

## Predator-prey interaction between two threatened species in a Brazilian hotspot

Gustavo Rodrigues Canale<sup>1,3</sup> & Christine Steiner São Bernardo<sup>2</sup>

<sup>1</sup>Universidade Federal de Mato Grosso, Instituto de Ciências Naturais, Humanas e Sociais, Núcleo de Estudos da Biodiversidade da Amazônia Mato-Grossense, Cuiabá, MT, Brazil.

<sup>2</sup>Universidade do Estado de Mato Grosso, Programa de pós-graduação em Ciências Ambientais, Cáceres, MT, Brazil.

<sup>3</sup>Corresponding author: Gustavo Rodrigues Canale, e-mail: [g.canale@cantab.net](mailto:g.canale@cantab.net)

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**Abstract:** Conflicts in conservation may arise if two or more threatened species are involved in prey-predator interaction. Predators may have a profound effect on small prey populations, thus conservation actions must consider inter-specific interactions involving threatened species. Here we report nest predation events on a wild population of the Endangered red-billed curassow *Crax blumenbachii* Spix, 1825 by a group of the Critically Endangered yellow-breasted capuchin monkeys *Sapajus xanthosternos* Wied-Neuwied, 1820 in the Brazilian Atlantic Forest. This is the first study to report egg predation of an threatened gamebird by an threatened primate. We recommend that systematic conservation planning for these threatened species consider interactions, especially considering upcoming reintroduction programs indicated in the National Action Plans for these species conservation.

**Keywords:** Atlantic Forest, coexistence, conservation, *Crax blumenbachii*, diet, *Sapajus xanthosternos*.

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**Resumo:** Conflitos em conservação podem ocorrer quando duas espécies ameaçadas são envolvidas em interações presa-predador. Predadores podem ter um profundo efeito sobre pequenas populações de presas, portanto ações de conservação devem considerar estas interações interespecíficas envolvendo espécies ameaçadas. Reportamos aqui a predação de ovos em uma população selvagem de mutum-do-sudeste *Crax blumenbachii* Spix, 1825 por um grupo monitorado de primatas criticamente ameaçados, macaco-pregodo-peito-amarelo *Sapajus xanthosternos* Wied-Neuwied 1820 na Mata Atlântica. Este é o primeiro estudo a reportar a predação de ovos de uma espécie ameaçada de ave cinegética por um primata também ameaçado de extinção. Recomendamos o planejamento conciliado de ações de conservação para ambas espécies ameaçadas, especialmente por os futuros programas de reintrodução indicados para as respectivas espécies em seus Planos de Ação Nacionais para a Conservação de Espécies Ameaçadas de Extinção.

**Palavras-chave:** Mata Atlântica, coexistência, conservação, *Crax blumenbachii*, dieta, *Sapajus xanthosternos*.

## Introduction

Species conservation action plans generally focus on ranking conservation priorities, and although the loss of one species may be dire, the loss of species interactions may be even more problematical (Soulé et al. 2003). Thus, conservation actions must also consider the interactions between species (e.g. predator-prey), especially when populations of both of them may be threatened. Researchers have reported conflicts in conservation, when predation influences population survival of threatened prey species (Chadès et al. 2012, Roemer & Wayne 2003, Verissimo et al. 2012), however, most interactions involving threatened species remain understudied.

The Atlantic Forest is currently one of the most fragmented and human-altered biodiversity hotspots (Ribeiro et al. 2009). Fragmentation and isolation of forest remnants might lead to mesopredator release due to the reduced density of populations of apex predators (Crooks & Soulé 1999). In the northern Atlantic Forest, local

extinction of top predators are widespread (Canale et al. 2012) and capuchin monkeys are one of the extant mesopredators known to prey on small vertebrates and bird eggs (Canale et al. 2013a).

Several researches report capuchin monkeys as one of the most important nest predators in the tropics (Fedigan 1990, Sieving 1992, Feeley and Terborgh 2008). Egg predation was observed for various species of capuchin monkeys, such as *Sapajus apella*, *Cebus capucinus*, *C. albifrons* and *C. olivaceus* (Janson and Boinski 1992, Riehl and Jara 2009). Moreover, studies with artificial nests have revealed high rates of egg predation in habitat islands harbouring capuchins (Terborgh et al 1997). In Costa Rica, *Cebus capucinus* are known to regularly search for nests during the nesting seasons, and to feed on eggs of many species of birds (Fedigan 1990). Here we report on the predation of eggs of a wild population of the Endangered red-billed curassow (*Crax blumenbachii*) by the Critically Endangered yellow-breasted capuchin monkey

(*Sapajus xanthosternos*). This rare predation event raises the need for strategic coupled conservation actions, such as nest monitoring, for both threatened species.

## Methods

### 1. Study site

The study was developed in Una Biological Reserve (UBR; 18,500 ha) one of the largest forest fragments legally protected in the range of *S. xanthosternos* and *C. blumenbachii* in the Atlantic Forest of southern Bahia (Figure 1). This region is considered a hotspot for biodiversity conservation within the Atlantic Forest hotspot (Martini et al. 2007, Laurance 2009). Annual temperature average 24 to 25°C, and rainfall is aseasonal, with about 2000 mm/year (Martini et al. 2007). UBR contains primary forest, secondary forest, swamps, and abandoned plantations.

### 2. Species

The original distribution of the yellow-breasted capuchin comprises Bahia, Sergipe and northern Minas Gerais, while the red-billed curassow is found in Bahia, Espírito Santo, eastern Minas Gerais and Rio de Janeiro (IBAMA 2004, Lernould et al. 2012). They are both endemic to a small portion of the Brazilian Atlantic Forest and threatened by hunting pressure, habitat loss and forest fragmentation (IBAMA 2004, Lernould et al. 2012). The overlapping area of their original distributions is restricted to a small region in Bahia (Figure 1).

### 3. Data collection

A group of 14 individuals of *S. xanthosternos* was monitored from September 2007 to December 2008 in UBR. Behavioural scan samples ( $n = 2,598$  scans) were collected every 15 minutes during 3-5 days a month (Altmann 1974). Capuchins were followed from dawn to dusk ( $n = 55$  full days), whenever we were not able to follow them a full-day, we completed sampling period in the

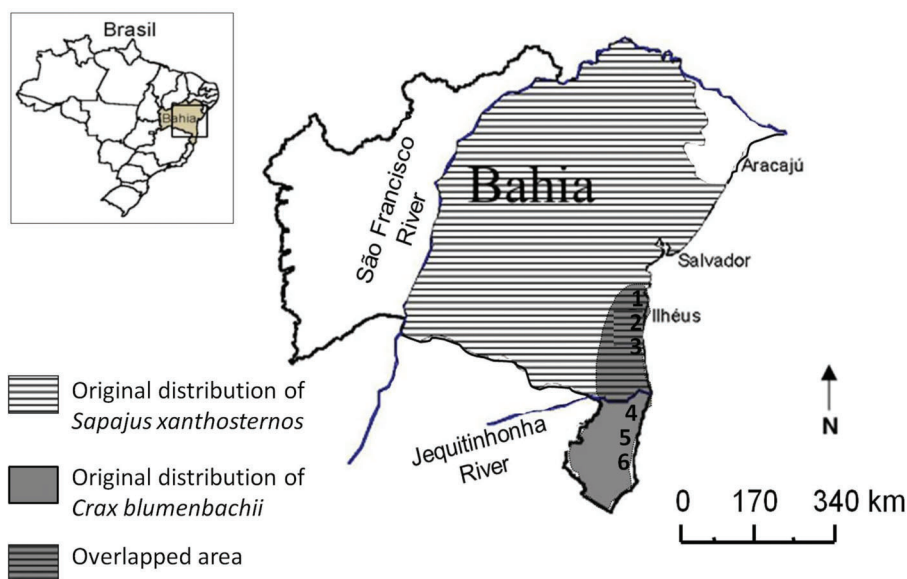
following day ( $n = 42$  half days). We collected data on two behaviours associated with food resources: *Feeding* (chewing, swallowing and bringing food to mouth with hands); and *Foraging* (search for food using hands or using teeth to break trunks and branches).

## Results

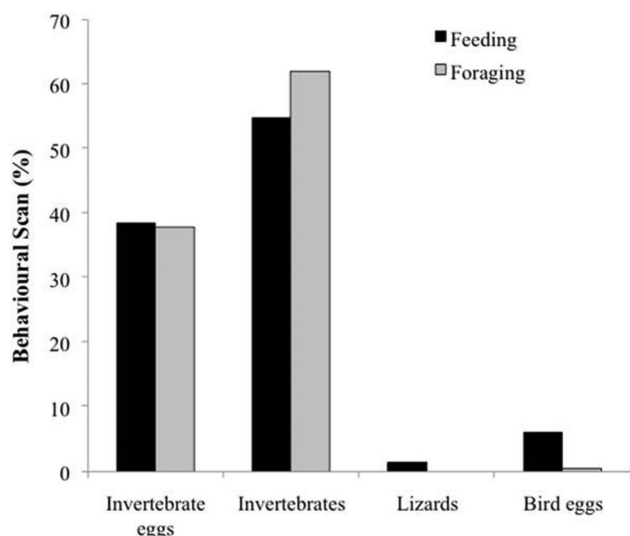
Fruits represented  $38.3 \pm 8.6\%$  of feeding events, whilst animal prey in the capuchin's diet averaged  $36 \pm 6.6\%$ , reaching up to 47% of total feeding events in January 2008. Capuchins fed on four animal items: invertebrate eggs, invertebrates, lizards and bird eggs (Figure 2); the latter summed 6% of total of 86 events of consumed animal items identified and recorded during scan samples.

During behavioural scan observation four sub-adult monkeys (two males and two females) were observed feeding on eggs of at least two bird species (*Crax blumenbachii* and non-identified Passeriformes), in five egg predation events. The nests of the non-identified birds were between 8 and 19 m height and all of them were located in the secondary forest. No additional information about nest description was collected (e.g. open cup, cavity) because nests were not completely visible to observers. An eggshell of another Cracidae, the rusty-margined guan (*Penelope superciliosus* Temminck, 1815) was also dropped by one capuchin monkey during the behavioural scan interval.

On 24/10/2007 at 15:03 h, GRC observed a sub-adult female capuchin approaching a red-billed curassow nest, which was located in a 10 m tall liana-covered tree in young secondary forest, estimated to be 10 to 30 years old (Faria et al. 2009). Both the cock and hen were adults ( $> 3$  years-old) and perched less than a metre from the nest. When the capuchins approached the nest, the male curassow glided to the ground, followed by the female. The capuchin fed on both eggs present in the nest and licked the eggshells until 15:22 h. No food-sharing was observed. Because the aim of the research was focused on monkey behaviour, specific nests were not being monitored.



**Figure 1.** Extent of overlap between the original distributions of the yellow-breasted capuchin (*Sapajus xanthosternos*) and the red billed curassow (*Crax blumenbachii*) within Bahia (Brazil). Areas from 1 to 3 represent the only areas where both species coexist nowadays (1 = Michelin Reserve, 2 = Serra do Conduru State Park, 3 = Una Biological Reserve, the study area). Areas from 4 to 6 represent the areas where the red-billed curassows still coexist with *S. robustus* in Bahia (4 = Pau Brasil National Park, 5 = Monte Pascoal National Park, 6 = Descobrimento State Park).



**Figure 2.** Animal prey in the diet of a *Sapajus xanthosternos* group during field observation in Una Biological Reserve at the northeastern Atlantic Forest, Brazil.

## Discussion

Few studies reporting egg predation by primates specifically identify the bird species predated (Janson & Boinski 1992, Estrada et al. 2002). Here we report for the first time the predation of eggs of the Endangered red-billed curassow by the Critically Endangered yellow-breasted capuchin in one of the most threatened biomes of the world, the Brazilian Atlantic Forest. Both species occur in very low densities in the wild (Bernardo et al. in prep), which makes this type of record even rarer. Curassows nests are very difficult to find in the wild and there are only few descriptive studies published (Sick 1970, Lima et al. 2008, Herrera et al. 2009, Toledo-Lima et al. 2013).

Although the predation of red-billed curassow eggs was recorded only once in UBR, we found a high frequency of bird egg predation by yellow-breasted capuchins (6%) in relation to other capuchins (0.6 – 2.3% of bird eggs and nestlings in animal prey) (Janson & Boinski 1992). Predation events are rarely recorded, and observing these events may be difficult even during intensive behavioural monitoring (Fedigan 1990). Thus, any information regarding this issue is useful to contribute to future investigations. The proportion of bird egg consumption alone may be too low to have an immediate impact on population size, but we must consider predation in a broad context (e.g. in synergy with habitat reduction, high hunting pressure) and not as an isolated event.

Generalist predators (mesopredators) may be more abundant in fragmented landscapes due to the extinction of apex predators (Crooks and Soulé 1999, Ritchie et al 2012). Capuchin monkeys are one of the most important mesopredators among the other Neotropical primates and may be superabundant in small forest fragments, especially when subsidized by exotic fruit species in the surrounding crop matrix (Michalski and Peres 2007). The overabundance of capuchins may depress populations of passerine birds as reported by birdwatchers in the Rio de Janeiro Botanical Garden and researchers in Tijuca National Park (Cunha et al 2006). Indeed, capuchins change foraging areas to those where birds nests are more likely to be found (Jason & Boinski 1992). Despite that populations of capuchins are reported to increase in small forest fragments, this is not the case for *S. xanthosternos* that is more

commonly seen in large blocks of forests, from where most of the apex predators have already been wiped out, and are often absent from small fragments (Chagas and Ferrari 2010, Canale et al 2012). Due to overhunting in the northeastern Atlantic Forest, the yellow-breasted capuchin and the red-billed curassow are currently restricted to large forest patches (IBAMA 2004, Canale et al 2012).

Predator-prey interactions are rarely included in species conservation planning because of unreported natural history data. Nest predation effects are sometimes difficult to assess at a local scale, but landscape-scale studies indicate the need to protect large blocks of continuous forests to reduce predation of bird eggs and support avian conservation plans (Stephens et al 2004). Due to the lack of a high number of large protected forests available to reintroduce threatened bird species, such as the red-billed curassow, there might be a careful selection of areas with preferably lower densities of nest predators, such as capuchin monkeys.

Our findings help to augment knowledge on two of the most threatened species in the Brazilian Atlantic Forest which remain poorly studied. Here, predator and prey are focus of conservation efforts by IUCN species specialist groups (SSG) and Brazilian environmental agencies. Among others, captive breeding programmes followed by the future reintroduction of animals into the wild are actions being considered (IBAMA 2004, Lernould et al. 2012). Predator-prey interactions such as nest predation by capuchin monkeys, however, are not explicitly considered in the action plans of both species. Thus, reintroductions of yellow-breasted capuchin monkeys should be planned synchronically with the presence of red-billed curassows and vice-versa. For instance, all three areas indicated for future reintroductions of red-billed curassows in Bahia (IBAMA 2004) harbour populations of yellow-breasted capuchins. Hence, we recommend that prey-predator interaction should be taken into account when assessing population viability of the red-billed curassow (e.g. using Vortex), and, during the monitoring and management of both threatened species (e.g. observation of nests of red-billed curassows).

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