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Front cover: Varied white-fronted capuchin (*Cebus versicolor*). Photo taken at San Juan de Carare, Santander, Colombia. Jessica W. Lynch.

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ARTICLES

HUMAN-MONKEY INTERACTION DYNAMICS AND THEIR DIETARY IMPACTS ON CENTRAL AMERICAN WHITE-FACED CAPUCHINS (*CEBUS IMITATOR*) AT MANUEL ANTONIO NATIONAL PARK, COSTA RICAMeredith Schulte¹, Gustavo Gutiérrez-Espeleta² and Jessica W. Lynch^{1,3}¹Anthropology Department, Washington State University, Pullman WA, USA, e-mail: <mschulte@phoenixunion.org>²Escuela de Biología, Universidad de Costa Rica, San Pedro de Montes de Oca 2060, San José, Costa Rica, e-mail: <gutierrezespeleta@gmail.com>³Institute for Society and Genetics and Department of Anthropology, University of California, Los Angeles, CA, USA, e-mail: <jlynchalfaro@g.ucla.edu>

Abstract

Wild capuchin monkeys are highly adaptable to anthropogenic environments. We assessed how the interaction dynamics between humans and three groups of Panamanian white-faced capuchin monkeys (*Cebus imitator*) in Manuel Antonio National Park, the most visited national park of Costa Rica, affected the feeding behavior and diet of these animals in 2008-2009. On average, individual monkeys acquired 2.4 human food items per focal hour during peak hours of park visitation by humans. Although human visitors directly and indirectly provisioned monkeys in the park, 71 % of monkeys' acquisition of human food items were a result of monkey-initiated interactions (MIIs) rather than human-initiated interactions (HIIs), and adult male monkeys were the most frequent initiators (with 157 adult male MIIs in the study period, compared to 33 initiated by adult females and 84 by juveniles). Adult male monkeys were also the most likely to make direct contact with humans to grab food (35 of 50 direct grabs of food from humans were by adult male monkeys). Adult females acquired food from humans through HIIs at about the same rate as adult males in their group. Secondary acquisition of human food from other monkeys accounted for about one-third of all events of monkey acquisition of human food, and juvenile monkeys had higher median hourly rates than adults in their group to acquire human food through secondary acquisition. Humans frequently offered fruit when provisioning (61.4 % of provisioning events), but monkeys actively acquired fruit, meat, candy, condiments, chips, crackers and dairy items, and only 36.5 % of MIIs were to acquire fruit. Our results suggest that in parks where humans have frequent contact with capuchin monkeys, park regulations should not only prohibit direct provisioning, but require visitors not to bring food into parks. Stronger measures such as fines or park expulsion for those interacting with monkeys might be more effective, and environmental education is necessary as a strategy to inform visitors what to expect from the monkeys and how to avoid accidental provisioning.

Keywords: Ethnoprimateology, tourism, anthropogenic diet, *Cebus capucinus*, gracile capuchin monkeys

Resumen

Los monos capuchinos silvestres son altamente adaptables a los ambientes antropogénicos. Evaluamos cómo la dinámica de interacción entre los humanos y tres grupos de monos capuchinos cariblanco panameños (*Cebus imitator*) en el Parque Nacional Manuel Antonio, el parque nacional más visitado de Costa Rica, afectó el comportamiento alimentario y la dieta de estos animales en 2008-2009. En promedio, los monos individuales adquirieron 2.4 alimentos de humanos por hora focal durante las horas pico de la visita de humanos al parque. Aunque los visitantes humanos provisionaron directa e indirectamente a los monos en el parque, el 71 % de la adquisición de ítems alimentarios de humanos por parte de los monos fue el resultado de interacciones iniciadas por los monos (MII) más que de interacciones iniciadas por los humanos (HII), y los monos machos adultos fueron los iniciadores más frecuentes (con 157 MII machos adultos en el período de estudio, en comparación con 33 iniciados por hembras adultas y 84 por juveniles). Los monos machos adultos fueron también los que más probabilidades tenían de entrar en contacto directo con los seres humanos para tomar alimentos (35 de las 50 tomas directas de alimentos de los seres humanos fueron realizadas por monos machos adultos). Las hembras adultas adquirieron comida de los humanos a través de las HIIs en aproximadamente la misma proporción que los machos adultos de su grupo. La adquisición secundaria de alimentos de otros monos representó alrededor de un tercio de todos los casos de adquisición de alimentos de humanos por parte de los monos, y los monos jóvenes tuvieron tasas horarias medias más altas que los adultos de su grupo para adquirir alimentos de humanos a través de la adquisición secundaria. Los humanos frecuentemente ofrecían fruta al provisionarles (61,4 % de los eventos de provisionamiento), pero los monos adquirían activamente fruta,

carne, dulces, condimentos, patatas fritas, galletas y productos lácteos, y sólo el 36,5 % de los MII fueron para adquirir fruta. Nuestros resultados sugieren que en los parques donde los humanos tienen contacto frecuente con los monos capuchinos, las regulaciones de los parques no sólo deberían prohibir el aprovisionamiento directo, sino también exigir a los visitantes que no traigan comida a los parques. Medidas más estrictas, como multas o expulsión del parque para quienes interactúen con monos, podrían ser más eficaces, y la educación ambiental es necesaria como una estrategia para informar a los visitantes sobre lo que deben esperar de los monos y cómo evitar el aprovisionamiento accidental.

Palabras Clave: Etnoprimatología, turismo, dieta antropogénica, *Cebus capucinus*, monos capuchinos gráciles

Introduction

Capuchin monkeys (*Cebus* and *Sapajus*) are found throughout most of Central and South America. They are highly adaptable to anthropogenic environments and populations can persist alongside humans. As monkeys become more habituated to human food through mechanisms such as crop-foraging or provisioning by humans in parks, human-monkey conflict can escalate due to the combination of increased human presence and increasingly habituated monkeys' bold and direct foraging for human food, together putting both species at risk for injury and disease transmission, as well as for diet-related health consequences in monkeys.

At the time of our study, in the late 2000s, Costa Rica was home to a flourishing ecotourism industry, associated with increased development and habitat fragmentation around primate habitats (Broadbent et al., 2012). Central American white-faced capuchin monkeys (*Cebus imitator*) experienced intense contact with humans and access to human food at Manuel Antonio National Park (MANP). Tourist groups brought large amounts of food into the park to consume at the beach or picnic tables, so capuchins had access to a wide variety of human foods in addition to their natural diet. Previous studies about capuchin use of human resources found they will consume diverse human foods, from fruit to cooked foods, condiments, sweets and dairy products (Sabbatini et al., 2006, 2008; McKinney, 2011; Campbell, 2013). At MANP, Kaufman (2014) calculated that already in 1998, a capuchin group with high exposure to human visitors spent 46 % of its feeding time eating human-resourced foods. However, Kaufman (2014) also noted that capuchins got much of their human food by actively searching through garbage and grabbing food from picnic tables or out of backpacks, rather than from provisioning initiated by humans.

Our study examined which particular human-possessed food resources were acquired by three capuchin groups in MANP in 2008–2009, as well as how often and through what means. We were particularly interested to understand whether monkeys most often initiated interactions involving food with humans, or if it was humans that initiated provisioning of the monkeys. We also aimed to determine what percentage of food-related human-monkey interactions involved physical contact.

While there is an increasing amount of research on the impact of anthropogenic disturbances on primate diet and behavior, many studies of provisioned, semi-provisioned, human-commensal and human-sympatric primates define the categories of primate overlap and interaction in diverse ways (Sabbatini et al., 2006, 2008; McKinney, 2011; Campbell, 2013). A bidirectional approach to categorizing inter-primate interactions adds additional granularity to our understanding of the complex motivations and variations in the way that human and non-human primates engage with each other around food resources in a natural area. In order to understand the human-monkey dynamics of food transfer at MANP, we collected data on human-initiated versus monkey-initiated interactions.

Human-initiated interactions (HIIs) involve humans selecting food for the monkeys to consume based on previous impressions about the diets of “monkeys” as well as what is available to feed the monkeys, while monkey-initiated interactions (MIIs) involve capuchin individuals making diet choices based on the availability of human and natural food items, as well as their own behavioral ecology and diet preferences. A study of black capuchins (*Sapajus nigritus*) in Brazil showed that most interactions between humans and monkeys were HIIs (Fahy, 2013). In contrast in Curú Wildlife Refuge, Costa Rica, nearly all of the interactions that white-faced capuchin monkeys had with humans were MIIs (McKinney, 2014).

Sabbatini and colleagues (2006) performed a survey of visitors at a national park in Brazil where bearded capuchin monkeys (*Sapajus libidinosus*) utilized human foods. From a total of 300 respondents, 64.7 % thought capuchin monkeys had strictly vegetarian diets (Sabbatini et al., 2016). Additionally, when respondents were given a list of potential foods for capuchins and asked to select those that capuchins consume, fruit was the most common food category chosen (45 %), followed by leaves (28 %; Sabbatini et al., 2016). In another study of *Sapajus* sp. in a park in the urban matrix of Foz de Iguaçu, respondents who visited the park reported that they gave the monkeys fruits or cultivated items over 90 % of the time, rather than processed foods, although respondents also mentioned that other people gave a somewhat higher percentage of processed foods, with fruit still as the majority (Suzin, 2015). These findings led to our hypothesis that HIIs would involve fruit at significantly higher rates than other foods.

While capuchin diets do contain a high percentage of fruit, they also contain much more protein and fat than the diets of frugivorous and folivorous primates, due to capuchins' consumption of insects and vertebrate prey (Hladik et al., 1971; Fragaszy et al., 2004). We predicted that human foods with higher protein and fat content would be obtained more frequently by MIIs than by HIIs, as capuchins are likely to prefer these foods while human visitors to the park are unlikely to consider them potential food for monkeys.

Capuchin monkey sex, age, and group characteristics all may affect the frequency and type of acquisition of human food. Studies of white-faced capuchin foraging behavior suggest that adult male capuchin monkeys may show higher rates of MII acquisition behaviors as well as a higher rate of direct contact interactions with humans compared to adult capuchin females. At Santa Rosa National Park, Costa Rica, adult male *Cebus imitator* displayed foraging patterns that involved more opportunistic and higher-risk foraging strategies compared to adult females (Rose, 1994). Adult males have reduced vulnerability to predators compared to female capuchins, due to significant sexual dimorphism (Rose, 1994). Direct contact interactions are high risk interactions for monkeys as they involve extreme proximity to humans, a potential predator and disease carrier. In areas with low human impact, female capuchins rely on a low-risk, stable diet consisting of foraging behaviors that limit exposure to predators and spend less time than males on the ground (Rose, 1994). A study of *Cebus imitator* in Cahuita National Park in Costa Rica where monkeys have access to human food showed that 100% of monkey-initiated human food acquisitions were by adult males, and that all of these MIIs were agonistic (Campbell, 2013).

Juvenile capuchins may be more likely to obtain human resources via secondary acquisition than adults, because juveniles often show more interest in other monkeys' food than adults do (Visalberghi et al., 1998), with the majority of the food interest directed towards adult capuchins rather than other juveniles (Fragaszy et al., 2004; Agostini and Visalberghi, 2005). Juvenile capuchins exhibit greater levels of begging and receive more food via tolerated food transfer than adults (Perry and Rose, 1994).

Monkeys' proactive human food acquisition behavior may vary based on amount of exposure to humans, with capuchin groups that range most often in areas with high human presence more likely to actively acquire food. Here we compare human-resourced food acquisition rates for three different groups of capuchin monkeys with different degrees of exposure to humans. The aim of this study was to investigate the influence of human presence and food-provisioning on the feeding behavior of capuchins in MANP. Specifically, we studied the behavior of three capuchin groups with different levels of interaction with MANP's visitors to assess: (i) the types of human-capuchin interactions observed related to human food acquisition,

(ii) frequency of HIIs compared to MIIs, and whether interactions included direct or indirect contact between monkeys and humans; (iii) the influence of age, sex and group categories on the frequency of interactions and the proportion of interaction types.

Methods

Study site

This study was carried out during a 15-month period (February-August 2008 and January-August 2009) in MANP, Puntarenas province, Central Pacific coast, Costa Rica (Table 1). This park is not only Costa Rica's smallest national park in terms of the land area (1,625 terrestrial ha according to SINAC, Sistema Nacional de Areas de Conservación, in Costa Rica), but it is also the most heavily visited national park in Costa Rica (ICT, 2017), and at the time of the study was receiving between 400 to 1000, or more, human visitors per day; in 2011, MANP had over 300,000 visitors (ICT, 2017) and by 2018 this had increased to over 500,000 visitors annually (ICT, 2017). MANP is home to howler monkeys *Alouatta palliata*, squirrel monkeys *Saimiri oerstedii citrinellus*, and white-faced capuchin monkeys *Cebus imitator* (sensu Rylands et al., 2013; formerly called *Cebus capucinus* or *Cebus capucinus imitator*), and many tourists visit this park to see these primates, although according to a survey of visitors, primates are not the main draw, and could in fact be detractors from visiting the park due to negative monkey-human interactions (Kaufman, 2014).

Capuchin study groups

We collected behavioral data on three *Cebus imitator* groups exposed to varying levels of interaction with humans (Table 1). The high-interaction group HI was composed of 15 individuals that had near daily high-proximity and food-related interactions with hundreds of national and international visitors. The foraging area of HI included a mangrove lagoon, wet tropical forest, the volunteer bunk house and park ranger house and the two most popular beaches in the park (Manuel Antonio and Playa Dos). Facilities included a large picnic area, benches, individual picnic tables outside of the picnic area, and trash cans. The HI group spent several hours almost every day along Manuel Antonio Beach, the picnic areas, and the beach trail, which were often occupied by hundreds of humans.

The low-interaction groups L1 and L2 were composed of 12 and 15 individuals, respectively (Table 1); they each had occasional food-related interactions with smaller numbers of visitors. The foraging area of L1 included a hilly peninsula at the end of the two aforementioned beaches and their steep cliffs, and a loop trail around the perimeter of the peninsula. There were no trash cans or picnic tables in the L1 territory. The ranging area of L2 included part of the mangrove lagoon, an extensive wet tropical forest away from hiking trails and development, as well as the main

trail into the park, two side trails, the houses of volunteers and park rangers, and a small side beach often populated by visitors. There were no picnic tables or trash cans in the territory of L2, but this group occasionally visited the Manuel Antonio beach into HI territory with access to trash cans.

Table 1. Capuchin monkey study group compositions by age-sex classes for focal animal sampling at MANP. Infants were not included as focal subjects and so not included here.

	Adult Males	Adult Females	Juveniles
HI	4	3	8
L1	3	3	6
L2	6	4	5

Capuchins were identified individually using facial features, hair color and length, scars, birthmarks, and body size. Using body size, genital traits, and behavior we classified the focal individuals in three main age-sex classes: adult males, adult females, and juveniles. Due to the difficulty in sexing juvenile capuchin monkeys (Carosi et al., 2020), they have not been separated by sex in our analyses. Infants were not included in the study as focal subjects because they did not forage on their own or interact with humans.

Behavioral data collection

Due to park regulations, researchers only had access to MANP during 'open hours', 9 a.m. to 4 p.m., except for Mondays, when the park was closed to visitors, but the researchers were allowed to visit during the same hours. This meant that researchers would have to find the monkey groups each day, often with help from park guides or rangers. Some areas of the park were inaccessible due to the lagoon and surrounding vegetation. For this reason, data collection was biased towards afternoon hours.

Behavioral data were collected by author M.S. and field assistants between 9 a.m. to 4 p.m., upon finding the groups for the day, using 10-min focal animal sampling at 15-min intervals (Altmann, 1974), collected specifically when the monkeys were in general proximity to humans, in order to capture human-monkey interactions. Focal animal samples alternated through individuals in different age-sex categories. Within each focal sample *ad libitum* data were collected on all social, human interaction, and human resource acquisition behaviors. Focal samples were discarded if the individual was not visible for more than two scan samples. Inter-observer reliability between the primary investigator (M.S.) and field assistants was tested by performing simultaneous focal samples on the same animal and determining a percentage of discrepancies based on total discrepancies observed and total behaviors recorded.

Human resource acquisition bouts were categorized in the following ways, based on observational data collected *ad libitum* during the early days of the study prior to the onset systematic focal animal follow data collection:

Monkey-Initiated Interactions (MIIs)

Direct Grab: the taking of human resources directly from a person or from a bag/object being held or worn by a person. This included grabbing food items out of a person's hand, grabbing plastic bags containing food out of a person's hand, charging a person with a threat face until a food item was dropped due to fear and then collecting the food item, jumping on a backpack that was being worn, or otherwise directly removing a human resource from a person who was not offering the food item to the monkey at that time.

Indirect Grab: the taking of human resources from a person when the resources were not in the person's direct possession. This included taking items from unattended backpacks or off of unattended towels, or from tables when the food was not in someone's personal possession. This also included grabbing food items out of trash bags on someone's towel. To be classified as an indirect grab, it needed to be clear that the human possessor of the food did not put the food out intentionally for the monkey to take, indicated by surprise or anger when the monkey obtained the food, or an attempt to discourage the monkey from eating or taking the food.

Human-Initiated Interactions (HIIs)

Direct Provisioning: the food item was given directly by a human to a monkey, through hand-to-hand or hand-to-mouth provisioning. To be considered direct provisioning, it must be clear that the human offered the food to the monkeys and was not simply holding food they intended to consume themselves. To be counted as direct provisioning the monkey had to accept the offered food item and taste, lick, bite or consume the food item.

Indirect Provisioning: the food item was offered from a human to a monkey by the human placing it in close proximity to a monkey or monkeys. This often consisted of humans setting pieces of food on a branch, table, or trash can surrounded by monkeys, or throwing a food item towards the group of monkeys. It could be distinguished from indirect grabs in that the provisioner did not express surprise or anger at the monkey taking the food, and there were attempts to encourage rather than discourage acquisition and consumption. It had to be clear that the provisioner intended for the monkeys to eat the food, and the monkey had to taste, lick, try or eat the food, to be classified as provisioning.

Secondary Acquisition: the acquisition of human food resources by one monkey from another monkey in the group. Secondary acquisition happened when one monkey obtained a food resource via one of the above means, and either tolerated a direct grab of pieces of the food item while still in its possession, or, discarded all or part of that resource allowing other monkeys to indirectly scavenge the remains.

Acquisition of a food item was counted once per focal sample per food type and acquisition method. For example,

being fed or grabbing a bag of cookies was counted as one provisioning incident or one grab regardless of how many cookies are eaten, or if the bag was dropped and picked back up by the same individual. However, a direct grab of a bag of cookies followed by a direct grab of a sandwich during one focal sample would be considered two direct grabs. Also, direct provisioning from a bag of chips followed later by a direct grab of that bag of chips was considered both a direct provisioning and a direct grab.

Data Analyses

Behavioral rates were calculated for each focal individual by taking the total number of times the behavior occurred for that individual divided by the total number of focal 'feeding near human' hours for that individual, calculated through summing 10-minute focal samples. Behavioral rates were calculated for age and sex classes within groups and are presented as medians (Quartile 1 – Quartile 3 (Interquartile range)) with outliers depicted in the figures. Calculations were performed using R software.

Results

Our study included a total of 240 observation days; during the 156 days of quantitative data collection we collected 251.5 focal 'feeding near human' hours across all three groups, with 97.33 focal hours for HI, 83 focal hours for L1, and 71.17 focal hours for L2. A total of 85.83 focal hours of data were collected for adult males (AM), 81.67 for adult females (AF), and 84 for juveniles (JU). Inter-observer reliability was confirmed at more than 95 % between the principal investigator (MS) and each field assistant prior to including any focal follow data from that field assistant in the study.

Types of human food acquired

Human food obtained by monkeys was classified into the following categories (Table 2): fruit, bread, chips, meat, cookies, candy, crackers, dairy, condiments, and 'other', which included coconuts (young green coconuts were sold outside the park for visitors to drink the coconut juice—they had a small hole sliced in the top for a straw; monkeys put their hands into the hole to scrape the meat off the inside of the coconut). Overall, human food items were acquired by monkeys at a rate of 2.4 items per focal hour, but the rate of human food acquisition varied widely by capuchin group: individuals from HI group acquired 4 human food items on average per focal hour, while L1 acquired 1.4 items and L2 acquired 1.2 items per focal hour. An overview of the different types of acquisition that occurred in the study and median individual hourly acquisition rates per group is depicted in Figure 1.

Table 2. Total occurrence of capuchin food acquisition of human food in this study. Numbers indicate total number of times a monkey in a focal animal follow gained possession of a human food resource, including direct or indirect acquisition from humans, as well as secondary acquisition.

Food Type	HI (97.3 hrs)	LO1 (83 hrs)	LO2 (71.2 hrs)	Total (251.5 hrs)
Fruits: bananas, mangos, apples, pineapple	175	78	41	294
Bread: Sliced white bread, baguettes, sometimes with mayonnaise	50	17	18	85
Chips: Tortilla chips, potato chips, cheese puffs	32	8	0	40
Meat: fried chicken, sliced lunch meat, hot dogs	35	3	1	39
Cookies (processed and packaged)	24	5	9	38
Candy: sour gummy candies, caramels, chewy candies	21	3	5	29
Crackers: cheese crackers, soda crackers, wheat crackers	16	2	2	20
Condiments: mayonnaise, ketchup	18	0	1	19
Other: flavored granola bars, cut whole coconut, unknown	11	1	7	19
Dairy: milk, cookie flavored milk, American cheese	7	0	3	10
Total items acquired	389	117	87	593
Mean overall rate of human food item acquisition per focal hour	4	1.4	1.2	2.4

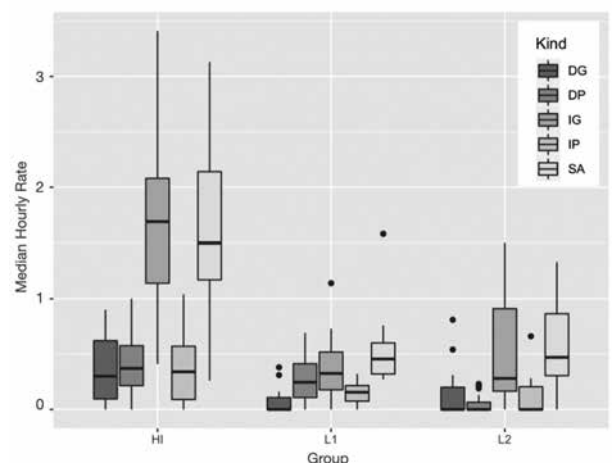


Figure 1. Median hourly rates (with quartiles and outliers) that human food was acquired by individuals during focal follows for each of the three monkey groups in the study (HI, L1, L2), separated by type of food acquisition (from left to right for each group: DG = Direct Grab, DP = Direct Provisioning, IG = Indirect Grab, IP = Indirect Provisioning, SA = Secondary Acquisition).

We expected that humans would be more likely to provision monkeys with fruit compared to non-fruit items. In fact, 70 out of 114 HIIs were with fruit (61.4%), whereas only 100 out of 274 MIIs were for fruit (36.5%). The most common non-fruit food item provisioned by humans to monkeys was bread (21.9% of HII events). In contrast, meat, candy, condiments, and dairy items were rarely or never offered by humans, but all of these were taken on many occasions by monkeys, especially in the HI group.

All three monkey groups accessed both fruit and non-fruit food items from humans, but at different rates. When taking into consideration both primary and secondary acquisition of foods by the monkeys, on average, HI group members acquired fruit in 3.13 bouts per focal hour, and non-fruit at 1.74 bouts per focal hour; L1 accessed fruit at 0.90 and non-fruit at 0.40 bouts per focal hour, and L2 accessed fruit at 0.38 and non-fruit at 0.86 bouts per focal hour. Some individual monkeys' acquisition of human-sourced food items strongly skewed toward fruit, while other monkeys ate far more non-fruit than fruit items from humans, although most monkeys acquired a mix of fruit and non-fruit resources.

For direct contact interactions, 63 of 114 were fruit (55.3%), whereas indirect contact interactions included fruit 107 of 274 times (39.1%). Bread, chips, cookies and crackers were the most common non-fruit items monkeys acquired in indirect interactions. Secondary acquisition of human food from other capuchin monkeys was an important mechanism, accounting for more than one-third of all human-food acquisition events observed (206 out of 593 events). Secondary acquisition was biased slightly toward nonfruit items (89 fruit events, 117 non-fruit events). The preference for secondary acquisition of non-fruit items over fruit items was most marked in the HI adult females, who acquired 23 non-fruit items but only two fruit items from other capuchin monkeys during focal follows in the study.

Resources provisioned to the monkeys through HIIs were always unwrapped or peeled by the humans, and offered ready to eat, while food that was grabbed by monkeys often had to be extracted from a bag, box, backpack or wrapper. Provisioning rarely involved travel on the ground, as food was often placed on trees, branches, tables, or directly into the hand of the monkey. In contrast, in MIIs, monkeys directly approached humans, jumped onto their backs to rummage through backpacks, or went to the ground, for example to grab food from backpacks set on towels at the beach.

One juvenile monkey appeared to use deception to manipulate other group members, so he could grab human food from the ground. He stood on a low branch, looking towards a bag of cheese-flavored tortilla chips on the ground, while five group mates foraged on the ground nearby. He emitted an alarm call and the other monkeys jumped and ran up into the trees, performing vigilant

warning behaviors. Immediately the juvenile jumped to the ground, ran to grab the chip bag, and carried it with him into the trees.

Group effects on human food acquisition

The group with the greatest exposure to human visitors (HI) showed the highest number of and the highest relative proportion of MIIs and direct interactions for human food acquisition. Acquisition of human resources by HI group was seen on 81.5% of observation days (note that on Mondays the park was closed to visitors; therefore, the monkeys were acquiring food from humans on almost every day that the park was open). Food acquisition behaviors included charging and threatening humans in possession of food; mobbing picnic tables where food was laid out; jumping onto individuals' backpacks and bags while they were being worn or carried; opening bags, backpacks, or other items on towels left unattended; opening "monkey-proof" trash cans to forage for scraps; picking up leftovers found on the ground; and being fed both by hand by visitors and indirectly by visitors who placed food on branches, tables, or trash can lids in front of monkeys.

In contrast, acquisition of human resources by L1 group was seen on 13.2% of observation days and for L2 group on 12%. The overlap in L1 and HI's home ranges included two smaller side beaches that were frequently populated by human visitors; this area was disputed frequently in intergroup encounters between these two groups. L1 interacted with humans when its ranging patterns crossed the trails on the peninsula several times per day, and occasionally when it traveled to one of the side beaches. On the beaches, L1 monkeys occasionally opened unattended backpacks and bags, and on trails they sometimes grabbed food being consumed by hikers, or they were provisioned by visitors. L2's interactions with humans occurred primarily along the trails, with occasional provisioning and grabbing of bags held by tourists or food carried by tourists, and some incidences of jumping onto worn backpacks, particularly by one young male. When L2 was on the beaches in its home range the monkeys sometimes explored bags, backpacks, and other items on towels that were unattended.

Sex and age differences in human food acquisition

As overall group acquisition rates for human food were significantly different from each other, we kept data separated by group in the subsequent analyses. Within each of the three study groups, on average adult males engaged in a higher median rate of food acquisition from humans and a higher proportion of MIIs to HIIs for primary human food acquisition than did adult females or juveniles (Fig. 2). The majority of adult male utilization of human resources in MANP were the result of grabs and indirect provisioning. Adult males for each group performed more indirect grabs than adult females for that group but, did not successfully acquire significantly more indirect provisioning items compared to adult females in their group. Within groups, on average adult females did not show large differences in

rates of MIIs compared to HIIs, or in indirect versus direct contact interactions. Juveniles in the HI group were more likely to initiate interactions to acquire food and, did so at a median rate of 2.46 times per focal hour, compared to juveniles in the low exposure groups, who performed successful MIIs much less frequently (LO1: 0.16; LO2: 0.30 times per focal hour).

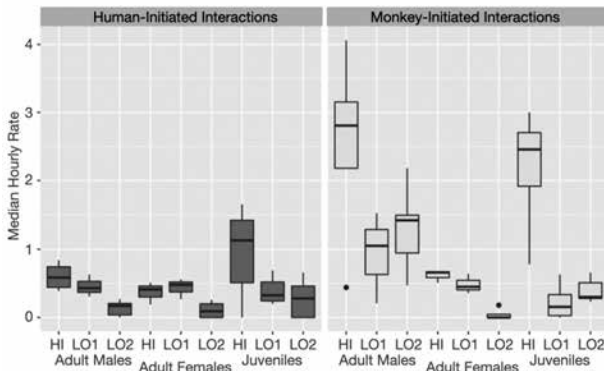


Figure 2. Median hourly rate (with quartiles and outliers) of human-initiated interactions (dark grey boxes) and monkey-initiated interactions (light grey boxes) during focal follows that led to primary monkey acquisition of human food resources, by capuchin age, sex and group membership.

When comparing frequency of interactions with direct versus indirect contact, all age-sex classes in all groups had more indirect interactions than direct interactions with humans. However, the median frequency of both direct contact and indirect contact with humans was significantly higher for adult males and juveniles of the high contact (HI) group compared to other age-sex-group categories (Fig. 3).

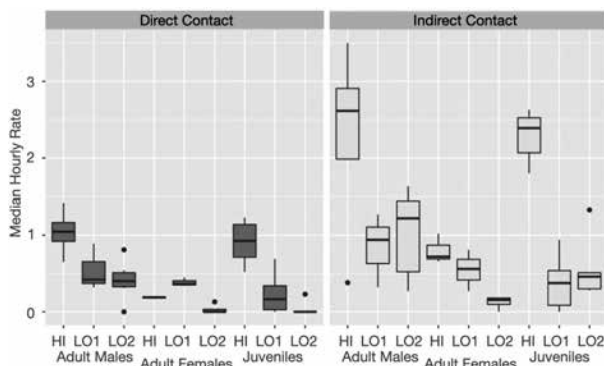


Figure 3. Median hourly rate (with quartiles and outliers) of direct contact (dark grey boxes) and indirect contact (light grey boxes) during focal follows as the means of primary acquisition of human feeding resources, by capuchin age, sex, and group membership.

Secondary acquisition of human food

Secondary acquisition made up a substantial proportion of all human food attained in capuchin monkeys' diet, for all sex-age classes. The HI group had a higher median hourly rate of secondary acquisition per focal hour (1.5 acquisitions) compared to the other two groups (LO1=0.46, LO2=0.47). In each group juveniles had higher median

rates of secondary acquisition of resources than their adult counterparts (Fig. 4).

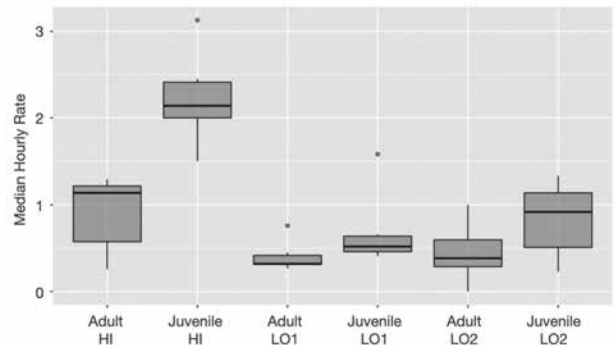


Figure 4. Median hourly rate (with quartiles and outliers) of secondary acquisition of human feeding resources, when one monkey acquires the human resource from another monkey, by capuchin age class and group membership.

Discussion

Understanding how white-faced capuchins utilize human resources is a key step in being able to manage and prevent conflict between humans and monkeys where park visitors have the opportunity to interact with wild monkeys. Preventing escalating monkey-human conflicts over human-sourced food is essential not only to protect the integrity of the local ecosystem and health of the monkey population but to ensure a truly sustainable ecotourism economy (Krüger, 2005; Webb and McCoy, 2014). Our results suggest that monkeys in MANP in our 2008-2009 study period initiated the majority of interactions to access human food. While MANP park regulations at the time focused exclusively on preventing tourists from provisioning the monkeys directly, our findings showed that the primary issue driving capuchin consumption of human food was capuchin access to human food, particularly for adult male and juvenile capuchins. Direct provisioning, although part of the habituation process, represents a relatively less frequent means by which capuchins obtain human resources. It is currently unknown whether indirect access to human food precedes monkey willingness to accept food directly from humans or whether direct feeding by humans is the initial driver toward human-food seeking behaviors in monkeys. However, the indirect access to human food not intentionally facilitated by humans was a large proportion of the human food consumed by monkeys in this park, and reducing that access is essential for managing the monkey consumption of human resources. We suggest that prevention of access to human resources within parks with a high volume of visitors should be expanded beyond regulations restricting direct provisioning, including using more effective monkey-proof trash cans, limiting human food consumption to an enclosed area, or restricting visitors from bringing food into the parks. We also suggest that stronger measures, such as fines or expulsion from park for those interacting with monkeys, might be more effective, and that environmental education is necessary as a strategy to

inform people what to expect from the monkeys and how to avoid accidental provisioning.

In fact, in the years after our study, MANP has enforced stricter regulations, in which visitors are not allowed to bring food in the park, and there are spot inspections to check bags for food at the entrance gate. While this has clearly improved the monkey-human interactions at the park, capuchin monkeys still patrol the beaches looking for food in close contact with humans (JWL, pers. obs.); this suggests that once capuchins are habituated to the possibility of human food as a resource, it is hard to extinguish their interest or habituation to humans.

Adult male capuchin monkeys at MANP initiated more food acquisition interactions and had higher levels of direct contact interactions than adult females in the same group. In white-faced capuchins, males are the dispersing sex, and they often disperse several times during their lifetime, alone or in groups (Jack and Fedigan, 2004; Fedigan and Jack, 2012). This, in combination with males' increasingly aggressive food acquisition techniques, suggests that when habituated males from these groups disperse, they will continue to actively acquire human resources in their new group. Juveniles obtained more of their human resources via secondary acquisition compared to adults, suggesting a route by which dispersing males, who are the most active at grabbing food from humans, will have a significant impact on the diet choices of juveniles in their new groups. The role of social facilitation in the development of capuchin diets means that juvenile capuchins in groups where adult capuchins regularly consume human foods will learn to rely on human foods as a standard part of their diet. This suggests a small window of time for correction and mitigation between the habituation and provisioning of monkeys by humans and the time at which monkey populations view human foods as a central part of their standard diet.

Relatedly, secondary acquisition of human-resourced food occurred in all age-classes and groups in our study. It is important to recognize that human-resourced food items do not only go to the first monkey that acquires them; they also are shared within the capuchin group, potentially affecting diet and health of even those group members that never become strongly habituated to close contact with humans. For example, adult females in the HI group were relatively risk-averse foragers, with lower rates of primary acquisition of human food than adult males or juveniles, but almost all of the food that they acquired secondarily from other group members was non-fruit—in other words, high sugar, high fat content with potential health implications.

Analysis of capuchin groups with different levels of interaction with humans may help researchers understand how acquisition rates change over time as human presence and monkey habituation increase. As expected the group with the highest level of contact with tourists showed a higher proportion of MIIs and direct contact interactions

compared to other groups. MIIs with humans may be contingent on high familiarity with and desire for human resources, indicating enough previous exposure to a particular resource so it no longer provokes neophobia, as well as a perceived value which outweighs the opportunity cost of acquisition (Visalberghi et al., 2003; Fragazy et al., 2004; Agostini and Visalberghi, 2005).

At MANP humans preferentially offered monkeys more 'natural' food items like fruit. However, store-bought fruit often has drastically higher sugar content and lower fiber content than fruits in monkeys' natural diet, such as palm fruit. In addition, monkeys initiated most food interactions and preferred to acquire sugar-dense, salt-dense foods. The types of human foods consumed by the study subjects and the high consumption rate were likely cause of acute health problems such as vomiting and diarrhea observed during the study. The fat, refined sugar, and sodium content of foods such as cookies, candy, potato chips, fried chicken, mayonnaise, and many other foods the capuchins encounter and eat have the potential to cause long-term health problems with reproductive consequences. In addition, the direct contact with humans and increased time spent on the ground retrieving human food may result in higher human-primate disease transmission or parasitic infections. While aggression was not the primary focus of this study, our observations indicated that levels of aggression between monkeys over human food resources was similar to aggression observed over high-fat, high-protein foods in their natural diet, but that human food resulted in intragroup aggression almost daily while high-fat, high-protein natural foods were consumed much less frequently.

Future studies on acquisition of human food by primates should include data regarding all available types of human foods at the study site as well as any incidences of humans unsuccessfully offering food to monkeys in order to better differentiate between opportunistic and preferential foraging. Collecting focal animal data across the waking hours of the primates, not just during visiting hours of parks, or when monkeys were in proximity to humans, would also lead to less biased estimates of human food consumption by primates. Concurrent data collection on natural food item consumption versus human food consumption would also help to distinguish the degree of impact human food had on primate diet in areas where they are exposed to human foods.

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ANTI-PREDATOR BEHAVIOR OF COIMBRA-FILHO'S TITI MONKEYS (*CALLICEBUS COIMBRAI*)

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Abstract

Predation pressure has an important role in shaping the behavioral, ecological and social patterns of primates. In this study, we describe two types of anti-predator behavior performed by Coimbra-Filho's titi monkeys (*Callicebus coimbrai*), and compare our reports with the anti-predator strategies adopted by other Neotropical primates. The reports were performed on a small and isolated Atlantic forest fragment (14 ha) located in a highly-fragmented landscape in north-eastern Brazil. Although the titi monkey group was systematically monitored (July/2009 - August/2012: 1,513 hours) over the years, the events were recorded *ab libitum* method. Four events of anti-predator behavior were reported: three were in response to a medium-sized arboreal primate, the yellow-breasted capuchin monkey (*Sapajus xanthosternos*), and one in response to a large bird, the turkey vulture (*Cathartes aura*). When in the presence of *S. xanthosternos*, the titi monkeys emitted a quiet alert vocalization and descended to the dense undergrowth in order to avoid predation. On the other hand, when the titi monkeys were exploiting fleshy fruit on a tree, they verified the presence of an individual of *C. aura* and jumped to the ground. Both types of anti-predator behavior had been previously described for Neotropical primates. The anti-predator behaviors performed by the titi monkeys can contribute to the understanding of the adaptive processes of these poorly studied primates in fragmented habitats. Moreover, the passive behavior and the habitat characteristics may be an important aspect in the choice of strategy to be used, since the habitat provided adequate refuges and allowed the titi monkeys to seek an alternative escape route.

Key Words: Atlantic Forest, *Sapajus xanthosternos*, *Cathartes aura*, anti-predator strategy

Resumo

A pressão da predação tem um papel importante nos padrões comportamentais, ecológicos e sociais dos primatas. Neste estudo, descrevemos dois tipos de comportamento anti-predadores realizados por indivíduos de um grupo de Guigó-de-Coimbra-Filho (*Callicebus coimbrai*) e comparamos nossos registros com as estratégias anti-predadores adotadas por outros primatas neotropicais. Os registros foram realizados em um pequeno e isolado fragmento de Mata Atlântica localizado em uma paisagem altamente fragmentada na região nordeste do Brasil. Embora o grupo tenha sido sistematicamente monitorado (julho/2009 – agosto/2012: 1,513 horas) ao longo dos anos, os eventos foram registrados de forma *ab libitum*. Foram relatados quatro eventos de comportamento anti-predador: três foram em resposta a um primata arborícola de tamanho médio, o macaco-prego-do-peito-amarelo (*Sapajus xanthosternos*), e um em resposta a uma ave de grande porte, o urubu-de-cabeça-vermelha (*Cathartes aura*). Quando na presença de *S. xanthosternos*, os guigós emitiram vocalização de alerta e desceram até o sub-bosque denso a fim de evitar a predação. Por outro lado, quando os guigós estavam consumindo frutos, eles verificaram a presença de um indivíduo de *C. aura* e pularam para o chão. Ambos tipos de comportamentos anti-predador já tinham sido previamente descritos para primatas Neotropicais. Os comportamentos anti-predadores realizados pelos guigós podem contribuir para a compreensão dos processos adaptativos destes primatas pobremente estudados em áreas fragmentadas. Além do mais, o comportamento passivo e as características do seu hábitat podem ser um aspecto importante na escolha de estratégia a ser utilizada, uma vez que proporcionavam refúgios adequados e permitiam que os guigós buscassem uma rota de fuga alternativa.

Palavras-chave: Mata Atlântica, *Sapajus xanthosternos*, *Cathartes aura*, estratégia anti-predador

Introduction

It is extremely difficult to document predation on primate species due to the low occurrence of events, the difficulty in observing quick predatory attacks, the nocturnal habits of many predators (owls and leopards), the effect

of the presence of human observers to inhibit predation bouts, and therefore the large amount of time and energy needed to obtain these reports (Isbell, 1994). However, predation pressure has an important role in the behavioral, ecological and social patterns of primates (van Schaik, 1983; Cheney and Wrangham, 1987; Stanford, 2002).

This pressure results in specific behavioral responses linked to different types of predators and prey (Ferrari, 2009). Predators or potential predators of primates include hawks (Heymann, 1990; Sherman, 1991; Julliot, 1994; Gilbert, 2000; Vasquez and Heymann, 2001; Deffler, 2004), felids (Olmos, 1993; Novak et al., 2005; Ludwig et al., 2007), other primate species (Sampaio and Ferrari, 2005), and even snakes (Heymann, 1987; Corrêa and Coutinho, 1997; Teixeira et al., 2016). In order to avoid predation, the behavioral response of primates can vary between active (i.e., mobbing, monitoring or alarm calling) and passive (i.e., avoiding, hiding or fleeing) behaviors (Ferrari, 2009).

Anti-predator strategies can be strongly linked to predator type (Edmunds, 1974; Table 1). Practically all predators (or potential predators) of primates demonstrate solitary foraging behavior (Ferrari, 2009). Terrestrial predators such as mammalian carnivores can either engage in astonishing high-speed pursuits in open habitats or can stalk, ambush and pounce to overpower prey (Macdonald et al., 2010; Wilson et al., 2013; Wilson et al., 2013). On the other hand, aerial predators (raptors) tend to use active search or sit-and-wait strategies to pursue and capture prey (see Tables 1 and 2 in Jaksic and Carothers, 1985). Moreover, arboreal predators (primates) seem to have used a “surprise attack or ambush” strategy to capture a small-bodied primate (Albuquerque et al., 2014).

Active anti-predator behaviors may be used to communicate the presence of such surprise-effect dependent predators (terrestrial predators) to conspecifics. In the presence of terrestrial predators, primate behavior can vary between mobbing (*Brachyteles hypoxanthus*: Dias and Strier, 2002; *Cacajao calvus*: Bowler, 2007), ascending up trees (*B. hypoxanthus*: Mendes, 1997), approaching and mobbing (*Callicebus nigrifrons*: Cäsar et al., 2012), or producing alarm calls (*Chiropotes utahicki*: Ferrari et al., 2004). In terms of aerial predators, primates can adopt a combined active/passive anti-predation strategy aiming to avoid predation. When under attack from aerial predators, primates variously produce loud calls and descend within the forest canopy (*Alouatta clamitans*: Miranda et al., 2006), hide and remain vigilant (*A. palliata*: Gil-da-Costa et al., 2003; *Callithrix jacchus*: Bezerra and Souto, 2008), demonstrate mobbing behaviors (*Saimiri oerstedii*: Boiniski 1987), or display piloerection (*Plecturocebus cupreus*: Dolotovskaya et al., 2019). When potential arboreal predators are noticed, primates can flee quickly and hide in vine tangles (*Plecturocebus cupreus*: Dolotovskaya et al., 2019), or moving rapidly, produce alarm call and mobbing vocalizations (*Callithrix jacchus*: Albuquerque et al., 2014). Thus, the anti-predator strategy adopted will depend on the context of each predation event as well as the primate species involved.

Primates that display passive anti-predator behaviors tend to present cryptic pelage coloration, live in small

family groups and maintain strong social structures (Ferrari, 2009; Dolotovskaya et al., 2019). Owl monkeys (*Aotus*) and titi monkeys (*Callicebus*, *Cheracebus* and *Plecturocebus*) are Neotropical primates that possess all these features (Norconk, 2011). Titi monkeys (*sensu* Byrne et al., 2016) are small-bodied primates (*ca.* 2 kg) distributed widely across diverse habitats in South America (Bicca-Marques and Heymann, 2013). They live in small groups comprising a monogamous breeding pair with one to three offspring (Bicca-Marques and Heymann, 2013). They are primarily frugivorous, exploiting alternative food resources such as new leaves and invertebrates during periods of lower fruit availability (Caselli & Setz, 2011; DeLuycker, 2011; Souza-Alves et al., 2011) and use low and middle forest strata (Heiduck, 2002; Chagas and Ferrari, 2010). Owing to behavioral and morphological characteristics (shiny and cryptic pelage), titi monkeys have demonstrated efficient passive anti-predator strategies (Ferrari, 2009).

Here we described two types of anti-predator behavior performed by Coimbra-Filho's titi monkeys (*Callicebus coimbrai*) inhabiting a small Atlantic forest fragment in north-eastern Brazil, and we compare them to the anti-predator strategies adopted by other Neotropical primates. Coimbra-Filho's titi monkeys are a highly frugivorous species; they live in small groups, use low and middle forest strata, inhabit disturbed sites, demonstrate an income breeding strategy, and use the forest floor frequently (Chagas and Ferrari, 2010; Chagas and Ferrari, 2011; Souza-Alves et al., 2011, Souza-Alves et al., 2019), all features that put them at a high risk of predation (Ferrari, 2009). As such, we expected that Coimbra-Filho's titi monkeys would demonstrate different anti-predator behaviors when facing terrestrial, arboreal and aerial potential predators living in fragmented habitats.

Methods and Study Site

Our study took place in a small Atlantic forest fragment (14 ha) at Fazenda Trapsa (11°12' S, 37°14' W), located in the municipality of Itaporanga d'Ajuda, state of Sergipe, north-eastern Brazil. The site is embedded in a mosaic of eight forest fragments varying in their forest structure, size, shape and degree of conservation (Chagas and Ferrari, 2011). The study site is characterized by small trees (mean = 8.3 m) with basal area of 39.5 m², high density of lianas (940 ind/ha) and is classified as being in an early stage of regeneration (Souza-Alves et al., 2018). The predominant botanical families are Fabaceae, Myrtaceae, and Sapotaceae (Souza-Alves et al., 2014). Monthly rainfall level (mm) was collected at the meteorological station of RPPN Caju – Embrapa Sergipe, located 1 km from the study area. During the 11-year period from 2000-2011 the annual mean of rainfall recorded there was 120.9 mm (Semarh, 2017). Köppen's classification characterizes the regional climate as *As* (Tropical zone with dry summer: Alvares et al., 2013).

At the time of the study, the Coimbra-Filho's titi group comprised four individuals, with one monogamous breeding pair, a juvenile and an infant (Souza-Alves, 2010). The subjects were previously well-habituated to human presence (Souza-Alves and Ferrari, 2010). Observations described here were obtained during the behavioral and ecological monitoring of this titi group through scan sampling for five days per month (see Souza-Alves, 2013 for more details). Unusual behaviors, such as anti-predator behavior performed by individuals, were reported using an *ad libitum* method (Altmann, 1974). When in the presence of the predator, we recorded the time of day, predator taxon, and titi monkey behavior during and after the encounter. Here we present data related to anti-predator strategies.

Results

The Coimbra-Filho's titi monkey focal group was observed from July 2009 to August 2012, for a total of 1,513 hours. Four events of anti-predator behavior were reported; three of these were in response to a medium-sized arboreal primate, the yellow-breasted capuchin monkey (*Sapajus xanthosternos*), and one towards a large-sized bird, the turkey vulture (*Cathartes aura*).

The first event took place in July 2009, at approximately 6:30 am, when the Coimbra-Filho's titi group was at one of their sleeping trees (*ca.* 1 m), *Licania littoralis* (Chrysobalanaceae). A group of *Sapajus xanthosternos* composed of 18 to 19 individuals approached quickly and extremely noisily. These factors allowed the members of Coimbra-Filho's titi group to leave the sleeping site quickly. The titi monkeys moved to another tree in order to facilitate their observation of the capuchin monkeys, and one individual emitted a quiet call to alert the group. On the same day around 10:45 am, the capuchin monkeys were foraging and walking towards the titi monkey group. This advance triggered the titi monkeys to quickly and quietly descend from their current location (at 12 m height) to approximately 3 m, where they remained and kept silent and still. All four of the titi monkeys remained stationary and quiet for 15 to 20 minutes to avoid detection before returning to their activities. Throughout this day, however, the group of titi monkeys monitored the capuchin monkey group and sought to perform their activities with caution, keeping close together and scanning the area due to the continued presence of the capuchin monkeys.

The second event occurred on May 2011 at 12:00 pm. Three members of the titi monkey group were eating fleshy fruits on the *Tapiriva guianensis* tree (Anacardiaceae) at ~15 m height and perceived the approach of the capuchin monkey group. All the titi monkeys descended to the understory (*ca.* 3 m) and hid in the vine tangles. The third event was reported on February 2010 at 10:00 am when

the adult male of the focal titi monkey group visually noticed the capuchin monkeys and began moving rapidly between trees in the opposite direction. The researchers did not hear any alarm call from this individual to alert the other members of titi group, but the other members followed this individual to avoid interaction with the capuchin group. The titi breeding pair ran in one direction and lay at rest 6 m from the ground until the capuchin monkey group had passed. In contrast, the infant titi moved in the opposite direction of the titi breeding pair and eventually came close to a capuchin monkey. The infant titi sighted a capuchin 3 m away and stopped. The capuchin monkey looked at the infant and continued on his route, then the infant titi moved towards the breeding pair where they remained until after the capuchin monkeys left the quadrant, at which time the titi monkeys resumed their usual activities. The titi monkeys also left and did not return to this location until the end of the day.

The last anti-predator strategy event was reported in October 2009, at approximately 09:40 am. A turkey vulture flew near three members of the Coimbra-Filho's titi group. One adult and the infant were at a height of between 7 and 9 m, feeding on *Xylopia frutescens* seeds (Annonaceae). The sub-adult was at a height between 2 and 3 m feeding on young leaves of unidentified vines. Noticing the turkey vulture flying over the tree canopy, the titi monkeys jumped to the ground, stood still for 1 to 2 min and emitted an alert vocalization (quiet call). The individuals looked up in an attempt to observe the vulture and see if it had left the area. When on the ground, the titi monkeys were at distances of between 1 and 2 m from the human observer, without showing any concern. After departure of the vulture, the individuals returned to their normal activities.

Discussion

Our results demonstrate that, like other Neotropical primates, Coimbra-Filho's titi monkeys respond differently when threatened by an arboreal versus an aerial potential predator (Table 1). When exposed to a potential arboreal predator (*Sapajus xanthosternos*), the titi monkey group tended to descend to lower forest strata (understory), hide in vine tangles, remain still and give quiet alarms. They remained in the understory to perform all their daily activities. Robust capuchins are known to prey on titi monkeys (see Sampaio & Ferrari, 2005 – *Sapajus apella*) as well as on common marmosets (see Albuquerque et al. 2014 – *Sapajus xanthosternos*). In contrast, in the presence of a potential aerial predator (*Cathartes aura*), the titis fled to the forest floor in order to avoid predation. Although some other studies have verified primate anti-predation behavior in the presence of vultures, there are no reports of vulture predation on live primates (Gleason & Norconk, 2002; Suscke et al., 2017).

Table 1. Overview of response of the passive anti-predator behavior from Neotropical primates.

Type of predator	Species	Anti-predator response	Source
Aerial	<i>Alouatta clamitans</i>	Descend trees	Miranda et al. (2006)
	<i>Alouatta palliata</i>	Hide	McKinney (2009)
		Hide/Vigilant	Gil-da-Costa et al. (2003)
	<i>Brachyteles hypoxanthus</i>	Infant ran	Dias and Strier (2002)
	<i>Cacajao calvus</i>	Look up and alert	Bowler (2007)
	<i>Callicebus coimbrai</i>	Looking up and jumping down from trees	Present study
	<i>Callicebus nigrifrons</i>	Hide/descend trees	Căsar et al. (2012a, b)
	<i>Callithrix jacchus</i>	Hide	Bezerra and Souto (2008)
	<i>Cebus capucinus</i>	Scan the sky/descend trees	Fitchel et al. (2005), Gros-Louis et al. (2008), Digweed et al. (2005)
	<i>Plecturocebus cupreus</i>	Piloerection/hide	Dolotovskaya et al. (2019)
Terrestrial	<i>Brachyteles hypoxanthus</i>	Ascend trees	Mendes (1997)
	<i>Callithrix jacchus</i>	Stay motionless	Bezerra and Souto (2008)
	<i>Cebus capucinus</i>	Ascend trees	Fitchel et al. (2005), Gros-Louis et al. (2008), Digweed et al. (2005)
	<i>Plecturocebus cupreus</i>	Piloerection/hide	Dolotovskaya et al. (2019)
	<i>Plecturocebus discolor</i>	Call/hide/piloerection	De Luna et al. (2010)
Arboreal	<i>Callicebus coimbrai</i>	Hide	Present study
	<i>Callithrix jacchus</i>	Alarm and mobbing calls/moving	Albuquerque et al. (2014)
	<i>Plecturocebus cupreus</i>	Flee and hide	Dolotovskaya et al. (2019)
	<i>Plecturocebus moloch</i>	Call/agitated	Sampaio and Ferrari (2005)

Both types of anti-predator behavior were previously observed in other titi monkeys (*Callicebus nigrifrons*, *Plecturocebus cupreus*, and *P. discolor*) when in the presence of eagles and tayras (De Luna et al., 2010; Căsar et al., 2012) and capuchin monkeys (Dolotovskaya et al., 2019). When in the presence of an aerial predator, red titi monkey (*P. cupreus*) individuals have been found to emit alarm vocalizations, display piloerection, and move to denser parts of the tree crown (Dolotovskaya et al., 2019). On the other hand, *Callicebus nigrifrons* individuals have been observed to move to protected areas and “freeze” (Căsar et al., 2013).

Neotropical primates often use lower and denser forest vegetation in order to hide from and avoid potential arboreal predators. These sites appear to be an optimal refuge chosen by primates. Cryptic pelage coloration and the small size of Coimbra-Filho's titi monkeys has likely favored flight behaviors and increased their ability to hide from capuchin monkeys to avoid predation. Similar passive anti-predator behavior has been verified for other titi monkey species. For example, *Plecturocebus discolor* in equatorial Amazonia hid in vine tangles in more than half of its encounters with tayras (De Luna et al., 2010), and *P. cupreus* hid in vine tangles to avoid encountering tayras, squirrel monkeys and capuchin monkeys at the Estación Biológica Quebrada Blanco, north-eastern Peruvian Amazon (Dolotovskaya et al., 2019).

Several anti-predator strategies against aerial predators have been reported for Neotropical primates, including alarm calls, freezing or taking cover instantaneously (Ferrari, 2009). Brown howler monkeys (*Alouatta guariba clamitans*) have been observed to descend to the understory and remain silent and motionless when under attack from a black-hawk eagle (*Spizaetus tyrannus*) (Miranda et al., 2006). An adult *Plecturocebus cupreus* male emitted alarm calls and moved to a denser part of the forest in the presence of a juvenile grey-headed kite (*Leptodon cayanensis*) (Dolotovskaya et al., 2019). Similarly, sakis (*Pithecia aequatorialis*) have been shown to give alarm calls for 10 minutes and drop to lower branches due to the presence of an unknown bird species (De Luna et al., 2010).

Escaping to the ground seems to be a common behavioral activity of Neotropical primates in the presence of a potential aerial predator. Most of species tend to descend to the lower forest strata with the aim of hiding. Under predation pressure from a turkey vulture, common marmosets (*Callithrix jacchus*) emitted alarm vocalizations, hid under leaves, and descended to the forest ground (Lyra-Neves et al., 2007). *Callithrix* parents also transferred their infants from their back to their ventral region while descending and hiding (Lyra-Neves et al., 2007). A novel anti-predator strategy by *Saguinus mystax* and *Leontocebus fuscicollis* is to fall down out of trees after observing aerial predators (Heymann, 1990).

At our study site, jumping to the ground may be a risky escape alternative for Coimbra-Filho's titi monkeys, due to presence of a large terrestrial predator (*Puma concolor*: Chagas et al., 2010). However, risk of being predated by a puma – these felids present an ambush strategy – probably is lower than being predated by raptors. It is likely that the vegetation structure of the forest fragment (edge forest, discontinuous canopy) and the structure of the feeding tree (open canopy, low leaves, thin and long branches) “forced” the titi monkeys to jump to the ground. Their cryptic pelage coloration reduces the probability of being found in suitable hiding places (vine tangles). However, in open areas the same pelage can facilitate localization of titis by potential predators.

Unlike *Plecturocebus cupreus* individuals, who did not emit alarm calls during encounters with capuchin monkeys (Dolotovskaya et al., 2019), Coimbra-Filho's titi monkeys emitted an alarm vocalization at least once in this study to alert the other individuals to the presence of a potential predator. Titi monkeys are known for emitting different types of alarm calls when in the presence of aerial and terrestrial predators (Cäsar and Zuberbühler, 2012; Cäsar et al., 2013) and alarm calls were emitted by individuals of *Callicebus nigrifrons* groups when observing capuchin monkeys (Cäsar et al., 2012). Emitting loud alarm calls in the presence of an arboreal predator will likely increase the chances of a predator finding their potential prey. However, quiet calls will favor intra-group communication in order to coordinate the escape. In this event, Coimbra-Filho's titi monkeys appeared to emit an alarm (short and high-pitched: Cäsar et al., 2012) call solely to get the attention of other group individuals, signaling them to flee and hide. This allowed for the group to move together to a suitable area to avoid predation.

Anti-predator behaviors performed by Coimbra-Filho's titi monkeys can contribute to the understanding of adaptive processes of these understudied primates in fragmented forest areas. In this study, Coimbra-Filho's titi monkeys used different strategies to avoid predators and potential predators. Their cryptic behavior aided in their escape from capuchin monkeys, however, they were required to choose an alternative escape route when under the predation pressure of a potential aerial predator. An active anti-predator strategy, such as emitting quiet alarm calls, was used only to bring the small group together. Coimbra-Filho's titi monkeys usually adopted passive anti-predator strategies, and the characteristics of their habitat seemed to be an important aspect in their choice of strategy, as it provided suitable hiding places and allowed the titi monkeys to search for an alternative escape route.

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NOT SO PEACEFUL: AGGRESSIVE ENCOUNTERS BETWEEN BENI TITI MONKEY (*PLECTUROCEBUS MODESTUS*) GROUPS IN BOLIVIA

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Abstract

We report observations of intergroup interactions from a free ranging group of the endemic and threatened Beni titi monkey (*Plecturocebus modestus*). Our observations over the course of one study year suggest that competition for food resources is the main reason for most observed intergroup encounters (n = 64), including aggressive interactions (n = 28). Additionally, threats to group integrity, such as potential loss of members, might promote very aggressive encounters, including three fights observed between adults of neighbouring groups. We provide new information on the intraspecific relationships for these endemic primates related to their use of space and food resources.

Key Words: *Plecturocebus modestus*, intergroup interactions, use of space, Beni, Bolivia.

Resumen

Damos a conocer información sobre las interacciones de un grupo libre de mono lucachi cenizo o tití del Beni (*Plecturocebus modestus*) con otros grupos vecinos. Nuestras observaciones realizadas durante un año sugieren que la competición por recurso alimenticio es la razón principal para la mayoría de los encuentros entre grupos (n = 64), incluyendo interacciones agresivas (n = 28). Adicionalmente, amenazas a la integridad de grupo, como es la potencial pérdida de integrantes, podrían promover encuentros muy agresivos tales como tres peleas observadas entre adultos de grupos vecinos. Proveemos nueva información sobre las relaciones intraespecíficas de estos primates endémicos, vinculadas a su uso del espacio y de recursos alimenticios.

Palabras Clave: *Plecturocebus modestus*, interacciones intergrupales, uso del espacio, Beni, Bolivia.

Introduction

In social species, such as primates, interactions between conspecific groups vary in frequency and type depending on the degree of territoriality in the species (Cheney, 1987). Species living in small groups tend to have small spatial requirements, promoting marked territorial behavior as groups try to maintain exclusive access to areas, as observed in distinct Neotropical primate species (Peres, 1989). Apart from the relationship between the frequency of intergroup encounters and group density, intergroup encounters can occur due to: a) competition for access to limited defendable resources, and b) the need to assess dispersal and mating possibilities in surrounding groups (Sicotte and Macintosh, 2004).

Territorial defense helps a group to ensure food availability in its home range (Peres, 1989). Nevertheless, this task represents an energetic investment in which trade-offs are more favorable for species with small home ranges, capable of patrolling most of their territory (Sugiura et al., 2000). Intergroup encounters related to social processes such as mating and infant defense usually involve aggression between individuals (Thompson et al., 2012). However, the cost-benefit balance conditions the type of interaction between groups, which can vary from relatively neutral

interactions such as territorial vocalizations, to aggressive encounters (Sugiura et al., 2000; Thompson et al., 2012). Information about the degree of aggression during encounters can help us gain a better understanding of how social ecology and intraspecific competition condition how populations use or share resources.

Titi monkeys (*Callicebus*, *Cheracebus*, *Plecturocebus*; Byrne et al., 2016) are a group of Neotropical primates, characterized by their emission of territorial calls which regulate intergroup spacing and help to avoid direct interactions or aggression between groups (Kinzey, 1981; Bicca-Marques and Heymann, 2013). Nevertheless, some aggressive encounters between conspecific groups of titi monkeys have been reported, although it is not clear whether they correspond to resource or mate defense (Robinson, 1979; 1981; Price and Piedade, 2001). In general, titi monkey home ranges are small (usually less than 30 ha) which, together with their territorial and monogamous mating system, suggests food resource competition might be the most likely cause for territorial defense (Peres, 1989; Bicca-Marques and Heymann, 2013). Ecological data is not available for many titi monkey species, highlighting the need for research on this diverse primate subfamily (Bicca-Marques and Heymann, 2013).

The Beni titi monkey, *Plecturocebus modestus*, is an Endangered Bolivian endemic found in naturally fragmented forest habitats (Martinez and Wallace, 2010, 2016a; Wallace et al., 2013). To gather natural history knowledge not previously available for this species, we conducted a behavioral study, and here we report on intergroup interactions from one focal group, including the frequency and type of interactions (distant, direct, and aggressive), their relative location, as well as details of three fight events with individuals from neighboring groups. In this way, we provide valuable information for a better understanding of the mechanisms underlying intergroup relationships in Callicebinae.

Methods

We conducted our study at San Miguel cattle ranch in the southwestern portion of Beni Department, Bolivia (13°57'5.49"S, 66°50'5.07"W), in the Llanos de Moxos ecosystem where forest patches are immersed in a grassland matrix (Hanagarth, 1993). Two groups of *P. modestus* were observed, but only the Maramacho group (adult pair, one juvenile, and one infant) had three direct neighboring groups with whom it interacted (Chontal, Sujo, and Mangal). This group was located in the southeastern edge of a large 65 ha forest patch, so neighboring groups were to the northwest of the focal group (Fig. 1). We present information on this focal group, observed from July 2010 to June 2011 (dry and wet seasons) for 10 days per month for an average of 10 hours per day.

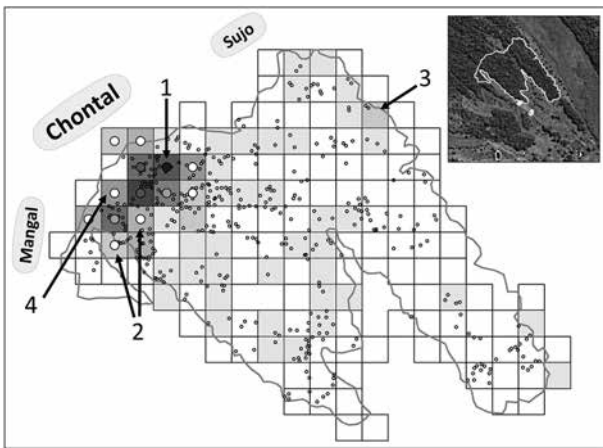


Figure 1. Map showing intergroup interactions in the area occupied by our focal group Maramacho and neighboring groups (group names in gray circles show relative location) in relation to the amount of food plants (smallest marks). Grid cells (25 × 25 m) show the places occupied by our focal group during the study with shading corresponding to the relative amount of intergroup interactions (darker shading indicates higher amount of records). Circles indicate cells with aggressive interactions Maramacho - Chontal (more records in darker circles). Numbers indicate cells with occurrence of: 1) first fight observation, 2) fights when adults fell from trees, 3 and 4) encounters with Sujo and Mangal groups, respectively. The inset photo is a reference image showing the area occupied by our focal group in relation to forest coverage.

We sampled the occurrence of intergroup interactions by means of *ad libitum* behavioral sampling (Altmann, 1974). An ‘effective interaction’ between groups was considered when a vocal or visual stimulus from a group promoted an immediate response in another group (vocal, movement, or other). We differentiated effective interactions based on the degree of contact between individuals of distinct groups. ‘Indirect interactions’ consisted of the exchange of territorial calls or displacements between individuals of distinct groups with no visual contact due to distance or visual barriers, such as dense vegetation. As territorial calls can be heard from more than 500 m, indirect interactions can involve both direct neighboring or more distant groups. ‘Direct interactions’ were considered when individuals of distinct groups interacted with visual contact, distinguishing ‘aggressions’ as chasing-retreat displays and ‘fights’ involving aggressive physical contact.

We registered the location of our focal group during each interaction event by means of compass bearing and distance to reference points. As part of our behavioral study, we registered the locations of plants consumed by the focal group during the entire study. This spatial information was mapped using a 25 × 25 m grid overlapped on the forest patch occupied by the focal group. Additionally, from all occurrence sampling of group displacements and feeding events (Altmann, 1974), we calculated the total amount of time and the feeding time spent by monkeys per grid cell.

Based on observation hours, we calculated the frequency of the distinct intergroup interactions observed. For aggressions and fights, we determined the winning group based on the behavioral context. With the frequencies and locations of the interactions, we estimated the number of intergroup interactions per cell grid. We assessed the relationship between interactions and feeding behavior reflected through feeding time and the number of plants per grid cell (SPSS v.24, significance level 0.05).

Results

We registered 227 effective intergroup interactions between our Maramacho focal group and surrounding groups from 574 cases when stimuli for interactions were detected (from 1,236 hours of observation). Most of these effective interactions (76.65 %) occurred between our focal group and the Chontal group (Table 1), while interactions with other direct neighboring groups were less frequent (9.69 % and 1.76 % for the Sujo and Mangal groups, respectively). The remaining interactions (11.69 %) were territorial call exchanges between our focal group and other more distant groups in distinct forest patches. This trend was similar for indirect interactions between groups (Table 1).

Table 1. Number of each type of intergroup interaction between our Maramacho focal group and neighboring groups. Direct neighboring groups marked in bold.

Group	All stimuli	Effective interactions	Indirect interactions	Direct interactions	Aggression	Fight
Chontal	259	174	112	62	27	3
Sujo	64	22	21	1	1	0
Pozero	104	21	21	0	0	0
Corral	39	4	4	0	0	0
Mangal	12	4	3	1	0	0
Tapao	72	1	1	0	0	0
Far OSO	14	1	1	0	0	0
Oeste	7	0	0	0	0	0
Guayabochi	1	0	0	0	0	0
Far NNO	1	0	0	0	0	0
Far NNE	1	0	0	0	0	0
	574	227	163	64	28	3

Direct interactions (with visual contact between groups) occurred almost exclusively between our focal group and its neighbor Chontal ($n = 62$), with only one direct interaction with each of the Sujo and Mangal groups (Table 1, Fig. 1). Direct interactions took place in the northwestern part of the area occupied by our focal group, that corresponds to 9.74% of the group home range (0.94 of 9.63 ha, Fig. 1). From these interactions, we observed 27 cases of aggressive chase-retreat encounters between our focal group and Chontal, with the loser group leaving the 'conflict' site. The Chontal group won the majority of these encounters (14 vs. 11). There was only one aggressive encounter observed between the Maramacho and Sujo groups, which was won by Maramacho (Table 1).

We observed three fights (aggressive body contact) between individuals of the Maramacho and Chontal groups. In the first case (05/17/2010 at 12:00 h), both adults of our focal group confronted the adult male of Chontal group after he caused the retreat of the juvenile and infant of our focal group, apparently in an accidental way as the groups had not interacted previously in the day. During the encounter, the Maramacho adult female hit the side of the body of the Chontal male with her hand, and immediately the Maramacho adult male approached, pilo-erecting his body fur. There was not any direct contact between males as the Chontal adult male then ran away towards his territory, and this encounter was considered as a win for the Maramacho group.

The other two fights were separated by almost exactly one year and occurred in nearby locations (Fig. 1). In the first one (06/16/2010), groups met unexpectedly when moving during the morning (08:28 h). Just after visual contact, the adult males of each group charged each other until they made contact holding each other by the shoulders, apparently trying to bite each other's arms. As a result of the

struggle, both individuals lost equilibrium and fell to the ground from a height of around 7 m. A few seconds later, both monkeys climbed trees and returned to their respective groups. No further interactions occurred and there was not a clear winner.

The second case (06/10/2011) occurred in the late afternoon (17:12 h), after groups were in close proximity for almost an hour. The Maramacho infant was moving far from the adults and was chased by the Chontal adult male, instigating the fight. Similar to the previous case, the Maramacho male charged the other male and repeated a similar fight display with the same result of both individuals falling from a similar height. Again, the males retreated to their respective groups with no clear winner of this encounter.

Most interactions between the Maramacho and Chontal groups occurred during the wet season, but aggressive encounters, including the intergroup fights, took place mainly in the dry season (Table 2; from 619 and 617 hours of observation in wet and dry seasons, respectively). Interactions with the Sujo neighbor group occurred mainly in the wet season, but the opposite happened for the Mangal group.

The locations of intergroup interactions between Maramacho and Chontal groups had relatively high plant food source densities (mean of 6.8 plants per grid cell, range: 0-16, $n = 15$; Fig. 1). We found that aggressive interactions mainly took place in cells with a high amount of plant food sources (Spearman correlation: $r_s(52) = 0.282$, $p = 0.039$). Monkeys also spent more time in these cells ($r_s(174) = 0.798$, $p < 0.001$), and invested more time on feeding ($r_s(174) = 0.826$, $p < 0.001$). Nevertheless, fight events occurred in cells that did not necessarily have the highest plant food source densities (5-9 plants per cell). The only direct and aggressive encounter between the Maramacho and Sujo groups occurred in a grid cell with just two food plants.

Table 2. Seasonal variation in the number of interactions between our focal Maramacho group and its three direct neighboring groups.

Group	Season	Effective interactions	Indirect interactions	Direct interactions	Aggression	Fight
Chontal	Dry	77	48	29	15	3
	Wet	97	64	33	12	0
Sujo	Dry	4	4	0	0	0
	Wet	18	17	1	1	0
Mangal	Dry	4	3	1	0	0
	Wet	0	0	0	0	0

Discussion

Titi monkeys are well known as monogamous and territorial species (Kinzey, 1981; Bicca-Marquez and Heymann, 2013). Some studies have revealed low degrees of territoriality related to large home ranges, consisting exclusively of territorial calls (*Cheracebus torquatus*, Kinzey and Robinson, 1983; *Callicebus personatus*, Price and Piedade, 2001). More direct intergroup interactions occur in species needing to defend smaller home ranges (*Cheracebus lugens*, Robinson, 1979, 1981). Compared to other titi monkey species, the home range of *Plecturocebus modestus* (9.69 ha) is relatively small (Martinez and Wallace, 2016a). Thus, our observations of direct intergroup interactions suggest our focal group needed to defend a relatively small territory from conspecific intruders.

Determining the underlying causes of the observed interactions can help to understand intraspecific competition in Beni titi monkeys, who already face spatial restrictions in the fragmented forests they inhabit (Cheney, 1987; Martinez and Wallace, 2010; Wallace et al., 2013). In the three observed fight events, male participation suggests mate and infant defense in order to ensure reproductive success (Thompson et al., 2012). This type of aggression is usually initiated by incursions of males looking for reproductive opportunities; this can include solitary males, or males who have left their original group temporarily, as observed in white-thighed colobus (*Colobus vellerosus*: Sicotte and Macintosh, 2004). Before two of the three fights reported here, the infant of our focal group was chased by the Chontal adult male. This shows that infant defense may have driven the most aggressive encounters observed between the Maramacho and Chontal groups.

As well as reproductive opportunities, the need to ensure access to food resources can promote active territorial defense and can be distinguished according to which group members are involved (Sigiura et al., 2000; Sicotte and Macintosh, 2004). Female active defense of food resources is expected to ensure reproductive success, but similar defense can be carried out also by males as an indirect way to ensure permanence of female(s) in a group (Thompson et al., 2012). In our study, a great majority of the direct interactions involved both male and female adults of the

focal group during chase-retreat events, which suggests the interest of both adults to maintain food resources for their benefit. Nevertheless, it could also be linked to the monogamous social organization of titi monkeys, with the adult pair sharing most activities, including territorial defense (Kinzey, 1981).

As food resources are not homogeneously distributed, areas with higher amounts of food should be defended more vigorously, as was observed in grey-cheeked mangabeys (*Lophocebus albigena*) and redtail monkeys (*Cercopithecus ascanius*; Brown, 2013). Our spatial data of intergroup interactions clearly show that the areas with most direct Maramacho-Chontal interactions offered a higher number of plant food sources as compared to other zones. Moreover, we found that our focal group spent most of the time in grid cells with a high amount of food plant sources. This may also explain the relative lack of interactions with other neighboring groups that occurred in areas of low food availability.

In addition, even though forest fragmentation in the range of *P. modestus* is mainly the result of natural processes (Hanagarth, 1993), this landscape configuration results in high food resource densities towards the center of forest patches due to edge effects (Rogan and Lacher, 2018). Our focal group, that inhabits a marginal zone of the forest patch, moved frequently to the central part of the patch to look for food. This demonstrates how these primates assessed the cost-benefits of obtaining food over the risks of aggressive intraspecific interactions, which might be more relevant for groups living in the marginal areas of forest patches. Increased levels of forest fragmentation amplify edge effects and could reduce the size of feeding sites for *P. modestus*, which might increase aggressive encounters between groups and could even affect the abundance of this threatened primate species (Rogan and Lacher, 2018).

Reduced availability of food resources during lean periods can promote their vigorous defense, but species with small home ranges are more sensitive to intergroup encounters and may need to defend their food resources against invaders even during periods of food abundance, as observed in Tana River crested mangabeys (*Cercocebus galericus*; Kinnaid, 1992). Our data shows the latter trend, with more interactions between the focal Maramacho group and its

neighbors during the wet season, with aggressive encounters occurring mainly in the dry period when the youngest individual of our focal group showed independence from adults. This suggests that the most frequent motivation for intergroup interactions for our focal *P. modestus* group might be food resource defense against individuals of other groups.

Based on our results, there seem to be two main triggers for the distinct intergroup interactions observed between our focal group of *P. modestus* and its neighbors. Food resources are vigorously defended, but not with so high intensity as occurs with mate or infant defense, as observed in moustached tamarins (*Saguinus mystax*: Garber et al., 1993) and Japanese macaques (*Macaca fuscata*: Saito et al., 1998), showing that long-term reproductive success has higher priority than short-term disputes over food. Our observations suggest that territorial calls and chase-retreat events might be a sufficient response for food resource defense, whereas infant defense is in response to high risks to reproductive success, making fight encounters worthwhile.

Aggressive interactions between groups can result in reduced access to areas with resources by the losing group (Gordon, 1996), which could affect group permanence in the long term, as was reported for baboons (*Papio cynocephalus*) unable to exploit food resources in a conflict area (Mackhan et al., 2012). Although the neighboring Chontal group won more of the intergroup encounters against our focal group, the difference was not great (14 vs. 11), and we observed our focal group using food resources in the conflict area during the entire study. Home range overlaps of up to 16.6% was reported in groups of *Cheracebus lugens*, whose home ranges varied between 3 and 4 ha (Robinson, 1979). In our case, the overlap corresponds to around 10% of the home range of our focal group, which was more than twice the previous size (9.63 ha). Additionally, a study on territorial calls of *Plecturocebus modestus* suggested that these primates do not face intense spatial competition (Martinez and Wallace, 2016b). Thus, both groups could be sharing the conflict area with confrontations occurring only occasionally during close encounters.

On the other hand, fights can have lethal results, as reported for white-faced capuchins (*Cebus capucinus*; Gros-Louis et al., 2003) and white-bearded gibbons (*Hylobates albibarbis*; Cheyne et al., 2010). The fights we observed did not seem so dangerous, especially as titi monkeys do not have large canines to produce serious damage (Hershkovitz, 1990; Kobayashi, 1995) and because these events lasted for just a few seconds. Nevertheless, falling from a height of 7 m represents a serious risk of broken bones, or immediate or subsequent death. Considering the monogamous social organization of titi monkeys (Kinzey, 1981; Bicca-Marques and Heymann, 2013), this would represent a serious risk for group survival, as adult individuals guide access to food and guard against predation risk.

This is the first study about intergroup relationships of *Plecturocebus modestus*, providing valuable knowledge to better understand how these endemic Bolivian primates use and defend food resources and retain group integrity. Although our data come from just one focal group, they represent a good starting point for further detailed research on intraspecific relationships in this threatened primate within the naturally fragmented forests of southwestern Beni Department, Bolivia.

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UNUSUAL BEHAVIORAL RESPONSES OF THE SOUTH AMERICAN COATI (*NASUA NASUA*) TO THE HOODED CAPUCHIN (*SAPAJUS CAY*) IN THE PARAGUAYAN UPPER PARANÁ ATLANTIC FOREST

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Abstract

In eastern Paraguay, the South American coati *Nasua nasua* and hooded capuchin *Sapajus cay* are sympatric across most of their range. Both species are diurnal, arboreal, omnivorous mammals and have similar diets consisting of fleshy fruits and insects and are therefore potential competitors. In this article, we report three observations of unusual behavioral responses of coatis to the presence of hooded capuchins. On two occasions groups of coatis elected to show avoidance behavior by hiding from capuchin groups, despite the much closer proximity of human observers. On another occasion coatis and capuchins were seen to feed side by side in a fruit tree without antagonism for over half an hour. We also review the literature to begin the process of identifying the factors that may influence the frequency and outcome of such encounters.

Key Words: Atlantic Forest, Behavior, Cebidae, Interspecific competition, Paraguay, Procyonidae

Resumen

En el oriente de Paraguay, el coatí sudamericano *Nasua nasua* y el capuchino encapuchado *Sapajus cay* son simpátricos en la mayor parte de su rango. Ambas especies son mamíferos diurnos, arbóreos y omnívoros y tienen dietas similares que consisten en frutos carnosos e insectos y, por lo tanto, son competidores potenciales. En este artículo, reportamos tres observaciones de respuestas de comportamiento inusual de los coatíes a la presencia de capuchinos encapuchados. En dos ocasiones los grupos de coatíes eligieron mostrar un comportamiento de evasión escondiéndose de los grupos de capuchinos, a pesar de la proximidad mucho más cercana de los observadores humanos. En otra ocasión se vio que los coatíes y los capuchinos se alimentaban uno al lado del otro en un árbol frutal sin antagonismo durante más de media hora. También revisamos la literatura para comenzar el proceso de identificación de los factores que pueden influir en la frecuencia y el resultado de tales encuentros.

Palabras Clave: Bosque Atlántico, Comportamiento; Cebidae, Competición interespecífica; Paraguay; Procyonidae

Introduction

Interspecific interactions are an important and yet frequently overlooked part of wild animal ecology (Jones et al., 1994), and they may vary in nature depending on the ecological relationships between those species involved (Resende et al., 2004; Fack et al., 2019). The most commonly reported interspecific interactions between primate and non-primate species include agonistic interactions (predator–prey and competitive interactions) and non-agonistic interactions (affiliative and neutral interactions) (Asensio and Gómez-Marín, 2002; Rose et al., 2003; Resende et al., 2004; Cristóbal-Azkarate et al., 2015; Fernandez et al., 2017).

The hooded capuchin (*Sapajus cay*: Illiger, 1815) is found in sympatry with the coati throughout eastern Paraguay, south-east Bolivia, northern Argentina, and Brazil (states

of Goiás, Mato Grosso, Mato Grosso do Sul and marginally into Rondônia) (Stallings, 1985; Lynch Alfaro et al., 2012; Wallace, 2015). Hooded capuchins live in large multi-male, multi-female groups (Pinto, 2006; Fernandes Jr., 2013; Smith and Briggs, 2015), however the only interspecies interactions that we are aware of include feeding associations with collared peccary *Pecari tajacu* in the Brazilian Pantanal (Tortato et al., 2014), sleeping, and sometimes feeding, in the same area as black-and-gold howler monkeys (*Alouatta caraya*) in Nueva Gambach, Paraguay (Rebecca L. Smith, *pers. obs.*) and an observation of predation of a black tailed marmoset (*Mico melanurus*) in the Brazilian Pantanal (Porfilio et al., 2017). In general, very little is known about the behavioral ecology of the hooded capuchin, with very few studies, and no long-term studies, published from any part of its range (Brown and Zunino, 1990; Smith and Briggs, 2016; Smith, 2017; Smith and Payne, 2017; Smith et al., 2018; da Costa et al., 2020).

The South American coati *Nasua nasua* Linnaeus, 1766 is widely distributed from Venezuela and Colombia, south to Uruguay and northern Argentina (Alves-Costa et al., 2004, Emmons and Helgen, 2016). Coatis are mainly found in forested areas, both humid and dry, including in Paraguay gallery forest, Atlantic Forest, palm savannas, Cerradón and xeric Chaco forests (Emmons, 1990; Gompper and Decker, 1998; Beisiegel, 2001; Trovati et al., 2010). They are a social procyonid, living in large groups made up of adult females and their offspring, with males typically being solitary (Russell, 1981; Haugaasen and Peres, 2008; Hirsch, 2011). Adult males will occasionally associate with groups of females (Hirsch, 2011), though usually only one male per group (Hirsch, 2006). Coatis have been reported as forming feeding associations with birds (Booth-Binczik et al., 2004, Beisiegel, 2007), peccaries *Pecari tajacu* (Desbiez et al., 2010), tapirs *Tapirus bairdii* (Overall, 1980), and primates (Haugaasen and Peres, 2008, Desbiez et al., 2010).

The coati occurs in sympatry over much of its South American range with several other species of capuchin monkeys (*Sapajus* and *Cebus* species) with which feeding associations have also been reported (Resende et al., 2004, Haugaasen and Peres, 2008). Coatis, in common with many Neotropical primates (including capuchins), are diurnal omnivores that forage mainly on mature fruits and invertebrates (Izar, 2004; Resende et al., 2004; Costa et al., 2009; Hirsch, 2009; Hirsch et al., 2013; de Almeida et al., 2018), creating potential for interaction at feeding sites (Alves-Costa et al., 2004; Cristóbal-Azkarate et al., 2015; Fernandez et al., 2017). In several publications that have commented on interactions between coati and primate species, interactions were apparently either mutualistic or commensal (Haugaasen and Peres, 2008, Desbiez et al., 2010), yet others resulted in conflict (Fragaszy et al., 2004; Resende et al., 2004; Fack et al., 2018), Gracile capuchins (genus *Cebus*) have even been reported to predate coati pups (Newcomer and de Farcy, 1985; Fedigan, 1990; Perry and Rose, 1994). Though we are unaware of published reports of robust capuchins (genus *Sapajus*) predated coatis, they are known to consume vertebrate prey (Izawa, 1978; Terbourgh, 1983; Galetti, 1990; Resende et al., 2003; Sampiao and Ferrari, 2005; Carretero-Pinzón et al., 2008; Rebecca L. Smith, *pers. obs.*).

Frequencies of coati-primate encounters are likely mitigated by movement patterns, with most Neotropical monkeys foraging in the trees and coatis usually foraging on the ground (Hirsch et al., 2013). Capuchins additionally show a largely lineal foraging pattern in the canopy, while coatis follow a more circuitous route on the ground, often visiting the same fruiting tree more than once a day (Hirsch et al., 2013). However, the existence of cross-site differences in foraging behavior in capuchins is well known, even in geographically proximate populations (Panger et al., 2002).

Here we provide descriptions of new observations of interactions between South American coatis and hooded capuchins from eastern Paraguay, and through reviewing the published literature we attempt to identify what factors may influence the frequency and outcome of such encounters.

Methods

The observations described here were obtained at two study sites in eastern Paraguay. Rancho Laguna Blanca (RLB) is an 804 ha property in San Pedro department, eastern Paraguay, including an isolated and disturbed 243 ha fragment of Upper Paraná Atlantic Forest. This fragment is home to two groups of hooded capuchins: O Group (18 individuals) (Smith and Briggs, 2015) and F Group (21 individuals). The population size of coatis in this fragment was unknown. Encounters between the monkeys and other mammalian species were observed occasionally. At the time we recorded our observations, the capuchins were in the process of being habituated to researcher presence. A typical response to human presence was for them to alarm call and flee.

“Área para Parque” San Rafael is a 73,000 ha patch of near pristine Upper Paraná Atlantic Forest (BAAPA) in departments Itapúa and Caazapá in the south of Paraguay. San Rafael the largest remaining tract of BAAPA left in Paraguay and consists of more than 50 private properties. Nueva Gambach is the southernmost property with 15 ha of forest connecting at its northern end to the rest of San Rafael. Nueva Gambach is home to four groups of hooded capuchins (20-25 individuals per group) and an unknown number of coatis.

Observations were obtained during daily monitoring (from 2013 to 2017 at RLB, and from 2017 to present at Nueva Gambach) as part of the Para La Tierra Capuchin Research Project. Data were collected six days per week at RLB and for 15 days per month at Nueva Gambach. The capuchins were followed for as long as possible between dawn and dusk and all social behavior was recorded using one-minute scan sampling (Altmann, 1974), including interspecific interactions.

Previous studies have reported that when groups of coatis are disturbed in the trees they come to the ground and escape on the ground (Gompper and Decker, 1998). Coatis are hunted by people at both sites and it was not the normal response to either approach humans, or to remain close and keep still, in the presence of human observers. Normally, observer encounters with solitary individuals or larger groups of coatis in the absence of capuchins resulted in the coatis either moving into the forest canopy and hiding from observers or fleeing on the ground while vocalizing loudly. Retreating higher into the canopy was more commonly observed for solitary individuals than for groups at both sites.

Results

Rancho Laguna Blanca: On 16 July 2014 at 08:14, a presumed adult male coati (solitary) was observed while the authors were following O Group (RLB: -23.829444, -56.294722). The coati had pushed its body underneath a large mass of woody vines on a tree trunk approximately 1 m above the ground. The capuchin group was located 8 m laterally from the coati and between 5 to 7 m higher up in the canopy, while the human observers were approximately 2 m from the coati. Rather than fleeing on the ground (as is habitual), the coati slowly tried to move higher into the tree, freezing whenever the alarm call of the monkeys could be heard. Three adult male monkeys then began to threaten the observers by vocalizing loudly and breaking branches, but the coati remained completely still and silent. Despite the closer proximity of the humans, the coati's gaze remained directed towards the monkeys as they vocalized, switching the gaze back to the human observers during the pauses. The coati remained in this position for 11 minutes until the capuchins travelled out of sight; at that point, the coati moved higher into the tree apparently to increase the distance from the human observers.

On 2nd September 2014 at 08:30, three adult coatis were encountered sitting silently on an exposed branch at a height of 5 m from the ground, just below the canopy of a mid-canopy tree (RLB: -23.829814, -56.296003). The coatis remained still and watched the human observers for around four minutes. The coatis then shifted their gaze eastwards through the canopy and did not return their gaze to the observers on the ground. Without vocalizing, the coatis then moved slowly and quietly into the denser leafy vegetation of the tree top branches, approximately 9 m high and out of sight of the observers. Once the coatis were out of sight observers spotted the O Group capuchins approximately 50 m southeast of the tree in which the coatis hid, in the same direction that the coatis had been looking prior to hiding in the treetop.

Nueva Gambach: On the 17th August 2017, a group of capuchins (around 20 individuals) was encountered feeding in a *Ficus enormis* at 15:55 (-26.62128, -55.66998). Also feeding in the same tree, there was a large group of coatis (around 15 individuals) and a group of Paraguayan howler monkeys (*Alouatta caraya*) (four individuals). At 16:15, an adult coati of undetermined sex approached an adult male capuchin while he was feeding. The capuchin turned his back on the coati and continued to feed and the coati travelled past him. All of the animals fed in close proximity to one another with no obvious aggression for 31 minutes before the capuchins and the coatis left the tree at 16:26 in opposite directions, the feeding patch apparently depleted.

Discussion

There are conflicting published reports on interactions between capuchins and coatis in the wild (Table 1). As

a result of their belligerent natures, capuchin species can frequently behave aggressively towards competitors (Freese, 1978; Rose, 1997; Dias and Strier, 2000; Rose et al., 2003; Resende et al., 2004; Buchanan-Smith et al., 2013). The most commonly observed interactions between capuchins in two areas of São Paulo, Brazil (*Sapajus spp.* in Tiete Ecological Park and *Sapajus nigritus* in Carlos Botelho State Park) and coatis were attacks and threats by the capuchins (Resende et al., 2004). The same study also recorded both interspecific playing and four capuchin attacks on coati nests (though there was no definitive evidence of consumption of coatis by the monkeys) (Resende et al., 2004). Haugaasen and Peres (2008) however reported "*Cebus apella*" (probably *Sapajus macrocephalus* Spix, 1823) in the Purus region of Amazonian Brazil feeding side by side with coatis for prolonged periods with no interaction or aggression; this was similar to what we observed between the hooded capuchins and the coatis in Nueva Gambach. Clearly interactions between capuchins and coatis are more complex than fixed interspecific antagonism or indifference, and many other factors may also influence the outcome of these interactions, including, but not restricted to context, age or status of individuals involved, levels of threat posed, resource availability, and environmental conditions.

The differential response of coatis to humans in the presence or absence of capuchins at RLB suggests that they may be assessing risk in deciding how to respond. It is clear from the flight reaction in the absence of capuchins that humans are viewed as a threat, yet the presence of capuchins significantly alters this response. The apparent reluctance of the Rancho Laguna Blanca animals to draw the attention of the capuchins to their presence might suggest that interspecific reactions between the two species at this site are potentially agonistic, and the differential response to the presence of human observers when the capuchins are also present could indicate that the coatis perceive the monkeys to represent a greater risk. However, in reality the risk being assessed is rather more complex.

The observations in which coatis adopted a cautious response to the presence of monkeys involved a small number of individuals, greatly outnumbered by the capuchins. On the other hand, the peaceful foraging situation observed at Nueva Gambach involved similar-sized troops of both species (~20 and ~15 individuals respectively). Previous studies have discovered that both coatis and capuchins are individually less vigilant when they are in larger groups than in smaller groups (Burger and Gochfeld, 1992; Burger, 2001; Di Blanco and Hirsch, 2006). Similar interactions between small groups of coatis and primates present in larger groups have been reported perhaps indicating that primates are most likely to respond with aggression when they outnumber the competitor (capuchins: Fragaszy et al., 2004; Resende et al., 2004; Asensio et al., 2007; woolly monkeys (*Lagothrix flavicauda*): Fack et al., 2018).

Table 1. Summary of interactions between coatis and capuchins.

Capuchin species	Coati species	Type of Interaction	Behavior	Study site	Reference
<i>Sapajus cay</i>	<i>Nasua nasua</i>	Avoidance	Coati hid close to human observers until capuchin group had moved away	Rancho Laguna Blanca, San Pedro, Paraguay	This study
<i>Sapajus cay</i>	<i>Nasua nasua</i>	Avoidance	Stayed silent in the presence of human observer until capuchins had moved away	Rancho Laguna Blanca, San Pedro, Paraguay	This study
<i>Sapajus cay</i>	<i>Nasua nasua</i>	Neutral	Feeding in same tree with no aggression (howler monkeys also present)	Nueva Gambach, Itapúa, Paraguay	This study
" <i>Cebus apella</i> " (<i>Sapajus macrocephalus</i>)	<i>Nasua nasua</i>	Neutral	Feeding in same area with no aggression	Purus region of Amazonian Brazil	Haugaasen and Peres, 2008
<i>Cebus capucinus</i>	<i>Nasua narica</i>	Neutral	Drinking together at a waterhole with occasional threat from capuchins towards coatis	Santa Rosa National Park, Costa Rica	Freese, 1978
<i>Sapajus spp.</i> (Tiete Ecological Park) & <i>Sapajus nigritus</i> (Carlos Botelho State Park)	<i>Nasua nasua</i>	Affiliative	Playing together	Tiete Ecological Park and Carlos Botelho State Park in São Paulo, Brazil	Resende et al., 2004
<i>Sapajus libidinosus</i>	<i>Nasua nasua</i>	Agonistic	Capuchins directed threats and attacks towards coatis	Tiete Ecological Park and Carlos Botelho State Park in São Paulo, Brazil	Resende et al., 2004
<i>Cebus capucinus</i>	<i>Nasua narica</i>	Agonistic	Capuchins preying on coati nestlings	Santa Rosa National Park/ Lomas Barbudal, Costa Rica	Rose et al., 2003
<i>Cebus capucinus</i>	<i>Nasua narica</i>	Agonistic	Capuchins chasing larger coati pups and drowning of larger pups	Santa Rosa National Park/ Lomas Barbudal, Costa Rica	Rose et al., 2003
<i>Sapajus spp.</i> (Tiete Ecological Park)	<i>Nasua nasua</i>	Agonistic	Nest attacks	Tiete Ecological Park, São Paulo, Brazil	Resende et al., 2004

Resource availability may play an important role in how species interact. It has been hypothesized that robust capuchins will prey on coati nestlings under certain ecological conditions such as food shortages for capuchins coinciding with coati birth season, high population densities or high home range overlapping (Resende et al., 2004). Affiliative behavior between capuchins and coatis was never observed at RLB, though neither was direct predation on coatis. Both capuchin groups at RLB were observed to aggressively mob other large mammals including tayra (*Eira barbara*) (three observations), Paraguayan howler monkeys (*Alouatta caraya*) (six observations), and puma (*Puma concolor*) (one observation). In forest fragments competition can play a much greater role in regulating the abundance of species within different niches (Kozakiewicz, 1993). As coatis and capuchins show dietary overlap (Resende et al., 2004) it may be that the capuchins in Laguna Blanca presented a greater threat to the coatis, not solely as potential predators but as a result of increased competition for more limited resources in a poorer quality forest.

Though different taxa are involved in these observations, we suggest that it oversimplifies the complexity of interactions of highly cognitive species such as the coati and the capuchin if we assume that such interactions are fixed at the interspecific level rather than multi-factorial, ecologically-influenced or learned (Romero and Aureli, 2008; Hirsch et al., 2012; Gasco et al., 2016). No systematic investigation of interspecific interactions of large mammals has been carried out in the Paraguayan Atlantic Forest and there is little information regarding the hooded capuchin in general across its entire range. Further studies are required to identify the potentially multiple and complex factors that may determine such behaviors.

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TRENDS IN THE USE OF STUDBOOKS IN CAPTIVE BREEDING PROGRAMS OF NEOTROPICAL PRIMATES

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Abstract

Studbooks are databases of individual genealogical records of *ex situ* populations. Since they are an essential tool in management and planning, we conducted a search of studbook reports to explore historical trends in breeding programs of Neotropical primates and implications for *ex situ* conservation. We accessed two databases: one made by the World Association of Zoos and Aquariums (WD) and another one compiled from academic reports and public internet records (PD). WD was comprised of 104 reports (1998-2011) from three habitat and seven non-habitat regions for 44 species. PD consisted of 222 reports for 34 species from two habitat and three non-habitat regions (1973-2019). International studbooks were more frequent in PD (82%), whereas regional reports were more frequent in WD (55.8%). Both databases showed that IUCN levels (LC, NT, VU, EN, CR and DD) with a larger number of species contain a larger number of species with studbooks and a larger number of studbooks. Therefore, there is a bias towards more studbooks on LC (Least Concern) species. Despite limitations in availability and access to studbook records, our results revealed a discrepancy between regions where *in situ* conservation and *ex situ* conservation actions have been made. This underscores the need for international cooperation to strengthen conservation efforts, build infrastructure, increase effective population sizes and ultimately establish viable populations. Finally, we advise assessing opportunities for *ex situ* conservation of threatened or DD (Data Deficient) species whose conservation in the wild is unlikely in the near future.

Key Words: New World primates, Neotropics, *ex situ* population, husbandry, conservation

Resumen

Los studbooks son bases de datos de registros genealógicos individuales en poblaciones *ex situ*. Puesto que son una herramienta esencial en planeación y manejo, realizamos una búsqueda de reportes de studbooks para explorar tendencias históricas en programas de cría de primates neotropicales y sus implicaciones en conservación *ex situ*. Accedimos a dos bases de datos: una construida por La Asociación Mundial de Zoológicos y Acuarios (WD) y otra compilada a partir de registros públicos (PD). WD comprendió 104 reportes (1998-2011) de tres regiones hábitat y siete no hábitat para 44 especies. PD consistió en 222 reportes de 34 especies de dos regiones hábitat y tres no hábitat (1973-2019). Los studbooks internacionales fueron más frecuentes en PD (82%), mientras que los regionales lo fueron en WD (55.8%). Ambas bases de datos mostraron que las categorías de la UICN (LC, NT, VU, EN, CR y DD) con un mayor número de especies contienen un mayor número de especies con studbooks y un mayor número de studbooks. Por lo tanto, existe un sesgo hacia un mayor número de studbooks in especies LC (Preocupación Menor). A pesar de las limitaciones en la disponibilidad y acceso a registros de studbooks, nuestros resultados revelaron una discrepancia entre las regiones donde se han llevado a cabo acciones de conservación *in situ* y de conservación *ex situ*. Esto resalta la necesidad de la cooperación internacional para fortalecer los esfuerzos de conservación, construir infraestructura, incrementar los tamaños efectivos poblacionales y en últimas establecer poblaciones viables. Finalmente, recomendamos evaluar oportunidades de conservación *ex situ* de especies amenazadas DD (Datos Deficientes) cuya conservación en el medio silvestre es improbable en el futuro cercano.

Palabras Clave: Primates del Nuevo Mundo, Neotrópico, poblaciones *ex situ*, cría en cautiverio, conservación

Introduction

Captive breeding of wild species has conferred a remarkable alternative for conservation of threatened species through establishment of populations in controlled environments, and it has been seen as a potential source of specimens for

release or reintroduction (Pelletier et al., 2009; Dulloo et al., 2010; Leus, 2011). Such is the emblematic case of the golden lion tamarin (*Leontopithecus rosalia*), whose conservation program achieved a population recovery and status change from Critically Endangered to Endangered (Soorae, 2010; Kierulff et al., 2012). In fact, the International

Union for Conservation of Nature (IUCN) has formulated guidelines to help identify in five steps those cases when *ex situ* management might be an appropriate conservation strategy (IUCN/SSC, 2014). Since the first signatories to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in the 1970s, zoos and animal parks have managed to establish *ex situ* populations of species whose collection from the wild is no longer permitted (Gippoliti, 2012; Bowkett, 2014; Gilbert et al., 2017; CITES, 2019).

During the transition to CITES, research centers of Neotropical primates mainly in the USA and Europe also established *ex situ* breeding programs for a variety of purposes including scientific and medical research (Gozalo and Montoya, 1990; Johnsen et al., 2012). *Ex situ* colonies of New World primates include marmosets, tamarins, squirrel monkeys, owl monkeys, capuchins and titi monkeys (Tardif et al., 2006; Smith, 2012; European Association of Zoos and Aquaria, 2019; NPRC, 2019). These non-conservation-oriented centers have allowed the gathering of relevant information of interest to conservation, in areas related to social behavior, reproductive biology, parasitology, physiology and ecology, but they have also served as a tool for education in conservation, and professional training (Mittermeier et al., 1994; Giovanini, 2002; Weigl, 2005; Nuss and Warneke, 2010; Brito et al., 2010).

Nonetheless, the role of captive breeding programs of wild-life species in conservation has been criticized for: (1) the potential emergence of demographic problems caused by the small size of *ex situ* populations, which makes them prone to rapid loss of genetic diversity (genetic drift) and overall fitness reduction (inbreeding depression) (Thornhill, 1993; Snyder, et al., 1996); (2) the aptitude of captive bred animals for release can also be compromised by their physiological, morphological and behavioral adaption to captive environments. Several traits may include adaptation to confinement, tameness and adaptive response to prevalent parasites in such environments, an effect that increases with the number of generations a species spends in captivity (De Vleeschouwer et al., 2003; O'Regan and Kitchener, 2005; Williams and Hoffman, 2009); (3) limited knowledge of target populations where animals are released (Snyder et al., 1996). Also, political instability and budget constraints have been argued as factors that can hamper the management of *ex situ* populations in the long term.

Despite some criticism of captive breeding programs as a recovery strategy and recognized issues of this practice, effective *in situ* conservation of primate species, i.e., conservation in their native habitats, may be unrealistic in areas with heavy disturbance or loss of native habitat. Around 40 % of the Neotropical primates (Platyrrhini) are threatened, mainly due to habitat loss and fragmentation (Mittermeier et al., 2009; Dulloo et al., 2010; Laurance et al., 2014; Estrada et al., 2017), and therefore establishment of healthy populations in captivity may no longer be

disregarded. Indeed, it has become a sensible or even an unavoidable alternative (Lascuráin et al., 2009; Pelletier et al., 2009; Dulloo et al., 2010; Leus 2011; Soto-Calderón et al., 2015).

An essential tool for successful establishment and management of *ex situ* populations is the studbook (Conway, 1986; Glatston, 1986). It consists of a database with updated individual records for age, sex, location, genealogical relationships, and survival. These records are necessary to estimate demographic and genetic parameters, make management decisions, and ultimately develop viable *ex situ* populations, while minimizing the risk of inbreeding and erosion of genetic variation (Glatston, 1986, 2001; Valeggia et al., 1999). Unfortunately, studbook databases are frequently restricted to regional communities or experts; thus, identification of trends in species of interest and temporal variation in such cases are hardly traceable.

Given the importance of studbooks as an essential tool in the establishment and management of *ex situ* populations, we conducted a review of available studbook reports associated with Neotropical primate breeding programs to identify historical emphasis on particular taxa, species of interest for conservation, and level of collaboration between institutions from different regions. We also considered the implications of such trends for future conservation of Neotropical primates.

Methods

A database of Neotropical primate studbooks released between 1998 and 2011 was kindly provided by Laurie Bingaman Lackey (WAZA, the World Association of Zoos and Aquariums) as part of the WAZA Studbook Library (WAZA, 2011); hereafter the WAZA or WD database. We also compiled an alternative database from public sources and peer-reviewed journals (the Public database or PD), consisting of studbook reports starting with the first available studbook record found, continuing up to 2019. To do this, we used “Studbook + *Genus name*” or “Breeding program (in English) + *Genus name*” as key phrases in Google, Google Scholar and Scopus databases. We also retrieved studbook reports from all of the editions of the International Zoo Yearbook and from the list of references in scientific publications. A complete list of records is available from the authors upon request. We classified studbooks in both databases by taxon (subspecies, species or genus), year of publication and country. Studbooks at the genus level with no indication of the species were excluded (*Ateles* spp., *Cebus* spp., *Aotus* spp., and *Callicebus* spp.). We categorized a studbook as regional when target populations were located in zoos or animal parks in a single country; otherwise, we classified it as international. Since records frequently fail to distinguish between new studbooks and updates, we treated every record as an independent report (Supplementary Fig. 1). We followed the taxonomy and Red List categories of The International Union for Conservation of

Nature (IUCN) as of April the 8th 2020 (Supplementary Table 1). These categories are: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD), considering VU, EN, and CR as increasing threat levels for extinction. We used a Spearman-rank correlation (r_s) to test the hypothesis that IUCN levels with larger number of species also contain larger numbers of assessed species and studbook reports. We evaluated differences in the number of reports and managed taxa for each threat level between the two databases with Fisher's Exact tests. The authors declare that they have no conflict of interest.

Results

WAZA Database (WD)

We identified 104 studbook reports for 44 Neotropical primate species in the 14-year period spanned by this database (1998-2011) (Supplementary Fig. 2A). This list includes single reports for *Cebus olivaceus* in 2007 and *Cebus albifrons* in 2010, and two reports for *Pithecia pithecia* in 2009 and 2011; each of these taxa were split into several species after the release of such studbooks (Boubli et al., 2012; Marsh, 2014; Lima et al., 2017). Institutions from different locations in three habitat countries (Brazil, Colombia and Costa Rica) and seven non-habitat regions (USA, Europe, New Zealand, Mexico, Colombia, Australia and Japan) compiled these reports through regional efforts or international collaboration in 58 (55.8%) and 46 cases (44.2%), respectively. The most productive regions were Europe and the USA, with a total of 79 records (76%) for 42 of the 44 Neotropical primate taxa in the database. These regions were followed by institutions from Japan and Brazil, each with six studbook reports for a total of 12 different primates (Supplementary Fig. 2A).

Reports from habitat countries included the black lion tamarin (*Leontopithecus chrysopygus*), the crested capuchin (*Sapajus robustus*), the Peruvian spider monkey (*Ateles chamek*), the white-fronted spider monkey (*A. belzebuth*), the black spider monkey (*A. paniscus*) and the white-cheeked spider monkey (*A. marginatus*) in Brazil; the cotton-top tamarin (*Saguinus oedipus*), the white-footed tamarin (*S. leucopus*) and the black-handed spider monkey (*A. geoffroyi*) in Colombia; and the Central American squirrel monkey (*Saimiri oerstedii*) in Costa Rica. Several taxa stand out with five studbook reports, as in the case of *Saguinus oedipus* with three regional (Australia, Colombia and Japan) and two international studbook reports, as well as *A. geoffroyi* with three regional (New Zealand, USA and Colombia) and two international reports from Europe. The genus with the most reports is *Ateles* with 30, followed by *Saguinus* with 17.

Of the 44 Neotropical primate species with at least one studbook report, 24 species (54.5%) were classified under an increased threat level (VU, EN, or CR), 16 (36.4%) were categorized as LC, one (2.3%) as NT and the remaining

three (6.8%) were assigned to other species whose taxonomy changed after the release of their studbooks (*Cebus albifrons*, *Cebus olivaceus* and *Pithecia pithecia*). No reports for DD species were recorded in this database (Table 1). A total of 65 studbooks (62.5%) were compiled for threatened taxa. Also, 34 reports (32.7%) corresponded to LC taxa and one (1.0%) to NT (Table 1). We observed a significant correlation between the total number of species in each IUCN threat level with both the number of managed species ($r_s=0.94$, $p=0.017$) and the number of studbook reports ($r_s=0.89$, $p=0.033$).

Table 1. Number of Neotropical primate taxa in the IUCN Red List of Species with their corresponding number of studbook reports, available in the WAZA (WD) and in the Public (PD) databases.

	WD		PD	
	No. Taxa (%)	No. Reports (%)	No. Taxa (%)	No. Reports (%)
LC	16 (36.4)	34 (32.7)	14 (41.2)	71 (32.0)
NT	1 (2.3)	1 (1.0)	1 (2.9)	3 (1.4)
VU	10 (22.7)	21 (20.2)	6 (17.6)	34 (15.3)
EN	9 (20.5)	28 (26.9)	7 (20.6)	65 (29.3)
CR	5 (11.4)	16 (15.4)	5 (14.7)	38 (17.1)
Other *	3 (6.8)	4 (3.8)	1 (2.9)	11 (5.0)
Total	44	104	34	222

LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered. * Species reclassified as two or more species since studbook report.

Of the 104 reports in WD, we had to exclude 23 records with unavailable publication date from yearly statistics. Of the remaining 81, the average annual number of reports was 5.8 (S.D. = 5.9), with the highest number of reports in 2006 and 2010 with 18 reports for each year, followed by 2009 with ten and 2011 with eight (Supplementary Fig. 1A). We found no records for the 1999-2000 period. The first set of reports for Neotropical primates was published in 1998 for spider monkeys (*Ateles chamek*, *A. geoffroyi*, *A. belzebuth* and *A. fusciceps*). The most recent reports were published in 2011 for the pygmy marmoset (*Cebuella pygmaea*), the cotton-top tamarin (*Saguinus oedipus*), the black-headed night monkey (*Aotus nigriceps*), the southern night monkey (*A. azarae*), the grey-legged douroucoulis (*A. lemurinus*), the white-faced saki (*Pithecia pithecia*), the white-headed marmoset (*Callithrix geoffroyi*), and the black-handed spider monkey (*Ateles geoffroyi*).

Public Databases (PD)

We found a total of 222 studbook reports produced between 1973 and 2015 for 34 species, including eight studbook reports for *Pithecia pithecia* that were released before this species was divided into two species *P. pithecia* and *P. chrysocephala* more recently (Marsh, 2014). These studbooks were compiled by institutions in three non-habitat

(USA, Europe and Australia) and two habitat regions (Brazil and Colombia) (Supplementary Fig. 2B). Institutions from non-habitat regions, mainly Europe and the USA, have participated in the development of 94.6% (210) of all reports at both regional and international levels. We identified 182 (82.0%) international reports for 32 taxa, and 40 (18.0%) regional reports from habitat and non-habitat countries for 16 taxa (Supplementary Fig. 2B). Only eleven studbook reports were developed in habitat countries, including seven for the black lion tamarin (*Leontopithecus chrysopygus*) endemic to Brazil, along with three for the white-footed tamarin (*Saguinus leucopus*) and one for the brown-headed spider monkey (*Ateles fusciceps*) endemic to Colombia. Two tamarins (*L. rosalia* and *S. oedipus*) and one howler monkey (*Alouatta caraya*) stand out for having the largest number of studbook reports, mostly developed in non-habitat countries. The genus with the most studbook reports was *Leontopithecus* with 40, followed by *Saguinus* with 32.

Among the 34 taxa with at least one studbook report in PD, the Red List category with the largest representation was LC with 14 taxa (41.2%), followed by 18 species classified under an increased threat level (52.9%), one NT (2.9%), and one remaining species with recent taxonomical changes (2.9%) (Table 1). No DD taxa were present in this database. Threatened taxa were represented by 137 reports (61.7%), LC by 71 reports (32.0%), NT by three (1.4%) and other taxa by 11 reports (5.0%) (Table 1). The number of studbooks but also the number of managed species in each IUCN level increased with the total number of species in each level, but this relationship was only significant in the second case ($r_s = 0.89$, $p = 0.033$).

The average number of reports per year was 4.63 (S.D. = 6.07) starting in 1973 with a studbook compiled for the golden lion tamarin (*Leontopithecus rosalia*) (Jones, 1973). The most recent reports were released in 2019 for 28 species (Supplementary Fig. 1B). The most productive years were 2016, 2017 and 2019. We found no publications for 1974 and 1975. Only one studbook report in PD was missing the date of release.

Combined databases

We detected no differences between the two databases, neither in the number of reports for species in each Red List category (Fisher's test, $p = 0.704$) nor in the number of managed species in such categories (Fisher's test, $p = 0.992$). However, a comparison of the two databases for the same time frame (1998-2011) showed that WD was more geographically diverse and covered more taxa than public databases. WD comprised reports from New Zealand, Japan, Mexico, and Costa Rica that were unavailable in PD. Also, WD comprised a larger number of species for this time period, including all the taxa present in PD.

A total of 45 (27.8%) out of 162 Neotropical primate species recognized in the Red List (after excluding *Cebus*

albifrons, *Cebus olivaceus* and *Pithecia pithecia*) had at least one studbook in either of the two databases. LC contains the largest number of species with at least one studbook (17, 37.8%). A total of 27 threatened species (VU, EN and CR) have studbooks and represent 60.0% of all managed species. We failed to find active studbooks for three threatened species that had been previously managed (Supplementary Figure 1B). The most concerning case is the Wied's marmoset (*Callithrix kuhlii*), which seems to have a single regional studbook issued in 2003. The two other threatened species are the Geoffroy's spider monkey (*Ateles geoffroyi*) and the common woolly monkey (*Lagothrix lagothricha*), with studbooks issued in 2010 and 2017, respectively. Only five out of 18 CR species have been managed (27.8%), all with actively updated studbooks in European zoos (Fig. 1 and Supplementary Table 1). The 13 CR species with no record of previous management were the following: the black-faced lion tamarin (*Leontopithecus caissara*), the Ecuadorian capuchin (*Cebus aequatorialis*), the ka'apor capuchin (*C. kaapori*), the Trinidad white-fronted capuchin (*C. trinitatis*), the blond capuchin (*Sapajus flavius*), Barbara brown's titi (*Callicebus barbarabrownae*), the Caqueta titi (*Plecturocebus caquetensis*), the Rio Mayo titi (*P. oenanthe*), the black-bearded saki (*Chiropotes satanas*), the northern muriqui (*Brachyteles hypoxanthus*), the southern muriqui (*B. arachnoides*), the Colombian woolly monkey (*Lagothrix lugens*) and the yellow-tailed woolly monkey (*L. flavicauda*).

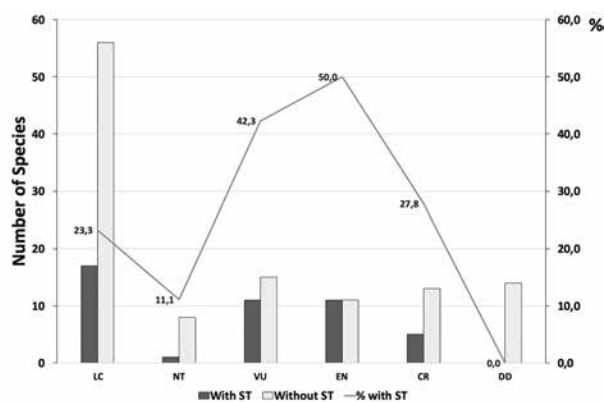


Figure 1. Number of Neotropical primates with presence versus absence of at least one previous studbook (ST), for each IUCN category. The left Y-axis indicates the number of species, and the right Y-axis the proportion of species with at least one studbook for each IUCN category. LC: Least Concern; NT: Nearly Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; DD: Data Deficient.

Discussion

We searched for studbook reports of Neotropical primate species as a means to identify husbandry programs and diagnose their current and/or future use in conservation. We are aware that our results do not reflect the actual number of studbooks but instead, the number of reports of *ex situ* breeding programs of Neotropical primate species based on two independent sources of information. Since studbooks

are not an obligation but a service that institutions provide free of charge to peer institutions (Glatston, 1986), studbook updates are not necessarily reported or accessible and they may not contain comprehensive information regarding studbook keepers or host institutions. This limitation prevented us from distinguishing between novel studbooks and updates of previous studbooks, and there was no unequivocal way to validate simultaneous reports of a given studbook in the two databases; i.e. those present in both PD and WD databases. However, we were able to identify similar trends in both databases, but also compare temporal variations in the number of reports and emphasis made on particular taxa.

Both databases comprised studbook reports exclusively produced by zoos around the world, since studbooks developed by non-zoo institutions were unavailable and therefore out of the scope of this review. This is unfortunate because, despite the relevance of scientific knowledge from research centers in understanding the biological requirements of species for reproduction in captivity and their potential for *in situ* conservation, integration with efforts from zoos and other conservation-oriented institutions seems to be only occasional, if not entirely missing.

Most studbook reports in PD are international, whereas those in WD were mainly regional. The fact that international studbooks require stronger collaboration of stakeholders, and as a consequence, they have more visibility in international journals and other sources available on internet, may account for the high percentage of international studbooks in PD. This contrasts with the higher prevalence of regional studbooks in WD. A similar pattern was found in other monitored taxa in WAZA zoos, where only 15% of studbooks are international (Traylor-Holzer, 2011), indicating that management efforts are mainly conducted at the regional level. Information for specific animal species in zoos around the world is available to the WAZA community through international studbook reports (WAZA, 2018). This may be used to foster integration of efforts from local, regional and international stakeholders to increase effective population sizes through careful metapopulation management, and in so doing improve the genetic and demographic health of established populations and their expected viability to the long term.

Our results showed that institutions from countries in the Neotropics have led only a minority of studbooks, which uncovers a disparity between regions where captive breeding has been stressed and those where *in situ* conservation efforts are required. This is strongly influenced by differences in financial resources and infrastructure between regions, since primate habitats are mostly located in developing countries with less financial capacity, staff and infrastructure (Cuarón, 2005). Also, recent simulations forecast a growing conflict caused by agricultural and human expansion in areas of high primate species richness in the Neotropics, especially in countries such as Brazil,

Colombia and Peru (Güneralp and Seto, 2013; Estrada et al., 2017). Once again, cooperation between institutions from habitat and non-habitat countries could be quite advantageous, in this case to integrate *in situ* conservation efforts in the Neotropics with scientific research and infrastructure derived from *ex situ* populations (European Association of Zoos and Aquaria, 2019).

The fact that threatened New World primate species account for 60% of all species with previous studbooks shows that management of *ex situ* populations may have a remarkable impact on conservation of threatened species. However, a previous survey of birds and mammals showed that species in zoos are less threatened than related species not held in zoos (Martin et al., 2014). Among the 18 CR Neotropical primate species, only five have been the target of a studbook because in addition to conservation purposes, other reasons and motivations may guide the decision to whether or not to establish a studbook of a given species (Mendes et al., 2008; Estrada et al., 2017; IUCN, 2017). Some of these include the cost to keep an *ex situ* population in captivity, preference for more charismatic species to attract visitors or restrictions to access species of interest (Bowkett, 2014; Fa et al., 2014). In fact, the two databases compiled in this study revealed that the larger the number of species in a given IUCN level, the larger the number of species with at least one studbook and the larger the number of studbooks. This explains the overrepresentation of studbooks and managed species in LC as compared to other levels, a pattern also seen in other vertebrates (Oberwemmer et al., 2011).

Changes in IUCN categorization and taxonomy also may explain the deficit of studbooks in certain species, and arguably of *ex situ* populations. The genus *Cebus* is a taxon with intricate phylogeography whose taxonomy and systematics has undergone radical changes over the past few years (Boubli et al., 2012; Lima et al., 2017). In particular, a studbook for the capuchin monkey *Cebus olivaceus* was released in 2007, but this taxon is in process of being divided into multiple species including *C. olivaceus*, *C. brunneus*, *C. castaneus*, and the critically endangered *C. kaapori*, all of which lack a subsequent studbook. Likewise, the capuchin monkeys *Cebus albifrons*, *C. versicolor*, *C. aequatorialis*, *C. cesarae*, *C. trinitatis*, *C. cuscinus* and *C. malitiosus* were all subsumed within *C. albifrons* until recently; a taxonomic change that took place after the release of a studbook for this species in 2010. Similarly, *Pithecia pithecia* was recently split in *P. pithecia* and *P. chrysocephala*, after the release of multiple studbooks between 1989 and 2011 (Marsh, 2014). Following these taxonomic changes, it turned out that several newly named species were classified as threatened, and it is probably too early to have managed the foundation of new *ex situ* populations (e. g., *C. aequatorialis*, *C. malitiosus*, *C. versicolor*, *C. trinitatis*, *C. kaapori*, and *Pithecia chrysocephala*). Similar cases are the critically endangered blond capuchin *Sapajus flavius*, which was recently rediscovered (Oliveira and Langguth, 2006), the

two species of miqui (*Brachyteles arachnoides* and *B. hypoxanthus*), formerly considered the same species (Groves, 2001; 2005), and lastly the titi monkeys with at least nine new species of *Callicebus* and *Plecturocebus* described since 2010 (Wallace et al., 2006; Deffler et al., 2010; Byrne et al., 2016; Boubli et al., 2019; Mittermeier and Rylands, 2020).

We found no studbooks of DD species in our data. Many of these are highly endemic or distributed in relatively remote areas, with limited or untested survival and/or reproductive success in captivity (Müller et al., 2011; Martin et al., 2014a). As a consequence, specimens and *ex situ* populations of these primates are also virtually absent in zoos. Within DD taxa are for instance several species of *Pithecia* and *Plecturocebus* that have been recently described or *Aotus*, such as *A. zonalis* and *A. jorgehernandezii* that have been poorly studied in the field (Deffler, 2010; Marsh, 2014; Byrne et al., 2016).

Since habitat loss poses the main threat for conservation of Neotropical primates, it is important to scrutinize the pertinence and viability of prioritizing *ex situ* conservation programs for the most threatened taxa (Estrada et al., 2017). Along with protection of native habitats, *ex situ* conservation may be a plausible conservation alternative for species such as the black-faced lion tamarin (*Leontopithecus caissara*), the blond titi (*Callicebus barbarabrownae*), the Caquetá titi (*Plecturocebus caquetensis*) and other CR species with no studbooks or managed populations, whose estimated population sizes have fallen to critically low numbers with a steady trend to decline (Lorini and Persson, 1994; García et al., 2010; Printes et al., 2011). Should conservation strategies of these species rely on *ex situ* populations in the near future, they will depend on careful prioritization of target species for conservation, identification of *in situ* and *ex situ* strategies, the availability of resources to invest in building infrastructure and research in reproductive biology and creation of collaborative international networks (Martin et al., 2014b).

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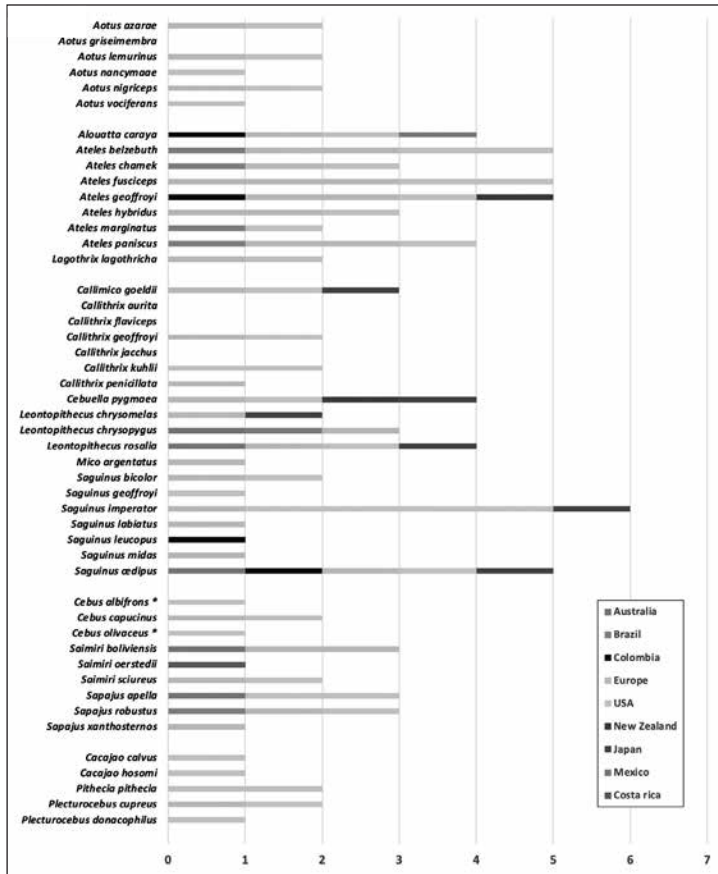
Supplementary Table 1. List of Neotropical primate taxa with at least one studbook record, sorted by IUCN conservation status.

IUCN Status	Taxa with no studbook	Taxa with studbook	
CR	<i>Brachyteles arachnoides</i>	<i>Ateles fusciceps</i>	
	<i>Brachyteles hypoxanthus</i>	<i>Ateles hybridus</i>	
	<i>Callicebus barbarabrownae</i>	<i>Saguinus bicolor</i>	
	<i>Cebus aequatorialis</i>	<i>Saguinus oedipus</i>	
	<i>Cebus kaapori</i>	<i>Sapajus xanthosternos</i>	
	<i>Cebus trinitatis</i>		
	<i>Chiropotes satanas</i>		
	<i>Lagothrix flavicauda</i>		
	<i>Lagothrix lugens</i>		
	<i>Leontopithecus caissara</i>		
	<i>Plecturocebus caquetensis</i>		
	<i>Plecturocebus oenanthe</i>		
	<i>Sapajus flavius</i>		
EN	<i>Alouatta pigra</i>	<i>Ateles belzebuth</i>	
	<i>Alouatta ululata</i>	<i>Ateles chamek</i>	
	<i>Aotus miconax</i>	<i>Ateles geoffroyi</i>	
	<i>Callicebus coimbrai</i>	<i>Ateles marginatus</i>	
	<i>Cebus malitiosus</i>	<i>Callithrix aurita</i>	
	<i>Cebus versicolor</i>	<i>Callithrix flaviceps</i>	
	<i>Chiropotes albinasus</i>	<i>Leontopithecus chrysomelas</i>	
	<i>Chiropotes utahickae</i>	<i>Leontopithecus chrysopygus</i>	
	LC	<i>Alouatta arctoidea</i>	<i>Alouatta caraya</i>
		<i>Alouatta guariba</i>	<i>Aotus azarae</i>
<i>Alouatta juara</i>		<i>Aotus nigriceps</i>	
<i>Alouatta macconnelli</i>		<i>Aotus vociferans</i>	
<i>Alouatta nigerrima</i>		<i>Callithrix geoffroyi</i>	
<i>Alouatta palliata</i>		<i>Callithrix jacchus</i>	
<i>Alouatta puruensis</i>		<i>Callithrix penicillata</i>	
<i>Alouatta sara</i>		<i>Cebus capucinus</i>	
<i>Alouatta seniculus</i>		<i>Mico argentatus</i>	
<i>Aotus trivirgatus</i>		<i>Plecturocebus cupreus</i>	
<i>Cacajao melanocephalus</i>		<i>Plecturocebus donacophilus</i>	
<i>Callibella humilis</i>		<i>Saguinus imperator</i>	
<i>Cebus brunneus</i>		<i>Saguinus labiatus</i>	
<i>Cebus castaneus</i>		<i>Saguinus midas</i>	
<i>Cheracebus lucifer</i>		<i>Saimiri boliviensis</i>	
<i>Cheracebus lugens</i>	<i>Saimiri sciureus</i>		
<i>Cheracebus purinus</i>	<i>Sapajus apella</i>		
<i>Cheracebus regulus</i>			
<i>Cheracebus torquatus</i>			
<i>Chiropotes chiropotes</i>			
<i>Leontocebus cruzlimai</i>			

IUCN Status	Taxa with no studbook	Taxa with studbook	IUCN Status	Taxa with no studbook	Taxa with studbook
EN	<i>Lagothrix cana</i>	<i>Leontopithecus rosalia</i>	LC	<i>Leontocebus fuscus</i>	
	<i>Plecturocebus modestus</i>	<i>Saguinus leucopus</i>		<i>Leontocebus illigeri</i>	
	<i>Plecturocebus olallae</i>	<i>Sapajus robustus</i>		<i>Leontocebus lagonotus</i>	
VU	<i>Alouatta belzebul</i>	<i>Aotus griseimembra</i>		<i>Leontocebus leucogenys</i>	
	<i>Alouatta discolor</i>	<i>Aotus lemurinus</i>		<i>Leontocebus nigricollis</i>	
	<i>Aotus brumbacki</i>	<i>Aotus nancymae</i>		<i>Mico acariensis</i>	
	<i>Cacajao ayresi</i>	<i>Ateles paniscus</i>		<i>Mico chrysoleucos</i>	
	<i>Callicebus melanochir</i>	<i>Cacajao calvus</i>		<i>Mico emiliae</i>	
	<i>Callicebus personatus</i>	<i>Cacajao hosomi</i>		<i>Mico intermedius</i>	
	<i>Cebus leucocephalus</i>	<i>Callimico goeldii</i>		<i>Mico mauesi</i>	
	<i>Cheracebus medemi</i>	<i>Callithrix kuhlii</i>		<i>Mico melanurus</i>	
	<i>Lagothrix poeppigii</i>	<i>Cebuella pygmaea</i>		<i>Mico saterei</i>	
	<i>Mico leucippe</i>	<i>Lagothrix lagothricha</i>		<i>Pithecia aequatorialis</i>	
	<i>Mico rondoni</i>	<i>Saimiri aertzeddi</i>		<i>Pithecia albicans</i>	
	<i>Pithecia mittermeieri</i>			<i>Pithecia chrysocephala</i>	
	<i>Plecturocebus ornatus</i>			<i>Pithecia inusta</i>	
	<i>Saguinus niger</i>			<i>Pithecia monachus</i>	
	<i>Saimiri vanzolinii</i>			<i>Pithecia napensis</i>	
NT	<i>Callicebus nigrifrons</i>	<i>Saguinus geoffroyi</i>			<i>Plecturocebus aureipalatii</i>
	<i>Cebus cuscinus</i>			<i>Plecturocebus baptista</i>	
	<i>Leontocebus tripartitus</i>			<i>Plecturocebus bernhardi</i>	
	<i>Mico nigriceps</i>			<i>Plecturocebus brunneus</i>	
	<i>Saguinus martinsi</i>			<i>Plecturocebus caligatus</i>	
	<i>Saimiri ustus</i>			<i>Plecturocebus cinerascens</i>	
	<i>Sapajus libidinosus</i>			<i>Plecturocebus discolor</i>	
	<i>Sapajus nigrurus</i>			<i>Plecturocebus dubius</i>	
DD	<i>Aotus jorgehernandezi</i>			<i>Plecturocebus hoffmannsi</i>	
	<i>Aotus zonalis</i>			<i>Plecturocebus moloch</i>	
	<i>Cebus cesariae</i>			<i>Plecturocebus pallescens</i>	
	<i>Mico humeralifer</i>			<i>Saguinus fuscicollis</i>	
	<i>Mico marcai</i>			<i>Saguinus inustus</i>	
	<i>Pithecia cazuzai</i>			<i>Saguinus melanoleucus</i>	
	<i>Pithecia hirsuta</i>			<i>Saguinus mystax</i>	
	<i>Pithecia irrorata</i>			<i>Sapajus cay</i>	
	<i>Pithecia isabela</i>			<i>Sapajus macrocephalus</i>	
	<i>Pithecia milleri</i>				
	<i>Pithecia pissinattii</i>				
	<i>Pithecia vanzolinii</i>				<i>Cebus albifrons</i>
	<i>Plecturocebus stephennashi</i>				<i>Cebus olivaceus</i>
<i>Plecturocebus vieirai</i>				<i>Pithecia pithecia</i>	
			Other *		

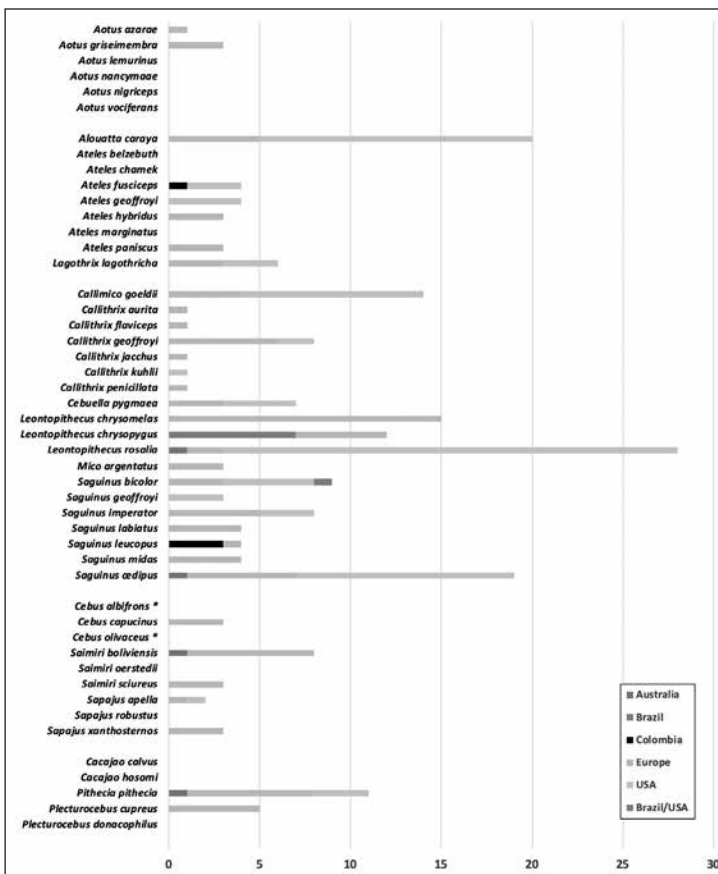
IUCN status (2020): CR (Critically Endangered), EN (Endangered), VU (Vulnerable), NT (Nearly Threatened), DD (Data Deficient) and LC (Least Concern). * Species reclassified as two or more species since studbook report.

Supplementary Figure 2. Representation of 48 Neotropical primate taxa in studbook reports published across different countries and regions.



A. Records between 1998 and 2011 in the WAZA database (WD).

* Studbooks are categorized by family, taxon and location of the chief organization involved in the development of each studbook.



B. Records between 1973 and 2019 in the Public database (PD).

* Studbooks released before introduction of taxonomic changes.

OCORRÊNCIA, ECOLOGIA E CONSERVAÇÃO DO GUIGÓ-DA-CAATINGA (*CALLICEBUS BARBARABROWNAE* - HERSHKOVITZ, 1990)

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Resumo

O guigó-da-caatinga, *Callicebus barbarabrownae* - Hershkovitz 1990, é o único primata endêmico do bioma caatinga no nordeste da Bahia. A espécie encontra-se ameaçada de extinção pela perda de habitat, causada principalmente pela supressão da vegetação e fragmentação das florestas onde se encontram. O presente estudo teve como objetivo localizar, com o auxílio de *playback*, e registrar os fragmentos ocupados por grupos de guigós no município de Banzaê, Bahia – Brasil. Além do registro de novas áreas de ocorrência, foi descrita a utilização de frutos dos gêneros *Capparis* (Brassicaceae) e *Manilkara* (Sapotaceae) pelos guigós.

Palavras-chave: Primatas, extinção, Banzaê

Abstract

The blonde titi-monkey, *Callicebus barbarabrownae* - Hershkovitz 1990, is the only primate endemic to the Caatinga biome in northeastern Bahia. The species is threatened with extinction due to habitat loss, mainly caused by vegetation suppression and fragmentation of the forests in which they are found. The aim of the present study was to locate, with the aid of playback, and to record the fragments occupied by groups of titis in the city of Banzaê, Bahia, Brazil. In addition to documenting new occurrence localities, the use of fruits of the genera *Capparis* (Brassicaceae) and *Manilkara* (Sapotaceae) was described.

Key Words: Primates, extinction, Banzaê

Introdução

A Caatinga no nordeste brasileiro ainda é um bioma pouco estudado. No entanto, apesar da escassez de conhecimentos sobre sua biodiversidade, a Caatinga se apresenta ameaçada e fragmentada, contrastando com a sua relevância biológica o bioma pode ser considerado um dos mais ameaçados do Brasil (Leal et al., 2003). Poucos são os mamíferos endêmicos da Caatinga (Leal et al., 2003). Dentre essas espécies está o guigó da caatinga (*Callicebus barbarabrownae* – Hershkovitz, 1990) (Veiga et al., 2008; Gutiérrez e Marinho-Filho, 2017), habitando fragmentos de caatinga no estado da Bahia, é ainda o símbolo de resistência à insensatez e à destruição humana.

Considerada como espécie a partir de 2002 (Printes, 2007), *Callicebus barbarabrownae* foi descrita por Philip Hershkovitz (1990) como uma subespécie de *C. personatus* (E.

Geoffroy, 1812). Poucos estudos relacionados à espécie podem ser encontrados, o que a torna uma espécie ainda mais fragilizada e ameaçada de extinção. O desconhecimento sobre essa espécie inviabiliza ações que possam contribuir para a sua preservação. Um dos principais fatores responsáveis pela redução populacional em primatas não humanos é o desmatamento e a consequente perda de habitat (Isabirye-Basuta e Lwanga, 2008; Kierulff et al., 2012; Hilário et al., 2017). Muitas das espécies do gênero *Callicebus* estão ameaçadas de extinção, devido à destruição do habitat, desmatamento e caça (Nagy-Reis, 2012).

Na mais recente revisão (Byrne et al., 2016) o gênero *Callicebus*, que anteriormente abrangia 34 espécies distribuídas geograficamente desde a região sudeste do Brasil à floresta amazônica, ficou restrito às espécies da faixa litorânea brasileira entre os estados de Sergipe e São Paulo. Permanecem distribuídos no gênero *Callicebus* apenas as espécies do

grupo *personatus*: *C. melanochir*, *C. personatus*, *C. nigrifrons*, *C. coimbrai* e *C. barbarabrownae*. Com exceção de *C. barbarabrownae*, as outras espécies do gênero ocupam porções da Mata Atlântica (Culot et al., 2019). *C. barbarabrownae* está restrito à caatinga da região nordeste do Brasil entre os estados de Bahia e Sergipe.

Callicebus configura-se como um gênero predominantemente arborícola, ocupando os estratos de médio ao baixo das florestas, dificilmente descendo ao solo. Alimenta-se preferencialmente de frutos, folhas ou flores, e nos períodos de escassez destes itens pode incluir insetos em sua dieta (Souza Alves, 2010, 2011).

O objetivo desse trabalho foi localizar e registrar a ocorrência dos guigós, em fragmentos de Caatinga. Mapear a distribuição desses grupos de guigós é fundamental para a tomada de decisões na escolha de grupos mais propícios para prosseguir com pesquisas relacionadas à conservação dos habitats e à ecologia da espécie.

Materiais e métodos

Área de estudo

A escolha do município se deu através de um encontro de Educação Ambiental, promovido pelo Governo do Estado da Bahia, através Fundação Luís Eduardo Magalhães e a Secretaria de Meio Ambiente do estado. Realizado na cidade de Tucano, no mesmo estado, estavam presentes representantes de órgãos públicos e sociedade civil, envolvidos em ações ambientais. Participaram desse encontro entre 15 e 20 pessoas oriundas de municípios da região do semiárido baiano (Banzaê, Tucano, Serrinha, Coronel João Sá, Cícero Dantas, Ribeira do Pombal, Euclides da Cunha).

Durante este encontro um dos pesquisadores fez uma apresentação sobre o guigó da Caatinga para os representantes municipais e ao final foi mostrado uma imagem e acionado um playback com a vocalização do guigó. Após esse momento foi perguntado aos presentes sobre a existência ou relato de existência desse primata em seus municípios. As respostas positivas vieram apenas dos representantes dos municípios de Serrinha e Ribeira do Pombal (município este que faz divisa com Banzaê). Pela solidez nas afirmações quanto aos relatos de ocorrência, optamos pelas incursões no município de Banzaê. Além desta cidade já ter sido citada como área de ocorrência por outro pesquisador (Printes, 2007, 2011).

O local escolhido foi o que se mostrou mais propício à confirmação de localização dos guigós, devido ao maior número de relatos de sua existência no local. Apesar desses relatos, nenhum dos informantes afirmou ter avistado a espécie. A existência era confirmada apenas pela vocalização do guigó da Caatinga.

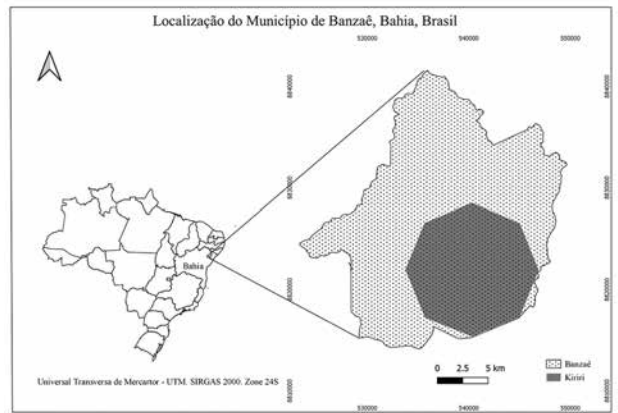


Figura 1. Mapa de localização do município de Banzaê, elaborado a partir de banco de dados do Instituto Brasileiro de Geografia e Estatística – IBGE, e Fundação Nacional do Índio – FUNAI.

O município de Banzaê (Fig. 1) está inserido no “Polígono das Secas”, apresentando um clima do tipo megatérmico semiárido, com temperatura média anual de 24,3°C, precipitação pluviométrica média no ano de 600 a 800 mm e período chuvoso de maio a julho (CPRM, 2005). A população estimada é de 13,229 pessoas, e a área do município é de 409,507 km² (IBGE, 2019). De acordo com o Censo Agropecuário de 2006, o município possuía um rebanho bovino de 12.895 cabeças, caprinos 1,231, equinos 682 e ovinos 4.289 (IBGE, 2006).

Procedimentos de campo

Foram feitos contatos com alguns moradores da região - preferencialmente moradores da zona rural que nasceram, e/ou, tenham residido a maior parte de sua vida na região - através de contato direto por um dos pesquisadores que nasceu no município e já possuía o conhecimento prévio dessas pessoas (apicultores, criadores de gado e agricultores). Na oportunidade, foi esclarecido às pessoas com quem mantivemos contato direto durante as pesquisas (moradores das localidades de ocorrência dos primatas e apicultores) sobre a existência de uma espécie ameaçada de extinção na região. Destacamos a essas pessoas o papel que a espécie desempenha na manutenção dos ecossistemas onde habitam, visando com esses esclarecimentos, contribuir para a boa relação entre população humana e a biodiversidade. Populações rurais, no geral, percebem no ambiente apenas os bens naturais que podem gerar lucros ou outros benefícios imediatos (Torres Junior, 2015). No contato com esses moradores, além de apresentar imagens durante as coletas de informações, era apresentada também a vocalização da espécie.

Entre os meses de abril e setembro de 2016, os esforços de amostragem somaram um total de 09 dias de campo, especificamente nas localidades com probabilidades de se encontrar os guigós. Dias de campo, para o registro das localizações e visualizações, foram feitos uma ou duas vezes por mês, com saída de Salvador com destino à Banzaê às sextas, e retorno às segundas-feiras.

Como os guigós geralmente vocalizam pela manhã ou ao entardecer (Freitas, 2010; Rocha, 2011), nos dirigíamos ao fragmento previamente selecionado logo após o clarear do dia, entre 4:00 e 5:00 horas da manhã. O fragmento Soturno foi uma exceção, onde acampamos e dormimos no local. Utilizamos *playbacks* para localizar os guigos (Jerusalinsky et al., 2006; Printes, 2011; Cäsar et al., 2012). Para o *playback* utilizamos vocalizações (não publicadas) de três espécies de guigós: *C. coimbrai*, *C. nigrifrons* e *C. barbarabrownae*. O áudio de *C. coimbrai* foi obtido no município de Simões Filho, estado da Bahia, *C. nigrifrons* proveniente do estado de Minas Gerais e *C. barbarabrownae* no município de Lamarão estado da Bahia. Optamos por acionar o *playback* com intervalos de cinco minutos entre reproduções até que a primeira resposta fosse ouvida. Após confirmação desta primeira resposta, seguimos o mesmo padrão de intervalos entre reproduções se as respostas continuavam até a aproximação dos guigós. A quantidade de reproduções realizadas variou em número de acordo com a distância entre os pesquisadores e os guigós e o tempo decorrido até uma possível visualização da espécie. Após a visualização, dificilmente prosseguíamos com o *playback*, a não ser que precisássemos visualizá-los por um período de tempo maior (para fotografar). Se as reproduções não obtinham resposta optamos também por não ultrapassar um total de dez reproduções. A resposta ao *playback* na maioria das vezes sempre ocorria no máximo após a terceira reprodução do *playback*.

Printes (2007) em estudos com *C. barbarabrownae*, utilizou a vocalização de *C. personatus* obtendo um bom resultado de respostas ao *playback*. No entanto, pelo fato de termos usado ao menos duas vocalizações diferentes no *playback*, não podemos tirar uma conclusão definitiva sobre o padrão de respostas às reproduções, pois alguns fatores podem influenciar na resposta, além da reprodução da vocalização de uma ou outra espécie. Esses fatores incluem a distância entre os pesquisadores e os grupos de guigós, a qualidade da reprodução, o clima ou até o contexto em que a espécie está inserida, tais como: local com presença humana próxima e a relação destes com a espécie, a convivência pacífica ou conturbada - caça, movimentação e fluxo de pessoas, barulho excessivo ou fora dos padrões de um ambiente de

selva - entre as espécies. O registro da localização foi feito com o GPS Garmin modelo Etrex 30. Os pontos foram marcados no aparelho e anotados em caderno de anotações no momento da chegada ao fragmento e antes de acionar o *playback*.

Resultados

Entre o período dos levantamentos de campo os pesquisadores participaram de uma reunião na Associação de Apicultores de Banzaê onde puderam conversar com os apicultores locais e fazer uma breve apresentação da espécie, seu estado de conservação e a necessidade de preservação da Caatinga para a manutenção das populações de guigós na região. Através de conversas informais, colhemos ainda algumas informações sobre a localização dos primatas, mas a maioria das pessoas desconheciam a espécie, a não ser pelos relatos de localização e visualização por parte de um apicultor indígena habitante da Reserva Kiriri.

No total foram comprovadas 05 localidades (Tabela 1 e Fig. 2) com ocorrência dos guigós no município de Banzaê, sem adentrar nas terras indígenas. A localidade “Soturno” já havia sido visitada anteriormente por Printes (2007); as outras quatro são novos registros. São as seguintes localizações: Soturno, Retiro, Doroteia, Camamu e Grota (denominação do local dada pelos pesquisadores) próxima à zona urbana de Banzaê (em torno de 500 metros).

Nas Fazendas Soturno e Camamu, foram confirmadas a presença dos guigós em dois fragmentos separados. Na primeira localidade, foram duas idas a campo. Na primeira incursão apenas ouvimos as vocalizações em resposta ao *playback*, mas na segunda ida, quando acampamos local, foi possível a visualização de três indivíduos (Fig. 3) Na Fazenda Camamu, no primeiro fragmento visitado, obtivemos apenas resposta acústica, mas ao acionarmos o *playback* em outro fragmento um grupo vocalizou em resposta e se aproximaram dos pesquisadores, permitindo assim a visualização de cinco indivíduos. Mas ao perceberem a nossa presença, o bando se afastou em fuga.

Tabela 1. Localidades e registros de vocalização e visualização de *Callicebus barbarabrownae* no município de Banzaê, estado da Bahia, Brasil.

Localidade	Coordenadas Geográficas Lat./Long. (WGS84)	Vocalização	Visualização	Indivíduos visualizados
Soturno	-10.59066 / -38.58969	Sim	Sim	03
Retiro	-10.51546 / -38.64423	Sim	Sim	01
Doroteia	-10.54476 / -38.65069	Sim	Não	00
Camamu	-10.59623 / -38.57611	Sim	Sim	05
Grota prox. Zona Urbana	-10.59298 / -38.60181	Sim	Sim	01

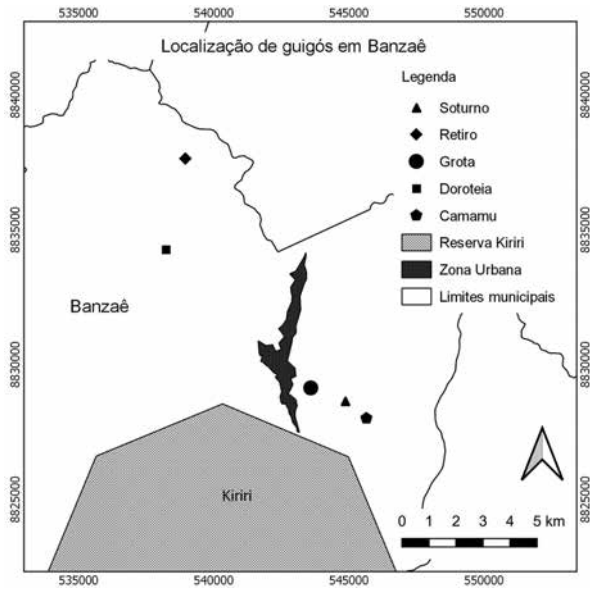


Figura 2. Mapa de localização dos guigós no município de Banaê, estado da Bahia, registrados durante o período de realização do presente estudo.



Figura 3. *Callicebus barbarabrownae*, fotografado na Fazenda Camamu. Imagem: Júnior Monteiro.

No Retiro, fragmento onde avistamos um indivíduo, o acesso é difícil, com a trilha beirando um despenhadeiro. Este também foi um dos locais visitados que apresentou o melhor estado de conservação da floresta. Esse fragmento foi visitado posteriormente, contudo, nessa segunda incursão não obtivemos resposta acústica ou visual. Na serra da Doroteia foram duas as incursões. A primeira sem respostas, mas na segunda, após o acionamento do playback os guigós responderam a uma distância aparentemente próxima (menor que dez metros), entretando, devido à composição estrutural da vegetação não conseguimos visualizá-los. No Retiro e na Doroteia há ainda fragmentos possíveis de abrigarem guigós, de acordo com relato dos moradores que nos guiaram. Em alguns desses fragmentos foi acionado o *playback*, entretanto, não obtivemos resposta na ocasião.

Na localidade mais próxima à zona urbana de Banaê, a qual denominamos Grota, avistamos apenas um indivíduo de *Callicebus barbarabrownae*. Devido às pequenas dimensões e ao grau de antropização do fragmento, apesar da dificuldade de penetração na mata, a manutenção de um grupo viável nesse local é quase impraticável.

Durante os meses de abril e maio encontramos vários frutos de icó - *Capparis yco* – Brassicaceae (Souza, 2008) - no fragmento Soturno, com marcas de mordidas. Esta espécie é encontrada com facilidade em todos os fragmentos visitados e alguns grupos de guigós foram avistados próximos ao local de frutos encontrados com mordidas recentes. No fragmento Retiro, no local de avistagem do guigó, frutos da maçaranduba - *Manilkara* spp. – Sapotaceae (Souza, 2008) - foram encontrados com marcas de mordidas recentes. O morador que nos acompanhou a este fragmento relatou, o que foi compartilhado por outros moradores, que os guigós também se alimentam deste fruto.

Pernoitar no fragmento onde se encontram os guigós, como no caso do fragmento da Fazenda Soturno, mostrou-se bastante proveitoso quanto à percepção de movimentação e vocalização dos grupos. Por volta das 4:00 horas, vocalizações curtas (como aquelas geralmente executadas pelos guigós antes de iniciarem as vocalizações em dueto) já podiam ser ouvidas. E entre 5:00 e 6:00 horas, algumas vocalizações espontâneas (sem indução por *playback*). No mesmo dia, durante o período da tarde, entre as 15:00 e 16:00 horas, nesse mesmo fragmento, ouvimos mais vocalizações espontâneas.

Discussão

O fato de um dos pesquisadores ter nascido e residido na região, influenciou sobre maneira na obtenção dos resultados. O conhecimento local e o envolvimento com os moradores e as causas ambientais, facilitaram o acesso às propriedades e uma redução de tempo e despesas financeiras pelo contato antecipado com as pessoas mais bem informadas sobre os guigós. Seria proveitoso, sempre que possível, o trabalho conjunto nas regiões de pesquisa, entre pesquisadores e associações ou movimentos locais envolvidos com as questões ambientais atuantes na região.

Na região de Banaê, os guigós ocupam fragmentos de caatinga arbórea. E para a região, se confirmam os resultados obtidos por Printes (2011) de que, há maior importância da atividade pecuária, em vez de outras atividades agrícolas, nas propriedades onde os guigós foram localizados. Em todos os fragmentos visitados durante a pesquisa, os guigós foram encontrados nas serras, na parte alta das propriedades, onde geralmente ainda predomina vegetação bem conservada, que devido à dificuldade de acesso, não foram suprimidas para dar lugar às pastagens. O sistema agropastoril apresenta-se como o fator que maior pressão exerce sobre a cobertura vegetal do semi-árido nordestino (Alves de Andrade et al., 2005).

Os guigós provavelmente são indicadores de matas bem conservadas (Printes, 2011). Entretanto, mesmo em fragmentos de difícil acesso, nas partes altas das serras, às vezes beirando despenhadeiros, nota-se a presença de rebanhos bovinos e caprinos, estes em menor ocorrência. Os guigós que habitam os fragmentos na Serra da Doroteia são uns dos mais ameaçados registrados neste estudo, pois, além da presença do gado há uma trilha cortando a serra, onde se realiza evento de *motocross*. Em uma das reproduções de *playback* neste fragmento, a resposta veio logo em seguida, mas foi bruscamente interrompida quando os pesquisadores conversaram em tom um pouco elevado durante a espera sob as árvores, e neste dia não houve mais resposta.

Talvez, a presença humana para os guigós, seja mais ameaçadora que a presença de outro grupo ou indivíduo da mesma espécie. Reforça essa hipótese o fato de que várias respostas, em diversos fragmentos, foram interrompidas depois de certo número de vocalizações e a reprodução do *playback* por até seis vezes, num intervalo entre a faixa de cinco a dez minutos, após a última resposta. Ao se aproximarem, os guigós possivelmente avistaram os pesquisadores (na maioria das vezes não sendo vistos por estes) o que fez com que dispersassem.

Apesar da Reserva Indígena Kiriri (Fig. 1) ocupar uma grande extensão territorial do município de Banzaê (FUNAI, 2016) optamos por não fazer nenhuma expedição a estas terras, sem antes manter contato com o órgão responsável, Fundação Nacional do Índio (FUNAI, 1995). Entretanto, em conversas com moradores que frequentam tais áreas, incluindo um índio da tribo Kiriri, o número de guigós tem aumentado dentro da reserva. Mas a caça ainda é praticada.

Pode-se também observar, ao passar por entre as terras indígenas (a rodovia BA 388, que leva à sede do município, corta a aldeia) o avançado estado de regeneração da vegetação em muitas áreas. Este fator pode ter contribuído para o aumento da população de guigós. Esses dados, para serem confirmados e aproveitados a favor da preservação da espécie, precisam de estudos e análises concretas. Mesmo, não tendo conhecimento do status de conservação dos guigós, ou ainda sem saber da existência da espécie em sua propriedade, alguns proprietários manifestam interesse em preservar os fragmentos onde foi confirmada a ocorrência dos guigós, e numa sondagem sobre a criação de RPPNs alguns se mostraram interessados. No entanto vale ressaltar que, apesar do desejo de alguns proprietários em preservar estes fragmentos, todos estão ameaçados por motivos diversos, tais como: a presença de gado e o corte ilegal de madeira, em grande parte das localidades esses fragmentos fazem parte da Reserva Legal (RL) da propriedade, e de acordo a legislação brasileira, devem ser preservados.

A criação de RPPNs, uma articulação com as secretarias de Educação e Meio Ambiente, corredores ecológicos, recuperação e manutenção dos fragmentos identificados como prioritários para a sobrevivência dos guigós, são ações que

podem contribuir para a conservação da espécie na região de Banzaê.

Agradecimentos

Nossos agradecimentos à Associação de Apicultores de Banzaê, ao apoio precioso durante a realização da pesquisa em campo, de Lourinho e João de Licero, que nos acompanharam e dividiram conosco seus conhecimentos adquiridos ao longo da vida no contato com esse ambiente impar e maravilhoso, que é a caatinga, e à FAPESB, Agência de Fomento à Pesquisa do Estado da Bahia.

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POPULATION DENSITY ESTIMATE FOR THE WHITE-FACED CAPUCHIN MONKEY (*CEBUS IMITATOR*) IN THE MULTIPLE USE AREA MONTAÑA LA BOTIJA, CHOLUTECA, HONDURAS, AND A RANGE EXTENSION FOR THE SPECIES

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Abstract

Honduras is one of the Neotropical countries with the least amount of information available regarding the conservation status of its wild primate species. Understanding the real conservation status of these species is relevant, since they are of great importance for ecosystem dynamics due to the diverse ecological services they provide. However, there are many threats that endanger the conservation of these species in the country such as deforestation, illegal hunting, and illegal wildlife trafficking. The present research is the first official registration of the Central American white-faced capuchin monkey (*Cebus imitator*) for the Pacific slope in southern Honduras, increasing the range of its known distribution in the country. A preliminary population density estimate of the capuchin monkey was performed in the Multiple Use Area Montaña La Botija using the line transect method, resulting in a population density of 1.04 groups/km² and 4.96 ind/km² in the studied area. These results provide us with a first look at an isolated primate population that has never been described before and demonstrate the need to develop long-term studies to better understand the population dynamics, ecology, and behaviour, for this group in the zone.

Key Words: Distribution, population density, *Cebus imitator*, Capuchin monkeys, Honduras.

Resumen

Honduras es uno de los países del Neotrópico en donde menos información se tiene acerca del estado de conservación de sus especies de primates silvestres. El conocimiento del estado real de conservación de estas especies es relevante ya que son de gran importancia para las dinámicas de los ecosistemas debido a los diversos servicios ecológicos que ofrecen. Sin embargo, en el país se presentan amenazas que ponen en riesgo la conservación de estas especies como son: la deforestación del bosque, la cacería y el tráfico ilegal de especies silvestres. En esta investigación se hace el primer registro oficial de monos capuchinos cara blanca (*Cebus imitator*) para la vertiente del Pacífico en el sur del país, de esta forma se amplía su rango de distribución para Honduras. Se realizó una estimación preliminar de las densidades poblacionales de esta especie en el Área de Usos Múltiples Montaña La Botija, utilizando el método de transectos lineales, dando como resultado una densidad poblacional de monos capuchinos de 1.04 grupos/km² y 4.96 ind/km² en el área de estudio. Estos resultados nos dan un acercamiento a una población de primates aislada de la que no se tenía ningún registro previo y nos muestran la necesidad de realizar estudios a largo plazo con esta población para poder entender de mejor manera las dinámicas poblacionales, ecología y comportamiento de este grupo en la zona.

Palabras Clave: Distribución, densidad poblacional, *Cebus imitator*, monos capuchinos, Honduras.

Introduction

Neotropical primate species are of great importance in tropical ecosystem dynamics, since they act as seed dispersers, pollinators and are an important part of the food chain as prey and predators (de la Torre, 2000). They are primarily arboreal with a wide variety of diets (Chapman and Chapman, 1990) and complex social systems (Kinzey and Cunningham, 1994). They also encompass wide diversity in body size and color (Robinson and Redford, 1984). While the biodiversity of Neotropical primates is highest in tropical rainforests, some species prefer deciduous, gallery or montane forests at more than 2,000 m a.s.l. (Chivers, 1982).

Honduras has high overall biodiversity due to its topography and its location in a tropical zone, among other factors (SERNA, 2001). Currently three wild primate species are reported in the country: the spider monkey *Ateles geoffroyi* (Kuhl, 1820), the capuchin monkey *Cebus imitator* (Thomas, 1903), and the howler monkey *Alouatta palliata* (Gray, 1849). However, none of these species are officially registered in the southern region of Honduras. Reid (2009) indicates the presence of these species in most of the country in the distribution maps in the publication "A field guide to the Mammals of Central America And Southeast Mexico," however these are very general maps without mention of any specific locality where these species might be present in Honduras.

Some of the main factors that have a negative impact on global biodiversity are: habitat loss (Brooks *et al.*, 2002), competition with invasive species (Clavero and Garcia-Berthou, 2005), host-pathogen interactions (Roche *et al.*, 2012), climate change (Alan Pounds *et al.*, 2006) and illegal hunting (Grayson, 2001); with hunting the main cause attributed to the extinction of large mammals and birds (Peres, 2000; Barnosky *et al.*, 2004; Suarez *et al.*, 2009). All of these factors are currently present in most of the protected areas in Honduras (Secaria, 2013), one of the Neotropical countries with the least amount of information available regarding the conservation status of its wild primates and with little research published. Two doctoral theses provide some of the most relevant data available for wild primates in Honduras. The first one, by Buckley (1983) described feeding behavior, social behavior, and ecology of the white-faced capuchin monkey (*Cebus imitator*) near the city of Trujillo, in the north of Honduras. The second doctoral thesis, by Hines (2005), the first study on spider monkeys (*Ateles geoffroyi*) in Honduras, focused on the ecology and taxonomy of spider monkeys at the Pico Bonito National Park in the department of Atlántida. Additionally, there is a note about an albino spider monkey in captivity in the city of Catacamas at the department of Olancho, Honduras (Espinal *et al.*, 2016).

Given the current conservation concerns and lack of knowledge about Honduran primates, it is important to develop long term studies to know and learn more about the ecology, behavior, distribution, and conservation status of the existing primate species in the country. The main goal for this research was to verify the presence and estimate the population density of white-faced capuchin monkeys (*Cebus imitator*) in the Multiple Use Area “Montaña La Botija” (AUMLB), Honduras.

Materials and Methods

Study area

The AUMLB was declared a protected area in 2005. It is located in the department of Choluteca, in the southern region of the Pacific slope of Honduras (ANED, 2009). In order to select the study area, interviews were conducted with the local residents and satellite images of the area were studied to determine the place with the most likely conditions to encounter the species (less human intervention, greater amount of forests, and where the locals mentioned greater probability to find it). The chosen place was “La Montaña del Ojochal” located in the dry tropical forest life zone (Holdridge, 1967). The annual rainfall is between 1,000 and 2,000 mm and temperatures are above 24°C during the whole year (Holdridge, 1967). This area is located between 450 and 900 m a.s.l. (ANED, 2009).

A preliminary six-day trip was carried out, to prepare and establish the transects inside the study area: “El Ojochal” with a length of 2 km (13°17'47.6" N 86°44'35.3" W),

“El Tamarindo” with 2.2 km (13°17'39.5" N 86°48'42.3" W), “Los Mogotes” with 1.8 km (13°17'08" N 86°44'37" W) and the “Montaña Oscura” transect with 2.5 km (13°17'54.5" N 86°44'54.3" W) (Fig. 1). A total of 8.5 linear km of sampling transects were created, located between 500 to 1,200 m a.s.l.

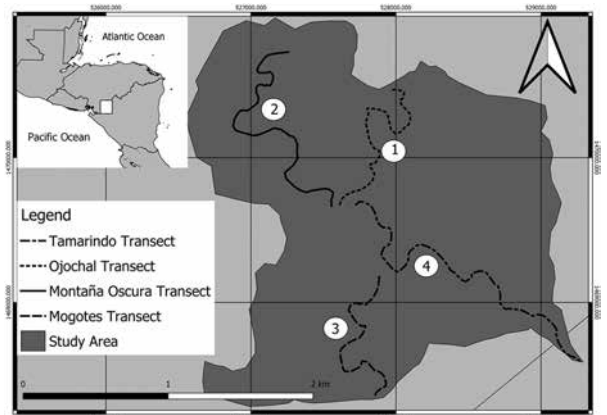


Figure 1. Study area and the 4 transects used: (1) transect El Ojochal, (2) transect Montaña Oscura, (3) transect Los Mogotes, (4) transect El Tamarindo.

Data Collection

Data collection occurred during June to December 2011. It consisted of monthly field trips with an average duration of 10 days, for a total of 65 days of field work. The duration of each trip varied based mainly on the weather conditions of the study area.

To estimate the population density of *Cebus imitator*, the line transect method was used, following the proposed guidelines by NRC (1981) and Peres (1999b). This method has been widely applied during the last three decades to quantify primates' population abundance in tropical forests (Peres, 1999b). The four transects were randomly walked, one each day and not repeating the same transect on two consecutive days, an average of three times each transect per field trip. For round trip walks on the transect, the travel in each direction was considered as independent. The outward walks were done from 06:00 to 10:00 hours, and the return walks were done from 14:00 to 18:00 hours, waiting approximately 3 hours at the end of the transect, usually at midday when the primates are less active, time enough for the animals to redistribute on the space (Wallace *et al.*, 1998; Peres, 1999b; Quinten, 2016). It is also important to mention that there was never more than one encounter in a given transect on the same day.

When a group of the studied species was detected, observations were made during a standardized amount of time (ten to fifteen minutes). Guidelines in the methodology included that the observer should remain on the census transect path and not follow the animals outside the transect line (Peres, 1999b). When possible, the following information was registered for the studied species during the

census walks: time and location in the transect, location of the sighted population (angle calculated using a field compass and the perpendicular distance from the transect to the first sighted individual), group composition by age and sex, and opportunistic observations (species of feeding trees utilized).

Thanks to these censuses it was possible to determine the number of individuals per transect area and subsequently for the study area. It was also possible to estimate the number of groups of existing primates, as well as the composition and quantity of individuals in each of them. Additionally, maturity stage was categorized as follows: adult (large individuals with fully developed sexual characteristics), sub-adult (same size as the adult but with a slimmer body structure), juvenile (medium individual with less developed sexual characteristics), infant (small individual who spent most of its time being carried by an adult).

In addition to data collected to estimate capuchin population density, samples were collected from all the trees for approximately 5 m from each side of the transect with a circumference larger than 15 cm at breast height; samples with flower or fruit could be classified more precisely, however due to factors such as crown height or because a tree was not flowering or fruiting at the time, this was not always possible. Collected samples were identified by professionals at the Herbarium of the Biology Department at the Universidad Nacional Autónoma de Honduras.

Study species

Cebus imitator (Thomas 1903)

The IUCN places this species in the Least Concern category (LC) (Rylands *et al.*, 2013). CITES places it in the II appendix for Honduras (many populations are threatened by deforestation and illegal trafficking). This species belongs to Cebidae and is distributed in Central America from northwest Honduras to Panama, and from sea level to 1,500m (Boubli *et al.*, 2012; Rylands *et al.*, 2013). Its fur is black, except the face and ears, the sides of the neck, the shoulders, the chest, and the upper part of the arms, which are white-yellowish. It has a black prehensile tail (Emmons and Feer, 1997). White-faced capuchins live in large multi-female, multi-male troops of up to 40 individuals, with female philopatry and male dispersal to other groups as juveniles (Oppenheimer, 1968; Freese, 1978; Fedigan, 1993). Within the groups' dominance levels, both sexes present a linear hierarchy (Perry, 1995; Jack and Fedigan, 2006). In females, this hierarchy, is due to matrilineal kinship and coalitions, while in males is mainly, due to intrasexual competition (Perry, 1995; Perry, 1998; Jack, 2003). Capuchins are territorial animals with a consistent home range that sometimes can overlap with other groups. They are omnivorous and have one of the most varied diet among the Neotropical primates, feeding on vegetable matter (fruits, flowers, shoots, nuts), insects and small vertebrates (Chapman and Fedigan, 1990; Eisenberg and Redford, 1999). They

are highly opportunistic foragers, capable of manipulating a wide range of materials and substrates whether to feed, move or defend themselves since they have great skills with their hands (Rose, 1994). Their varied diet allows them to make changes in their feeding resources in different parts of the year when, for example, some fruits are scarce or are not in season (Chapman and Fedigan 1990). This flexibility reduces competition with other arboreal mammals like spider monkeys, squirrel monkeys, coatis, anteaters, and even some birds. The capuchin monkey uses all the forest levels and travels on the ground to cross open areas, drink water and forage. Their active hours start early in the day and they are more active during the morning and afternoon (Reid, 2009).

Results

The presence of the capuchin monkey (*Cebus imitator*) was registered in the Pacific slope of Honduras through several encounters in three of the four transects used within the study area (El Ojochal, El Tamarindo and Los Mogotes). During these encounters, pictures and videos of different individuals were taken for identification purposes, as well as to provide evidence for the presence of the species in the zone (Fig. 2).

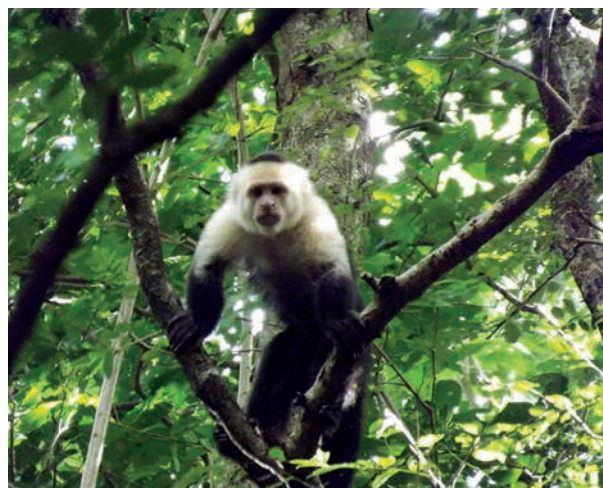


Figure 2. Photograph of an adult male (AM) in the transect El Ojochal.

Each transect was walked 34 times during the study, for a total of 28 km and more than 800 hours of work, resulting in 142 minutes of visual contact with the species and more than 20 minutes of video recorded for different individuals. From these walks there were a total of nine encounters with capuchin monkeys and a total of 43 individuals registered, with an average group size of 4.7 ind/group (3-9 range). Due to the low number of encounters it was not possible to use the software Distance to run the population density analysis. However, it was possible to estimate the individual and group density per transect and for the whole study area using the formulas established by the National Research Council (NRC, 1981; Table 1).

Table 1. Population density of *Cebus imitator* on each of the transects used during the research.

Transect	Group density (groups/km ²)	Individual Density (individuals/km ²)	Variance	Confidence limits by 95 %	Accuracy %
El Ojochal	3.06	14.38	1.8663	0.6535	14.00
El Tamarindo	1.12	5.27	1.2916	0.4523	9.046
Los Mogotes	0.46	2.16	0.3429	0.1200	12
Montaña Oscura	0	0	_____	_____	_____
Total area	1.04	4.96	1.4987	0.2951	6.1787

It was not always possible to identify sex due to the animals' fast movement, low visibility because of the forest cover, and the field's irregular topography. However, it was possible to differentiate stage of maturity, based on size (30 adults, 10 sub-adults and 3 juveniles).

Plants identified in the forest included 689 individual trees, which were distributed in 62 different species pertaining to 32 families, with *Lysiloma auritum* the most abundant species (133 individuals or 19.3%), followed by *Bursera simaruba* and *Neomillspaughia paniculata* (52 individuals or 7% each), *Quercus* sp. (53 individuals or 7%) and *Brosimum alicastrum* (41 individuals or 5%). Some of the registered plants were used as food by the capuchin monkeys during the study, including the fruit, the flower or less commonly, the leaf (Table 2).

Table 2. Plant species used as food by *Cebus imitator* inside the study area.

Family	Species	Item
Anacardiaceae	<i>Spondias purpurea</i>	Fruit
Apocynaceae	<i>Tabernaemontana donnell-smithii</i>	Fruit
Burseraceae	<i>Bursera simaruba</i>	Fruit
Fabaceae	<i>Acacia deamii</i>	Young leaves
Fabaceae	<i>Inga vera</i>	Fruit
Malpighiaceae	<i>Byrsonima crassifolia</i>	Fruit
Malvaceae	<i>Guazuma ulmifolia</i>	Flower
Moraceae	<i>Brosimum alicastrum</i>	Fruit
Moraceae	<i>Ficus cotinifolia</i>	Fruit
Muntingiaceae	<i>Muntingia calabura</i>	Fruit
Rubiaceae	<i>Chiococca alba</i>	Flower

Discussion

The presence of *Cebus imitator* inside AUMLB was confirmed, the first official registration of this or any non-human primate species in the Honduran Pacific slope in the southern part of the country. The capuchin monkey, one of the three primate species reported in Honduras, is the only one present in the study area. It is distributed in El Cañon del Ojochal, a remnant of tropical dry forest located

by the Tinto riverbank. This is one of the best-preserved forest patches in the area, although it has been recently affected by human activity.

This research had a total of nine focal encounters with *Cebus imitator* in the whole research area, which is a low number of encounters in comparison with some other studies of the species (Chapman *et al.*, 1988; Estrada and Coates-Estrada, 1996; Timock and Vaughan, 2002; Tinsley Johnson *et al.*, 2020), but similar to the ones reported in the wildlife refuge centre "Rio Escalante-Chococente", in the south of Nicaragua (Williams-Guillén *et al.*, 2013), although these authors mention their study was possibly an under-registration of encounters for the species in this area. Estimations obtained from a low number of encounters must be cautiously interpreted (Plumtre, 2000; Gonzales-Solis *et al.*, 2001), but the data are especially relevant when there is no other information available for the species in the study area.

Encounters with capuchin monkeys occurred in three out of the four established transects for the study. The transect "Montaña Oscura" was the only one without any encounters with the species, despite being the most extensive transect in length (Fig. 1) with the same number of walks performed as in the other ones. This may be attributed to many factors, including its elevation from 800 to 1,040 m.a.s.l., which in the study area corresponds to a shift in the dominant plant species to *Quercus* sp. and *Pinus oocarpa*. This transect was also the one closest to a main road, with three communities and an active mine (during data collection) where cars and the mine's engines produced loud noises that could have affected the monkeys' presence or the possibility to detect them.

A population density of 1.04 groups/km² and 4.96 ind/km² was estimated for AUMLB. From 142 minutes of visual contact and more than 20 minutes of video recorded, it was possible to differentiate 6 individuals (2 adult males, 1 adult female, 2 subadult males and 1 subadult female), using scars and physical characteristics as a reference. The six differentiated individuals were from the same group, subjects of several encounters along the Ojochal transect. During the encounters in the Tamarindo and Mogotes transects, it wasn't possible to differentiate the individuals, so it could not be determined if this was the

same group from the Ojochal transect or a different one. However, based on the field conditions and the distances between transects, I believe it is possible there are at least two different groups in the study area. No capuchin infants were observed during the walks, but this could be explained by the timid and evasive behavior of the species in the presence of the researcher, making direct observations difficult for all individuals in the group. Another factor could be the limited experience of the researcher at the time of the development of the study, as well as the possibility of birth seasonality patterns of the species in the study area (Di Bitetti and Janson, 2000), or long interbirth intervals like the ones reported for this species in Costa Rica (Fedigan and Rose, 1995). This situation could also serve as a wake-up call, since the absence of infants could be a symptom of the population's poor health, bringing up serious doubts about the likelihood of continuity of the species in the zone.

For a better understanding of the current situation of the species in the study area, the results here were compared with population densities obtained for *Cebus imitator* in Panama, Costa Rica, and Nicaragua (Table 3).

Table 3. Capuchin monkey population density comparison across studies.

Number of individuals (ind/km ²)	Location	Source
12.3 +/- 7	Punta Leona Private Wildlife Refuge, Costa Rica	Timock and Vaughan, 2002
17.73 – 32.57	Santa Rosa National Park, Costa Rica	Chapman et al., 1988
1.08	Coiba Island National Park, Republic of Panama	Mendez-Carvajal, 2012
31 +/- 26	Manuel Antonio National Park, Costa Rica	Estrada et al., 2006
34.47	Santa Rosa, Costa Rica	DeGama-Blanchet and Fedigan, 2006
11	Southwestern Nicaragua	Williams-Guillén et al., 2013
36.24	Taboga Forest, Costa Rica	Tinsley Johnson et al., 2020
4.96	Multiple Use Area "Montaña La Botija", Honduras	Present study

Factors affecting the population density of capuchin monkeys in the study area include: selective logging, and the transformation of forest into grassland for extensive cattle

ranching or agriculture for annual crops of corn or beans. The existence of these crops has created a conflict between monkeys and humans, as local people express they are experiencing economic losses because of the damage the monkeys cause to their crops, mainly in corn fields. Another factor is forest cover loss because of fires during dry seasons. In addition, local people are not aware of the importance of this species on the ecosystem, and finally, there is no protection from the government towards this or other species living within the limits of the country's protected areas (Secaria, 2013).

Food resource availability is a determining factor for primate abundance; deforestation is the most significant problem capuchins face in AUMLA (Terborgh, 1983; Balcomb et al., 2000; Stevenson, 2001; 2016). Capuchin monkeys are susceptible to habitat loss and tend to recover more slowly compared with other primate species like the howler monkey (Roncancio and Gomez-Pozada, 2009; Amato *et al.*, 2014). This is related to their diet, since capuchin monkeys need a greater area of forest to fulfill feeding needs, and in periods of fruit scarcity, are forced to travel greater distances to find food, different from howler monkeys that can survive on a folivorous diet (Milton and Fedigan, 2004).

It is probable that the presence of the *Cebus imitator* in the area is a result of the existence of an old biological corridor that connected the Honduran and the Nicaraguan "Mosquitia" with the south of Honduras and went all the way around the Coco o Segovia River. This biological corridor was also used by other species that local people have mentioned seeing in the area a long time ago, such as the jaguar (*Panthera onca*), the howler monkey (*Alouatta palliata*), and the spider monkey (*Ateles geoffroyi*), among other species (Marineros and Martinez, 1998) that are no longer present in the area.

The continuous forest that once allowed for the movement of capuchin monkeys and other species between the north and south of Honduras has been logged and fragmented to build up cities, roads, agriculture fields and cattle ranching, leaving scattered patches of forests in the whole region, and limiting the flow of species between the two slopes (Fig. 3). This impact is so strong that the closest registered population of capuchin monkeys according to Marineros and Martinez (1998) can be found approximately 89 km away in the Valle de Jamastran in the department of El Paraiso (Figure 3); these two populations are completely isolated from each other, with cities and towns between them. Figure 3 includes other registered locations of known populations of *Cebus imitator* at the moment in Honduras. Table 4 shows the corresponding localities and coordinates, as well as sources including books, management plans for protected areas, a doctoral thesis, and the author's personal observations.

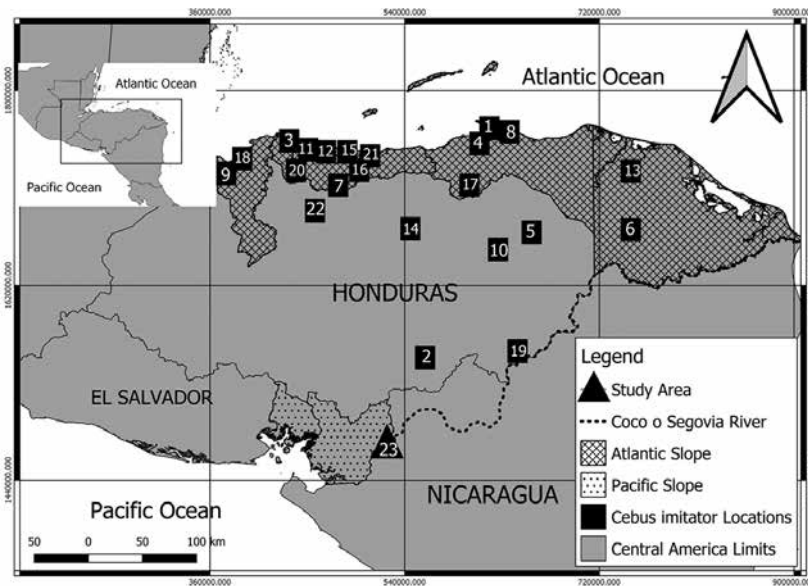


Figure 3. Map of the Atlantic and Pacific slopes and their connection through the Coco o Segovia River.

Table 4. Localities and coordinates of other populations of *Cebus imitator* in Honduras.

Number	Locations	Coordinates	Source
1	Trujillo Mangroves	15°55'56.34"N 85°55'0.24"W	Buckley, 1983
2	Jamastran Valley	13°59'22.26"N 86°27'39.50"W	Marineros and Martinez, 1998
3	Laguna de los Micos	15°48'15.40"N 87°36'20.12"W	Marineros and Martinez, 1998
4	Capiro y Calentura National Park	15°52'19.51"N 85°56'27.94"W	Marineros and Martinez, 1998
5	Pisijire village, Olancho	15°10'17.93"N 85°26'49.37"W	Marineros and Martinez, 1998
6	Krausirpi village, Gracias a Dios	15° 2'39.05"N 84°52'26.76"W	Marineros and Martinez, 1998
7	Texiguat Wildlife Refuge	15°27'44.29"N 87°16'53.72"W	Marineros and Martinez, 1998
8	Laguna de Guaymoreto	15°57'58.60"N 85°51'35.92"W	Marineros and Martinez, 1998
9	Cusuco National Park	15°33'46.39"N 88°18'12.44"W	Marineros and Martinez, 1998
10	Sierra de Agalta National Park	14°58'1.92"N 85°51'47.66"W	Marineros and Martinez, 1998
11	Jeannette Kawas National Park	15°49'6.54"N 87°22'12.32"W	PROLANSATE, 2004
12	Punta Izopo National Park	15°49'27.38"N 87°21'4.75"W	PROLANSATE, 2004
13	Biosfera del Río Plátano	15°27'4.89"N 84°48'50.08"W	Zambrano, 2008
14	La Muralla Wildlife Refuge	15° 4'58.16"N 86°45'22.03"W	CEAH, 2010
15	Cuero y Salado Wildlife Refuge	15°46'45.11"N 87° 8'27.37"W	Portillo and Carrasco, 2012
16	Pico Bonito National Park	15°36'59.03"N 86°51'42.77"W	Carrasco <i>et al.</i> , 2013

Number	Locations	Coordinates	Source
17	Botaderos National Park	15°26'3.02"N 86° 4'50.36"W	Guillen and Guillen, 2013
18	San Antonio village, Cortés	15°45'18.54"N 88° 2'47.38"W	Personal observation
19	Patuca National Park	14°17'54.14"N 85°13'53.01"W	Personal observation
20	Santiago village, Atlantida	15°39'4.09"N 87°37'51.94"W	Personal observation
21	Nombre de Dios National Park	15°47'49.16"N 86°32'40.32"W	Personal observation
22	Pico Pijol National Park	15°10'26.09"N 87°34'25.26"W	Mioñes et al., 2018
23	Montaña La Botija Multiple Use Area	13°17'38.03"N 86°44'41.81"W	Current study

These preliminary results point to a clear need to continue the study of this capuchin monkey population (*Cebus imitator*) in southern Honduras in order to determine with greater certainty its current conservation status. It is also necessary to search for closer populations to this study area to better understand migration dynamics as this capuchin monkey population, the only one reported up to this point in this region of the country, is in real danger of disappearing from the area.

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REDUCCIÓN EN LA DENSIDAD POBLACIONAL DEL TITI GRIS (*SAGUINUS LEUCOPUS*) EN EL ORIENTE DE CALDAS, COLOMBIA

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Resumen

El monitoreo de parámetros poblacionales es básico para formular y adaptar las estrategias de manejo de la vida silvestre. En el oriente de Caldas, en el marco de alianzas público-privadas, se han venido implementando estrategias de manejo y monitoreo de titi gris (*Saguinus leucopus*) como especie prioritaria para la región. Esta especie está En Peligro debido a la reducción y fragmentación de su hábitat y a la cacería por comercio. Durante el 2015 se llevaron a cabo estimaciones de densidad poblacional para actualizar el diagnóstico del estado de conservación del primate y compararlo con estimaciones previas de 2006 y 2008. En este muestreo, las densidades encontradas en el oriente de Caldas estuvieron entre 14 y 109 ind/km². Para dos de las cuatro localidades en donde se hizo un segundo muestreo se presentaron reducciones del 61 y 70% en comparación con el 2008. Es altamente probable que estas disminuciones estén asociadas a cacería por comercio producto del aumento de la accesibilidad por los cambios sociopolíticos de la región.

Palabras Clave: Monitoreo efectivo, cambios sociopolíticos, densidad poblacional, titi gris

Abstract

Monitoring of population parameters is basic to plan and adapt the management strategies of wildlife. In the east of Caldas region, in a framework of the public-private alliances, they have implemented management strategies and monitoring of white-footed tamarin (*Saguinus leucopus*) as a priority species to this region. This species is in Endangered due to habitat reduction and fragmentation and pet trade. During 2015 we carried out a population density estimation to get current the diagnosis of conservation status of the primate and to compare with previous estimates in 2006 and 2008. In this sampling, the population densities were between 14 and 109 ind/km². In two out of the four localities that were sampled a second time, there were reductions of 61 and 70% compared with 2008. It is highly probable that these decreases are associated with the pet trade as a result of the increase in accessibility to the area driven by the socio-political changes in the region.

Key Words: Effective monitoring, socio-political change, population density reduction, White-footed tamarin

Introducción

El manejo efectivo de áreas protegidas y otras estrategias de conservación depende de la aplicación de acciones de manejo efectivas. Definir las acciones de manejo apropiadas requiere de información confiable derivada de la evidencia científica además de la experiencia que los administradores adquieren en su ejercicio (Possingham et al., 2001; Pullin y Knight, 2005; Nichols y Williams, 2006). En el caso de las especies amenazadas o de las que son usadas como elementos sustitutos de la diversidad en un paisaje para orientar acciones de manejo, es necesario hacer diagnósticos cuantitativos de su estado de conservación (Yoccoz et al., 2001; Gielh et al., 2017).

Un paso inicial para conocer el estado de una población es hacer una estimación empírica de su abundancia, no

obstante, una estimación de la densidad poblacional de una especie es preferible dado que este parámetro refleja la relación que hay entre la población y el área que ocupa (Witmer, 2005). Por otro lado, dado que los parámetros demográficos como la densidad poblacional son dinámicos espacial y temporalmente, su monitoreo efectivo es esencial para detectar sus tendencias y las relaciones que tienen con los factores que los modulan y de esta forma poder adaptar las acciones de manejo (Gibbs et al, 1998; Gibbs et al, 1999; Legg y Nagy, 2006; Lyons et al., 2008; Lindenmayer et al., 2011). El monitoreo en sentido amplio se entiende como cualquier medida repetida de un fenómeno. Sin embargo, en conservación es necesario que quede explícito que un monitoreo efectivo, debe lograr en los estimadores la precisión necesaria para detectar cambios si los hay (potencia estadística) (Elzinga, 2001; Sutherland, 2006; Field et al., 2007; Marsh y Trenham, 2008).

Saguinus leucopus es una especie En Peligro (Morales et al., 2008) dado que su distribución se encuentra en una zona con alto impacto por actividades humanas, que generan un continuo proceso de reducción y fragmentación de hábitat. El área de distribución original de la especie, que cubría aproximadamente 48,000 km², ha perdido más del 40 % de hábitat disponible (Roncancio et al., 2013) y actualmente está conformada por cultivos (23 %), pastos (22 %), y coberturas vegetales naturales (32 %). Las coberturas naturales incluyen principalmente Bosque Denso con fragmentos de entre menos de 0.1 a 300 km² hasta 6,000 km² (media = 60 km² ± DE 1640), de formas irregulares (Índice Medio de Forma = 1.8), y con conectividad media (Índice de yuxtaposición - interpersión = 52) (análisis hechos en este trabajo con la capa de coberturas IDEAM et al. 2012). Particularmente en el oriente de Caldas (Municipios de Samaná, Norcasia, Victoria y La Dorada) en un territorio de 2,100 km² los bosques y áreas seminaturales han pasado desde el 2002 de cubrir 845 km² a 757 km² en 2009 y a 2012 cobijaban poco más de 630 km² (30.3%), para una pérdida de más de 20,000 ha en 10 años. Las coberturas vegetales naturales a 2012 en el oriente de Caldas estaban representadas por 402 parches de aproximadamente 158 ha en promedio (DE = 322) con formas irregulares (mayor efecto de borde) (IMF = 3.36) y son en su mayoría vegetación secundaria o en transición (52 %) y bosques de galería (24 %) (análisis hechos en este trabajo con la capa de coberturas IDEAM et al. 2012).

Por otro lado, esta especie es el primer primate y segundo mamífero más traficado de Colombia (MADS, 2012). En ese sentido se han reconocido, bajo criterios de severidad, proporción de área de distribución afectada y reversibilidad, a la reducción y fragmentación del hábitat y a la cacería para comercio como las dos principales amenazas para la conservación de esta especie con una ponderación de muy alta y alta respectivamente (Franco y Roncancio, 2011). En el oriente de Caldas se han hecho estimaciones de densidad poblacional de tití gris entre el 2005 y el

2008 en al menos seis sitios diferentes, encontrando densidades que varían entre 54 y 149 ind/km² (Roncancio et al., 2011; Sanchez-Londoño, 2013). Sin embargo, no se han hecho replicas temporales que permitan evaluar la respuesta de estas poblaciones a la reducción y fragmentación de su hábitat y otras amenazas como la presión de cacería en diferentes escenarios. Por lo tanto, este trabajo, además de evaluar nuevos sitios para la especie en el oriente de Caldas, tuvo como objetivo evaluar el cambio de la densidad población del primate en sitios ya muestreados.

Métodos

Área de estudio

El oriente de Caldas en jurisdicción de los municipios de La Dorada, Norcasia, Victoria y Samaná es el área del departamento en donde se encuentra parte de la distribución de *Saguinus leucopus* (Roncancio, 2013). Algunas de estas áreas se encuentran bajo una figura de protección mientras que otras, producto de las dinámicas sociales y de uso del suelo de la región, aún son áreas de conservación o, en ellas se han dado procesos de regeneración. Las estimaciones de la densidad poblacional de *S. leucopus* se llevaron a cabo en seis localidades que difieren en tamaño, forma, distancia de aislamiento, altitud y cobertura vegetal, representando toda la variación que presenta el paisaje del oriente de Caldas dentro del rango altitudinal preferido por la especie (0 – 1,100 m). Las seis localidades evaluadas fueron, Distrito de Manejo Integrado (DMI) Charca de Guarinocito (5°20'13"N; -74°44'06"W), Reserva Natural de la Sociedad Civil (RNSC) de Río Manso (5°40'40"N; -74°46'26"W), La Habana (Finca Pozo Redondo) (5°38'48"N; -74°45'58"W) y la RNSC Venecia – Jagual (5°38'21"N; -74°50'21"W), Embalse Amaní, dividida en seis sitios (Carrizales, Los Mangos, Sasaima, Cañaveral, La Clara y el trasvase del Río Manso) (5°33'17"N; -74°53'38") y el sector Bella Vista – Delgaditas – Guarinó (5°22'28"N; -74°56'20") (Tabla 1, Fig. 1).

Tabla 1. Localidades en donde se estimó la densidad poblacional de *Saguinus leucopus*.

Localidad	Área (ha)	Altitud (m s.n.m.)	Cobertura
DMI Charca de Guarinocito	21	200	Bosques de galería
RNSC Río Manso	313	220 -340	Bosque denso
La Habana	52	200 - 250	Bosque denso
RNSC Venecia – Jagual	100	380 -420	Bosque denso y bosque de galería
Amaní	2552	250 - 850	Bosque denso y bosque fragmentado
Bella Vista – Delgaditas – Guarinó	431	440 -1,030	Bosque denso y bosque de galería

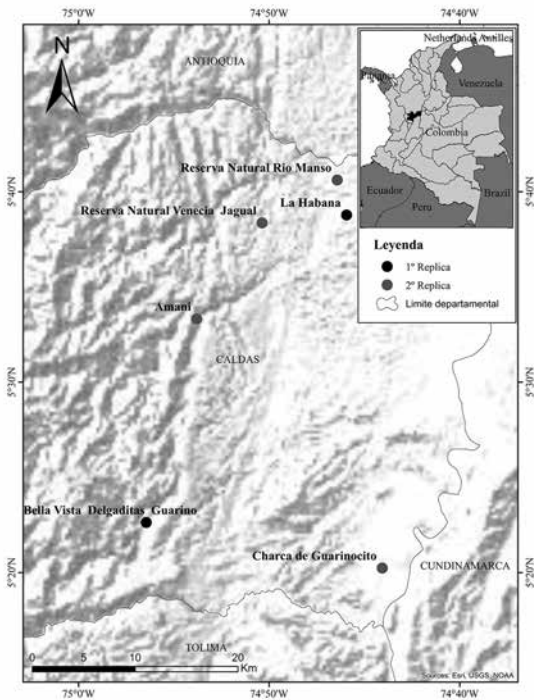


Figura 1. Área de estudio, en donde se indican las localidades en donde se llevó a cabo la segunda replica temporal en el muestreo para estimar la densidad de *Saguinus leucopus* (círculos negros).

Toma de datos

RNSC Río Manso, La Habana, RNSC Venecia-Jagual, Amaní, Bella Vista - Delgaditas-Guarinó.

Para estimar la densidad poblacional de *S. leucopus* en estas localidades se hizo uso del método de muestreo por distancias con transectos lineales (Buckland et al., 2001). Este método implica contar los animales vistos por un observador que camina a lo largo de una línea de transecto, midiendo la distancia perpendicular hasta el punto donde se observó el animal o hasta el centro geográfico del grupo observado (Buckland et al., 2010). El rumbo, la distancia y orientación de los transectos establecidos en cada localidad dependió del tamaño, la topografía y la forma de bosque evaluado en cada una (Tabla 2).

Tabla 2. Número de transectos y esfuerzo de muestreo por localidad.

Localidad	Número de transectos	Longitud media de transectos m (DE)	Esfuerzo total de muestreo (km)
RNSC Río Manso	35	263 (76)	108.45
La Habana	16	288 (75)	109.62
RNSC Venecia – Jagual	18	319(14)	100.44
Amaní	38	622(304)	197.62
Carrizales	5	1,100 (12)	44.84
Los Mangos	5	860 (22)	28.5
Sasaima	4	720 (150)	41.9
Cañaveral	2	550 (50)	8.8
La Clara	5	750 (48)	35.92
Tras. Manso	17	550 (60)	37.66
Bella Vista – Guarinó – Delgaditas	52	300 (62)	428.38

Los muestreos se llevaron a cabo desde las 8:00 hasta las 12:00 h y de las 14:00 hasta las 17:00 h y fueron ejecutados por tres observadores recorriendo simultáneamente un transecto cada uno. Para garantizar que durante el recorrido de cada transecto se mantuviera constante la probabilidad de detección se fijó la velocidad de desplazamiento en 500 metros por hora. Cada vez que fue ubicado un grupo se permaneció no más de 15 minutos (Peres, 1999) intentando hacer el conteo completo del grupo. Los muestreos se llevaron a cabo en la RNSC de Río Manso entre el 3 de febrero y el 13 de marzo. En la Habana entre el 15 de marzo y el 21 de abril y entre el 5 y 12 de junio. En la RNSC Venecia se hicieron entre el 6 de abril y el 21 de mayo. En Amaní entre el 14 de julio y el 15 de septiembre, y, en Bella Vista – Guarinó y Delgaditas entre el 19 de septiembre y el 31 de octubre de 2015.

DMI Charca de Guarinocito

El muestreo se llevó a cabo entre el 30 de enero y el 2 de febrero de 2015. Dado que el DMI Charca de Guarinocito es un fragmento pequeño (21 ha) y alargado (permite tener una visual de todo el ancho) no se usó el método de muestreo por distancia con transectos lineales para hacer la estimación de la densidad; se hizo un censo (conteo completo), dado que las condiciones de sitio permiten satisfacer los supuestos de que se puede evaluar toda el área de interés y contar todos los objetos buscados. Cuatro profesionales hicieron búsqueda y seguimiento de grupos entre las 6:00 y 18:00 hasta confirmar la estructura y composición de cada grupo y su área de uso. El esfuerzo de muestreo acumulado en el DMI Charca de Guarinocito fue de 64 horas/hombre.

El muestreo por distancia es uno de los métodos más eficientes para estimar densidades poblacionales. Es decir, uno de los métodos que produce estimados válidos y más precisos (i.e., con menor varianza muestral) para un esfuerzo de muestreo dado (Buckland et al., 2001; Harris y Burnham, 2002; Norvell et al., 2003; Kissling y Garton, 2006; Somershoe et al., 2006). Por esta razón, se asume que los estimados de densidad poblacional obtenidos con este método y con conteos completos son comparables (Yoccoz et al., 2001).

Análisis de datos

La densidad poblacional de *Saguinus leucopus* se estimó con el programa DISTANCE 7.0 (Thomas et al., 2009). El objetivo del análisis es ajustar una función de detección a la distribución de frecuencias de las distancias perpendiculares de las observaciones (Thomas et al., 2002) utilizando seis modelos teóricos. El mejor modelo se seleccionó con base en el menor valor del criterio de información de Akaike (AIC), (Buckland et al., 2001). La varianza de la densidad (CV) para Río Manso fue estimada asumiendo que la distribución de la tasa de encuentro se ajustaba a la distribución Poisson de probabilidad (Buckland et al., 2001); en la Habana, Venecia y Amaní se hizo la estimación de la varianza empíricamente. En todas las localidades se usó el tamaño de grupo estimado tomado del análisis de regresión entre el tamaño de grupo y la probabilidad de detección para el cálculo de la densidad.

Comparación de las densidades poblacionales de S. leucopus para las localidades en la que se hizo segunda replica temporal
La comparación entre las densidades estimadas para *S. leucopus* entre la presente evaluación y las estimaciones hechas en Amaní (Sanchez-Londoño, 2013, datos tomados en 2006), Charca de Guarinocito, RNSC Río Manso, RNSC Venecia (Roncancio et al., 2011, datos tomados en 2008),

se hizo por medio de un gráfico de intervalos de confianza (IC). Cuando los IC de dos estimados de densidad presentaron un traslape mayor a un 25 %, se consideró que no había evidencia de que las densidades poblacionales entre ambos fueran significativamente diferentes, con un nivel de confianza del 95 % (Cumming et al., 2007).

Resultados

RNSC Río Manso: Durante el muestreo se lograron 44 registros visuales de *S. leucopus*. El modelo Uniforme con serie de expansión Coseno arrojó el valor más bajo del criterio de información de Akaike (AIC) y mejor ajuste de las distribuciones observada y esperada de distancias perpendiculares. El tamaño de los grupos varió entre uno y seis individuos, estimando un valor medio de 4.23 (IC95 % = 3.5–5). Se estimó una densidad poblacional de 55 individuos/km² (IC95 % = 35–85) y 13 grupos/km² (IC95 % = 9–20), con un coeficiente de variación del 22.5 y 20.6 % respectivamente. La varianza de la densidad estuvo compuesta por la probabilidad de detección en un 39 %, por la tasa de encuentro en un 44.9 % y por el tamaño de grupo en un 16.1 %. Los resultados de esta y las otras localidades están resumidos en las Tablas 3 a 6 y pueden ser leídos siguiendo el anterior formato en el mismo orden en el que están las tablas.

Tabla 3. Modelos ajustados basados en la distribución de las frecuencias de las distancias de detección de las observaciones de *Saguinus leucopus* para cada localidad.

Localidad	Número de registros	Modelo	Serie de expansión
Charca de Guarinocito	-	-	-
RNSC Río Manso	44	Uniforme	Coseno
La Habana	39	Semi-normal	Coseno
RNSC Venecia – Jagual	26	Semi-normal	Coseno
Amaní	59	Uniforme	Coseno
Bella Vista – Guarinó – Delgaditas	45	Semi-normal	-

Tabla 4. Tamaño de grupo de *Saguinus leucopus* para cada localidad.

Localidad	Tamaño de grupo	Tamaño grupo IC 95 %	Rango
Charca de Guarinocito	5.3	-	5 - 6
RNSC Río Manso	4.23	3.5 - 5	1 - 6
La Habana	4.9	3.9 – 6.1	1 - 7
RNSC Venecia – Jagual	2.9	2.13 – 4.02	1 - 7
Amaní	3.37	2.9 – 3.9	1 - 8
Bella Vista – Guarinó – Delgaditas	3.76	3.05 – 4.62	1 - 7

Tabla 5. Densidad poblacional de individuos de *Saguinus leucopus* para cada localidad. CV D=Coficiente de variación de la densidad de individuos.

Localidad	Densidad Ind/km ²	Densidad IC 95 %	CV D	Densidad poblacional Grupos/km ²
Charca de Guarinocito	75	-	-	14.2
RNSC Río Manso	55	35 - 85	22.5	13
La Habana	109	63 - 191	25.6	22
RNSC Venecia	40	20 - 77	30.6	13
Amaní	47	29 - 78	25	11
Bella Vista – Guarinó –Delgaditas	14	8.4 – 21.9	25	3.6

Tabla 6. Componentes de la varianza de la densidad poblacional de *Saguinus leucopus* para cada localidad.

Componentes de la varianza de la densidad	Charca de Guarinocito	RNSC Río Manso	La Habana	RNSC Venecia	Amaní	Bella Vista – Guarinó –Delgaditas
Probabilidad de detección	-	39	37.6	49.3	14.1	28
Tasa de encuentro	-	44.9	45	30.5	74.1	54.2
Tamaño de grupo	-	16.1	17.4	20.2	11.8	17.8

Comparación de la densidad de Saguinus leucopus para las localidades en la que se hizo segunda replica temporal

Para la Charca de Guarinocito se registró un aumento de dos individuos en la abundancia total pero mantiene el número de grupos. En este sentido, la “población” en este DMI es consistente con el muestreo llevado a cabo en 2008 (Roncancio et al., 2011) (Fig. 2). En la RNSC Río Manso los resultados reflejan una disminución significativa en la densidad poblacional del primate de un 61 %. Asumiendo un modelo lineal en la tasa de crecimiento poblacional podría estimarse una reducción anual continua de alrededor del 8.7%. Igualmente, para la RNSC Venecia – Jagual se encontró una disminución significativa de un 70 % en el parámetro para una disminución lineal anual estimada del 9.8 % (Fig. 2).

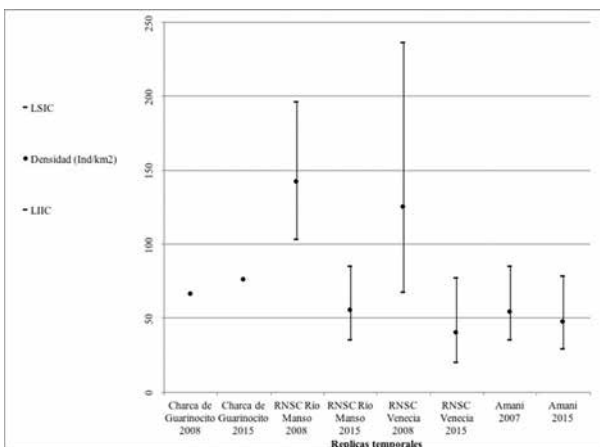


Figura 2. Análisis gráfico comparativo de las densidades del presente muestreo con estimaciones previas para el DMI Charca de Guarinocito, RNSC Río Manso, RNSC Venecia (Roncancio, 2011) y Amaní (Sanchez-Londoño, 2013). Cuando los IC de dos estimados de densidad presentan un traslape mayor a un 25 %, se considera que no hay evidencia de que las densidades poblacionales en ambos son significativamente diferentes, con un nivel de confianza del 95 % (Cumming et al., 2007).

Por otro lado, para Amaní no se encontró un cambio significativo en la densidad poblacional de *S. leucopus* con respecto a los resultados de 2006 (Sanchez-Londoño, 2013) (Fig. 2). No obstante, es necesario tener en cuenta que el muestreo en el 2006 se hizo sobre un área inferencial de aproximadamente 5.5 km², los cuales representan poco más del 20 % del presente esfuerzo y que estuvo focalizada en el sector de Los Mangos con un tamaño muestral de solo cinco transectos. En Amaní, se encontraron diferencias numéricas entre algunos de los seis sectores evaluados. Si bien, dada la cantidad de datos que se obtuvieron por sector no es razonable hacer un análisis por bloques de la densidad, es plausible, asumiendo que la probabilidad de detección de la especie entre los sectores es igual (mismos observadores, coberturas vegetales similares, muestreo hecho en un corto periodo de tiempo, condiciones ambientales constantes y homogéneas), que la comparación se puede hacer a partir de las abundancias relativas (número de registros por kilómetro recorrido). En este sentido se detectó que los sectores de la Clara y Carrizales presentaron las abundancias relativas más bajas, siendo numéricamente entre 3 y 25 veces menores que en las otras localidades.

Tabla 7. Abundancias relativas (número de registros por kilómetro recorrido) de grupos e individuos de tití gris (*Saguinus leucopus*) en los diferentes sitios evaluados en el área de influencia del embalse Amaní.

Sitio	Grupos/km	Individuos/km
Berlín	0.35	1.25
Cañaveral	1.48	3.86
Carrizales	0.18	0.54

Sitio	Grupos/km	Individuos/km
Clara	0.06	0.17
Mangos	0.74	2.18
Sasaima	0.26	0.88

Discusión

En este muestreo las densidades encontradas en el oriente de Caldas estuvieron entre 14 y 109 ind/km². En contraste, en los muestreos llevados a cabo entre 2005 y 2008 las densidades encontradas estuvieron entre 54 y 149 ind/km² (Roncancio et al., 2011). Puntualmente, dos de las cuatro áreas en donde se hizo un segundo muestreo, RNSC Río Manso y RNSC Venecia – Jagual presentaron reducciones del 61 y 70% respectivamente con respecto al 2008. Esta reducción fue apenas detectable por la magnitud del cambio. Tener la capacidad de detectar cambios menores implica incrementar el tamaño de la muestra (Field et al., 2005). En ese sentido es necesario gestionar los recursos suficientes para hacer los muestreos completos y alcanzar la precisión requerida para concluir que efectivamente no hubo cambios, principalmente reducciones y no que simplemente no fueron detectados, es decir, mejorar la potencia estadística y reducir la probabilidad de cometer un error tipo II en el rechazo de la hipótesis (Lindermayer y Likens, 2009; McDonald-Madden et al., 2010; Reynolds et al., 2011).

A pesar de las 20,000 ha que se han perdido en el oriente de Caldas en los últimos 10 años, la RNSC Río Manso y Venecia el Jagual no han sido afectadas. La reducción de la densidad de *S. leucopus* en estas dos localidades se puede atribuir al tráfico, tal y como lo confirmó el propietario de Venecia - el Jagual quien declaró que en el 2013 se presentaron ingresos de traficantes a la reserva y que extrajeron una gran cantidad de individuos del primate. En el caso de Amaní, a pesar de no detectarse una reducción, la extracción de *Saguinus leucopus* no se puede descartar, dado que la menor abundancia relativa en el sector bordeado por la carretera entre Dorada y Norcasia (Sector La Clara), que no difiere aparentemente en otras condiciones de los otros sectores, puede estar reflejando un impacto derivado de la mayor accesibilidad de potenciales traficantes (Laurance et al., 2008).

El tráfico de especies silvestres es un importante y creciente motor de pérdida de biodiversidad (Warchol et al., 2003; Sodhi et al., 2004; Wyler y Sheikh, 2008; Fernandes-Ferreira et al., 2012). No obstante, son escasos los estudios que puedan cuantificar su impacto sobre las poblaciones naturales, además del ámbito y la escala del tráfico. Particularmente para el tráfico de animales vivos el 16% lo representan los primates. El tráfico de primates vivos involucra decenas a cientos de miles de individuos en el mundo y ha venido aumentando desde 1995 (Nijman et al., 2011). En Perú, después de los psitácidos los primates fueron el grupo más traficado (Shanee, 2012) y la mayoría son individuos

inmaduros lo que sugiere el sacrificio del parental en la captura y baja probabilidad de soportar las condiciones de cautiverio (Duarte-Quiroga y Estrada, 2003).

Basados en la información informal de las comunidades locales, el tráfico de fauna en la zona puede estar asociado al aumento de la accesibilidad de foráneos después de la desmovilización en el 2006 de los grupos de paramilitares y al progresivo desmantelamiento del frente 47 de las FARC consolidado en 2008. En algunos casos, los conflictos socio políticos y la guerra pueden liberar la presión sobre la biodiversidad productos de los cambios en los patrones de asentamiento humano, la creación de zonas de protección de hecho y la reducción de las actividades económicas basada en recursos (Hanson et al., 2009). Adicionalmente, en muchos escenarios, los traficantes pueden desconocer o pueden no sentirse afectados por la legislación o el costo para ellos por apearse a la ley llega a ser más grande que no hacerlo y las penas pueden ser menores que la ganancia por el tráfico (Dutton et al., 2013). Este antecedente determina la necesidad del fortalecimiento institucional que incluye la articulación de las diferentes instancias de control (autoridad ambiental, fuerzas policivas y militares, jueces y fiscales) para la gestión efectiva de las áreas protegidas y en general de los recursos naturales en los escenarios actuales de post-acuerdo y posconflicto. En ese sentido, el control efectivo implica un abordaje multifocal que incluye la educación y comunicación hacia las comunidades buscando reducir la tolerancia a estas prácticas en su territorio, modificando la actitud de las personas hacia la especie, el contexto social y posicionando la norma; revisando la dependencia económica de las comunidades a estas actividades, generando la conversión de los sistemas productivos y fortaleciendo la capacidad de gestión interinstitucional e intersectorial para planear e implementar con idoneidad técnica y operativa las actividades de control y vigilancia (Warchol et al., 2003; Shepherd, 2010; Daut et al., 2015).

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SHORT ARTICLES

PRIMATE DENSITIES AT RÍO PURÉ NATIONAL PARK, EASTERN COLOMBIAN AMAZONIA

Erwin Palacios

Introduction

Colombia is one of the three most megadiverse countries of the world (Mittermeier et al., 1997; Butler, 2019). Among primate diverse countries, Colombia is fifth, after Brazil, Madagascar, Indonesia and the Democratic Republic of Congo (Mittermeier, 2013) with 38 primate species and 45 taxa (APC, 2005). Protected areas in Colombian Amazonia represent a significant proportion of the known distribution area in the country of some primate species (*Lagothrix lagothricha*, *L. lugens*, *Ateles belzebuth*, *Cacajao melanocephalus*, and *Pithecia hirsuta* amongst others). Nevertheless, there is still scarce knowledge about their population status within such protected areas, as historically few research activities have been conducted either by primatologists or other researchers, due to the presence of illegal armed groups over decades, and the difficulty and logistical costs to reach very isolated regions. There are also populations of these species outside of protected areas, but in many cases, they are subject to diverse sources of anthropogenic disturbance, and information on their status is also very limited.

This gap of information does not allow us to put into perspective (qualify and quantify) the role of protected areas in conserving primate fauna and weakens government and nongovernment institutions' strategies for protected areas and areas outside them, to effectively conserve primates and wildlife in general; it also limits the ability to make informed decisions when working with local communities to implement participative conservation strategies in their territories.

As part of an effort of Conservation International Colombia to generate data on the abundance of about 24 medium and large vertebrate species in eastern Colombian Amazonia, including within protected areas and indigenous reserves, a series of standardized line-transect surveys were carried out in four forest sites within Río Puré National Park (hereafter Río Puré NP) to document the densities of primate species in one of the most isolated regions of Colombian Amazonia.

Study site

The Río Puré NP is located in the interfluvial area between Caquetá and Putumayo rivers in the Amazonas department, southeastern Colombia (Fig. 1). The park, declared in 2002, comprises 999,880 ha of primary forest, and along with conserving biological diversity and complementing a

corridor of protected areas and indigenous reserves of ca. 10 million hectares in northwestern Amazonia, protects the Yuri, a group of isolated indigenous people, in order to guarantee their decision to not have contact with the majoritarian society. The entire area of the park corresponds to a mainly flat surface, with some strongly undulating areas, but without significant altitude differences, all over an area of ancient alluvial terraces; ninety-eight percent of the park's area is covered with dense high terra firme forest, while flooded forest comprises just 1.0 % of the area and is concentrated along the Puré River and its main tributaries (Quebrada Aguanegra, Quebrada Arapa, Caño Mateo) and the various systems of lakes dispersed along the river's course; the remaining area corresponds to a mix of nine additional types of forests (IGAC, 1999; Instituto Sinchi et al., 2000; Murcia et al., 2014). According to the National Parks Unit (2015), based on studies of the Sinchi Institute, 1,583 species of vascular plants belonging to 133 families have been recorded in the park, among which the best represented are Rubiaceae, Annonaceae, Moraceae, Mimosaceae, Fabaceae and Sapotaceae; 252 bird species, belonging to 46 families were recorded for the park in four different sites (Alarcón-Nieto, 2007).

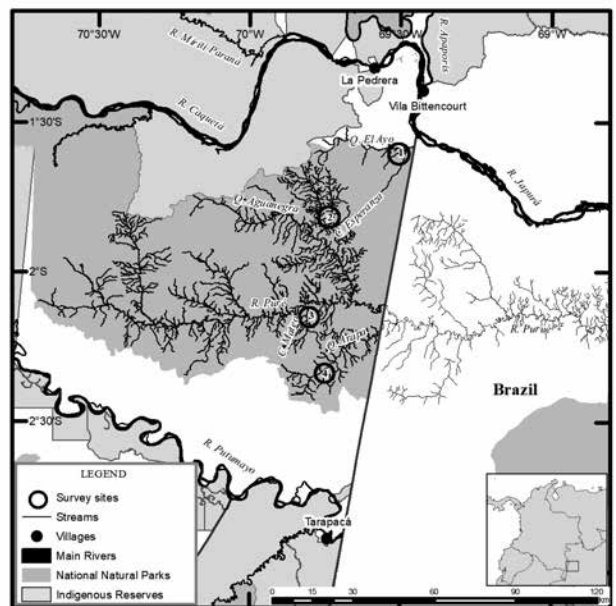


Figure 1. Interfluvial region between the Caquetá and Putumayo Rivers in Colombian Amazonia, where survey sites inside the Río Puré National Park are indicated.

Methods

Linear transects

Between 2000 and 2006 I carried out surveys in four sites in Río Puré NP: Quebradón El Ayo (1°35'S, 69°30'W), Caño Mateo (2°08'S, 69°49'W), Caño Esperanza (1°50'S, 69°43'W) and Quebrada Arapa (2°19'S, 69°44'W) (Fig. 1). All of these sites except Q. El Ayo are located in the core area of the park, between 42 and 70 km away from the closest human settlement, including those of the Yuri people, more than 80 km away. Access to these sites is only possible by

river, after navigating the Caquetá/Japurá River to reach the mouth of the Purú River (Puré in Colombia) and then navigating it further within Brazilian lands to reach the border between Brazil and Colombia; a boat trip of nearly 600 km, plus 12–120 km after leaving the Purú River and navigating towards the headwaters of its first and second order tributaries, selected in advance to establish the survey transects. Camps sites were always at least 3 km in a straight line from the closest major water course (from Japurá River, 9.5 km Q. El Ayo; from Purú River, 3.5 km C. Mateo and 24 km Q. Arapa, and, from Quebrada Agua Negra—the major tributary of Purú River, 10 km C. Esperanza), and high ground was always selected, given that water level in such small second order (12–15 m wide) tributaries varies significantly according to local rainfall, causing variations of up to 2 meters in the water level from one day to another. At each site (except in the Ayo, where just two were cut), three 5-km linear transects were cut and marked with colored flagging tape every 50 meters to facilitate the accurate positioning of sightings, and they were left to rest at least for one day before starting censuses. Starting points of transects were positioned at least 300 m away from the camp sites. Sightings were recorded in accordance with standardized and widely used methodologies (Peres and Cunha, 2011). Each transect was walked by an independent observer during days without rain at a continuous speed of 1.25 km/h, between 06:30–11:15 h and between 13:30–16:30 h; during return walks, average speed increased slightly (1.6 km/h) but this did not affect detection probabilities. Over the years, a group of 8 people from local indigenous communities of the lower Caquetá River (ca. 120 km north towards the Park) has been trained in line transect methodology and participated in large vertebrate surveys in eastern Colombian Amazonia, including those at Río Purú NP. At each survey site a team of four people was able to alternate walks on the different transects in order to minimize estimation biases for perpendicular distances. Every 3 days a different member of the team was able to rest. We expected to carry out a 300-km census at each site, but this was not possible due to adverse weather conditions; census effort totaled 989.7 km (200.7 km Q. El Ayo, 288 km C. Mateo, 251 km C. Esperanza and, 250 km Q. Arapa).

Every time we detected any of the target species, we recorded its location along the transect and the perpendicular distance to the animal observed. We recorded the number of individuals, and, to the extent possible, we attempted a complete count of the group's individuals, for which we did not spend more than 15 minutes. Sightings made during return walks were also recorded and contributed to the detection models, and allowed us to get a more accurate estimate of the mean group sizes (see Palacios & Peres, 2005). Group spread distance for large non-cohesive groups (e.g., woolly monkeys or squirrel monkeys) were also estimated.

Population density estimates

Data were analyzed with DISTANCE 5 software. Either the hazard rate or half-normal models with a cosine adjustment (Buckland et al., 1993) were used to obtain group

density estimates, using ungrouped perpendicular distances from transect to the first animal sighted. Animals detected by acoustic signals but not sighted within the transect area were not included in the analysis. Whenever necessary, I truncated five percent of the outlying data, and pooled data across different sites for those species with a small number of detection events, in order to strengthen the site-specific density estimates. For this subset of species with a limited sample size, density estimates (D) were calculated using:

$$D = ND/L * 2(ESW)$$

where:

- D = Group density (groups per km²);
- ND= Number of sightings for each species;
- L = Cumulative transect length walked in each site;
- ESW = Effective strip width, defined as the largest perpendicular distance observed for each species, but excluding obvious outliers.

This was the case for the white-fronted capuchin (*Cebus albifrons*), the squirrel monkey (*Saimiri cassiquiarensis*), and the red howler (*Alouatta seniculus*), which were regularly recorded three or fewer times at a given site. For species living in large, non-cohesive groups—such as the woolly monkey (*Lagothrix lagothricha*)—which can spread out over hundreds of meters in the forest, I added one third of the mean group spread to the ESW estimated by DISTANCE in order to avoid inflated-density estimates (Peres, 1997). Mean group sizes, derived from reliable group counts, were then multiplied by group density estimates in order to obtain mean population densities at each site. Crude population biomass was calculated using the mean body weight of a given species, defined as 80 percent of the average adult body weight of males and females of each species (Peres, 1993), multiplied by its density estimate.

Results

The mean primate population density for all sites was 64.4 individuals per square kilometer. The highest total primate density was found at Quebradón El Ayo (86.9 ind/km²), while the lowest was at Caño Mateo (42.5 ind/km²). Both, Quebrada Arapa and Caño Esperanza had similar intermediate total primate densities (Table 1). Total aggregated biomass showed a somewhat similar pattern, with the highest primate biomass at Quebradón El Ayo (169.5 kg/km²) and Quebrada Arapa (157 kg/km²), and the lowest at Caño Mateo. Biomass at Caño Esperanza reached an intermediate value (Table 1). Mean aggregated biomass for the four surveyed sites was 133.9 kg per square kilometer. Differences in density and total biomass between sites were driven both by the large-bodied woolly monkeys, *Lagothrix lagothricha*, and the medium-sized brown capuchin, *Sapajus apella*. For example, woolly monkey densities at C. Esperanza and Q. Arapa were between 1.5 and 2.0 times higher than in C. Mateo and Q. Ayo and represented 47.2 and 60.9 percent of their total

primate biomass, while this species only represented 28.5 percent and 36.0 percent of the total primate biomass at Q. El Ayo and C. Mateo respectively. On the other hand, *S. apella* density at Q. El Ayo represented a very particular case, as it was between 4.1 and 15.2 times higher than in any other site surveyed in this study. Consequently, its biomass at Q. El Ayo represented 35 percent of the total primate biomass. There were also remarkable differences in the densities of *Cebus albifrons*, *Saimiri cassiquiarensis* and *Leontocebus fuscus* between the surveyed sites, especially for *L. fuscus* (1.3 to 3.7 times higher at C. Esperanza and Q. Arapa), but these did not significantly affect the total primate biomass at any particular site. Other species such as *Alouatta seniculus*, *Cheracebus lucifer* and *Pithecia hirsuta* showed minor differences in their densities. Primate biomass represented between 36 percent and 49.1 percent of the total large vertebrates aggregated biomass at the surveyed sites (Palacios, unpublished data). During census walks we never recorded *Cebuella pygmaea*, but at Caño Esperanza, on a rainy afternoon before starting censuses, at around 17:30h three individuals of the species got tangled in a mist net we inadvertently left unfolded after carrying out bird sampling.

Discussion

Population densities of mid-sized and small primates were similar to those estimated for other forests in western Amazonia (Peres, 1990). In the majority of cases the densities of *Leontocebus fuscus*, *Saimiri cassiquiarensis*, *Cheracebus lucifer*, and *Pithecia hirsuta* were in the range of densities previously reported for other sites in Amazonia. The remarkable difference in *Sapajus apella* densities across sites in the study suggests that particular ecological factors could be determining the abundance of this species. For instance, the densities for the species at Caparú Biological Station and Caño Pintadillo at the black-water lower Apaporis River, and Q. El Ayo (20.4–30.9 ind/km²) (Palacios and Peres, 2005) differ greatly from those at C. Mateo and C. Esperanza (2–3.4 ind/km²), which in turn, are slightly higher to those estimated for the species at Curare indigenous community (1.2 ind/km²) (E. Palacios, unpublished data). Curare is an area subject to hunting pressure but, can be considered as reflecting natural density of *S. apella*, as only five of 1,337 hunting events recorded in that community during ca. 10 years correspond to this species (E. Palacios, unpublished data).

Defler (2003) has suggested that some type of ecological displacement between *Sapajus apella* and *Cebus albifrons* could be the cause of the lower densities of the latter when both species are present in the same area. This suggestion is partially supported by the density estimates of both species at sites inside indigenous reserves north towards Río Puré NP (Curare and Borikada, 1.2 and 8.8 ind/km² of *S. apella* respectively, vs. 0 and 2.7 ind/km² of *C. albifrons* – Palacios unpublished data), sites in the Yaigojé Apaporis indigenous Reserve/National Park (Caparú and Caño Pintadillo, 30.9 and 20.4 ind/km² of *S. apella* respectively, vs.

3.6 and 1.8 ind/km² of *C. albifrons* – Palacios and Peres, 2005) and at Quebradón El Ayo (30.4 ind/km² of *S. apella* vs. 2.5 ind/km² of *C. albifrons*). Nevertheless, the opposite situation occurred in C. Mateo and C. Esperanza (6.5 and 4.6 ind/km² of *C. albifrons* respectively, vs. 2.0 and 3.4 ind/km² of *S. apella*), suggesting that such ecological displacement may operate in both ways, although ecological factors directing it are still unknown.

Total primate density at all but one of the four sites (Caño Mateo) surveyed in Río Puré NP was higher than that reported by Defler (2013) (47.9 ind/km²) for his site on the right bank of the Puré River. C. Mateo is ca. 23 km away from Defler's site, and both sites are relatively close to the Puré's main course, therefore being more accessible to commercial hunters of spotted cats, that during the late 60's and the 70's intensively used large primates and other medium and large-sized vertebrates as bait. Hunters' parties periodically entered into the current Río Puré NP area and established camps along the Puré river and its tributaries for long periods (2-3 months) during which they processed and accumulated the skins and then took them to La Pedrera to the merchants who sponsored such raids (Elías Yucuna and Julián Yucuna, Pers. comm.). The primate density figures for these two sites are 25%-51% lower than those for the three additional sites surveyed in Río Puré NP and might reflect the impact of hunting on the local primate populations. Defler (1980) reported that primate populations in the Mirití-Paraná River, Colombia, affected by 20th century hide trade hunting had recovered, and Antunes et al. (2016) indicated that 70% of all populations of the lowest-fecundity and most prized game species affected by subsistence hunting (including Ateline primates) currently occur at carrying capacity at both landscape and basin-wide scales.

Nevertheless, it should be considered that in most recent times (during the decade of the 90's, and through the first five years of the 2000's) dozens of dredges for gold mining were permanently installed along the river and small tributaries, especially in the Brazilian portion (Purué River), but also in the lower Puré at the Colombian side, entering to the west farther than the C. Mateo, and also going upstream the Quebrada Agua Negra; in addition, during late 1990's and early 2000's a timber camp was established and active very near to the Colombian-Brazilian border, near to Defler's site. It is likely that the continuous need of protein for dredge crews and loggers may have been fulfilled using the local wildlife populations, including large primates such as *Lagothrix*. Density and primate biomass figures for the species in all sites surveyed in this study except Caño Mateo lie in the range of the figures for the species in 29 Amazonian non-hunted oligotrophic forests (Peres et al., 2016). However, density of *Lagothrix* in Caño Mateo (4.5 ind/km²) was below the lower end (6.42 ind/km²) of the range of values calculated by Peres et al. (2016); primate biomass (36%) was slightly higher than the lower end (28%) at Caño Mateo, and right at the lower end at

Table 1. Density (individuals/km²) and biomass (kg/km²) of primate species present at four sites in Río Puré National Park, eastern Colombian Amazonia.

Species	Quebradón El Ayo (200.7 km)			Caño Mateo (288 km)			Caño Esperanza (251 km)			Quebrada Arapa (250 km)														
	MGS	N	SR	GD	ID	B	MGS	N	SR	GD	ID	B	MGS	N	SR	GD	ID	B						
			Groups/ km ²		Ind/ km ²	Kg/ km ²			Groups/ km ²		Ind/ km ²	Kg/ km ²			Groups/ km ²		Ind/ km ²	Kg/ km ²						
<i>Leontocebus fuscus</i>	5.6	16	0.64	3.02	16.9	5.24	4.7	18	0.5	1.52	7.1	2.2	5.68	31	1.23	4.67	26.5	8.2	5.8	24	0.96	3.7	21.5	6.7
<i>Cheracebus lucifer</i>	2.6	7	0.35	2.63	6.8	6.52	2.4	21	0.58	2.8	6.7	6.4	2.4	15	0.6	1.91	4.6	4.4	2.7	17	0.68	2.5	6.8	6.5
<i>Saimiri cassiquiarensis</i>	18	1	0.05	0.63	11.3	8.47	7.3	15	0.42	0.69	5	3.8	9.25	4	0.2	0.4	3.7	2.8	5	6	0.24	0.7	3.5	2.6
<i>Sapajus apella</i>	7.2	11	0.55	4.24	30.4	70.8	5.6	30	0.83	1.16	6.5	15.1	5.7	10	0.4	0.7	4.8	11.2	5.7	11	0.44	1.3	7.4	17.3
<i>Cebus albifrons</i>	10	1	0.05	0.25	2.5	5.4	6.7	7	0.19	0.3	2	4.3	6.87	8	0.3	0.6	4.2	9.1	6.7	3	0.12	0.32	2.1	4.5
<i>Pithecia bursata</i>	4	18	0.9	2.8	11	19.36	3.14	65	1.8	2.94	9.2	16.2	3.27	26	1.03	3.26	10.7	18.8	3.7	22	0.88	2.3	8.5	15
<i>Alouatta seniculus</i>	5	1	0.05	0.21	1.05	5.46	3.4	7	0.19	0.44	1.5	7.8	P	P	P	P	P	P	10.5	2	0.08	2.3	1.7	8.8
<i>Lagothrix lagothricha</i>	12.7	19	0.76	0.54	6.9	48.3	6.7	14	0.38	0.67	4.5	31.4	11	29	1.2	0.6	6.6	48.8	20.2	20	0.8	0.75	13.7	95.6
TOTALS	74	74	14.3	14.3	86.9	169.5	147	147	10.52	42.5	87.2	123	123	12.14	61	103.3	105	105	13.87	65.2	157	157	157	157

MGS: Mean group size, N: Number of observations, SR: Sighting rate (number of sightings per 10 km of walked transect), GD: Group density, ID: Individual density, B: Biomass, p: species present at the site but not recorded during the censuses.

Quebradón El Ayo (28.5%). It is also well below the density estimated for the species in the high Algodón River (16.3 ind/km²) and just above the figure in the mid Tambo-ryacu River (3.5 ind/km²), in the Napo-Putumayo Rivers interfluvium in Perú, both sites highly affected by subsistence hunting and timber extraction (Aquino et al., 2016).

As previous surveys in eastern Colombian Amazonia have shown (Palacios & Peres, 2005; Defler, 2013), low primate densities and biomass at the forest sites surveyed at Río Puré NP seem to be a consequence of the limited habitat primary productivity as a result of the very low fertility of soils in eastern Colombian Amazonia (IGAC, 1997, 1999; Defler, 2003). Soil data from samples collected at Quebradón El Ayo, Caño Mateo and Caño Esperanza, every 800 – 1,000 m along each survey transect and analyzed at the Soils Laboratory of Instituto Geográfico Agustín Codazzi in Bogotá D. C. (E. Palacios, unpublished data), show they are very to extremely acidic soils (pH 3.7–4.7; 4.1–4.9, and 3.8–4.6 respectively), have a low to very low Cationic Exchange Capacity (1.2–15.2 meq/100g; 0.8–13.2, and 4.5–22.3), and a moderate to low fertility, following a typical pattern of oligotrophic terra firme forests of remote interfluvial areas (sensu Peres, 1999) along Amazonia lowland forests, due to their geochemical characteristics, and their severe nutrient limitations (Irion, 1978).

Overall, my results provide additional arguments supporting that soil fertility and vertebrate abundance are strongly correlated in Amazonian forests (Peres, 2008). Considering the low densities of primates, and in general of other medium and large sized terrestrial vertebrate species in terra firme forests that are not subject to hunting pressures in eastern Colombian Amazonia, it is important to implement monitoring schemes to generate information on their natural population dynamics, particularly on those areas subject to varying levels of anthropogenic activities around protected areas. Acknowledging that indigenous reserves cover more than fifty percent of the Colombian Amazon and include hundreds of square kilometers of habitats for more than 12 primate species, and about eighteen additional game species, strengthening their capacities to implement such schemes in their territories is also key. Indigenous authorities are in many cases willing to have their people trained and to develop these type of activities, in order to get technical information that can be articulated with their own knowledge, to complement their decision-making processes, on the use and management of resources that are of vital importance for their well-being, and whose state of conservation is an indicator of the role indigenous territories can play in maintaining healthy populations of mid-sized to large vertebrates in Amazonian forests.

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NEW RECORDS OF *BRACHYTELES ARACHNOIDES* (É. GEOFFROY, 1806) (PRIMATES: ATELIDAE) IN THE SOUTHERN ATLANTIC FOREST, IN PARANÁ STATE, BRAZIL

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Introduction

Primates of the genus *Brachyteles* Spix, 1923, popularly known as muriquis or monos (Auricchio, 1995), are endemic to the Atlantic Forest (Graipel, 2017). This biome is composed in large part of extremely fragmented and reduced areas (Ribeiro et al., 2009), and is considered one of the most threatened biomes in the world (Myers et al., 2000). Two species of muriqui are acknowledged to occur in different forest physiognomies: the northern muriqui, *Brachyteles hypoxanthus* (Kuhl, 1820) in the states Minas Gerais, Espírito Santo, Rio de Janeiro and Bahia, and the southern muriqui, *Brachyteles arachnoides* (É. Geoffroy, 1806) in the states

of Rio de Janeiro, São Paulo and Paraná. The second species is typically found in the phytoecological unit of Dense Rainforest, although there are also records of the species in Seasonal Semi-deciduous Forest and in Mixed Rainforest (Araucaria Forest), as well as in transition zones (Cunha et al., 2009). The muriquis, like other large primates, tend to occupy the higher strata of the forest (Peres, 1994).

According to information on the distribution of muriqui in the state of Paraná, its occurrence extends to the north of the state in the municipality of Castro (Cunha et al., 2009). However, the distribution is restricted and poorly known, with records in 1994 that mention its occurrence in the municipalities of Jaguariaíva and Guaraqueçaba (Martuscelli et al., 1994). Almost a decade later, a more southern population was registered by Koehler and collaborators (2002) in an isolated and unprotected fragment in the municipality of Castro. The third confirmed record for *Brachyteles arachnoides* was in Olho D'Água farm, municipality of Doutor Ulysses (Ingberman et al., 2016). Apart from these few occurrence records, the distribution and southern limit of this species is little known, a concern for its conservation; the species is classified as “critically endangered” in Paraná state (Paraná, 2010) and as “endangered” nationally (ICMBio, 2018) and internationally (IUCN, 2019).

Information related to the distribution and occurrence of populations of the southern muriqui is fundamental for the proposal of conservation measures. Here we contribute new occurrence records of the southern muriqui for Paraná state.

Methods

We registered the occurrence of *Brachyteles arachnoides* during mammalian fauna monitoring in two areas (Fig. 1). The first area is a High Conservation Value area located at Taquarussu Farm, with 1,367 ha of preserved forest (24°47'44.2" S, 48°47'53" W) in the municipality of Adrianópolis, PR, in the Vale do Ribeira region. The second area is a Private Reserve, the Reserva Particular do Patrimônio Natural (RPPN) Vale do Corisco (24°12'16" S, 49°21'26" W), with 396.6 ha, located at the eastern border of the Environmental Protection Area (APA) of the Devonian Scarp, in the municipality of Sengés, PR. Both areas belong to the company Arauco Forest Brasil.

Mammalian fauna were monitored in these areas between January 2015 and December 2019, for a total of 48 months of sampling, with an average of three days per month spent in monitoring. Censuses were based in the analysis of direct (visualization and acoustic signals) and indirect methods (analyses of footprints, marks and carcasses), together with camera traps. Species identification was made according to specialized field guides (Becker and Dalponte, 2013; Reis et al., 2009, 2014).

Monitoring was always performed by at least two observers in non-linear transects in search for traces of the

species. Transects included abandoned roads, natural trails and margins of streams, lakes and rivers. At the end of the study period, we had actively searched for

680 hours (340 hours per area), covering approximately 965 km on foot or on motorized vehicle.

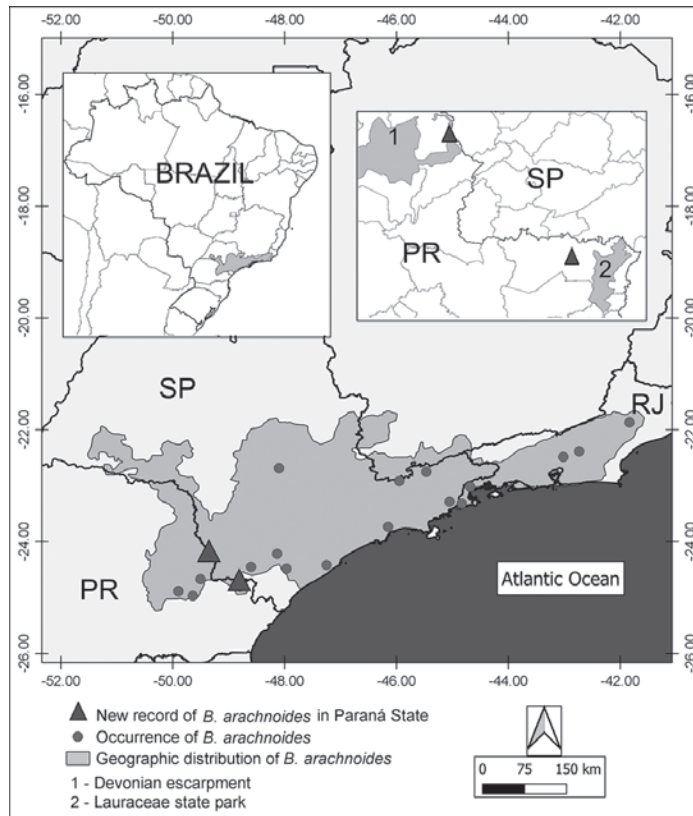


Figure 1. Triangles - location of the records of *B. arachnoides* at Taquarussu Farm, municipality of Adrianópolis, and at the Reserva Particular do Patrimônio Natural Vale do Corisco, municipality of Sengés, PR. Circles represent occurrence records based on information in the literature and historical geographic range of *B. arachnoides* (gray area), adapted from species distribution modeling by Ingberman et al. (2016).



Figure 2. Photographs of the *Brachyteles arachnoides* female in the RPPN Corisco Valley. A = female resting; B and C = female moving through the forest canopy; D = the prehensile tail.

Results

Here we present two new records of *Brachyteles arachnoides* for the state of Paraná. The first record was in the Vale do Ribeira, in the Taquarussu Farm, municipality of Adrianópolis, in December 28, 2016, when a group of mureiquis was registered by their vocalizations. Due to difficulties in accessing points closer to the group, the individuals were not observed visually. The second record was on November 22, 2019, in the RPPN Vale do Corisco, municipality of Sengés, Paraná. On this day, a lone female was photographed and filmed in the forest canopy (Fig. 2).

Discussion

Muriqui distribution in Paraná state is poorly known and previously described populations are restricted to small isolated forest fragments (Ingberman et al., 2016). Both the lack of knowledge and the isolation of populations are threats to the persistence of the species in the medium and long term. In addition, hunting and forest fires are imminent threats to the preservation of mureiqui in the state.

Mureiquis are relatively cautious and quiet, and they spend half of the diurnal hours at rest, so they may often go unnoticed. When active they can move quickly through the forest due to morphological adaptations such as the prehensile tail, long arms and hooked hands (Rosenberger and Strier, 1989). In addition, vocalization episodes of southern mureiqui are less frequent than in the northern mureiqui (Talebi, 2005). In the two places that we registered the mureiquis, the species can be considered to be rare, because despite all of our sampling efforts, the species was registered only once at each site.

Mureiqui usually move around in groups that vary in composition according to the season and food availability in their natural habitat (Talebi and Lee, 2010). Sex-biased dispersal has been described for *Brachyteles arachnoides*, in which adolescent females typically disperse from their natal group (Printes and Strier, 1999). The female registered alone in the RPPN Vale do Corisco may have been foraging alone or perhaps emigrating.

Only three previous records are available for the mureiqui in the state of Paraná. The record by Martuscelli et al. (1994), in Jaguariaíva municipality (at the border with Sengés), in the Environmental Protection Area (APA) of Guaraqueçaba remains unverified due to the lack of material proof (Ingberman et al., 2016). Koehler et al. (2002) reported the occurrence of the species in Fazenda João Paulo II, in the municipality of Castro, Paraná, in a small patch of mixed forest along the rivers Ribeira and Açungui (Koehler et al., 2002). Another population was registered in the Olho D'Água Farm, municipality of Doutor Ulysses (Ingberman et al., 2016).

Our records add new information about the distribution of *Brachyteles arachnoides*, principally for the state of Paraná. In particular, we would like to highlight the importance of remaining forest areas along the Devonian Scarp. Although many of these areas are fragmented and/or reduced, they can still support populations of various species. We recommend surveys to evaluate the size of the population of *B. arachnoides* in the area. This information could be used to propose measures for the conservation and protection of the mureiqui, especially in the Paraná State, where information on the species is scarce.

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**PITHECIA MITTERMEIERI (MARSH, 2014)
GEOGRAPHIC DISTRIBUTION: NEW RECORDS
EXTEND THE RANGE EAST OF THE JURUENA
RIVER**

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Odair Diogo da Silva
Ana Lúcia Cardoso Martins
Vancleber Divino Silva Alves
Manoel dos Santos Filho

Introduction

The range of Mittermeier's saki monkey (*Pithecia mittermeieri*) (Primates: Platyrrhini) was originally proposed to extend throughout the region east of the Madeira River up to the Juruena River as well as along the entire Guaporé River (Marsh, 2014). It had been suggested by Miranda-Ribeiro (1914), Hershkovitz (1987) and Sampaio et al. (2012) that the taxon that corresponds to the modern *P. mittermeieri* also exists east of the Juruena River. However, this distribution was not followed by Marsh (2014), who instead restricted its distribution to the region west of this river. The name *Pithecia mittermeieri* is deployed here, despite questions about the validity of the *Pithecia* taxonomy of Marsh (2014) raised by Serrano-Vilavicencio et al. (2019). Genetic studies are needed to resolve the relationship between *P. mittermeieri* and *P. irrorata*.

Recently, new populations of *Pithecia mittermeieri* have been recorded in the Upper Paraguai River Basin (De Lazari et al., 2014; Gusmão and Santos-Filho, 2015; Orsini et al., 2017). Some of these records (24 and 26, Fig. 1) not only extend the range of *P. mittermeieri* 300 km south-eastward, but they are also the easternmost points for the genus as a whole in Mato Grosso state, Brazil. They also represent new population records in the ecotonal region between the Amazon, Pantanal, and Cerrado. Such new sites suggested that *P. mittermeieri* species distribution was greater than that formerly recognized, and here we report additional records that extend the species' geographical distribution still farther eastward.

Methods and observations

Our survey was conducted at Fazenda Camargo Correa in the municipality of Diamantino, state of Mato Grosso, in a 307,880 ha block of continuous terra firma forest. Cerrado enclaves (RadamBrasil, 1978) are also present. The area is located on the Chapada dos Parecis (Fig. 1, point 28). The climate of the region is AW with 1,900mm mean annual rainfall, and 23°C mean annual temperature (Alvares et al., 2014).

Primate surveys were conducted using line-transect methodology adapted from Peres (1999), where three trails were

traversed every morning (from 5h to 12h) from October 5th to October 15th, 2018, with a total of 106 km of sampling effort. All vegetation strata were scanned to locate and identify members of the regional primate fauna. During the survey period, two *Pithecia mittermeieri* sightings were obtained (Fig. 2) while groups of the animals were moving along tree branches. Seven adults and subadult individuals were observed during the first sighting, and

five individuals, including one juvenile and four adults and subadults in the second. Subsequently, locality records available in Sampaio et al. (2012), Marsh (2014), Gusmão and Santos-Filho (2015) and Orsini et al. (2017) were compiled along with those from the current study in order to produce a map with all known records for the species (Fig. 1). The corresponding updated species occurrence records are provided in Table 1.

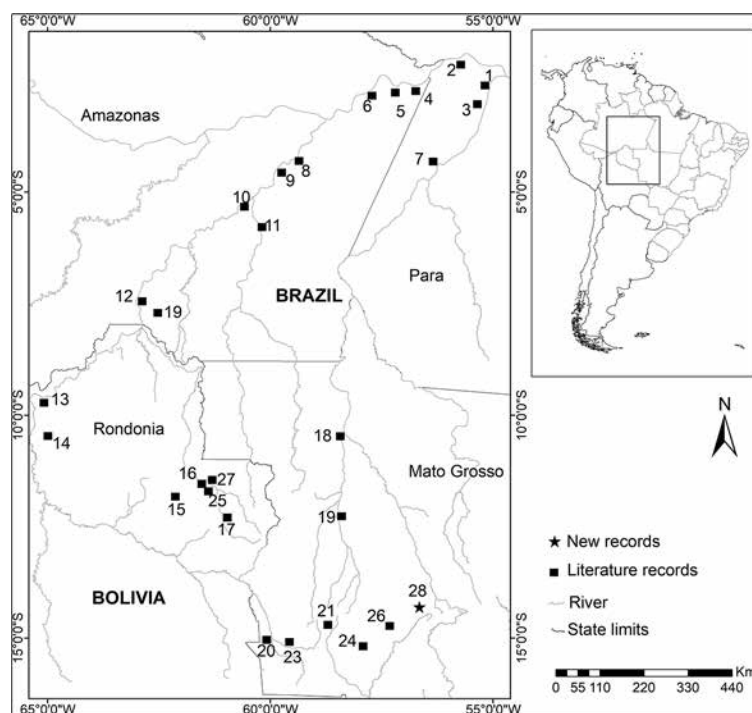


Figure 1. Distribution map of *Pithecia mittermeieri*, with squares indicating the locations available in the literature, and the star the new locality from this study. Numbers correspond to locations listed in Table 1.



Figure 2. Adult male *Pithecia mittermeieri* photographed in Fazenda Camargo Correa, Diamantino municipality, Mato Grosso state, Brazil. Photo: O. D. S.

Table 1. Records of *Pithecia mittermeieri* obtained from the literature and from field data in Brazil.

Area	Locality	Latitude (S)	Longitude (W)	Reference
1	Amorin, Brabo, Limoatuba (Olalla collection, by gazetteer, Paynter Jr. & Traylor Jr. 1991)	02°25'16"	055°07'30"	Marsh (2014)
2	Rio Arapiuns, Aruá (Olalla collection, by gazetteer, Paynter Jr. & Traylor Jr. 1991)	02°39'	055°37'59"	Marsh (2014)
3	Limoal near Boim (Olalla collection, by gazetteer, Paynter Jr. & Traylor Jr. 1991)	02°43' 05"	055°13'23"	Marsh (2014)
4	Parintins, Amazonas	02°37'12"	056°52'48"	Marsh (2014)
5	Rio Andira	02°46'12"	057°03'36"	Marsh (2014)
6	Lago Andira	02°45'	057°09'36"	Marsh (2014)
7	Itaituba, Villa Braga	04°25'00"	056°16'59"	Marsh (2014)
8	Igarapé Auara (Olalla collection, by gazetteer, Paynter Jr. & Traylor Jr.1991)	04°17'13"	059°25'48"	Marsh (2014)
9	Borba	04°24'00"	059°34'59"	Marsh (2014)
10	Rio Aripuanã	05°11'38"	060°23'35"	Marsh (2014)
11	Lago do Cipotuba	05°32'06"	060°22'23"	Marsh (2014)
12	Humaitá, Amazonas	07°25'44"	063°00'07"	Marsh (2014)
13	Destacamento do Ribeirão (Natterer 1883)	10°15'	065°16'	Marsh (2014)
14	Rio Pacáas Novos (Natterer 1829)	10°48'07"	065°07'41"	Marsh (2014)
15	Nova Brasília (PoloNoreste 1985)	10°44'24"	10°44'24"	Marsh (2014)
16	Cacoal State Park	11°09'	061°34'	Marsh (2014)
17	Chupinguaia	12°	061°	Marsh (2014)
18	Retiro do Veado Branco, Serra do Norte (Comissão Rondon)	11°19'59"	059°	Marsh (2014)
19	Km 16 on BR 230 (approx.)	07°32'17"	062°44'53"	Marsh (2014)
20	Cravari, Mato Grosso	14°49'	60° 6'	Hershkovitz (1987)
21	Tapirapuá, Rio Cipotuba, Mato Grosso	12°56'	58°40'	Hershkovitz (1987)
22	Brasnorte, Mato Grosso	12°32'	57°52'	Sampaio et al. (2012)
23	Pontes & Lacerda, Mato Grosso	15°01'	59°37'	Sampaio et al. (2012)
24	Tangara da Serra, Mato Grosso	14°35'23"	057°24'27"	Gusmão and Santos-Filho (2015)
25	RPPN Água Boa, Cacoal, Rondônia	11°29'	061°26'	Gusmão et al. (2014)
26	Lambari do Oeste, Mato Grosso	15°11'42"	057°44'43"	Orsini et al. (2017)
27	Linha 9, km 3.5, Cacoal, Rondônia	11°28'	61°21'	Cavalcante et al. (2018)
28	Fazenda Camargo Correa, Diamantino, Mato Grosso	14°16'9"	56°40'13"	Current study

Discussion

The data presented in this study reinforce the opinion voiced in Sampaio et al. (2012) that geographical distribution extensions were likely for this species in the eastern Juruena River region. Gusmão and Santos-Filho (2015) extended the range some 200 km to the east, and Orsini et al. (2017) recorded another population about 70 km to the south of the limit proposed of Gusmão and Santos-Filho (2015). The eastern-most known records available in Mato Grosso state are those given in this study, an eastern extension for the genus range as a whole in Mato Grosso,

corresponding to an extension of more than 90 km within the Chapada dos Parecis. As the species had been reported only within the Amazon until now, and the current study took place in the extreme southeastern edge of the Amazon rainforest, *Pithecia mittermeieri* seems unlikely to be found beyond these limits.

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PREDATION BY A SLATE-COLORED HAWK, *LEUCOPTERNIS SCHISTACEA*, ON JUVENILE GRAELL'S BLACK MANTLED TAMARINS, *LEONTOCEBUS NIGRICOLLIS GRAELLSI*

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Stella de la Torre

Introduction

Predation is considered an important factor in callitrichid ecology and evolution (Caine 1993; Pulliam 1984). However, predation events on wild groups are difficult to observe (Ferrari 2009). Here we report two predation events by the slate-colored hawk *Leucopternis schistacea* on one group of Graell's black mantled tamarins *Leontocebus nigricollis graellsi* in Amazonian Ecuador.

Study site

The predation events took place in Sacha Lodge Reserve, a private area of well-preserved forest in the northern bank of the Napo River in Amazonian Ecuador (0°28'16.55" S, 76°27'32.38" W). A group of seven Graell's black mantled tamarins, *Leontocebus nigricollis graellsi* (2 adults, 24–26 cm; 3 subadults, 22–23 cm; and 2 juveniles that were probably twins (14–15 cm)), was followed from May 30 through August 9, 2018, to collect data of their feeding behavior.

Results and Discussion

On June 23, 2018, at 11:55 (local time), the tamarins were feeding on *Parkia* sp. exudates and resting at about 25 m above ground. One of the individuals suddenly started to

emit alarm calls after a slate-colored hawk captured one of the juveniles that was resting in the treetop of a *Cecropia* sp. The rest of group moved quickly to the treetop where the tamarin was caught, emitting alarm calls and apparently trying to mob the hawk, but it flew to a nearby tree, holding the juvenile in its claws (Fig. 1a and b). Once perched, with its right claw the hawk grabbed the upper part of the tamarin, while using its beak to tear off the skin, moving its head from side to side. At that moment, the rest of the tamarins moved back and hid in other trees. Twenty-two minutes after the hunt, the hawk left with the carcass. The tamarins remained vigilant, producing sporadic alarm calls. About 30 minutes after the hawk left, the tamarins started moving very slowly and silently. They moved to an area 500 m away from the hunting scenario, resting for 45 minutes on a tree about 30 m high. Late in the afternoon, hours after the hunt, the group continued to be alert; they were difficult to follow, moving rapidly and quietly. At dusk the group remained together in a tree. The next day, June 24, the group started moving early, at around 6:03 am, emitting very few vocalizations. The group traveled quickly through the forest all day, with a path length that day of 875 m. Two days after the hunt, the tamarins seemed to return to their normal behavior, emitting more vocalizations and reducing their daily path to 750 m (daily paths were measured with ArcMap software using the GPS coordinates recorded every time the group moved).



Figure 1. Slate-colored hawk *Leucopternis schistacea* feeding on a juvenile Graell's black mantled tamarin *Leontocebus nigricollis graellsii* in Sacha Lodge Reserve, Amazonian Ecuador.

On August 4, 2018 at 9:35 we observed a second predation event by a slate-colored hawk on the same tamarin group. The six tamarins were resting in a kapok tree (*Ceiba pentandra*) at about 20 m above ground. The hawk caught and squeezed the remaining juvenile with its claws while the tamarin emitted distress calls. The hawk flew into the forest while the rest of the tamarins began to move quickly emitting alarm calls.

About 30 minutes after the predation event, the tamarins were silent and vigilant, moving very slowly to an area about 600 m away. By late afternoon, the tamarins remained hidden and quiet in the dense vegetation of the treetops until nightfall. The next day the tamarins were quiet, emitting only very few alarm calls. They rested hidden the whole morning and only moved in the afternoon. Three days later, the group returned to their normal daily travel pattern.

These two successful predation events carried out in less than two months point to the importance of the slate-colored hawk in controlling this tamarin population. This species was reported hunting saddle-back tamarins in Peru (Lledo-Ferrer et al., 2009) but, to our knowledge, ours is the first report of effective attacks of this raptor on Graell's black-mantled tamarins. It is remarkable that in both occasions, the hawk hunted a juvenile, suggesting that it may use specific criteria to select its prey while observing tamarin groups before the attack. The response of this tamarin group to a predation event, moving faster, hiding and emitting fewer vocalizations in the next three to four days after the attack, is similar to that reported by Lledo-Ferrer et al. (2009) for saddle-back tamarins in Peru. This consistent response points to the strong influence that predation pressure may have on tamarins' behavior.

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OBSERVATIONS OF DIURNAL ACTIVITY IN A 'STRICTLY' NOCTURNAL PRIMATE, THE PERUVIAN NIGHT MONKEY (*AOTUS MICONAX*), YAMBRASBAMBA, PERU

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Dan Doolan
Nestor Allgas
Claudia Salazar
Vinciane Fack

Introduction

Cathemerality, defined as “sporadically active throughout a 24-hour day” (Fleagle 1988, p.52), or as “when significant amounts of activity, particularly feeding and/or traveling, occur within both the light and dark portions of that cycle” (Tattersall 1987, p. 201), is widespread across many mammal species, in all major biomes (Curtis and Rasmussen 2006). As with nocturnality, cathemerality must confer an evolutionary advantage. This advantage may be in the form of decreased interspecific competition, coping with deficits in ambient light and temperature, and/or predator avoidance or prey capture (Curtis and Rasmussen 2006).

It is probable that modern primates are descended from nocturnal basal taxa (Ross et al. 2007; Santini et al. 2015). In the extant primates, nocturnal behavior is well established in the lorises and galagos, as well as several genera of lemur (Colquhoun 2011), and cathemerality is known in two genera of lemurs, *Eulemur* and *Hapalemur* (Colquhoun 2011). There are also several published records of nocturnal behavior in other diurnal primate species including *Cebus capucinus*, *Lemur catta*, *Macaca fuscata yakui*, *Pan troglodytes*, and *Rhinopithecus brelichi* (Nishikawa and Mochida 2010; Parga 2011; Perry 2012; Donati et al. 2013; Tan et al. 2013; Krief et al. 2014).

Night monkeys (*Aotus* spp.) are the only nocturnal haplorhine, and subsequently the only nocturnal platyrrhines (Fernandez-Duque 2011). Most *Aotus* are considered ‘strictly’ nocturnal, with only two species (*A. azarae* and *A. nigriceps*), in the southernmost, most seasonal, part of the genus distribution, showing cathemerality (Mann 1956;

Wright 1989; Donati and Borgognini-Tarli 2006; Fernandez-Duque and Erkert 2006; Erkert et al. 2012; Khimji and Donati 2014). Nocturnal and diurnal activity in *Aotus* spp. is influenced by moon luminosity and ambient temperature (Fernandez-Duque 2003; Fernandez-Duque and Erkert 2006). The paucity of field studies on most *Aotus* species means that many aspects of their behavioral ecology are still unknown, and diurnal activity may be more common than thought.

The Peruvian night monkey (*Aotus miconax*) is one of the least studied of all Neotropical primates. This species is endemic to northern Peru (Shanee et al. 2015) and restricted to montane and pre-montane forests between ~1,200 and 3,100 m a.s.l. (Shanee et al. 2015). This species is considered Endangered by the IUCN (2019). *Aotus miconax* is considered a ‘strictly’ nocturnal night monkey (Fernandez-Duque 2011) and previously had only been observed leaving and arriving at its nest sites between sunset and sunrise (Shanee et al. 2013). The diet of *A. miconax* is highly omnivorous, composed of large amounts of ripe fruits, leaves and insects, and smaller amounts of buds and flowers (Shanee et al. 2013). Two studies have suggested the possibility of diurnal activity in *A. miconax* (Shanee et al. 2013; Campbell et al. 2019), but these studies did not document diurnal activities first hand.

Here we present *ad libitum* observations of diurnal behavior in *Aotus miconax* gathered in 2012 and 2018. The first observations, from 2012, were made whilst surveying forest fragments in preparation for presence/absence surveys of *A. miconax*, and the 2018 observations, during behavioral studies of *Lagothrix flavicauda*, in continuous forest. As cathemerality in *A. azarae* and *A. nigriceps* is influenced by light and temperature, we tested whether moon illumination, moon phase, or ambient temperature had an effect on instances of diurnal behavior in *A. miconax*.

Study site and Methods

Observations were made at the El Toro field site, in Amazonas region, Peru (05°39'46" S, 77°54'32" W) (Fig. 1), an area of made up of ca. 700 ha of disturbed primary forest and regenerating secondary forest, interspersed with pasture, that is part of continuous forest leading to the Amazonian lowlands. Terrain in the area is very rugged, with high ridges and deep valleys between 1,800 and 2,400 m a.s.l. Annual rainfall is ca. 1,700 mm, with a drier season from August to December. The primary premontane and montane forests of the area have been selectively logged over the past ~ 30 years and have a thick mid- and understory with an average canopy height of 15–25 m. The land is titled to the *Campesino Community* of Yambrasbamba, with a single land title of 80,545 ha. People in the community are predominantly subsistence farmers (tubers, corn and beans), with some small-scale commercial production (cattle, coffee and ‘rocoto’).

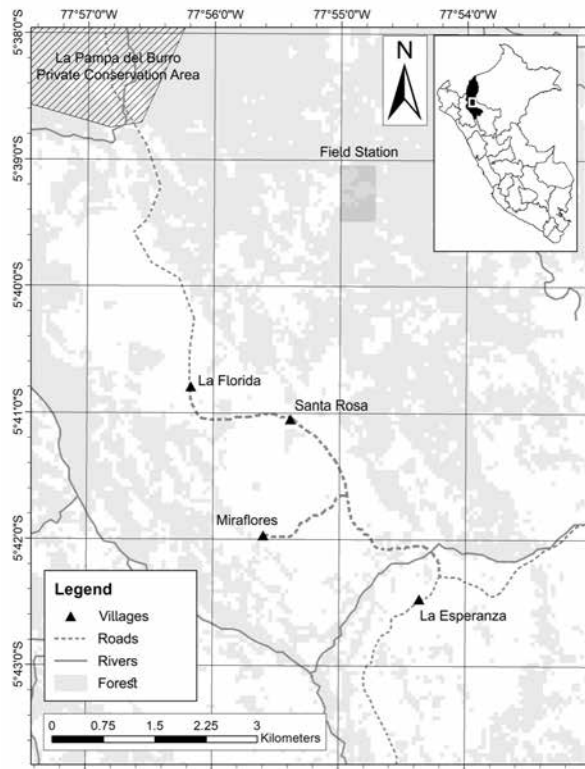


Figure 1. Map showing location of field site and surrounding villages.

Field trips for behavioral data collection on *Lagothrix flavicauda* were carried out continuously from 2008 to 2019. Trips were made every two weeks and lasted five days. Researchers left the field station at ~06:00h each day and returned at ~19:00h each day during field trips. Additional nocturnal surveys of *Aotus miconax* were made between March and June 2018 (Doolan 2018). All data collection was made by at least one researcher accompanied by experienced local field guides. Researchers carried standard field equipment; handheld GPS units were used to georeference primate sightings and observations were aided by the use of binoculars and cameras with telephoto lenses. Observations of *Aotus* diurnal activity were made during 2012 and 2018.

We used moon illumination and phase data given in our handheld GPS units. We used ambient temperature data for 2018 gathered on site (Lacrosse ws1600). As we only collected weather data during our standard fieldwork we did not have a complete set for the entire period (March – June 2018). When data were missing we used records from the *Servicio Nacional de Meteorología e Hidrología del Perú* weather station at Chachapoyas (<https://senamhi.gob.pe/?&p=estaciones>). This station is the closest to the field site (~60 km south), that is at a similar elevation (2,400 m a.s.l.). No temperature data were available for 2012, so these observations were not included in hypothesis testing. We also recorded instances of diurnal behavior reported to us by local informants and field guides. These reports consisted of information volunteered during normal

conversation, generally people sought us out as they knew of our interest in local primates. These reports occurred sporadically during the entire period (2012-2018); we did not note the specific date of each report.

Results

We observed diurnal activity in *Aotus miconax* on 13 occasions during field work in 2012 (three observations) and 2018 (10 observations). All records were of *ad libitum* encounters either during behavioral follows of *Lagothrix flavicauda* in continuous forest, during preparatory field work or during surveys of forest patches. Moon illumination on the nights preceding observations varied considerably (Table 1), between 10% and 99% (mean 43.09, \pm 34.91), and showed no discernible trend (One sample Kolmogorov-Smirnov Test, 0.096). Average temperatures during the months of March to June 2018 were 19.6°C during the day, and 11.5°C at night. There was no significant difference across the study period between diurnal and nocturnal temperatures when diurnal behaviour was and was not observed (T-Test, $t=0.472$, $df=242$, $p=0.637$). There was no significant difference from average daytime temperatures on days when we observed *A. miconax* active during daylight hours (T-Test, $t=0.168$, $df=120$, $p=0.867$). There was no significant difference from average nighttime temperatures on nights immediately preceding days when we observed *A. miconax* active during daylight hours (T-Test, $t=1.276$, $df=120$, $p=0.204$).

Table 1. Moon phases of the previous night, before diurnal observations.

Date of observation	Moon illumination (% of full moon)	Moon phase
27/1/12	23%	Waxing
15/2/12	49%	Waning
26/2/12	26%	Waxing
2/3/18	99%	Full moon
25/3/18	54%	First quarter
17/4/18	10%	Waxing
17/5/18*	13%	Waxing
30/5/18*	99%	Full moon
12/6/18	11%	New moon
25/6/18	77%	Waxing

* Two separate observations on the same day

Ad libitum observations from 2012

On the morning of the 28th of January 2012, during field surveys of *Lagothrix flavicauda* in continuous forest, one unknown adult *Aotus miconax* individual, and three individuals (two adults and one juvenile) from a known group of *A. miconax*, were observed locomoting through the forest within the vicinity of the known group's habitual

sleeping site in a vine tangle in the lower crown, approx. 8 meters high, of a *Ficus* sp. tree. The observation took place at approximately 09:00 h.

On the 16th of February 2012, in a small patch of secondary forest, ~1.4 ha (Shanee et al. 2013), just above the village of La Esperanza, two adult *Aotus miconax* individuals were observed feeding on ‘naranjillo’ (*Styloceras laurifolium*) fruits. The observation took place at approximately at 09:00 h.

On the 27th of February 2012, in a small forest patch, < 1 h, just below the village of La Esperanza three *Aotus miconax* individuals (two adults and one juvenile) were observed feeding on fruits in a fig tree (*Ficus* sp.). The observation took place at approximately 16:00 h.

Ad libitum observations from 2018

On the 3rd of March 2018, we encountered a known group of three *Aotus miconax* (two adults and one juvenile) that live close to the field station, awake and out of their nest. The group then travelled to a nearby tree where they fed on figs (*Ficus* sp.). The observation took place at 13:06 h. On the 26th of March 2018 two members of the same *Aotus miconax* group (one adult and one juvenile) were again seen active during the day, this time traveling through the trees. This observation took place at 12:34 h.

On the 18th of April 2018, again, two members of the same *Aotus miconax* group (one adult and one juvenile) were observed traveling through the trees. This observation took place at 09:46 h.

On the 18th of May 2018, we observed two different groups of *Aotus miconax*, one of four members (three adults and one juvenile) and two members (both adults), traveling through the trees. Both observations took place at approximately 10:4 h but, were recorded by different groups of observers simultaneously at different points of the field site. On the 31st of May 2018, we again observed two instances of different *Aotus miconax* groups travelling during the day time. The two groups (two adults, and two adults and a dependent infant, respectively) were seen at 08:49 h and 16:22 h, by different groups of observers in different areas of the field site. The presence of a group of *Lagothrix flavicauda* passing through the area could have disturbed the *A. miconax* groups on these occasions, but no obvious interactions were observed, and the *A. miconax* groups had still not returned to their nests for over 10 minutes after the *L. flavicauda* group had passed.

On the 13th of June 2018, three *Aotus miconax* individuals (two adults and one juvenile) were seen travelling at 14:23 h. Again, this was possibly due to disturbance by a *Lagothrix flavicauda* group in the area. The group did not return to its nest or enter a new one for the 16 minutes of our observations. On the 26th of June 2018 an unknown group of three *Aotus miconax* was found out of their nest

at 09:25 h during follows of *Lagothrix flavicauda*. The *L. flavicauda* group was causing much disturbance, jumping through the canopy and vocalizing, during this observation and probably disturbed the *A. miconax* group, although no direct interaction between the species was observed.

Additional observations

During presence/absence surveys and habitat characterization of *Aotus miconax* in forest patches and continuous forest in 2018 (Doolan 2018), we inferred diurnal behavior on five occasions when we left groups at a nest site in the morning and did not find them there in the afternoon, or vice versa, when a group did not return to a particular nest in the morning but, was found there before sunset. Other observations during this study included pairs of *A. miconax* seen locomoting at ~10 a.m., but most probably this was due to disturbance by dogs in the area (Doolan, pers. obs). On several other occasions, groups left their nests before sunset or did not return until after sunrise, but these observations occurred within an hour of sunset or sunrise. A number of residents of the villages of La Esperanza, Miraflores, and Santa Rosa (Fig. 1) have recounted observations of *A. miconax* active during daylight hours whilst passing through fragmented habitats to get to their fields. These anecdotal reports cover the entire study period as well as years preceding the start of our investigations.

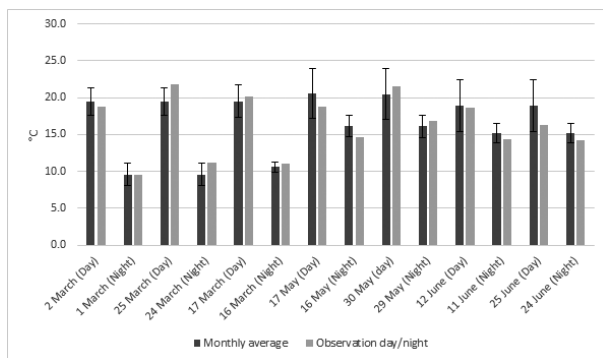
Discussion

Our observations show that, although classed as a ‘strictly nocturnal’ night monkey species, *Aotus miconax* is also active diurnally on occasion. This activity appears to be sporadic and rare and is likely not enough to class it as catemeral to the same degree as *A. a. azarai* (Fernandez-Duque 2003; Fernandez-Duque and Erkert 2006). Although field trips occurred during the intervening period, we did not observe any diurnal *A. miconax* behavior during these years. It is possible that diurnal activity in *A. miconax* was less frequent during these years, although local residents still reported instances to us. It is more probable that these behaviors occurred at the same frequency, they were just not noticed by ourselves or other researchers, particularly as we were not carrying out other investigations on *A. miconax* during these periods.

This is not the first report of *Aotus miconax* being active during daylight hours. For example, Campbell et al. (2019) recorded a group leaving their nesting site during daylight hours. Similarly, diurnal activity was inferred by Shanee et al (2013) when leaving groups at nesting sites in the morning, then finding the sites empty prior to starting evening observations later the same day. However, in neither of these studies were the animals observed feeding or traveling during daylight hours. Here we present many direct observations, showing that diurnal behaviors are more common than previously thought.

Nocturnal and diurnal activity in *Aotus* spp. is influenced by moon luminosity (Fernandez-Duque 2003; Fernandez-Duque and Erkert 2006). *A. azarai azarai* in the Argentinian Chaco show marked periodicity in their activity rhythms, being active throughout the night during full moon nights, and displaying much less cathemerality (Fernandez-Duque 2003; Erkert 2004; Fernandez-Duque and Erkert 2006). Our observations did not show any correlation of moon luminosity with diurnal behavior in *A. miconax*, with animals seen active during the day light hours on days preceded by anywhere between 11 and 99% illumination (Table 1).

Temperature also has been linked to changes in nocturnal and diurnal activity in *Aotus* spp. (Erkert 1991; Fernandez-Duque 2003; Fernandez-Duque and Erkert 2006). Temperatures on the nights preceding, and the days when *A. miconax* were active in 2018 were not significantly different to averages across the period (Fig. 2). Seasonal changes in temperature, rainfall, and resource availability have not been found to influence occurrences of diurnal behavior in *A. azarae* (Fernandez-Duque and Erkert 2006; Erkert et al. 2012). At our study site, just 5° south of the equator, temperatures are fairly steady throughout the year. There are seasonal shifts in rainfall and resource production, although our limited data set preclude possibilities of testing the influence of seasonality. Interestingly, sympatric *Lagothrix flavicauda* groups at the study site have been



noted to significantly change their activity budgets and diets between seasons (Fack et al. submitted).

Figure 2. Average monthly diurnal and nocturnal temperatures on days and nights, immediately preceding, observations of diurnal activity in *Aotus miconax* in 2018.

Some of our observations occurred through disturbance of the night monkeys by other animals. Nocturnal activity in several species of diurnal primate have been observed (Nishikawa and Mochida 2010; Parga 2011; Donati et al. 2013; Tan et al. 2013; Krief et al. 2014), in some cases provoked by the activity of nocturnal species (Nishikawa and Mochida 2010; Krief et al. 2014). During our surveys, *Aotus miconax* were disturbed from their nests by *Lagothrix flavicauda* on a number of occasions. Similarly, a group of four *A. nigriceps* was observed locomoting between 09:30 and 10:00 h at Tambopata National Reserve, in Southern Peru, and another group of *A. nancymaae*, observed

moving through the trees in the Pacaya Samiria National Reserve at approximately 11:00 h. In both cases the groups had disturbed by the activities of other primates, in these cases *Plecturocebus brunneus* and *Sapajus macrocephalus*, respectively (N. Allgas, pers obs). Domestic animals have also been observed to cause diurnal activity in *A. miconax*, where individuals remain in or near human settlements after dawn, drawing the attention of dogs (Shanee and Shanee 2011). It is also possible that at least some of these observations were due to unintentional disturbance by observers, or other human activity in the area. However, this likely was not true in all cases, as on several occasions the animals were already engaged in other activities and away from their nesting sites before our arrival, and there were no other humans in the vicinity.

The forests of Northern Peru suffer massive deforestation for agriculture, cattle ranching and timber extraction (IBC 2016). Deforestation has caused the fragmentation of much of the remaining habitat of *Aotus miconax*, and most remaining habitat is disturbed (Shanee et al. 2015). Species that persist in heavily disturbed forests often develop new ecological strategies to enable them to survive (Shanee and Shanee 2011; Marsh et al. 2013), with those that are successful showing a high degree of behavioral and dietary plasticity (Castano et al. 2010; Shanee and Shanee 2011; Marsh et al. 2013).

Very few observations of diurnal activity have been reported for *Aotus* spp. (Mann 1956; Khimji and Donati 2014) other than *A. a. azarai* (Fernandez-Duque 2003; Fernandez-Duque and Erkert 2006), and this behavior has only previously been inferred for *A. miconax* on a handful of occasions (Shanee et al. 2013; Campbell et al. 2019). As with most species of *Aotus*, detailed studies of all aspects of *A. miconax* behavioral ecology are lacking. It is very possible that further observations of this species will indicate that diurnal activity is more common than thought.

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BOOKS

Skeletal Anatomy of the Newborn Primate, by Smith, T. D., DeLeon, V. B., Vinyard, C. J. and Young, J. W. Cambridge University Press, 328pp. 2020. ISBN: 978-1107152694. This is the first book dedicated to newborn skeletal and dental anatomy and how it varies across primate species. Structured according to anatomical regions, the book includes hundreds of detailed anatomical illustrations, including a color atlas illustrating entire skeletons in representative taxa. Whilst the book is primarily a guide to comparative anatomy, it also highlights the links between development and behavior. *Content:* 1) Introduction; 2) Primate development and growth; 3) Why ontogeny matters; 4) The skull; 5) Dentition; 6) The postcranial axial skeleton; 7) The pectoral girdle and forelimb skeleton; 8) The pelvic girdle and hindlimb skeleton; 9) The newborn primate body form: phylogenetic and life history influences; 10) Ontogeny of feeding; 11) Ontogeny of locomotion.

Neotropical Ethnoprimatology: Indigenous Peoples' Perceptions of and Interactions with Nonhuman Primates (Ethnobiology), edited by Urbani, B. and Lizarralde, M. Springer, 427pp. 2020. ISBN: 978-3030275037. This book reviews the complex interconnections between different indigenous peoples with New World monkeys that sympatrically share their ancestral territories. It includes study cases in a geographic range that covers all of the Neotropics, from southern Mexico through northern Argentina. *Contents:* 1) Perceptions and uses of primates among Popoluca indigenous people in Los Tuxtlas, Mexico - Pinto Marroquin, M., et al.; 2) Mental state attribution to nonhuman primates and other animals by rural inhabitants of the community of Conhuas near the Calakmul Biosphere Reserve in the Yucatan Peninsula Mexico - Urquiza-Haas, E. G., et al.; 3) Local knowledge and cultural significance of primates (*Ateles geoffroyi* and *Alouatta pigra*) among Lacandon Maya from Chiapas,

ARTICLES

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ABSTRACTS

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MEETINGS

AMERICAN ASSOCIATION OF PHYSICAL ANTHROPOLOGISTS MEETING

The 90th AAPA annual meeting will be held in Baltimore, Maryland from April 7-10, 2021. For more information, please visit physanth.org/meetings-and-webinars/90th-annual-meeting-7-10-april-2021-baltimore/

IPS/SLAPRIM CONGRESS 2020 POSTPONED TO 2021

Because of COVID-19 global situation the joint meeting of the 28th IPS Congress and the IV Congress of the SLAPRIM will be postponed to August 15 – 21st, 2021 in Quito, Ecuador. A “second-chance” registration period will be opened in early 2021 for anyone who is not currently registered but would like to register and submit a new abstract for the rescheduled meeting. For more information go to www.internationalprimatologicalsociety.org/announcements.cfm

INTERNATIONAL PRIMATOLOGICAL SOCIETY

The 29th IPS Congress has been rescheduled to be 2 years later, in 2023 in Kuching, Malaysia.

PRIMATES DE COLOMBIA
GUÍA DE IDENTIFICACIÓN DE BOLSILLO

Authors: Andrés Link, Gabriela de Luna, Nathalia Bustamente, Russell A. Mittermeier and Anthony B. Rylands. Illustrations and design by Stephen D. Nash. ISBN: 978-0-692-09447-1. First Edition. 2018.

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Illustrated by Stephen D. Nash. \$7.95. (price includes UPS ground shipping to U.S. addresses)
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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 BOTH: Erwin Palacios, Conservación Internacional – Colombia, e-mail: epalacios@conservation.org and to Jessica Ward Lynch, University of California, Los Angeles, email: jlynchalfaro@g.ucla.edu. 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 platyrrhines. 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. When reporting geographic coordinates please utilize one of the following formats consistently throughout the manuscript: DMS (degrees, minutes, seconds) 4°36'19.1"N, 74°3'20.7"W or DD (Decimal Degrees) 4.605306, -74.055750.

Tables. Tables should be double-spaced, using font size 10, and prepared with MS Word. Each table should have a brief title.

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.

References. Examples of house style may be found throughout this journal. In-text citations should be first ordered chronologically and then in alphabetical order. For example, "... (Fritz, 1970; Albert, 1980, 2004; Oates, 1981; Roberts, 2000; Smith, 2000; Albert et al., 2001)..."

In the list of references, the title of the article, name of the journal, and editorial should be written in the same language as they were published. All conjunctions and prepositions (i.e., "and", "In") should be written in the same language as rest of the manuscript (i.e., "y" or "e", "En" or "Em"). This also applies for other text in references (such as "PhD thesis", "accessed" – see below). Please refer to these examples when listing references:

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.

Book

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

Thesis/Dissertation

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

Report

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.

Website

UNESCO. 2005. UNESCO Man and the Biosphere Programme. United Nations Educational, Scientific, and Cultural Organisation (UNESCO), Paris. Website: <http://www.unesco.org/mab/index.htm>. Accessed 25 April 2005. ("Acessada em 25 de abril de 2005" and "Consultado el 25 de abril de 2005" for articles in Portuguese and Spanish respectively).

For references in Portuguese and Spanish:

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"MSc Thesis" changes to "Dissertação de Mestrado" and "Tesis de Maestría" for articles in Portuguese and Spanish respectively.

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

Neotropical Primates

A Journal and Newsletter of the IUCN/SSC Primate Specialist Group

Vol. 26(1), September 2020

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