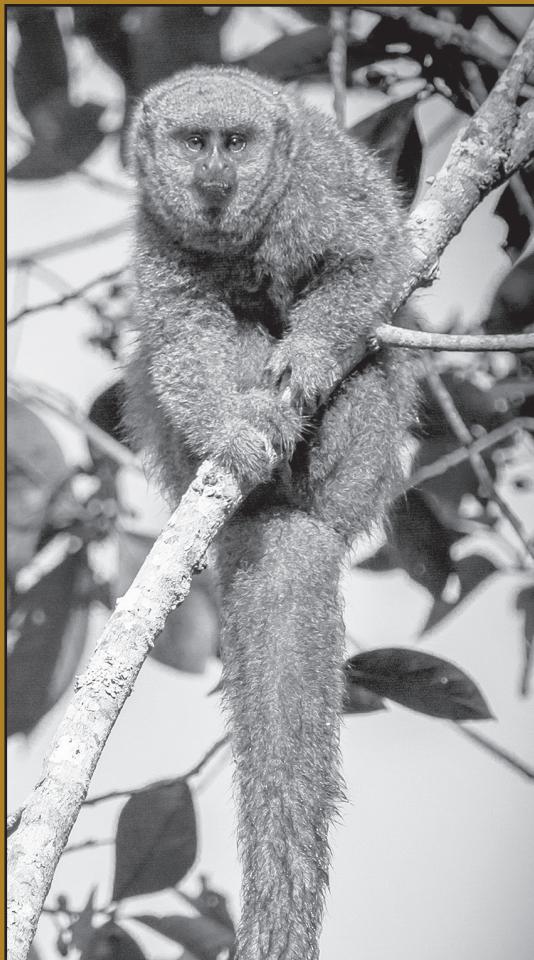


NEOTROPICAL PRIMATES



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Photo taken by Breno Dias Vitorino.

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ARTICLES

***CALLITHRIX AURITA*: A MARMOSET SPECIES ON ITS WAY TO EXTINCTION IN THE BRAZILIAN ATLANTIC FOREST**

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Abstract

The buffy-tufted-ear marmoset (*Callithrix aurita*) is a small primate endemic to the montane regions of the southeastern Atlantic Forest in Brazil. The species was formerly listed as “Vulnerable” (VU) on the Brazilian Official National List of Threatened Fauna Species, but in December 2014 it was re-classified as “Endangered” (EN) as a result of habitat loss, forest fragmentation and, especially, competition and hybridization with invasive marmosets (*Callithrix* spp.). This article gives an overview of the current conservation status of and field research on *C. aurita* that includes the objectives set forth by the *C. aurita* Conservation Project (spearheaded in December 2014 by a group of *C. aurita* researchers), and the related set of integrated conservation actions. These actions include expanded geographical surveys of *C. aurita* populations, improvements to a captive *C. aurita* breeding program, and the establishment of new protected areas as part of a *C. aurita* metapopulation management program. Despite these current efforts, however, the strengthening and consolidation of urgent conservation actions to protect the buffy-tufted-ear marmoset still depend on a variety of factors, including increased institutional collaboration and augmented financial support. Enhancing institutional and financial backing for *C. aurita* conservation will improve our understanding of the various challenges involved and, facilitate the rapid development of alternative strategies to mitigate ongoing threats to the species.

Keywords: Callitrichids, invasive species, buffy-tufted-ear marmoset, primate conservation

Resumo

O sagui-da-serra-escuro (*Callithrix aurita*) é um pequeno primata endêmico das regiões montanhosas da Floresta Atlântica do sudeste brasileiro. Essa espécie foi considerada “Vulnerável” (VU) na Lista Vermelha do Brasil, mas desde dezembro de 2014, ela foi reclassificada como “Em perigo” pela Lista Nacional de Espécies de Fauna Ameaçadas, como consequência da perda de habitat, da fragmentação florestal e, especialmente, da competição e hibridação com espécies de saguis invasores (*Callithrix* spp.). Este artigo oferece uma visão geral do estado de conservação atual do *C. aurita* e resume as últimas pesquisas publicadas sobre a espécie. Também são descritos os esforços recentes direcionados para a conservação do *C. aurita*, que incluem os objetivos estabelecidos pelo Projeto de Conservação do *C. aurita* (projeto lançado em dezembro de 2014 por um amplo grupo de pesquisadores de *C. aurita*), e um conjunto de ações integradas que estão sendo realizadas para sua conservação. Entre estas ações estão a ampliação dos levantamentos das populações de *C. aurita*, o aperfeiçoamento do programa de criação de *C. aurita* em cativeiro, e o estabelecimento de novas áreas protegidas para servir como parte de um programa de manejo da metapopulação de *C. aurita*. No entanto, apesar dos esforços atuais, o fortalecimento e a consolidação dessas ações urgentes de conservação para proteger o sagui-da-serra-escuro ainda dependem de uma variedade de fatores, como o aumento de colaborações institucionais e o aumento de apoio financeiro. Aumentar o apoio institucional e financeiro para a conservação de *C. aurita* melhorará decisivamente a nossa compreensão dos vários desafios à conservação do *C. aurita* e viabilizará o desenvolvimento rápido e efetivo de estratégias alternativas para mitigar as ameaças em curso à sobrevivência dessa espécie.

Palavras-chave: Calitriquídeos, espécies invasoras, sagui-da-serra-escuro, conservação de primatas

Introduction

The buffy-tufted-ear marmoset (*Callithrix aurita*, Figure 1) is a small callitrichid 500–580 mm in head-body length (Vivo, 1991) and 400–450 g (Garber, 1992) in weight. It is endemic to montane regions of the Atlantic Forest in the Brazilian states of Rio de Janeiro, São Paulo (northeastern part), and Minas Gerais (southeastern part) (Coimbra-Filho, 1991; Brandão and Develey, 1998; Melo *et al.*, 2015). The species was formerly listed as Vulnerable (VU) on the Official National List of Threatened Species (Melo and Rylands, 2008) and the IUCN Red List of Threatened Species (Rylands *et al.*, 2008), as well as the Rio de Janeiro state list (Bergallo *et al.*, 2000). In 2010, however, it was listed as Endangered (EN) in the state of Minas Gerais (Brazil, 2010). São Paulo state maintained it as Vulnerable until 2014 (Port-Carvalho and Kierulff, 2009), when it was also re-categorized as Endangered (Brazil, São Paulo, 2012). In December 2014, the species was classified as Endangered on the Brazilian national list (Brazil, MMA, 2014), and has been indicated for this category in the recent (2015) international reassessment of the IUCN Red List (IUCN SSC Primate Specialist Group, *in prep.*). The main reason for the reassessment was the inference of a population reduction of at least 50% over three generations (18 years) resulting from habitat loss, forest fragmentation, and, especially, competition and hybridization with invasive marmosets (*Callithrix* spp.).

In 1982, the Rio de Janeiro Primate Center (Centro de Primatologia do Rio de Janeiro – CPRJ) began a captive breeding program for the species due to concerns about its status in the wild (Coimbra-Filho, 1971, 1986, 1990). While there was rapid growth of the captive *C. aurita*

population at CPRJ, reaching 40 individuals, maintaining them was challenging due to the occurrence of progressive wasting syndrome in the animals, as well as mortality due to apparent leukemia. Proper nutrition of *C. aurita* was also problematic due to the species' specialized diet resulting from adaptations to high-altitude habitats. A further challenge was finding proper housing for *C. aurita*, as the marmosets were placed into enclosures formerly occupied by Amazonian species of *Mico* (formerly *Callithrix*) and *Saguinus*. These accommodations could have facilitated virus transmission to *C. aurita* and led to the aforementioned cases of leukemia.



Figure 1. Buffy-tufted-ear marmoset, *Callithrix aurita*. Photo credit: R. Carvalho.

Due to its threatened status, *C. aurita* was included in the *National Action Plan for the Conservation of the Central*

Atlantic Forest Mammals (Escarlate-Tavares *et al.*, 2016). Research efforts focusing on the ecology and genetics of *C. aurita* were increased following the recommendations of this action plan, revealing that the threatened status of *C. aurita* was more worrisome than previously thought, and further justifying the reassessment of its conservation status.

Threats to conservation of wild *C. aurita* populations

Recent ecological research has shown that *C. aurita* faces competition from invasive marmosets (Pereira, 2006, 2010; Rylands *et al.*, 2008; Melo and Rylands, 2008; Pereira *et al.*, 2008, 2014; Port-Carvalho and Kierulff, 2009; Nogueira *et al.*, 2011; Bechara, 2012; Carvalho *et al.*, 2013; Carvalho, 2015; Melo *et al.*, 2015; Nunes, 2015; Gonçalves, 2016), and genetic research also demonstrates hybridization between *C. aurita* and their introduced congeners (Pereira, 2010; Nogueira *et al.*, 2011; Carvalho *et al.*, 2013; Carvalho, 2015). The invasive presence of exotic marmosets within the natural range of *C. aurita* is the result of the legal and illegal pet trade within Brazil. The species involved are black-tufted ear marmosets (*Callithrix penicillata*), occurring in the Cerrado and Caatinga of Central Brazil, and, predominantly, common marmosets (*Callithrix jacchus*), otherwise native to Northeast Brazil (Rylands *et al.*, 2009; L. Oliveira, A. Pissinatti, pers. obs.).

The common destinations of exotic *C. jacchus* and *C. penicillata* have been the rural areas and urban centers of Rio de Janeiro, São Paulo and Minas Gerais (Oliveira and Grelle, 2012). Pet marmosets are subsequently released by their “owners,” and establish themselves in anthropogenically altered and disturbed habitats at forest-urban interfaces. They exhibit elevated adaptability to the highly-urbanized areas of Southeast Brazil and prosper; rapidly colonizing the native range of *C. aurita* throughout its range. This phenomenon is even observed in more preserved areas where native *C. aurita* are now commonly in contact with or close to these exotic populations of their congeners.

The growing invasion (here considered as the establishment of the breeding population of a non-native species with impacts on the local biodiversity) of exotic marmosets is rapidly affecting native populations of the buffy-tufted-ear marmoset. Indeed, groups of exotic and hybrid marmosets are physically replacing native *C. aurita* populations (Pereira, 2006, 2010; Bechara, 2012; Oliveira, 2012; Carvalho *et al.*, 2013; Carvalho, 2015; Melo *et al.*, 2015; Nunes, 2015). Besides physical replacement, hybridization undoubtedly affects the genetic integrity of pure *C. aurita* populations through genetic introgression. Genetic material from exotic *C. jacchus* and *C. penicillata* can ingress into the *C. aurita* genome through backcrossing of

hybrid marmosets with pure *C. aurita*, although previous studies have shown that *C. aurita* and *C. jacchus/C. penicillata* belong to two distinct subgroups within the genus (see discussion in Malukiewicz *et al.*, 2017). This introgression of exotic marmoset genetic material into *C. aurita* carries serious, unknown evolutionary and conservation consequences.

The speed and potential consequences of this invasive process that *C. aurita* faces is well exemplified by the situation in the Serra dos Órgãos National Park in Rio de Janeiro State. Five years of observations of two pure *C. aurita* groups in the park indicated no contact of these native groups with any invasive marmosets. However, field data and film from 2015 demonstrated, for the first time, the presence of exotic marmosets near the monitored native groups. Further, the replacement of one of the pure *C. aurita* groups by a mixed group of exotic and native species was also observed in 2015. These sorts of mixed group are a threat to genetic integrity of *C. aurita* as they facilitate hybridization, backcrossing, and introgression. A recent genetic study has also evidenced ongoing hybridization within the Serra dos Órgãos National Park (Carvalho, 2015). This situation in the Serra dos Órgãos National Park is emblematic of the invasive process that is happening in other parts of *C. aurita*’s native range (C. Knogge, W. Lacerda, R. Carvalho, L. Oliveira, D. Pereira, J. Malukiewicz, pers. obs.). *Callithrix aurita* also hybridizes naturally with its parapatric neighbors *C. flaviceps* (Ferrari and Mendes, 1991; Melo, 1999) and probably *C. geoffroyi* (in the basin of the Rio Santo Antônio), including some natural contact areas in the vicinity of Rio Doce State Park, Minas Gerais (Coimbra-Filho, 1971; Mendes, 1989; F. R. Melo, pers. obs.). These appear to be stable hybrid zones (Coimbra-Filho *et al.*, 1993).

One limitation for conservation actions is that for many parts of the native *C. aurita* distribution, such as São Paulo State, up-to-date information on the occurrence of remaining *C. aurita* populations and the effects of invasive marmosets on *C. aurita* is still scarce. Moreover, there is not enough field information to identify the critical and key remaining populations of *C. aurita* that could be targeted for conservation action to reverse the population decline and protect viable populations. There are still a number of pure *C. aurita* populations living, but forest destruction is a major threat to this species (Rylands *et al.*, 2008), and, consequently, remaining populations are frequently isolated in forest patches as small as 10 ha (R. Carvalho, pers. obs.) Such isolated populations may potentially suffer genetic, demographic and ecological problems of inbreeding, such as rare reproductive opportunities, limited food resources, and increased disease susceptibility (Keller and Waller, 2002). When close to human settlements, they also suffer from road kill and predation by dogs. These scenarios are frequently observed in several cities in São Paulo State,

including Mogi Guaçu, Mairiporá and Atibaia (M. Port-Carvalho, pers. comm.).

A conservation plan for *C. aurita* populations

The situation of *C. aurita* has now attracted the attention of a wider group of primatologists, conservationists and public agents, and has resulted in the preparation of a comprehensive conservation plan for the species. An inter-institutional meeting occurred on April 4, 2014, to prioritize urgent research and management measures for the conservation of *C. aurita*. It was held during the 1st Callitrichid Conservation Husbandry Workshop, sponsored by the Durrell Wildlife Conservation Trust, the National Center for Research and Conservation of Brazilian Primates (CPB) of the Instituto Chico Mendes de Conservação de Biodiversidade (ICMBio), and CPRJ. Institutions represented included ICMBio/CPB, CPRJ, UERJ (Universidade Estadual do Rio de Janeiro), Guarulhos Zoo, Sorocaba Zoo and Durrell. The group decided on the initial steps to establish the *Callithrix aurita* Conservation Project. Thereafter, eight other meetings were held at UERJ (July 31, 2014), Serra dos Órgãos National Park, (June 26, 2015) the São Paulo Forestry Institute (May 11, 2015; August 05, 2016), the Wildlife Department of the Environmental Secretary of São Paulo (June 10, 2016), during the XIV Brazilian Primatology Congress in Manaus (Nov 12, 2015), and at Guarulhos Zoo (October 21, 2015; March 03, 2016). They resulted in the prioritization of the following objectives: (1) to survey and determine areas of *C. aurita* occurrence under a standardized field protocol; (2) to enhance and expand a captive *C. aurita* breeding program; (3) to use field survey data to identify priority *C. aurita* conservation areas and establish protective refuges for wild *C. aurita* populations; (4) to create a specific decision tree for field work and management of introduced marmosets occurring inside *C. aurita*'s native range; and (5) to conduct the necessary scientific research to support an adaptive management plan for effective *C. aurita* conservation.

In March 2015, São Paulo State (SP) took the initiative of drafting its own conservation plan for *C. aurita*. The plan drafted by the Permanent Protection Committee of the Primates of the State of São Paulo (Brazil, São Paulo, 2014) embodied the general objectives above as well initiatives to: 1) develop a phenotypic identification key for *C. aurita* using published data and expertise of primate specialists; 2) elaborate an Action Plan for *C. aurita* conservation in São Paulo; 3) implement outreach and environmental education activities aimed at marmoset conservation; 4) implement management actions for *C. aurita* metapopulations *in situ*; 5) manage critical areas with introduced and/or hybrid marmoset populations; and 6) conduct research on *C. aurita* genetic diversity and hybridization with exotic congeners.

Current conservation actions to preserve remaining *C. aurita* populations

The first actions of the collaborative initiative for the *C. aurita* Conservation Project have started to be implemented, mainly through surveys to assess the species' current distribution and conservation threats. These surveys have been carried out since October 2015 by the NGO Muriqui Biodiversity Institute, the Environmental Secretariat of São Paulo, the research team and managers of the Serra dos Órgãos National Park, and the NGOs Instituto Bioma (Rio de Janeiro) and PREA (Minas Gerais). They have received the support of ICMBio, and three international institutions—Beauval Nature, Association Française des Parcs Zoologiques and the Margot Marsh Biodiversity Foundation. Another important initiative is a legislative proposal by the state of São Paulo, which has been under consideration by the office of the state's Environmental Secretary since 2016 to establish reproductive restrictions for allochthonous *Callithrix* legally held in captivity within São Paulo, in order to reduce surplus, legally-captive marmosets and reduce undue releases of exotic *Callithrix* into the wild.

Another important measure was the creation of a studbook for the captive population; a result of the 2nd Callitrichid Conservation Management Workshop, held in Manaus, in November 2015, and with the help of the Golden Lion Tamarin International Studbook keeper, Dr. Jennifer Mickelberg of Zoo Atlanta. There are very few currently in captivity; recent counting showed only about 33 (Studbook Keeper, C. Igayara, pers. comm.), and it is imperative that the growth of this small population is managed in such a way that its genetic diversity is maximized.

Preserving the diversity of *C. aurita* is especially important because wild *C. aurita* face a continued influx of invading marmoset species from the ongoing illegal wildlife trade, as well as from hybrid marmoset populations established in the surroundings areas (Moraes *et al.*, 2008). The ubiquitousness of introduced and hybrid marmosets is flagrant and widespread throughout the state of Rio de Janeiro, and the captive *C. aurita* population could be an important reservoir to ensure the species' survival and its reintroduction back into the wild.

Genetic and genomic studies have begun in order to assess levels of biodiversity with *C. aurita*. Carvalho (2015) conducted one of the first genetic studies of *C. aurita* that included individuals from within São Paulo and Rio de Janeiro states. Using the mitochondrial (mtDNA) cytochrome oxidase I (COI) locus, the genetic data showed 3 distinct haplotypes among 11 *C. aurita* genetic sequences. The *C. aurita* COI haplotypes had an average genetic p-distance of 5% in comparison to the COI haplotypes of *C. jacchus*, *C. penicillata*, *C. geoffroyi* and *C. kuhlii*, and, also formed

a sister clade with that of the latter set of species. Currently, a project is underway to assess genetic diversity of *C. aurita* over the entire mtDNA genome. Further, plans are being formulated to create a draft version of the nuclear *C. aurita* genome, and study introgression of *C. jacchus* and *C. penicillata* genomes into that of *C. aurita* (J. Malukiewicz and R. Carvalho, pers. comm.). Such genomic data will be important for future considerations of creating areas to preserve wild *C. aurita* populations and translocation of any such populations.

New reserves are being created and proposed in the states of São Paulo and Rio de Janeiro that we expect will benefit *C. aurita*. A new protected area is in the final stages of implementation in the Itapeti mountain range (1,763.45 ha) covering parts of the municipalities of Mogi das Cruzes, Guararema and Suzano (Brazil, São Paulo, Secretário do Meio Ambiente, 2017). An area adjoining the Ecological Station of Mogi Guaçu is being considered for a change in status from an experimental station to a state forest to extend the total protected area from 1,300 to 4,000 ha. This change would join together a mosaic of conservation units with the biological reserve administered by the Botanical Institute (in São Paulo), which is composed of over 470 hectares of a region formally called the Campininha farm (Barreto and Cabello de Brito, 2015). In Rio de Janeiro, the municipal government of Nova Friburgo is fast-tracking the creation of a local reserve for *C. aurita* with the support of the municipality's residents.

Conclusion and future outlook

Continued implementation of the objectives and actions of the *C. aurita* Conservation Project, as suggested and planned by the scientific community, requires direct participation of the personnel working in protected areas that have populations of *C. aurita*. Managers of these protected areas will be responsible for the implementation of scientific conservation measures. The supporting staff to whom this conservation work will subsequently be delegated possess indispensable experience and knowledge of the local flora and fauna. Thus, early and ongoing involvement of both managers and staff in the *C. aurita* Conservation Project is crucial to the project's success. Such participation is already happening at the Serra dos Órgãos National Park, the Mananciais do Rio Paraíba do Sul Environmental Protection Area, and protected areas in the urban district of São Paulo. There are many small populations of *C. aurita* on privately-owned land, which must also be integrated into the management plan by the willingness of landowners to transform this land into conservation units such as Brazilian Private Natural Heritage Reserves.

A crucial challenge to overcome is deciding control measures for invasive marmoset species that threaten *C. aurita*,

in the face of the diverse opinions of the different stakeholders involved (scientists, NGOs, park managers, general public). Acceptance among stakeholders is essential for a set of effective management actions, as this agreement may give greater support to implement the actions. Even though there is a set of agreed upon principles to deal with the threat of invasive species towards conservation units, published in the national action plan (Escarlate-Tavares *et al.*, 2016), a decision stalemate exists as to the destination of marmosets that are captured, and this has been a major obstacle, because it has led to a lack of action and the permanence of introduced marmosets. These issues were recently broached at the "Integrative Actions for the Conservation of the Buffy-Tufted-Ear Marmoset and Resolving Threats from Invasive Congeners: Proposals and Alternatives" workshop, held at the Serra dos Órgãos National Park (June 26, 2015). This workshop highlighted the importance of implementing conservation strategies that draw from both scientific and applied expertise in order to achieve the conservation of *C. aurita*.

Besides the scientific and environmental communities, the general public will also play an indispensable role in the conservation of *C. aurita*. For example, we have received important records of the occurrence of *C. aurita* and introduced marmosets from the general public via social media, cell phone applications, and birdwatchers. Such information highlights the notion that efficient communication with the general public and the involvement of citizen-science strategies is an important conservation tool. Furthermore, all conservation measures taken by scientists, NGOs, public officials, and parks managers/staff are important for environmental education about *C. aurita* and the threats this species faces. Accordingly, one future priority of the *C. aurita* Conservation Plan will be to amplify our outreach efforts to educate and communicate with the public.

Of the many important issues that were highlighted at the XVI Brazilian Congress of Primatology, one has deserved special attention: the recent alarming indications that wild *Callithrix aurita* may be on an irreversible path to extinction. This issue raised concern that *C. aurita* is among the Neotropical primates at highest risk, particularly due to impacts from congeneric species. As such, urgent conservation actions to protect the buffy-tufted-ear marmoset must be implemented by better analyzing the various scenarios that threaten *C. aurita* conservation and by rapidly developing alternatives to mitigate ongoing threats to the species.

Special attention must also be given to licensing procedures involving urban development and construction ventures throughout the geographical distribution of *C. aurita*, especially in the larger municipalities of São Paulo and Rio de Janeiro. Licensing procedures include environmental

impact studies to investigate the possible occurrence of threatened species within forest fragments slated for development. Improper identification of threatened species under environmental licensing can lead to the mismanagement of both species conservation and legal requirements to offset the environmental impact of development. In addition to conservation measures and mitigation proposals in the areas of occurrence of the species, *in situ* information on ecology and behavior are needed for sound decision-making in licensing procedures to authorize major construction and development operations.

Current systematic surveys to identify regions with pure *C. aurita* populations, hybrid groups and invasive *Callithrix* spp., have already begun in some parts of the species' range (Pereira, 2010; Lacerda *et al.*, 2015; Melo *et al.*, 2015; Nunes, 2015), along with studies of ecology, population density, population genetics, and conservation medicine. Such work will make it possible to accurately evaluate the best strategies and chances for the species' recovery and survival. The first steps of raising awareness for *C. aurita*'s plight and mobilization of a conservation plan have been laid out, but our future conservation efforts will require partnerships with other researchers and institutions in order to synergize efforts to face the various challenges of saving *C. aurita* as an evolutionarily and ecologically unique Neotropical primate.

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ANÁLISE DA VIABILIDADE POPULACIONAL DE BUGIOS-RUIVOS *ALOUATTA GUARIBA CLAMITANS* (CABRERA, 1940), EM UMA PAISAGEM FRAGMENTADA NO SUDESTE DO BRASIL

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Resumo

Estudos de análise de viabilidade populacional em áreas sujeitas a fortes pressões antrópicas são de grande importância para a conservação, auxiliando no manejo focado em fatores que ameaçam as populações. Os objetivos deste estudo foram: (1) obter a probabilidade de extinção em 100 anos de populações de bugios-ruivos (*Alouatta guariba clamitans*) em fragmentos de Mata Atlântica, (2) identificar o tamanho populacional mínimo viável (PMV) e (3) a área mínima dos remanescentes para manter a PMV. Entre agosto de 2014 e julho de 2015, foram percorridas trilhas, das 8h às 17h, em 21 fragmentos florestais remanescentes, utilizando-se o levantamento extensivo, totalizando um esforço amostral de 84 dias de campo (672 horas). A presença do bugio foi confirmada em 12 fragmentos. Foram simulados cenários com migração entre fragmentos distantes até 50 m entre si e sem migração acima dessa distância, por meio de 1,000 iterações no VORTEX v. 10.1. Foram considerados diferentes tipos e frequências de catástrofes, como fragmentação (de 1 a 3% ao ano), eletrocussão (0-1%), ataque de cães domésticos (0-1%), atropelamento (0-0.5%) e caça (0-1%). Foi obtida uma probabilidade de extinção menor do que 10% para 50% (n = 6) dos remanescentes, configurando um sistema metapopulacional. Os resultados sugerem que é essencial um manejo que garanta a conectividade e a proteção dos fragmentos contra catástrofes. Se as taxas dessas perturbações, como a fragmentação não aumentarem, pode-se esperar uma relativa estabilidade da metapopulação de bugios na região, com exceção de um remanescente isolado, de 37 ha, no qual a probabilidade de extinção atingiu 89%. Particularmente, para esse fragmento, o reforço populacional ou a translocação dos indivíduos é necessária, uma vez que a extinção dessa população é iminente.

Palavras-chave: *Alouatta*, AVP, modelagem, população mínima viável, VORTEX.

Abstract

Analyses of population viability in areas under strong anthropic pressures are of great value to conservation, assisting in the management focused on factors that harm the populations. The aims of this study were: (1) obtain the extinction probability, in 100 years, for populations of brown howler monkeys (*Alouatta guariba clamitans*) inhabiting remnants of Atlantic Rainforest in Taubaté, Southeast Brazil, (2) identify the minimum viable population size (MVP), and (3) the minimum dynamic area (MDA). Between August 2014 and July 2015, from 8 h until 17 h, we carried out broad surveys in 21 forest fragments, totalizing 84 field days (672 hours) of sampling effort. The presence of brown howler monkeys was confirmed in 12 fragments. Using the software Vortex v.10.1, through 1,000 iterations, we then simulated scenarios considering the existence of migration between fragments distant up to 50 m from each other, and no migration above this distance. We considered different types and frequencies of catastrophes: fragmentation (1 to 3% per year), electrocution (0 to 1%), attacks by domestic dogs (0 to 1%), running over (0 to 0.5%), and hunting (0 to 1%). We obtained a probability of extinction smaller than 10% for 50% (n = 6) of the forest remnants, configuring a metapopulation system. The results suggest that is essential ensuring connectivity and protection the fragments against catastrophes. If the rate of disorders, such as fragmentation, doesn't increase, we can expect a relative stability of the brown howler monkeys metapopulation in the region. The exception is the local population inhabiting an isolated fragment of 37 ha, for which the extinction seems to be imminent (89% of probability), unless some management measure (assuring population reinforcement) is taken.

Keywords: *Alouatta*, PVA, modeling, minimum viable population, VORTEX.

Introdução

O tamanho populacional é o resultado de fatores extrínsecos naturais, como predação, competição e doenças e fatores intrínsecos, como fecundidade, mortalidade e migração, os quais ajudam a determinar a tendência de longo prazo da dinâmica populacional (Hernández-Pacheco *et al.*, 2013). No entanto, fatores antrópicos como a fragmentação afetam negativamente a dinâmica populacional das espécies, ao alterar a configuração da paisagem, tanto pela diminuição do tamanho dos remanescentes como pelo aumento do grau de isolamento entre manchas (Dias *et al.*, 2015; Arroyo-Rodríguez *et al.*, 2017). Algumas espécies de primatas encontram dificuldades em deslocar-se por matrizes homogêneas e pouco permeáveis ou por matrizes heterogêneas compostas por um mosaico de fragmentos pouco favoráveis (Arroyo-Rodríguez *et al.*, 2014; Silva *et al.*, 2017). A diminuição de áreas nativas faz com que as populações de primatas concentrem-se em áreas pequenas, nas quais o tamanho é frequentemente um fator limitante para sua sobrevivência (Ordóñez-Gómez *et al.*, 2015; Arroyo-Rodríguez *et al.*, 2017). Em paisagens fragmentadas, observa-se uma relação entre a redução de habitat e a diminuição da probabilidade de dispersão entre remanescentes (Da Silva *et al.*, 2015). O isolamento reduz o fluxo gênico e aumenta o grau de parentesco entre indivíduos residentes de uma mesma mancha, tornando a população suscetível à extinção devido à endogamia (De Vleeschouwer e Raboy, 2013; Puig-Lagunes *et al.*, 2016).

No entanto, não raramente em paisagens fragmentadas as espécies estabelecem-se em sistemas metapoplacionais nos quais embora as populações vivam em manchas distintas, interagem entre si, por meio de eventos de migração (Arroyo-Rodríguez *et al.*, 2017). A partir desse contexto, a Análise de Viabilidade Populacional (AVP), surge como uma valiosa abordagem analítica para propor recomendações de gestão, a fim de aumentar a persistência das populações de primatas (Volampeno *et al.*, 2015). Por meio da análise de viabilidade, é possível avaliar o efeito de diferentes variáveis em populações pequenas e contribuir no estabelecimento de estratégias que reduzem a chance de extinção de uma dada população (Da Silva *et al.*, 2016).

A utilização da AVP em estudos com primatas tem explorado diferentes abordagens. Em particular, o efeito dos parâmetros demográficos sobre o crescimento da população tem sido usado como um índice, para avaliar a importância de certas fases da vida para a conservação. Em um estudo no México, utilizou-se a AVP para obter a contribuição de parâmetros demográficos no crescimento de populações de *Alouatta palliata mexicana* e para comparar a probabilidade de extinção local da espécie em dois cenários, um de populações isoladas e outro metapoplacional (Mandujano e Escobedo-Morales, 2008). Na Costa Rica, a AVP também foi utilizada para comparar populações de *A. palliata* em

cenários com metapopulações e populações isoladas (Rodríguez-Matamoros *et al.* 2012). Na Argentina, um estudo de AVP buscou examinar o impacto da febre amarela como uma catástrofe que afeta *A. guariba clamitans* (Agostini *et al.*, 2013). Já no Brasil, a maioria das análises de viabilidade em primatas foram realizadas com o mico-leão-dourado (*Leontopithecus rosalia*) (Paglia, 2003) e com o muriqui-do-norte (*Brachyteles hypoxanthus*) (Strier e Ives, 2012).

O bugio-ruivo, *Alouatta guariba clamitans*, é um primata arbócola, endêmico da Mata Atlântica e de ampla distribuição, sendo encontrado desde o sul da Bahia até o Rio Grande do Sul (Bicca-Marques *et al.*, 2015). Devido a sua alimentação frugívora-folívora, a pequena área de vida e a capacidade de explorar a matriz, suas populações têm persistido em fragmentos de tamanho reduzido, nos quais outras espécies de primatas não conseguem sobreviver (Arroyo-Rodríguez e Dias, 2009; Silva *et al.*, 2017). Apesar dos bugios serem citados como táxons relativamente tolerantes à perda e fragmentação das florestas tropicais, estes têm se tornado localmente extintos em diversas paisagens fragmentadas, o que ressalta a influência negativa da perda de habitat sobre suas populações (Puig-Lagunes *et al.*, 2016).

Atualmente, *A. guariba clamitans*, na classificação nacional encontra-se vulnerável (VU) (Portaria MMA nº 444, 2014) e ameaçada para o estado de São Paulo (São Paulo/Decreto nº 60.133, 2014). Esse cenário faz com que sejam urgentes ações de conservação, que forneçam informações sobre o atual estado das populações, e as principais ameaças as quais a espécie está sujeita (Agostini *et al.*, 2013).

Este estudo teve por objetivo geral produzir estimativas de probabilidade de persistência de populações de bugios-ruivos em remanescentes florestais em Taubaté, SP. Os objetivos específicos foram: (1) Estimar as chances de persistência dessas populações; (2) Identificar o tamanho populacional mínimo viável (PMV) para a manutenção da espécie nos diferentes fragmentos; (3) Estimar a área mínima dos remanescentes para manter a PMV. A principal hipótese testada neste estudo foi que fragmentos pequenos e/ou isolados não apresentam populações mínimas viáveis e estas devem apresentar baixa probabilidade de persistência para os próximos 100 anos.

Material e métodos

Área de estudo

O trabalho de campo foi conduzido em 21 fragmentos de Mata Atlântica, localizados no município de Taubaté (23° 01' 30" S e 45° 33' 31" W), Vale do Paraíba, SP (Fig. 1). A região apresenta temperatura média de 22°C e 1,335 mm de precipitação anual, tendo duas estações bem definidas: uma chuvosa que corresponde ao verão e outra seca que corresponde ao inverno (Fisch, 1995).

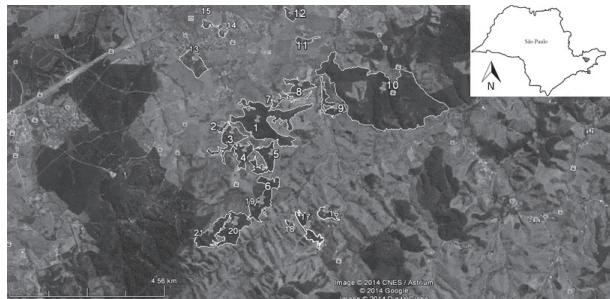


Figura 1. Localização de Taubaté em relação ao estado de São Paulo. Em destaque os remanescentes amostrados. Fonte: Google Earth, 2014

Planejamento da amostragem

As amostragens foram realizadas entre agosto de 2014 e julho de 2015, nos quais, foram percorridas trilhas das 8 às 12 h e das 13 às 17 h, utilizando-se o método do levantamento extensivo (*broad surveys*) (NRC, 1981). Esse método assim como a transecção linear busca amostrar todo o remanescente, mas diferencia-se do anterior por possibilitar ao observador sair das trilhas durante a amostragem, caso julgue necessário. O levantamento extensivo é ideal para amostrar grandes áreas geográficas em um curto período de tempo. As observações são realizadas frequentemente em trilhas pré-existentes ou estradas, sendo possível obter a distribuição de uma espécie ao longo da paisagem, a abundância relativa em diferentes áreas e informações básicas sobre a composição e a idade das populações (NRC 1981; Fortes, 2008; Silva *et al.*, 2017).

O número de visitas dependeu do tamanho do fragmento, de modo que, remanescentes com até 11 ha foram amostrados em 3 dias, os de tamanho entre 12 e 35 ha em 4 dias, e os maiores que 35 ha em 5 dias. O número de trilhas percorridas por fragmento variou de 3 a 10, com um tamanho médio de 1 km por trilha. O esforço amostral por área também variou de acordo com o tamanho do remanescente, de 30 km a 80 km percorridos em cada mancha. Ao todo foram 84 dias de campo, 7 por mês e um esforço de 672 horas em campo. Para a etapa inicial, de presença/ausência da espécie, esta foi considerada presente no fragmento quando houve registro direto (visual ou auditivo) ou indireto (fezes). Quando a presença da espécie foi confirmada em um remanescente, a etapa seguinte foi a de levantamento populacional, na qual a cada avistamento era anotado o número de indivíduos e sua classificação sexo-e-tária segundo Mendes (1989).

Para caracterizar a paisagem foram consideradas como métricas a área do remanescente e o grau de isolamento. Foram selecionadas estas duas métricas após um estudo prévio realizado na região. Apesar desse estudo ter encontrado relação apenas entre a presença do bugio-ruivo com a área do fragmento (Regressão logística múltipla; $\chi^2 = 1.16$; $P = 0.00$; $N = 21$) e não ter obtido relação entre a ocupação

dos remanescentes com outras métricas da paisagem, tais como índice de forma e grau de isolamento (Silva *et al.*, 2017) optamos por manter essa última métrica neste estudo. Como eram necessárias informações sobre a possibilidade de migração de indivíduos entre manchas para executar as análises de viabilidade, utilizou-se o fragmento mais próximo (DFP) como métrica representativa do grau de isolamento. As análises da paisagem foram realizadas no software ArcGIS 9.3 (ESRI, 2008).

Foram realizadas análises de viabilidade populacional para as populações de cada uma das manchas. A população foi considerada extinta quando restavam indivíduos de apenas um sexo sem possibilidade de migração. O tamanho inicial da população foi estabelecido a partir do cálculo de abundância (número de indivíduos avistados/10 km percorridos) para cada remanescente. Já à capacidade suporte foi considerada como um pouco mais do que o dobro da população inicial (Agostini *et al.*, 2013). Quanto à depressão por endogamia (número de equivalentes letais), o valor médio citado na literatura para populações de mamíferos em cativeiro é de 3.14 equivalentes letais (LE) (Ralls *et al.*, 1988). No entanto, as populações selvagens que vivem em ambientes potencialmente mais hostis, são mais vulneráveis à endogamia do que as populações cativas. Assim, o impacto de endogamia para este estudo foi modelado como 6 equivalentes letais sobre a mortalidade juvenil, com 50% do efeito devido a alelos recessivos letais (O'Grady *et al.*, 2006).

A população de bugios foi modelada por um período de 100 anos (cerca de 15 gerações) para que as tendências populacionais de longo prazo pudessem ser observadas (Agostini *et al.*, 2013). A fim de obter um cenário mais completo da simulação da população foram realizadas 1,000 repetições no programa VORTEX v. 10.1 (Lacy e Pollak, 2015). Parte dos parâmetros utilizados para gerar os modelos foram retirados de Agostini *et al.* (2013). Os demais parâmetros foram obtidos de estimativas geradas a partir dos dados de Silva (2013) e dos dados coletados em campo (Tabela 1).

Para obter a viabilidade da metapopulação foi simulado um modelo com todos os fragmentos em um cenário com migração a uma taxa de 1%/número de remanescentes ao ano, entre fragmentos distantes até 50 m e sem migração acima dessa distância. O valor de 50 m foi estabelecido a partir das distâncias máximas de deslocamento observadas ($n = 3$) em campo na região. Apesar de haver registros na literatura para *Alouatta* spp. de 656 m (Mandujano *et al.*, 2004), sabe-se que a distância de deslocamento terrestre é bastante variável entre populações e dependente da configuração espacial dos remanescentes. Como para a região, temos 7 anos de monitoramento e nenhum registro de deslocamento terrestre acima dos 50 m optamos por manter essa distância.

Tabela 1. Valores utilizados nas análises de viabilidade. *Valores retirados de Agostini *et al.* (2013); ** Valores calculados a partir dos dados de Silva (2013); *** Valores obtidos das observações em campo.

Parâmetros	Valores
Número de Iterações	1,000
Número de anos	100
Duração de cada ano (em dias)	365
Número de populações	12
Definição de extinção	Resta somente 1 sexo
Depressão por endogamia (Número de equivalentes letais)*	6
Efeito de endogamia devido a alelos recessivos letais (%)*	50
Sistema de cruzamento*	Poligínica
Idade da primeira reprodução para fêmeas (anos)*	5
Idade da primeira reprodução para machos (anos)*	6
Idade máxima de reprodução para fêmeas e machos (anos)*	16
Idade máxima (em vida livre)*	16
Número máximo de reprodução por ano*	1
Número de prole por reprodução*	1
Proporção sexual no nascimento*	1:1
Fêmeas adultas reprodutivas no grupo (%)***	Varia para cada fragmento
Taxa de mortalidade nos primeiros quatro anos de vida (%)**	Varia para cada fragmento
Probabilidade de catástrofes/ano tipo I: Fragmentação (%)**	Varia para cada fragmento
Probabilidade de catástrofes/ano tipo II: Eletrocussão (%)**	Varia para cada fragmento
Probabilidade de catástrofes/ano tipo III: Ataque de cães (%)**	Varia para cada fragmento
Probabilidade de catástrofes/ano tipo IV: Atropelamento (%)**	Varia para cada fragmento
Monopolização de cópulas por parte dos machos (%)*	100
Tamanho inicial da população***	5 a 40
Capacidade suporte (K)	15 a 100
Probabilidade de mudança na capacidade suporte em 10 anos (%)**	-5
Caça***	Não
Simulação de reforço genético por translocação de indivíduos	Não

Resultados

Dos 21 fragmentos amostrados, o bugio-ruivo esteve presente em 57.14% ($n = 12$) dos remanescentes. A espécie

ocupou fragmentos com tamanho médio de 73.5 ha (6.9 ha a 460 ha) e as distâncias do fragmento mais próximo variaram entre 10 e 1,000 m (Tabela 2).

Tabela 2. Métricas da paisagem e distância total percorrida em cada fragmento cuja presença dos bugios foi confirmada ($N = 12$).

Fragmento	Tamanho do fragmento (ha)	Distância do fragmento mais próximo (m)	Distância percorrida (km)
1	140	26	80
2	6.9	11	30
3	36.4	12	60
4	26.1	15	50
5	38	15	60
6	14.3	36	40
8	22.9	22	48
10	460	42	80
13	37	1,000	55

Fragmento	Tamanho do fragmento (ha)	Distância do fragmento mais próximo (m)	Distância percorrida (km)
19	33	10	55
20	52	10	68
21	37.2	12	60

As probabilidades de extinção em 100 anos para as doze populações simuladas variaram de <0.01 % a 89 %, e a taxa de crescimento populacional, de 0.011 a 0.53. A probabilidade de extinção foi menor do que 10 % para 50 % ($n=6$) dos fragmentos. O remanescente 10 foi o que apresentou menor probabilidade de extinção, e uma população final estimada de 75 ± 2 indivíduos. Em contrapartida, o fragmento

13 apresentou a maior probabilidade média de extinção, estimando-se que a população diminua de 19 para 2 indivíduos em 100 anos. O fragmento 19 foi o segundo com maior probabilidade média de extinção, de 53 %, seguido dos remanescentes 20 e 21, com 49 % e 47 % de chance das populações se extinguirem, respectivamente (Tabela 3).

Tabela 3. Resultado das 1,000 iterações para as populações de bugios na região.

Fragmento	Taxa de crescimento populacional (r)	Probabilidade de extinção (PE)	Tamanho inicial da população (N)	Tamanho final esperado da população (N)
1	0.085	<0.01	23	47 ± 5
2	0.13	0.29	8	7 ± 4
3	0.14	0.03	12	14 ± 3
4	0.14	0.01	19	20 ± 2
5	0.15	0.04	17	14 ± 3
6	0.081	0.13	12	12 ± 5
8	0.11	0.04	13	14 ± 3
10	0.15	<0.0001	13	75 ± 2
13	0.011	0.89	19	2 ± 2
19	0.063	0.53	14	7 ± 6
20	0.53	0.49	12	9 ± 8
21	0.33	0.47	13	14 ± 13

A capacidade suporte estimada variou de 20 a 80 indivíduos/fragmento. A maioria das populações locais nesta simulação apresentou um breve crescimento inicial seguido de declínio, porém evidenciando uma tendência ao equilíbrio em longo prazo no contexto metapopulacional simulado. Poucas delas mostraram tendência a um declínio gradual, com o passar do tempo, e apenas uma (no maior fragmento) apresentou tendência de crescimento até atingir um tamanho estável (Fig. 2).

Os resultados das 1,000 repetições para os doze fragmentos sugerem que a população mínima viável (PMV) para a região estudada, em um período de 100 anos, é de cerca de 140 indivíduos, desde que haja migração entre os fragmentos e, catástrofes não previstas no modelo, como epidemias, não acometam os animais. A PMV por fragmento, quando há migração de bugios entre as manchas, é de 12 ± 2 indivíduos, na qual a probabilidade de extinção é inferior a 10 %, em um intervalo de 100 anos. A área mínima viável é 18 ± 3 ha por fragmento, novamente quando há deslocamento de indivíduos entre os remanescentes.

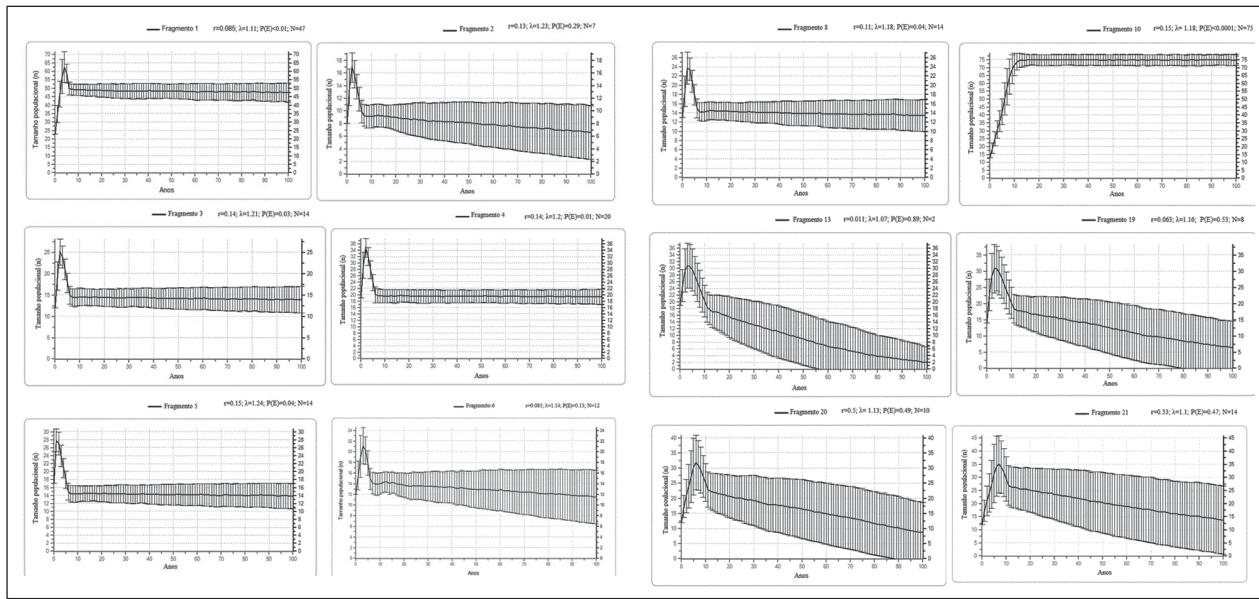


Figura 2. Análise de viabilidade para as populações dos 12 remanescentes. A curva mostra o tamanho populacional esperado (média ± desvio padrão) em um intervalo de 100 anos. Legenda: r: taxa de crescimento populacional; lambda (λ): taxa de crescimento determinístico; P(E): probabilidade de extinção; N: tamanho esperado da população em 100 anos.

Discussão

A baixa probabilidade de extinção para a maior parte das populações de bugios deste estudo (<10 % para 6 populações), por um lado, poderia ser considerado um bom indicativo para a conservação da espécie na região. A ausência de efeitos marcantes do isolamento dos fragmentos sobre as populações locais indica que a configuração da paisagem e possivelmente a permeabilidade da matriz não oferecem limitações severas à dispersão, configurando um sistema metapopulacional (Silva *et al.*, 2017). Por outro lado, o gênero *Alouatta* é relativamente resistente às fases iniciais da fragmentação, beneficiando-se da falta de grandes predadores e da proliferação da vegetação secundária, de modo que a resposta temporal do gênero às modificações ambientais pode ser lenta (Arroyo-Rodríguez e Dias, 2009; Arroyo-Rodríguez *et al.*, 2017). Em um estudo populações de *A. caraya* mantiveram-se estáveis, tanto em número de indivíduos, quanto em densidade ao longo de 22 anos de fragmentação e retirada de madeira (Zunino *et al.*, 2007).

Embora haja uma tendência das simulações apresentarem probabilidade de extinção associada ao tamanho inicial das populações, a extinção esteve mais relacionada à conectividade dos remanescentes do que ao tamanho populacional inicial. O que sugere que fragmentos isolados não conseguem manter populações mínimas viáveis corroborando com nossa hipótese. Uma das explicações é que à medida que o tamanho populacional diminui e o isolamento aumenta, surgem novas ameaças (catástrofes) que comprometem a estabilidade e a persistência das populações (Volampeno *et al.*, 2015; Silva *et al.*, 2017). Catástrofes são eventos raros e difíceis de serem observados que, no entanto, comprometem a sobrevivência das populações (Agostini *et al.*, 2013). Como exemplo, a ocorrência de epidemias

de febre amarela tem sido apontada como uma das principais ameaças para a conservação dos bugios (Moreno *et al.*, 2015; Oklander *et al.*, 2017). Em um estudo de AVP na Argentina, com *A. guariba clamitans* simulações mostraram que se a febre amarela tivesse uma probabilidade de ocorrência de 6 % ao ano, o efeito nas populações seria grave, matando até 80 % dos indivíduos em um período de surto (Agostini *et al.*, 2013).

Outro estudo comparou a estrutura genética e os padrões de dispersão de duas populações de *A. caraya*, uma em uma floresta contínua e outra em uma floresta fragmentada. Os resultados mostraram uma recente diferenciação genética entre os grupos residentes na floresta fragmentada. Em contraste, os grupos da floresta contínua não apresentaram qualquer diferenciação (Oklander *et al.*, 2010). Diferenças entre habitats podem refletir em um reduzido fluxo gênico fornecendo evidências genéticas que sustentam que o isolamento limita a capacidade do bugio de se dispersar (Fortes, 2008; Silva, 2013; Oklander *et al.*, 2017). Em remanescentes isolados há uma perda genética ainda maior do que aquela originada pela redução do tamanho populacional. Uma situação ainda mais grave é que o isolamento pode promover a fixação de alelos deletérios ao longo das gerações, levando-as rapidamente à extinção (Arroyo-Rodríguez *et al.*, 2017). Ainda que para o fragmento 13 haja uma população significativa de bugios, sua sobrevivência não está assegurada em longo prazo, devido aos endocruzamentos e à consequente perda da variabilidade genética.

Além disso, a endogamia provoca um aumento da suscetibilidade a flutuações estocásticas que podem levar à extinção (Oklander *et al.*, 2017). Desse modo, medidas de conservação como a translocação dos indivíduos, podem ser realizadas, tendo em vista tanto a extrema vulnerabilidade da população, quanto o isolamento, dificultando, assim,

a criação de um corredor ecológico. Outra possível solução seria o reforço populacional, por meio da introdução de indivíduos na área, o que poderia contribuir para o aumento da variabilidade genética da espécie na região e a redução das chances de extinção (Marsh, 2003).

A área do fragmento é citada como um fator chave nas simulações de viabilidade populacional para *Alouatta*. Alguns estudos têm encontrado elevadas probabilidades de extinção para o gênero quando os remanescentes considerados apresentam tamanho reduzido, abaixo de 15 ha (Agostini *et al.*, 2013). Isso pode ser explicado pelo fato de que fragmentos pequenos suportam um baixo número de indivíduos, além de que com a redução da área, diminui a qualidade do habitat (Arroyo-Rodríguez *et al.*, 2017), o número de alelos e a diversidade genética, conforme observado para os primatas neotropicais (Oklander *et al.*, 2017).

Os resultados da AVP sugerem direções importantes para o manejo das populações (Volampeno *et al.*, 2015; Da Silva *et al.*, 2016) indicando que são essenciais medidas que assegurem a manutenção da conectividade das áreas e a proteção dos remanescentes, contra catástrofes previstas no modelo, como a fragmentação, e não previstas, como um surto de febre amarela ou incêndios. Se as taxas dessas catástrofes não aumentarem, com base nos resultados, pode-se esperar uma relativa estabilidade da metapopulação de bugios na região, com exceção do fragmento 13, no qual a extinção local da população é iminente.

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SHORT ARTICLES

CARACTERIZAÇÃO DAS INTERAÇÕES ENTRE SAGÜIS (*CALLITHRIX PENICILLATA*) E HUMANOS

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Introdução

A forma como um recurso é obtido, sua distribuição e abundância no ambiente, influência diretamente os padrões comportamentais dos animais bem como seus deslocamentos, uso do território e a estrutura social de seus grupos (Lapenta, 2006; Sacramento, 2014). Em relação próxima com os seres humanos e/ou mediante as pressões ambientais, algumas espécies são capazes de modificar seu comportamento prévio, alterando seus padrões de busca e consumo de alimentos, reprodução e padrão de atividades diárias (e.g. Moreno, 2008; Sabbatini *et al.*, 2008; Alves *et al.*, 2011; De Castro *et al.* 2014). Algumas espécies de primatas conseguem se habituar a essas pressões, modificando comportamentos naturais para, geralmente, objetivar uma fonte de recurso com melhor balanço energético (Robinson, 1986; Chapman and Fedigan, 1990). Espécies presas em fragmentos florestais, acabam procurando alternativas energéticas através de alimentos fora dele para suplementação de sua alimentação, e muitas vezes as alternativas são resultados de atividades antrópicas (Paula *et al.*, 2005; Lousa, 2013; Sacramento, 2014). Esse comportamento oportunista comum entre os primatas da espécie *Callithrix penicillata* faz com que convivam facilmente com humanos quando alimentados por estes (Mendes *et al.*, 2005; Paula *et al.*, 2005; Sabbatini *et al.*, 2006; Saito *et al.*, 2010; Sacramento, 2014)

Callithrix penicillata (E. Geoffroy, 1812) é um sagui comumente encontrado em áreas próximas a ambientes urbanos, nas Regiões Sudeste (Paula *et al.*, 2005) e Sul do Brasil (Nunes, 2006), e também em campus universitários (Gheler-Costa *et al.*, 2002), cujos representantes são conhecidos como saguis de tufos pretos ou micos-estrela. Tratam-se de primatas de pequeno porte (entre 300 e 450g), que habitam áreas neotropicais, com pelagem estriada no dorso e cauda, ornamentos pilosos nas orelhas e uma mancha branca na testa (Stevenson and Rylands, 1988). Formam grupos de dois a quinze indivíduos, geralmente com um casal de adultos, jovens e infantes, mas normalmente com apenas uma fêmea reprodutora, dominante que produz gêmeos (Stevenson and Rylands, 1988), devido à sua ampla capacidade adaptativa e à sua plasticidade comportamental (Rylands, 1996; Modesto and Bergallo, 2008), são capazes de aprender e explorar o ambiente, adaptando-se a variações ambientais causadas principalmente pela ação humana (Stevenson and Rylands, 1988).

Contudo, uma aproximação excessiva entre pessoas e indivíduos de *C. penicillata* pode ocasionar mudanças comportamentais na espécie com uma dependência dos humanos no sentido de obtenção de alimento, diminuição dos comportamentos antipredatórios, redução dos comportamentos de medo que a espécie naturalmente apresenta quando mantida no ambiente silvestre sem o contato com pessoas, e até mesmo atos agressivos contra humanos (Paula *et al.*, 2005, Leite *et al.*, 2011). Secundariamente também existem os problemas que a ingestão de alimentos antropogênicos podem causar como estomatite por hipovitaminose; enterite não infecciosa (causada pela troca brusca de dieta, dietas inadequadas e estresse); hepatite, desencadeada por desnutrição e pneumonia (Kindlovits, 1999). Além das doenças que podem ser transmitidas de saguis a humanas e vice-versa. Em particular, *Callithrix sp.* são potenciais transmissores de raiva, Herpes B, Varíola dos macacos, resfriado, poliomielite, sarampo, e servir de reservatório para doenças como febre amarela, dengue, dentre outros (Kindlovits, 1999; Araújo *et al.*, 2008; Aguiar *et al.*, 2012).

Estudos comportamentais em áreas antrópicas, podem ajudar a compreender como essas relações afetam e modificam o comportamento dos primatas. Sendo assim, este trabalho teve como objetivo caracterizar as interações comportamentais entre saguis (*C. penicillata*) e humanos, registrar os padrões comportamentais exibidos pelos animais, bem como os horários de ocorrência, e os itens alimentares oferecidos aos saguis no momento das interações.

Material e Métodos

Área de Estudo

O estudo foi conduzido no campus da Universidade Federal de Juiz de Fora, Minas Gerais (21° 46' S; 43° 21' O, altitude média de 678m), com uma área total de 1,346,793 km², composta de fragmentos de Mata Atlântica e populações vegetais invasoras (Moreira *et al.*, 2013). O município apresenta clima do tipo tropical de altitude, segundo a classificação de Koopen (1970) com duas estações bem definidas uma seca que vai de abril a setembro e uma chuvosa que vai de outubro a março. As observações foram realizadas em áreas previamente conhecidas como locais de interações entre saguis e pessoas, totalizando quatro locais de observação: os institutos de Ciências Exatas (ICE), Ciências Biológicas (ICB), Ciências Humanas (ICH) e Pórtico Norte da Universidade nesses locais existem fragmentos de mata que ligam os três Institutos e o Pórtico Norte da Universidade que também possui um fragmento de mata.

Coleta de dados

O objeto de estudo foi composto por três grupos de saguis, (com cada grupo possuindo respectivamente 11, 6 e 6 indivíduos) de vida livre, que habitam o campus da UFJF, monitorados seis horas semanalmente de agosto de 2010 a abril de 2011. Foram realizadas observações

"ad libitum" (sensu Altmann, 1974), onde um observador anotava as interações entre saguis e pessoas, mantendo-se sempre a uma distância mínima de cinco metros, sem interferir nas mesmas, em horários variados, das 07:00 às 18:00 horas, totalizando 33 eventos, 20 na estação seca e 13 na estação chuvosa. Foram consideradas interações os eventos em que houve oferta de alimentos e aceitação por parte dos animais, sendo registradas as seguintes informações: dia, hora, local e duração das interações (minutos); número de animais no grupo; quantidade de pessoas no local; o tipo de alimento oferecido; iniciativa da interação (pelos saguis ou pelas pessoas); e os comportamentos exibidos pelos saguis.

Análises Estatísticas

As frequências foram analisadas através do teste qui-quadrado, a um nível de significância de 5% e foram considerados significativos se $p < 0,05$. O qui-quadrado foi escolhido por se tratar de um teste de hipóteses, que consegue avaliar a associação existente entre duas variáveis qualitativas. Os dados descritivos foram apresentados como média ± DP.

Resultados e discussão

Das 33 observações, 61% (20) ocorreram na estação seca e 39% (13) na estação chuvosa, com o número de animais que participou de cada interação variando de 1 a 9. O número de interações na estação seca demonstrou-se significativamente maior ($\chi^2 = 8,45$ df = 2 $p < 0,025$) quando comparado ao número de interação registradas na estação chuvosa. Naturalmente os primatas alteram sua dieta de acordo com a sazonalidade, a oferta e abundância dos alimentos no ambiente (Lapenta, 2006; Sacramento, 2014); primatas que possuem acesso a uma fonte alimentar alternativa, em períodos de escassez de alimentos naturais aumentariam a busca por estas fontes (Sabbatini *et al.*, 2008; Albuquerque *et al.*, 2010), o que corrobora o maior número de interações registrados na estação seca,

no presente estudo. Em média as interações duraram 14 ± 9 (2-46) min, a quantidade de pessoas presente no local no momento da interação variou de 1-50 (12 ± 15), e o número médio de animais que interagiu variou de 1-9 (5 ± 2). O horário de maior ocorrência das interações foi por volta de 13:00 horas, período de maior concentração de pessoas nos locais, sugerindo um possível condicionamento dos animais ao horário. Leite *et al.* (2011) em um estudo com saguis (*C. penicillata*), também observaram um horário mais frequente que ocorriam interações com humanos, coincidindo com o horário de maior visitação ao parque. O condicionamento animal através do provisionamento é conhecido não só para primatas (Paula *et al.*, 2005; Oliveira and Dias 2007) mas para outros grupos de animais como golfinhos (Alves *et al.*, 2011), onças (Sales, 2010), ursos, guaxinins, pássaros dentre outros (Oliveira and Dias 2007).

Os comportamentos exibidos pelos saguis durante as interações foram anotados resultando em 238 registros agrupados em 17 categorias, sendo Aproximar das pessoas (Ap) 19,32% (46), Vocalizar (Vc) 11,76% (28), e Afastar das pessoas (Af) 11,76% (28) os comportamentos mais frequentes (Tabela 1). Na maioria dos eventos (85%), os saguis interagiam em grupos. Todos os grupos possuíam infantes, mas apenas adultos e juvenis interagiram, os infantes não interagiram e ficaram sempre em posição mais afastada ou agarrada aos adultos, o que pode ser explicado pelo fato dos jovens estarem adquirindo experiência além de serem mais frágeis e vulneráveis (Santos and Martins, 2000). Esse comportamento de cuidado parental é comum em saguis, onde nos primeiros dois a três meses de vida os filhotes permanecem agarrados aos adultos (Santos and Martins, 2000; Albuquerque *et al.*, 2009), e após o primeiro mês de vida além do leite materno passam a contar com recursos alimentares oferecidos voluntariamente pelos membros do grupo, no quarto mês já começam a forragear sozinhos (Albuquerque *et al.*, 2009).

Tabela 1. Comportamentos exibidos pelos saguis (*Callithrix penicillata*) durante as interações. Descrição dos comportamentos conforme proposto por Smith *et al.*, 2010.

Evento comportamental	Descrição do comportamento	Número de ocorrências
Comportamento Social		
Catação (grooming) (Ct)	Manipular a pele de outro membro do grupo com as mãos ou dentes, para limpeza.	2
Aproximar (Ap)	Mover-se em direção a outro membro do grupo (a uma distância < 10cm)	46
Afastar (af)	Afastar-se de outro membro do grupo, a uma distância > 10cm	11
Partilhar o alimento (PA)	Oferecer passivamente o alimento a outro membro do grupo.	4
Comportamentos ligados a fisiologia do animal		
Excretas	Defecar ou urinar	2
Comportamento territorial e de comunicação		
Vocalização (Phee calling)	Vocalização alta composta por um único ou múltiplos assobios	28

Comportamento Agressivo		
Alerta (Or)	Olhar ao redor, alerta.	10
Agredir	Morder, arranhar, bater ou perseguir outro animal	4
Roubar Comida (Rb)	Tomar de forma agressiva, ou lutar por item alimentar pertencente a outro animal	1
Comportamentos em resposta as interações com humanos		
Observar ao redor (Op)	Observar a(s) pessoa(s) que oferece(m) o alimento.	20
Observar o alimento(Oal)	Olhar para o alimento.	18
Descer (Dsc)	Descer ao chão.	18
Comer o alimento (Afa)	Afastar-se das pessoas para ingerir o alimento.	18
Afastar (Af)	Afastar-se das pessoas.	17
Pegar o alimento diretamente (Pad)	Pegar o alimento com as patas dianteiras, estabelecendo contato direto com a pessoa.	20
Pegar o alimento indiretamente (Par)	Pegar alimento colocado na árvore ou em outro local, sem estabelecer contato direto.	8
Comer no solo (Alc)	Alimentar-se no chão.	8
Receber o alimento diretamente (Pab)	Pegar o alimento com a boca, estabelecendo contato direto com a pessoa.	3
Total		238

Em aproximadamente 84,6% ($n=28$) das interações, os saguis tomaram a iniciativa de interagir aproximando-se das pessoas, este comportamento de procura por humanos também foi observado em macacos pregos (Sabbatini *et al.*, 2008). Pegar o alimento diretamente (Pad) foi um comportamento mais frequente ($n=20$) que pegar o alimento indiretamente (Par, $n=8$) demonstrando a perda do comportamento de medo ((Almeida *et al.*, 2006; Leite *et al.*, 2011), que naturalmente seria exibido em áreas sem contato com humanos, nestes casos os animais evitam se aproximar de pessoas e emitem vocalizações de alerta quando se sentem ameaçados (Almeida *et al.*, 2006). O uso do solo para alimentação ($n=8$) também foi observado tanto na presença de humanos como na ausência, apesar de serem primatas arborícolas, adaptados a vida saltatória (Stevenson and Rylands, 1988), podem forragear no solo (David, 2006).

Os alimentos oferecidos foram identificados e classificados em três categorias: Frutas (banana, maçã, melancia; 57% (13)), Massas (pão, biscoito, polvilho, 17% (4)) e Doces (bombons, balas, 26% (6)) (Fig. 1). Destaca-se que as bananas, porém, foram o alimento oferecido com maior frequência (48% (11)) dentre todos os alimentos ofertados, provavelmente devido ao hábito das pessoas de associar as bananas como comida de macaco. A ingestão destes alimentos de alto nível calórico, podem aumentar os níveis de glicose e colesterol, causar obesidade, problemas cardíacos e diabetes, o açúcar pode provocar o aparecimento de cárries e seu baixo potencial nutritivo pode causar déficit nutricional aos macacos (Sabbatini *et al.*, 2006). A ingestão de lixo também foi observada (Fig. 2), alimentos em péssimo estado de conservação, como os que são encontrados no lixo, podem alterar a função gastrintestinal, e

comprometer o sistema imunológico e do estado de saúde dos animais (Sabbatini *et al.*, 2008). Comportamentos agonísticos como Roubar ($n=1$) e Agredir ($n=4$) foram raros, não se observando casos de agressão entre as partes (humanos e saguis).



Figura 1. Saguí se alimentando de pão.



Figura 2. Saguí se alimentando de lixo.

Considerações finais

Saguis hoje ocupam várias áreas urbanas e por serem animais mais capazes de habituar-se a esses locais e incluírem itens antropogênicos na sua alimentação, alguns grupos tem sua atividade de forrageio baseada na oferta de alimentos que as pessoas fazem. Tal fato pode trazer riscos para os animais que sofrem esse tipo de provisionamento, desde a alteração dos seus padrões comportamentais ao surgimento de diversas doenças. Durante essas interações as pessoas se expõem ao risco de contraírem doenças e serem vítimas de comportamentos agressivos. Um trabalho de educação ambiental deve ser realizado visando conscientizar as pessoas dos problemas que podem trazer aos animais através da alimentação artificial.

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- SEED DISPERSAL OF A PIONEER TREE SPECIES, *CASTILLA ELASTICA*, BY MANTLED HOWLING MONKEYS (*ALOUATTA PALLIATA*) IN REGENERATING FOREST IN COSTA RICA.**
- Jill D. Pruetz
Heather D. Davis
- ### Introduction
- Howling monkeys are well-known seed dispersers for tropical trees (Estrada and Coates-Estrada, 1986; Chiarello and Galetti, 1995; Julliot, 1996), but their importance in general to tropical forest regeneration has been demonstrated for only a few sites (Arroyo-Rodriguez et al. 2015). Studies have demonstrated that both primate species and seedlings of primate-dispersed tree species occur at low densities in forest fragments compared to intact forest areas (Kibale National Park, Uganda: Chapman & Onderdonk 1998), but data on the life history of plants dispersed, excluding basic germination data, are usually lacking. Since howling monkeys (*Alouatta* sp.) are often found in disturbed areas where other primate species are locally extinct, they may be especially important in dispersing seeds in forest fragments where specialized frugivores are absent (Chiarello and Galletti, 1994; Anzures-Dadda et al., 2016).
- Seed dispersal requires a number of steps in order to positively affect the reproductive success of the host tree including that passage through an animal's gut does not adversely affect seed germination (Garber and Lambert, 1998). Julliot (1996) found that passage through the gut of a red howler (*A. seniculus*) enhanced seed germination for some species but reduced germination in others. Germination of *Tetragastris panamensis* seeds was not affected by gut passage in *A. palliata* (Howe, 1980). Germination experiments are among the steps needed to assess gut passage effects on seed viability.
- General assumptions regarding seed dispersal are that, by moving seeds away from a parent tree, survival is improved by reducing competition among seeds and by reducing competition with the parent tree, and that seedling mortality may be reduced by moving seeds away from areas (such as near the parent tree) that attract seed predators. Seedling survival beneath parent trees also varies between species (Chapman and Chapman, 1995).
- Studies of pioneer plant species in Costa Rica showed that the restraints associated with seed dispersal and the reproductive success of plant species vary (Murray, 1986). To

understand the seed dispersal strategy of any species, it is necessary to consider its life history and specific adaptations (Murray, 1986), for example, different pioneer species require different-sized light gaps to permit or stimulate germination. Thus, information on the behavior of potential seed dispersers, as well as on the life histories of host trees, is necessary to understand processes of seed dispersal, and ultimately forest regeneration.

While studying howling monkeys in La Suerte Biological Field Station, Costa Rica in June-July 1997, we found large numbers of seeds of *Castilla elastica* (Family Moraceae) in their feces, deposited more than 25 m from the parent tree. This tree is found from Mexico through Ecuador (Berg 1972). While pioneer tree species usually disseminate a large number of small seeds, *C. elastica*, considered a colonist/pioneer (Berg 1972), has relatively large seeds, about 9-12 mm in length (Estrada, 1993). The guild of dispersers for such a species is less inclusive than for small-seeded pioneer species (e.g., *Cecropia*). Based on these observations, we examined the role of mantled howling monkeys as seed dispersers of *C. elastica*. Specifically, we tested the hypotheses that passage through a howling monkey's gut enhances the germination of *C. elastica* seeds, and that seeds transported away from the parent tree are more likely to survive than seeds deposited beneath the parent crown. To do this we obtained data on (1) experimental seed germination rates, (2) howling monkey feeding and ranging patterns, (3) feeding behavior by potential dispersers on a fruiting *C. elastica* tree, (4) offspring survival beneath parent *C. elastica* trees and (5) the pattern of distribution of adult *C. elastica* trees.

Methods

La Suerte Biological Field Station (LSBFS) is in the Province of Limón, about 20 km from the Atlantic coast of northeastern Costa Rica [83° 46' 15" W, 10° 26' 30" N]. The site was characterized by areas of secondary, disturbed, lowland rainforest surrounded by cattle pastures and/or crops (pineapple, coconut). Subjects were members of two howler groups living in the "Small Forest" (15 ha). They had overlapping home ranges and were of similar sizes: 11 and 10 individuals (Pruett and Leasor, 2002). We collected data on the distribution of adult *C. elastica* trees, and the survivorship of seedlings beneath the parent trees within the home range of the 11-member group, including the overlap area. Both groups were observed to feed in at least one fruiting *C. elastica* tree in the overlap area. JDP collected data on 98 focal individual feeding bouts during 64.42 group contact hours from May-August 1997. Bouts were defined as the continuous feeding and foraging behavior of an individual, usually within a single tree's crown.

Ninety-five *C. elastica* seeds were planted between 1-20 July, 1997 to assess germination rates under different conditions. We planted 29 seeds voided by howling monkeys, 31 seeds manually cleaned of pulp, and 35 seeds with pulp

intact. Four to five seeds per container were planted on top of a humus and soil mixture within an herbarium slightly shaded by a mesh cover and monitored to record germination. Seedling height was measured in January 1998, 6 months after planting. Of the 95 seeds planted, 23 survived to six months, and mean seedling height was 14.7 cm, ranging from 9-20 cm.

In January-February 1998, we recorded the distribution of *C. elastica* trees in an area representing 10% (1.3 ha) of the Small Forest. We divided the area into 131 quadrats each of 10 m² and calculated the mean number of trees per quadrat that were over 3 m in height (considered "immature"). We also collected data on mature trees (Table 1). Those over 9 m tall were considered reproductively mature, since smaller trees were never seen to produce fruit. We measured the occurrence of seedlings, saplings and poles within a 5-m radius from the trunk of the mature trees. Since maximum crown width was 8.5 m (Table 1), a 10 m diameter allowed all seeds deposited beneath parent trees to be recorded. Based on the growth rate of experimentally planted seeds (see above), seedlings over 0.25 m in height were assumed to be from the current year's fruit crop and were recorded as such. From 16-23 July, 1997 a single, large (15 m in height) fruiting *C. elastica* tree in a river-corridor area connecting two forest patches was monitored to record potential seed dispersers (Pruett *et al.*, 1998). Fruit cover was about 10% of the crown cover during this time. Two-minute instantaneous sampling was used to record the general activity of animals in the tree. The tree was monitored for about 18 h over the course of 8 days, with samples spread evenly throughout the day. The tree was not watched systematically at night, although we saw kinkajous (*Potos flavus*) entering the tree on one occasion.

Table 1. Characteristics of the *C. elastica* 'parent trees' surveyed.

Tree Dimension	Mean and SD	Range	Sample Size
Height	12.5 +1.7 m	9.5-17.0 m	19
Crown width	5.0 + 1.7 m	1.8-8.5 m	19
Girth	0.9 + 0.5 m	0.5-2.5 m	19
Crown height	2.8 + 1.0 m	1.5-4.5 m	19
NN distance*	8.9 + 5.2 m	2.0-17.0 m	15
NN height*	11.6 +2.3 m	4.5-13.5 m	14

*NN = nearest neighbor

Results

Feeding on *C. elastica* fruit accounted for 6% of all howling monkey feeding bouts from May-August 1997. Fifteen birds, three mammals, and two reptiles were also observed to feed on fruit of the focal *C. elastica* tree (Pruett *et al.*, 1998). Species seen to swallow both pulp and seeds included: the collared aracari (*Pteroglossus torquatus*), keel-billed toucan (*Ramphastos sulfuratus*), mealy parrot (*Amazona farinosa*), iguana (*Iguana iguana*), and the double-crested

basilisk (*Basilisk plumifrons*). Mealy parrots were recorded most often (47% of observation time), with capuchins observed next frequently (19.5% of time). Capuchins (*Cebus capucinus*) were seen to spit seeds, but Smith (2004) noted that they also dispersed *C. elastica* seeds in their feces at LSBFS. Iguanas (6.3% of time), and basilisks (5.1% of time) were also frequent visitors. Howlers did not feed in the focal tree during vigils but were seen there on other occasions.

Thirty-seven *C. elastica* trees between 3 m and 9 m in height were recorded in the 1.3 ha survey area. The high degree of variation (1.21 trees) around the mean number of trees per quadrat (0.28) indicates a clumped distribution of *C. elastica* of this height (Madrigal, 1998). The mean distance to nearest neighbor was 6.08 m (Table 1). ANOVA tests revealed that the number of seedlings, saplings, and poles beneath parent trees did not vary significantly between those that were in light gaps (of at least 10 m²) or not (Table 2).

Table 2. Mean number of seedlings, saplings and poles within 5 m of adult *C. elastica*.

Tree Location	Height categories (m)						All heights
	0-0.25*	0.26-0.50	0.51-1.0	1.01-2.0	2.1-5.0	>5.0	
Gap (N=8)	14.4 +22.5	0.8 + 1.0	0.9 + 2.1	0.4 + 0.7	0.3 + 0.5	0.6 + 1.1	17.5 + 25.0
No Gap (N=11)	12.7 + 15.8	0.7 + 2.1	0.1 + 0.3	0.2 + 0.4	0 + 0	0.4 + 0.7	13.6 + 15.9

* This year's fruit crop seeds

A Chi-square test using the voided condition to generate expected germination probability (Madrigal, 1998) showed a significant difference in the number of seeds germinating 24 days after planting ($\chi^2 = 5.00$, df = 1, $p < 0.05$). Experimental plantings showed that more voided seeds (90%) and manually scraped seeds (87%) germinated sooner than pulped seeds (55%). Time to germination for 50% of all planted seeds (after Julliot, 1996) was shorter for voided seeds (11 days) compared to pulped seeds (19 days) and scraped seeds (18 days). Differences in survivorship to six months under the different conditions (scraped, voided, pulp intact) were not significant and varied from 14% to 34%.

Discussion

Our experiments showed that passage through a howling monkey's intestinal tract significantly improved the probability of and reduced the latency to germination of *C. elastica* seeds. Ninety percent of the seeds that had passed through a howling monkey's gut germinated, and they germinated more quickly than scraped seeds or seeds with pulp intact. However, scraped seeds also germinated more quickly than seeds with the pulp remaining on them. Zhang and Wang (1995), likewise, found that seeds voided by *Cebus apella* and *Ateles paniscus* did not germinate significantly faster compared to seeds that had been scraped of pulp. Germination for 50 percent of all seeds planted in the current study was slower for both scraped seeds and pulped seeds compared to voided seeds.

The survival of *C. elastica* seedlings beneath parent trees indicates that transport away from a parent tree is not necessary for seed germination in this species. Survival rates tended to be higher in light gap areas than in less open areas in the disturbed forest fragment surveyed here, but the difference was not significant. This finding suggests that *C. elastica* is a pioneer species that can germinate in

small and large gap areas (pattern C in Murray, 1986). However, the distribution pattern of adult *C. elastica* trees implies that most of the offspring beneath parent trees will not survive to reproduce. The nearest-neighbor conspecific distance was greater between mature trees (8.9 m) than between immature trees (6.0 m) (see Table 1), showing that competition between trees is an important factor affecting seedling survival, and thus scattering the seeds away from parent trees is beneficial for this particular pioneer species. Additionally, the number of seedlings below parent trees that were >1 year of age was significantly less than new seedlings, possibly due to high mortality.

Data on the feeding and ranging behavior of howling monkeys in the LSBFS "Small Forest" illustrate that *C. elastica* is an important seasonal food source for howlers at this site (see also Smith 2004). This study and others (Smith 2004) found that howlers ingest and disperse a large number of seeds. Evidence that howlers pass viable seeds, improve the likelihood of germination by passing seeds, and move seeds considerable distances from parent trees supports the hypothesis that these primates contribute to the reproductive success of this tree species.

Data on a focal *C. elastica* tree during a period of high fruit availability showed that, in addition to mantled howling monkeys, other vertebrates such as keel-billed toucans, collared aracaris, iguanas, and basilisks eat the fruits and ingest the seeds and are as such potential seed dispersal agents for the species (Pruett et al., 1998). Smith (2004) reported that capuchins at La Suerte also swallowed *C. elastica* seeds. The biomass, number of individuals, and behavior of potential dispersers are important variables affecting seed dispersal of fruiting trees. The relative density of howling monkeys is higher than that of capuchins at this site (73 howlers/km² vs. 29 capuchins/km²; Pruetz and Leasor, 2002), as is howling monkey biomass (see Nowak 1999). It is possible that capuchins ingest more *C. elastica* fruits than

do howling monkeys, given their more frugivorous tendencies; however, they were observed to pick seeds from the fruits before eating the pulp, and dropped large portions of whole fruits. Howling monkeys' emphasis on *C. elastica* in their diet – together with their relatively high density at LSBFS – suggest they may be the most important primate seed disperser of *C. elastica* in regenerating forest at this site. Future studies need to detail the feeding behavior of other potential dispersers, if we are to have a clear understanding of the relations between the abundance and distribution of *C. elastica* and its seed dispersers and seed predators. Howe (1980), for example found that mealy parrots destroyed all *Tetragastris panamensis* seeds they eat.

Chiarello and Galetti (1994) noted that howlers are important seed dispersers in isolated forest fragments where specialized frugivores are absent. Pulp removal would seem to be a significant variable affecting seed germination in this tree, and this may also be done by secondary dispersers (for example rodents or ants, see Forget, 1992) that may also play an important role in determining the abundance and distribution of *C. elastica* in the forest fragments of La Suerte. Overall, dispersers depositing seeds in gaps, away from other trees, undoubtedly contribute to forest regeneration, but the precise relation between forest structure and composition and the role of primates is one of the key questions to be answered in understanding their “ecological services” for the maintenance of healthy forest functioning and their conservation.

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IMMIGRATION OF A FEMALE *ALOUATTA GUARIBA CLAMITANS* INTO A GROUP INHABITING A RESTINGA FOREST IN SOUTHERN BRAZIL

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Introduction

Among primates, dispersal may result from aggressive interactions (competition for reproductive positions, social status or food resources) or from a result of events such as changes of social hierarchy, infanticide avoidance, fission of a group or habitat destruction (Pusey and Packer, 1987). Although there are benefits attributed to primate dispersal (increased genetic variability, reduced inbreeding and possibly diminished competition for reproductive opportunities), predation risk increases and the chances of finding food and familiarity with the environment decrease when an individual disperses (Chepko-Sade *et al.*, 1987; Pusey and Packer, 1987; Shields, 1987; Jones, 2005). Additionally, arboreal primates face high costs for traveling in open anthropic areas to reach other forest fragments (e.g., predation, morbidity associated with automobile, illegal trade) (Rodriguez-Toledo *et al.*, 2003; Mandujano *et al.*, 2004). The relations between intrinsic factors (social, demographic and genetic) and habitat factors (deforestation, hunting and others) that influence the decision of an individual to stay or leave its natal group are complex and may vary among species and sexes (Mandujano *et al.*, 2004; Jones, 2005).

Female philopatry is common among primates (Pusey and Packer, 1987) but Neotropical primates polygamous species tend to a female-biased dispersal (e.g. *Brachyteles hypoxanthus* and *Ateles chamek*) or bisexual dispersal (e.g. *Cebus olivaceus*, *Leontopithecus rosalia* and *Saguinus fuscicollis*) (Campbell *et al.*, 2007; Strier, 2008). For howler monkeys, the dispersal of both males and females has been observed in *Alouatta palliata* (Glander 1992; Jones 1980, 1999; Mandujano *et al.* 2004, Clarke and Glander, 2008), *Alouatta seniculus* (Rudran, 1979; Crockett, 1984; Crockett and Pope, 1993; Agoramoorthy and Rudran, 1993; Palacios, 2000; Pope 2000), *Alouatta caraya* (Rumiz, 1990; Calegaro-Marques and Bicca-Marques, 1996; Giudice, 1997), and *Alouatta pigra* (Brockett *et al.*, 2000). For *Alouatta guariba clamitans* some cases cited in the ecological studies report the dispersal of howlers, mostly adult and sub-adult males (Mendes,

1989; Katz and Otta, 1991; Strier *et al.*, 2001; Jardim, 2005; Miranda *et al.* 2006; Podgaiski and Jardim, 2009).

Methods

Ten groups of howler groups (*Alouatta guariba clamitans*) (Cabrera, 1940) were monitored as part of a study of population ecology (Jardim, 2005) in three forest fragments around the cities of Porto Alegre and Viamão in state of Rio Grande do Sul: Lami (30° 15' S; 51° 03' W); Morro da Extrema (30° 01' S; 51° 04' W) and Parque Estadual de Itapuã (30° 23' S, 51° 30' W). The determination of the group composition was conducted according to the age-sex classification used for *A. g. clamitans*, in Caratinga, Minas Gerais (Mendes, 1989). Howlers were individualized mainly by body size, pelage color and scars. After the initial definition of the social composition (from June to November 1999), the howler groups were followed every second month from December 1999 to December 2001.

Thirteen surveys were carried out and the following information was registered: date, time, location, and social composition of each group. Every change in group composition due to births, deaths, and dispersal was documented as the group was encountered. The groups were observed by the method *ad libitum* (Altmann, 1974) for at least two hours at each encounter. The average interval between the surveys was 50.2 days, with a total of 149 days on-site (586 hours of direct observation) and 214 encounters with groups of howler monkeys.

Results

On February 16, 2000, we recorded the immigration of an adult female into a resident group in a Restinga forest fragment in Lami, a private property in Porto Alegre. This group originally contained eight individuals (two adult females, one adult male, four juveniles, and one infant). This same composition was observed in three surveys previous to immigration. When the group was first seen with the new female, we made the following observations: the immigrant female, while vocalizing, moved towards one of the resident adult females, which moved away, apparently showing submission. The second female was carrying an infant on her back and was about 50 meters from the rest of the group. The male was seemingly indifferent to the females' behavior. In the following months, no aggressive behaviors or displays of domination-submission among the females were observed. Similarly, aggressive behavior was not observed among females in the same group in other groups observed. Agonistic interactions were always observed between females of different groups in the context of intergroup conflicts. In July 2001, approximately 18 months after her arrival, the immigrant female gave birth. Throughout the survey, there was no other alteration of the social composition of this group, except for four births. In the other groups,

sixteen disappearances cases (emigrations and/or deaths) were observed including adult and sub-adult males, an adult female, and juveniles. Although the fates of these animals are unknown, these data are consistent with a tendency of dispersal for both sexes, with a predominance of adult males and juveniles.

Discussion

In the genus *Alouatta*, female emigration seems to be a consequence of aggressive interactions among adult females, and the competitive behavior among females is well documented (Crockett, 1984; Pope, 2000). Aggression followed by emigration has been observed for *A. seniculus* in Venezuela (Pope, 2000), *A. pigra* in Belize (Brockett *et al.*, 2000), and *A. caraya* in southern Brazil (Calegaro-Marques and Bicca-Marques, 1996) and Argentina (Giudice, 1997). The opportunities for females to enter groups that are already established may be uncommon (Rudran, 1979; Crockett, 1984; Brockett *et al.*; 2000; Palacios, 2000; Pope, 2000). For this reason, the most frequent situation is for females to join other individuals to establish new groups (Calegaro-Marques and Bicca-Marques, 1996; Palacios, 2000; Pope, 2000; Miranda *et al.* 2006).

Some authors have suggested that there may be a maximum number of howler females per group as a result of competition for reproductive positions (Crockett, 1984; Crockett and Pope, 1993). For *A. seniculus* and *A. caraya*, it is thought that four females are the limit (Pope, 1966; Thorington *et al.*, 1984; Rumiz, 1990; Palacios, 2000). For *A. g. clamitans*, records of 4 adult females per group are uncommon and the limit reproductive females may be lower (Mendes, 1989; Steinmetz, 2001; Jardim, 2005; Miranda *et al.*, 2006; Fortes, 2008). On the other hand, groups containing a smaller number of females may be likely to receive female immigrants. Calegaro-Marques and Bicca-Marques (1996) observed in *A. caraya* the recruitment of a female by a group that previously lost a female as a result of emigration. Crockett (1984) observed the immigration of two females of *A. seniculus*. In both cases, the females joined groups after the death of one of the adult females. Palacios (2000) described the female immigration of *A. seniculus* to a howler group with two adult females, both rearing infants. Our observation of the arrival of an adult female is consistent with this hypothesis, as this group had only two resident adult females. Moreover, one of them was carrying a newborn and the other was pregnant.

The year and a half interval between the first record of immigrant female and her giving birth described in this study, is similar to the average delay for the first litter of immigrant females of *A. palliata* (19.7 months, Zucker *et al.* 2001). The reproduction of the immigrant female and her interactions with the other individuals of the group indicate that the immigration was successful.

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A FAILED IMMIGRATION ATTEMPT BY A MOUSTACHED TAMARIN, *SAGINUUS MYSTAX*

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Introduction

Dispersal, i.e. leaving the natal group or home range and immigrating into a different group or new area, is a critical stage in the life of organisms and often associated with high risks of mortality (Pusey and Packer, 1987; Weisser, 2001). Successful dispersal and immigration into a new group do not only depend on the survival in the transitional phase

of leaving the old and arriving in a new group, but also on whether or not an individual becomes integrated into a new group. Depending on age, sex, dominance or reproductive position within a group, established group members may resist immigration attempts.

While in most primates, dispersal is mainly or exclusively by members of one sex (Pusey and Packer, 1987), the flexible mating system of tamarins – which includes polyandry and monogamy (Goldizen, 1988) – implies that both sexes may disperse. In fact, dispersal of both sexes has been recorded in several tamarin species (Goldizen et al., 1996; Savage et al., 1996; Löttker et al., 2004). However, the actual events surrounding immigrations are rarely directly observed. Here we report a failed immigration attempt into a group of moustached tamarins, *Saguinus mystax*, small cooperatively breeding primates, where both males and females in a group help to care for twin litter produced by a single breeding female.

Group observation

The observation was made at the Estación Biológica Quebrada Blanco (EBQB) in north-eastern Peru (for details of the study site see Heymann, 1995) during a study on vigilance behaviour (Stojan-Dolar and Heymann, 2010a, b). The observed group consisted of an adult male, the breeding female and three offspring of different ages: another adult male, an adult female and a juvenile female. The group had lost an adult male, and two 2-month old infants about six weeks before the observed event. The male who disappeared was often observed to transport infants, as were the adult offspring who were still in the group. The group was usually associated with a group of seven saddle-back tamarins, *Leontocebus nigrifrons* (previously *Saguinus fuscicollis nigrifrons*). The group was one of three *S. mystax* study groups at EBQB regularly under observation since February 2006 by MSD. It was usually followed from the sleeping tree in the morning to the sleeping tree in the evening for six observation days per month. An observation block started on 21 February 2007.

On 21 February 2007, the *S. mystax* group spent notably more time in locomotion than usual. The *L. nigrifrons* individuals were not present during that day. At 1452 h, the group entered a sleeping tree. At this moment we realized the presence of an unknown adult male who was vocalizing from a distance of about 20 m from the sleeping tree. Two group members (who could not be unequivocally identified due to restricted visibility) rapidly exited and re-entered the sleeping tree two times but did not move towards the strange male. Tamarins usually do not exit the sleeping tree once all the group members have entered. At 1500 h, the unknown male moved away. At 1502 h, the group left the sleeping tree, and moved towards another sleeping tree which they entered at 1509 h. The unknown male returned at 1511 h and started vocalizing again. At 1514 h, the entire

group exited the sleeping tree and ran towards the strange male, who retreated slightly. There was a lot of vocalizing, but it was not possible to observe whether physical contact between the group members and the new male occurred. Group members were moving in different directions before coalescing again and re-entering the first sleeping site at 1524 h. The unknown male moved off and was not seen again, neither on this nor on the following days. The composition of the group did not change during the following 5 months when continuous observations of the group were stopped.

Discussion

The failed immigration attempt is interesting for two reasons. First, immigrations appear to be more successful when newcomers fill a vacancy in a group after an individual has died, dispersed or disappeared. In the *S. mystax* population at EBQB, a new female successfully immigrated into a group after the death of the reproductive female (Löttker et al., 2004). She was initially met with some aggressive resistance but, became integrated into the group within two days. In *Leontopithecus rosalia*, 75 % of successful immigration events were replacements of the breeding individual, where 5 out of 6 were males (Baker and Dietz, 1996). As the observed group had also recently lost an adult male, the group members could be expected to show less resistance to accept a newcomer. Second, in several mammal species the presence of helpers increases survival probability of offspring (Jennions and Macdonald, 1989; Clutton-Brock et al., 2001). In callitrichids the number of helpers in a group appears to increase reproductive success (Garber et al., 1984; Koenig, 1995; Culot et al., 2011). However, the observed group had 4 adults, which already exceeded the average for this population (2.5 ± 0.7 adults per group, $n=8$ groups, Löttker et al. 2004). The relative contribution of an additional helper may not offset increased male competition for access to the breeding female. By losing a group member, other individuals may have increased their fitness. This is in line with the notion that despite specific characteristics of the callitrichid cooperative mating system, immigration into groups with more helpers is more difficult (Schaffner and French, 1997).

Immigration is a rare event and observations are thus necessarily anecdotal. However, only through the accumulation of this kind of information can patterns eventually emerge that can provide insights into mechanisms of immigration.

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BIOACOUSTICS OF THE BLACK-HEADED NIGHT MONKEY, *AOTUS NIGRICEPS*

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Introduction

Only three studies have assessed *Aotus* vocalizations (known as either owl or night monkeys). None of these studies have assessed the black-headed night monkey (*A. nigriceps*) found in southeastern Peru, northern Bolivia, and central-western Brazil, nor have they focused on bioacoustics of *Aotus* spp. in the wild. Of these three captive-based studies, 13 different call types have been described in *A. lemurinus* (Andrew 1963; Moynihan 1964) and *A. azarae* (Kantha et al. 2009). Most of these calls are distinct from one another; however, there are some inconsistencies in naming that need to be addressed, as described in Table 1. First, the Trill described by Andrew (1963) has similar structure and bandwidth to the Scream described by Moynihan (1964). Moynihan does describe a Low Trill which is distinct from the Trill in Andrew (1963), and the Low Trill described by Kantha et al. (2009) does not resemble structure, bandwidth, or call duration of the Trill in Andrew (1963) or the Low Trill in Moynihan (1964). Therefore, we suggest that the Trill in Andrew (1963) is structurally distinct from the Low Trill in Moynihan (1964), and the Low Trill in Kantha et al. (2009) appears to be a distinct call from the other two studies. Secondly, one of the representative Squeaks described by Andrew (1963) is very similar to the Gruff Grunt (Moynihan 1964). Each has numerous harmonics, a similar descending frequency across the exact call duration, and a very similar bandwidth. Therefore, the Gruff Grunt should be renamed Squeak, as it was previously described in Andrews (1963). Thirdly, the Squeak described by Moynihan (1964) is structurally similar to the Twitter described by Andrews (1963) and should be renamed. Fourth, neither the Long Scream nor the Short Scream described by Kantha et al. (2009) appear to be similar in structure, bandwidth, or duration to the Scream in Moynihan (1964) and should potentially be renamed. Fifth, the Moan described by Moynihan (1964) is not similar to the Moan in Kantha et al. (2009) in structure, bandwidth, or duration. The low frequency band is structurally similar to a variant Low Trill described by Moynihan 1964, though the quality of the spectrogram in Kantha et al. (2009) makes it difficult to confirm this possibility. And finally, the Gulp described by Kantha et al. (2009) is similar to the Gulp in Moynihan (1964); however, the bandwidth in the

earlier study is far less than 1 kHz, while the Kantha et al. (2009) study shows an upper frequency of at least 10 kHz. Based on the available data and without further descriptive

analysis in Kantha et al. (2009), these should likely be considered distinct calls.

Table 1. Vocal descriptions from all previously published captive and semi-captive *Aotus* studies. Several similar calls were found in both Moynihan 1964 and Kantha et al. 2009, though both were included because they were found in different species and have different bandwidth and duration.

Species	Call type	Mean Bandwidth (Hz)	Mean Duration (msec)	Description
<i>Aotus lemurinus griseimembra</i> (a)	Twitter	2000-8000	40	Descending from 3.5-4 kHz to 2-3 kHz; Long rapid series once every 200 msec. A fundamental frequency (2-4 kHz) with a second harmonic at 5-8* kHz
	Trill	1000-7000*	300	Series of Twitters
<i>Aotus lemurinus griseimembra</i> (b)	Squeak	500-5000	100	"Guinea pig squeak" starting at lower frequency (500 Hz) and rising steeply to 4-4 kHz; or, simply protracted lower frequency (500-700 Hz)
	Sharp Call	1000-15000	150-250	Sometimes sharp initial click. Once every 150-250 msec
	Boom	150	1000+	Low soft call by vibration of false vocal cords
	Low Trill	240-500*	600*	Bubbling series of low-pitched notes, rapid but distinguishable series. Varied from 3-12 notes
	Gulp	0-650	100-260	Very common. Moderately loud and rather "liquid" sounding. Uttered in series of 2 to 3 notes. Series repeats rapidly
	Gruff Grunt	100-4000*	100*	Most common. Uttered as singly or in short series of two to five notes. Successive notes uttered at slightly irregular intervals. Longer pauses. Low-pitched, moderately long, and moderately loud. Multiple harmonics
	Squeak	1000-9500*	50*	1-3.5 kHz fundamental frequency, followed by two harmonics ranging from 4-9.5 kHz
	Sneeze Grunt	0-1000*	200*	Sneeze superimposed upon a loud Gruff Grunt. Usually uttered as a single note, though sometimes two in quick succession. Often associated with Gulps, single Low or High Trill, or Moan
<i>Aotus azarae</i> (c)	Resonant Grunts	Unknown	Unknown	More complex than Gruff Grunt and rarer. Speed loudness, and pitch varied considerably. Long series of 10-15 notes. Most common series included soft and low notes first half of series (softer than Gruff Grunt), and progressively louder towards middle of series. Towards climax similarly loud, resonating, and rapid. Finally, slowed in tempo, lower and softer
	Moan	220-480*	600*	Brief, soft, moan. Most common call type in captive individuals. Often uttered along with other calls before or after, including Low Trills, Gulps, and Sneeze Grunts
	Scream	2000-8500*	800	High pitched but wavering. Quite prolonged. Multiple harmonics (though an exact number not given)
	Moan	140-300	500	No description given
	Long Scream	2800-5800	260	No description given
	Gulp	1800-5800	54	No description given
	Low Trill	2000-3100	52	No description given
	Short Scream	980-3300	190	No description given
	Sneeze Grunt	1580-3310	50	No description given

(a) Andrew 1963 (2 laboratory animals) and (b) Moynihan 1964 (12 semi-captive animals) originally classified as *A. trivirgatus*; (c) Kantha et al. 2009 (16 laboratory animals). *Estimates based solely on published spectrogram.

Vocalization analysis for owl monkey species is particularly important as it is difficult to differentiate between individuals or determine group dynamics because they are nocturnal. A vocal assessment could potentially be used to differentiate individuals and assess group membership during

new group encounters simply based on bioacoustics (Salmi et al. 2014). The objective of this study, consequently, was to add to the *Aotus* bioacoustic literature by sampling several geographically dispersed groups of wild *A. nigriceps* (Fig. 1) in southeastern Peru.

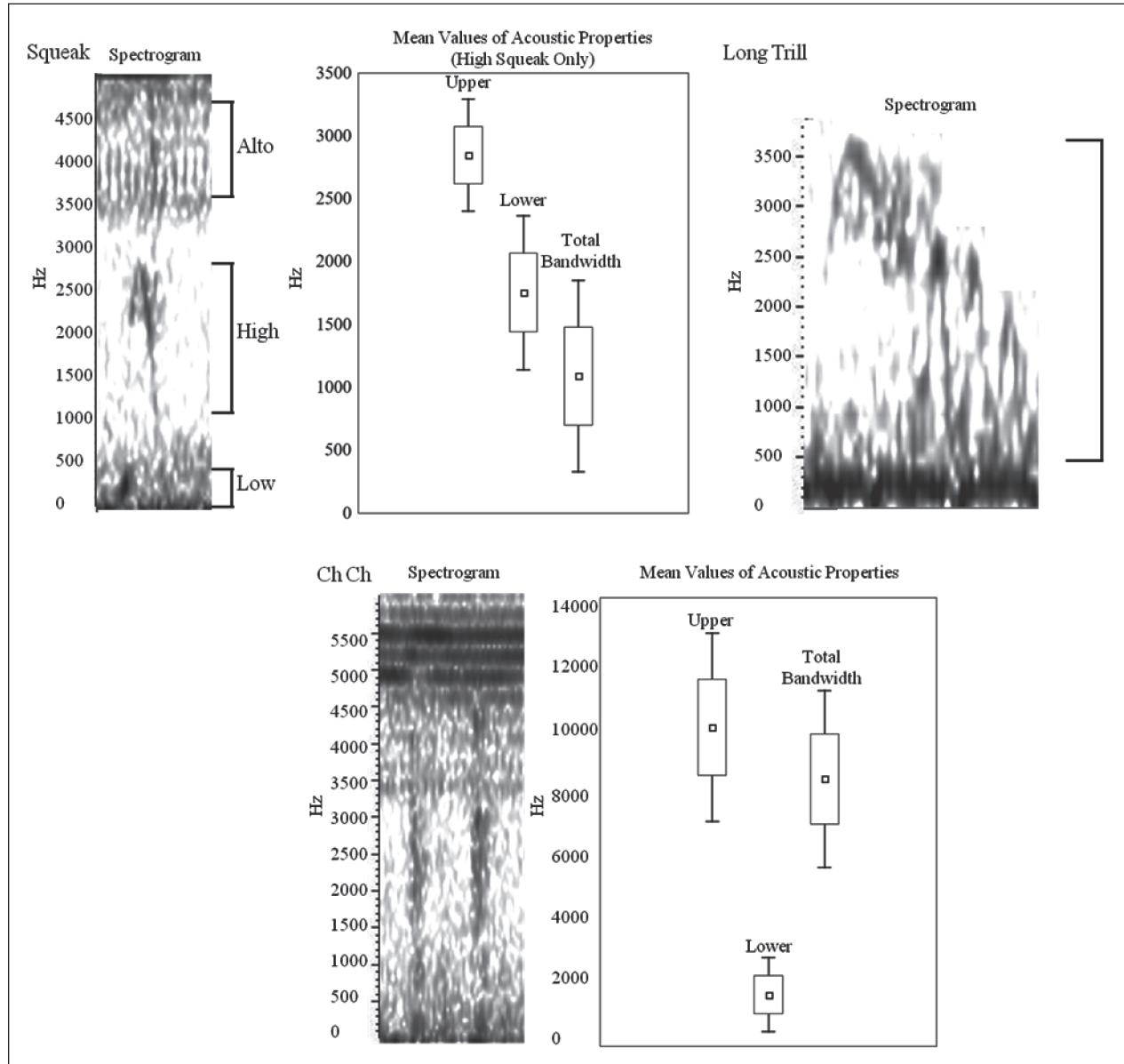


Figure 1. Spectrogram images (left) and frequency distribution of calls (right) for three described calls: Twitter (High), Ch Ch, and Long Trill. Frequency distributions represent upper frequency range (A), lower frequency range (B), and bandwidth (C) for each call. Box and whisker represent mean, 1 standard deviation, and 2 standard deviations. For squeak, only low, high, and alto spectrograms are shown. Ch Ch calls shown as common pair.

Methods

Bioacoustic recordings were collected from eleven *A. nigriceps* groups ranging in size from 2-5 individuals. Sampling occurred April-May 2016, October-November 2016, and April 2017, for a total of twenty-eight days at Villa Carmen Biological Station ($12^{\circ}53'39''S$, $71^{\circ}24'16''W$) and nine days at Manu Learning Center (CREES) research station ($12^{\circ}47'22''S$ $71^{\circ}23'32''W$) - both in premontane rainforest. Seven groups were sampled Villa Carmen and four groups at CREES, both located on the edge of Manu National Park buffer zone in the Peruvian Amazon. Villa Carmen has a long history of development, ecotourism and agriculture. Sampled areas were largely dominated by secondary forest. At CREES, groups were sampled in areas of rainforest regeneration.

Groups of 2-7 researchers searched for night monkey groups from 5:30-7:30 am and 5:30-7:30 pm, times when *A. nigriceps* groups are known to be active near their nesting sites. Two recordings took place before 5:30 am, when researchers left the field station early to visit more distant night monkey groups. Additional vocalizations were heard during the day, though none were included in this study. A Zoom H1 Handy Recorder was coupled with a RØDE NTG-2 condenser shotgun microphone and shoe shockmount on a micro boompole. Recordings were collected at a sampling frequency of 48 kHz at a distance varying from 2-25 m. Certain groups were sampled more extensively than others, due to logistic feasibility. When feasible, behaviors associated with vocalizations were categorized into three activities: resting, traveling, or feeding. All calls were compared to the three previous

Aotus studies (Andrew 1963; Moynihan 1964; Sri Kantha et al. 2009). Audio recordings were analyzed using the spectral audio program Raven Pro 1.5 Sound Analysis Software (Cornell Lab of Ornithology Bioacoustics Research Program, Ithaca, New York). Duration of calls, dominant and fundamental frequencies, high and low frequencies, and total bandwidth were then measured. Amplitude was not analyzed because we could not control for size or age of individuals. All recordings were conducted non-invasively, minimized impact on behavior, and avoided excessive disturbance, and the research was therefore deemed exempt from the Institutional Animal Care and Use Committee approval. All research adheres to the principles for the ethical treatment of primates set forth by Neotropical Primates. Audio files analyzed during the current study are available from the corresponding author on reasonable request through ResearchGate.

Results

Three distinct calls were identified in our study, including the Twitter ($N=165$), Ch Ch ($N=122$), and Long Trill ($N=3$) (Figure 2). In a limited number of cases, we were able to note an associated behavior with calls. Of 46 High Twitter calls, 47.8% took place while the individual was traveling and 52.1% of calls took place while resting. Of 19 Ch Ch calls, 36.8% were associated with travel, and 63.2% with resting. No behaviors were recorded during the Long Trill.

Table 2. Acoustic properties of three calls in wild black-headed night monkeys, *Aotus nigriceps*. The squeak is characterized by a fundamental frequency (low), and dominant frequency (high).

Call Type	Bandwidth (Hz)	Mean Duration (msec)	Description
Twitter			Similar in structure of Twitter described by Andrew (1963), though additional harmonics described here.
Ultra	3562-4808	49	
Alto	3666-4140	20	
High	1755-2847	43	
Low	191-553	21	
Ch Ch	1611-9961	183	Similar to Gulp described by Kantha et al. (2009); however, this name does not correspond with the Gulp described by Moynihan (1964) which has a much lower frequency (<1000 Hz). Therefore, we have renamed to reflect a new call type.
Long Trill	470-3046	170	Similar to original Trill described by Andrew (1963) and the Scream described by Moynihan (1964). There are some structural differences which is why we refer to it as the Long Trill

The Ch Ch call is similar to the Gulp described by Kantha et al. (2009); however, this name does not correspond to the Gulp described originally by Moynihan (1964). Therefore, we have renamed the call as an onomatopoeic description, Ch Ch. The Ch Ch call was recorded as two closely paired repetitive sounds in ten out of eleven groups (84.4% of measured cases), a Ch Ch Ch (triplet) in four groups (14.8% of measured cases), and a Ch Ch Ch Ch (quadruplet) in one group (0.01% of measured cases). Only four groups at Villa Carmen exhibited a triplet Ch Ch, and a group at CREES produced the call in a quadruplet. The Long Trill is



Figure 2. Photo of the black-headed night monkey, *Aotus nigriceps*. Photo credit: Jessica A. Suarez.

The Twitter was named after the similarly structured Twitter call described by Andrew (1963), though measurable differences exist in number of harmonics and bandwidth (Table 2). The Twitter was found in all but one group and had up to 3 additional harmonics beyond the fundamental frequency (191-553 Hz), ranging from a mean of 1,755–2,847 Hz (High), to 3,666–4,140 Hz (Alto), to 3,562–4,808 Hz (Ultra). The low fundamental frequency and high dominant harmonic were always present in the Twitter, whereas the Alto and Ultra were only found in single groups at Villa Carmen. The mean bandwidth of the Ch Ch call was 1,611–9,961 Hz with a mean duration of 183 msec.

named in part after the Trill described originally by Andrew (1963), though structurally there are differences. Namely, in our study the call descends in frequency, whereas there is an oscillation around 3,500-5,000Hz in *A. lemurinus*. The Long Trill is also found primarily between 3,500-5,000HZ, whereas our study had a higher frequency around 3,000HZ. There were several instances of the Long Trill, but only in two groups found at Villa Carmen Biological Station. However, only a single instance had a clear spectrogram that could be used for analysis due to the complexity of the acoustic landscape at that particular frequency.

Discussion

No known studies have assessed the bioacoustics of any wild *Aotus* species. Furthermore, no studies have analyzed *Aotus nigriceps* vocalizations, even in captivity. This study describes three calls in *A. nigriceps* (Twitter, Ch Ch, and Long Trill), though continued field research may reveal additional calls. Thirteen other calls have previously been described in *A. azarae* and *A. lemurinus*, which suggests that the vocal repertoire of *Aotus nigriceps* is likely larger than described here. However, captive settings allow researchers to control for background noise and to elicit calls in response to experimental stimuli, which may increase the number of calls found in captivity compared to a wild setting. Bioacoustic information in wild primates is also likely to be different than those in captivity because of their capacity to adjust calls in an environment filled with background white noise from both biotic and abiotic factors (Brumm et al. 2004). For example, the frequency range of captive *Aotus* species was previously reported to be 140–5,800 Hz; however, some of our calls peaked at 13,612 Hz (e.g., Ch Ch), and all but one call fell within the previously reported range. This could be an adaptation to a much more crowded acoustic environment, where other organisms use a similar bandwidth (Ey and Fischer 2009). We report initial findings of behavioral associations with vocalizations, though caution must be taken in interpreting these results since the majority of behaviors couldn't be documented due to dense foliage or total darkness. Our continued research includes aspects of intra- and inter-group variability, geographic variability, inter-species diversity, and behavioral playback experiments in wild *Aotus nigriceps* populations.

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NEW RECORDS OF THE BLACK TITI MONKEY (*PLECTRUOCEBUS CINERASCENS*) (PRIMATES, PITHECIIDAE) IN THE ALTO VALE GUAPORÉ BORDER REGION BETWEEN BRAZIL AND BOLIVIA

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Introduction

The black titi monkey, previously classified as *Callicebus cinerascens* (Spix, 1823), from molecular evidence is currently included in the genus *Plecturocebus* (Byrne et al., 2016). Has a gray coat over almost all the body with a contrasting brown patch on the back. It feeds on fruits, leaves, insect and seeds. It inhabits dry land environments, Campinarna (forest fragments with poor, rocky, shallow soil and a mix of trees and bamboo), secondary forests and relatively open areas. Its known distribution is still imprecise due to the limited number of records for the species (Veiga et al., 2008). Current knowledge about *Plecturocebus cinerascens* distribution indicates occurrence in the Madeira-Tapajós interfluviums (Noronha et al., 2007), with records on the left bank of the Juruena River, the region of the headwaters of the Roosevelt River, the right bank of the Cabixi River, the right bank of the Alto Guaporé River among municipality of Vila Bela da Santíssima Trindade and Pontes e Lacerda, and within the Juruena-Teles Pires interfluviums (Sampaio et al., 2012). The western limit may be the municipality of Pimenteiras do Oeste, in the middle of the Vale do Guaporé, in the state of Rondônia, Brazil (Gusmão and Costa, 2014). The species is considered endemic to Brazil.

For this poorly known species (Sampaio et al., 2012) with an imprecise distribution delimitation especially in relation to its southern and southeastern limits (Veiga et al., 2008), new record reports are extremely important. The present study presents four new observations of *P. cinerascens* in the

region of Alto Guaporé, in the municipality of Comodoro, Mato Grosso state, Brazil.

Study area

The observations were carried out in two different sample sites, in the region of Alto Guaporé, municipality of Comodoro, western Mato Grosso state, Parecis microregion. The first sampling site is in the southwestern portion of the municipality, within the domain of the privately owned Conguape farm, in a Permanent Protection Area. The second sampling site is near the municipal port in Comodoro. The two sites are located in tropical semi-deciduous forest areas (Veloso, 1992), and are separated by approximately 30 km distance. East of the sites are the indigenous lands of the Vale do Guaporé and Nambikwára. Both sites connect to the right bank of the Guaporé River, in a border region with the Noel Kempff National Park in Bolivia.

Sampling

The observations of *P. cinerascens* were carried out *ad libitum*, by means of walks made in preexisting tracks in the two sampling sites, during an inventory of birds. For the observations, we used Bushnell legacy 8x40 binoculars and the photographs were with a camera Canon 7D with a lens of 100x400mm. The species identification was made through comparing with illustrations, photographs, and descriptions in the literature by Van Roosmalen et al. (2002), Veiga et al. (2008) e Sampaio et al. (2012).

Results and discussion

The black titi was observed three times at sampling site 1. The first recording took place on July 24, 2015 around 5:00 pm with two individuals photographed in the canopy of a tree approximately 50 meters from the right bank of the Guaporé River ($13^{\circ}47'44.52''S / 60^{\circ}27'55.31''W$). The second recording was performed on July 28, 2015 around 10:00 am, through visual and auditory contact with two individuals, where one was photographed ($13^{\circ}45'32.98''S / 60^{\circ}25'8.23''W$). The third record was from July 29, 2015, around 10:00 am, when two individuals were photographed (individuals 1 and 2) and observed foraging in the canopy of a tree ($13^{\circ}45'22.98''S / 60^{\circ}25'11.97''W$) (Fig. 1). The first photograph of the species in the wild was presented by Sampaio et al. (2012), and so far, no new images from wild animals have been published. Here we present two more photos of the species, which may be useful for identifying them in other areas (Figs. 2 and 3). At sampling site 2, the species was recorded through visual contact on August 4, 2015 while two individuals moved through vegetation ($13^{\circ}59'18.48''S / 60^{\circ}15'26.61''W$) (see Fig. 1). This sampling site is threatened due to current deforestation pressure occurring in the region of the municipal port of Comodoro.

Considering the importance of these areas for the maintenance of *P. cinerascens*, it is recommended to develop studies on the conservation status of the species in the region, as well as the implementation of conservation measures aimed at maintaining stable populations, especially at the sampling site 2, since, according with Valeça-Montenegro (2015), the main threats to the taxon are directly linked to the loss of habitat.

These observations help fill gaps regarding the spatial distribution of the species in its southern portion, for which, according with Sampaio et al. (2012), evidence is still meager. The records presented here, added to those of Sampaio et al. (2012) and Gusmão and Costa (2014), constitute the known southern distributional limits of the species (see Fig. 1). The three observations described for sampling site 1 are on the right bank of the Guaporé River at the Brazil and Bolivia border, like the record made by Gusmão and Costa (2014), drawing attention to the possible occurrence of *P. cinerascens* in Bolivia. Factors such as the narrow width and sinuosity of the river in some portions of this area, together with the number of water hyacinths that are carried downstream, may favor the crossing of the species to the left bank of the river, where one of the largest preserved remnants of Bolivia, Noel Kempff National Park, is located.

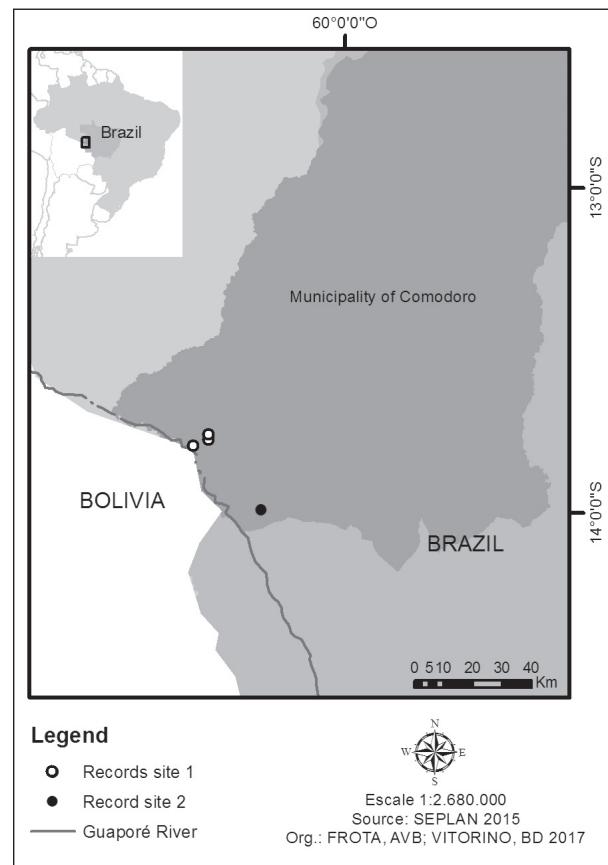


Figure 1. Location of records of *Plecturocebus cinerascens*, in the municipality of Comodoro, the region of Alto Vale Guaporé, Brazil.



Figure 2. Individual 1 of *Plecturocebus cinerascens*, registered in sample site 1, municipality of Comodoro, Mato Grosso state, Brazil.



Figure 3. Individual 2 of *Plecturocebus cinerascens*, registered in sample site 1, municipality of Comodoro, Mato Grosso state, Brazil.

New expeditions are recommended for assessing the status of the species in the region of Alto Vale Guaporé. Incursions that also contemplate the left bank of the Guaporé River, for evaluation of the inference raised here are stimulated.

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these roads cross protected areas, such as in the Amazon National Park, they can cause a considerable impact on populations (Gumier-Costa and Sperber, 2009; Murali Krishna *et al.*, 2013). Primate roadkill has rarely been recorded because the concern for monitoring fauna roadkill has developed only recently in Brazil (Cáceres *et al.*, 2010; Garbino, 2011; Gumier-Costa and Sperber, 2009; Secco and Bager, 2014).

The tassel-eared marmoset (*Mico humeralifer*) is a neotropical primate in the Callitrichidae family. Its occurrence is restricted to the Amazon, in the area south of the Amazon River and west of the Tapajós River, in the States of Pará and Amazonas. In this area between rivers, their presence is registered in three major conservation units: one with full protection, the Amazon National Park; and two for sustainable use, the Tapajós-Arapiuns Extractive Reserve and Amana National Forest. *Mico humeralifer* was categorized as of “least concern” (LC) in the latest assessment of threatened species (Buss and Ravetta, 2015).

The Amazon National Park has 1,084,895 ha and is situated in western Pará State (Figure 1a). It is transected by the Trans-Amazonian Highway (BR-230) in the Itaituba – Jacareacanga stretch, which is unpaved, 112 km long, and has little vehicular traffic (Brusnello *et al.*, 2010). The Park had its boundaries amended by Law number 12 678 of June 25, 2012 (Brazil, 2012). One of the objectives of this amendment was to enable the construction of the São Luiz Hydropower Plant (UHE), which will cause flooding in the southern part of the Park reaching stretches of the BR-230 highway (Fig. 1a). In addition to all the negative impacts related to habitat alteration, this venture should cause an increase in vehicle traffic on BR-230. Despite the existence of the highway and considering the rich fauna of primates in the Amazon National Park (Branch, 1983), there are no published record of primates run over by vehicles in the area (Brusnello *et al.*, 2010).

Observations and discussion

In August of 2010, we found a male tassel-eared marmoset (*Mico humeralifer*) (Fig. 1b) that died from being run over on the BR 230 Trans-Amazonian Highway, inside the Amazon National Park in Itaituba, PA (04031'26.1"S and 56018'2.2"W-Datum SAD69). Other marmosets were on the same road, at a distance of approximately 70 m from the dead marmoset during its removal by the researchers (Fig. 1c).

Biological material (fur and muscle samples) and some biometric data were collected from the dead marmoset and sent to the National Center for Research and Conservation of Brazilian Primates (CPB/ICMBIO). The animal was deposited in the Emílio Goeldi Museum, in Belém (PA). The animal's biometric data were: 130.68 g weight, 550 mm total length, 220 mm head-body length, 330 mm tail length, and 145 mm chest circumference. The low weight of the

MICO HUMERALIFER ROADKILL IN THE AMAZON NATIONAL PARK, BRAZIL

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Introduction

Roads can have a negative impact on wildlife (Forman and Alexander, 1998; Laurance *et al.*, 2009) and when

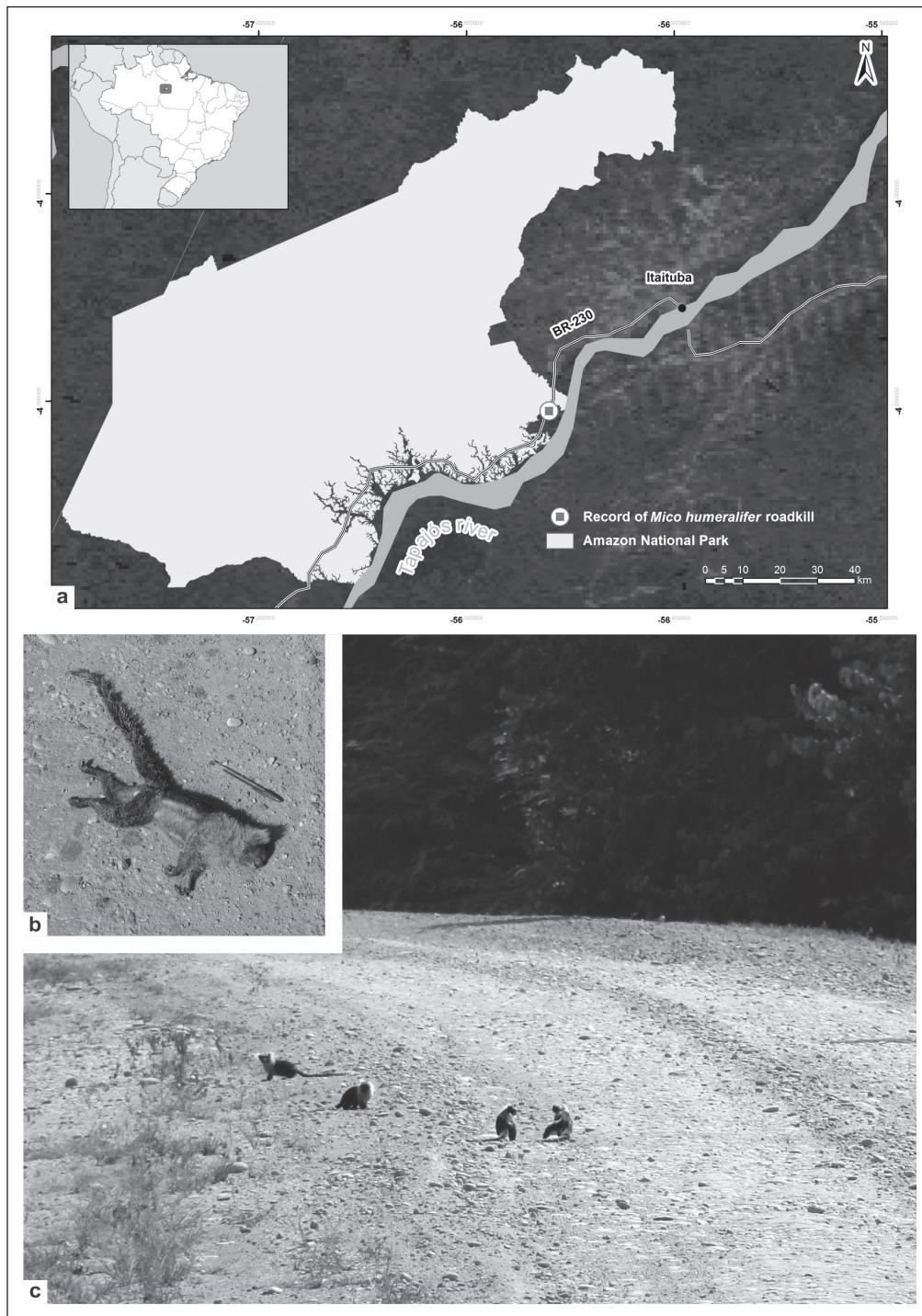


Figure 1. a) Location of the roadkill site of tassel-eared marmoset (*Mico humeralifer*) in the Amazon National Park, Itaituba (PA); b) *Mico humeralifer* trampled inside the Amazon National Park, BR-230; c) Group of *Mico humeralifer* on the edges of the BR-230 highway.

studied animal may indicate young age because the average adult weight is $475 + 42$ g (Muniz *et al.*, 1986). The relative length measurements are within the limits known for the species (200 to 270 mm head-body length and 310 to 370 mm tail length, $n = 10$) (Ferrari, 2008).

One of the factors that may lead groups of marmosets to cross the highway is the search for food, which is a determinant of their behavior (Oates, 1987; Lambert, 1998). The availability of water and overnight shelters also contribute

to highway crossings, exposing these animals to the risk of roadkill. Road crossings are reinforced by the preference of marmosets for areas of secondary forest (Branch, 1983; Rylands and Mittermeier, 2013) because the vegetation on the edge of the road is attractive to the species. Although factors suggest that marmosets could be victims of road accidents, there have been no previous records in the Amazon National Park of trampled marmosets or primates in general, particularly in the road stretch reported here. This lack of records may be related to factors such as the low flow of

vehicles, unpaved road, weak tracking activity of accidents, and high rate of carcass removal by scavengers and carnivorous species.

Considering the impact that highways can have on primates, roadkill is the second most cited impact by specialists because of its potential to adversely affect the local abundance of a species living close to a highway area (Secco and Bagger, 2014). Fauna roadkill incidents in the Amazon National Park can be expected to intensify due to a considerable increase in traffic that should occur with the construction of the São Luiz Hydroelectric Plant. The planned construction of new road sections, related to the formation of the hydroelectric lake, could also strongly impact the primate community. In the Carajás National Forest, for example, Gumier-Costa and Sperber (2009) recorded the roadkill of primates such as *Saguinus* sp., *Alouatta* sp., and *Cebus apella* in a stretch of just 25 km of a paved road with a high flow of vehicles. Therefore, the development of continuous monitoring of roadkill incidents in the BR-230 highway in the Amazon National Park is necessary from the beginning of the hydroelectric plant construction. This monitoring system will contribute to proposed mitigating measures for the impact of increased regional traffic on local wildlife.

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RECENT PUBLICATIONS

BOOKS

Handbook of Primate Behavioral Management, edited by Steven J. Schapiro. Taylor and Francis Group. 545 pp. ISBN: 978-1498731959. This book provides a centralized reference for many issues related to the care and behavioral management of captive nonhuman primates. This comprehensive handbook summarizes and synthesizes this information. One of the principal goals is to highlight and synthesize basic science advances that can be adapted and applied to enhance the behavioral management of captive non-human primates. Content: 1) Introduction to the Handbook of Primate Behavioral Management – Schapiro S; 2) The behavioral management consortium: a partnership for promoting consensus and best practices – Baker KC, Bloomsmith MA, Coleman K, Crockett CM, Worlein J, et al; 3) Rules, regulations, guidelines and directives – Hau J, Bayne K; 4) Behavioral management: the environment and animal welfare – Bettinger TL, Leighty KA, Daneault RB, Richards EA, Bielitzki JT; 5) Variation in biobehavioral organization – Capitanio JP; 6) The role of stress in abnormal behavior and other abnormal conditions such as hair loss – Novak MA, Hamel AF, Ryan AM, Menard MT, Meyer JS; 7) Individual differences in temperament and behavioral management – Coleman K; 8) Depression in captive nonhuman primates: theoretical underpinnings, methods and application to behavioral management – Shively CA; 9) Antipredator behavior, its expression and consequences in captive primates – Caine NG; 10) Future research with captive chimpanzees in the United States: integrating scientific programs with behavior management – Hopkins WD, Latzman RD; 11) Utility of systems network analysis for understanding complexity in primate behavioral management – McCowan B, Beisner B; 12) Positive reinforcement training and research – Graham ML; 13) Positive reinforcement training and health care - Magden ER; 14) The veterinarian-behavioral management interface – Hutchinson E; 15) Social learning and decision making Hopper LM; 16) Collaborative research and behavioral management – Schapiro SJ, Brosnan SF, Hopkins WD, Whiten A, Kendal R, et al; 17) Pairing strategies for cynomolgus macaques – McGrew K; 18) Managing a behavioral management program – Lambeth SP, Schapiro SJ; 19) Behavioral management of *Macaca* species (except *Macaca fascicularis*) – Gottlieb D, Coleman K, Prongay K; 20) Behavioral management of long-tailed macaques (*Macaca fascicularis*) – Honess P; 21) Behavioral management of *Chlorocebus* spp. – Jorgensen MJ; 22) Behavioral management of *Papio* spp. – Lutz CK, Nevill CH; 23) Behavioral management of *Pan* spp. – Reamer L, Haller R, Lambeth SP, Schapiro SJ; 24) Behavioral management of Neotropical primates: *Aotus*, *Callithrix*, and *Saimiri* – Williams L, Ross CN; 25) Behavioral management

of Prosimians – Dye MH; 26) Behavioral management, primate jackets, and related equipment – Woodger T; 27) Nutrition, feeding and behavioral management – Schultz CL; 28) Providing behavioral manageable primates for research – Fernandez L, Griffiths MA, Honess P; 29) Behavioral management of laboratory primates: principles and projections – Bloomsmith MA.

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ABSTRACTS

Resúmenes de ponencias orales del III Congreso de la Sociedad Latinoamericana de Primatología (SLAPRIM), Xalapa, Veracruz, México; 28 de Octubre – 1 de Noviembre, 2017.

Aristizabal, J. F., Rothman, J. M., García-Fería, L. M., Serio-Silva, J. C. Caracterizando la ingestión de proteínas/energía basado en el tiempo y peso: el dilema del consumo en *Alouatta pigra*.

Ayala Camacho, L. M., Vidal-García, F., Serio-Silva, J. C. La conservación participativa como estrategia para preservar el hábitat del mono aullador negro (*Alouatta pigra*), en dos áreas naturales protegidas de México.

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Zaldaña, K., Sánchez, L., Nuñez, G., Gutiérrez-Espeleta, G., Girón, L., Rodríguez, M. Diversidad y estructura genética de *Ateles geoffroyi* en El Salvador.

MEETINGS

41ST MEETING OF THE AMERICAN SOCIETY OF PRIMATOLOGISTS

The 41st meeting of the ASP will be held in **San Antonio, TX, from August 8-11, 2018**, at the Hyatt Regency San Antonio Riverwalk. More information at: <https://www.asp.org/meetings/conference.cfm>

XXVII INTERNATIONAL PRIMATOLOGICAL SOCIETY CONGRESS

The Great Apes Survival Partnership (GRASP) will gather over 800 of the world's leading primate experts, scientists and researchers at the XXVII International Primatological Society (IPS) Congress. GRASP's bid to host the meeting was built upon the theme, 'Global Connectivity to Ensure the Future of Primates,' and proposes to include Nairobi-based UN experts in areas such as climate change, deforestation, sustainable development, and civil conflict, among others, in IPS symposia, workshops and panels. The congress will be held from August 19-25, 2018 at the UN Headquarters, Giri, in Nairobi, Kenya. More information at: <http://www.internationalprimatologicalsociety.org/meetings.cfm>

31ST CONFERENCE OF THE FRANCOPHONE SOCIETY OF PRIMATOLOGY

The 31st conference of the Francophone Society of Primatology will be held from 17-19 October, 2018 at the Musée

de l'Homme in collaboration with the Parc Zoologique de Paris. More information at: http://sfdp-primatologie.fr/IMG/doc/bulletin_inscription_sfhp_2018.doc

46TH WORKSHOP OF THE ASSOCIATION OF PRIMATE VETERINARIANS

The 46th workshop of the Association of Primate Veterinarians will be held from 24-27 October, 2018, in Baltimore, MD. More information at: <https://www.primatevents.org/workshop>

NC3RS PRIMATE WELFARE MEETING

The NC3Rs Primate Welfare Meeting will be held at London, UK on November 15, 2018. This is a unique, international event for sharing best practice in the use and care of non-human primates (NHPs). Typically, this meeting covers the latest developments in NHP husbandry and training, the refinement of scientific procedures, advances in welfare assessment and other topics, with plenty of opportunities for networking with colleagues in NHP research, breeding and management.

PRIMATE SOCIETY OF GREAT BRITAIN WINTER MEETING

The Primate Society of Great Britain Winter Meeting will be held on December 4th and 5th, 2018 at the Bristol Zoo. It is organized by Dr. Amanda Webber. More information at: <http://www.psgb.org/meetings.php>

V CONGRESO COLOMBIANO DE ZOOLOGIA – IV SIMPOSIO DE PRIMATOLOGIA

El IV Simposio Colombiano de Primatología, organizado por la Asociación Primatólogica Colombiana (APC), se desarrollará en el marco del V Congreso Colombiano de Zoología; se enfocará en la divulgación de avances recientes en la investigación y la conservación de los primates en Colombia, y en discusiones sobre los retos actuales para la primatología en el país. Además, durante el Simposio se realizarán reuniones orientadas a la socialización del Programa Nacional para la Conservación de Primates, y actividades destinadas a promover la participación de estudiantes, investigadores y entidades en el desarrollo del mismo. Para más información acceder a: <http://vccz.aczcolombia.org/primatologia/>

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Notes to Contributors

Scope

The journal aims to provide a basis for conservation information relating to the primates of the Neotropics. We welcome texts on any aspect of primate conservation, including articles, thesis abstracts, news items, recent events, recent publications, primatological society information and suchlike.

Contributions

Manuscripts may be in English, Spanish or Portuguese, should be prepared with MS Word, and must use page and line numbering. The full name and address for each author should be included. Please avoid abbreviations and acronyms without the name in full. Authors whose first language is not English should have their manuscripts written in English carefully reviewed by a native speaker. Send all contributions to: Erwin Palacios, Conservación Internacional – Colombia, e-mail: epalacios@conservation.org. Manuscripts that do not conform to the formal requirements (formatting, style of references etc.) will be returned to authors without review. They can be resubmitted, provided all formal requirements are met.

Articles. Each issue of Neotropical Primates will include up to three full articles, limited to the following topics: Taxonomy, Systematics, Genetics (when relevant for systematics and conservation), Biogeography, Ecology and Conservation. Text for full articles should be typewritten, double-spaced with no less than 12 cpi font (preferably Times New Roman) and 3-cm margins throughout, and should not exceed 25 pages in length (including references). Please include an abstract in the same language as the rest of the text (English, Spanish or Portuguese) and (optional) one in Portuguese or Spanish (if the text is written in English) or English (if the text is written in Spanish or Portuguese). Tables and illustrations should be limited to six, except in cases where they are fundamental for the text (as in species descriptions, for example). Full articles will be sent out for peer-review. For articles that include protein or nucleic acid sequences, authors must deposit data in a publicly available database such as GenBank/EMBL/DNA Data Bank of Japan, Brookhaven, or Swiss-Prot, and provide an accession number for inclusion in the published paper.

Short articles. These manuscripts are usually reviewed only by the editors. A broader range of topics is encouraged, including such as behavioral research, in the interests of informing on general research activities that contribute to our understanding of platyrhines. We encourage reports on projects and conservation and research programs (who, what, where, when, why, etc.) and most particularly information on geographical distributions, locality records, and protected areas and the primates that occur in them. Text should be typewritten, double-spaced with no less than 12 cpi (preferably Times New Roman) font and 3-cm margins throughout, and should not exceed 12 pages in length (including references).

Figures and maps. Articles may include small black-and-white photographs, high-quality figures, and high-quality maps. (Resolution: 300 dpi. Column widths: one-column = 8-cm wide; two-columns = 17- cm wide). Please keep these to a minimum. We stress the importance of providing maps that are publishable.

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News items. Please send us information on projects, field sites, courses, Thesis or Dissertations recently defended, recent publications, awards, events, activities of Primate Societies, etc.

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Journal article

Stallings, J. D. and Mittermeier, R. A. 1983. The black-tailed marmoset (*Callithrix argentata melanura*) recorded from Paraguay. *Am. J. Primatol.* 4: 159–163.

Chapter in book

Brockelman, W. Y. and Ali, R. 1987. Methods of surveying and sampling forest primate populations. In: *Primate Conservation in the Tropical Rain Forest*, C. W. Marsh and R. A. Mittermeier (eds.), pp.23–62. Alan R. Liss, New York.

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Napier, P. H. 1976. *Catalogue of Primates in the British Museum (Natural History)*. Part 1: Families Callitrichidae and Cebidae. British Museum (Natural History), London.

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Wallace, R. B. 1998. The behavioural ecology of black spider monkeys in north-eastern Bolivia. Doctoral thesis, University of Liverpool, Liverpool, UK.

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Muckenhirn, N. A., Mortensen, B. K., Vessey, S., Fraser, C. E. O. and Singh, B. 1975. Report on a primate survey in Guyana. Unpublished report, Pan American Health Organization, Washington, DC.

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"Unpublished report" changes to "Relatório Técnico" and "Reporte no publicado" for articles in Portuguese and Spanish respectively.

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