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Front cover: White-cheeked spider monkey (*Ateles marginatus*). Photo taken at Cristalino Private Heritage Reserve (RPPN), northern Mato Grosso, Brazil. December 2016. Photo taken by Jessica Ward Lynch.

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ARTICLES

DEMOGRAPHIC DYNAMICS OF PERUVIAN BLACK-FACED SPIDER MONKEYS *(ATELES CHAMEK)* REINTRODUCED IN THE PERUVIAN AMAZON

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Abstract

Reintroductions of animals are important conservation tools for different taxa around the world. A reintroduction program in the Peruvian Amazon is focusing on black-faced spider monkeys (*Ateles chamek*). We investigated life-history parameters such as stage-specific survival and female fertility rates using a capture-mark-recapture framework and data from the literature. We estimated growth rate and probability of extinction for a reintroduced group using matrix models, as well as testing whether population growth depends more on survival of juvenile females or adult females. Our results suggest the population of the reintroduced group is decreasing. After projecting the group size for the next 25 years using different scenarios, we found that in order for the group to persist, survival rate of the female adult stage needs to exceed 79 %. Given that group growth rate is more sensitive to the survival of adult females, management measures actions that target this demographic are required to guarantee survival of the group. Extrapolations of our results are subject to restrictions imposed by the small sample size and the conditions specific to this reintroduction program. However, this study may provide valuable lessons for reintroduction programs attempting the recovery of wild populations of similar species.

Keywords: *Ateles chamek*, Madre de Dios, matrix models, reintroduction

Resumen

La reintroducción de animales es una herramienta importante para la conservación de diferentes taxa a lo largo del mundo. Un programa de reintroducción en la Amazonía peruana está enfocada en monos araña negros (*Ateles chamek*). Investigamos los parámetros de historia de vida tales como la tasa de supervivencia por etapa específica y fertilidad de las hembras, utilizando el marco de referencia de captura-marca-recaptura y datos de literatura. Estimamos la tasa de crecimiento poblacional y la probabilidad de extinción del grupo reintroducido utilizando modelos matriciales, asimismo, probamos si el crecimiento poblacional depende de la supervivencia en las etapas de hembras juveniles o adultas. Nuestros resultados sugieren que la población del grupo reintroducido está disminuyendo. Después de proyectar el tamaño grupal para los próximos 25 años utilizando diferentes escenarios, encontramos que para para persistir la tasa de supervivencia de las hembras adultas debe exceder 79 %. Dado que la tasa de crecimiento del grupo es más sensible a la supervivencia de las hembras adultas, las acciones de manejo deben enfocarse en este sector particular de la población para garantizar la supervivencia de la misma. Las extrapolaciones de nuestros resultados están sujetas a restricciones impuestas por el reducido tamaño muestral y las condiciones específicas del programa de reintroducción. Sin embargo, este estudio puede proveer lecciones valiosas para programas de reintroducción que intenten recuperar poblaciones silvestres de especies similares.

Palabras clave: *Ateles chamek*, Madre de Dios, modelos matriciales, reintroducción

Introduction

Reintroductions consist of the re-establishment of species in areas of their historical range where they have become extinct or were extirpated (Seddon et al., 2014). Species from a variety of taxonomic groups have been successfully reintroduced in many parts of the world (barred bandicoot, Backhouse et al., 1994; bison, Pyne et al., 2010; black-footed ferret, Santymire et al., 2014; California condor, Walters et al., 2010; golden lion tamarin, Kierulff et al., 2012; gray wolf, Bangs and Fritts, 1996; guanaco, Barri, 2016; red wolf, Hinton et al., 2013; scimitar-horned oryx, Woodfine and Gilbert, 2016; wild dog, Gusset et al., 2010). Reintroduction programs are considered a conservation tool (Kleiman, 1989; IUCN, 1998), a strategy to deal with defaunation (Barri, 2016), and a way to deal with individuals confiscated from illegal animal-trafficking operations (IUCN, 2002a). For species with high conservation value, the reintroduction process should be conducted under a well-defined management plan and result in reintroduced individuals capable of survival in the wild without external intervention (Griffiths et al., 1989; IUCN, 2002b). Further, long-term post-release monitoring programs of reintroduced individuals or groups should be supported with knowledge about the species' ecology (Baker, 2002; Trayford and Farmer, 2012).

A number of non-human primate species have been reintroduced into the wild (Konstant and Mittermeier, 1982; Kleiman et al., 1986; King et al., 2011; Beck, 2017) with varying degrees of success. Black-handed spider monkeys (*Ateles geoffroyi*) on Barro Colorado Island (BCI), Panama, is an example of a successful reintroduction (Milton and Hopkins, 2005), which started with few individuals and currently has a healthy population.

Spider monkeys (*Ateles* spp.) are long-lived Neotropical primates that can live > 30 years (Link et al., 2018; Milton and Hopkins, 2005; Ramos-Fernández et al., 2017), and that exhibit long periods of maternal care (Di Fiore and Campbell, 2005). Male:female sex ratios in wild populations of *Ateles chamek* (aka *Ateles belzebuth chamek*) were reported in the range of 0.56-1 for adult and subadults (mean 0.77 ± 0.22 SD, Shimooka et al., 2008). Spider monkeys have a high degree of fission-fusion dynamics (Aureli et al., 2008; Di Fiore and Campbell, 2005), where females disperse from social groups in search of new mates whereas males are philopatric (McFarland Symington, 1988). Unfortunately, most spider monkey species are considered as "Endangered", principally due to their long-lived, slow reproducing, and social nature makes them susceptible to habitat loss and overhunting (Mittermeier et al., 1989). The Taricaya Rescue Center started the "Program for the reintroduction of spider monkeys in the southeastern Peruvian Amazon" in 2009 with the goal of reintroducing rescued and rehabilitated black-faced spider monkeys (*Ateles chamek*) to the wild. The Peruvian government legally recognizes this program and approved of its management plan in 2012. Most of the spider monkeys in the program were seized from illegal traffickers or were being kept illegally as pets in Peru. Twenty two black-faced spider monkeys were released between 2011 and 2017 with the goal of establishing a stable, self-sustaining group. Since reintroduction, the program has carefully tracked the details of the release process and post-release monitoring activities, including monitoring animal behavior and resource use by the reintroduced spider monkeys (Bello et al., 2018). The future of the group, constituted by 13 individuals (10 females and three males) in 2017, is uncertain. Information on demographic dynamics and projections of population size over the next few decades is needed to help guide program management decisions and for planning future reintroductions.

In this paper, we address the following questions: (1) What are the stage-specific survival rates and female fertility rates for the group of reintroduced black-faced spider monkeys? (2) What is the group's population growth rate? and, (3) What is the probability of the group extinction in the upcoming decades? Based on what is expected for species that are slow to mature and have low reproductive rates (Stahl and Oli, 2006), we hypothesize that the population growth rate of the reintroduced group of black-faced spider monkeys is more sensitive to the survival of adults than to any of the other life stages. In this study we faced the challenge of working with the small sample size of only a single group of reintroduced black spider monkeys for estimating demographic parameters, which is why we also chose to include estimates found in the literature. The sample size limitation will restrict the extent to which context our results can be extrapolated, however, we consider this study to be important since reintroduction programs are only getting more common, but data available on reintroduced populations are scarce and the outcomes of these programs are not commonly reported.

Methods

Study Area

The reintroduction area is located on the south bank of the Madre de Dios River inside the Tambopata National Reserve in Madre de Dios Department, Tambopata Province, and Tambopata District in southeastern Perú (12°32'11.882" S, 69°00'14.227" W, 601 m.a.s.l.) (Fig. 1). This area consists primarily of subtropical wet forest according to Holdridge life zones system; it may flood during the wet season (INRENA, 2003) and it experiences an average temperature and annual precipitation of 26.5 °C and 2,387 mm, respectively (SENAMHI, 2015). The dry season occurs from May to September and the wet season from October to April.

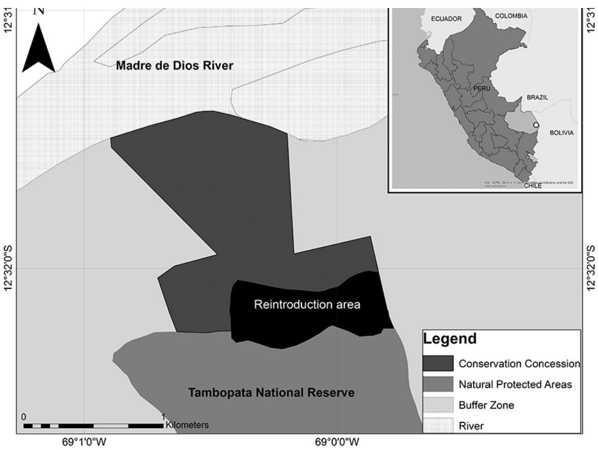


Figure 1. Map with the location of the reintroduction area in Madre de Dios, Perú.

Spider Monkey Data

We utilized data from seven consecutive years (2011 to 2017) and four release events (2011, 2013, 2014, and 2016) of rehabilitated black-faced spider monkeys (*Ateles chamek*). Data were provided by the "Program for the reintroduction of spider monkeys in the southeastern Peruvian Amazon". Data were collected by R. Bello and a team of volunteers during the post-release monitoring program. Individuals were identified by their body characteristics, face coloration and behavior, and were each assigned a name (Table S1 in Supplementary Material). During the first three months post-release, the activity of each individual was constantly monitored. Details about the monitoring procedure can be found in Bello (2018) and Bello et al. (2018). In the year following the post-release period, individuals were monitored during 2-3 days a week. Finally, following the first year after release, individuals were monitored twice a month to count individuals. Some individuals were equipped with radio tracking collars that allowed them to be located more easily. Individuals were considered dead if they were not sighted again after a month of searching. Each year that an individual was sighted again was considered a "recapture" in our analysis. Data collection on reintroduced black-faced spider monkeys followed international standard guidelines for non-human primate reintroductions (IUCN, 2002b).

Following MacFarland Symington (1988) and Shimooka et al. (2008), each individual was assigned to the following life stages: infants (0-12 months of life), juveniles (12-60 months of life), subadult (60-96 months), and adult (after 96 months or after the eight year of life). The data included in this study involved 28 individual life histories, 22 of them corresponding to individuals that were released into the wild when they were juveniles, sub-adult, or adults, and six of them that were subsequently born in the wild (Table S1 in Supplementary Material). Only six of the 22 reintroduced individuals survived in the wild to 2017. Predation by harpy eagles (*Harpia harpyja*; three events) and casual hunting (one event) accounted for the death of four reintroduced individuals. In seven cases (six females and one male) individuals disappeared and their current whereabouts remains unknown. Though they may have dispersed out of the study area, they were considered as deceased for the purpose of this analysis. In five cases, four of which were female, individuals in poor health conditions (individuals with fractures or infections) or individuals who separated from the group (Bello et al., 2018) were removed from the wild by the monitoring team and were taken to the Taricaya Rescue Center to recover. In some cases, a second reintroduction attempt took place once the individuals recovered to good condition. For the analysis, we did not consider data from individuals following a second attempt at reintroduction. Between 2013 and 2016, six individuals were born in the wild from reintroduced parents. In 2017, the group of reintroduced black-faced spider monkeys consisted of 12 individuals (1 adult male, five adult females, 2 young males, 4 young females), including six of the original reintroduced individuals and six new individuals that were born into this group post-reintroduction.

Parameter Estimation

Capture-Mark-Recapture Model

We used a Capture-Mark-Recapture (CMR) framework and Cormarck-Jolly-Seber (CJS) models to estimate the survival parameters as used in other studies (Campell and Lagueux, 2005; Cormack, 1964; Kraus et al., 2008; Olsen and Vøllestad, 2001). We estimated age-dependent survival-rate parameters for different life stages assuming post-breeding census. We assumed all individuals had the same probability of being detected, and that there was no migration into the group. To generate the models, we transformed observation histories for each individual into a Mark format database (Table S2, in Supplementary Material). Removal but not subsequent reintroduction of individuals were accounted for in the analysis, and we only considered individuals' life histories up until the first removal event. For analysis we pooled infants and juveniles into a single life stage "young" (infants correspond to young 1), as well as pooling adults and sub-adults for the analysis, since reproductive maturity has been reported to occur after the fifth year of life, especially in males (Klein, 1971; Eisenberg, 1976; Milton, 1981; van Roosmalen, 1985), but was also observed in females in this population (Bello et al., 2018; R. Bello personal communication).

We generated three models using data from 2011 until 2017, considering each year as a discrete occasion. The first model was based on age and sex; the second only using age of the individuals; and the third model was based on age from the female individuals only. Specific survival rates for females were used for further analyses related to fertility rate. We used program E-SURGE (Choquet et al., 2008; Choquet et al., 2011) to estimate probability of survival. Models were set to have the same probability of detection for all individuals and a recapture probability of one since all individuals were monitored. For details on how we defined the effects on the parameters for each model, see Supplementary material. We ran the models and selected the best model based on deviance values, quasi Akaike information criterion (QAIC) and QAIC corrected for small sample sizes (QAICc). The best model was used to estimate the following parameters: probability of an individual in young 1 stage to survive and grow to young 2 stage (P1); probability of young 2 stage to survive and grow to young 3 stage (P2); probability of young 3 stage to survive and grow to young 4 stage (P3); probability of young stage 4 to survive and grow to adult stage (P4); and the probability of individuals surviving and remaining as adults the next year (G5, Fig. 2). We considered P2 to P4 to be the same (see Supplementary Materials for model details). Due to the small sample size, we used a randomization procedure to generate simulated sets of samples. For this we draw one individual history at a time with replacement and extracted it from the pool of individuals of this study. With the randomly reduced pool of life-histories we ran the selected model in

E-SURGE using the package "R2SURGE" (Hines, 2017) in R (R Development Core Team, 2015) to estimate the survival probabilities. We repeated this 200 times to allow the model to approach the distribution of the estimated parameters. Next, we estimated the mean value of survival probability parameters and the confidence intervals for each of the different life stages. Additionally, we estimated the percentage of individuals per stage that survived along the study period, without considering the individuals that were removed from the wild.

Fertility rate
In order to estimate the fertility rate for females in the adult stage, we used an average inter-birth interval 34.5 ± 5.8 months (2.88 ± 0.48 years) reported for *A. chamek* from wild populations in Manu National Park, Perú (McFarland Symington, 1988). In other words, on average 0.35 (range of values 0.3-0.42) individuals were born per year. Since spider monkeys rarely produce twins (Link et al., 2006), we standardized the number of offspring per birth to one. We considered the probability of newborns to be female as 0.73 (female:male sex ratio among neonates 2.67:1 for *A. chamek* in Symington, 1987; and 2.7:1 for *A. belzebuth* Link et al., 2018) so that the fecundity rate or average number of daughters per female spider monkey per year was 0.26 (range of values 0.22 - 0.31). Using data from our study site (2011-2017), we estimated fertility rates assuming post-breeding census calculated as l(i)/l(i-1), where l(i) is the probability of surviving from birth to age i (Caswell, 2001). The estimated fertility rate for reintroduced individuals was pooled into the life stage "adults".

Stage-Structured Matrix Models

We constructed a matrix model (Caswell, 2001) including survival rates per life stage (Fig. 2), including the fertility rate of adults (F6).

For estimating population growth rate (λ) of the reintroduced group, we used the stage-specific survival-rate parameter estimates obtained with the CMR analysis. We projected the group size for the next 25 years - a period of time that covers the life cycle of an individual spider monkey. For our projection, we used nine individual females (number of females in the group by 2017) as initial group and different sets of values for the stage-specific survival parameters: (A) the estimated values, and (B) using parameter values reported in the literature for a wild population of *A. chamek* (survival probabilities young 1 = 0.67 and adults = 0.97; McFarland Symington, 1988) and *A. geoffroyi* (young = 0.9, from young to adult females = 0.9; Milton and Hopkins 2005).

We ran an elasticity analysis to determine which life-history parameters the population growth rate was more sensitive to, proportionally. With this information, we generated a fourth scenario (C) changing the parameter to which population growth was more sensitive by the threshold value at which the population would start growing if all other survival rate parameters had a value of one. For the analyses, we used the "popbio" package (Stubben and Milligan, 2007) in R (R Development Core Team, 2015).

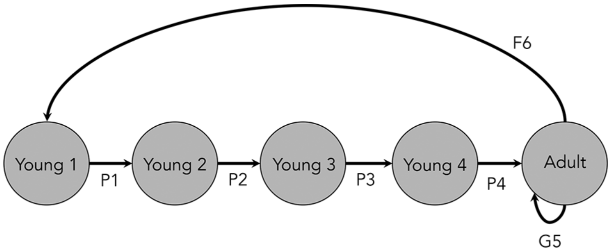


Figure 2. Life cycle graph of reintroduced black-faced spider monkeys (*Ateles chamek*) in Madre de Dios, Perú, between 2011-2016. P1-P4 are the probability of survival from one state to the next. F6 is the fertility rate of adult individuals. G5 is the probability to remain in adult stage. Circles represent stage classes; arrows and arcs represent transitions in survival and fertility rates.

Results

Parameter Estimation
Direct estimations using the data from individual histories showed that the percentage of individuals that survived the entire study period were: 100 % for young in their first year of life (for both sex, 4 females and 2 males), 83 % for females (n = 6) and 100 % for males (n = 1) in young stage years 2 to 4, and 45 % for adult females (n = 11) and 20 % for adult males (n = 5).

Under the CMR framework the model based on data from only adult females showed the lowest QAIC value (Table 1). We used the survival rate parameters obtained from this model to estimate specific fertility rates for females and for further analysis (Table 2).

Table 1. Metrics of CMR models for *Ateles chamek*, Madre de Dios, Perú, data from years 2011 to 2017. QAICc is QAIC corrected for small sample sizes.

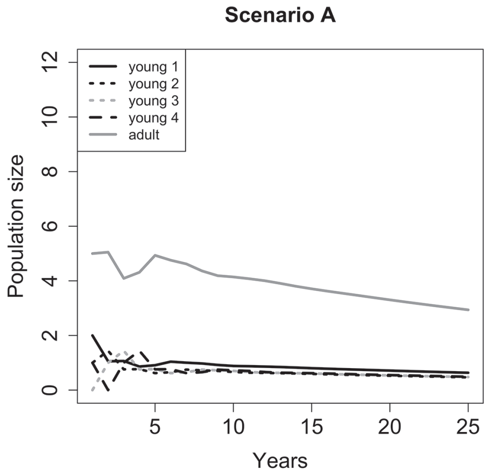
Model	Number of Parameters	Deviance	QAIC	QAIC*c*
Stage & Sex	7	51.99	65.99	67.54
Stage	4	53.55	61.55	62.09
Females	4	34.25	42.25	43.02

Table 2. Stage-specific survival and fertility rates for *Ateles chamek* in Madre de Dios, Perú, based on data from 2011 to 2017, for the following scenarios: (A) using estimated parameter values, (B) using parameter values reported in the literature (McFarland Symington, 1988; Milton and Hopkins, 2005), and (C) changing the parameter to which population growth is more sensitive to the value at which the population starts growing if all the other parameters are maximized. CI = Confidence interval.

Parameter	Stage	A	95 % CI	B	C
Survival rate	Young 1	0.717	0.711-0.724	0.67	1
	Young 2	1	-	0.9	1
	Young 3	1	-	0.9	1
	Young 4	1	-	0.9	1
	Adult	0.81	0.809-0.813	0.967	0.79
Fertility rate	Adult	0.21	-	0.25	0.09

Stage-Structured Matrix Models

According to the group growth rates estimated using life history parameters for female individuals (scenario A), the reintroduced group will likely decrease (lambda = 0.98). Under scenario A, we expect that the group would decrease to only five individuals (Figure 3) over the next 25 years. Alternatively, scenario B (lambda = 1.06) predicts an increase in the population to 40 female individuals (24 adults and 16 young) by year 25. The elasticity analysis indicated that group growth rate was most sensitive to small proportional changes in the adult stage survival rate under scenarios A and B (elasticity values 0.49 and 0.67 respectively). When values of all other parameters are maximized (values of 1.0; scenario C), adult survival rate must be higher than 0.79 to achieve a positive group growth rate (Fig. 3).



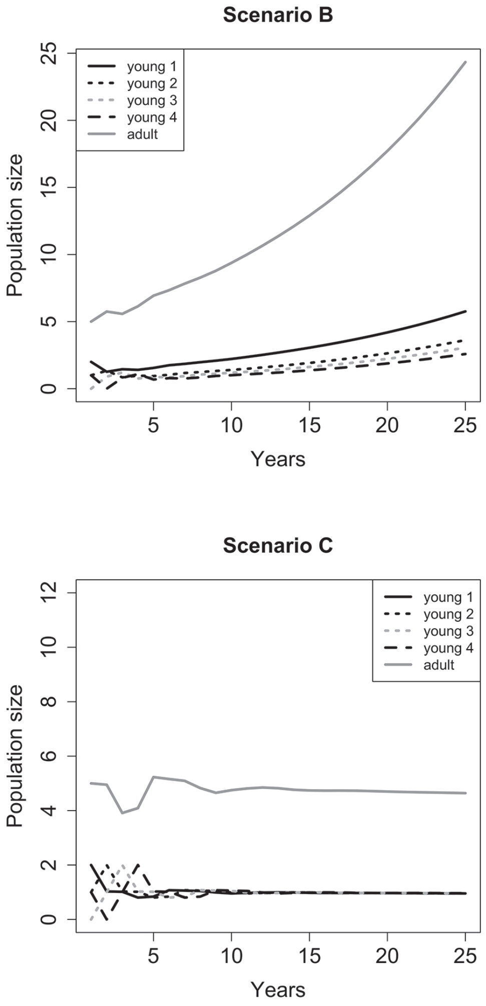


Figure 3. Projections for a reintroduced group of *Ateles chamek* in Madre de Dios, Perú using data from 2011 to 2017 under scenarios with different sets of values of survival probability: (A) using the estimated parameter values, (B) using parameter values reported in the literature (McFarland Symington, 1988; Milton and Hopkins, 2005), (C) changing the parameter (to which group growth is more sensitive) to the value at which the group starts growing if all the other stage-specific parameters are maximized.

Discussion

Our results indicate that in order for this reintroduced group of black-faced spider monkeys to persist over time, it would be necessary to improve the probability of survival for female individuals, especially those in adult stages. The female-only model relies on the critical assumption that the group requires the presence of adult males to ensure its persistence in time, thus, the importance of males in the group cannot be disregarded. The reintroduced population of *Ateles geoffroyi* on Barro Colorado Island showed that the presence of one adult male might be enough to maintain the group (Milton and Hopkins, 2005). By 2017, our study group included one adult male, one infant male, and one male juvenile of four years old. Losing the male individuals in the group will imply its extinction. The reintroduction program will need to guarantee the presence of males in the group over time to allow for breeding.

Under scenario A, and as a result of our small sampling size, the estimated survival probability for young 2, young 3 and young 4 was 1.0. The lowest estimated probability of survival was for female individuals in young 1 life stage. Probability of adult survival may be biased because we only had access to seven years of data, which is not enough to estimate real adult survival rates, considering adults of other species in the genus have been reported to live ~ 30 years (Milton and Hopkins, 2005; Ramos-Fernández et al., 2017). This should be taken into account when considering whether or not to utilize the estimated survival rates from this study in other contexts. The group remaining by 2017 was composed by 9 female individuals, accompanied by three males, which can be considered to be adapted to wild conditions. Group population growth rate based on estimates from our study group (scenario A) indicated that the reintroduced group was decreasing and would be close to extinction in 25 years. However, projections obtained under scenario B using parameters from the literature showed the potential for an increase in population size, reaching 40 individuals in 25 years. This last scenario is based on survival rate value for a combination of wild (*A. chamek*) and reintroduced (*A. geoffroyi*) individuals, which imply different conditions that may or may not be reached by the study group.

The elasticity analysis shows that the survival rate of adult females is critical for population growth. These results differ from those obtained in an elasticity analysis of a free-ranging *Ateles geoffroyi* population in Yucatán, Mexico, where survivorship of females during the first 5 years was critical (Ramos-Fernández et al., 2017; Ramos-Fernández et al., 2018). The same study also considered critical the fertility of females between 17 and 21 years old, which could not be measured in this study since we ignored the exact age of the oldest adult individuals in the group.

In the reintroduction experience at BCI, although only four individuals (3 females, 1 male) survived from a group of at least 18 individuals that were originally released, this was sufficient to allow the establishment of a group that persisted over the first seven years of the project (Milton and Hopkins, 2005). Even though the context and species considered are different from this study, it provides a good example of how resilient species in the genus *Ateles* can be. In this study, the group of monkeys reintroduced in Madre de Dios included five adult females of reproductive age and only an adult male of reproductive age since 2014, when a second male of reproductive age was killed in a hunting event. By December 2016, six new individuals had been born in the wild, including two offspring of the male killed in 2014. Since it is possible that inbreeding problems will appear with only one reproductive male in the group, the survival of the other males until their reproductive maturity needs to be guaranteed. In order to secure the persistence of the population over time, female survival rate of adult females needs to remain above the specific thresholds of 0.79, below which the population size of the group will not increase.

There are several factors that were not considered in our analysis of group population growth and may have affected our results. First, under the CMR framework it is not possible to distinguish true mortality from permanent emigration (Hunter et al., 2010). This may be critical for spider monkeys because females emigrate to other groups. Indeed, apparently two of the reintroduced females, which are not in the group anymore, could have left after remaining in the group for only two and three years (R. Bello, personal communication). These individuals were in the age range for dispersal for *Ateles belzebuth belzebuth* (63 to 79 months, Link et al., 2018). Moreover, five female individuals were sighted two kilometers away from the study group in August 2017, in an area where the species is locally absent. According to Shimooka et al. (2008), females may travel long distances searching for new groups to join. It is likely that some of the individuals sighted away from the original group were considered as deceased in this study. Another factor not considered in our analysis is natal philopatry of males (McFarland Symington, 1988). While male immigration may occur under certain demographic circumstances (Aureli et al., 2013), this flexibility in their social system could influence the sex ratio in the group (Aureli et al., 2013). In addition, we do not include habitat measurements that would be useful to estimate the carrying capacity of the area where the reintroductions are taking place. Further, a study of the predator presence would be instrumental for management decisions, since they play a key role in the persistence of any group of spider monkeys (Shimooka et al., 2008).

Management actions are necessary to avoid extinction of the group of black-faced spider monkeys reintroduced to the Tambopata National Reserve in Perú. Specifically, actions should focus on minimizing mortality risk of adults and males in general. Reintroduced individuals that were previously kept as pets may have issues in their adaptation to the wild (Bello, 2018), despite the great efforts to prepare them made by the reintroduction program specialists. Reducing access of local hunters to the area, and temporary removal and subsequent release of injured individuals also might contribute to population growth. In addition, future attempts to increase the size of the group should focus on reintroducing reproductively fit individuals that arrive at the Taricaya Rescue Center in early life stages. Further, individuals that will be released together should spend their rehabilitation period as a group, avoiding future negative interactions in the wild. To have a self-sustaining population, establishment of other groups of reintroduced individuals in the same area would be beneficial, as it would allow movement of females among groups. The final goal is to create a metapopulation where the groups or populations could interact and persist over time.

Finally, extrapolations of our results to populations of free-ranging spider monkeys is not recommended due to the restrictions imposed to our results as a consequence of small sample size and specific conditions (i.e., intense post-monitoring program, reintroduction area without human activities). However, the life-history parameters we estimated may serve as reference for other reintroduction efforts. Most reintroduction programs start with only a few individuals sometimes releasing only one group that may not persist in the wild in the mid-term. However, this study may provide valuable lessons for reintroduction programs attempting the recovery of wild populations of similar species.

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Supplementary material

Model parameter definitions

We defined effects on the parameters for each model as follows. The first model is based on age and sex and we use the notation g(3).a(1,2 3 4) + g(3).a(5) & g(1) + g(4).a(1,2 3 4) + g(4).a(5)&g(2), In this model, g(3) correspond to young males, g(4) to young females, g(1) to adult males, g(2) to adult females, and "a" refers to the age of young individuals; the plus (+) sign separates individuals by stage and sex. In the section that corresponds to males, g(3).a(1,2,3,4) + g(3).a(5) & g(1), the first part (before the plus sign) accounts for the young males who stayed in that stage during the first four years of life. Since we deem the youngest individuals to have lower survival probabilities, we are considering the survival probabilities for ages 2, 3, 4 to be the same, the notation is (a(1,2 3 4)). The second part correspond to adult male individuals, including young males that reached the fifth year of life and became adults (g(3).a(5)) as well as the ones that were adults when released into the wild (g(1)). For female individuals, the interpretation is similar.

In the second model, the notation was g(1 2) & g(3 4).a(5) + g(3 4).a(1,2 3 4). The first part before the plus sign corresponds to the adult stages including individuals of both sexes that were already adults (g(1 2)) and the young individuals from both sexes that became adults in their fifth year of life (g(3 4).a(5)). The second part corresponds to young individuals of both sexes during each of their first 4 years of life: g(3 4).a(1,2,3,4).

In the third model, we defined the effects on the parameters for the model as follows: g(1)&g(2).a(5)+g(2).a(1,2 3 4). The first part before the plus sign corresponds to the female adult stages that were already adults (g(1)) and the young female individuals that became adults in their fifth year of life (g(2).a(5)). The second part corresponds to young female individuals during each of their first 4 years of life: g(2).a(1,2 3 4).

Table S1. Data for 28 individual life histories

ID	Sex	Age when released	2011	2012	2013	2014	2015	2016	2017	Comments
RIVER	female	adult	1	1	1	1	1	1	1	
ABIE	female	3	1	1	1	1	1	1	1	
MAQUI	female	adult	1	1	1	0	0	0	0	Removed
NIZZA	female	adult	0	0	1	0	0	0	0	Predated
WAWA	female	0	0	0	1	1	1	1	1	Born in the wild
LUCHA	female	adult	0	0	0	1	1	1	1	
MAYA	female	adult	0	0	0	1	1	0	0	Disappeared
CHOLA	female	adult	0	0	0	1	0	0	0	Disappeared
LILA	female	adult	0	0	0	1	1	1	1	
SHUSHU	female	adult	0	0	0	1	1	1	0	Disappeared

(cont.)

ID	Sex	Age when released	2011	2012	2013	2014	2015	2016	2017	Comments
CHINA	female	adult	0	0	0	1	1	1	1	
GAIA	female	0	0	0	0	0	1	1	1	Born in the wild
NICOL	female	adult	0	0	0	0	0	1	0	Disappeared
FE	female	adult	0	0	0	0	0	1	0	Disappeared
LOLA	female	0	0	0	0	0	0	1	1	Born in the wild
ALIAH	female	0	0	0	0	0	0	1	1	Born in the wild
NENA	female	4	0	0	0	0	0	1	0	Removed same year of release
FLACA	female	3	0	0	0	0	0	1	0	Disappeared
PACHA	female	4	0	0	0	0	0	1	0	Removed next year of release
MARUJA	female	5	0	0	0	0	0	1	0	Removed next year of release
SAMBO	male	3	1	1	1	1	1	1	1	
CHAMEK	male	4	1	1	1	1	0	0	0	Hunted
BALOU	male	3	1	0	0	0	0	0	0	Predated
SIMON	male	adult	0	0	1	0	0	0	0	Removed same year of release
OTTO	male	4	0	0	1	0	0	0	0	Predated
PERU	male	infant	0	0	1	1	1	1	1	
MARTIN	male	adult	0	0	0	0	0	1	0	Disappeared
RAYO	male	infant	0	0	0	0	0	1	1	

Table S2. Individual histories in Mark format for the 28 individuals considered in this study. First column shows the individual histories, second column correspond to adult males, third column to adult female, fourth column to young males and fifth column to young females. "-1" indicates the individual was removed from the group.

1111111	0	1	0	0 ;
1111111	0	0	0	1 ;
1110000	0	-1	0	0 ;
10000	0	1	0	0 ;
11111	0	0	0	1 ;
1111	0	1	0	0 ;
1100	0	1	0	0 ;
1000	0	0	0	1 ;
1111	0	1	0	0 ;
1110	0	1	0	0 ;
1111	0	1	0	0 ;
111	0	0	0	1 ;
10	0	1	0	0 ;
10	0	1	0	0 ;
11	0	0	0	1 ;
11	0	0	0	1 ;
10	0	0	0	-1 ;
10	0	0	0	1 ;
10	0	0	0	-1 ;
10	0	-1	0	0 ;
1111111	0	0	1	0 ;
1111000	0	0	1	0 ;
1000000	0	0	1	0 ;
10000	-1	0	0	0 ;
10000	0	0	1	0 ;
11111	0	0	1	0 ;
10	1	0	0	0 ;
11	0	0	1	0 ;

PROLONGED INTER-SPECIFIC ASSOCIATION BETWEEN *ATELES FUSCICEPS FUSCICEPS* AND *ALOUATTA PALLIATA AEQUATORIALIS* (ATELIDAE) IN A FOREST FRAGMENT IN NORTH WESTERN ECUADOR

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Abstract

Changes in the behavior of primates caused by habitat disturbance are important indicators of their survival ability in fragmented landscapes. In Ecuador, few studies have examined the effect of habitat fragmentation on primate behavior. We present data of a prolonged interspecific association between a brown-headed spider monkey (*Ateles fusciceps fusciceps*) living within a troop of Ecuadorian mantled howler monkeys (*Alouatta palliata aequatorialis*) in a protected forest fragment in northwestern Ecuador. We collected 274 hours of observations, at 10-minute intervals, on the *A. f. fusciceps* individual in both the wet and dry seasons. Data included the amount of time that the *A. f. fusciceps* individual spent associating with, and apart from, the *A. p. aequatorialis* troop. Our observations suggest a close relationship between the individuals of the two species, with similarities in their behavior and diets found during the study. Interspecific communication was observed frequently, with all *A. p. aequatorialis* individuals interacting directly with the *A. f. fusciceps* individual. The behavior of the *A. f. fusciceps* individual was similar to that found in studies of other *Ateles* spp. living in fragmented and disturbed habitats, but differed from that observed in other studies of the same species in continuous forest, suggesting adaptation to conditions in fragmented habitat and possibly to living in close proximity with the howler troop.

Keywords: Primate behavior, habitat disturbance, symbiosis, adaptation.

Resumen

Cambios en el comportamiento de primates causados por la intervención de hábitat son indicadores importantes de habilidad de supervivencia en ecosistemas fragmentados. En Ecuador existen pocos estudios que examinen los cambios en el comportamiento de especies causados por la fragmentación. Este estudio documenta la asociación interespecífica entre un mono araña de cabeza café (*Ateles fusciceps fusciceps*) conviviendo con una tropa de monos aulladores de la costa (*Alouatta palliata aequatorialis*) dentro de un remanente de bosque protegido en el noroccidente del Ecuador. Colectamos 274 horas de muestras instantáneas, registradas cada 10 minutos, de *A. f. fusciceps* durante las estaciones lluviosa y seca. El registro de datos incluyó tiempo en el que *A. f. fusciceps* estaba asociado y separado de la tropa de *A. p. aequatorialis*. Los resultados sugieren que la relación entre ambas especies es estrecha, con similitudes en los patrones de comportamiento y dieta encontrados a lo largo del estudio. Se observó con frecuencia una comunicación interespecífica, con todos los individuos de *A. p. aequatorialis* interactuando de cierta forma directamente con *A. f. fusciceps* individualmente. El comportamiento del individuo *A. f. fusciceps* fue similar a lo encontrado en otros estudios de *Ateles* spp. viviendo en hábitats fragmentados e intervenidos, pero diferente de lo observado en otros estudios de la misma especie en bosque continuo. Esto último sugiere una adaptación a las condiciones de fragmentación de hábitat y posiblemente a la estrecha proximidad de la tropa de aulladores.

Palabras clave: Comportamiento de primates; alteración de hábitat; simbiosis; adaptación.

Introduction

Habitat destruction has led to reductions and isolation of many primate populations and, as consequence, various adaptations in behavioral and ecological responses in primate communities have occurred (Marsh *et al.*, 2013). This has included changes in dietary selection, population densities and group sizes, reproductive fitness, stress levels and susceptibility to disease (Martínez-Mota *et al.*, 2007; Schwitzer *et al.*, 2011; Abondano and Link, 2012; Marsh *et al.*, 2013; Carretero-Pinzón *et al.*, 2016; Rondón *et al.*, 2017) and those better able to adapt are, probably, more likely to survive this habitat alteration, at least for the short term (Schwitzer *et al.*, 2011).

The four species of primates that inhabit the coastal region of Ecuador are threatened by hunting, habitat loss and fragmentation (Rowe and Myers, 2016). The most threatened species, the brown-headed spider monkey (*Ateles fusciceps fusciceps*), is restricted to remaining areas of forest on Ecuador's Pacific coast. This species is listed as Critically Endangered (Tirira *et al.*, 2017; IUCN, 2018a) and is considered one of the 25 most threatened primate species (Schwitzer *et al.*, 2017) due to a nearly 80% reduction in its habitat (Tirira *et al.*, 2017). Hunting is also a major problem for remnant populations of this species (IUCN, 2018a). Similarly, the Ecuadorian mantled howler monkey (*Alouatta palliata aequatorialis*) is threatened due to population reduction from habitat loss and hunting (IUCN, 2018b) and is considered Vulnerable by the IUCN (2018b) and Endangered in the *Red Book of the Mammals of Ecuador* (Tirira, 2011). Despite these species' sympatry, no information on a close long-term relationship between them has been published to date.

Inter-specific associations have been documented in various Neotropical primates (e.g. van Roosmalen, 1985; Pontes, 1997; de la Torre, 2000; Heymann and Buchanan-Smith, 2000; Defler, 2004; Lehman *et al.*, 2006; Shanee *et al.*, 2007; Haugaasen and Peres, 2009; Silva and Ferrari, 2009; Oliveira and Dietz, 2011; Shaffer *et al.*, 2016). These associations provide advantages such as increased access to resources and predator avoidance (Norconk, 1990; Terborgh, 1990; de la Torre, 2000; Oliveira and Dietz, 2011). Some studies report low levels of interspecific interactions for *Ateles* spp. (van Roosmalen and Klein, 1988; Haugaasen and Peres, 2009), however, there are several published observations of inter-specific associations between spider monkeys and other sympatric primates (van Roosmalen, 1985; Defler, 2004; Shanee *et al.*, 2007; Blake *et al.*, 2010; Link *et al.*, 2011). Interspecific associations have also been reported between *Alouatta* spp. and other primates (Pontes, 1997; Lehman *et al.*, 2006; Haugaasen and Peres, 2009; Silva and Ferrari, 2009), including with spider monkeys (Cristóbal-Azkarate *et al.*, 2015).

We conducted a short study on the activity budgets, diet and inter-specific interactions of a solitary *A. f. fusciceps* living with a group of *A. p. aequatorialis* in a forest fragment in Ecuador. The aim of this study was to describe the possible behavioral and ecological responses of both species to the intense anthropogenic disturbance in the area and their close interspecific association.

Methods

Study site

The study was carried out in the Ashiringa Ecological Reserve, a private reserve in Pichincha province, Northwestern Ecuador (00°04'24.9"S, 78°58'04.4"W). The reserve consists of approximately 107 hectares of remnant forest (~50 hectares of primary forest and ~57 hectares of secondary forest), and altitudes ranging from 500 to 700 meters. The reserve is surrounded by a matrix of orchards, pasture and artisanal fish farms. An unpaved road runs through the reserve (Fig. 1).

Forests in the area are pre-montane evergreen Western Andes Cordillera forest (Sierra, 1999) with multiple vegetation strata, with both lowland and premontane forests (Guevara and Morales, 2013). Canopy height is 15 to 19 m with occasional emergent trees of up to 30 m with an average diameter at breast height of 405 cm (Moscoso, 2010). Weather is very humid sub-tropical with daytime temperatures between 17 and 26 °C and annual rainfall of 3,000 mm, and 500 mm in the wettest month (Hijmans *et al.*, 2005). Topography in the area is characterized by steep hills which have contributed to the conservation of remnant forest areas. The principle threats to habitat in the area come from mining and human population growth with its associated expansion of the agricultural frontier leading to deforestation and isolation of remaining forest fragments (Centro de Investigaciones Sociales del Milenio, 2006; Vandegrift *et al.*, 2018).

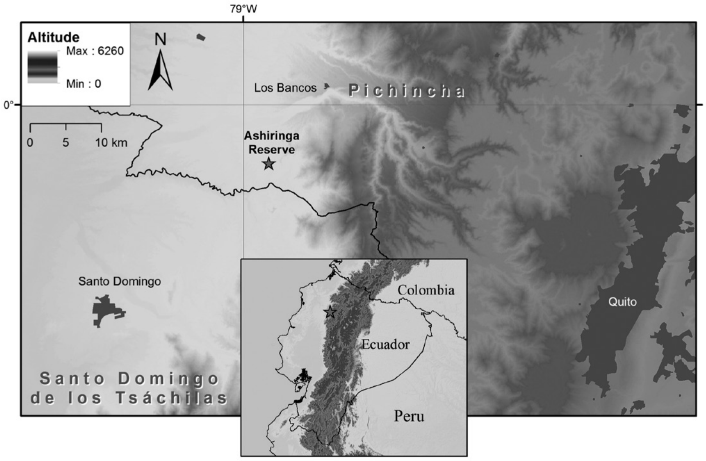

Figure 1. Map showing the location of the study area, Ashiringa Ecological Reserve, Pichincha Province, northwestern Ecuador.

Field surveys

Field work was carried out for four months in two periods: during the wet season (September to October 2008) and the dry season (June to July 2009). Focal animals were followed daily between 06:00 and 18:00 (Brockelman and Ali, 1987). At the start of the study period the *A. p. aequatorialis* troop consisted of four individuals: one adult male; one adult female with a dependent infant; and one juvenile female. A juvenile male joined the group during the last week of the study (July 2009). During the study period, we did not find any con-specifics of *A. f. fusciceps* in the surrounding area. Other groups of howler monkeys are found in adjacent fragments, however no interactions were observed with the *A. f. fusciceps* individual during the study period.

We used a combination of focal animal sampling for observations of the *A. f. fusciceps* individual, and group scan sampling for observations of the *A. p. aequatorialis* group (Altmann, 1974), recording activity of each visible individual in turn. We recorded activities every ten minutes using five previously defined, mutually exclusive behavioral categories based on Martin and Batenson (2007): resting, feeding, social activities, travelling, and vocalization (Appendix 1). We considered associations to be any time when the *A. f. fusciceps* individual was with the howler group. Details of all inter-specific interactions between individuals of both species were recorded in five categories: body contact, avoidance, aggression, play, and other. We identified food types consumed as: young leaves, mature leaves, unripe fruit, ripe fruit, flowers and other (including buds, bark, nectar, bromeliads, ferns, and insects). Plant resources consumed by both species were collected and identified. We also recorded forest strata used by all individuals at 10 minute intervals.

Data analysis

We calculated activity budgets using the frequency of occurrence of each behavioral category. We selected a 10 minutes interval between scans, and all data were averaged to reduce pseudoreplication (Martin and Bateson, 2007). Similarly, only non-parametric statistics were used as sample sizes were small and data may not have been normally distributed. To estimate dietary preference, we calculated frequencies for consumption of each food type as well as frequencies of plant families and species consumed by *A. f. fusciceps*. We tested for differences in activity budgets and dietary preferences using chi-square tests. To examine the relationship between the *A. f. fusciceps* individual and the *A. p. aequatorialis* troop we calculated frequencies for each type of interaction between each pair of individuals, also examining possible correlations in interactions between seasons. We also compared activity budgets from our study with those reported in the literature for *Ateles* spp. and *Alouatta* spp.

Results

Activity budgets and association times

We collected 274 hours of behavioral data over 41 days (23 full day follows and 18 partial follows). These were split between 147.3 hours (21 days) and 126.6 hours (20 days) during the wet and dry seasons, respectively. There were no differences in seasonal activity budgets for each species (all x^2, $p > 0.05$). Significant differences in activity budgets were found between species in the wet season ($x^2 = 25.259$, $df = 4$, $p < 0.001$), dry season ($x^2 = 9.634$, $df = 4$, $p = 0.047$) (Fig. 2). Post-hoc tests (Bonferroni), with Alpha significance set to 0.05 (adjusted significance for 10 comparisons = 0.005), showed that these differences were in the frequencies of resting and locomoting.

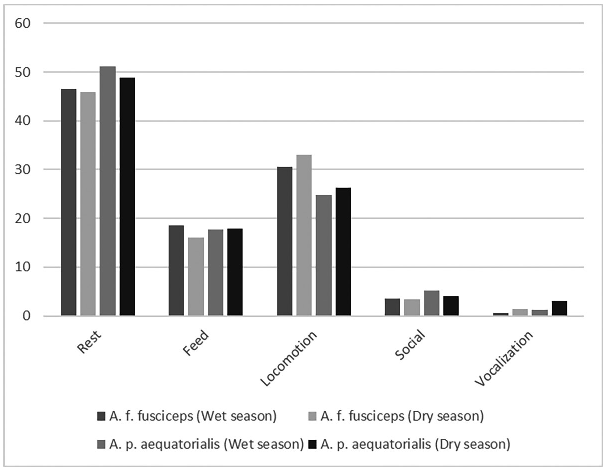

Figure 2. Comparative activity budgets between the wet and dry seasons for *Ateles fusciceps fusciceps* and *Alouatta palliata aequatorialis* at Ashiringa Ecological Reserve, Pichincha Province, northwestern Ecuador.

Comparisons of the activity budget for *A. f. fusciceps* from this study showed large differences with those found for *Ateles* spp. in other studies (Table 1).

Table 1. Comparison of activity budgets of *Ateles* spp. and *Alouatta* spp. from this and other studies.

Species	Rest	Social	Feed	Travel	Vocalization	Other	Source
Ateles f. fusciceps	46	4	17	33	1	<1	This study
At. f. fusciceps	10	23*	37	30	-	-	Gavilánez-Endara (2006)
At. f. fusciceps	8	-	17	58	17	-	Moscoso (2010)
At. f. fusciceps	20	10	20	34	14	-	Moscoso (2010)
At. f. fusciceps	-	10	-	80	-	10	Moscoso (2010)
At. f. fusciceps	25	4	36	30	-	4*	Fuentes *et al.* 2018
Ateles belzebuth	61	-	22	10	-	7***	Klein and Klein (1977)•
At. belzebuth	45	-	18	36	-	1***	Nunes (1995)•
At. belzebuth	58	-	17	25	-	17***	Suarez (2006)•
Ateles. chamek	45	-	29	26	-	12***	Symington (1988)•
At. chamek	46	-	19	30	-	6***	Wallace (2001)•
Ateles geoffroyi (Continuous forest average)**	34	-	40	15	-	11	Chavez *et al.* (2011)
At. geoffroyi (Fragmented forest average)**	34	-	48	9	-	10	Chavez *et al.* (2011)
At. geoffroyi	24	-	34	33	-	10***	Chapman *et al.* (1989)•
Alouatta p. aequatorialis	50	5	18	25	2	<1	This study
Al. p. aequatorialis	14	39*	23	19	*	-	Gavilánez-Endara (2006)
Alouatta belzebul	59	-	20	18	-	3***	Pinto (2002)•
Al. belzebul	56	-	8	19	-	17***	Bonvicino (1989)•
Alouatta caraya.	62	-	16	18	-	5***	Bicca-Marques (1993)•
Alouatta guariba	72	-	17	11	-	0***	Mendes (1989)•
Al. guariba	58	-	19	19	-	5***	De Marques (1995)•
Al. guariba	64	-	19	13	-	4***	Chiarello (1993)•
Alouatta palliata	66	-	16	10	-	8***	Milton (1980)•
Al. palliata	80	-	17	2	-	1***	Estrada et al (1999)•
Al. palliata	73	-	18	8	-	2***	Teaford and Glander (1996)•
Al. palliata	56	-	25	14	-	6***	Stoner (1996)•
Al. palliata	57	-	14	27	-	2***	Williams-Guillen (2003)•
Al. p. aequatorialis	66	8*	16	10	-	-	Milton (1980)
Alouatta pigra	62	-	24	10	-	4***	Silver et al (1998)•
Al. pigra	83	-	10	4	-	3	Pozo-Montuy *et al.* (2013)
Alouatta seniculus	79	-	13	6	-	3***	Gaulin and Gaulin (1982)•
Al. seniculus	67	-	22	11	-	-	Neves and Rylands
(1991)							
Al. seniculus	63	-	22	10	-	-	Palma *et al.* (2011)

=* Including vocalizations, ** Author calculation, *** includes social, • In Di Fiore et al. (2011).

Inter-specific interactions

Inter-specific associations between the species accounted for 218.2 observation hours (80%). Time spent in association between seasons was very similar, 83% and 79% during the wet and dry seasons, respectively. Over half of associations, 56%, lasted the full follow, with the remaining days' associations being partial (34%) or absent (10%).

The 82 direct interspecific interactions observed were divided into five categories: body contact (42%), avoiding (22%), aggression (7%), play (17%) and other (12%). Individual inter-specific interactions between the *A. f. fusciceps* and *A. p. aequatorialis* group members showed differences between individuals. The juvenile female had the most inter-specific interactions (41%), followed by the adult male (21 %), juvenile male (14 %), adult female (13 %) and infant (10 %). Table 2 presents qualitative details of the interaction types observed. We also observed multi-member interactions, and vocal communication between the howler group and the *A. f. fusciceps* individual (group members responding to calls when ripe fruits were encountered). On occasion the *A. p. aequatorialis* group members would become agitated and vocally active when the *A. f. fusciceps* individual would approach the juvenile female, especially at the end of the dry season.

Table 2. Qualitative details of inter-specific interactions between the *A. f. fusciceps* individual and *A. p. aequatorialis* group members.

***A. palliata* group member**	**Frequency of interaction (%)**	**Description**
Juvenile female	41	Body contact, involving hugging, attempted mounting, pulling of tails and other body parts (by the *A. fusciceps*), often received with evasion or as play.
Adult male	21	Evasion, as moving away when the *A. fusciceps* came close, aggression and exploration of new areas away from the group.
Juvenile male	14	Aggression, evasion and body contact
Adult female	13	Body contact on few occasions received with evasion
Infant	10	Play

Diet

We observed 48 different plant species from 19 families consumed by the *A. f. fusciceps* individual during the study period (Appendix 2). Species from three families made up over 50 % of plant resources consumed: Moraceae (24 %), Fabaceae (17 %) and Cecropiaceae (12 %). Ripe fruit was the most commonly consumed food type by the *A. f. fusciceps* individual during the wet season (43 %), followed by immature leaves (41 %). During the dry season this changed to a higher consumption of immature leaves (62 %) and lower consumption of immature fruits (15 %); these differences were found to be significant ($x2$ 47.21, $df = 5$, $p < 0.001$). For *A. p. aequatorialis* immature leaves were the most commonly consumed food type during the wet season (52 %), followed by ripe fruit (34 %). During the dry season, there was a higher consumption of immature leaves (73 %) and lower of fruits (ripe fruit 9 % and immature fruit 8 %) these differences were also significant ($x2$ 29.62, $df = 5$, $p < 0.001$) (Fig. 3).

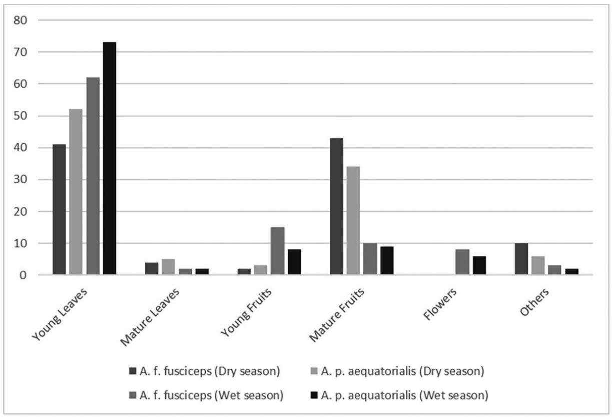

Figure 3. Percentage of dietary components between season for *Ateles fusciceps fusciceps* and *Alouatta palliata aequatorialis*.

Discussion

In this study both species had similar activity budgets, which may be surprising due to the intrinsic differences in the species' biology and ecology (Di Fiore *et al.*, 2011). Primates of the genus *Ateles* are physiologically adapted to travel large distances in a short time which has a large impact on their dietary requirements (Strier, 1992). On the other hand, *Alouatta* spp. are known for their sedentary behaviors and lower energetic requirements (Strier, 1992). However, studies on *Ateles* spp. in fragmented and disturbed habitats (i.e., under sub-optimal conditions), have shown that they can adapt their behavior and diet to better cope with available resources (Abondano and Link, 2012; Schaffner *et al.*, 2012).

The only significant differences observed between the species' activity budgets, was, as expected, greater instances of travelling and lower instances of resting by the *A. f. fusciceps* individual. Spider monkeys tend to spend a large portion of their time travelling, much higher than howler monkeys (see Table 2). On the other hand, similar changes in activity budgets have been observed in some species of *Ateles* living in fragmented habitat. Schaffner *et al.* (2012) found that a group of *A. geoffroyi yucatanensis* substantially altered their activities in the aftermath of two hurricanes, reducing time spent travelling, whilst increasing time spent feeding on leaves, compared to prior to the hurricanes. Other studies have shown similar patterns in the behavior of *A. geoffroyi* and *A. hybridus* in fragmented habitats (Abondano and Link, 2012; Chaves *et al.*, 2011). For example, Chavez *et al.* (2011) reported that *A. geoffroyi* living in fragmented forests spent less time traveling and more time feeding than groups in continuous forest (Table 1).

Another interesting observation was the high percentage of resting seen in the *A. f. fusciceps* individual (Fig. 2), which again could be an adaptive behavior to living in sub-optimal habitat (Abondano and Link, 2012; Schaffner *et al.*, 2012), although comparative resting times in *Ateles geoffroyi* groups living in fragmented and continuous forest did not show such marked patterns (Chaves et al., 2011 and table 1). Similarly, Abondano and Link (2012) found that *A. hybridus* living in heavily fragmented habitat in Colombia spent more time resting than either feeding or travelling (~40 % resting, and ~25 % in feeding and travelling, respectively).

A. f. fusciceps individual in our study and those from other studies of the same species (Gavilanez-Endara, 2006; Moscoso, 2010; Fuentes *et al.*, 2018) show large differences in activity budgets (Table 1), especially in resting times, which are generally much lower in *A. f. fusciceps* (Gavilanez-Endara, 2006; Moscoso, 2010; Fuentes *et al.*, 2018). This may have had a knock-on effect, including lower resource consumption, as energetic requirements are lower with lower activity levels (van Roosmalen, 1985; Symington, 1988; Nunes, 1998; Suárez, 2006), and, the lower levels of travel similarly related to less need to find food, or *vice-versa*.

The inter-specific relationship observed is almost permanent and should not be considered as a casual association. The reason for the association could be that, as social animals (Strier, 2015), the *A. f. fusciceps* individual associated with the group as he could find no conspecifics in the area. Several well documented interspecific associations in Neotropical primates exist; in the Ecuadorian Amazon, *Sapajus macrocephalus* and *Saimiri cassiquiarensis* have a symbiotic relationship, where *S. cassiquiarensis* takes advantage of the ability of *S. macrocephalus* to access otherwise unattainable resources whilst *S. macrocephalus* gains an early warning system against predation (de la Torre, 2000). There are also reports of multi-specific relationships, for example between Callitrichids in the Bolivian, Brazilian and Peruvian Amazon where species travel together all taking advantage of the increased defensive benefit and foraging opportunities (Heymann and Buchanan-Smith, 2000). The advantages of *Ateles* spp. ecological cognitive abilities (Di Fiore and Suarez, 2007), combined with faster reaction times, when compared to those of *Alouatta* spp. could be useful in group defense.

There have also been a handful of reports of inter-specific relationships with species of the genus *Ateles*. Van Roosmalen (1985) reported the formation of temporal subgroups with *Chiropotes satanas*. Most interestingly for this study, Defler (2004) mentions a female *A. belzebuth* living within a troop of *A. seniculus* in Colombia, and Shanee et al. (2007) reported a solitary *A. belzebuth* associating with a troop of *Lagothrix flavicauda* in Peru. That same individual was seen associating with the same *L. flavicauda* troop on several subsequent occasions (S. Shanee, pers. obs.), the nearest known population of *A. belzebuth* is found ~10 km to the Northwest. Possibly a dispersing animal got lost or failed to be accepted into a new group and now associates with the nearest acceptable alternative, although in this case it is not a permanent association (S. Shanee, pers. obs.). Even so, observations of interspecific associations, and particularly long-term associations, with *Ateles* spp. are scarce, especially in competitive situations (van Roosmalen and Klein, 1988). The types of interactions observed between the *A. f. fusciceps* individual and each member of the howler group was different. There was a high level of interaction with the juvenile female, the only reproductively available member of the group when she reached the reproductive age. Conversely, interactions observed with the group's males were more of a solely cooperative nature, commonly observed intra-specifically in groups of both *Alouatta* spp. and *Ateles* spp. (Di Fiore *et al.*, 2011).

Dietary preferences observed in the *A. f. fusciceps* individual were similar to those reported for some other *Ateles* spp. (van Roosmalen and Klein, 1988; Suárez, 2006). Although the choice of items differed from previous studies on this species (Gavilánez-Endara, 2006; Estévez-Noboa, 2009; Tirira, 2011). The low consumption of ripe fruits by the *A. f. fusciceps* individual was initially surprising, as was the high consumption of young leaves in a predominantly frugivorous species. However, this kind of adaptation has been seen in both *A. hybridus* and *A. geoffroyi* in fragmented or heavily disturbed areas (Chaves *et al.*, 2011; Abondano and Link, 2012; Schaffner *et al.*, 2012; De Luna *et al.*, 2017), with both species consuming a much higher percentage of leaves then expected from previous studies of *Ateles* spp.

Although diets were similar between the two species there was separation in food resource consumption, especially during the wet season, which might have reduced interspecific competition and facilitated the acceptance of the *A. f. fusciceps* by the howler troop. Dietary separation was noted by Defler (2004) as a possible mechanism to avoid conflict between sympatric populations of *A. belzebuth* and *Lagothrix lagothricha* in the southern Colombian Amazon. The differences found in the diets of both species between seasons will probably be a result of differences in resource availability (van Shaik *et al.*, 1993), with both species consuming a wide variety of food types. The comparatively high consumption of fruits by the *A. p. aequatorialis* group could result from their availability (Milton, 1981; Janson and Chapman, 1999) and possibly, from the absence of other large bodied arboreal frugivorous in the Ashiringa Reserve (José Macas, pers. comm.). The high consumption of leaves by the *A. f. fusciceps* individual is probably an adaptive behavior to survive in this highly fragmented area (Abondano and Link, 2012; Schaffner *et al.*, 2012; De Luna *et al.*, 2017), where higher quality resources are scarce, especially during the dry season.

An alternative, or at least complementary hypothesis for the similarities we found between the species' behaviour and diets in this study, stems from the fact that similar species living under the same ecological conditions and environmental pressures can develop similar behavioural and ecological tendencies, even more so than two separate populations of the same species living under different conditions (Strier, 2015). The similarity in activity budgets between the species could be an adaptation of the *A. f. fusciceps'* activity rhythms to living with the *A. p. aequatorialis* group, as well as to fragmentation. The observed association could represent a symbiotic relationship, rather than more tolerance (or even difficulty on the part of the *A. p aequatorialis* group in 'escaping' the presence of the *A. f. fusciceps* individual), in that both benefit from the relationship (Strier, 2015). The *A. f. fusciceps* individual benefits from incorporation into a group, winning greater protection and social contact (Chance, 1955). Whereas, the *A. p. aequatorialis* group benefits through increased group size for vigilance and in locating resources. The association also appears to be stable, with the *A. f. fusciceps* individual relating socially with all the howler group members. It is likely that the philopatric dispersal system of *Alouatta* spp. (Di Fiore *et al.*, 2011) facilitated the acceptance/tolerance of the *A. f. fusciceps* individual and/or that the individual was adopted by the howler troop as an infant, which has previously been reported by Strier (2015). However, this interpretation would need much more investigation before being accepted.

This study shows that forest fragmentation and population reductions can lead to various adaptations in behavioral and ecological responses in primates (Schwitzer *et al.*, 2011). It is possible that observations such as ours will become more common in the future as habitats are reduced and groups/individuals become increasingly isolated from populations of conspecifics.

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Appendices

Appendix 1. Description of behavioral definitions for *Ateles fusciceps fusciceps* and *Alouatta palliata aequatorialis* at Ashiringa Ecological Reserve, Pichincha Province, northwestern Ecuador.

Behavioral category	Behavioral sub-category	Definition
Resting		To be inactive in either a standing, sitting or lying position (either alone or in a group) including auto-grooming.
Feeding	Feeding	To handle, process or consume any food item.
	Foraging	To be actively and engaged in searching for food items as the predominant behavior.
Locomotion		To purposefully change location, either within or between trees, or further. This is exclusive of incidental movement whilst foraging or engaged in another behavior within the same tree.
Vocalization		To be primarily active in calling, exclusive of vocalizations during play, aggressive or sexual encounters.
Social activities	Play	To be actively engaged in repetitive, exaggerated and disjointed, solitary or social behavior with no observable goal (exclusive of all other active behaviors).
	Sexual	To be engaged in copulation or related behaviors.
	Allo-grooming	To be primarily engaged in non-aggressive physical contact with another individual (either grooming or being groomed by another individual or individuals, exclusive of sexual contact).
	Aggression/evasion	To attack, provoke or show fear towards a conspecific from within the same group or with another group (including vocalizations, branch shacking, mooning and physical contact).
Other		Watching observer. Out of sight.

Appendix 2. List of plants consumed by *A. f. fusciceps* at Ashiringa Ecological Reserve, Pichincha Province, northwestern Ecuador.

Family	Scientific name	*Item*
Apocynaceae	*Aspidosperma spruceanum*	Young leaves
Apocynaceae	*Forsteronia myriantha*	Young leaves
Bromeliaceae	*Bromelia* spp.	Young leaves
Boraginaceae	*Cordia hebeclada*	Flowers
Boraginaceae	*Cordia eriostigma*	Leaves/flowers/fruits
Cardiopteridaceae	*Dendrobangia boliviana*	Mature fruits
Cecropiaceae	*Cecropia garciae*	Hearts
Cecropiaceae	*Coussapoa herthae*	Leaves/flowers/fruits
Cecropiaceae	*Coussapoa contorta*	Mature leaves
Cecropiaceae	*Coussapoa* spp.	Fruits
Cecropiaceae	*Pourouma* spp.	Leaves
Ericaceae	*Macleania pentaptera*	Flowers
Euphorbiaceae	*Tetrorchidium macrophyllum*	Mature fruits
Fabaceae	*Dioclea* spp.	Young leaves
Fabaceae	*Pterocarpus officinalis*	Young leaves
Fabaceae	*Abarema barbouriana*	Leaves
Fabaceae	*Inga acuminata*	Fruits
Fabaceae	*Inga pezizifera*	Leaves
Fabaceae	*Inga lallensis*	Leaves/mature fruits
Fabaceae	*Inga nobilis*	Leaves
Fabaceae	*Inga silanchensis*	Fruits
Fabaceae	*Inga oerstediana*	Fruits/leaves
Fabaceae	*Dussia lehmannii*	Mature fruits
Meliaceae	*Carapa guianensis*	Bark
Meliaceae	*Guarea kunthiana*	Mature fruits
Moraceae	*Castilla* spp.	Fruits
Moraceae	*Sorocea jaramilloi*	Mature fruits
Moraceae	*Ficus trigona*	Leaves
Moraceae	*Ficus* spp.	Young leaves
Moraceae	*Ficus tonduzii*	Leaves
Moraceae	*Ficus maxima*	Young leaves
Moraceae	*Ficus rieberiana*	Leaves
Moraceae	*Ficus cuatrecasasiana*	Young leaves
Moraceae	*Naucleopsis naga*	Leaves
Moraceae	*Maquira guianensis*	Young leaves
Moraceae	*Ficus cuatrecasasiana*	Leaves
Moraceae	*Ficus carchiana*	Young leaves/hearts
Moraceae	*Brosimum utile*	Leaves/mature fruits
Myristicaceae	*Virola reidii*	Mature fruits
Myrtaceae	*Myrcia fallax*	Leaves/mature fruits
Myrtaceae	*Psidium* spp.	Mature fruits
Rubiaceae	*Guettarda ochreata*	Mature fruits
Rubiaceae	*Guettarda hirsuta*	Mature fruits
Sapindaceae	*Paullinia capreolata*	Leaves
Sapindaceae	*Billia rosea*	Mature fruits
Sapotaceae	*Pouteria capacifolia*	Young leaves/fruits
Solanaceae	*Solanum* spp.	Fruits
Violaceae	*Gloeospermum grandifolium*	Mature fruits/leaves

DEMOGRAPHY, HABITAT USE AND ACTIVITY BUDGET OF A WILD GROUP OF BLACK-FACED BLACK SPIDER MONKEYS (*ATELES CHAMEK*) IN LAS PIEDRAS, SOUTH-EASTERN PERÚ

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Abstract

Spider monkeys are one of the main seed-dispersal agents in the Amazonian ecosystem and therefore help regenerate the rainforest. The black-faced black spider monkey (*Ateles chamek)* is internationally recognized as Endangered, and its range is limited to Peru, Bolivia and Brazil. Spider monkeys are a difficult genus to study and little is known about their populations in the wild. Here we present the results of a study on demography, habitat use, activity budget and preliminary notes on ranging pattern and diet of a wild group of *A. chamek* studied in a floodplain forest in south-eastern Peru. The group (in total eight to nine individuals) had a home range of approximately 1.6 km^2 (160 hectares) with a daily path length of approximately 1,200 m. The group was encountered at canopy levels above 20 m in height 75.2% of the time and rarely descended to lower forest levels. There was a weak but significant positive correlation between the number of encounters with individuals of the study group and the number of feeding trees in an area ($R^2 = 0.38$, $N = 93$, $P > 0.001$). The majority of their diet consisted of fruits, followed by leaves. Resting accounted for 41.9% of their activity budget, with foraging accounting for 30% and traveling 23.8%. Most findings of this study are consistent with other studies on the species, but we found that the group size in our study was unusually small. However, this did not seem to have an influence on home range size or activity budget.

Keywords: spider monkey, *Ateles*, demography, home range, activity budget, habitat use, ranging pattern, diet.

Resumen

Los monos araña son uno de los principales agentes de dispersión de semillas en el ecosistema amazónico y por lo tanto ayudan a regenerar la selva. El mono araña negro (*Ateles chamek*) está reconocido internacionalmente como En Peligro, y su área de distribución se limita a Perú, Bolivia y Brasil. Los monos araña son un género difícil de estudiar y se sabe poco sobre sus poblaciones en estado silvestre. Aquí se presentan los resultados de un estudio sobre demografía, uso del hábitat, presupuesto de actividades y notas preliminares sobre la pauta de distribución y la dieta de un grupo silvestre de *A. chamek* estudiado en un bosque de llanura inundable en el sudeste del Perú. El grupo (en total, ocho o nueve individuos) tenía un área de distribución de aproximadamente 1.6 km^2 (160 hectáreas) con una longitud de recorrido diario de aproximadamente 1,200 m. El grupo se encontró en niveles de copas de más de 20 m de altura el 75,2% del tiempo y rara vez descendió a niveles inferiores del bosque. Hubo una correlación positiva, débil pero significativa, entre el número de encuentros con los individuos del grupo de estudio y el número de árboles en que se alimentan en una zona ($R^2 = 0,38$, $N = 93$, $P > 0,001$). La mayoría de su dieta consistió en frutos, seguidos de hojas. El descanso representó el 41,9% de su presupuesto de actividades, la búsqueda de alimento el 30% y los viajes el 23,8%. La mayoría de los hallazgos de este estudio son consistentes con otros estudios sobre la especie, pero encontramos que el tamaño del grupo en nuestro estudio era inusualmente pequeño. Sin embargo, esto no pareció tener influencia en el tamaño del área de distribución o en el presupuesto de actividades.

Palabras clave: mono araña, *Ateles*, demografía, rango de hogar, presupuesto de actividad, uso de hábitat, patrón de recorrido, dieta.

Introduction

Spider monkeys (genus *Ateles,* Fig. 1) represent some of the most charismatic and ecologically-important primates found in the neotropical rainforest. The genus *Ateles* consists of seven species (following Groves, 2001; Morales-Jiménez *et al.*, 2015) which occur in tropical forests ranging from Mexico to Bolivia (Collins, 2008). However, *Ateles* are under serious threat from both habitat loss and poaching. Little is known about the demography and behavior of distinct populations, as *Ateles* are a particularly hard genus to study due to their preference for higher canopy levels. *Ateles* have evolved distinct morphological characteristics which allow them to thrive in the highest level of the forest canopy (Campbell *et al.*, 2005; Rosenberger *et al.*, 2008; Hooper, 2014). Many aspects of their physiology are distinct from other primates and are specialized for movements such as below-branch suspension and brachiation, rather than leaping and quadrupedal travel (Fontaine, 1990; Rosenberger *et al.*, 2008; Lindshield and Rodrigues, 2009). For instance, skeletal modifications to the wrist and elbow, and the absence or reduction of the thumb, all assist *Ateles* in these suspensory activities which are essential for life in the canopy (Rosenberger *et al.*, 2008; Lindshield and Rodrigues, 2009). In addition to specialized forelimbs, *Ateles* also possess a prehensile tail that can support the animal's entire body weight (Youlatos, 2008).

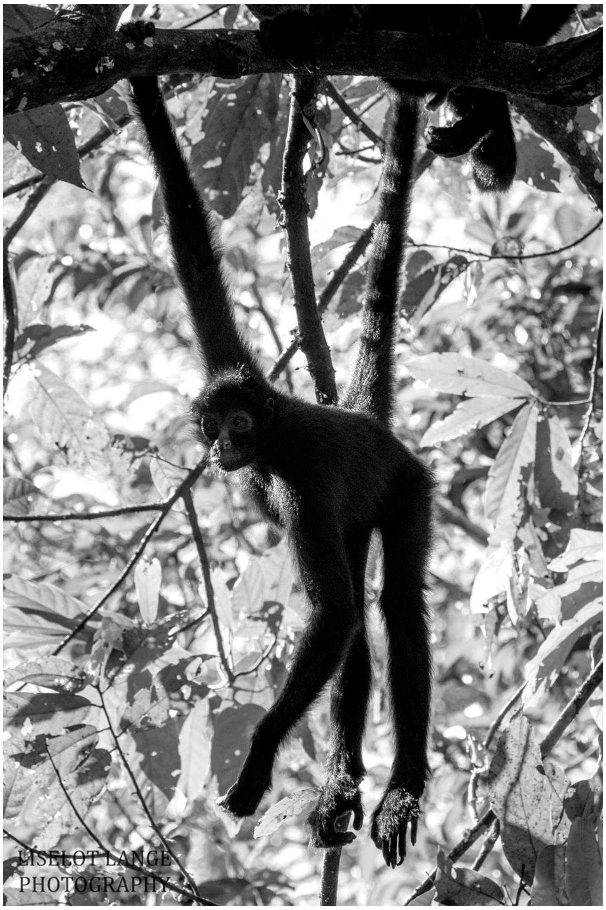

Figure 1. An example of *Ateles chamek* with its distinct morphological characteristics, e.g. the long limbs and prehensile tail. Photo credit: Liselot Lange (2016).

Ateles usually prefer primary, closed-canopy forests (Michalski and Peres, 2005; Wallace, 2008; Salvador *et al.*, 2011), and they are found to spend more than 70% of the time in the higher canopy levels above 25 m (Van Roosmalen, 1985; Wallace, 2008). Ateles may be restricted to the highest canopy levels due to dietary and physical specialization. *Ateles* are extremely frugivorous (Campbell *et al.,* 2005; Wallace 2008), and ripe fruit is seldom found in lower forest levels (Campbell *et al.*, 2005). Furthermore, their shoulder joint modifications and elongated forelimbs do not allow for terrestrial quadrupedism, making it harder for *Ateles* to visit the ground (Campbell *et al.*, 2005). They are believed to descend to the forest floor only for drinking, visiting clay licks, eating soil or decaying wood, and during social conflicts (Campbell *et al.*, 2005).

Ateles exhibit a larger home range than other primates in the same habitat due to the distribution of fruit patches (Takahashi, 2008; Defler, 2010). Home ranges of *Ateles* have been recorded between 32 and 900 ha with daily path lengths between 500 and 5,600 m (McFarland Symington, 1988a; Wallace, 2006, 2008; Spehar, Di Fiore and Link, 2010; González-Zamora *et al.*, 2012, 2015; Velázquez-Vázquez *et al.*, 2015).

The activity budget of *Ateles* is often described using four mutually exclusive categories: resting, foraging, traveling, and other (see Table 1) (McFarland Symington, 1988a; Wallace, 2001). On average, social behaviors account for less than five percent of *Ateles* activity budgets (Slater, Schaffner and Aureli, 2007, 2009), which is less than for most primates. The largest portion of *Ateles* daily activity budget (nearly half) consists of resting (White, 1986; McFarland Symington, 1988a; Nunes, 1995; Wallace, 2001). Traveling accounts for between 14.8 and 32.6% of the activity budget, and foraging between 18 and 50.5% (Chapman, Chapman and McLaughlin, 1989; Wallace, 2006). Time spent resting and traveling is likely influenced by levels of fruit abundance and distribution.

Ateles feed 70 to 90% of the time on large-seeded fruits (Di Fiore *et al.*, 2008; Felton *et al.*, 2008). *Ateles* are very important seed dispersal agents as they rarely masticate the seeds and instead swallow them whole, therefore contributing to the regeneration of forests (Link and Di Fiore, 2006; González-Zamora *et al.*, 2012; Link *et al.*, 2012). In times of fruit scarcity, *Ateles* complement their diet with leaves, flowers, seeds, decaying wood, clay, soil, and a very small percentage of invertebrates (Di Fiore *et al.*, 2008; Rylands and Mittermeier, 2013).

Spider monkeys are of particular interest to primatologists because they exhibit a fission-fusion social structure similar to that of chimpanzees, which is unique among Neotropical primates (Anaya-Huertas and Mondragón-Ceballos, 1998). This structure involves the division of a group, that can consist of over 50 individuals, into temporary subgroups (Shimooka *et al.*, 2008). Subgroups fluctuate in size and composition throughout the day, averaging three to four individuals at a time (Van Roosmalen, 1985; Chapman, 1988; Shimooka, 2005; Lange, 2016). Due to the clumped distributions of their primary food sources (González-Zamora *et al.*, 2008) and the fact that *Ateles* often deplete fruit supplies in their feeding trees (Chapman, 1988), this social system evolved to reduce intragroup competition for food resources (Asensio *et al.*, 2008; Spehar and Di Fiore, 2013). Therefore, group fission is evoked when fruit is scarce, and conversely, fusion occurs in instances of high fruit availability (Asensio *et al.*, 2008; Aureli and Schaffner, 2008). Hence, subgroups need to visit fewer food patches to find sufficient food (Aureli and Schaffner, 2008).

Most research on spider monkeys has been conducted in protected areas (González-Zamora *et al.*, 2008), and little is known about their behavioral ecology in unprotected areas (Hagell, Whipple and Chambers, 2013). In this study, we report the demography, habitat use, activity budget and preliminary notes on ranging patterns and diet of *Ateles chamek* in an area not part of a national park or reserve.

Methods

Study site

This study was conducted at the Las Piedras Amazon Center (LPAC), a 4,465-hectare ecotourism and conservation concession run by the non-governmental organization (NGO) the Alliance for Research and Conservation in the Amazon (ARCAmazon). The site is located in the Madre de Dios department of Peru (-12.0709367 S, -69.5005917 W), approximately 65 km from the town of Puerto Maldonado and 55 km from the border with Brazil. The site consists of terra firme and floodplain forest ranging from 200 to 400 m in elevation along the Las Piedras River. Our research was conducted between May 2016 and December 2017. During this time, minimum temperature averaged 22°C, maximum temperature 35°C, humidity levels averaged between 60 and 90% and average daily rainfall between 10 and 220 mm (Weather Underground, 2019; World Weather Online, 2019). Field work was based out of the research center at LPAC, which takes up less than one hectare of the land and consists of sleeping platforms and communal areas. The concession contains approximately 37 km of mapped trails, some of which were used to observe the focal group in the north-east of the concession. A stream (the Loboyoc) cuts from the south-west to the north-east of the concession and joins with the Las Piedras River. The stream is traversable by the study group which has multiple crossing points along its course. Within the concession, multiple groups of spider monkeys are found without any major geographical boundaries separating the groups. This study solely focused on one of the groups in the north-east of the concession.

The river shed of Las Piedras is an extraction forest, and most concessions are used for the exportation of Brazil nuts and timber. Hunting (mostly illegal) is a common practice in the concessions surrounding LPAC, as the region does not lie within a national park or reserve and there is little protection for wildlife. ARCAmazon acquired the LPAC-concession in April 2015 with the aim to preserve the land and create a corridor for flora and fauna while forming alliances with other NGOs and landowners. Ten species of non-human primates are found within the concession (Lange, 2016).

Subjects

The focal group consisted of eight well-habituated, individually recognizable *Ateles chamek* at the start of the study (May 2016). As there had been tourism in the years before the study, the spider monkeys had become accustomed to the presence of humans. There were three adult males (Ezra, Luca, Scar) and five females, where we group both subadult and adult females into one category (Juno, Mami, Manchas, Flor, Rose). The individuals were identified by facial characteristics and were given names to ease data collection and communication in the field. Throughout the study, the group's composition fluctuated due to death and newborn individuals. In August 2016 an infant male (Leaf) was born to Juno. Later in June 2017, the oldest female (Manchas) passed away from natural causes. The remains were discovered in a decomposing state, after which it was discovered that the subject's left ankle and foot were missing. Post-mortem examination showed the animal had worn teeth and brittle bones; indicators of old age. The individual also had a healed fracture of the left humerus, but did not show limitations in movement whilst alive. Around the same time of this death, a female infant (Maya) was born to Mami. By the end of the study (December 2017), the group consisted of three adult males (Ezra, Luca, Scar), two (sub)adult females (Flor, Rose), two lactating females (Juno, Mami), one juvenile male (Leaf), and one infant female (Maya).

Data collection

The data on *Ateles chamek* were collected through focal follows of the study subjects. Follows took place in surveys between 05:00 and 19:00, covering all hours in which *Ateles* are known to be active. Existing trails within the concession were walked at a slow speed (between one and two km/h) to locate the study group. Upon encountering a subgroup or the entire group, a random individual was chosen for the focal observations. In this study data were collected only on adult individuals, as the infants and juveniles' behavior is strongly correlated with their mother's behavior. Data were collected on adult males, sub and adult females (without offspring), and lactating females (with offspring). Behavioral data were collected on the focal individual every fifth minute, using instantaneous focal sampling (Altmann, 1974). For gathering data on their activity budget, the following categories were used; traveling, resting, foraging, and other (Table 1). The forest level use of the focal individual was also recorded every fifth minute (between the ground and 10 m high, between 10 m and 20 m high, or above 20 m high). The focal animal was followed for one hour, until out of sight for more than ten minutes, until no longer possible to follow, or until the sun set and the focal settled at a sleeping site. After one hour of following a focal individual, a new individual was selected. The focal individual's movements were recorded by creating a track with a handheld GPS-system (GARMIN 64s).

Data were also collected on diet by recording and identifying food items consumed by the spider monkeys (fruits, flowers, leaves, bark, clay or invertebrates). Additionally, ad libitum data were taken on social interactions and group composition. Finally, all feeding trees and sleeping sites were marked with the GPS-system.

Table 1. Description of the used activity categories.

Activity categories	Description
Traveling	Moving for more than thirty seconds or between trees
Resting	Sleeping, being stationary or small movements less than thirty seconds
Foraging	The looking for, handling of, or ingestion of food or water
Other	Behaviors not fitting into any of the other categories, e.g. social interactions between individuals, interaction with observers, defecating and/or urinating

Data analysis
All GPS data were uploaded into the computer software Basecamp (Garmin Ltd., 2019). By creating a polygon of the outer points of *A. chamek* encounters and follows, we calculated the home range (in ha) and created a map presenting habitat usage (Fig. 2). Additionally, a second map was created showing the distribution of the feeding trees and sleeping sites within the home range (Fig. 3). A non-parametric regression analysis was used to verify whether a correlation exists between grid-cell use and the number of feeding trees present within that cell. An estimation of the encountered subgroups' daily path length was made by calculating their average speed during a follow and multiplying this by average time spent traveling per day. The group's activity budget was calculated by combining the frequency of behavior in all samples. The activity budgets of adult males, (sub)adult females (without offspring) and lactating females (with offspring) are compared through descriptive analyses. No statistical analyses were applied due to the small sample size. All food items consumed were categorized (fruits, flowers, bark, clay and invertebrates) and frequency of consumption of each category was expressed as a percentage of all feeding observations throughout the study.

Results

A total of 1,519 instants, obtained from 149 focal follows, were analyzed. On average the focal follows lasted 45.60±20.11 minutes.

Demography
Total group size fluctuated between eight and nine individuals over the course of the study due to one death and two newborns. Observed subgroup size ranged from one to nine individuals, with an average of 4.63±1.92 members. The subgroups also varied in composition (Fig. 2). The most common type of subgroup consisted of one or more females with their offspring, which accounted for 41.2% of encounters. The second most common group observed was both males and females with offspring, which accounted for 31.9% of subgroups. Interestingly, while 10.9% of observed subgroups consisted of males only, female-only subgroups without offspring were never encountered. The percentage of solitary encounters were low, with solitary females and males accounting for only 3.4 and 3.6% of subgroups respectively. For the group as a whole, male to female ratio at the start of the study was 1:1.67, but this decreased to 1:1.25 by the end of the study.

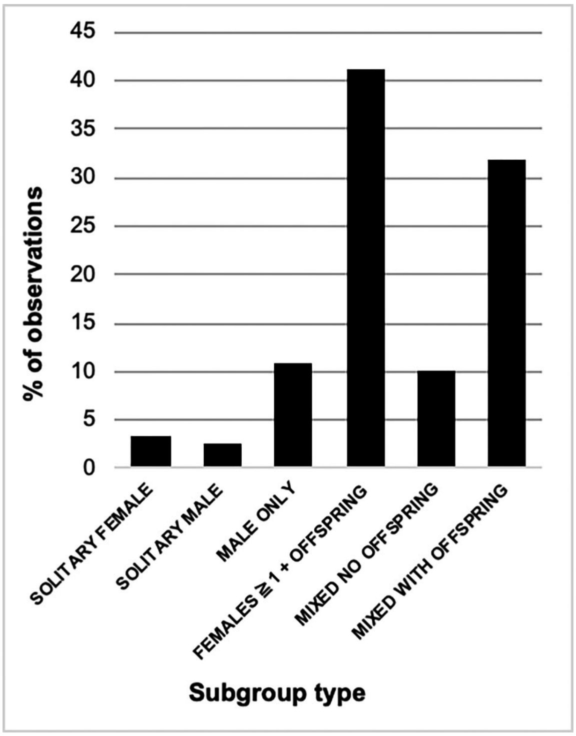

Figure 2. A histogram showing the relative frequency of *A. chamek* subgroup types encountered (n= 119 encounters).

Habitat use
The group occupied forest levels higher than 20 m for 75.2% of the time, levels between 10 and 20 m for 23.2% of the time and were rarely found below 10 m. The home range was approximately 160 ha, consisting entirely of floodplain forest. Figure 3 shows the intensity of area use within the home range and includes bordering areas (represented in white) rarely or not visited by the study group.

A significant positive correlation was found between the number of feeding trees within a cell and the frequency of *Ateles chamek* encounters within that cell ($R2 = 0.38$, $N = 93$, $P < 0.001$). Figure 4 shows the distribution of 79 feeding trees and four sleeping sites that were located throughout the study period.

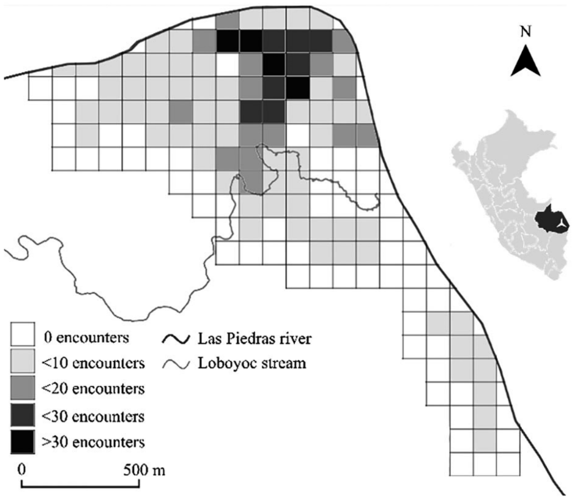

Figure 3. One-hectare grid map of the approximately 160 ha home range of the focal *Ateles chamek* group at the Las Piedras Amazon Center, Peru, showing the frequency of encounters within each cell.

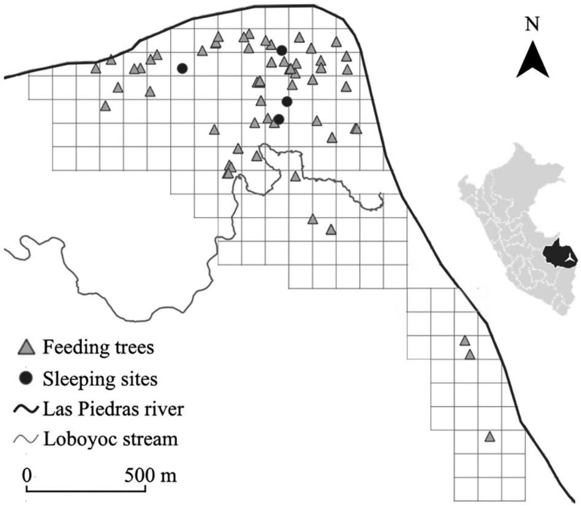

Figure 4. One-hectare grid map with the distribution of feeding trees and sleeping sites throughout the home range of the focal *Ateles chamek* group at the Las Piedras Amazon Center, Peru.

Preliminary notes on ranging pattern

On average, the individuals encountered traveled two hours and 47 minutes per day and their speed was approximately 440 m per hour. This means the group's estimated daily path length was 1,200 m per day. More in-depth research is required to determine whether subgroup size has an influence on ranging patterns.

Activity budgets

The activity budget of the spider monkeys consisted of 41.9% resting, 23.8% traveling, 30% foraging and 4.3% other behaviors. The category 'other' consisted of 3.8% social interactions between group members, for instance affiliative behaviors such as playing and handling other female's offspring, and also agonistic behaviors such as aggressive chases. The remaining time was spent on behaviors such as urination, defecation, and interaction with observers. Our results (see Figure 5) show that lactating females (with offspring) spent the least time resting out of the three age-sex classes of *A. chamek,* and (sub)adult females (without offspring) spent most time resting. In regard to traveling, adult males traveled most and lactating females (with offspring) least. Lactating females (with offspring) spent far more time foraging than the other two age-sex classes, with adult males spending the least amount of time foraging. Lastly, adult males demonstrated other behaviors more frequently, such as interactions with observers and social behaviors.

Preliminary notes on diet

A total of 383 records of foraging events were analyzed for the study period. The majority of the group's diet consisted of fruits (84.4%, *n*=325), with leaves being the second most consumed item (9.7%, *n*=37). The group supplemented these food items with small amounts of seeds, flowers and bark. One instance of geophagy was observed where a lactating female (with offspring) consumed clay from an arboreal ant nest.

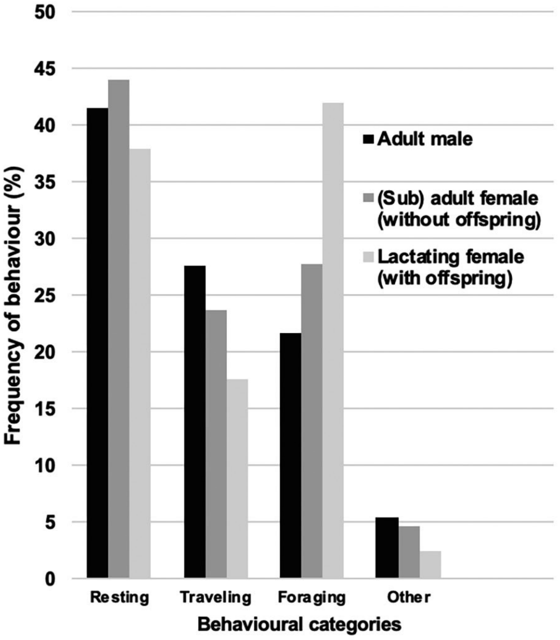

Figure 5. Differences in activity budgets between three different age-sex classes of *Ateles chamek.*

Discussion

The total size of this particular group (eight to nine individuals) is unusually small at this site. Other (sub)groups within the concession with larger numbers of individuals (usually between 15 and 20) were sighted and we have no clear understanding of why the study group in particular is so small. Despite no clear geographical boundaries existing within the concession, no interactions were recorded between the study group and other *Ateles* groups. Previous research on the genus and species report larger group sizes, between 15 and 50 individuals per group (Van Roosmalen, 1985; McFarland Symington, 1988a; Shimooka *et al.*, 2008). However, one long-term study by Ramos-Fernandez *et al.* (2005) followed a group of *Ateles geoffroyi* of a similar size (8 adults); this group lived within a fragmented forest, and the habitat was likely a major limitation on their group size. The average subgroup size that we found was, however, very similar to other studies (van Roosmalen, 1985; Chapman, 1988; Shimooka *et al.*, 2008). Therefore, it appears that subgroup size is not correlated with group size. We propose that a possible reason for subgroup size to be around this number is to maximize safety. It is possible that smaller subgroups are less likely to detect a potential predator whilst more likely to be predated upon. Furthermore, it is likely that smaller subgroups are less capable of defending their territory against rival *Ateles* groups. The subgroup composition also stayed similar to groups with more individuals (Chapman 1990), where females with offspring were the most common composition of subgroups. This is expected, as females without offspring are known to display maternal behaviors towards other female's offspring, potentially to practice motherhood themselves and, therefore, stay close to these females (Slater *et al.* 2007). The male to female ratio within the focal study group was found to be lower than most other groups studied (Chapman, *et al.* 1989), however, we do not consider this surprising due to the extremely small size of the focal group.

The home range that we found is similar to the home ranges reported in other studies (McFarland Symington, 1988a; Wallace, 2008). We had anticipated a much smaller home range considering the small size of this group compared to group size in other studies on the genus. Campos *et al.* (2014) state that there is a positive relationship between primate group size and home range size, and it would be reasonable to assume that a smaller group would experience less competition for resources and thus would not have to travel as far to meet resource demand. Therefore, their equally sized home range could be explained by a potential fruit scarcity in the focal group's home range, causing them to travel further to find sufficient resources. By conducting a more in-depth study on the ecology of their home range (through botanical plots) we could more accurately reveal whether fruit abundance has an influence on home range size in this case. In contrast to Campos, Wallace (2008) found that home range size did not correlate with resident *Ateles* group size, and therefore there may be other factors contributing to home range size other than group size and food availability. For instance, noise disturbance and the presence of humans could force communities to retreat to less disturbed areas (Kirkby *et al.*, 2000; González-Zamora *et al.*, 2012), hence increasing home range size. We expect that a construction project that took place at the Las Piedras Amazon Center (within the group's home range) during the study could have caused the group to range further than expected. However, comparative data from after the construction period is required to determine whether home range size and ranging patterns were affected.

Daily path lengths for spider monkeys appear to vary largely (Symington *et al.,* 1988a, Nunes, 1998). Our findings present a shorter average daily path length than the average reported by Symington *et al.* (1988a) and Nunes (1998), however this is likely due to the larger group size of the groups in those studies (18 to >35 individuals). Larger group size would likely mean the spider monkeys need to cover more distance on a daily basis to find sufficient resources, hence explaining why the study group has shorter daily path lengths.

During the study we observed one feeding event of geophagy, in which a lactating female (with offspring) consumed clay from an arboreal ant's nest. The main reasons for soil consumption by animals are to supplement the animal's diet with minerals otherwise unobtainable, and that the consumption of soil supposedly aids in detoxification and alleviation of gastrointestinal problems (Link *et al.*, 2011). It appears that geophagy is more common during particular life history events like lactation or pregnancy (Link *et al.*, 2011, Pebsworth, *et al.*, 2018). Whereas other studies report *Ateles* spp. consume clay at clay licks, we did not identify any clay licks within the group's home range. Arboreal ant nests and termitaria could be a source of minerals for primates in areas where there are fewer or no clay licks available. The mineral composition of termitaria and ant nests is usually even higher than that of topsoil (Veiga and Ferrari, 2007). This allows *Ateles* to obtain minerals whilst staying in the canopy. Further research is required to better understand the physiological factors driving geophagy in spider monkeys, to gain insight into the increased consumption of clay during specific life events and finally to understand the use of arboreal ant nests and termitarium for clay consumption.

Lactating females (with offspring) rested least out of the different age-sex classes. We expected lactating females to spend the most time resting in order to compensate for the exertion of carrying and nursing a young. However, time spent resting can sometimes serve as a pool from which time needed to accomplish other behaviors can be drawn (Dunbar, 1988). In this case, it is possible that resting time was substituted for foraging time as the lactating females spent the most time foraging. We assume that this is due to the energy demands for lactating females being higher than those without a dependent young.

Although the study site is not located within any government-protected area, no noticeable differences were found in the habitat use and activity budget of the study group in comparison with studies conducted within governmental-protected areas. Further research is required on the populations of *Ateles* along the Las Piedras River shed to create large-scale conservation strategies for this region.

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DENSIDAD POBLACIONAL Y COMPOSICIÓN DE GRUPOS DE *AOTUS NANCYMAAE* EN ÁREAS DE APROVECHAMIENTO DE LA ESPECIE PARA EXPERIMENTACIÓN BIOMÉDICA EN EL TRAPECIO AMAZÓNICO COLOMBIANO

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Resumen

El uso de fauna, así como de otros recursos naturales, es fundamental para el desarrollo y bienestar humano. No obstante, garantizar su conservación depende de un manejo basado en información confiable, es decir, rigurosamente colectada y analizada, y adecuados esquemas de regulación; de lo contrario se pueden sobreexplotar dichos recursos. La sobreexplotación es uno de los cinco motores de perdida de diversidad y ha sido identificada como una amenaza directa para algunos primates. Las poblaciones de las especies del género *Aotus* en el sur de la Amazonía colombiana han sido usadas para experimentación biomédica desde hace aproximadamente 30 años, no obstante, el impacto de este proceso no ha sido suficientemente evaluado. Ante la reciente confirmación de un nuevo taxón para Colombia, *Aotus nancymaae*, el adecuado diagnóstico del estado de conservación de sus poblaciones, la revisión de los planes de manejo y monitoreo, incluidos los procedimientos de aprovechamiento, cobran mayor importancia, dada su restringida área de distribución y aprovechamiento inespecífico, que determinan como Vulnerable a la especie en Colombia. Se presentan resultados preliminares de algunos parámetros poblacionales, como paso inicial para determinar la salud de estas poblaciones. Los resultados y la comparación con otros estudios permiten concluir que existe una alta carga de incertidumbre sobre información básica para poder hacer un manejo sostenible de las especies en este paisaje.

Palabras clave: Especies amenazadas, experimentación biomédica, manejo de vida silvestre.

Abstract

The use of wildlife as a natural resource is fundamental to human welfare and development. However, to guarantee wildlife conservation, wildlife management needs to be based on reliable information, in other words, data that are rigorously collected and analyzed, and an accurate regulatory system; otherwise wildlife overexploitation can occur. Overexploitation is one of the five drivers of biodiversity loss and has been identified as a direct threat to some primate species. Captured animals from the wild populations of *Aotus* species in the southern Colombian Amazon have been used for biomedical experimentation since approximately 30 years ago; however, the impact of this process needs to be evaluated further. Since the recent confirmation of a new taxon to Colombia, *Aotus nancymaae*, it has become even more important to accurately assess the conservation status of owl monkey populations in this region, as well as to review the management and monitoring plan, including protocols for use. Due to its restricted distribution and its human use, this species is considered Vulnerable in Colombia. Here we show preliminary results of some population parameters as an initial step to determine the health of this population. The results and the comparison with other studies allow us to conclude that there is a very high uncertainty about basic information needed to plan sustainable management of these species in this landscape.

Keywords: Threatened species, biomedical experimentation, wildlife management.

Introducción

Los seres humanos siempre han cazado y explotado recursos naturales para sobrevivir. La explotación, a diferencia de la cosecha, implica la extracción de individuos o partes de individuos de poblaciones silvestres y no de plantaciones o producciones animales (Sutherland, 2000). Se estima que la sobreexplotación amenaza cerca de un tercio de las especies de vertebrados raros, vulnerables o amenazados (Groombridge, 1992). En gran parte del mundo los recursos son explotados lo más rápido posible. Si existe un mercado para un producto, los habitantes locales lo buscarán y lo venderán usando cualquier método disponible para obtener el recurso. La sobreexplotación de una especie se da rápidamente cuando se empieza su aprovechamiento en un lugar donde anteriormente no era usada y tanto el comercio legal como ilegal son responsables de la reducción de algunas especies. La sobreexplotación de un recurso ocurre, entre otras razones, por falta de conocimiento del sistema de aprovechamiento (Primack, 2010).

Actualmente los primates son el orden más amenazado de mamíferos en Colombia, con 26 de sus 46 taxones incluidos en las categorías de amenaza de la Unión Internacional para la Conservación de la Naturaleza (UICN, 2017). Para algunos primates, como por ejemplo, *Saguinus oedipus* y *S. leucopus*, además de la destrucción del hábitat, la extracción de individuos para experimentación biomédica o para comercio como mascota se ha definido como una amenaza para su conservación (Defler, 2010). Las especies del género *Aotus* en el sur de la Amazonia colombiana, de quienes hasta ahora no hay conclusiones definitivas acerca de su distribución (Bloor et al., 2014) y abundancias, han sido usadas durante los últimos 30 años como modelos biológicos para experimentación biomédica. Desde octubre de 2005 hasta junio de 2012 se extrajeron de las poblaciones silvestres a orillas del río Amazonas en Colombia, poco más de 4,500 individuos (Registros Corpoamazonia). Estas extracciones no necesariamente pueden considerarse mortalidades, dado que como parte del proceso de la experimentación biomédica se contempla la reincorporación de los individuos aprovechados al medio natural. Así, entre octubre de 2006 y septiembre de 2012 fueron liberados 4,041 individuos en la región (Registros Corpoamazonia). Sin embargo, el impacto de los diferentes procedimientos del proceso de aprovechamiento sobre las especies del género en esta zona (Fidic, 2007; Hernández y Díaz, 2010; Maldonado, 2011), no puede determinarse adecuadamente, ya que el estado de conservación de sus poblaciones no ha sido determinado con suficiencia.

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 (Begon et al., 2009). La densidad poblacional es un parámetro dinámico espacial y temporalmente, por tanto, la estimación inicial de la densidad es útil mientras se asuma como base de un programa de seguimiento, que permita determinar sus tendencias. De esta forma se pueden estimar tasas de crecimiento poblacional y evaluar el comportamiento de este parámetro en poblaciones sometidas a diferentes niveles de aprovechamiento (Anzures-Dadda y Manson, 2007; Arroyo-Rodríguez et al., 2008). Siguiendo estas consideraciones, se estimó la densidad poblacional de *Aotus nancymaae* en un área en la cual se extrajeron 184 individuos entre febrero de 2011 y abril de 2012 (Registros Corpoamazonia). Adicionalmente se presentan estimaciones de composición de grupo de esta especie a una escala espacial más amplia, como primer paso en la evaluación de la población de esta recién confirmada especie para Colombia (Bloor et al., 2014) y que se encuentra categorizada como vulnerable (VU) (Maldonado et al., 2017).

Materiales y métodos

Área de estudio

El área de estudio está ubicada en el Resguardo Ticoya, jurisdicción del municipio de Puerto Nariño, departamento de Amazonas, Colombia. Para la determinación de la composición de grupos los muestreos se hicieron específicamente en sitios cercanos a las comunidades: San Pedro de Tipisca (-70°35’36”W, -3°41’12”S), Doce de Octubre (-70°30’15”, -3°44’10”), Naranjales (-70°31’47”, -3°52’18”), San Juan de Atacuari (-70°39’34”W, -3°49’26”) y Santa Clara de Tarapoto (-70°24’51”, -3°48’02”). El muestreo para estimar la densidad poblacional de la especie se llevó a cabo en los alrededores de la comunidad Naranjales, en aproximadamente 19 km^2 de área inferencial, es decir, de donde se puede asumir que el muestreo es representativo, conformados por un mosaico de humedales permanentes y zonas altas inundables conocidas localmente como “restingas” (Fig. 1).

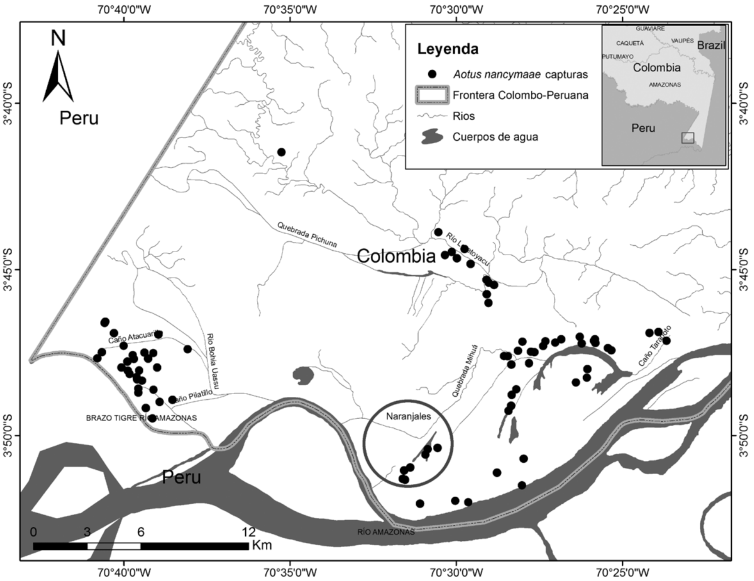

Figura 1. Área de estudio. El circulo en la comunidad de Naranjales corresponde a la zona en donde se establecieron los transectos para la estimación de la densidad poblacional. Los puntos negros son los sitios de capturas de individuos o grupos de *Aotus nancymaae.*

Para la ejecución del proyecto, se elevó la consulta previa reglamentaria ante el Ministerio del Interior y se obtuvo respuesta aclarando que no se requería la consulta debido a que el proyecto de investigación no generaba ninguna afectación a los grupos étnicos. No obstante, se socializó el proyecto en las 22 comunidades del resguardo Ticoya. Entre julio y noviembre de 2012 se desarrolló el trabajo de campo.

Toma de datos

Densidad poblacional

Para estimar la densidad de *A. nancymaae* alrededor de la comunidad de Naranjales, se empleó el método de muestreo por distancias con transectos lineales, mediante el cual se registra el número de animales vistos por un observador que camina a lo largo de un transecto, y la distancia perpendicular hasta el punto donde se observaron los animales o hasta el centro geográfico del grupo observado (Buckland et al., 2007; Buckland et al., 2015; Thomas et al., 2010). Los transectos se ubicaron de acuerdo a la configuración del área, dado que existen humedales permanentes que impiden el acceso. Se establecieron 18 transectos con una longitud total de 29.6 km y un promedio de 1,644.4 m (DS ± 407.6 m); algunos correspondieron a caminos ya existentes, mientras se pudieran satisfacer los supuestos de que a 0 metros de distancia perpendicular la probabilidad de detección sería del 100 % y de la independencia de las observaciones, es decir, que no hubiera probabilidad de contar los mismos animales más de una vez en un mismo recorrido (rectitud del transecto) y, de que no se contara el mismo grupo en dos transectos distintos en recorridos simultáneos por las acciones evasivas del grupo ante una primera detección. Cada transecto fue recorrido en promedio 2.89 veces, con una distancia promedio de 4.9 km por transecto, acumulando un esfuerzo de muestreo de 88.6 km. Los transectos fueron recorridos silenciosamente escrutando la vegetación, a una velocidad promedio de 1.03 km/h. Se realizaron conteos simultáneos con un observador por transecto. Los transectos fueron recorridos desde las 3:30 hasta las 5:30 horas, y desde las 17:35 hasta las 19:35 horas. En los muestreos sólo se incluyeron los registros visuales. El recorrido de los transectos y la hora en que éste se efectuó, se distribuyó proporcionalmente entre los observadores, para eliminar posibles sesgos asociados a un mismo observador recorriendo repetidamente un mismo transecto y/o haciéndolo a la misma hora (Roncancio et al., 2009). Con el objetivo de mantener constante la probabilidad de detección a lo largo de un transecto, se procuró tener la misma velocidad durante el recorrido; por tal motivo, una vez ubicado un grupo, el observador permaneció máximo hasta 15 minutos con el grupo para intentar su conteo completo (Peres, 1999). Cada vez que fue localizado un grupo, se registró la hora, el número de individuos, se midió la distancia perpendicular al transecto, se registró la coordenada y la actividad que los animales desarrollaban.

Estructura y composición de grupos

Los datos para estos análisis se colectaron en el marco de la investigación para determinar la identidad de las especies del género *Aotus* que habitan en el trapecio amazónico colombiano (cinco localidades evaluadas en el resguardo Ticoya) y algunos de sus parámetros demográficos, lo cual implicaba la captura de individuos libres. Estas capturas fueron hechas por un equipo conformado por un biólogo, un veterinario y expertos locales. Todo el proceso de captura, toma de muestras y marcaje de los animales se ejecutó bajo tres principios: 1. garantizar la integridad física de las personas que participaban en el proceso, 2. garantizar la integridad física de los animales y 3. garantizar la calidad de las muestras y los datos. El procedimiento se desarrolló de la siguiente forma: inicialmente los expertos locales hacían jornadas de búsqueda y seguimiento a partir de la 3:00 y hasta la 6:30 horas, en las cuales intentaban ubicar un grupo de *Aotus* y seguirlo hasta su nido. Una vez el grupo entraba al nido, los colectores permanecían hasta aproximadamente las 6:30 horas verificando que el grupo no se desplazará a otro lugar. Posteriormente, los colectores regresaban al sitio de reunión con el resto del equipo e informaban las características del nido y la viabilidad de la captura conforme a los tres principios de seguridad y calidad. Las capturas se realizaron a partir de las 9:30 y las 10:00 y hasta las 15:00 horas, periodo en el que los individuos de la especie de este género se encuentran menos alerta. En esta zona los nidos de *Aotus* son básicamente de dos clases. Los primeros están ubicados en vegetación densa en la parte alta de un árbol "Chamiceras", mientras los otros están ubicados en huecos de árboles. El primer tipo de nido solo se puede alcanzar por medio de tala de entre 300 y 500 m^2 alrededor del árbol y poda del árbol en el que se encuentra el nido, por tanto, los grupos que se encontraron en este tipo de nido no se intentaron capturar. Por otro lado, los primates que se encontraron en huecos de árboles se capturaron de dos formas dependiendo de la altura y la cantidad de huecos de salida que tenía el nido. La primera fue por medio de un acceso sigiloso, respetando la distancia mínima de fuga a los huecos o hueco del nido, con el objetivo de taparlos con tela plástica usando varas de palma "marona", si la distancia de acceso lo demandaba. La segunda técnica implicó la intimidación de los animales para que no se fugaran del nido, utilizando varas de alrededor de 40 cm de longitud, lanzadas desde el suelo mientras uno o dos integrantes del equipo asciende a tapar el nido con tela plástica o mallas. Luego de que el nido estaba asegurado, se verificaba la profundidad del mismo y se procedía a la extracción de los animales obligando su desplazamiento hasta el fondo del nido, la boca del agujero del mismo o, hasta una abertura hecha para su extracción. Para esta actividad se contó con equipo certificado de ascenso a dosel el cual incluía cuerda, arneses, cascos, cordinos, cintas tubulares, mosquetones, ascendedores, descendedores (Ocho y ATC) y guantes. Cada integrante del equipo recibió previamente entre seis y 12 horas de instrucción en el manejo de los equipos y en técnicas de ascenso a dosel.

Una vez capturados los individuos, estos fueron ubicados individualmente en bolsas de tela negra; en el suelo, cada animal fue tranquilizado con Ketamina vía intramuscular en la parte posterior del muslo, con dosis de entre 5 y 15 mg/kg de peso (los individuos eran pesados previa inoculación del medicamento). Este proceso fue monitoreado a través de la lectura continua de la temperatura, frecuencia cardiaca y frecuencia respiratoria. A los animales capturados se les tomaron los siguientes datos: peso, longitud total, longitud oreja, longitud de pie, longitud de cola, longitud corporal, circunferencia, sexo, estado reproductivo (gestante, lactante, presencia de testículos escrotales), se hicieron registros fotográficos de diferentes planos, de los dientes y de un tatuaje que se le hacía en la cara ventral de muslo (para identificar recapturas). Para la estructura de la población se definieron preliminarmente cuatro categorías de desarrollo, adultos, subadultos, juveniles e infantes con base en los criterios utilizados por Castaño et al. (2010).

Análisis de datos

Densidad poblacional

La densidad poblacional de *A. nancymaae* en Naranjales se estimó con el programa DISTANCE 7.1 (Thomas et al., 2010). El objetivo del análisis del muestreo a distancia es ajustar una función de detección de las distancias perpendiculares de las observaciones y usar esta función para estimar la proporción de objetos que no se detectaron en el muestreo (Buckland et al., 2001; Buckland et al., 2015). Para la estimación de la densidad de individuos se usó el tamaño de grupo estimado E(s), a partir de la regresión entre la probabilidad de detección y el tamaño de grupo, de tal forma que se evite el sesgo generado por la reducción en la detectabilidad de los grupos más pequeños registrados durante los muestreos en los transectos. Se comparó la distribución de frecuencias de las distancias perpendiculares con seis modelos: 1. *Half normal* con serie de expansión Coseno, 2. *Half normal* con *Hermite polynomial*, 3. *Uniforme con Coseno*, 4. *Uniforme con Simple polynomial*, 5. *Hazard-rate con Coseno* y 6. *Hazard-rate con Simple polynomial.* De los anteriores modelos se eligió el que presentó el menor valor de AIC (Criterio de Información de Akaike). El AIC es un método cuantitativo para la selección del modelo que mejor se ajusta a los datos y que emplea el menor número de parámetros (Burnham y Anderson, 2002).

Tamaño y composición de grupos

Para determinar el tamaño medio de grupo en esta zona del trapecio amazónico (cinco localidades del resguardo Ticoya) se tuvo en cuenta la información de todos los grupos (capturados y no capturados) para los cuales se logró su conteo completo. Para determinar la composición de los grupos se tuvieron en cuenta aquellos grupos que fueron capturados en su totalidad; para la composición se evaluó la proporción de cada categoría de edad y de los géneros. Se evaluó además la relación entre machos adultos y hembras adultas y entre hembras adultas e inmaduros (juveniles más infantes).

Resultados

Densidad poblacional

Se obtuvieron 24 registros visuales de *A. nancymaae.* La distribución de frecuencias de las distancias perpendiculares presentó un mejor ajuste al modelo *Uniforme* con serie de expansión coseno. La densidad poblacional de *A. nancymaae* en la localidad de Naranjales fue de 23.9 individuos/km^2 (IC95 % = 13,6 – 42,3) y 8.8 grupos/km^2 (IC95 % = 5,1 – 15,2), con coeficientes de variación del 28,8 % y 27,2 % respectivamente. La varianza de la densidad fue influenciada por la probabilidad de detección (59,6 %), la tasa de encuentro (29,1 %) y el tamaño de grupo (11,3 %).

Tamaño y composición de grupos

Se capturaron 150 individuos de *A. nancymaae* en las cinco localidades. Cincuenta y ocho por ciento de los individuos capturados fueron adultos (37 % hembras y 21 % machos), 5 % subadultos y 29 % inmaduros (Tabla 3).

Tabla 3. Estado de desarrollo y género por localidad de los individuos capturados del género *Aotus*.

Estado de desarrollo	**Adulto**		**Infante**		**Juvenil**		**Subadulto**		**Total**
Localidad/Género	H	M	H	M	H	M	H	M	
Doce de Octubre	8	7			4	3		1	23
Naranjales	11	2			2	6	4	1	26
San Juan de Atacuari	23	13		1	6	3	2	2	50
Santa Clara de Tarapoto	13	10			10	10	4	4	51
Sub-total	55	32	1	1	22	22	10	9	150
Total	87		2		44		8		

De las 55 hembras adultas capturadas 62 % estaban reproductivamente activas (19 gestantes y 15 lactantes). Se capturó un infante, aparentemente nacido durante la primera quincena de noviembre. El tamaño promedio de grupo fue de 3.06 individuos (IC 95 % = 2.89 – 3.22, n = 138) con un rango de dos a cinco individuos; 36 con dos individuos, 51 con tres, 34 con cuatro y 11 con cinco. Se registraron seis individuos solitarios. Se capturaron 17 grupos completos: la relación hembras: machos fue 1: 0.94 y, de hembras: inmaduros 1: 0.52.

Discusión

Para la localidad de Naranjales se estimó una densidad poblacional de alrededor de 24 ind/km^2 y para las cinco localidades evaluadas un tamaño promedio de grupo de tres individuos. Comparando los intervalos de confianza (Cumming et al., 2007), la densidad encontrada no presenta diferencia significativa con otras estimaciones hechas para la especie o al menos para especies gemelas en la cuenca del Amazonas en Perú (Aquino y Encarnación, 1986; Aquino y Encarnación, 1988), y en áreas cercanas a esta localidad en Colombia (Fidic, 2007; corregido de Hernández y Díaz 2010; Maldonado, 2011) (Fig. 2). No obstante, un resultado publicado por Maldonado (2011) el cual indica una densidad de cerca de 7 ind/km^2 en Perú, podría ser significativamente menor, pero este no fue tenido en cuenta, dado que presenta un coeficiente de variación de entre 3.3 y 4.1 ind/km^2, el cual deja por fuera el estimador puntual, reflejando un error en el análisis o en la presentación de los resultados.

La ausencia de diferencias significativas entre estos resultados puede deberse a que los coeficientes de variación de la densidad poblacional para todas las localidades fueron altos (>10 % para los que presentan medidas de dispersión). Esta imprecisión en la estimación de la densidad está influenciada usualmente, en mayor proporción, por la variación en la tasa de encuentro, producto del bajo número de transectos dispuestos para los muestreos (Hernández y Díaz 2010). El método de muestreo por distancia con transectos lineales, apegado al principio de replicación de inferencia estadística, está propuesto para ser implementado con un tamaño de muestra de entre 25 y 30 transectos (Buckland et al., 2001; Buckland et al., 2007; Buckland et al., 2010a; Thomas et al., 2010). No obstante, los estudios citados usan entre seis y ocho transectos y el presente 18. Es necesario diseñar muestreos con un mayor tamaño muestreal para aumentar la precisión de los estimados y de esta forma poder detectar diferencias espaciales y temporales si las hay (evitar cometer error tipo II al no detectar diferencias cuando las hay), y de esta forma poder tomar las decisiones de manejo correspondientes (Elzinga, 2001; Janson, 2011). A pesar de la imprecisión señalada, en general los resultados previos a este estudio indican que la densidad de esta especie está usualmente entre los 20 y 40 ind/km^2, valor que puede ser considerado como línea de base y umbral para definir objetivos de manejo, es decir, para determinar si es necesario aumentar o se puede mantener la densidad poblacional de la especie en las localidades evaluadas.

Con relación al tamaño de grupo, tres de seis estimaciones hechas recientemente (Maldonado, 2011; Hernández y Díaz, 2010) fueron significativamente menores (2.0 ± 0.22 en Chineria & Yahuma-Perú; 1.88 ± 0.16 en Vista Alegre-Perú y 2.05 ± 0.13 en Calderón, Maldonado, 2011). Las estimaciones de Mocagua (3.3 ± 1.4, Maldonado, 2011), Reservas Privadas-Colombia (3.5 ± 0.11 Maldonado, 2011) y San Juan de Atacuari-Siete de Agosto (2.74 ± 0.96 Hernández y Díaz, 2010) no resultaron significativamente diferentes. La estimación del tamaño de grupo en este estudio se hizo con base en grupos para los cuales se asumió conteo completo. Las estimaciones de los otros estudios se hicieron durante los muestreos para estimar la densidad.

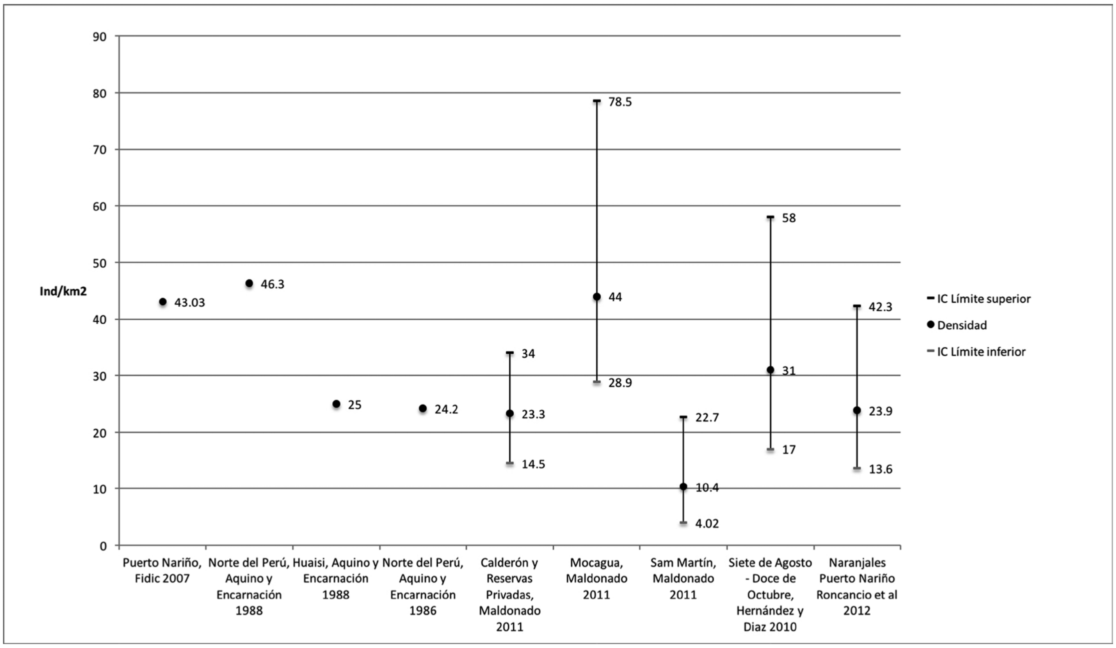

Figura 2. Comparación de densidades poblacionales de *Aotus* sp. en la cuenca del Río Amazonas.; Calderón, Mocagua, San Martín.

Cuando se estiman densidades poblacionales con el método de muestreo por distancias con transectos lineales, hacer el conteo completo de los grupos es usualmente difícil y esto se ve reflejado en relaciones encontradas entre el tamaño de grupo y la probabilidad de detección o entre la distancia perpendicular y el tamaño de grupo (cuando el grupo es más grande, mayor probabilidad de detección o, a mayor distancia perpendicular la estimación del tamaño de grupo tiende a ser menor, porque es más difícil contarlo); en este sentido, si se usa el tamaño medio de grupo, las densidades tienden a subestimarse; por tanto, la densidad debe ser calculada con el tamaño estimado de grupo dada la regresión (Buckland et al., 2007). Los estimados de tamaño de grupo presentados por Maldonado (2011) no especifican si son los estimados con base en la regresión o son el tamaño medio. Si son el tamaño medio de grupo contado durante los muestreos de densidad, probablemente estén subestimados, más aún, tratándose de una especie con hábitos nocturnos (Buckland et al., 2010a; Buckland et al., 2010b). Por otro lado, las diferencias encontradas, pueden estar reflejando cambios ecológicos reales y en este sentido habría que plantear hipótesis para dilucidar qué factores están determinando estas diferencias (Janson, 2011).

La relación machos adultos-hembras adultas es típica para las especies de esta familia, en donde los grupos están conformados por la pareja reproductiva y sus crías (Wright, 1978; Aquino y Encarnación, 1986; Aquino y Encarnación, 1988; Fernandez-Duque et al., 2001; Castaño et al., 2010; Hernández y Díaz, 2010). La población de *A. nancymaae* evaluada presentó una baja proporción de individuos inmaduros, con una relación hembras adultas: inmaduros (1: 0,5). Esta situación, de ser generalizada, podría llevar a un incorrecto remplazamiento de los individuos adultos (Defler, 1981). La relación entre el número de hembras adultas: inmaduros (juveniles más infantes), puede ser un indicativo del "estado de salud" de una población; donde relaciones menores a 1: 0,75 sugieren poblaciones en dificultades o en disminución (Heltne et al., 1976; Estrada et al., 2002). No obstante, sólo con estudios a largo plazo, se puede determinar si una población está aumentando o disminuyendo, o si simplemente existen fluctuaciones intra e interanuales en el número de individuos, debido a la variación intrínseca en la natalidad o supervivencia de los juveniles (Struhsaker., 1981). En este sentido, no se puede concluir acerca del impacto que generan los diferentes procedimientos (captura, extracción y liberación) del proceso de experimentación, a la población. Esta incertidumbre se asocia en primer lugar, con la falta de robustez de los diseños de muestreo y consecuentemente una baja potencia estadística que no permite comparar las densidades entre zonas con y sin intervención y, segundo, con la falta de trazabilidad de los animales capturados; integrantes de la comunidad local manifestaron que algunos de los individuos ingresados a la FIDIC como provenientes de Naranjales fueron extraídos realmente de la zona de Caballococha en el Perú. Adicionalmente las liberaciones pueden estar cumpliendo el papel de refuerzos o suplementos como estrategia de conservación basada en el desplazamiento de organismos vivos (UICN 2013). De los 150 individuos capturados, 19 eran individuos que estuvieron en la FIDIC y fueron liberados (basados en el hallazgo de los tatuajes de la FIDIC). Los animales encontrados tenían un tiempo de sobrevivencia de entre siete meses y tres años-nueve meses (según registros de Corpoamazonia). Todos los individuos capturados que estaban marcados pertenecían a grupos conformados por dos o tres individuos.

Con base en estos resultados consideramos que, todo el procedimiento de manejo de la especie y en general de las especies del género *Aotus* aprovechadas con fines biomédicos, debe ser revisado y ajustado muy conservadoramente considerando 1) la falta de conocimiento básico, especialmente de parámetros poblacionales, 2) que para *A. nancymaae* no había permiso de aprovechamiento dado que su presencia en Colombia no había sido confirmada, 3) que su área de distribución podría ser muy reducida (aproximadamente 652 km^2) (Maldonado et al., 2017) y, 4) que los protocolos de los diferentes procedimientos no garantizan trazabilidad de los sitios de extracción de los individuos para su posterior liberación (Roncancio, 2012) y por lo tanto no se puede evaluar el impacto de todo el proceso de aprovechamiento, ni planificar su manejo adaptativamente (CMP, 2007).

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FIRST RECORDS OF GASTROINTESTINAL PARASITES IN WOOLLY MONKEYS *(LAGOTHRIX LAGOTHRICHA)* IN COLOMBIA, FROM WILD, CAPTIVE AND REINTRODUCED INDIVIDUALS

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Abstract

Interest about parasites in vertebrate populations during translocation and reintroduction programs is increasing; thus, a description of parasites in captivity infecting animals to be relocated is necessary. This study aimed to characterize the communities of gastrointestinal parasites in woolly monkeys (*Lagothrix lagothricha*) from captive and wild individuals, as well as the change in parasite prevalence in four individuals during a reintroduction process. To accomplish this goal, we used a fecal flotation technique to analyze the collected samples. In captivity, 95% of the screened samples were infected with at least one parasite, while only 77% of wild primate samples showed infection, indicating higher prevalence in captive vs. wild individuals. Overall, wild and captive woolly monkeys shared many groups of parasites (Strongylidae, Oxyuridae and Entamoebidae) and we found a trend of lower parasite prevalence after release in captive individuals. Our data showed a consistent difference between captive and reintroduced individuals suggesting that variables related to diet, overcrowding and human presence may be the most important factors explaining parasite communities.

Keywords: conservation ex-situ, woolly monkeys, nematodes, intestinal parasites.

Resumen

El interés sobre el impacto de los parásitos en las poblaciones de vertebrados durante los programas de translocación y reintroducción ha aumentado últimamente; esto hace necesario una descripción de los parásitos que infectan a los animales en cautiverio que van a ser reubicados. El objetivo de este estudio fue el de caracterizar las comunidades de parásitos gastrointestinales en monos churuco (*Lagothrix lagothricha*) de individuos cautivos y silvestres, así como el cambio en la prevalencia de parásitos en cuatro individuos durante un proceso de reintroducción. Para lograr este objetivo, utilizamos una técnica de flotación fecal para analizar las muestras colectadas. En cautiverio, el 95% de las muestras examinadas estaban infectadas con al menos un parásito, mientras que solo el 77% de las muestras de primates silvestres mostraron infección, lo que indica una mayor prevalencia en individuos en cautiverio frente a los silvestres. En general, los monos churuco salvajes y en cautiverio compartieron muchos grupos de parásitos (Strongylidae, Oxyuridae y Entamoebidae) y se encontró una tendencia de menor prevalencia después de la liberación de los individuos. Nuestros datos mostraron una diferencia consistente entre individuos cautivos y reintroducidos, lo que sugiere que variables relacionadas con la dieta, hacinamiento y la presencia humana pueden ser los factores más importantes que explican las comunidades de parásitos.

Palabras clave: conservación exsitu, churucos, nematodos, parásitos intestinales

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Introduction

Primates are one of the most important taxonomic groups in terms of conservation challenges, due to the danger of extinction most of them face (Chinchilla et al., 2005; Estrada et al., 2017). Non-human primates are particularly susceptible to parasitic infections because they can get infected from other animal parasites, in spite of not being the primary host (Johnson-Delaney, 2009). In addition, primates are vulnerable to parasitic infections due to the social structure, which facilitates their transmission (Freeland, 1983). Habitat fragmentation and population size can also compromise the population's health and increase the prevalence and richness of parasites (Gillespie and Chapman, 2008; Püttker et al., 2008). That is the reason why the prevalence of parasites usually increases in smaller areas where the possibility of re-infection is higher caused by an unusual increase in primate crowding (Müller, 2007). This is the scenario in zoos and rescue centers, where high population densities and poor sanitation favor high prevalence of parasites (Guerrero et al., 2012).

Information about gastrointestinal parasites in Old-World primates is well known (Gillespie et al., 2005; Opara et al., 2010; Petrezelkova et al., 2010), on the contrary, in South America information gaps remain and an enormous sampling effort is needed (Hopkins and Nunn 2007). Woolly monkeys (*Lagothrix lagothricha*) are among the less well-known species and to our knowledge, in Colombia there are no studies describing gastrointestinal parasites either from wild or captive populations. These primates are critically endangered according to IUCN (2008) due to hunting pressure and habitat fragmentation that have reduced the natural populations of this species to local extinction in some areas (Stevenson and Aldana, 2008). In this context, the aim of this study is to provide a first characterization of gastrointestinal parasite communities in Colombian woolly monkeys (*Lagothrix lagothricha*) from captive and wild individuals, and to characterize the parasite community in four reintroduced individuals. We first evaluated if there were differences in the prevalence of gastrointestinal parasites between captive and wild individuals to evaluate if they shared the same parasites. Then, we compared these results with parasites found in reintroduced individuals into the wild, to assess the potential parasite loss or gain after release. We expected a higher density of zoonotic parasites in captive individuals, given their proximity to humans and their limited home range. Similarly, we expected a higher prevalence of parasites in captive primates compared to released ones as a result of changes in population density and diet.

Methods

Study Sites

Fecal samples from captive primates were collected between June and November 2015 in two different enclosure sites in Colombia. The first site was Fundación Bioandina located at Mesitas, Cundinamarca (4° 34’36.603”N, 74° 27’ 3.944”W). This captivity site is located at an altitude of 990 m a.s.l. with a mean annual precipitation of 1,561 mm, and temperature ranges between 17.3–26.8 °C. (Fig. 1).

Here we found five individuals, two adult females, one adult male, one sub-adult female and one juvenile female belonging to two subspecies (*Lagothrix lagothicha lugens* and *Lagothrix lagothricha lagothricha*). The individuals were found in two small enclosures located side by side permitting contact between them. The other site was Pereira`s Centro de Atención y Valoración (CAV), Risaralda (4° 48’ 17.176”N, 75° 47’ 1.687”W). This captivity site is located at an altitude of 1,411 m a.s.l. with a mean annual precipitation of 2,441 mm. Temperature ranges between 14.7–26.8 °C (Fig. 1). Here we found four individuals, two adult males, one adult female, and one juvenile female, also from both subspecies. All the individuals were located in a big enclosure enriched with sticks and planks to encourage their locomotion.

Samples from wild individuals were obtained between September 2010 to April 2013 from two groups of wild woolly monkeys (*L. l. lugens)* inhabiting a pristine forest in Parque Nacional Natural Cueva de Los Guacharos (PNNCG), Huila, Colombia (1° 33’ 0” N, 76° 7’ 59.998” W). This National Park is located in a montane forest with an extension of 9,000 hectares with a mean altitude of 2,000 m a.s.l. and a mean annual precipitation of 3,100 mm; temperature ranges between 12–20 °C (Fig. 1). Here we found two habituated woolly monkey groups varying in size from 18 to 27 individuals.

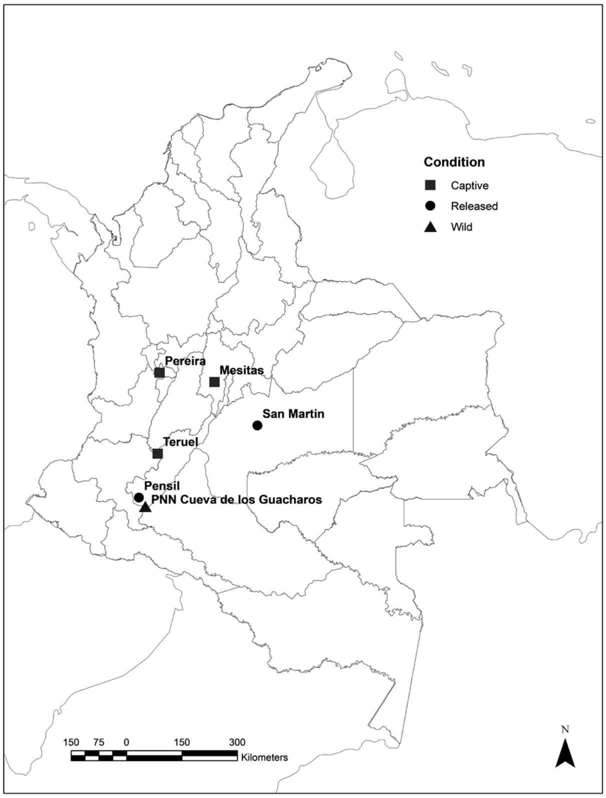

Figure 1. Map showing the different study sites where primates were sampled. The shape of the figures corresponds to the three different conditions of the sampled individuals.

Regarding reintroduced primates, fecal samples from two captive individuals were taken between March and July 2017 from a captivity site at Teruel’s CAV, Huila (2° 49’ 53.93”N, 75° 50’ 0.775”W). This captivity site is located at an altitude of 910 m a.s.l. with a mean annual precipitation of 1635 mm; temperature ranges between 19.1–30.3 °C (Fig. 1). The individuals shared a big enriched enclosure (260 m^3) with 10 other primates. They were fed twice a day with a mixture of fruits and vegetables that does not correspond to their diet in natural habitats. Individuals were released in August 2017 in a biological corridor located at El Pensil, Huila (1° 45’ 43.949”N, 76° 17’ 11.68”W). This forest is located at a mean altitude of 1,850m a.s.l. with a mean annual precipitation of 2,284 mm, and temperature ranges between 12–20 °C (Fig. 1). Fecal samples were collected from the moment of release through March 2018. The other two individuals were sampled in captivity at Teruel between March of 2018 and November of the same year and released in a Biological Reserve located in San Martín, Meta (3° 31’ 6.24”N, 73° 24’ 11.88” W). This release site is located at a mean altitude of 280 m a.s.l. and a mean annual precipitation of 2,513 mm; temperature ranges 25 – 28 °C (Fig. 1). Fecal samples were obtained from the time of release through April 2019.

Sample collection

Fecal samples were collected immediately after defecation and to avoid environmental contamination, only 2 grams of primate feces not in direct contact with the ground were sampled in 15 ml Falcon tubes filled with 10 % formaldehyde. Tubes were shaken to maximize the contact surface between the sample and formaldehyde. For each sample, study site, date, time, individual name and sex were recorded. The samples were kept at room temperature until transport to Laboratorio de Ecología de Bosques Tropicales y Primatología (LEBTYP) at Universidad de Los Andes, Colombia where they were stored until processing.

Sample processing

Samples were processed at Centro de Investigaciones en Microbiología y Parasitología Tropical (CIMPAT) at Universidad de los Andes, Colombia. For parasite identification, we followed the fecal flotation method suggested by Gillespie (2006), using a saline solution calibrated with a pycnometer at a specific gravity of 1.28. One gram of each preserved sample was placed in a 15 ml Falcon tube filled 2/3 with distilled water and the sample was homogenized. Then the sample was manually centrifuged for 10 minutes, the supernatant was discarded, and the fecal matter was re-suspended with the saline solution filling the tube to form an inverted meniscus where a cover slip was placed. After centrifuging manually for 10 minutes, the cover slip was removed and analyzed under a microscope using 4x, 10x and 40x magnification. Eggs, cysts and larvae were counted and measured with a micrometer. We used a drop of dilute Lugol's iodine solution (20 %) to facilitate the identification of protozoan cysts. Photos of representative individuals were taken.

Data analysis

Information of parasite prevalence was defined as the number of samples infected with one parasite group divided by the total number of samples taken in each study site. We performed Chi-square analysis between the prevalence of each group of parasites to identify the difference in parasite communities between study sites.

Results

A total of 185 samples were collected and analyzed. From these, 43 belonged to wild woolly monkeys, 41 to captive and 101 to reintroduced (56 taken when still in captivity and 28 after release into the wild at Pensil and 17 at San Martín). A great variety of gastrointestinal parasites was found: six Nematode families (Trichostrongylidae, Oxyuridae, Ancylostomatidae, Ascarididae, Strongylidae and Trichinellidae), eggs belonging to the class Cestoda and Trematoda, and one protist belonging to the family Entamoebidae (Fig. 2).

In captive individuals at Mesitas and Pereira, we found that 95 % of the samples had at least one parasite individual (egg, cyst or larvae) and 90 % had polyparasitism. We identified five groups of parasites: four members of the phylum Nematoda (Trichostrongylidae, Strongylidae, Trichinellidae and Oxyuridae) and one protist of the family Entamoebidae.

Families with higher prevalence were Oxyuridae (83 % of samples in Mesitas), and Trichstrongylidae (80 % in Mesitas and 88 % in Pereira).

We found significant differences between samples taken from primates in captivity sites (*X2* = 76.1, df = 5, $p < 0.01$) due to the fact that Pereira was the only study site where family Trichinellidae was recorded. When prevalence of parasitic families between the two captivity sites was compared, we only found significant differences in the Oxyruridae, for which Mesitas had a greater prevalence (*X2* = 9.96, df = 1, $p < 0.05$) (Fig. 3).

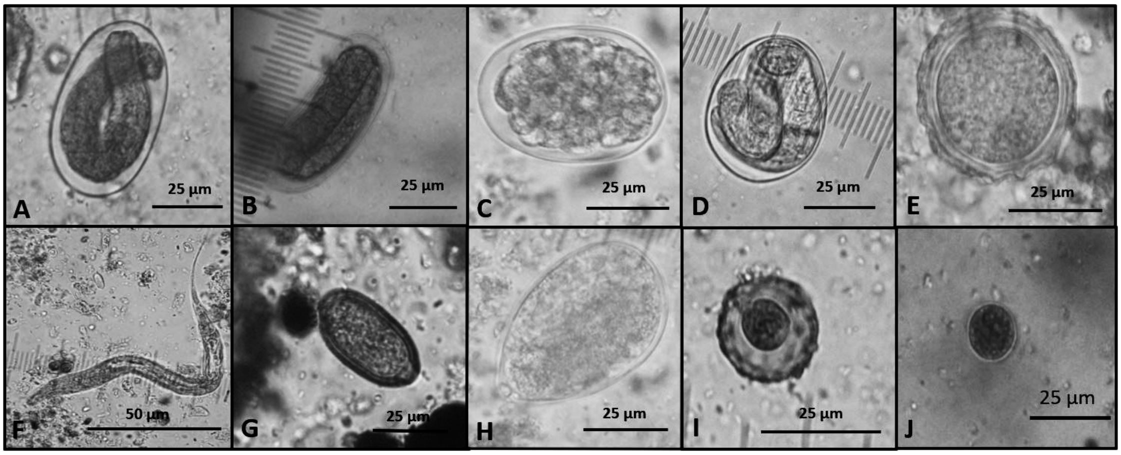

Figure 2. Gastrointestinal parasites found in captive and/or wild woolly monkeys. (A) Trichostrongylidae, (B) Oxyuridae, (C) Ancylostomatidae, (D) Ascarididae, egg without cortex (E) Ascarididae, (F) Strongylidae, (G) Trichinellidae, (H) Trematoda, (I) Cestoda, (J) Entamoebidae.

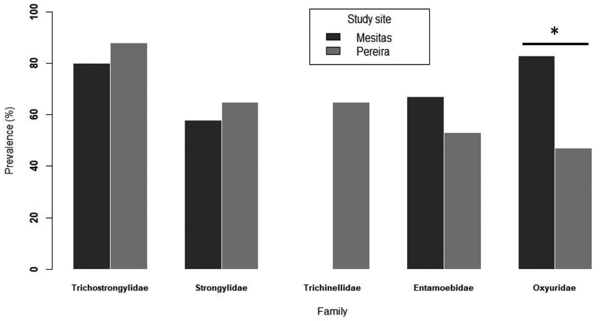

Figure 3. Prevalence of gastrointestinal parasites in woolly monkeys in each captive site. Mesitas (n = 24), Pereira (n = 17).

Regarding wild woolly monkeys at PNNCG, we found that 77 % of the samples analyzed had at least one parasite individual. We identified five groups of parasites: a protist from the family Entamoebidae, three nematode families (Oxyuridae, Ascarididae and Strongylidae) and one Cestode. We found that 46 % of the samples had Helminths and 42 % Protists.

When we evaluated the samples of the reintroduced individuals, we found eight groups of parasites, five helminths (Trichostrongylidae, Oxyuridae, Ascarididae, Ancylostomatidae and Strongylidae), one protist (Entamoebidae), one Trematode and one Cestode. In both reintroduction sites, we found significant differences between captive and released individuals (Pensil: $X2 = 57.8$, df = 8, $p < 0.01$ and San Martín: $X2 = 69$, df = 8, $p < 0.01$) where a prevalence reduction was shown in almost all parasite groups. Based on this result we separated the samples in captive and released categories for further analysis. We found an evident reduction of positive samples for almost all nematodes ($X2 = 31.692$, df = 8, $p < 0.01$) including families Trichostrongylidae, Oxyuridae, Ancylostomatidae and Ascarididae (Fig. 4).

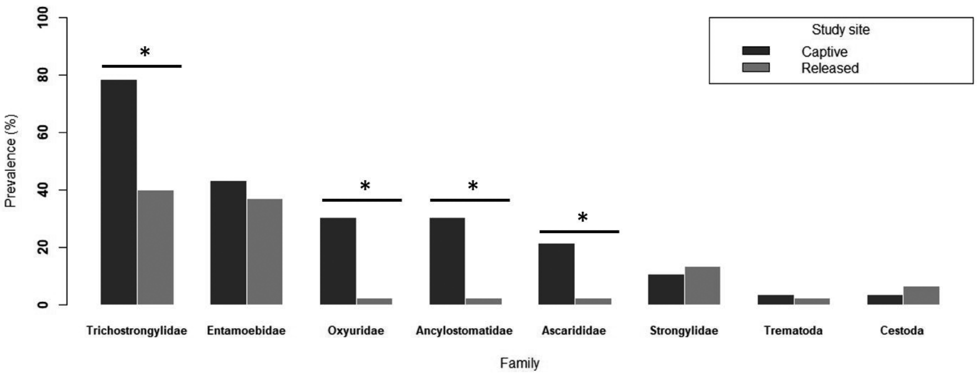

Figure 4. Prevalence of gastrointestinal parasites in woolly monkeys in captive (n = 56) and released (n = 45) individuals.

We observed that captive individuals had a higher prevalence of nematodes than wild and released ones but no differences in the prevalence of protists and cestodes were found. Also, we found that trematodes were present in captive and released individuals but not in the wild (Table 1).

Table 1. Prevalence (positive samples/total samples (*100)) of gastrointestinal parasites in captive individuals in Teruel, wild individuals at PNNCG and released individuals at Pensil and San Martín.

	Captive (n = 56)	Wild (n = 43)	Released (n = 45)
Nematodes	91 %	46 %	45 %
Protists	43 %	42 %	37 %
Trematodes	4 %	0 %	2 %
Cestodes	4 %	2 %	7 %

Discussion

For the first time, gastrointestinal parasites infecting captive and wild Colombian woolly monkeys were studied. As expected, many of the parasite families found have been reported in the same primate genus (Michaud et al., 2003; Larrañaga and Shanee, 2012; Pinto et al., 2013) but we found four new parasite records for these primates: Entamoebidae, Trichostrongylidae, Trematoda and Cestoda. We found differences between sites where primates were held in captivity since the family Oxyuridae had a higher prevalence in Mesitas compared to Pereira. This can be explained by the fact that these parasites are transmitted mainly by contact between individuals, and overcrowding in captivity can promote this behavior facilitating their transmission (González-Hernández et al., 2014). All parasites present in Mesitas and Pereira have been commonly reported in captivity sites or near urban areas in different primate species (Hasegawa et al., 2004; Soto-Calderón et al., 2016) and have been reported in humans, which may suggest possible zoonotic infections (Yamashita, 1963; Legesse and Erko, 2004). Parasites found in captivity were similar to the ones found in the wild at PNNCG. Three of the five parasite families found there (Strongylidae, Oxyuridae and Entamoebidae) were found in wild woolly monkeys with the exception of Trichinellidae and members of the Trichostrongylidae family that only appeared in captivity. Ascarididae and Cestoda were the parasites found in the wild that were absent in captivity.

As for the reintroduced individuals, we found a tendency to reduction in parasite prevalence after being released. These differences between sites can be associated to higher rates of infection in the captivity sites due to overcrowding, since primates share the enclosure with other 10 individuals. The higher prevalence of family Trichostrongylidae, Oxyuridae, Ancylostomatidae and Ascarididae may be because these parasites are geohelminths (Bethony et al., 2006; Botero and Restrepo, 2015) and infect the primates when they come into contact with the floor. The presence of members of the Ascarididae family supports this idea, since these parasites need a maturation time in the floor before being infective (CDC, 2010). On the contrary, released individuals have better chances to explore higher forest strata and avoid contact with these parasites. The higher prevalence of Oxyuridae may be explained by the reasons we mentioned before that these parasites are transmitted mainly by contact between individuals. A similar situation has been reported in spider monkeys, where the number of grooming interactions was positively correlated to the presence of *Strongyloides* and *Trichostrongylus* (Rimbach et al., 2015). Fewer encounters with conspecifics can then reduce the prevalence of parasites in released individuals when compared to those in captivity.

Another factor that may be influencing differences in parasite prevalence is primate diet. Many authors have reported a negative relation between the consumption of some plants and parasitic infections (Huffman et al. 1997; Stoner and González-Di Pierro 2006). Many of the plant families that primates consume in the wild and were not consumed in captivity belong to the families Moraceae, Rubiaceae, Araceae and Lauraceae, which have been found to have deworming effects (Waller et al. 2001; MacIntosh and Huffman 2010). These plant families are consumed by woolly monkeys in high and low lands (Stevenson et al. 1994 and Ramirez et al. 2014), perhaps a switch on the diet in reintroduced individuals promoted a reduction in some parasite prevalence's similar to the ones in wild individuals.

Our data showed a consistent difference between study sites suggesting that diet, overcrowding and human presence may be the most important factors explaining parasite communities in woolly monkeys in Colombia. We do not consider environmental variables to be playing an important role, since captivity sites were different among them, but similar in parasite communities; the same tendency was found in wild and released individuals. Due to the fact that some parasites were found in captive and released individuals, but not in the wild ones, we support the idea of restoring parasite-host balance before releasing the individuals as Armstrong and Seddon proposed (2008). To achieve this, it is convenient to reduce the number of individuals in an enclosure and limit the contact of the individuals with the ground to reduce infection rates and zoonotic infections. Additionally, it may be useful to provide the primates with deworming plants, mainly those common in the diet of wild woolly monkeys prior to reintroduction.

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SHORT ARTICLES

FUR RUBBING BEHAVIOUR IN FREE RANGING BENI TITI MONKEYS *(PLECTUROCEBUS MODESTUS)* IN BOLIVIA

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Introduction

Fur rubbing is a mammalian behaviour in which a foreign substance is vigorously rubbed over some parts of the body with hands or feet (Baker, 1996; Huffman, 1997; Paukner and Suomi 2012). This behaviour has been observed in Neotropical primate species using distinct substances such as plant parts or insects, and has been related to distinct functions. Health benefits of fur rubbing were inferred as protection against mosquito blooms in rainy months and for healing wounds from fur rubbing observed in white-faced capuchin monkeys (*Cebus capucinus*), as insecticidal – repellent and fungistatic properties were found in one of those plant species used (*Piper tuberculatum*; Huffman, 1997; Palacios et al., 2009; Bazán-Calderón et al., 2011). Repellent functions were also suggested for plants used in fur rubbing by robust capuchins, *Sapajus apella* (Paukner and Suomi, 2008).

The repellent functions of fur rubbing seem valid when substances are spread over most of the individual's body as was observed in white-faced capuchin monkeys (*C. capucinus*; Baker, 1996). Nevertheless, Campbell (2000) related extensive fur rubbing behavior as a part of social interaction in spider monkeys (*Ateles geoffroyi*), when they applied foreign substances on some parts of their bodies. Potential changes in olfactory cues between individuals after applying pungent substances to fur could increase affiliative intra-group interactions. However, after unexpected aggressive interactions were observed in captive capuchin monkeys (*Sapajus apella*) after fur rubbing behavior, Paukner and Suomi (2008, 2012) hypothesized that the medicinal purposes of fur rubbing could be more relevant than group cohesion ones.

Fur rubbing has also been observed in some titi monkey species. Individuals of *Cheracebus torquatus* rubbed fur from throat to chest with a small ball of wadded unidentified leaves wetted with saliva (Defler, 2010). Similar behaviour was observed in *Plecturocebus donacophilus* using leaves of *Piper tuberculatum* (Ryan, 2011), a plant with insecticidal and fungicidal properties (Palacios et al., 2009; Bazán-Calderón et al., 2011). Recently, important efforts have been made to increase natural history knowledge and promote conservation actions for *Plecturocebus modestus*, an Endangered titi monkey species endemic to Bolivia (Veiga et al., 2008; Martinez and Wallace, 2010, 2016; Wallace et al., 2013). Here we report fur rubbing using plants observed in individuals of two groups of *P. modestus*, during a behavioral study of the species. We provide details regarding plant species used, individuals involved, and seasonal variations in the frequency of fur rubbing, as well as attempt to elucidate the probable function of this behaviour.

Methods

We conducted our study at San Miguel cattle ranch located in the southwestern portion of the Beni Department, Bolivia (13°57'5.49"S, 66°50'5.07"W). This site, selected according to available distributional information for *Plecturocebus modestus* (Felton et al., 2006; Martinez and Wallace, 2007; Wallace et al., 2013), is in the Llanos de Moxos ecosystem characterized by a landscape dominated by a grassland matrix where forest patches are immersed (Hanagarth, 1993). We selected two groups of *P. modestus* to be observed. The Maramacho group had four individuals (adult pair, one juvenile and one infant) inhabiting an area of large forest patches (>10 ha), and the Corral group had two adult individuals occurring in an area of small forest patches.

We sampled the occurrence of unusual behaviours such as fur rubbing by means of *ad libitum* sampling (Altmann, 1974), registering the duration of each fur rubbing event. We observed the focal groups all day from sunrise to sunset for 10 days per month, during 12 months (July 2010 – June 2011) covering dry and wet seasons. We calculated absolute frequencies and time accumulated in fur rubbing for each focal group and individual. Plant species used in fur rubbing were collected and voucher specimens were identified at the Bolivian Herbarium in La Paz.

Results

In all our observations, fur rubbing consisted of an individual harvesting leaves of a plant that were then chewed for a short time, before the monkey rubbed the chewed plant mixture against its throat and chest with repeated energetic vertical movements. Titi monkeys used both hands for this task and chewed the leaves several times while they sat upright on branches, looking ahead. Although the behavioural display was similar between focal groups, the plant species used varied. Individuals of the Maramacho group used leaves of the herb *Piper callosum* (Piperaceae, collection number FZR-17816), while the Corral group used leaves of the vine *Tynanthus schumannianus* (Bignoniaceae, collection number FZR-17817). Leaves of both plant species had a mint smell and were dropped after fur rubbing. They were never eaten.

Most of the fur rubbing observed was performed by the Corral group in the small forest patches (18 events, 73 minutes, on 8 days), and both adult individuals performed this behaviour (Table 1). Fur rubbing was less frequent in the Maramacho group (3 events, 7 minutes, on 2 days) where only the adult male and juvenile female performed fur rubbing.

Table 1. Accumulated time and frequency of fur rubbing for each individual of focal groups of *Plecturocebus modestus* (rows in bold correspond to total time for each group).

Group	Individual	Age	Sex	Time accumulated [min] (number of events)		
				Total	Rain	Dry
CORRAL	Mandingo	Adult	Male	38(9)	31(7)	7(2)
	Natusha	Adult	Female	35(9)	35(9)	0(0)
				73(18)	**66(16)**	**7(2)**
MARAMACHO	Timoteo	Adult	Male	4(2)	4(2)	0(0)
	Lita	Juvenile	Female	3(1)	3(1)	0(0)
				7(3)	**7(3)**	**0(0)**
Total				**80(21)**	73(19)	7(2)
Observation time (hours)						
CORRAL				**1143.8**	**582.8**	**561.0**
MARAMACHO				**1235.7**	**619.0**	**616.7**

The adult male of the Maramacho group performed fur rubbing alone one time (15% of the fur rubbing group time), and once just before the juvenile female (85% of the accumulated group time). For the Corral group, most of the fur rubbing was performed by the adult pair simultaneously (5 of 8 days, 84.9% of accumulated group fur rubbing time), on two days the male fur rubbed alone (9.6% of fur rubbing time), and on one day the female fur rubbed alone (5.5% of fur rubbing time). Titi monkeys performed fur rubbing separately, without any kind of body contact between them, even in those cases when two individuals were engaged in this activity in close proximity. Fur rubbing was observed almost exclusively in the wet season except two events involving the adult male of Corral group (9.6% of accumulated group time, Table 1).

No special situations were observed on the days when the individuals of Maramacho group performed fur rubbing. On two of the days when individuals of the Corral group performed fur rubbing, we observed the adult male grooming the adult female, and on one day he tasted the female's urine. However, grooming was commonly observed in this group (37% of observation days) and although only three events of urine testing were observed during the study, none of these observations occurred just after fur rubbing; they occurred over a half an hour later.

Discussion

Plant species observed in fur rubbing by individuals of *Plecturocebus modestus* are used in traditional medicine by Amazonian people. Brazilian and Bolivian people prepare a tea or poultice with leaves and stem pieces of *Piper callosum* to treat digestive and diuretic illnesses, and fungistatic, insecticidal, and antilarval properties found in this plant suggest its use as repellent (Souto et al., 2012; Silva et al., 2017; Bolivian Herbarium database). Similarly, tea made with fruits and stem pieces of *Tynanthus schumannianus* is traditionally used for treatment of diarrhea in Bolivia, while active compounds for treatment of malaria were also found in fruits of this vine with no apparent use as repellent (Muñoz et al., 2000; Cansian et al., 2015). This plant is used also to treat conjunctivitis and as women's perfume (Bolivian Herbarium database). As Beni titi monkeys did not ingest the plants used in fur rubbing, some external function such as repellent seems feasible for *P. callosum*.

Several primate species have sternal glands whose secretions are used for scent marking (Ewer, 1968). Spider monkey (*Ateles geoffroyi*) fur rubbing was related to scent marking, rubbing the chest against a substrate that seemed to stimulate secretions of sternal glands (Campbell, 2000). As scent marking shares diverse types of information about an individual (such as identity, condition, and social rank), fur rubbing could be related to social interactions through chemical communication (NRC, 1998). Scent marking using the sternal gland was reported for *Plecturocebus moloch* and *Cheracebus torquatus*, rubbing their chest on branches, although with no clear function (Moynihan, 1966; Kinzey, 1981). Chest rubbing seemed to help re-establish friendly relationships between individuals of captive *C. torquatus* after prolonged separation (Fernandez-Duque et al., 1997). The fact that we did not observe any scent marking behaviour nor prolonged separations of groups' individuals linked to fur rubbing, discards the scent marking function for fur rubbing in our groups of *Plecturocebus modestus*.

Capuchins and owl monkeys engage in social fur rubbing, with the participation of several individuals, using highly available rubbing materials such as mud, ants, or plant leaves, while solitary fur rubbing occurred with less abundant materials such as flowers or millipedes (Lynch et al., 2012). The same authors describe different levels of contact between individuals, such as rubbing on each other, or individuals rubbing their body against another whom already applied the rubbing substance. In our study, individuals performed fur rubbing with plants separately. Additionally, despite some coincidence of fur rubbing with grooming, there was not a direct relationship between the two behaviours that could suggest some social context for our fur rubbing observations.

Chemical communication could also help reproductive success, as was observed in sifakas (*Propithecus verreauxi*). Males of this species with stained chests caused by sternal gland secretions had higher copulation rates than males with clean chests (Dall'Olio et al., 2012). The only link we could report between fur rubbing and mating was when the Corral group male drank female's urine on the same day, but considerably later than the fur rubbing event. The assessment of females' fertility by male individuals based on drinking their urine has been reported for other mammals including the owl monkey *Aotus nancymaae* (Wolovich and Evans, 2007). Nevertheless, one isolated observation does not provide strong evidence for a link between mating behavior and fur rubbing.

Repellent functions, as well as usefulness against bacterial or fungal skin infections, were attributed to fur rubbing when substances were applied to almost the entire body, and especially during rainy season when risks of insects' bites and infections are higher (Huffman, 1997). This was observed in capuchin monkeys such as *Cebus capucinus* (Baker 1996), *Sapajus cay* (Giudice and Pavé, 2007), and *S. apella*, as well as distinct species of *Aotus* owl monkeys (Zito et al., 2003). In our case, the titi monkeys rubbed their throat and chest in a similar way as reported for *Cheracebus torquatus* (Defler, 2010), *Plecturocebus donacophilus* (Ryan, 2011), and *P. oenanthe* (Huashuayo-Llamocca and Heymann, 2017). The dense and long hair of titi monkeys, including *P. modestus* (Lönnberg, 1939; Martinez et al., 2013), would help prevent access to skin for biting insects, except for ventral zones with shorter and less dense hair, probably more vulnerable to insect bites. The marked occurrence of our fur rubbing observations during the wet season corresponds with the period of higher risk of insect bites due to increase of insect abundances (Huffman, 1997). Moreover, our focal groups occurred in ecotones of forest and savannahs with higher insect diversity than single habitats, including mosquito species that can be vectors of tropical diseases (Thongsripong et al., 2013). It is likely that a high abundance of mosquitos or other biting insects could be promoting the need of a repellent. Therefore, our observations of *P. modestus* treating their most vulnerable body areas with plant substances during the riskiest insect bite months suggest repellent as the most likely function of fur rubbing for this species.

We presented data on an uncommon behaviour observed in wild individuals of *Plecturocebus modestus*. Although we did not determine a conclusive function of fur rubbing, we provide valuable considerations for further research on the ecology of this endemic and threatened primate.

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GEOGRAPHICAL AND ALTITUDINAL RANGE EXTENSION OF WHITE-BELLIED SPIDER MONKEYS (*ATELES BELZEBUTH*) IN THE NORTHERN ANDES OF COLOMBIA

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Introduction

The geographic distribution of white-bellied spider monkeys (*Ateles belzebuth*) has been debated extensively, and there is no consensus on the historical continuity or discontinuity of its wild populations. Currently, white-bellied spider monkeys are known to have a disjunct distribution located across three regions: [1] the western piedmont of the Eastern Andes and the lowland rainforests of Colombia, [2] the forests in western Amazonia in Ecuador and Peru, as well as from [3] southern Venezuela and northwestern Brazil (Fig. 1). As mentioned by the IUCN Red List Assessment: "The distribution of this species is not well known and defies easy description" (Link *et al.*, 2019).

In Colombia, white-bellied spider monkeys are present in the lowland rainforests of Tinigua and Macarena National Parks, especially near the piedmont of the Eastern Andes. Some populations also occur in Guaviare and Caquetá departments, and a few "anecdotal" records have been documented in south-eastern Colombia. Nonetheless, Defler (2003) proposed that this handful of records in south-eastern Colombia actually correspond to isolated individuals, including two spider monkeys that were hunted by local persons given its rarity in the region. These spider monkeys are not present across a broad area of the Amazonian rainforests in Colombia (e.g. Amazonas department), nor are they found in northern Ecuador, north of the Cuyabeno River. Thus, based on reliable records, it seems that populations of white-bellied spider monkeys are divided into at least three disjoint populations (Fig. 1). The biogeographical, ecological and even anthropological drivers of this discontinuous distribution are still unknown.

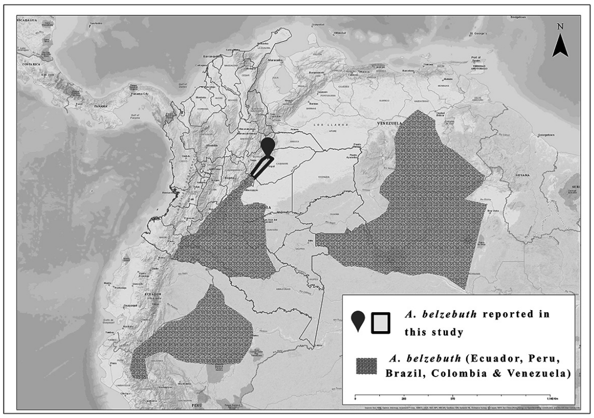

Figure 1. Geographical distribution of *Ateles belzebuth* (IUCN 2019). Shadow denotes reported populations and grey symbol denotes the northern population newly registered in this study.

The white-bellied spider monkey is classified as Endangered by the IUCN Red List (Link *et al.*, 2019) mainly due to the loss of habitat and the estimated reduction of its populations during the last decades. The demographic dynamics of white-bellied spider monkeys have been studied in the Ecuadorian and Colombian Amazon (Shimooka et al., 2008; Link et al. 2018) and it is clear that they have one of the slowest development cycles amongst living primates, with extended periods of infancy and sexual immaturity (Link et al., 2018). It has been proposed that their slow life history variables partly account for their high vulnerability to anthropogenic threats (Michalski & Peres, 2005). White-bellied spider monkeys also have long periods of development. Females begin reproducing only when they are approximately 7 – 9 years, most often have singletons (but see Link et al 2006), and have inter-birth intervals of approximately 30 – 36 months (Shimooka et al., 2008; Link et al., 2018). Spider monkeys also prefer undisturbed forests where they use large areas (160 – 400 hectares) to search for food, especially ripe fleshy fruits (Di Fiore et al., 2008). Spider monkeys' large body size makes them preferred hunting items for many indigenous and local communities, posing a strong threat on their wild populations (Franzen, 2008).

Here, we report on a previously unknown population of white-bellied spider monkeys living in the highland forests in the Eastern slope of the Eastern Andes in Colombia, in the departments of Casanare and Boyacá. This population accounts for the northern-most record of white-bellied spider monkeys in the Andes Piedmont in Colombia, and is present in highland forests that extend its altitudinal range to over 1,800 m. a.s.l. Given that in the Colombian Andes during the last centuries there has been a dramatic transformation of natural forests into agricultural fields and pastures for cattle ranching (Etter and van Wyngaarden, 2000; Armenteras et al., 2011), it is possible to speculate on the historical presence of a large and continuous population that might have been connected to those extant populations in northwestern Amazonia through a lowland and highland forest corridor west of the natural "Colombian and Venezuelan Llanos" savannas. We discuss the implications of these new records in light of the urgent need of conservation for these endangered primates in the Neotropics.

Methods

Study area.

The forests where the initial sightings of white-bellied spider monkeys took place in 2014 are located in the Eastern slope of the Eastern Andes cordillera, in the municipality of El Yopal - Corregimiento El Morro, vereda Marroquín - (5° 29.938'N, 72° 26.818'W) (Fig. 2), in Casanare Department. In 2018, we found other groups of white-bellied spider monkeys in forest fragments in the same broader region, specifically in the municipality of La Paya – veredas Guayabal de la Peña, La Unión and Milagros - (5° 35.626'N, 72° 21.218'W), in the department of Boyacá. The two localities are roughly 15 km apart.

According to Holdridge (1979) the area is considered as a premontane very humid forest and is characterized by steep mountains that oscillate between 1,100 and 2,200 m. a.s.l. Precipitation patterns are unimodal, with a rainy season from April through November, and a dry season from December through March. Annual rainfall ranges between 2,000 – 4,500 mm and average temperature oscillates between 12°C – 18°C (IGAC, 1999). The landscape is comprised by a matrix of pastures devoted to cattle ranching, subsistence agricultural plots and remnants of secondary and primary forests. Most forests have been selectively logged for timber but otherwise remain intact, although deforestation takes place in the broader region; between 2014 -2016, 114 ha of primary and secondary forests were cleared in the Paya alone (Pinza, unpublished data). However, since 2018, a payment for ecosystem services (PES) strategy is being implemented through Voluntary Conservation Agreements, where the owners of the forests receive monetary incentives from an oil company that operates down at the basin, as an environmental compensation, to preserve the forest for at least three years.

Characterization of the population of white-bellied spider monkeys in Casanare and Boyacá

We began to collect systematic data on the population of white-bellied spider monkeys at Yopal in 2018 and at Paya in 2019 (Fig. 2), as part of a regional on-going initiative to protect and conserve *Ateles belzebuth* in the premontane forests of the north-eastern Andes. We conducted population surveys at El Yopal in order to estimate primate population densities following the line transect methods proposed by Peres (1993) and Buckland et al. (1993). At Paya, we conducted *ad libitum* surveys in the forests during January and February in 2019 and conducted line transect surveys from April to September of the same year. For every visual observation of white-bellied spider monkeys we recorded the time of day, the number of individuals with age and sex categories whenever possible, and the location using a hand-held Garmin GPSMAP 64s Topo COL 100K GPS Handheld Receiver with 2.6-Inches Blacklit Display. Additionally, we conducted semi-structured interviews with locals in order to obtain information on the presence or absence of white-bellied spider monkeys in the different forest fragments in the broader region. We also asked for more detailed information (whenever possible) on the number of groups/subgroups present, specific behaviors and vocalizations, or other information about the species.

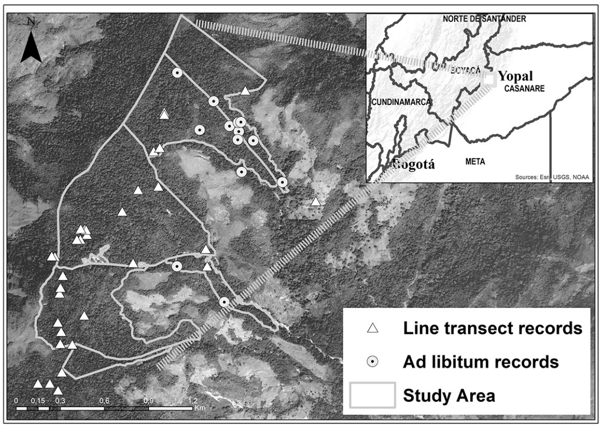

Figure 2. Records of *Ateles belzebuth* at Paya, Boyacá. Circles denote records from ad libitum surveys from January to February 2019; Triangles denote records from line transect surveys from April to September 2019.

Results

During the initial surveys (July to October 2018) at the municipality of Yopal we were unable to visually record the presence of *Ateles belzebuth*, however we were able to record several long-distance vocalizations, thus confirming their presence in the area. Moreover, the interviewees confirmed the presence of white-bellied spider monkeys in the adjacent forest fragments, and from the information gathered during these interviews we could infer the presence of at least two subgroups of around six individuals in different parts of the forest as well as solitary females traveling through the fragments, as expected given the high degree of fission-fusion dynamics described for the genus *Ateles* (Symingon, 1990; Aureli and Schaffner, 2008).

On the other hand, at Paya (January to March and April to September 2019) we obtained 56 sightings of subgroups of *Ateles belzebuth* in 170 ha of continuous forest (Appendix 1). The subgroups ranged in size from 1 to 9 individuals with a mean subgroup size of 3.8 individuals (SD = 2.5) (Appendix 1). This matches the information given by the peasants, who had seen groups between 2 and 5 individuals of *Ateles belzebuth* in both fragments, and closely resembles the average subgroup size of other populations of white-bellied spider monkeys in lowland forests (Link & Di Fiore, 2013).

In both localities, locals described two vocalizations: a long-distance call and a "barking" or "repeated bark" alarm call, previously described for several species of spider monkeys (Eisenberg, 1976; León & Link, 2013). Through hearing long-distance vocalizations, we were able to confirm the presence of *Ateles belzebuth* at Yopal, and to locate the subgroups during the ad libitum and transect surveys at Paya.

Discussion

The distribution of white bellied spider monkeys has been a matter of debate, given the current discontinuity between populations found on the eastern slope of the eastern Andes cordillera and in the Amazon rainforests (Link *et al.,* 2019). This study adds to this debate by documenting the northernmost populations of *Ateles belzebuth* in the Andes, and extending the distribution of this taxon for approximately 130 km from the locations of specimens collected in 1920´s and 1950´s in the departments of Cundinamarca and Meta, respectively (Fig. 2). Also, these records expand the altitudinal range for white-bellied spider monkeys from 1,300 m. a.s.l. (Hernandez-Camacho & Cooper, 1976) to 1,800 m. a.s.l. This geographical and altitudinal expansion poses an additional question about the continuity of these recently recorded populations with those in northwestern Amazonia in Colombia, and adds to the complexity of its current geographical distribution.

The biogeography of spider monkeys (*Ateles spp.*) has been largely explained by the separation of major clades due to riverine and mountain barriers (Collins & Dubach 2000; Morales-Jiménez et al. 2015). Nonetheless, these northern populations of white-bellied spider monkeys are currently located about 200 km south of records of brown spider monkeys (*Ateles hybridus*) with no evident geographical barriers between them. In the 1960´s there is a record of *Ateles hybridus* in Cucuta, Norte de Santander department, Colombia (see Defler, in press), and currently there is a population of brown spider monkeys at Caparó, in Venezuela (Aliaga-Samanez et al., 2017) (Fig 3). Thus, populations of both taxa might be currently in a process of range expansion (and have not reached a contact zone), or might have occupied these areas and have been locally extirpated elsewhere except for limited current residual populations.

The status of white-bellied spider monkeys in the northern Andes of Colombia is largely unknown and efforts should be made to better understand the size of this highland population, in order to plan successful conservation strategies. Mountain forests in Colombian Andes have been heavily degraded during the last centuries (Etter and van Wyngaarden, 2000), and the broader region where white bellied spider monkeys have been recently recorded in the Andes has high levels of forest fragmentation. Thus, understanding how common or rare is the presence of *Ateles belzebuth* in these forest fragments might drive conservation strategies focused on a few fragments or, in restoring connectivity between isolated populations, amongst other conservation actions. Studies on the ecology and behavior of *Ateles belzebuth* in highland forests are urgently needed to better understand the ecological flexibility of these endangered primates, as most of the information on the species has been recorded on populations in lowland Amazonian forests (Stevenson et al., 2000; Link et al., 2018).

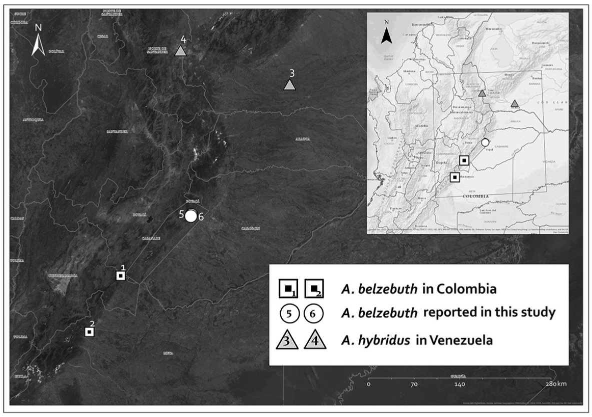

Figure 3. Records of *Ateles belzebuth* (1, 2, 5, 6) and *A. hybridus* (3,4) in Colombia and Venezuela. Circles (5, 6) show this study data at Casanare and Boyacá; Triangles show literature reports of nearest populations of *A. hybridus* and, Squares show literature reports of *A. belzebuth*. 1. Mambita, Cundinamarca, [N 4°45.08112´, W-73°19.6705´], 1923, AMNH76784, AMNH62815. 2. Villavicencio, Acacías, Meta, [N3°59.2285´, W-73°45.6075´], 1956, FMNH85816. 3. Caparó, Venezuela, [N7° 25.3´, W-70°59.7166´], 2014, direct observation, 4. Cúcuta, rio del Oro, [N7° 53.4963´, W-72° 30.102´], 1965, ICN1033.

In conclusion, the record of a new population of white-bellied spider monkeys living in the highland forests of the northern Andes of Colombia creates the need to prioritize urgent conservation actions to study and better understand spider monkey evolutionary history and behavioral flexibility, that allows them to adapt to highland ecosystems. *Ateles* may well represent some of the most important seed dispersers (see Link & Di Fiore, 2006; Dew et al., 2008) for these mountain forests, and may be playing a crucial role in the maintenance of the structure and composition of these threatened ecosystems (Link & di Fiore, 2006). Finally, given the high vulnerability of spider monkeys to anthropogenic pressure, spider monkeys can be used as flagship species; focusing conservation efforts on their wild population can drive indirect conservation of a large biodiverse ecosystem in the global biodiversity Hotspot of the Northern Andes in the Neotropics.

Appendix. Visual records of *Ateles belzebuth* at Paya, Boyacá, January to September 2019.

Date	Coordinates	Altitude (m)	Group size
21/01/2019	N5° 36.262’ W-72° 20.907’	1425	3
22/01/2019	N5° 36.373’ W-72° 20.998’	1610	3
23/01/2019	N5° 36.282’ W-72° 20.940’	1361	7
24/01/2019	N5° 36.232’ W-72° 20.910’	1329	3
25/01/2019	N5° 36.228’ W-72° 20.853’	1355	4
26/01/2019	N5° 36.268’ W-72° 21.050’	1460	6
28/01/2019	N5° 35.635’ W-72° 20.962’	1218	5
29/01/2019	N5° 36.113’ W-72° 20.897’	1311	3
31/01/2019	N5° 36.295’ W-72° 20.908’	1466	2
1/02/2019	N5° 36.297’ W -72° 20.898’	1460	1
29/04/19	N5° 36.606’ W -72°21’036’	1836	4
29/04/19	N5° 36’606’ W -72°21’029’	1833	1
29/04/19	N5° 36’560’ W -72°21’016’	1794	1
14/05/19	N5° 36.413’ W -72° 20.882’	1547	3
17/05/19	N5° 36.005’ W -72° 20.624’	1576	3
17/05/19	N5° 36.005’ W -72° 20.624’	1576	3
17/05/19	N5° 36.005’ W -72° 20.624’	1576	3
17/05/19	N5° 36.005’ W -72° 20.624’	1576	3
21/05/19	N5° 35.780’ W -72° 21.297’	1453	2
21/05/19	N5° 35.969’ W -72° 21.336’	1608	2
24/05/19	N5° 36.335’ W -72° 21.180’	1734	4
28/05/19	N5° 36.049’ W -72° 21.277’	1593	1
28/05/19	N5° 36.190’ W -72° 21.220’	1602	3
6/06/19	N5° 36.325’ W -72° 21.180’	1690	1
15/06/19	N5° 35.379’ W -72° 21.560’	1635	4
26/06/19	N5° 35.313’ W -72° 21.574’	1611	1
2/07/19	N5° 36.203’ W -72° 21.197’	1658	6
16/07/19	N5°59174° W -72°.35986°	1388	2
17/07/19	N5° 35.903’ W -72° 21.491’	1690	8
17/07/19	N5° 35.804’ W -72° 21.584’	1740	1
17/07/19	N5° 35.806’ W -72° 21.596’	1759	1
23/07/19	N5° 35.338’ W -72° 21.648’	1508	2
30/07/19	N5° 35.885’ W -72° 21.466’	1668	8
30/07/19	N5° 35.867’ W -72° 21.502’	1693	9
31/07/19	N5° 35.867’ W -72° 21.490’	1687	3
31/07/19	N5° 35.905’ W -72° 21.474’	1687	9
4/08/19	N5° 35.866’ W -72° 21.503’	1694	7
26/08/19	N5° 35.831’ W -72° 21.029’	1275	1
26/08/19	N5° 36.061’ W -72° 21.203’	1548	1
26/08/19	N5° 35.902’ W -72° 21.469’	1684	4
29/08/19	N5° 35.669’ W -72° 21.567’	1734	6
29/08/19	N5° 35.588’ W -72° 21.477’	1641	3
30/08/19	N5° 35.480’ W -72° 21.521’	1579	1
30/08/19	N5° 35.481’ W -72° 21.521’	1579	5
30/08/19	N5° 35550’ W -72°21.582’	1683	5
3/09/19	N5° 35.906’ W -72° 21.489’	1699	1

Date	Coordinates	Altitude (m)	Group size
3/09/19	N5° 35.767' W -72° 21.024'	1254	3
4/09/19	N5° 35.562' W -72° 21.574'	1723	7
5/09/19	N5° 35.528' W -72° 21.562'	1684	9
6/09/19	N5° 35.484' W -72° 21.565'	1670	9
6/09/19	N5° 35.734' W -72° 21.555'	1774	3
13/09/19	N5° 35.338' W -72° 21.604'	1617	6
13/09/19	N5° 35.690' W -72° 21.564'	1749	3

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PRIMER REGISTRO DE *PITHECIA MILLERI* (ALLEN, 1914) EN LA BAJA BOTA CAUCANA, CORREGIMIENTO DE MIRAFLOR, MUNICIPIO DE PIAMONTE, CAUCA

Laura Suárez
Hugo Mantilla-Meluk

Introducción

Los monos voladores o sakis, comprenden las especies de menor tamaño entre los Pitheciines y son considerados habitantes típicos de los bosques de varzea, igapó y tierra firme en la Amazonía (Rylands, 1988; Rylands y Mittermeier, 2009). *Pithecia milleri*, descrita como una especie separada de *P. monachus* en 1914 por Allen, fue remitida a subespecie de *P. monachus* por Hershkovitz (1987), criterio aceptado para las poblaciones de Colombia por Defler (2004); siendo elevada de nuevo al estatus específico por Marsh (2014). Es poca la información que en la actualidad existe sobre esta especie, considerada a la fecha en la categoría Datos Deficientes (DD) por la Unión Internacional para la Conservación de la Naturaleza (Marsh, 2015); dicho desconocimiento, sumado a la degradación por deforestación de los ambientes que ocupa en la porción de su distribución en Colombia, son las principales amenazas para este taxón. Según García *et al.,* (2017) *Pithecia milleri* se distribuye en Colombia entre los 200 y 1,070 m.s.n.m., sobre el flanco oriental de la Cordillera Oriental, en el Piedemonte Andino-Amazónico, con límite norte en San Vicente del Caguán, en el departamento del Caquetá, cubriendo las cuencas del río Caguán hasta su desembocadura en el río Caquetá; y al sur, a través del interfluvio de los ríos Caquetá y Putumayo, hasta el límite de los departamentos del Putumayo y Amazonas en la población de Guaquirá. A pesar de que la presencia de la especie fue sugerida para la Bota Caucana por García *et al.,* (2017), a la fecha no se cuenta con registros de *P. milleri* para el departamento del Cauca.

Observaciones y discusión

En el marco del desarrollo de las actividades de campo del proyecto Densidad Poblacional y Estructura de grupo de *Plecturocebus caquetensis* en la Baja Bota Caucana, bajo financiación de la Primate Society of Great Britain (PSGB), se reportan los primeros registros de mico volador (*P. milleri*) para el municipio de Piamonte, departamento del Cauca, en la Baja Bota Caucana (Fig. 1), correspondientes a tres avistamientos independientes: i) observación de un individuo solitario, el día 17 de septiembre de 2018 a las 7:07 horas, en el fragmento de bosque La Floresta, ubicado en el Resguardo Indígena Inga "La Floresta-La Española" corregimiento de Miraflor, municipio de Piamonte, en un bosque de tierra firme de Piedemonte a 302 m.s.n.m. (dosel denso: 15 –20 m) (1° 1'22.38"N, 76°26'29.77"O).

El individuo observado se encontraba posado sobre un árbol de Yarumo negro (*Cecropia angustifolia)* de 15 m. Al observar al investigador realizó despliegues agonísticos, emitiendo gruñidos y balanceando su cuerpo de un lado al otro en repetidas ocasiones, para luego huir rápidamente saltando en el estrato medio del bosque. De acuerdo al patrón de distribución y coloración del pelaje de la especie, y las características registradas para este individuo, consideramos que el individuo observado era una hembra; presentaba extremidades y cola con pelos largos negruzcos con puntas blanquecinas y manos con pelos blanquecinos, en contraste con lo reportado por Allen (1914) para los machos: puntas de los pelos en extremidades y cola de color amarillento pálido, y de color blanco amarillento en sus manos, ii) observación de un individuo solitario el día 26 de septiembre de 2018 a las 7:44 horas, en el fragmento de bosque La Floresta, 294 m.s.n.m. (1° 1'23.66"N, 76°26'31.40"O). Este individuo fue observado posado sobre un árbol (no identificado) de 12 m; al observar al investigador emite gruñidos y emprende la huida rápidamente. Quizá, este individuo sea el mismo reportado para el primer avistamiento ya que se encontraba a unos 60m de distancia del primer punto de observación reportado y era una hembra, iii) observación de dos parejas de sakis, realizadas el día 8 de octubre de 2018 a las 13:30 horas en un corredor de bosque que conecta el fragmento de bosque La Floresta y un segundo fragmento sin nombre (1° 0’47.41”N, 76°26’11.80”O). Las parejas de *P. milleri* se avistaron posadas sobre árboles de aproximadamente 20m de altura, distanciados 30m entre sí. El reporte corresponde a una comunicación del señor Nixon Palacios, dueño del predio y habitante de la localidad de Miraflor por más de 40 años. En sus palabras describe los monos como “una especie rara, nunca vista en la zona, de pelaje denso, negruzco y con canas”.

Estos registros en conjunto confirman la distribución de *P. milleri* para el área de la Bota Caucana, Departamento del Cauca, sugerida por García *et al.* (2017). Se llama la atención sobre la necesidad de realizar expediciones e investigaciones en los límites de su distribución, pues la carencia de información, sumada a la creciente deforestación, exigen la formulación pronta de estrategias para la conservación de la especie.

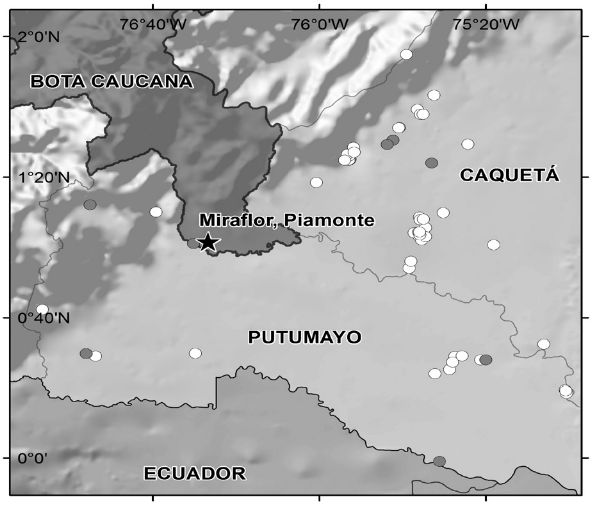

Figura 1. Primer registro de *Pithecia milleri* (estrella negra), para la Baja Bota Caucana (área en gris), y registros de la especie soportados por datos museológicos (puntos grises) y observaciones en campo (puntos en blanco). Modificado de García *et al.,* 2017.

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EVIDENCE OF OPOSSUM (*DIDELPHIS* SP.) PREDATION BY WHITE-FRONTED CAPUCHINS *(CEBUS YURACUS)* IN THE COPALLÍN PRIVATE CONSERVATION AREA, AMAZONAS, PERÚ

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Introduction

Capuchin monkeys (Genera *Cebus* and *Sapajus*) are omnivorous and known to opportunistically prey on small vertebrates including frogs, lizards, adult birds, eggs, nestlings, bats, squirrels, coatis and mice (Izawa, 1978; Fedigan 1990; Milano and Monteiro-Filho, 2009). However, there are a few reports of Capuchins feeding on larger mammalian preys. The white-faced capuchins (*Cebus capucinus*) have been observed feeding on coati pups (Newcomer and De Farcy, 1985; Fedingan, 1990; Perry and Rose, 1994), Ka’apor capuchins (*Cebus kaapori*) have been observed feeding on a young titi monkey (Sampaio and Ferrari, 2005), and black striped capuchins (*Sapajus libidinosus*) have been observed preying on snakes (Falótico et al., 2018). Milano and Monteiro-Filho (2009) reported Azaras's capuchins (*Sapajus cay*) chasing a mammal the size of an opossum, though conclusive identification was impossible before the monkey and prey animal were lost from sight. The black-horned capuchin (*Sapajus nigritus*) was observed attempting to consume a brown-eared woolly opossum (*Caluromys lanatus*) that had been run over; this occurred in Mata Santa Tereza, Brazil, a semi urban area where capuchins are accustomed to receiving food on the ground from local people which may alter their behavior (Palmeira and Pianca, 2012). Here we present an observation of a white-fronted capuchin (*Cebus yuracus*) preying on an opossum in the Copallín Private Conservation Area in Amazonas, northern Peru.

Methods

We placed four camera stations of three camera traps (Bushnell Aggressor No Glow Trail Cameras) each on the Las Higueras trail in the Copallín Private Conservation Area (S 05°37'16", W 78°16'46"), bordering the Santuario Nacional Cordillera de Colán (Fig. 1). Each camera was set facing animal trails at a height of ~ 40 cm above the ground. Cameras were configured to take one photo followed by 30 seconds of video. We set the cameras on the 13th and 14th of March, 2018 and they were taken down on the 14th and 15th of May, 2018. Once collected, the photos and videos from each trap were transferred to a hard drive for analyses and storage (Sanderson and Harris, 2013). The camera which recorded the predation event was set at an altitude of 2,413 m above sea level and recorded for 1,466 hours (62 camera days).

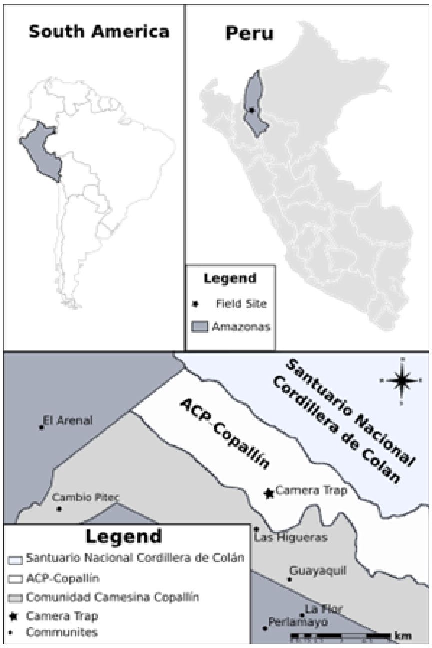

Figure 1. Location of our field site in the Andes of Northern Perú, department of Amazonas, districts of Copallína and Cajaruro. The black star indicates the location of the camera trap which captured the image of the capuchin and the opossum.

Results and discussion

On 2nd of April 2018 at 16:32, the camera of interest captured one photo of a capuchin (*Cebus yuracus*) on the ground and then 30 seconds of video of the capuchin clutching a dead *Didelphis* sp. to its underbelly and disappearing onto an animal trail (Fig. 2). This is the first and only time we have seen monkeys on our terrestrial camera traps despite sampling for almost a year.

Though vertebrate predation is well documented in Old World primates (Hausfater, 1976; Busse, 1977; Morris and Goodall, 1977; McGrew et al., 1978; Anderson, et al., 1983; McGrew 1983; Takahata et al.,1984; Boesch and Boesch, 1989; Wrangham and Riss, 1990; Alp, 1993; Basabose, and Yamagiwa, 1997; Wrangham, 1999; Surbeck, and Hohmann, 2008; Fowler and Hohmann, 2010), it has been much less studied in the New World primates (Izawa, K. 1978; Newcomer and De Farcy 1985; Perry and Rose, 1994; Sampaio and Ferrari 2005; Milano and Monteiro-Filho, 2009; Sanderson and Harris 2013; Falótico et al., 2018). Capuchins are well known to hunt but this is the first record we are aware of that documents mammal predation in *Cebus yuracus,* and the first confirmed report of a capuchin predating on an opossum. Additionally, there are very few records of capuchins preying on opossums, in the literature. The one observation we were able to find was unconfirmed but probable (Milano and Monteiro-Filho, 2009) and one attempt (Palmeira and Pianca, 2012). While there are few in-depth studies of Neotropical opossums (*Didelphis*), the Virginia opossum (*Didelphis virginiana*), the northern and central American species, has been extensively studied and found to be surprisingly resistant to rabies and ticks, however they are great sources for a number of other diseases and parasites, and therefore may be risky to consume (Tardieu et al., 2017).

We do not know how the opossum died. It could have been killed by the capuchin in a tree and fallen to the ground, or have already been on the ground, and dead, nearly dead or killed there. The capuchin did leave the relative safety of the canopy to the ground to retrieve its body, or kill the opossum, indicating that it is a high enough quality food to be worth the risk of coming down from the trees to the forest floor.

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Figure 2. Video stills from the video of the capuchin clutching a dead *Didelphis* sp. to its underbelly. The opossum's feet, and hairless tail as well as part of its body can be seen. The arrows point to the opossum.

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AMPLIACIÓN DEL ÁREA DE DISTRIBUCIÓN DEL MONO MAICERO CACHÓN (*SAPAJUS APELLA*): NUEVO REGISTRO EN EL PARQUE NACIONAL NATURAL LAS HERMOSAS-GVC, TOLIMA, COLOMBIA

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Jesús-A Sánchez-C
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Germán Rodríguez-P
Néstor Roncancio-D

Introducción

Producto de los cambios sociopolíticos que se han dado en Colombia en los últimos años, se ha podido ingresar a zonas que incluyen porciones del sistema de áreas protegidas, donde antes no era posible, y avanzar con la gestión de generar información primaria, e implementar sus planes de monitoreo y portafolios de investigación. Esto ha permitido explorar científicamente áreas que estuvieron vetadas por décadas y conocer más detalladamente aspectos de la ecología de algunas especies, e incluso descubrir algunas nuevas para la ciencia (Vieira-U y Karremans, 2018; Vieira-U y Moreno, 2018), conocimiento clave para revisar las prioridades de conservación y orientar el manejo ambiental de los territorios (Nichols y Williams, 2006; Pullin y Knight, 2005).

En el marco de la implementación del plan de monitoreo del oso andino (*Tremarctos ornatus*) y la danta de páramo (*Tapirus pinchaque*), y obedeciendo al diseño de muestreo definido para ellos, el equipo del PNN Las Hermosas – Gloria Valencia de Castaño ingresó a esta área protegida por el sector del departamento del Tolima, municipio de Chaparral, para hacer recorridos en donde históricamente el acceso había estado restringido.

Observación

El 15 de mayo de 2018 se registraron cuatro individuos de Mono maicero cachón (*Sapajus apella,* Asociación Primatológica Colombiana, 2016) (Sinónimos: *Cebus apella* en Defler, 2010; *Sapajus macrocephalus* en De la Torre et al., 2018), en el límite del área protegida, en el municipio de Chaparral, departamento de Tolima (3.75975N, -75.68392W) a 2,370 metros de elevación (Fig. 1).

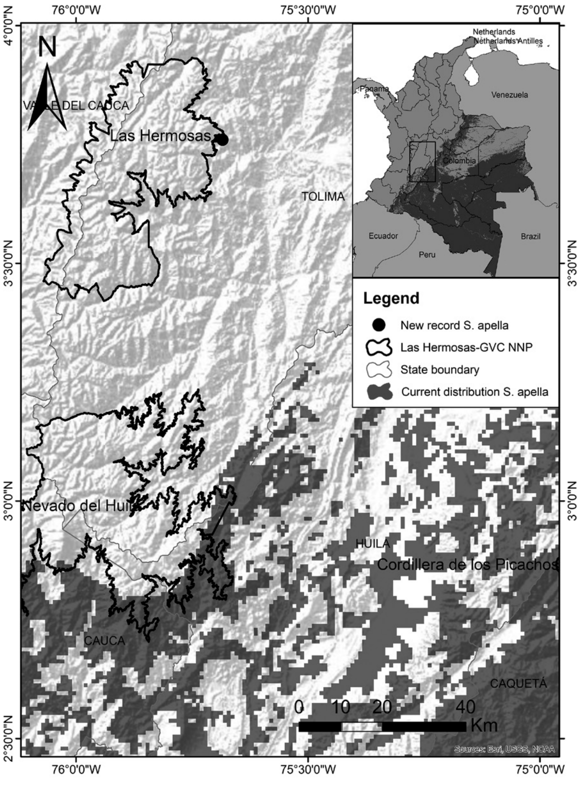

Figura 1. Área de estudio y sitio de registro de *Sapajus apella* en el PNN Las Hermosas – Gloria Valencia de Castaño

Discusión

Sapajus apella está categorizada como especie de preocupación menor (LC) pero se considera que su población está disminuyendo (De la Torre, 2018), y con la tendencia actual de deforestación podría perder cerca del 21% de su hábitat a 2030 (Carretero-P y Stevenson, 2018). En Colombia la especie tenía una extensión de ocurrencia estimada de aproximadamente 521,362 km^2, que abarcaba toda la Amazonía y parte de la Orinoquia colombiana, excepto en algunas zonas al oriente, en el departamento del Vichada, penetrando también en el alto valle del río Magdalena hasta el departamento de Huila (Defler, 2010; Carretero-P y Stevenson, 2018). Su distribución dentro de áreas protegidas representa 21.9%, correspondiendo el 17.3% a áreas del Sistema de Parques Nacionales Naturales y 4.6% a otras figuras de protección. Las coberturas vegetales dentro de su área de distribución estimada son bosque denso en un 78%, pastos limpios en un 7.61% y vegetación secundaria o en transición en un 2.32% (Carretero-P y Stevenson, 2018). Con este registro se amplía la distribución de la especie cerca de 100 kilómetros al norte sobre la cuenca del río Magdalena, más allá de áreas de bosque seco hoy en situación de alta reducción y fragmentación (IDEAM, 2012). Es probable que, la población en el PNN Las Hermosas-Gloría Valencia de Castaño (GVC) sea una población aislada en un hábitat marginal, dado que en general los primates Neotropicales tienden a preferir zonas bajas más cálidas (Defler, 2010).

Sapajus apella es tal vez la especie de primate con la mayor área de distribución en el país y la tercera con más estudios documentados. A pesar de ello, aún hay vacíos de información en aspectos tan elementales como su distribución (Guzmán-Caro et al., 2018), situación debida en parte probablemente a la dificultad de tener un muestreo representativo dada la extensión de ocurrencia de la especie. Este registro refleja que sigue siendo necesario obtener conocimiento adicional clave para planear, implementar y monitorear la gestión para la conservación de los primates en Colombia (Guzmán-Caro et al., 2018) y en particular de las áreas protegidas, que permitan hacer el manejo alineado a un proceso de toma estructurada de decisiones (Possingham et al., 2001).

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NEWS

AN UPDATE ON THE COIBA HOWLER MONKEY, COIBA ISLAND, PANAMÁ

After visiting Coiba Island in the Gulf of Chiriqui in 1999, and in 2001 as field assistant of Liliana Cortés-Ortiz in her research on the phylogeny of the genus *Alouatta*, I found that I had left a piece of myself there. Its mystique—a cruel and fearsome island, a hideout for pirates, and later a penitentiary—was augmented by my fascination of its beauty, spectacular wildlife, and almost untouched forest, and it was inspirational for my early career as a primatologist in Panama. I felt I was Jim Hawkins, visiting the Treasure Island of Robert Louis Stevenson. Leaving the island in 2001, I resolved to return someday as a Panamanian primatologist, to study the population and ecology of the howler monkeys and capuchins there. When I returned from Coiba in 1999, I become interested in the Coiba howler monkey, and reviewed the literature concerning the island and its wildlife, visiting the libraries of University of Panama and the Smithsonian Tropical Research Institute. I did my first publication about Coiba primates as "The kun-kun howler; an endemic primate at extinction risk", published in 2002 in a special edition about Coiba, "Coiba; an unpublished world", in the magazine *Icaro* of the National Association for Conservation (ANCON). This article was read by Alvaro Espinel, who showed it to Anthony Rylands, who helped me with my first scientific note in *Neotropical Primates Journal*, also in 2002. I briefly described the geography and biodiversity of Coiba and the smaller island of Jicarón, explaining that Coiba Island passed from the status of high security prison (since 1919), incorporated a scientific station (1996), and eventually become a national park (2005), also recognized as Natural Heritage of Humanity, awarded by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Having achieved my Masters' degree in Primate Conservation from Oxford Brookes University, UK (2008), I returned to Panama and created an NGO called the Fundación Pro-Conservación de los Primates Panameños (FCPP) (fcprimatespanama.org), and in 2010 began the first primate population survey on Coiba Island. In 2010 I invited Timothy Bearder as volunteer of my project from Oxford BBC Radio Station and he made a film, a brief documentary, which he donated (https://www.youtube.com/watch?v=EvldLq-Tsn4). The project "Population and Conservation Status of Azuero Peninsula and Coiba Endemic Primates" was supported by the Rufford Foundation (2011), and fulfilled my wish to study the Coiba howlers and capuchins.

Recently, our efforts to conserve the primates and the biological diversity of Coiba have been greatly helped with the formal creation of a field station there, the "Estación Científica Coiba AIP" created by Panama's National Science and Technology Secretary (SENACYT), with the FCPP being part of the committee as associate investigators with the project "Population ecology and genetic characterization of two subspecies of primates endemic to Coiba Island and the Azuero peninsula, Republic of Panama", in collaboration with Edgardo Díaz-Ferguson, an expert geneticist, and Coiba AIP's director (Panamá, SENACYT, 2019). New observations have been carried out in Coiba Island also for arboreal and volant mammals using the Orion Camera System (OCS) (Méndez-Carvajal, 2014). OCS consists of an array of canopy camera traps at 12 m high level that will allow us to understand activity patterns, interactions with arboreal mammals, and habitat use. Other studies being led by FCPP include research on bats and on the mammalian diversity in the forest understory of Coiba. The capuchin monkeys of Coiba have been studied to understand their different techniques of survival. A recently published description of their feeding behavior included descriptions of their use of tools (Méndez-Carvajal and Valdes-Díaz, 2017).

As we know more about Coiba, however, its exuberance and beauty are drawing increasing attention from tourists, a trend which is potentially detrimental. By 2014, FCPP advised the government the problem that cows and buffalos were causing negative impact in the understory and increasing the hematophagous bats density. The Panamanian government finally achieved the removal of the feral cows and buffalos from the island. Being Coiba Island an important point for fishing and tourism, the activities has subsequently increased, and is now being promoted by the Panamanian Government. The building of an airport on Coiba Island has been polemic, with local people from Santa Catalina beach, Banco beach and Montijo Gulf, arguing strongly against it. Tourism and development are now putting the Coiba howler monkey at increasing risk, resulting in an IUCN Red List assessment that places it as Endangered. New research is availing Coiba with more arguments for its conservation, with such as Carlos Ramos from the University of Panama, and her student Yohanny Pineda, studying population genetics aspects of Coiba and Azuero monkeys, Pedro González (Biology student) from the University of Panama (CRU-Coclé), Karol Gutiérrez (Chemistry student) from the Autonomous University of Chiriqui (UNACHI), Margie Tejada and Kimberly McIntosh (Parasitology students), Yohanni Pineda (Genetics student) from the University of Panama linked to FCPP-Coiba AIP (Del Moral, 2018), helping to study and protect the Coiba howler monkeys, and its habitat. An update of Coiba research "Long-term monitoring of the Coiba howler monkey *Alouatta coibensis coibensis* and other mammals from Coiba Island, Coiba National Park, Republic of Panama", was presented recently during the IV Rufford Small Grant Conference South America Science for the Conservation of the Eastern Tropical Pacific Region, on January 21 to 26, 2019, in the Galapagos Islands, Ecuador. We continue monitoring and studying Coiba for the conservation of its biodiversity, and now endangered howler monkeys.

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ACTIVITIES OF THE MESOAMERICAN PRIMATOLOGY THEMATIC GROUP (GIT-PRIMATES MESO) IN THE MESOAMERICAN SOCIETY FOR BIOLOGY AND CONSERVATION (SMBC)

The VI Mesoamerican Primate Symposium was held at the Sheraton Hotel in Panama City, Republic of Panamá, as part of the program of the XXII Congreso de la Sociedad Mesoamericana para la Biología y la Conservación, 21–25 November 2018. Seven of the eight Mesoamerican countries were represented at this event, held since 2012 to promote the exchange of information and encourage collaboration among primatologists from the region to improve and inspire new efforts from national primatologists to conserve our primate species. The meetings organized to date were in Panama (2012 and 2018), Belize (2016), and Costa Rica (2017), all organized by the Fundación Pro-Conservación de los Primates Panameños (FCPP) and its director Pedro Mendez-Carvajal, who is also the coordinator of GIT Primates Meso. The attendance was up compared to previous meetings due to the huge support received from anonymous donors besides the regular supporters (see Acknowledgements). The Symposia are attracting attention in South America and Caribbean side, and we welcome people from those regions. There were 14 participating primatologists who presented papers on ethology (Pedro Méndez-Carvajal, Pedro González), parasitology and zoonosis (Adela Palma, Enos Juárez), plant chemistry and the howler diet (Karol Gutiérrez), social hierarchy (Juan José Fernández-Castro), distribution (Danilo Chiari), conservation (Daniela Solano-Rojas, Melissa Rodriguez, Jarinton García, Luz Loría, Roger Morales, and Mynor Sandoval). The Mesoamerican region and the Mesoamerican corridor are under threat from the narco-deforestation, putting the last Panamanian spider monkeys (*Ateles geoffroyi panamensis*) at risk, according to the 2018 report of *Primates in Peril: The World's 25 Most Endangered Primates*. Efforts to protect the corridor have taken the lives of several conservationists. The symposium included a session concerning the importance of art as a tool for conservation. The first non-human primate mural in acrylic was presented by Victor Aleksander Martínez, a Panamanian artist from the University of Panama, creating a link between visual power, cultural importance, and conservation. In our opening and ending sessions, we reflected on the loss of Robert Horwich and his huge contribution in Mesoamerica for the conservation of non-human primates, working with the local communities, particularly in Belize, and also on the legacy of the celebrated Honduran Berta Cáceres, who fought so hard for wildlife conservation. Our message is that conservation cannot be blind. As local scientists and primatologists, we feel that conservationists and scientists need to have more support from IUCN and other organizations that promote conservation, a reality that we face year by year. We need to have a backup when a conservationist is under threat. This same argument was pronounced by the author as the representative from FCPP and GIT Primates Meso in the last Congress of the International Primatological Society (IPS) held in Nairobi, Kenya, in 2018. The improvement of primate studies in Mesoamerica need to be promoted and for this reason, we set up a new annual course in January 2018, "Monitoring Systems in Primates and Bats," at the Chucanti Natural Reserve, Maje Mountain Chain, Panama. The course is an initiative of the FCPP, supported by Adopta Bosque Panama (led by Guido Berguido), to train young biologists and students in related fields interested in learning basic techniques to carry out population surveys for primates and bats as arboreal and volant seed dispersers. Due to the lack of updated scientific information on the Mesoamerican primates, GIT Primates Meso and FCPP opened a webpage (https://primatesmesoamerica.org) to integrate new leaders and facilitate communication, not only between primatologists but also others who may be interested. Proceedings of the Mesoamerican Primate Symposium can be found at https://fcprimatespanama.org/noticias.html.

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OBITUARIES

FILOMENO ENCARNACIÓN: 1945-2019

Si en algún momento alguien va a escribir una historia de la primatología en el Perú, el nombre Filomeno Encarnación Cajañaupa va a figurar en un lugar prominente. Aunque no fue primatólogo por entrenamiento sino botánico, sus actividades desarrolladas como integrante del Proyecto Peruano de Primatología (PPP), muchas en compañía de Rolando Aquino, han sido extremamente importantes para avanzar y ampliar los conocimientos acerca de los primates del Perú. El tomo "Primates of Peru – Primates del Perú", publicado como edición bilingüe en la revista *Primate Report*, sigue siendo una referencia importante, no obstante los muchos cambios taxonómicos y la cantidad de conocimiento generada desde su publicación en 1994. Fue autor y co-autor de varias publicaciones sobre primates, pero también contribuyó al conocimiento de la flora de la Amazonía peruana.

Filomeno siempre tomaba una perspectiva conservacionista y después de su jubilación oficial seguía desarollando actividades pertinentes. Durante el 2° simposio "Primatología en el Perú" en Iquitos en noviembre 2013, Filomeno – junto con Rolando Aquino – fue condecorado con el "Premio Philip Hershkovitz" por su eminente contribución al desarollo de la primatología peruana y nombrado miembro honorario de la Sociedad Latinoamericana de Primatología.

Filomeno fue amigo mío desde que nos encontramos por primera vez a finales de 1982, en el Centro de Reproducción y Conservación de Primates del Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) en Iquitos. Estoy eternamente agradecido con él por el enorme apoyo que recibí a largo de los años para desarollar mis actividades primatológicas en el Perú, y sobretodo por apoyar el desarollo de la Estación Biológica Quebrada Blanco. Siempre le recordaré con mucho cariño y respeto, y le voy a extrañar. Estoy convencido que este sentimiento es compartido por la comunidad primatológica del Perú y allende de Latinoamérica. Filomeno falleció el 12 agosto de 2019; le sobreviven su esposa Yolanda y su hija Myrcia.

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HORACIO SCHNEIDER (1948-2018)

Professor Horacio Schneider, best known for his work on the phylogeny of New World monkeys, was a relentless advocate for the advancement of science in the Amazon. In publishing over 150 research articles, supervising over 50 graduate students and holding along the years various administrative positions at the Federal University of Pará (UFPA), Schneider helped shape policy and establish excellence in biodiversity research in Northern Brazil. With his death on September 27, at 70, the Amazon lost one of its champions.

Born in the city of São Paulo in 1948, Schneider entered UFPA in 1969 to study medicine. Influenced by the research of Francisco Mauro Salzano and Theodosius Dobzhansky, Schneider's interests quickly shifted to biology and he became a voluntary student researcher for Manuel Ayres, studying immune system diversity in indigenous populations.

He pursued both his Masters and PhD degrees at the Federal University of Rio Grande do Sul, under the supervision of the prominent Brazilian geneticist Francisco Mauro Salzano. In 1984, in his doctoral work, Schneider used protein electrophoresis to study protein polymorphisms in buffaloes.

By the late 80's, assessment of variation at the DNA level was the dominant method used to measure genetic differences for generation of phylogenetic trees. In 1990, Schneider joined the laboratory of Luigi Luca Cavalli-Sforza at Stanford University, where he learned and later applied molecular phylogenetics to unravel evolutionary relationships in primates.

Upon his return to UFPA in 1992, Schneider had a collaborative grant with Morris Goodman at Wayne State University, on the broad theme of molecular systematics studies in primates. The collaboration lasted nearly a decade, resulting in five PhD theses and numerous publications, including the first New World primate phylogeny based on DNA variation in 1993.

In 1998, Schneider threw himself into a new challenge: to establish a Biology Research Center in Bragança, a small town in the northeast coast of the State of Pará. During the early 2000's, his group was supported by research funding from the Millenium Institute program of the Brazilian Government, as well as from a collaborative partnership between Germany and Brazil (jointly coordinated with Ulrich Saint-Paul, University of Bremen), to conduct research on mangrove dynamics and management (MADAM). This represented a new avenue of investigation and his interests in phylogenetics and biogeography greatly expanded to include a myriad of Amazonian invertebrate and vertebrate species. In 2005, Schneider was a visiting researcher at the University of Nebraska, Lincoln, where he worked with Guillermo Ortí studying phylogenetic relationships in Amazonian cichlids.

Schneider held multiple administrative roles in his career, yet he is mostly known for his role as Vice Rector of the UFPA from 2009 to 2017, where he helped spearhead the expansion of infrastructure on UFPA campuses across the State via the federal funding program known as REUNI. Schneider was president of the Brazilian Society of Primatology from 1991 to 1994 and also largely respected among the Brazilian community of geneticists for being twice elected as president of the Brazilian Society of Genetics (2000 to 2002 and 2006 to 2008).

Over his career, Professor Schneider received numerous academic awards and distinctions, including some of the highest honors granted by Brazilian institutions. He was a full member of the Brazilian National Academy of Sciences since 2002 and received in 2002 the title of Commander of the Order of Scientific Merit (medal given in person by president Fernando Henrique Cardoso) and was later promoted in 2010 to the Grã-Cruz class. He was also a member of the advisory committee on Genetics at The Brazilian Council of Research and Development (CNPq).

In 1989, the journal Nature published an article entitled "An Amazon University for Amazonia", where it described the Schneider research team's effort as "quite heroic", highlighting the difficulties surrounding research in the Amazon, describing how "The laboratory roof sometimes leaks, the water and electricity supply are unreliable and 90 percent of their electrophoretic reagents have to be imported. The University is too poor to afford journal subscriptions". The article also underscored the enthusiasm of the research group: "the team is great in spirit". His resilience in face of adversity was a hallmark of his academic career and personal life.

On a more personal level, Professor Schneider was an elegant softspoken man with an everpresent smile, a witty sense of humor, and a fondness for music and poetry. He was a caring husband, father and grandfather, and an inspiration to his students and collaborators throughout the years. He also possessed an unabating and contagious optimism, a character trait much needed in times such as these. In his passing, science in the Amazon lost one of its most powerful voices. A tree fell in the forest and was heard by everyone.

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RECENT PUBLICATIONS

BOOKS

The Promise of Contemporary Primatology, edited by Riley EP. Routledge press 186pp. ISBN: 978-1629580715. This book argues for a contemporary primatology that recognizes humans as integral components in the ecologies of primates. This contemporary primatology uses a broadened theoretical lens and methodological toolkit to study primate behavior and ecology in increasingly anthropogenic contexts and seeks points of intersection and spaces for collaborative exchange across the natural sciences, social sciences, and humanities. *Content:* 1) Introduction: The promise of Contemporary Primatology; 2) Franz Boas, American Anthropology, and the Biological-Sociocultural Divide; 3) Primatology: Becoming Anthropology; 4) Primatology in Anthropogenic Context: An Extended Evolutionary Approach; 5) Primatology in Anthropogenic Contexts: The Emergence of Ethnoprimatology; 6) Beyond the Divide: Fieldwork, Reflexivity, and Multispecies worlds; 7) Primate Conservation in the Twenty-First Century, and Beyond; 8) Conclusions: Reclaiming Primatology as Anthropology.

Studying Primates: How to Design, Conduct and Report Primatological Research. Setchell J. Cambridge University Press. 360pp. ISBN: 978-1108434270. This accessible guide for graduate students and post-doctoral researchers explains how to develop a research question, formulate testable hypotheses and predictions, design and conduct a project and report the results. The focus is on research integrity and ethics throughout, and the book provides practical advice on overcoming common difficulties researchers face. *Contents:* 1) Asking the questions about primates; 2) Ethics in primatology; 3) Keeping science healthy: research integrity; 4) Inclusive science; 5) Understanding statistical evidence; 6) Communicating ideas in writing; 7) Introduction to the primates; 8) Why study primates?; 9) Identifying a research question; 10) Finding out what we know; 11) Reading journal articles; 12) Formulating hypothesis and predictions and designing a study; 13) Observing and manipulating; 14) Choosing measures; 15) Planning data analysis; 16) Sampling and statistical power; 17) Checking feasibility and finalizing your plans; 18) Writing research proposal; 19) Collecting data; 20) Conducting fieldwork; 21) Analysing and interpreting data; 22) General guidance; 23) Submitting to a peer-reviewed journal; 24) Presenting your work at a conference; 25) Conclusions.

ARTICLES

Arakaki, P. R., Borges, P. A., Hidalgo, R., Teixeira, F., Braga, F., et al. 2019. Testicular volume and semen characteristics in the endangered southern muriqui (*Brachyteles arachnoides*). *J. Med. Primatol.* 48(4): 244–250.

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MEETINGS

PRIMATE SOCIETY OF GREAT BRITAIN MEETING, SRING 2020

The PSGB Spring meeting is being hosted by Liverpool John Moores University on the 23-24 April, 2020. The theme is Latest Advances in Primatology. See https://www.psgb-ljmu2020.co.uk/ for further information.

43RD MEETING OF THE AMERICAN SOCIETY OF PRIMATOLOGISTS

The 43rd meeting of the American Society of Primatologists will be held in Denver, Colorado, May 28 - 31, 2020 at the Sheraton Denver Downtown Hotel. Abstracts are due January 21, 2020. For more info go to: https://asp.org/meetings/conference.cfm

JOINT MEETING OF THE INTERNATIONAL PRIMATOLOGICAL SOCIETY AND THE LATIN AMERICAN SOCIETY OF PRIMATOLOGISTS

The 28th edition of the IPS congress and the IV congress of the SLAPRIM will be held together in Quito, Ecuador, from August 15-21, 2021. For more information go to https://ipsquito.com/registration/

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:

"and" changes to "e" and "y" for articles in Portuguese and Spanish respectively. "In" changes to "Em" and "En" for articles in Portuguese and Spanish respectively.

"Doctoral thesis" changes to "Tese de Doutoramento" and "Tesis de Doctorado" for articles in Portuguese and Spanish respectively.

"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.

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