on the morphology of seed or fruit, which provides inference about the agent or vector of dispersal (Howe & Smallwood 1982). The agents of dispersion are both abiotic and biotic, and dispersal modes can be classified as: anemochory (wind dispersion), hydrochory (dispersion by water), autochory (auto - dispersion) and zoochory (dispersion by animals) (Levin *et al.*, 2003). The dispersal agents differ markedly in their effectiveness both quantitatively and qualitatively. Quality of seed dispersal is contingent upon the treatment received by seeds and the quality of their subsequent deposition. Seed treatment includes the level of seed destruction and the alteration of germination rates (Schupp 1993). On zoochory, the mechanism of dispersal commonly involves endozoochory (the consumption of the entire fruit, including its passage through the gut of the frugivores) (Tiffney 2004). The effects of seed passage through digestive tract depend on the frugivore species that consumes a given species of plant, and may increase, decrease or maintain neutral the germinability of seeds (Traveset 1998).

Ficus is one of the most diverse woody plant genus, with approximately 750 species distributed in the tropics and subtropics. This group has a variety of growth forms that includes shrubs, trees, climbers, epiphytes and hemi - epiphytic stranglers (Berg 1989). *Ficus* species has asynchronous fruiting between species and within species, providing fruits availability through all the year (Shanahan *et al.*, 2001). For this reason, they were described as 'keystone resources' in tropical forests, sustaining frugivores through periods of fruit scarcity (Terborgh 1986). To identify a *Ficus* seed disperser, the following items must be analyzed: propensity for fig - eating, feeding methods, distance moved (the mobility of the disperser and the time for gut passage), patterns of faeces deposition and effects of ingestion on seed viability and germination rates (Shanahan *et al.*, 2001).

Shanahan *et al.*, (2001) in a review regarding fig eaters, reported 990 bird species in 374 genera and 54 families and 284 mammal species in 153 genera and 38 families, as well as few fish and reptiles species as consumers of fig fruits. Between mammals, *Alouatta fusca* and *A. palliata* are known to defecate theses seeds intact and to elevate their germination rates (Estrada & Coates - Estrada 1986, Figueiredo 1993). *Alouatta caraya* (black howler monkey) has a folivorous - frugivorous diet (Milton 1980), and presents a high level of daily inactivity (Crockett & Eisenberg 1987). On diet studies of some *Alouatta*, fruits of *Ficus* species are between the items consumed (Miranda & Passos 2004, Pinto 2002,) in some cases, as the principal food resource (Pavelka & Knopff 2004, Aguiar *et al.*, 2003, Serio - Silva *et al.*, 2002). Although the genus *Alouatta* is one of the most studied between primates of the neotropics, there are few studies regarding the behavior and ecology of *Alouatta caraya* (Ludwig 2006).

OBJECTIVES

The goal of this study is to verify if passage of *Ficus pertusa* and *F. luschnathiana* seeds through the gut of *Alouatta caraya* affects their germination.

MATERIAL AND METHODS

Field study was conducted in one "capão"inside the São Bento farm, located in the municipality of Corumbá, Pantanal, sub - regions Miranda and Abobral (Adámoli 1982). The fig individuals sampled were those that the studied troop of *A. caraya* used as fruit resource, varying according their choice for feeding. "Capões" are natural islands of woody vegetation varying from 1 - 3 m of elevation up the ground, which is dominated by gramineous species. In the edges of the capão, typical species of Chaco and riparian forest occur, and in the interior, species typically from semideciduous forest (Prance & Schaler 1982; Damasceno *et al.*, 1999). The canopy height has between 10 - 15 meters being discontinuous in the central area, and closed on the edges (Damasceno *et al.*, 1999), where *Attalea phalerata* (Arecaceae) predominates. The climate is the tropical warm based on Köppen classification, with the rainy and the dry seasons well defined. Rains occur between November and March, and the dry period, between April - October (Allem & Valls 1987).

For south Pantanal, six species of *Ficus* are reported: *Ficus calyptroceras*, *F. insipida*, *F. luschnathiana*, *F. pertusa* (Pott & Pott 1994), *F. obtusifolia* and *F. crocata* (P.A.A.Cara,, unpublished data). In this study, the rates of germination of seeds after ingestion by *A.caraya* and those from fruits are compared only for *Ficus pertusa* and *F. luschnathiana*.

The studied group of *A. caraya* consisted of nine members: one dominant male, two adult females, three sub - adult males, one juvenile male and two immatures. Collection of faeces of individuals of this group were done after they consume fruits from one individual of *F. pertusa* (in October 2008) and from one individual of *F. luschnathiana* (in January 2009). Additionally, mature fruits from the same trees were collected, directly from the branches or from the ground (just those that fall while howlers were eating) down this individual. Faeces were maintained in paper bags, and fruits in plastic pot until arrive in laboratory. Then, they were washed inside sieves, and dried on paper towel. All seeds were observed under a stereoscopic microscope, and those whose embryos had been eaten by fig - wasps (Agaonidae) were discarded. Seeds were then sorted randomly, 250 from fruits and other 250 seed from faeces. They were put on a petri dish up to a filter paper. Every single petri dish contained 50 seeds, totalizing 10 dishes: 5 from faeces, 5 from fruits. Seeds were maintained under controlled conditions in a thermostatically controlled chamber (20^0C in dark, 30^0C in light, with photoperiod varying in 12 hours) and checked daily up to 30 days from the beginning of the test.

Percentage of germination (G), mean time of germination (t) and mean velocity of germination (V) were calculated as proposed by Labouriau (1983) and Santana & Ranal (2000), where:

Percentage of germination : G = (N/A) . 100, (N = number of seeds germinated; A: total number of seeds); mean time of germination: t = ($\sum$niti) / $\sum$ni, (ni = number of seeds germinated per day; ti= days of seed incubation); mean velocity of germination: V = 1/t ,(t= mean time of germination). Seed germination rates per petri dish were compared among the treatments by a Mann - Whitney Test (Zar 1966). For the analysis of mean velocity of germination, only those petri dishes that presented germinated seeds were used.

RESULTS AND DISCUSSION

Ficus pertusa

Percentage of seed germination differed significantly (U=25, p <0,01, df=1) between seeds from faeces (43,6% of all seeds germinated; =21,8 ± 2,49, n=5) and those from fruits (4% of all seeds germinated; = 2 ± 2,345, n=5). In this later treatment two petri dishes did not present any germinated seed. Difference in mean time of germination of seeds presented few significance between those from faeces (= 11,311 ± 0,685 d) and from fruit (=13,320 ± 12,345 d) (U=10, p=0,06, df=1). Seeds from faeces (= 0,089 ± 0,006 d - 1) germinated significantly faster than those from fruits (=0,046 ± 0,006 d - 1) (U=15, p <0,05, df=1).

Ficus luschnathiana

Percentage of seed germination differed significantly (U=24, p=0,016, df=1) between seeds from faeces (64% of all seeds germinated; =32 ±4,062, n=5), and those from fruits (26,8% of all seeds germinated; =13,4 ±8,414, n=5). Difference in mean time of germination presented few significance between seeds from faeces (=7,291 ± 0,451 d) and from fruits (=13,053 ± 2,678 d) (U=0, p=0,01, df=1). Seeds from faeces (= 0,138 ± 0,008 d - 1) germinated significantly faster than those from fruits (=0,079 ±0,015 d - 1) (U=25, p <0,01, df=1).

The seed passage through *A. caraya* gut in both species of *Ficus* increased germination rates. Howler monkeys have a capacious colon (43 cm long, 3.5 cm wide) (Milton 1981) in which food can be retained for a period and fermentation activities can occur effectively. Their gut capacity and relatively slow food passage rate appear to be related to an efficient digestion strategy, which can increase seed coat removal, break seed dormancy, or display an advanced germination of seeds (Righini *et al.*, 2004). Many studies found that passage through the gut of howlers increased seed germination (Figueiredo 1993, Righini *et al.*, 2004, Bravo *et al.*, 1995), but Julliot (1996) found that *Alouatta seniculus* did not altered significantly germination rates. In general, rapid germination can be advantageous in the field, because it reduces seed predation (Stevenson *et al.*, 2002). Our results suggests that the consumption of fruits of *F. pertusa* and *F. luschnathiana* by *A. caraya*, is advantageous because these seeds germinate faster and in a shorter time than those seeds that came directly from the fruits, providing higher chances of successful establishment, mainly when associated with propitious places of deposition.

Due to the low activity level of Howler monkey, defecation normally occurs under the canopy of the species they eat or close to it. This habit is disadvantageous for the success of the seeds establishment (Shupp 1993). In the studied capão, we recorded consumption of *Ficus* fruits on the edges and defecation on the canopy of *Attalea phaletara* (Arecaceae) individuals. This palm specie occurs in great density on the edges of the capão, and its trunk retains part of the petiole of old leaves, creating a microhabitat that is favorable for the establishment of a seed bank (Côrrea 2005). On our field observations, specially *Ficus pertusa* seems to be associated with *A. phalerata* trunks, and howlers habits of defecation may be improving seed deposition on the trunk Corrêa (2005) found that, from all seeds deposited on the trunks, *Ficus* species presented the highest richness and the second biggest abundance of occurrence, specially *Ficus pertusa*. However, to assess the complete role of *A. caraya* as

Ficus disperser, other factors should be considered, such as the importance of this species on howler monkeys diet, number of visits to each Ficus species, number of seeds dispersed per visit, and quality of deposition (movement and deposition patterns) (Shupp 1993).

CONCLUSION

Results from this study indicate the importance of seed passage through *Alouatta caraya* digestive tract, increasing germination rates, velocity and time of germination for *Ficus pertusa* and *F. luschnathiana* on the studied months. However, it is still important to evaluate the complete role (effectiveness both quantitatively and qualitatively) of *A. caraya* as seed disperser of these *Ficus* species in south Pantanal.

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