

## **Predation of Adult Palms by Blackcapuchin Monkeys (*Cebus nigrinus*) in the Brazilian Atlantic Forest**

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## PREDATION OF ADULT PALMS BY BLACK-CAPUCHIN MONKEYS (*CEBUS NIGRITUS*) IN THE BRAZILIAN ATLANTIC FOREST

Carlos Rodrigo Brocardo  
Henrique Santos Gonçalves  
Valesca Bononi Zipparro  
Mauro Galetti

### Introduction

Neotropical primates affect plant population through mutualistic interactions, such as seed dispersal, and antagonist interactions such as seed predation and herbivory (Peres, 1993; Russo and Augspurger, 2004; Mourthé *et al.*, 2008). Primates killing trees through herbivory is rarely documented (Rocha, 2000; Santos *et al.*, 2007). The genus *Cebus* (Erxleben, 1777) is considered as having the widest diet plasticity among neotropical primates, eating leaves, seeds, fruits, invertebrates and even vertebrates (Fedigan, 1990; Galetti and Pedroni, 1994; Susan and Rose, 1994; Rose, 1996; Ludwig *et al.*, 2005; Carretero-Pinzón *et al.*, 2008; Freitas *et al.*, 2008). In this paper, we documented the predation of two palm species through the consumption of palm heart (apical meristem) by black-capuchin monkey (*Cebus nigrinus* Goldfuss, 1809).

### Materials and methods

Our observations were carried out between June 2009 and June 2010 in “Carlos Botelho” State Park (CBSP) (24°06' and 24°14'S; 47°47' and 48°07'W), in São Paulo State, Brazil. The CBSP has an area of 37,644 ha of Atlantic Forest, and it is located in the Forest Continuum of Paranapiacaba massif. The annual average temperature varied

from 15 to 19 °C, and the annual precipitation varied from 1700 to 2400 mm (Instituto Florestal, 2008). The density of black-capuchin monkeys in this site is estimated at 10.5 ( $\pm 2.4$  SE) individuals/km<sup>2</sup>, and the average group size is 5.16 ( $\pm 0.55$  SE) individuals (Galetti *et al.*, unpub. data).

The records of palm heart predation (directly and indirectly) were taken during line transects of mammal survey (430 km, approach 500 hours) and during the displacements to line transects in the forest (about 200 field hours). Despite that the *C. nigrinus* groups were not accompanied directly, the animals are relatively habituated to observers. The line transects surveys were carried monthly (10–15 days per month), when we encounter predation events, *ad libitum* observations were made (with binoculars or naked eye), each predation event was recorded by a single observer. We sampled adult trees through randomized 15 0.04-ha plots, and juvenile trees through 15 0.01-ha plots to estimate the capuchin-monkey palm predation (sampling tree adapted from Durigan, 2003). Chi-square analysis was used to estimate differences in predation intensity between seasons.

## Results

We observed capuchin-monkeys preying upon palm hearts of *Euterpe edulis* Mart. in 14 occasions, being 12 times in the Winter (May–August), once in the Summer (November–February), and once in the Autumn (February–May). We recorded from one to four capuchin-monkeys (sub-adult and adult) feeding simultaneously on apical meristem, but each animal on a different palm. The group size in these events varied from 3 to 12 black-capuchin monkeys. Capuchin monkeys spend between 10 to 40 minutes (mean 25  $\pm 4$  SE) to open the palm heart, varying principally with palm diameter. Initially, the monkeys bite the outer leaves, forcing them down using both

hands, remaining supported with tail and posterior members on the palm stipe, then they repeat this process until liberate the apex of most leaves. After that, the animals bite the apex basis, to release it from the stipe, and consumed the apical meristem on other tree.

We found other 44 *E. edulis* killed by capuchins along the forest trails, of which 38 palms were killed in the Winter, four in the Summer, and two in the Autumn. The presence of recently signals permitted the identification of predation period (recently withdrawn leaves on the ground, recently destroyed apices and remains of consumed meristems; Fig. 1A and 1B). Other 12 palms were too old to determine the season of the predation (resting only the old destroyed apices). Considering direct and indirect observations of palms predation (only events where was possible determining the period of predation), the consumption of *E. edulis* differed significantly between seasons ( $\chi^2 = 73.0$ ,  $df = 2$ ,  $p < 0.001$ ), being 10 times higher in the Winter than Summer, and 18 times greater than in the Autumn. The *E. edulis* palms killed had diameter at breast height from 8.6 to 15.4 cm (mean 12.8  $\pm 0.55$  SE) and height from 7 to 20 m (mean 12.2  $\pm 0.94$  SE). *E. edulis* is the most abundant arboreal plant in the study area, with a mean density of 93.3 ( $\pm 22.8$  SE) adults/ha and 706.6 ( $\pm 90.7$  SE) juveniles/ha. We estimated *E. edulis* adult mortality by capuchin monkeys at 1.7 ( $\pm 1.6$  SE) individuals/ha per year (1.8 % of adult population).

Moreover, for the first time, we observed the predation of palm heart of *Geonoma gamiova* Barb. Rodr., an understory palm species, with height up to 4 m. Two adults *G. gamiova* were upon preyed by two adult capuchin monkeys (in the Winter). The process is similar to *E. edulis*, but beyond the animals supported on the palm, they supported in near lianas, taking for predation 8 minutes for a palm and 9 minutes for other.

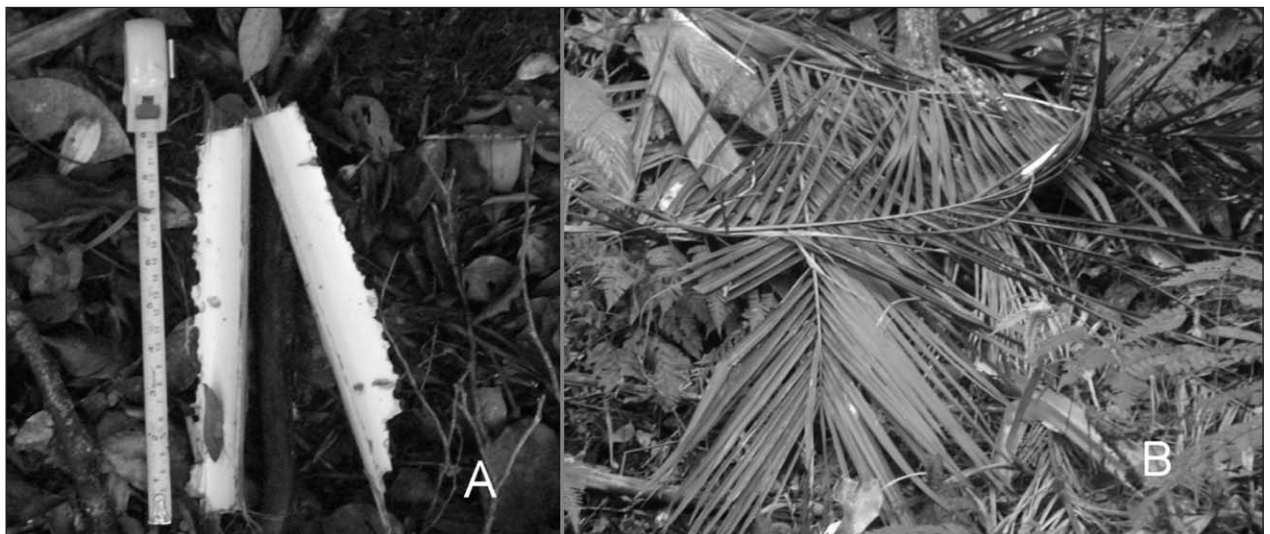


Figure 1. A) Remains of consumed apical meristem by *C. nigrinus* in CBSP. B) Recently withdrawn leaves of *E. edulis* on the ground.

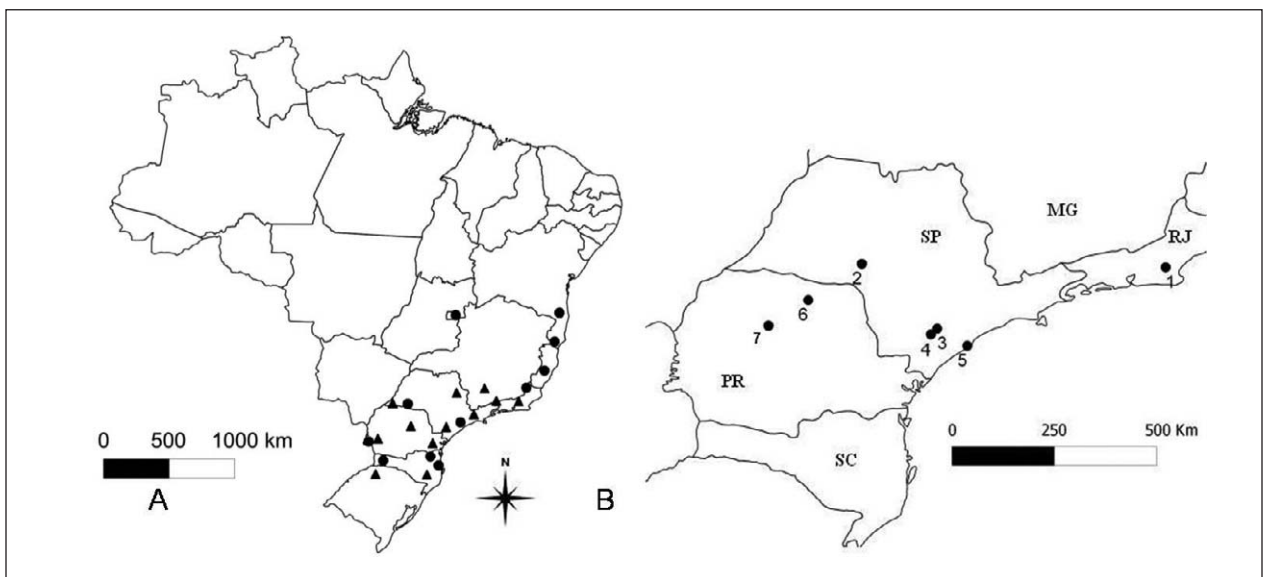
## Discussion

The distribution of *E. edulis* and *C. nigrinus* overlaps in most part of their occurrence in the Brazilian Atlantic Forest (Vilanova *et al.*, 2005; Herderson, 2000) (Fig. 2A). But, the palm heart predation by capuchin monkeys has been reported in a few places (Fig. 2B). In others areas we have worked, as the Iguaçu National Park (Araucaria Forest and Semidecidual Atlantic Forest, 185,262 ha continuous area, Paraná state, Brazil) and Semidecidual Atlantic Forest fragments in São Paulo state (“Mata São José” and “Mata Santa Genebra”, both approximately 250 ha), this behavior or predation signals were never recorded. It is possible that the use of this resource may be related to the group cultural inheritance, such as tool use and food-processing (Antinucci and Visalberghi, 1986; Rocha *et al.*, 1998; Fragaszy *et al.*, 2004; O’Malley and Fedigan, 2005; Canale *et al.*, 2009). The group cultural inheritance in *Cebus* species, as well as other primate species, involves social learning, when the animals observe and interact with other group members, acquiring behaviors (Panger *et al.*, 2002; Dindo *et al.*, 2008; Dindo *et al.*, 2009). The removal of the apical meristem demands dexterity and physical effort, being not accomplished by all members of a group, commonly this is done by some adults and sub-adults, and is observed for young animals.

Except humans, *C. nigrinus* seems to be one of the only vertebrate able to prey upon apical meristem of adults *E. edulis*, since white-lipped peccaries (*Tayassu pecari* Link, 1795) prey upon apical meristem of saplings (F. Rocha-Mendes unpubl. data), and one of the few primates killing an arboreal plant (see Santos *et al.*, 2007; Rocha, 2000).

*E. edulis* is a palm with single stipe (differently of *Euterpe oleracea*), and removal of apical meristem leads to the death of individual. In forest fragments the main cause of mortality of *E. edulis* and *Geonoma brevispetha* (adult and juvenile palms) is the impact of meristem predation by black-capuchin monkeys (Souza and Martins, 2006; Santos *et al.*, 2007; Portela, 2008; Portela *et al.*, 2010). In areas where this behavior occurs, the capuchin monkeys may be helping to modeling the forest structure, similar to observed for ungulates (Silman *et al.*, 2003; Wyatt and Silman, 2004; Beck, 2007). The palm heart predation by capuchins may have consequences for other species, especially birds, rodents and ungulates that depend on *E. edulis* fruits during the Winter (Galetti *et al.*, 1999; Mikich, 2002). Nevertheless, this impact is much smaller than the one caused by human extraction, which may extirpate locally entire adult populations, being the higher threat to conservation of *E. edulis* (Galetti and Aleixo, 1998; Galetti and Fernandez, 1998; Pizo and Vieira, 2004).

Taira (2007) suggests that the consumption of palm heart in the Winter is an alternative source to insect scarcity, but not to fruit scarcity, which also occurs in the Winter at CBSP (Nakai, 2007). On the other hand, several papers concerning the diet of *C. nigrinus* and congeners reported the use of alternative food resource in period of scarcity of fruits which normally constitute the main part of *Cebus* diet (Galetti and Pedroni, 1994; Peres, 1994; Freitas *et al.*, 2008). Therefore, we suggest that palm heart of *E. edulis* and, at a lesser extent, of *G. gamiova*, might be considered as a fallback food of *C. nigrinus*. Indeed, fallback foods are defined as “foods consumed during seasons when preferred foods are unavailable” (Altman, 1998) or as “foods



**Figure 2.** A) Distribution of *Cebus nigrinus* (triangles) and *Euterpe edulis* (circles) in Brazil (adapted from Vilanova *et al.*, 2005 and Herderson, 2000); B) Areas with records of apical meristem predation of *E. edulis* by *C. nigrinus*: 1 –Poços das Antas Biological Reserve, fragment (Portela, 2008; Portela *et al.*, 2010); 2 - Caetetus Ecological Station, fragment (R. Lázara pers. com.); 3 – CBSP, continuous (this paper, Taira, 2007); 4 –Intervalas State Park, continuous (Zipparro and Galetti pers. ob.); 5 –Juréia-Itatins Ecological Station, continuous (P. Rubim pers. com.); 6 –“Mata” Doralice, fragment (Ludwig *et al.*, 2005); 7 –Vila Rica do Espírito Santo State Park, fragment (Santos *et al.*, 2007).



whose use is negatively correlated with the availability of preferred foods" (Marshall and Wrangham, 2007; reviewed in Lambert, 2009). *E. edulis* is known as a keystone-species, providing fruits and seeds for several animal species during the time of greatest shortage (Galetti *et al.*, 1999; Mikich, 2002). The consumption of meristem apical by *C. nigritus*, especially in the Winter, highlights another aspect of importance of this palm.

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**NOTEWORTHY RECORD OF A BLACK HOWLER MONKEY (*ALOUATTA CARAYA*) FROM THE CENTRAL DRY CHACO OF PARAGUAY**

Anthony J. Giordano  
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Howler monkeys (*Alouatta*) comprise a diverse genus of neotropical primates that range from southern Mexico (*A. palliata*, *A. pigra*) to northern Argentina and south-eastern Brazil (*A. guariba*, *A. caraya*) (Cortés-Ortiz *et al.*, 2003). Howler monkeys are the most folivorous of the Neotropical primates (Terborgh, 1983), and thus must forage for long periods to meet their high energetic demands. The southernmost distributed of the howler species, the South American black howler (*A. caraya*) has been reported to occur at the highest densities (Zunino and Rumiz, 1986; Bicca-Marques, 1990; Rumiz, 1990; Crockett, 1998). Considered principally an inhabitant of tropical lowland deciduous and semideciduous forests, black howlers are also known to frequent the gallery forests of the Rio Paraguay and Rio Paraná, as well as the seasonally inundated Pantanal in Brazil (Redford and Eisenberg, 1992; Crockett, 1998).

In Paraguay, black howlers are mostly associated with inland Atlantic forest fragments in the east and gallery forests of high rainfall in the Chaco (Stallings, 1985; Crockett, 1998). However, they have not been reported from the more xeric regions of the Chaco Boreal far from a major drainage system. Stallings and Mittermeier (1983: 161) found that *A. caraya* was “recorded from the higher forest [of the Chaco Boreal] but seemed to be rare in the region.” However, they made no specific reference to geographic location, as howlers were not the primary subject of their discussion. Furthermore, they did not reference the time of year their primate observations were made. In conducting primate transects at Chaco Defensores National Park, Stallings *et al.* (1989) failed to record an observation of