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Front cover: Adult male of Caquetá titi monkey (*Plecturocebus caquetensis*) at vereda La Leona, municipality of Valparaiso, Caquetá department, Colombia. Photo by Javier García.

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ARTICLES

A FIELD PROTOCOL FOR THE CAPTURE AND RELEASE OF CALLITRICHIDS

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Abstract

While primate trapping is a widely used field methodology, there are substantial health, safety and social risks to handling wild primates, necessitating sharing of best-practice methods to minimize such risks. Yet, comprehensive capture-and-release protocols are rarely published, and updated even less frequently, despite advances that significantly elevate animal safety. Here, we propose a modified capture and release protocol for small primates and demonstrate its effectiveness on free-ranging populations of *Saguinus weddelli* (the saddleback tamarin) and *Saguinus imperator* (the emperor tamarin) in southeastern Peru. This study was conducted over seven years, from 2009 to 2015, and resulted in 346 capture instances with recaptures of the same individuals over years. We present a modified trap design that is lighter, locally produced, easy to set up and maintain, and is safer for animals. We provide data on how a ‘caller animal’ may dramatically increase the success of a new trapping program, but is not necessary on an ongoing basis. We also propose a conversion from previously used single-step anesthetization methods, which are more likely to result in loss of habituation or potential injury, to a novel dual-phase anesthetization process with no delays in processing times or increases in the amount of anesthetic administered. We discuss modifications to traditional trapping strategies that decrease distress to the animals before, during and after trapping. This method ensures high recapture rates and sustained animal habituation to trap sites and observers while also prioritizing animal safety.

Keywords: Trapping, Callitrichidae, capture, Peru

Resumen

Aunque la captura de primates es una metodología de campo ampliamente utilizada, hay sustanciales riesgos de salud, seguridad y sociales al manipular primates silvestres, necesitando compartir las mejores prácticas de metodologías para minimizar tales riesgos. Sin embargo, protocolos completos de captura y liberación son raramente publicados, y aún menos frecuentemente actualizados, a pesar de los avances que significativamente incrementan la seguridad de los animales. Aquí proponemos un protocolo modificado de captura y liberación para primates pequeños y demostramos su efectividad en poblaciones silvestres de *Saguinus weddelli* (tamarin de Weddell) y *Saguinus imperator* (tamarin emperador) en el suroriente de Perú. Este estudio fue llevado a cabo durante siete años, de 2009 a 2015, lográndose 346 eventos de capturas con recapturas de los mismos individuos a lo largo de los años. Presentamos un modelo de trampa modificada que es más liviana, producida localmente, fácil de armar y mantener y, es más segura para los animales. Proveemos datos sobre cómo un ‘animal llamador’ puede incrementar dramáticamente el éxito de un programa nuevo de trampeo, pero no es necesario regularmente. También proponemos una conversión de los métodos previamente utilizados de anestesiamiento en un solo paso, que son más propensos en resultar en pérdida de la habituación o potencial daño, a un novedoso proceso de anestesiamiento de dos fases, sin demoras en los tiempos de procesamiento o incrementos en la cantidad de anestésico administrado. Discutimos modificaciones a las estrategias tradicionales de trampeo que disminuyen la angustia a los animales antes, durante y después de ser atrapados. Este método asegura altas tasas de recaptura y habituación sostenida de los animales a los sitios de trampeo y a los observadores a la vez que se prioriza la seguridad de los animales.

Palabras Clave: Trampeo, Callitrichidae, captura, Perú

Introduction

When studying wild nonhuman primates, establishing individual identities can be illuminating but difficult, especially in the case of arboreal primates that are often obscured by vegetation, low light levels, and high canopy heights. These difficulties are further exacerbated when the primates are small to medium-sized and lack obvious indicators of maturity or reproductive state (Glander et al., 1991; Fernandez-Duque, 2003). In such cases, observers often struggle to become proficient at instantaneously identifying study subjects, even when the population is well habituated.

Capture-and-release programs that allow for the placement of unique identification tags on individuals provide a solution to this problem. In addition to facilitating identification of individual subjects, such programs also enable monitoring of dental condition, health, development, and reproductive states. Tissue samples collected post-capture may be used for genetic, endocrine, and parasite analyses, and radio-collars can also be placed on individuals, resulting in valuable data that cannot be acquired via observation alone (Sapolsky and Share, 1998; Jolly et al., 2011). Despite these benefits, animal capture gives rise to a number of potential complications and risks to animal safety. Captures can cause elevated stress hormones (Rodas-Martínez et al., 2012), potentiate a negative response to human observers from bad capture experiences, and partial group captures may alter the social standing of animals in groups (Brett et al., 1982; Sapolsky and Share, 1998).

Even though callitrichids have often been captured (Garber and Teaford, 1986; Santee and Arruda, 1994; Dietz et al.,

1994; Goldizen et al., 1996; Windfelder, 1997; Suárez, 2007; Porter et al., 2007; Aragón, 2007; Díaz-Muñoz, 2010), there are only two comprehensive published protocols for capture-and-release. The first is a record of capture strategies (Encarnación et al., 1990) created by Peruvian biologists, and used for the export of some 30,000 primates per annum between 1961 and 1971 (Grimwood, 1968). The second is a 1993-description of trapping procedures of *Saguinus oedipus* in Colombia—the only detailed capture protocol of wild callitrichids intended for a subsequent behavioral study (Savage et al., 1993). Select protocols, with limited applicability to callitrichids, have been published for other primate species (Glander et al., 1991; Lemos de Sá and Glander, 1993; Agoramoorthy and Rudran, 1994; Sapolsky and Share, 1998; Karesh et al., 1998; Fernandez-Duque, 2003; Aguiar et al., 2007; Jolly et al., 2011; Stone et al., 2015), and general guidelines for primate trapping are available (Powell and Proulx, 2003; Fedigan, 2010; Sikes and Gannon, 2011; Jolly et al., 2011). However, due to variation in primate habitat, body mass, social organization, and feeding ecology, a capture-protocol used for one species can be largely unsuitable for another. Unfortunately, the majority of trapping protocols remain unpublished or are published in minimal detail, despite their obvious importance to safe and successful field research by decreasing the repetition of avoidable capture mistakes and reducing mortalities (Fedigan, 2010).

Here, we present a modified capture protocol based on Encarnación et al. (1990), also known as “the Peruvian method”, with improvements in trap design and animal handling methods that preserve habituation and minimize capture-related injuries. We compared published protocols with our modified protocol and demonstrate the success of

our methods on free-ranging populations of sympatric *S. weddelli* and *S. imperator*. While past long-term monitoring of *S. weddelli* (formerly *S. f. weddelli* cf. Matauschek et al. 2010) has involved capture-and-release programs (e.g., Goldizen et al., 1996), *S. imperator* has rarely been captured (Terborgh, 1983; Calegario-Marques and Bicca-Marques, 1994; Windfelder, 1997; Aragón, 2007) and never before in complete groups for population-level monitoring.

Methods

Study site and subjects

Our protocol was used in 346 capture instances of *S. weddelli* and *S. imperator* over a seven-year period (2009–2015) (Watsa, 2013) at the Estación Biológica Los Amigos (EBLA) in southeastern Peru. The small size (300–650 g), arboreal lifestyle, sexual monomorphism and morphological homogeneity of both target species (Hershkovitz, 1977) served as natural obstacles to reliable identification of the individuals in 21 study groups. After careful review of capture recommendations and guidelines (Sikes and Gannon, 2011), a capture and release program, as opposed to darting, was deemed justifiable for the collection of samples and placement of visible identification markings on each animal. Since emperor tamarins were not incorporated into the study until Season 2, our baiting strategy and processing protocol were largely crafted on *S. weddelli* during Season 1 (October 2009 – July 2010), and then applied to both species from Season 2 onwards.

Caller animal

All populations were completely naïve to non-native bananas, with the exception of one social group whose home range centered around the research station where Aragón (2007) had previously captured a group of *S. imperator*. We initiated the capture program in Season 1 by placing 79 feeding platforms in forested areas frequented by *S. weddelli*. After 4 months of little progress (only capturing the one previously habituated group near camp while all others ignored the bait), we acquired a *c.* 3-month-old saddleback tamarin from the Taricaya Rehabilitation Center in Puerto Maldonado, Peru, as a caller animal to inspire bait and trap habituation, an approach suggested by previous studies (Encarnación et al., 1990; Suárez, 2007). The animal was quarantined for several weeks before transportation to the study site, and for about four months accompanied researchers to new trapsites for approximately six hours each day. The results were remarkable, with unhabituated groups beginning to eat bananas within 3 days in some cases. For field seasons 2–6 (2010–2015), a caller animal was not required. Instead, naïve groups learned to eat bananas from habituated groups in areas of home range overlap.

Brief protocol description

We used multi-compartment traps similar in design to those used in the “Peruvian method” (Encarnación et al., 1990), with 6–10 compartments that are controlled manually by an operator located 10–15 m away (Fig. 1). Each trap was provisioned according to a baiting protocol consisting of 5 stages (Table 1) designed to entice animals to

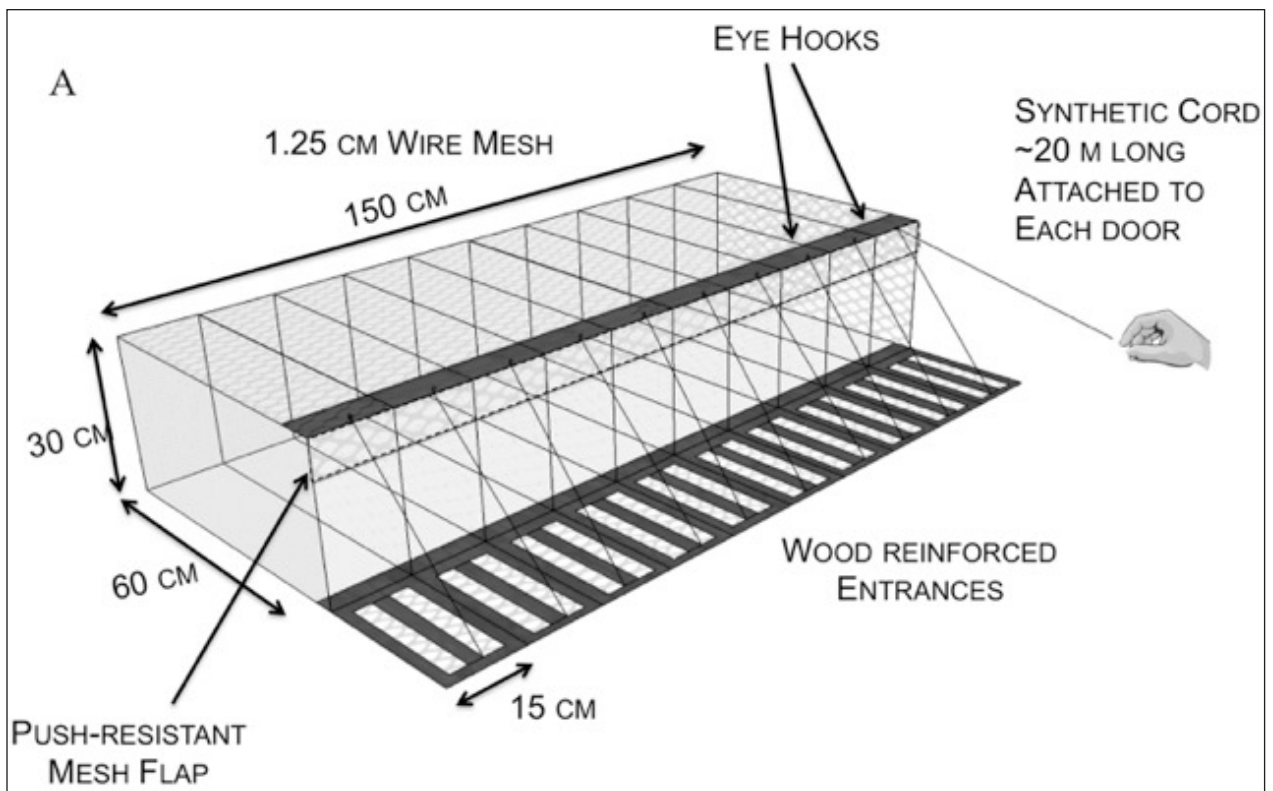


Figure 1. Tamarin trap design indicating materials used as well as the dimensions for a 10-compartment trap. The door-string is only shown for a single compartment.

Table 1. The five stages of baiting a trap.

Stage	Setup	Fruit Size	Fruit Placement	Minimum Conditions to Upgrade to the Next Stage
I	Platform	Whole fruit	Elevated above the platform (c. 4 m) using bamboo poles	Animals must try the bananas and/or venture onto the platform.
II	Trap	Whole fruit & small pieces	Whole fruit remain elevated, but small fruit are placed on the trap roof and doors	Animals must pick up pieces off the trap, and be spending time feeding at the whole fruit.
III	Trap	Small pieces	On trap doors and roof	Animals must descend to feed from the trap, and venture onto the doors.
IV	Trap	Small pieces	On doors and inside the trap, but not on the roof	Animals must venture inside the trap compartments, even if they only grab the fruit and leave to eat it in the trees.
V	Trap	Large pieces	Inside the trap only	Animals must remain within the compartments eating the fruit without removing it from the trap itself. At this stage, if all animals in the group are entering the trap, the group is ready for capture.

Table 2. Study population demographics at EBLA involved in the capture process.

	<i>S. imperator</i>	<i>S. weddelli</i>	Program Overall
Trapping years	Five: 2011–2015	Seven: 2009–2015	Seven: 2009–2015
Total # distinct individuals processed	60	106	166
Total # of group processing instances i. e. successful processing days	31	56	87
Total # distinct groups processed	7	14	21
Mean group size (range)	5.17 (3–8)	4.85 (3–8)	4.97 (3–8)
Total # of capture instances	126	220	346
Average # animals processed per year	25.2 ± SD 3.5	36.7 ± SD 12.6	31.5 ± SD 11.0
Total # of males processed	58	115	173
Total # of females processed	68	105	173
% of captures that were juveniles (c. 4 mo old)	17.5%	21.8%	20.2%
*% capture success 2009–2015	94.9%	97.3%	97.2%
** % re-capture success 2009–2015	89.4%	95.8%	93.8%

* % capture success = (number of individuals present) / (all individuals present)

** % re-capture success = (number of known individuals recaptured) / (number of known individuals present)

taste a previously unknown fruit bait, banana, and then gradually enter traps to feed. A stakeout was conducted at each trap location for about 6 hours each day to record animal behavior at the trap. During stakeouts, except for Season 1 when a caller animal was present, we used playbacks of contact-call vocalizations of adults and juveniles every 15 minutes to attract groups to the area. Durations for each baiting stage depended on the level of habituation of the entire group to the observer and the trap. Except for the first season that spanned nearly a full year, the trapping program was carried out annually during the dry season (May–August), when natural sources of fruit are scarce and banana bait is most appealing.

Once all the individuals in a group had consistently fed within the trap compartments, we captured entire groups together to avoid disruption of social dynamics. All captures were initiated as early in the morning as possible in

order to provide sufficient processing time for same-day release. No animal was released without spending a minimum of 1.5 h in a recovery chamber after its last dose of anesthetic. All animals received bleached tail rings and a novel twin-set beaded collar for field identification (Fig. 2).

The proposed protocol, although similar in terms of capture methodology to the Peruvian (Encarnación et al., 1990) and the Colombian protocols (Savage et al., 1993), has several significant modifications, particularly with regards to processing methodology. For a detailed, step-by-step description of our protocol please visit: <<https://go.gl/wfnLGM>>.

Evaluating the dual-step anesthetization protocol

Savage et al. (1993) recommended that a whole group be captured in a single event, and that only a single animal should be anesthetized and processed at a time (hereafter

referred to as *single-step anesthetization*). We found that this method resulted in the majority of animals spending long periods of time in trap compartments awaiting their turn to be processed. A capture event in Season 1 using single-step anesthetization also resulted in high stress to the tamarins, evidenced by self-inflicted injuries including fresh scrapes and bruising on faces and muzzles and the loss of habituation to observers.

To minimize stress to tamarins, we used a novel *dual-step anesthetization* process on a subset of groups in Season 1. After all animals had entered the trap, each was given a single low dose of anesthetic and rapidly transferred into a padded recovery chamber for holding (Step 1). Then, each animal was in turn removed from the recovery chamber, given a second dose of anesthetic, and processed for sample and data collection (Step 2). Upon completion of Step 2, each animal was returned to its recovery chamber until release. By providing an immediate, small dose of anesthetic to each animal and transferring it to a dark recovery chamber we dramatically reduced the amount of time animals spent fully awake and aware in traps. To evaluate this capture method, we compared mean processing times and total anesthetic doses relative to body weight for single and dual-step methods, and we documented the severity and number of self-inflicted injuries on all animals tested. For all habituated groups, we noted any changes in habituation post-capture (i.e. the inability to follow them for a minimum of 5 hours continuously), and for all groups, we recorded recapture rates as an assessment of maintenance of trap-habituation.

All research was conducted with annual authorization from the Institutional Animal Care and Use Committees (IACUC) of Washington University in St. Louis and the University of Missouri-St. Louis, as well as the General Directorate of Forestry and Wildlife in Peru. This research adhered to the American Society of Primatologists' Principles for the Ethical Treatment of Non-Human Primates. The caller animal was returned to the Rehabilitation Center unharmed and later rehabilitated to a local tamarin group.

Results

From 2009–2015, we used the modified capture protocol on 166 animals from 21 study groups of both species, including 70 juveniles, defined as individuals captured in the same season they were born (about 4 to 7 months of age) (Table 2). In each trapping season, we spent about 21 days attempting to capture groups or lone individuals, and we were successful 67.5% of the time. Overall trapping success was highest in the dry season with groups that were being newly introduced to the fruit, with visitations occurring most frequently in the early morning and just before dusk.

Comparison with previous protocols

We compared the Peruvian (Encarnación et al., 1990) and Colombian (Savage et al., 1993) protocols to our modified

protocol across a variety of factors relevant to behavioral habituation and animal well-being (Table 3). The modified protocol used a lighter version of the multi-compartment trap and was manually operated by researchers fully visible to the animals. Animals were processed at the trapsite, comprehensively sampled, and released on the same day (Table 4). We averaged a capture success (ratio of animals captured to animals present) of over 97% (Table 2).

Habituation to observation

In all cases, groups were released from capture and followed briefly to ensure that all animals were reunited with the group. In most cases, animals ran out of the recovery cages upon release and immediately re-entered the re-baited trap, spending about 20 min feeding inside of it. Of all individuals that remained in the study population, i.e. that did not disappear due to natural death, predation or dispersal from our study site, we recaptured 93.8% across the study period. All 21 groups captured over the three years were habituated to the presence of the observer at the baited sites before being trapped, and all groups returned to trapsites, with observers present, post capture. The only exception was a single *S. weddelli* group in Season 1 (recaptured in Season 2), which avoided researchers for several months after being captured. We attribute this to the use of single-step anesthetization that resulted in prolonged and stressful waiting periods in the trap and consequently a loss of habituation during that season.

Evaluating the two-step method

There was no significant difference (Mann-Whitney U, $p > 0.05$) between total anesthetic dose relative to body weight for the 35 individuals that underwent single-step processing (mean = $21.7 \pm \text{SD } 10.4$ mg/kg) or the 9 individuals who underwent dual-step processing (mean = $26.4 \pm \text{SD } 8.4$ mg/kg) in Season 1. For dual-step processing, the average step 1 dose was $8.87 \pm \text{SD } 4$ mg/kg. There was also no significant difference (Mann-Whitney U, $p > 0.05$) between processing times for 31 individuals (time not recorded on four individuals) that underwent single-step processing (mean = $72.3 \pm \text{SD } 43.6$ min) or the nine individuals who underwent dual-step processing (mean = $73.8 \pm \text{SD } 21.7$ min) in Season 1. Dual-step processing had no added effect on anesthetic doses or processing time, and it completely prevented the incidence of self-injury due to extended waiting periods in the trap (between 1.3 h and 4.7 h for groups of three and eight individuals, respectively).

Overall, adult *S. weddelli* received lower doses of anesthetic than adult *S. imperator*, which weigh 100–250 g more on average (Table 4). Relative to body weight, juveniles of both species received slightly higher doses of anesthetic on average than adults, though this was not significant (Mann-Whitney U, $p > 0.05$) (Table 4). More than 95% of the time, groups were captured before 9 am in the day. Average processing time for groups ranged from $3.97 \pm \text{SD } 0.8$ h for groups of 3 animals to $8.03 \pm \text{SD } 0.6$ h for groups of 8. All groups were released no later than 4 pm in the day, after

Table 3. Comparison of prior capture protocols for *Saguinus* spp. to this protocol.

Item	Encarnación et al (1990)	Savage et al. (1993)	This Protocol
Purpose	Export of animals.	Behavioral study without biological sampling.	Behavioral study with biological sampling.
Trap dimensions (cm)	L: 120–150, W: 40, H:36	L: 160, W: 45, H: 30	L: 90–150, W: 60, H: 30
Compartment width (cm)	12–15	16	15
# of compartments	10	10	6–10
Trap weight	Heavy - wooden frame used.	Heavy - wood frame and wire mesh.	Light - mesh and zipties. Wood only around door frames
Construction materials	Wood, nails, hinges, galvanized mesh, nylon thread, staples, wire, and rubber strips.	Wood, wire mesh, steel hinges and eye-screws.	Galvanized wire mesh, staples, zipties, and eye-screws.
Holding cages	Large structures for multiple animals housed together for export.	Not mentioned in protocol.	Two 4-compartment structures with padding and a cover sheet.
Tail protection during trapping	Not mentioned.	1 cm gap to prevent tail being injured.	None found to be necessary, but a modified top mesh flap reduced escape rate.
Caller animal	Yes, for faster habituation to bait.	Not used at all.	Yes, first trapping season only.
Caller animal source and fate	Captured; fate uncertain, probably exported.	Not applicable.	Borrowed from and returned to a Rehabilitation Center.
Trapping platform	Made of bamboo or wooden sticks.	Eight 0.3 m - rope extensions.	Temporary, small sheet of galvanized mesh with rope tied to all four corners.
Bait placement	Secured in cages to force animals to remain.	Unsecured bait.	Unsecured. Capture attempts aborted if animals do not voluntarily eat inside trap.
Trapper visibility	Hidden by blind	Hidden by blind	Visible within mosquito net.
Operator to trap distance	6–12 m	4–6 m	10–15 m
Blind construction	Involved structure of palm leaves and sticks.	Wood and burlap.	No cover required for blind: operators visible.
Strings	Grooved rod, fixed to ground with sticks involved.	Not specified in protocol	Simple braided string tied in trapdoor-order to a larger rope between trees.
Trapping duration	Trapping can extend to many hours, depending on skill of trapper.	On average, 2 to 6 h.	Animals only trapped if entire group enters - trapping duration minimal.
Trigger to end group capture attempt	Full group captured, or not enough compartments.	Complete group captured. Waited up to 24 hours until all animals in a group entered the trap; provisioning after 6 hours.	Pre-allotted time of 25 minutes, or animals released and capture attempted another day.
Partial group captures	Permitted - behavior unimportant for exported animals.	Avoided, but at cost to remaining group members via extended capture times.	Strongly avoided, capture typically abandoned if entire group does not enter.
Relocation for animal processing	Canoes or motorized boats used to move animals to camp.	Hand-carried to research station - distance unknown.	None - animals processed immediately at trapsite.
Animal identification	Not mentioned in protocol.	Tattoos, colored hair dye, and radio collars.	Microchips, 3-bead collars, one radio collar per group, and bleached tail-rings.
Morphometric measurements	Some measures recorded on some individuals.	Only body weight reported.	About 80 morphological measurements per animal
Provisioning during/after capture	Bananas and milk powder fed to animals for a week, minimum.	Two banana slices per animal, with additional slices for extended trapping (>24 h).	During recovery period 1–2 bananas are split between all individuals in a group.
Time to release	Purpose of capture not for release.	Within 24 hours of capture.	Same day, < 7 hours of capture.

Table 4. Anesthetization doses and processing times for each species across the study.

Trapping Evaluator	<i>S. imperator</i>	<i>S. weddelli</i>	Both species
Mean adult weight (g)	515.4 ± SD 66	386 ± 54 SD	435.5 ± SD 86
Mean infant weight (g)	264.1 ± SD 40	223.6 ± SD 35	236.8 ± SD 41
Mean total anesthetic for adults (mg/kg)	20.1 ± SD 6.4	18.2 ± SD 10.2	18.9 ± SD 9.4
Mean total anesthetic for juveniles (c. age 4 mo) (mg/Kg)	23.8 ± SD 4.7	18.9 ± SD 6	20.3 ± SD 6.1
Anesthetic dose 1 for adults (mg/kg)	7.4 ± SD 1.6	5.7 ± SD 2.1	6.4 ± SD 2.1
Anesthetic dose 1 for juveniles (mg/kg)	8.7 ± SD 3.2	9.5 ± SD 3.0	9.2 ± SD 3.0
Mean processing time for Step 1 per animal (min)	10.7 ± SD 4.0	13.7 ± SD 7.0	12.1 ± SD 5.0
Mean processing time for Step 2 per animal (min)	37.2 ± SD 10	37.6 ± SD 8	37.5 ± SD 9
Average processing time per group (h)	5.6 ± SD 1.5	5.4 ± SD 1.6	5.5 ± SD 1.6

the last individual given an anesthetic dose had recovered for about 90 min.

Caller animal

In Season 1 (from October 2009 – February 2010), *S. weddelli* did not eat bananas at any baiting site save one, where a group was successfully captured. Subsequent to encountering a caller animal, animals that had resisted eating bananas for five months consumed the bait in a matter of days. In Season 2 and beyond, we used only 7–10 baited trapsites placed strategically in areas of home range overlap between bait-habituated and bait-unhabituated groups, and trapping success was high at all sites. We conclude that a caller animal was essential to increase the effectiveness of our baiting strategy in Season 1, but was unnecessary during additional field seasons as bait habituation transferred between and within groups.

Discussion

Modifications to improve trapping safety

Although rifles and blowpipes have been used to anesthetize other free-ranging primates (Glander et al., 1991; Fernandez-Duque, 2003), darting is not recommended for tamarins due to their small size (Jolly et al., 2011). In addition, we recommend the use of manually controlled traps that eliminate non-target captures, which is a major disadvantage of Sherman/Tomahawk traps that have automatic doors. Across our study period we have documented *Cebus*, *Callicebus*, *Callimico*, tayras (*Eira barbara*), coatis (*Nasua nasua*), nocturnal marsupials and rodents exploring our traps. Furthermore, automatic traps have only a single compartment, which often precludes the possibility of capturing entire groups together. They are also typically positioned on large grid systems or transects (Pacheco et al., 2007; Blanco, 2008) that must be checked periodically, which creates longer awake and aware waiting times for trapped animals (hours) than this protocol (about 25 min), which can result in significant injuries.

Post-capture, we avoided transporting animals to a field laboratory in favor of processing all animals in a tent near the trap site, which resulted in a total processing time that

was much lower than previous protocols (a maximum of eight hours in this study, compared to as much as 24 hours in other studies). We also captured entire groups within 25 min and infrequently captured partial groups (about 14% of all instances) when a single animal was reluctant to enter the trap. In the two instances (of 346) that a juvenile would not enter the trap, an adult was released to remain with it while the rest of the group was processed (an option precluded by automatic traps). When possible, a trapsite would be revisited for a second attempt to capture individuals that did not enter previously. Since only trap-habituated groups were captured, we minimized the frequency with which missed captures occurred. Our trapping method, in concert with dual-step processing, not only reduced injuries and preserved animal habituation, but also avoided disturbance and distress to social groups. No mortalities associated directly with the trapping protocol were observed in this study. However, we observed that one young female who was captured and released successfully in Season 2 did not survive two hours after recovering from the first small dose of anesthetic when trapped in Season 3. Poor body condition, established during post-mortem examination, indicated a history of disease.



Figure 2. Marked individuals of both tamarin species post-capture. **A:** Bleached tails and beaded collars on *Saguinus weddelli*. **B:** Beaded collar on *Saguinus imperator*.

Modifications to marking individuals

A modified, double-beaded collar increased visibility of beads from multiple angles (Fig. 2). Collars have been known to cause injury to *Callicebus* in other trapping programs (Müller and Schildger 1994) and collars must be large enough to accommodate weight increase in the wet season but not so big that the collar can slip over the jaw and chip a canine. We strongly recommend collar sizing presented in the detailed protocol online, and do not recommend radio-collaring animals younger than one year of age. We also confirm that correctly sized radio collars around the necks of wild tamarins cause no observable negative health effects, but we do not recommend backpack radio transmitters, as this could affect infant-carrying behaviors in these cooperatively breeding primates.

We used hair bleach to successfully create a selection of 11 ringed patterns on the animals' tails, with better success on the darker saddleback tamarins than the emperor tamarins (Fig. 2). Infant tamarins were bleached very lightly in different patterns on their bodies, as their tails were too thin to be easily visible. The bleached sections routinely molted along with the rest of the pelage within 3–4 months of application, fading rapidly in the last month. No adverse effects on hair growth were observed in any recaptured individual, unlike freeze-banding of tails that may cause loss of a portion of the tail (Fernandez-Duque, 2003). Microchips used to permanently identify individuals were reliably detected during recaptures in all but two individuals. The beveled needle tips form an effective delivery system and cause no bleeding, and animals were not observed attempting to remove chips.

Modifications to improve trapping efficiency and outcomes

We suggest three major mechanical improvements to the multi-compartment traps. First, the use of galvanized mesh and zipties reduces trap weight from construction materials like wood used by both Savage et al. (1993) and Encarnación et al. (1990). We found no need for a 1-cm gap at the top of the door (Savage et al., 1993) to prevent injuring the tail of the animal. We installed a push-resistant mesh flap at the top of each entrance which eliminated escapes during capture caused by animals bending doors open by pushing on them. Finally, by using a mesh layer attached by rope to four trees as a trap platform, we avoided bulky and complicated systems used in the past and made trap setup and take down efficient and adaptable to varying forest conditions. We observed that for a team of 4–5 handlers, the processing of two animals simultaneously increased the number of variables that needed to be recorded at a given time and data omissions became increasingly common. Thus, we reaffirm that processing one animal at a time improves trapping efficiency.

The average anesthetic doses (excluding minimal dose during initial processing, which can be separated by hours from complete processing) received by both tamarin species are generally lower or in some cases on a par with those

used in other studies (about 25 mg/kg by Savage et al., 1993) (Table 3). The processing of each animal, including Steps 1 and 2, occurred in just under 49 min on average, but ranged from 47.5 to 50.5 min for the collection of 80 or more measurements and a variety of biological samples (see supplemental data for list). If collection of samples and data were minimized, as in the case of the Colombian protocol, we would be able to reduce processing times to between 20 and 30 minutes. The assignment of specific roles for handlers and improved data management methods (such as voice recorder backups) also contributed to streamlining processing.

Modifications to improve trapping success and habituation post-capture

Once a primate has undergone a negative experience associated with a foraging endeavor, it can be expected to form a negative association with that particular stimulus or setting, which jeopardizes the feasibility of capture-and-release programs conducted in conjunction with behavioral sampling. A survey of 120 studies involving trapping of about 65 species of free-ranging primates revealed that a well-planned study does not cause habituated animals to change their behavior towards observers (Jolly and Phillips-Conroy, 1993). There are several ways to measure the extent to which primates are habituated to an observer, such as the distance between the observer and the primate or the extent of contact time with the animals. However, we used qualitative behavioral indicators of familiarity to an observer instead, such as vocalization cues and lack of acknowledgement of the observer's presence, to describe habituation post-trapping. All habituated groups processed using the dual-step anesthetization protocol retained habituation to the observer and the trap. Groups unhabituated to the observer, but habituated to the traps, showed no fear of researchers at the trapsite, were observed feeding at the trap in the same season, and were able to be captured the following year in all cases. In a single case of the single-step anesthetization process, one group experienced long wait times and displayed significant loss of habituation to observers in that season; however, they were recaptured and became habituated to observers in all subsequent years.

We can also confirm that the number of new immigrants in a group negatively impacted the ease with which a previously habituated group could be followed by an observer, and increased the time it took for the group to be habituated to a bait site. Habituation is thus a dynamic representation of a primate group's tolerance to observation, and seven years of behavioral research with this tagged population demonstrates that it is indeed possible to conduct a capture program without diminishing habituation or affecting overall behavior.

General recommendations on the trapping of small mammals

The capture of animals in live traps with no more invasive methodology than a peripheral blood draw is supported by care guidelines specified by the American Society of

Mammalogists (Sikes and Gannon, 2011). These guidelines specify justifications for capture, including “livetrapping to tag (with radiotransmitters, necklaces, ear tags, or passive integrated transponder tags), mark (number, band, hair color, freeze brand, ear tag, or toe clip), or collect tissue” (Sikes and Gannon, 2011). Trained individuals should conduct the necessary chemical immobilization, with experience in the administration of anesthetics, tranquilizers, sedatives, and antidotes in the appropriate doses (West et al., 2007; Kreeger, 2007; Fowler, 2008). Finally, sedated animals should be monitored closely and released only when they have regained full consciousness and locomotion (Sikes and Gannon, 2011).

The data on health and physiology accumulated from capture-and-release programs has revolutionized our perspectives of both captive and wild animals, but the acquisition of data from wild populations should not be given higher priority than the health and safety of the animals themselves. As times change, we should continually re-assess trapping strategies and make use of new technology that alleviates stress to study subjects. If behavioral monitoring were required for all capture-and-release programs, the likely result would be the further improvement of trapping protocols.

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THE INFLUENCE OF STOCHASTIC EVENTS ON THE EXTINCTION RISK OF BLACK HOWLER MONKEY (*ALOUATTA PIGRA*) POPULATIONS IN CAMPECHE, MEXICO

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Abstract

Population viability analysis (PVA) allows assessing extinction risk, which is of paramount importance for conservation and natural resource management practices. In addition to the modeling of the influence of deterministic demographic processes on the extinction risk of populations, PVA allows simulating the consequences of stochastic factors. The aim of the present study was to model the potential effects of two stochastic sources of variation, anthropogenic disturbance events (ADE) and hurricanes, on demographic parameters of extinction risk for 11 populations of the Endangered black howler monkey, in Campeche, Mexico. Models were built using information collected during a seven-year demographic monitoring of the populations, as well as on published life history data. We used the software VORTEX to study four extinction parameters: population growth rate; final population size; probability of extinction; years to extinction. For each population we ran five models: a baseline model; one model with 5% increase in the frequency of ADE; one model with 10% increase in ADE; one model with 5% increase in hurricanes; one model with 10% increase in hurricanes. We ran a sixth model excluding ADE for populations that were known to be exposed to ADE in baseline models. Hurricanes did not impact extinction parameters. As ADE increased, population growth rate, final population size, and years to extinction decreased, whereas probabilities of extinction increased. When ADE was removed, population growth decreased more slowly, populations included more individuals, and extinction became less probable and was delayed. Small populations that were not affected by ADE faced high extinction risk. ADE is thus predicted to be a major stochastic factor influencing the extinction risk of black howler monkeys in Campeche, although population size is also determinant for long-term viability. Through PVA based on long-term demographic data, this study is the first to ascertain that decreasing anthropogenic disturbance may benefit the persistence of threatened populations of this species.

Keywords: Anthropogenic disturbance, conservation, extinction, hurricanes, population viability analysis

Resumen

Los análisis de viabilidad poblacional (AVP) permiten establecer el riesgo de extinción, lo cual es sumamente importante para la conservación y manejo de los recursos naturales. Además de permitir conocer la influencia de procesos demográficos determinísticos en el riesgo de extinción de las poblaciones, los AVP permiten simular las consecuencias de factores estocásticos. El objetivo de este estudio fue modelar los efectos potenciales de dos fuentes de variación estocástica, eventos de disturbio antrópico (EDA) y huracanes, en los parámetros demográficos de extinción de 11 poblaciones de monos aulladores negros en Campeche, México. Los modelos fueron construidos con base en información colectada durante el monitoreo demográfico de las poblaciones durante siete años, así como en datos publicados sobre la historia de vida de esta especie. Usamos el software VORTEX para estudiar cuatro parámetros de extinción: tasa de crecimiento poblacional; tamaño poblacional final; probabilidad de extinción; años hasta la extinción. Corrimos cinco modelos para cada población: un modelo base; un modelo con un incremento del 5% en la frecuencia de EDA; un modelo con un incremento del 10% en la frecuencia de EDA; un modelo con un incremento del 5% en la frecuencia de huracanes; un modelo con un incremento del 10% en la frecuencia de huracanes. Corrimos un sexto modelo excluyendo EDA para aquellas poblaciones que sabíamos que estaban expuestas a EDA. Los huracanes no afectaron los parámetros de extinción. A medida que los EDA aumentaron, la tasa de crecimiento poblacional, el tamaño poblacional final, y los años hasta la extinción disminuyeron, mientras que la probabilidad de extinción aumentó. Cuando excluimos los EDA, la disminución en el crecimiento poblacional fue más lenta, las poblaciones incluyeron más individuos, y la extinción se volvió menos probable o fue demorada. Las poblaciones pequeñas no afectadas por EDA enfrentaron un riesgo de extinción alto. Por lo tanto, se predice que los EDA son un factor estocástico que influye de manera importante sobre el riesgo de extinción de los monos aulladores negros en Campeche, aunque el tamaño poblacional es también determinante para la viabilidad a largo plazo. Con base en un AVP en el que usamos datos demográficos de largo plazo, este estudio es el primero que establece que una reducción en la perturbación antropogénica puede favorecer la persistencia de poblaciones amenazadas de esta especie.

Palabras clave: Disturbio antrópico, conservación, extinción, huracanes, análisis de viabilidad poblacional

Introduction

The International Union for Conservation of Nature and Natural Resources (IUCN) defines a taxon as extinct “when there is no reasonable doubt that the last individual has died” (IUCN, 2016). In practice, however, extinction may effectively occur when individuals belonging to only one sex remain in species with sexual reproduction (usually termed quasi-extinction, e.g., *Chelonoidis nigra abingdonii*: Nicholls, 2006), or when population size is inferior to that required to assure persistence (Shaffer, 1981). Given the numerous current threats to biodiversity (Laurance, 1999), understanding extinction processes and assessing extinction risk are of paramount importance in the context of conservation and natural resource management practices (Regan et al., 2005; Cardillo et al., 2008; Mace et al., 2008).

Deterministic models have been used for more than 40 years to study the effects of demographic fluctuations on the extinction risk of many species (Miller et al., 1974). In these models, demographic parameters (e.g., population growth rate) are deterministic functions of environmental variables, and variability in demographic parameters is considered negligible. In contrast, stochastic models focus on the effects of factors of uncertain nature on demographic parameters, such as demographic, environmental, and genetic stochasticity, as well as natural catastrophes (Shaffer, 1981). Both types of models have been used in the implementation of population viability analysis (PVA), which aims at calculating the probability that a population persists for some particular time (Beissinger and McCullough, 2002). Currently, demographic modeling through PVA represents a powerful tool for biodiversity conservation and management, and has been conducted to predict the extinction risk of a wide range of animal populations (e.g., Pe'er et al., 2014), including several primate species (e.g., King et al., 2013; Zeigler et al., 2013).

Black howler monkeys (*Alouatta pigra*) are arboreal Neotropical primates with a geographic distribution restricted to the Yucatán Peninsula in Mexico, Belize and north and eastern Guatemala (Cortés-Ortiz et al., 2015). This species is currently classified by the IUCN as Endangered and there is a trend for decreasing population sizes (Marsh et al., 2008), which, similarly to other howler monkey species, is strongly associated to anthropogenic disturbance (Arroyo-Rodríguez and Dias, 2010; Estrada, 2015). We have recently reported seven years of demographic data for 11 groups of black howler monkeys living in distinct populations in the Mexican state of Campeche (Dias et al., 2015). Campeche represents the state with the largest potential amount of suitable habitat for black howler monkeys in Mexico (Tobón et al., 2012), and likely, the largest population. Our results indicate that several habitat (e.g., habitat size, tree density, distance to human settlements) and landscape-scale attributes (the amount of available habitat, number of forest fragments) affect group structure and dynamics in this region (Dias et al.,

2015). For instance, infant survival is negatively related to tree density, shape of the fragments and distance to human settlements, and population growth is negatively affected by vegetation disturbance. Thus, extinction risk could vary among populations according to stochastic anthropogenic disturbance events, such as logging, fires, or hunting.

Campeche is affected by hurricanes originating in the north Atlantic Ocean basin (CONAGUA, 2016). Hurricanes have the potential to cause extreme environmental disturbance, and there are several accounts of the impact of these climatic events on animal populations (e.g., Lugo, 2008). For black howler monkeys, 88% reduction in the size of a population that lived in the path of a Category 4 hurricane (Saffir–Simpson Scale: NOAA, 2016) has been documented (Pavelka et al., 2007). Therefore, in addition to anthropogenic disturbance hurricanes may represent an important source of stochastic variation in demographic parameters in populations of this species living in Campeche, and as a consequence, affect their extinction risk. Furthermore, there is evidence that the frequency of intense hurricanes (Categories 4 and 5 of the Saffir–Simpson Scale: NOAA, 2016) in the Atlantic basin has been increasing (Webster et al., 2005), suggesting that in the future these extreme climatic events may pose stronger threats to black howler monkeys.

The aim of the present study was to perform a PVA to determine the potential effects of two stochastic sources of variation in demographic parameters on the extinction risk of 11 populations of black howler monkeys living in Campeche. To this end, we modeled the effects of variation in the frequency of hurricanes and anthropogenic disturbances on four extinction parameters: population growth rate; final population size; probability of extinction; years to extinction. Specifically, we expected that, as the frequency of hurricanes and anthropogenic disturbances increased, population growth rate, final population size, and years to extinction would decrease, whereas the probability of extinction would increase. To better understand which factors besides demographic stochasticity could relate to the observed results, we also explored the relationship between habitat size and extinction parameters, as habitat size has been found to consistently predict population size and distribution range of howler monkeys (Arroyo-Rodríguez and Dias, 2010).

Methods

Study site and subjects

We studied 11 groups of black howlers that lived in different locations in Campeche, Mexico (spatial and ecological attributes of the study sites are thoroughly described in Dias et al., 2014, 2015; Fig. 1). Mean annual rainfall in Campeche is 1300 mm, with a dry season from November to May (mean monthly rainfall \pm SD = 43.7 \pm 25.8 mm), and a wet season between June and October (218.9 \pm 14.1 mm). Mean annual temperature is 26 °C. The study

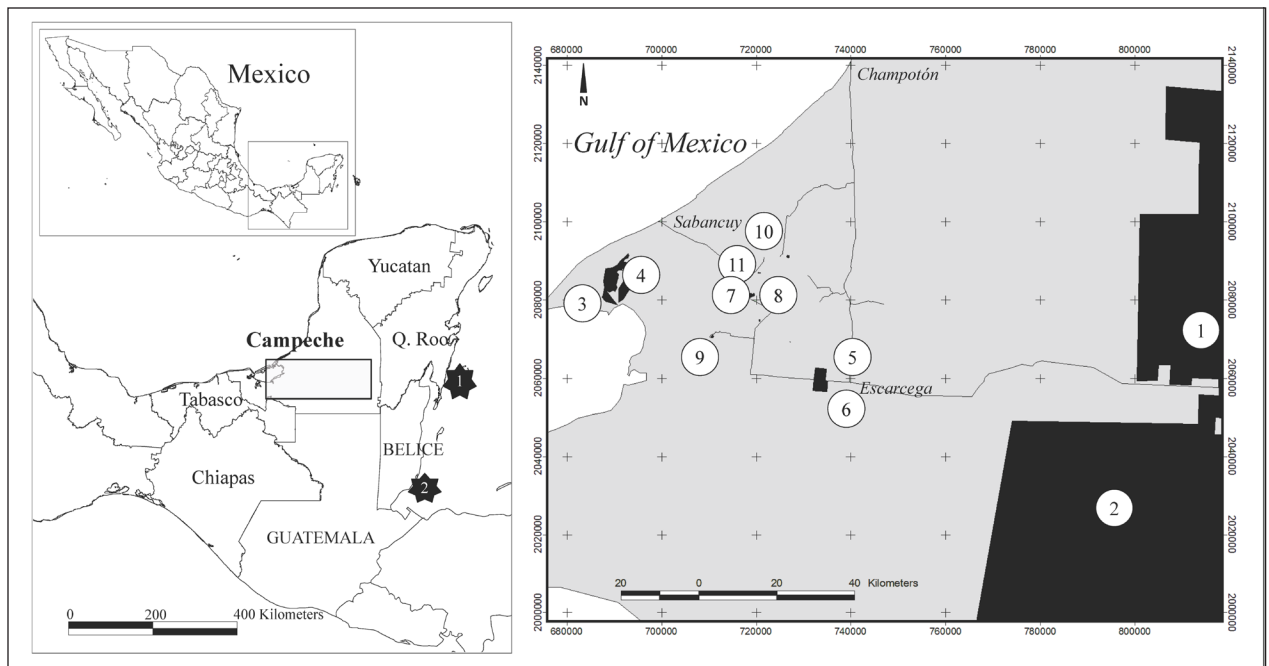


Figure 1. Location of the 11 populations of black howler monkeys studied in the state of Campeche (Mexico). The approximate location of the study area is represented in the map on the left by a light grey rectangle. Groups: 1 = Calakmul N, 2 = Calakmul S, 3 = Calaxchil, 4 = Calaxchil, 5 = Tormento N, 6 = Tormento S, 7 = AA Álamo, 8 = Chicbul, 9 = Manantiales, 10 = Oxcabal, 11 = R Álamo. Black stars in the map on the left represent approximate locations of (1) hurricane Dean landfall, and (2) the Monkey River study site.

encompassed total area of approximately 20,000 km² (Fig. 1), where original forest cover is mainly composed of medium to high semi-evergreen vegetation (Escalona-Segura and Vargas-Contreras, 2010).

Demographic data

Censuses of black howler monkey groups were carried out between February 2006 and February 2012, except for Chicbul (location 8 in Fig. 1) where the fragment was logged in February 2011 and we could not locate the group anymore. We recognized all individuals via ankle bracelets or their natural anatomical and physiognomic characteristics, such as body size and proportions, scars, broken fingers, and genital morphology and pigmentation (Dias et al., 2015). Each year, we sampled each group at least twice in each climatic season (i.e., dry and wet season). Each season sampling included a mean (\pm SD) of 67 (\pm 5.4) days, and we accumulated a total of 10,083 sampling days, with a mean (\pm SD) of 918.5 (\pm 125.3) per group.

Five of the 11 study groups (T61 Calax, AA Álamo, Chicbul, Oxcabal, R Álamo) lived in forest fragments that did not contain any other groups. In these cases, demographic data represented population-level demographics. For the remaining fragments, our data represents a sample of population-level demographics. We are, however, confident that our results for those groups are representative of population-level demographics because 1) the study encompassed several years and 2) sampled groups lived under ecological and social conditions similar to those of other groups within their habitats (Dias et al., 2015; Dias, unpublished data).

Our demographic monitoring allowed acquiring data on reproductive system, reproductive rates, mortality rates, catastrophes, and initial population size, which are essential for PVA modeling (Table 1; Lacy et al., 2015). Mortality rates for individuals > 4 years of age could not be directly estimated, because the disappearance of both males and females at this age could result from emigration (Dias et al., 2015). Therefore, we assumed a constant annual mortality rate of 1% for females and 1.5% for males of ages > 4 years in all groups and a standard deviation (SD) due to environmental variation of 0, as used before in studies of other Ateline species lacking direct estimations of mortality for the adult class (Britto and Grelle, 2006). By setting SD to 0, we omitted the effect of environmental variability on mortality rates of adult individuals (Lacy et al., 2015), although they were still affected by the severity of catastrophes (see below). To calculate initial population size, during the first sampling of each group we conducted censuses of the entire fragments for the presence of black howler monkeys following the methods described in Estrada et al. (2002) and Dias et al. (2013). Population density was calculated by dividing the total number of censused individuals by the area of the fragments that were surveyed, and population size was calculated by multiplying population density by the size of the fragment. These fragment-scale censuses were repeated three times during the study period, and we used mean values for the three censuses in simulations. Because there is not a quantitative estimation for carrying capacity in *Alouatta* (Mandujano and Escobedo-Morales, 2008), we followed previous PVA for other primates in assuming that all populations lived at carrying capacity (e.g., Holst et al., 2006; Ziegler et al., 2013). Thus, in this study

initial population size equates carrying capacity. Similarly, because there are no estimations of migration rates in black howler monkeys, all models were run under a single population scenario, not allowing dispersion to occur.

Stochastic events data

We modeled two types of stochastic events: hurricanes and anthropogenic disturbance events. In the period of 1924 to 2014, seven intense hurricanes (Categories 4 and 5: NOAA, 2016) made landfall in Mexico (CONAGUA, 2016). Of these, only three passed through Campeche (NHC, 2016). Therefore, the annual rate of occurrence of intense hurricanes in Campeche for this 90-year period was 0.03 (Table 1). In August 2007, a Category 5 hurricane (hurricane Dean) made landfall in the Yucatán Peninsula, ca. 200 km from our easternmost field site (Calakmul N; Fig. 1). In the aftermath of the storm we observed an increase in infant mortality in all sampled populations (Dias et al., 2015), and therefore defined in our models survival in hurricane years as 60% of that recorded in non-hurricane years. Although we did not notice a direct effect of the hurricane on the reproduction of individuals in Campeche, it is possible that it actually had an effect and our sampling

scheme did not allow us to detect it. Other researchers have observed occasional adult female mortality during storms, and suggested that food shortages resulting from habitat modification could reduce adult female fecundity (e.g., Behie and Pavelka, 2015). We therefore considered that 95% of the reproduction recorded in non-hurricane years should occur after a hurricane.

We defined anthropogenic disturbance events (ADE) as: the destruction or modification of the habitat (logging, fires) caused by human activities, hunting, road-kills, and attacks by dogs (e.g., Rangel-Negrín et al., 2011). We recorded these events while sampling the groups, and calculated an annual frequency of ADE per group as the number of days in which ADE were observed divided by the number of sampling days. ADE were only observed in AA Álamo, Chicbul, Manantiales, Oxcal, and R Álamo, so for simplicity of presentation of the models, we used a mean frequency of occurrence of ADE among these groups (Table 1). As in the case of hurricanes, we did not observe an effect of ADE on the reproduction of individuals; following the same reasoning explained above for the effects of hurricanes on reproduction, we considered that after an

Table 1. Simulation input derived from demographic data collected during seven years in 11 groups of black howler monkeys in Campeche, Mexico

Simulation input		Group a										
		1	2	3	4	5	6	7	8	9	10	11
Reproductive system	Sex ratio at birth (% of males)	57.1	58	47	50	53.8	50	60.7	85.7	60	77.8	62.5
Reproductive rates	% of adult females breeding	59.5	50	40.5	47.6	41.6	40.5	69	30	42.9	39.5	50
	SD in % breeding due to EV b	34.5	33.1	30.2	10	36	34	29	27	53.5	15.2	13
Mortality rates: females	0-1 years	10	10	10	10	15	10	30	13	35	20	30
	1-2 years	1	1	14	0	12	12	10	0	15	10	15
	2-3 years	1	15	1	5	15	0	15	20	2	9	10
	3-4 years	1	1	1	3	4	0	8	7	5	8	5
	> 4 years	1	1	1	1	1	1	1	1	1	1	1
Mortality rates: males	0-1 years	5	25	35	4	20	20	45	80	66.7	35	44.2
	1-2 years	1	1	16	0	14.4	10	0	0	15	18	15
	2-3 years	1	15	1	0	15	11	0	20	2	12	0
	3-4 years	5	1	1	5	4	2	15	7	5	8	5
	> 4 years	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Catastrophes: hurricanes	Frequency (%)	3	3	3	3	3	3	3	3	3	3	3
	Impact in reproduction	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	Impact in survival	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Catastrophes: anthropogenic disturbance	Frequency (%)	0	0	0	0	0	0	5	5	5	5	5
	Impact in reproduction	1	1	1	1	1	1	0.95	0.95	0.95	0.95	0.95
	Impact in survival	1	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8
Initial population size/carrying capacity		2750	8884	57	6.9	60.6	127.2	44.8	6	14	7	10.6

^a 1 = Calakmul N; 2 = Calakmul S; 3 = Calaxchil; 4 = T61 Calax; 5 = Tormento N; 6 = Tormento S; 7 = AA Álamo; 8 = Chicbul; 9 = Manantiales; 10 = Oxcal; 11 = R Álamo.

^b EV is environmental variation. EV is the annual variation in the probabilities of reproduction that arises from random variation in environmental conditions (Lacy et al., 2015). We used mean interannual SD in % of adult females breeding in each group.

ADE 95% of the reproduction should occur. Concerning survival, our observations indicated that between 0 and 90% of individuals could die after ADE, with a mean value of 20% (i.e., 80% of individuals survive; Table 1).

PVA models

We used VORTEX (version 10.0.7.0; Lacy and Pollak, 2014) to run our PVA. VORTEX is a free software program that allows modeling the impact of deterministic forces and stochastic events on wildlife population dynamics. Besides the demographic data described above, VORTEX requires additional information on the genetics, reproductive system, and mating behavior of the species (Table 2). For genetics, there is no information on the occurrence and consequences of inbreeding depression in black howler monkeys. We therefore used in our models the default severity of inbreeding depression suggested by Lacy et al. (2015). Concerning the reproductive system of the species, our data indicates that age of first offspring for female black howler monkeys is 5 years of age and 7 years for males (Dias et al., 2015). There is currently no data on the maximum lifespan of this species, but a closely related howler monkey species (*A. palliata*) has a lifespan of 30 years and females reproduce at least until 25 years of age (Glander, 2006). Due to close phylogenetic relatedness and similarity in the ecological conditions faced by these species (Cortés-Ortiz et al., 2015; Dias and Rangel-Negrín, 2015), we used lifespan and maximum age of reproduction reported for *A. palliata*. Female black howler monkeys give birth to a single infant, and produce a maximum of one infant per year (Dias et al., 2015). Although some adult males may be excluded from reproduction due to mating competition (Van Belle et al., 2012), they can potentially contribute to the breeding pool, so we considered that 100% of males can compete for mates (Table 1).

All models were run for 1,000 iterations and 100 years: 1,000 iterations allow for a rigorous description of the simulated population's behavior (Lacy et al., 2015); and 100 years is a time span sufficiently long to allow for the simulation of the occurrence of several infrequent stochastic events (i.e., hurricanes in the case of our simulations), but short enough to allow discussing realistic conservation and management actions (Fieberg and Ellner, 2000). Finally, we defined extinction as the absence of one sex, which is the most common choice when modeling the extinction process of sexually reproducing species (Lacy et al., 2015).

We started our modeling by running a baseline model for each population with the data described in Tables 1 and 2. We explored the relationship between habitat size and extinction parameters calculated for these baseline models with linear (population growth rate) and non-linear (final population size and extinction probabilities) regressions. We then ran four additional models with 5% and 10% increases in the frequency of hurricanes and ADE, respectively. For populations with baseline models that included ADE, we ran a sixth model excluding ADE. For each model we recorded four extinction parameters: population growth rate; final population size; probability of extinction; years to extinction. Population growth rate was calculated as:

$$r = \sum l_x m_x e^{-rx}$$

where l_x and m_x are the age-specific mortality and fecundity rates, respectively for age class x to $x+1$ (Lacy et al., 2015). Final population size was defined as the mean number of individuals in the population across all iterations, including those in which the population went extinct. Probability of extinction was calculated as the proportion of iterations in which the population went extinct. Years to extinction were calculated as the mean time to first population extinction

Table 2. Simulation input derived from the literature.

Simulation input		
Scenario settings ^a	Number of iterations	1,000
	Number of years	100
	Duration of each year	365 days
	Extinction definition	Only one sex remains
Species description	Lethal equivalents	6.29 ^a
	Percent due to recessive lethal alleles	50 ^a
Reproductive system		Polygynous ^b
	Age of first offspring females	5 years ^c
	Age of first offspring males	7 years ^c
	Maximum lifespan	30 years ^d
	Maximum number of broods per year	1 ^c
	Maximum number of progeny per brood	1 ^c
	Maximum age of reproduction	25 years ^d
Mate monopolization	% males in breeding pool	100 ^c

^a Lacy et al. (2015); ^b Van Belle et al. (2012); ^c Dias et al. (2015); ^d Glander (2006); ^e This study

considering iterations in which the population became extinct (Lacy et al., 2015). We describe the results by calculating percentage of change in extinction parameters between models as:

$$\text{Percentage of change} = \frac{I - F}{I} \times 100$$

where I is the initial and F is the parameter value.

Results

Baseline models

Only four of the 11 modeled populations showed a positive population growth rate and were extant by the end of the 100-year simulation (Table 3). Of these, three populations, Calakmul N, Calakmul S and Tormento S showed a -0.6%, a -2.2% and a -15% change from their initial to their final population sizes, respectively. The probabilities of extinction of the eight remaining populations varied from 33% (Calaxchil) to 100% (Chicbul and Oxcal). Conversely, time to extinction varied notably, from 4.7 years in Chicbul to 84.5 years in Calaxchil (Table 3). Habitat size was associated positively with population growth ($R^2 = 0.81$, $P < 0.001$; Fig. 2a) and final population size ($R^2 = 0.98$, $P < 0.001$; Fig. 2b), and negatively with the probability of extinction ($R^2 = -0.94$, $P = 0.002$; Fig. 2c).

Effects of hurricanes on extinction parameters

Variation in hurricane frequency resulted in minor variation in extinction parameters in all populations (Table 3). With a 5% increase in hurricane frequency the mean proportion of decrease was $3.4 \pm 5.8\%$ for population growth rate, $0.7 \pm 4.1\%$ for final population size, $3.4 \pm 16.5\%$ for probability of extinction and $0.1 \pm 1.7\%$ for years to extinction. With a 10% increase in hurricane frequency this variation remained similar: $4.3 \pm 7.4\%$ reduction in population growth rate; $1.2 \pm 3.6\%$ reduction in final population size; $3.5 \pm 13.1\%$ increase in probability of extinction; $1.02 \pm 2.4\%$ reduction in years to extinction.

Effects of anthropogenic disturbance events on extinction parameters

With a 5% increase in ADE there was a mean proportion of decrease in population growth of $84.7 \pm 90.1\%$, and this decrease was particularly pronounced in some of the populations living in large habitats, such as Calaxchil (400% decrease), Tormento N (109%) and Tormento S (109%). Final population size decreased a mean of $18.2 \pm 18.3\%$, or $22.3 \pm 17.8\%$ after excluding populations that had a final population size of 0 individuals in baseline models (i.e., Chicbul and Oxcal). The probabilities of extinction increased on average $96.5 \pm 189\%$ across all populations. This increase in ADE resulted in seven, four, and two-fold increases in extinction probabilities in Calaxchil, Tormento N and AA Álamo, respectively. With the exception of the Calakmul populations and Tormento S, 5% more frequent ADE reduced time to extinction by 9.7% (or a mean of 4.4 ± 2.6 years). For instance, in Manantiales extinction

changed from 44 to 37 years. Of particular interest in this scenario was the change observed in Tormento S, which in the baseline model was extant after 100 years, but presented a probability of extinction of 0.4% with 5% increase in ADE, being predicted to become extinct in 80.3 years.

With a 10% increase in ADE, mean population growth decreased by $162.5 \pm 230\%$, final population size (for populations extant by the end of the simulation time) was $36.4 \pm 23.1\%$ smaller, probabilities of extinction for

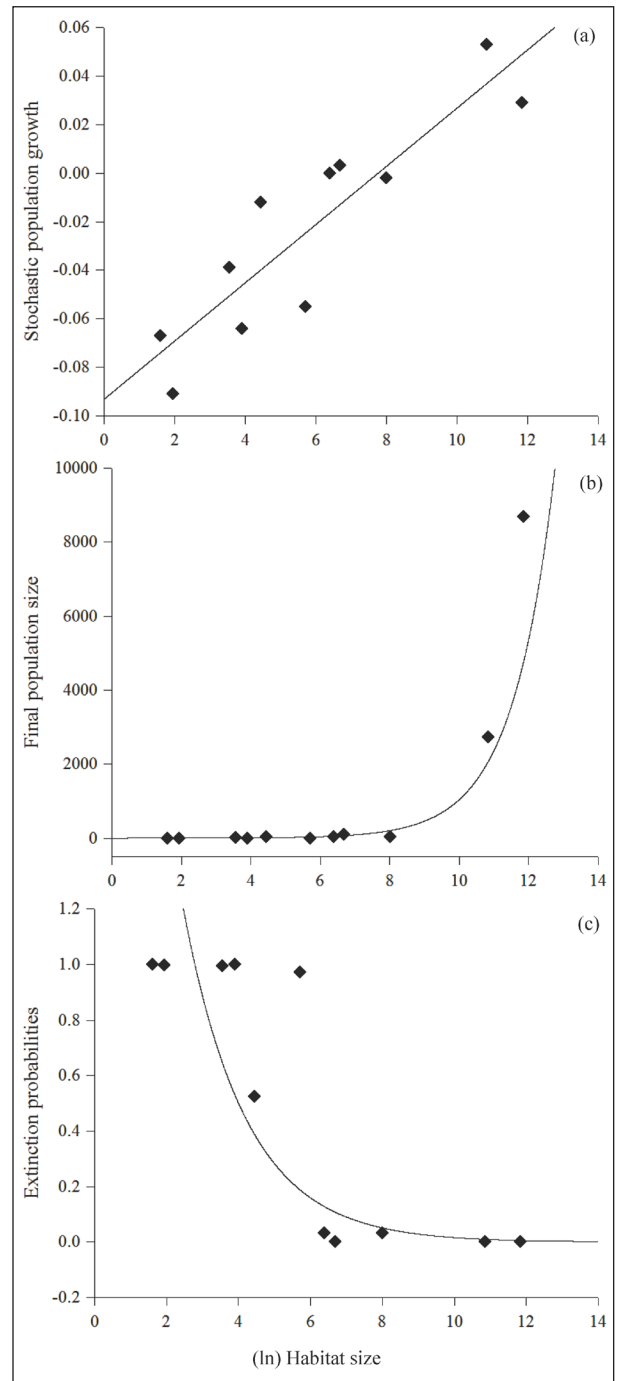


Figure 2. The relationships between habitat size and extinction parameters calculated using VORTEX (v. 10.0.7.0) for 11 populations of black howler monkeys in Campeche, México.

Table 3. Simulation (1,000 iterations) of the extinction process of 11 populations of black howler monkeys (*Alouatta pigra*) in Campeche (Mexico) over a 100-year period.

Population	Scenario ^a	Population growth rate (r) [mean(SD)]	Final population size [mean(SD)]	Probability of extinction	Years to extinction ^b
Calakmul N	Baseline	0.053 (0.05)	2732.3 (139.6)	0	>100
	5% more H	0.053 (0.05)	2733.4 (46.45)	0	>100
	10% more H	0.053 (0.05)	2731.1 (66.8)	0	>100
	5% more ADE	0.042 (0.07)	2665.5 (178.4)	0	>100
	10% more ADE	0.030 (0.09)	2535.8 (321.9)	0	>100
Calakmul S	Baseline	0.029 (0.05)	8692.9 (358.5)	0	>100
	5% more H	0.029 (0.05)	8681.2 (405.2)	0	>100
	10% more H	0.029 (0.05)	8694.4 (327.9)	0	>100
	5% more ADE	0.017 (0.73)	7984.3 (1208.5)	0	>100
	10% more ADE	0.007 (0.86)	6587.3 (2054.9)	0	>100
Calaxchil	Baseline	-0.003 (0.06)	33.98 (15.5)	0.033	84.5
	5% more H	-0.003 (0.06)	34.15 (15.4)	0.028	85.1
	10% more H	-0.003 (0.06)	34.72 (15.1)	0.030	85.0
	5% more ADE	-0.015 (0.09)	20.17 (13.6)	0.223	79.0
	10% more ADE	-0.026 (0.11)	13.07 (10.4)	0.533	72.2
T61Calax	Baseline	0.026 (0.12)	5.16 (1.52)	0.902	36.7
	5% more H	0.026 (0.12)	5.19 (1.42)	0.882	38.3
	10% more H	0.025 (0.12)	5.2 (1.5)	0.895	37
	5% more ADE	0.017 (0.14)	4.84 (1.29)	0.957	34.1
	10% more ADE	0.010 (0.15)	4.00 (1.41)	0.986	29.1
Tormento N	Baseline	-0.011 (0.08)	25.6 (15.5)	0.118	80.9
	5% more H	-0.012 (0.08)	25.23 (14.9)	0.178	81.4
	10% more H	-0.013 (0.08)	24.21 (15.2)	0.167	80.6
	5% more ADE	-0.023 (0.11)	14.7 (11.7)	0.441	74.5
	10% more ADE	-0.034 (0.12)	9.7 (8.22)	0.736	67.1
Tormento S	Baseline	0.011 (0.06)	108.15 (19.3)	0.000	>100
	5% more H	0.011 (0.06)	109.44 (17.3)	0.000	>100
	10% more H	0.011 (0.06)	109.69 (18.3)	0.000	>100
	5% more ADE	-0.001 (0.08)	77.04 (33.5)	0.004	80.3
	10% more ADE	-0.014 (0.1)	42.28 (31.9)	0.076	82.2
AA Álamo	Baseline	-0.016 (0.09)	18.3 (11.4)	0.33	70.6
	5% more H	-0.017 (0.09)	17.4 (11.6)	0.338	70.5
	10% more H	-0.017 (0.09)	17.9 (11.5)	0.352	69.1
	5% more ADE	-0.029 (0.11)	11.1 (8.0)	0.667	63.7
	10% more ADE	-0.040 (0.13)	8.1 (6.4)	0.882	56.6
	5% less ADE	-0.004 (0.05)	29 (12.5)	0.093	75.1
Chicbul	Baseline	-0.285 (0.18)	0.00 (0.0)	1	4.7
	5% more H	-0.286 (0.18)	0.00 (0.0)	1	4.7
	10% more H	-0.287 (0.18)	0.00 (0.0)	1	4.7
	5% more ADE	-0.296 (0.19)	0.00 (0.0)	1	4.5
	10% more ADE	-0.297 (0.19)	0.00 (0.0)	1	4.5
	5% less ADE	-0.064 (0.14)	0.00 (0.0)	1	24.4

Table 3. continued on next page

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Population	Scenario ^a	Population growth rate (r) [mean(SD)]	Final population size [mean(SD)]	Probability of extinction	Years to extinction ^b
Manantiales	Baseline	-0.029 (0.13)	5.71 (3.59)	0.951	44.3
	5% more H	-0.030 (0.13)	4.93 (2.35)	0.954	44.1
	10% more H	-0.030 (0.13)	6.13 (3.1)	0.944	43.3
	5% more ADE	-0.038 (0.14)	5.6 (2.67)	0.985	37.2
	10% more ADE	-0.047 (0.16)	4.6 (3.21)	0.995	31.6
	5% less ADE	-0.021 (0.12)	7.11 (3.19)	0.86	51.2
Oxcabal	Baseline	-0.064 (0.15)	0.00 (0.0)	1	13.2
	5% more H	-0.064 (0.15)	0.00 (0.0)	1	12.9
	10% more H	-0.067 (0.15)	0.00 (0.0)	1	12.2
	5% more ADE	-0.070 (0.16)	0.00 (0.0)	1	11.7
	10% more ADE	-0.079 (0.17)	0.00 (0.0)	1	10.4
	5% less ADE	-0.060 (0.14)	0.00 (0.0)	1	14.3
R Álamo	Baseline	-0.011 (0.14)	5.33 (2.16)	0.951	36.5
	5% more H	-0.013 (0.14)	5.97 (2.49)	0.964	35.8
	10% more H	-0.013 (0.14)	4.79 (1.79)	0.961	36.4
	5% more ADE	-0.021 (0.15)	3.61 (1.54)	0.982	31.3
	10% more ADE	-0.029 (0.16)	4.60 (2.07)	0.995	26.8
	5% less ADE	-0.004 (0.12)	5.8 (2.16)	0.901	41.6

^a H is hurricanes; ADE is anthropogenic disturbance events; ^b Models were run for a 100-year period. Therefore, time to extinction for populations that were not extinct in this period is represented as >100 years.

populations predicted to become extinct in baseline models increased 370.8±463%, and time to extinction was reduced 19.1±10.1 years. Under this scenario, only two populations would be extant in 100 years, 45.5% of all populations would become extinct in approximately 30 years and 81.8% in approximately 80 years. When ADE were removed from models of populations known to be exposed to their effects (AA Álamo, Chicbul, Manantiales, Oxcabal, R Álamo), population growth increased 50±31.6%, population size increased 30.6±25.4% (excluding Chicbul and Oxcabal, which were still predicted to include no individuals by the end of the simulation), probabilities of extinction decreased 28.9±30.7%, and time to extinction increased 92.7±182%, compared to baseline. In this scenario it was noteworthy the change in time to extinction in Chicbul, which increased approximately 20 years.

Discussion

Variation in the frequency of anthropogenic disturbance events (ADE), but not hurricanes, affected the extinction parameters analyzed for black howler monkey populations observed in Campeche. As ADE increased, population growth rate, final population size, and years to extinction decreased, whereas probabilities of extinction increased, with only two of 11 populations being extant after 100 years. Conversely, when ADE was removed from the model

for populations that are known to have experienced ADE, extinction was still predicted for all populations at the end of the simulation, but as the decrease in population growth was not as fast, the populations ended with a larger number of individuals, and extinction became less likely and was delayed for all the populations. Therefore, the occurrence of ADE is a major stochastic factor predicting the extinction risk of black howler monkeys in Campeche.

Similar to other howler monkey species, black howler monkeys may be found in highly disturbed environments, where the available habitat is reduced and food resources are limited when compared to pristine forests (e.g., Arroyo-Rodríguez and Dias, 2010; Pozo-Montuy and Serio-Silva, 2007). This observation, combined with evidence of behavioral flexibility in response to anthropogenic disturbance (Dias and Rangel-Negrín, 2015) and with the presence of individuals in habitats where other mammals are absent (Rangel-Negrín et al., 2014), has led to the idea that howler monkeys are highly resilient to habitat disturbance (e.g., Rosenberger et al., 2009). However, we have previously demonstrated that population growth and infant survival in black howler monkeys living in Campeche are negatively related to habitat disturbance (Dias et al., 2015), and the present study suggests that if current disturbance conditions are maintained, populations living in more disturbed habitats (i.e., those exposed to ADE in baseline

models) will go extinct during the next 100 years. For some populations (Chicbul and Oxcabal) current conditions were sufficient to predict extinction in the short-term, and variation in ADE had no impact in extinction parameters (in fact, the Chicbul group does not exist anymore due to the complete destruction of its habitat). We have previously speculated that, based on the demographic trends observed in populations living in highly disturbed habitats (lower population growth and infant survival in highly disturbed habitats; dispersal patterns positively related to amount of habitat in the landscape), many adult individuals may have been born before disturbance occurred, and/or come from less disturbed habitats (Dias et al., 2015). The predictions generated in the present study support this speculation, as it is possible that the smaller and more disturbed habitats represent sinks where populations go extinct. It is therefore possible that such habitats are being recolonized by individuals that move between forest fragments (Pulliam, 1988). By continuing to monitor these populations in the long-term, we will be able to validate our PVAs and to document ecological processes affecting populations in disturbed landscapes (Dunning et al., 1992).

Some populations where we did not record ADE were also predicted to go extinct. Calaxchil and Tormento N had low extinction probabilities in baseline models, but were predicted to go extinct in *ca.* 80 years and had negative population growth; and T61 Calax had a very high baseline extinction probability. The interaction between small population size and vital rates may explain why populations in protected areas still faced extinction risk. For instance, the population size of Tormento N was half of that in Tormento S and mortality rates of females and males during the first three years of age were on average 4.7% higher in the former than in the later. Calaxchil and Tormento N populations comprised approximately 50 individuals each, and T61 Calax was a single group living in a 300 ha habitat. Small populations are more vulnerable to the effects of demographic and environmental stochasticity, genetic drift, inbreeding depression, and Alleé effects (i.e., co-dependency between population size and gross population growth or some fitness component) (Fischer and Lindenmayer, 2007). At the individual level, these factors may lead to a reduction in survival and reproduction, whereas at the population level may derive in reduced population sizes and genetic diversity (Fahrig, 2003). Although habitat size has been reported as the main factor constraining howler monkey populations in disturbed habitats (Arroyo-Rodríguez and Dias, 2010), we found a non-linear relationship between habitat size and both final population size and extinction probabilities. Therefore, our results suggest that the persistence of some populations may be linked to demographic processes derived from small population size, which are not directly linked to habitat size. It is possible that the management of these populations through translocations and reinforcements (Baker, 2002; e.g., King et al., 2013) could decrease their extinction risk.

An additional indirect evidence for the strong effect exerted by small population size on extinction probabilities is the low impact that the removal of ADE had on the probability of extinction of populations known to be exposed to these types of events. Still, it is important to acknowledge that without ADE, predicted time to extinction increased by a mean of 7.5 years. From a conservation and management perspective, this additional time may be sufficient to develop actions aimed at promoting population growth and persistence (Grantham et al., 2009). For instance, two years was considered a time span long enough to evaluate the success of an environmental education program developed with human populations living in proximity with six primate species in Uganda (Kuhar et al., 2010); and seven years were sufficient to implement conservation and management actions recommended by a population and habitat viability assessment of lion tamarins (*Leontopithecus* spp.; Holst et al., 2006). Therefore, it is important to study more thoroughly ADE faced by black howler monkeys in Campeche, and develop strategies for their mitigation in order to avoid local extinctions.

In one of the best studied populations of black howler monkeys, high mortality was recorded after the occurrence of a Category 4 hurricane (Pavelka et al., 2007). It was recently suggested that hurricanes could represent a stronger threat to the persistence of mantled howler monkeys (*A. palliata*) living near the Gulf of Mexico than anthropogenic disturbance (Ameca y Juárez et al., 2015). We therefore included hurricanes as a source of stochastic variation in the demography of our study populations. Hurricanes, however, had a marginal impact in our models of extinction risk. Differences between the results of the present and of the above mentioned studies could be related to two main aspects. First, in contrast with the Monkey River population (Pavelka et al., 2007; Fig. 1), which is located near the Caribbean Coast where several hurricanes make landfall (NOAA, 2016), the majority of the Campeche territory is located inland, and its coast faces the southernmost portion of the Gulf of Mexico (Fig. 1). Therefore, hurricanes originating in the Atlantic basin never make direct landfall in Campeche, usually reach its territory with decreased intensity (CONAGUA, 2016), and are thus less destructive (as observed in the aftermath of hurricane Dean). Therefore, the level of severity we used to model the impact of hurricanes in Campeche was lower than that directly observed in Monkey River. Second, in contrast with Ameca y Juárez et al. (2015), we only modeled the frequency of hurricanes with the potential to cause an actual effect on individuals and their habitat (i.e., we did not include hurricanes in Categories 1-3 in our analyses), and estimated hurricane frequency for our study area based on the actual trajectories of hurricanes. Therefore, although intense hurricanes affect the survival of infants in our populations, they do not seem to pose a threat to the current or future persistence of black howler monkeys in the state of Campeche, even if hurricane frequency increases (Webster et al., 2005).

Despite several shortcomings (e.g. Reed et al., 2002), PVA represents an important tool for assessing the extinction risk of populations. When PVA are based on long-term data, their predictive value is expected to increase significantly (Brook et al., 2000), and are therefore of high value for policy development and management planning. This study is grounded on a 7-year monitoring of 11 black howler monkey groups, representing a reliable approach to model the future of black howler monkeys in Campeche. In sum, our results suggest that: 1) anthropogenic disturbance is a major source of stochastic variation in extinction risk; 2) small populations not currently affected by such disturbance face high extinction risk as well; and 3) the lessening of anthropogenic disturbance may benefit the persistence of threatened populations.

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USING CAMERA TRAPS TO DETERMINE GROUP DEMOGRAPHY IN A PARAGUAYAN POPULATION OF *SAPAJUS CAY*

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Abstract

The understudied Hooded Capuchin (*Sapajus cay*) is the only representative of its genus in Paraguay. The species is distributed throughout the Upper Paraná Atlantic Forest, a biome that historically covered most of eastern Paraguay but has been reduced to small, isolated fragments by agricultural encroachment. Understanding group composition and demographics is important for monitoring the viability of populations. In this study, video camera traps were used to monitor a single group of Hooded Capuchins during their visits to a provisioning platform in a small Atlantic Forest fragment in Reserva Natural Laguna Blanca, Departamento San Pedro, Paraguay. Video analysis enabled identification and assignment of age classes to all 18 individuals of the group. Sex determination was possible for 8 adults, 2 subadults, and 2 juveniles. This study provides the first information of group demographics and composition of wild Hooded Capuchins in Paraguay.

Keywords: Atlantic forest, group composition, hooded capuchin, paraguay, video camera trapping.

Resumen

El poco estudiado capuchino de Azara (*Sapajus cay*) es el único representante de su género en Paraguay. La especie está distribuida a lo largo del bosque Atlántico del alto Paraná, un bioma que históricamente cubrió la mayor parte del oriente de Paraguay pero que ha sido reducido a fragmentos pequeños y aislados por el avance de la agricultura. Entender la composición de grupo y la demografía es importante para monitorear la viabilidad de las poblaciones. En este estudio, trampas de video cámara fueron utilizadas para monitorear un grupo de capuchinos de Azara durante sus visitas a una plataforma de aprovisionamiento en un pequeño fragmento de bosque Atlántico en la Reserva Natural Laguna Blanca, Departamento San Pedro, Paraguay. El análisis de los videos permitió identificar y asignar clases de edad a 18 individuos del grupo. La determinación del sexo fue posible para 8 adultos, 2 subadultos y 2 juveniles. Este estudio provee la primera información de la demografía y composición de un grupo silvestre de Tufted capuchins en Paraguay.

Palabras clave: Bosque Atlántico, composición de grupo, capuchino de Azara, Paraguay, trampeo con video cámara.

Introduction

The taxonomy of the capuchins has long been debated. All capuchins were historically classified in the single genus *Cebus*, however Elliot (1913) split the capuchins into two groups: those with “heads without tufts on males” and those with “heads with tufts or ridges on males”. Hershkovitz (1949, 1955) agreed with this separation but argued *Cebus apella* should be classed as a member of the tufted group. Hill (1960) reduced the 12 recognized species of tufted capuchin to one, *Cebus apella*, with 16 subspecies. Grooves (2001) recognized 4 species (*C. apella*, *C. libidinosus*, *C. nigrurus* and *C. xanthosternos*) with 13 subspecies. Silva Jr. (2001) argued that, morphologically, the tufted and untufted capuchins displayed sufficient differences to be classified as separate subgenera: *Sapajus* (Kerr 1792) for the tufted or robust species and *Cebus* (Erxleben, 1777) for

the untufted or gracile species. Studies of the mitochondrial genes 12S and cytochrome *b* (Lynch Alfaro *et al.*, 2012) and 10 distinct ALU elements (Martins *et al.*, 2014) have since confirmed that *Sapajus* and *Cebus* diverged around the late Miocene era, possibly as a result of the establishment of the Amazon River (Hoorn *et al.*, 2010; Halsam, 2012). The present sympatry of *Cebus* and *Sapajus* species observed in the Amazon Basin is thought to result from a late Pleistocene invasion of *Sapajus* species from the Atlantic Forest (Lynch Alfaro *et al.*, 2012; Nascimento *et al.*, 2015). Currently, 8 species are recognized within the *Sapajus* genus (*S. macrocephalus* (Spix, 1823), *S. apella* (Linnaeus, 1758), *S. libidinosus* (Spix, 1823), *S. flavius* (Schreber, 1774), *S. xanthosternos*, (Wied-Neuwied, 1826) *S. robustus* (Kuhl, 1820), *S. nigrurus* (Goldfuss, 1809) and *S. cay* (Illiger, 1815)) and are distributed across all countries in

South America except Chile and Uruguay (Lynch Alfaro *et al.*, 2012).

The Hooded capuchin (*Sapajus cay*) formerly known as *Cebus apella cay* (Illiger, 1815) and *C. libidinosus paraguayanus* (Fischer, 1829), is found in south-east Bolivia, northern Argentina, and Brazil (states of Goiás, Mato Grosso, Mato Grosso do Sul) and is the only representative of the genus found in Paraguay (Wallace, 2015). In Paraguay, it occurs in the humid semi-deciduous Upper Paraná Atlantic Forest throughout the east of the country (Lowen *et al.*, 1996; Rylands *et al.*, 2013), but its range does not extend into the Paraguayan Chaco (Stallings, 1985). In Paraguay, the average group size for the capuchin has been estimated at 7 individuals with a population density of 4 groups/km² or 28 individuals/km² (Stallings, 1985). Across its range, very little is known about the Hooded Capuchin and little information exists regarding its reproduction, movement and activity patterns, home range, and social organization (Rylands *et al.*, 2013).

Baseline demographic analysis is essential for monitoring the viability of a population (Lynch Alfaro *et al.*, 2014). Studying fluctuations in demographic factors can help to determine the future viability of small, isolated populations of Neotropical primates (Belle and Estrada, 2005; Strier *et al.*, 2006). The effects of stochastic variation on the fecundity and mortality rates in large populations will be mitigated by the high number of individuals within the population; however, in small or isolated populations such variations can have serious consequences for the viability of the population, increasing extinction risk (Colishaw & Dunbar, 2000). Changes in group size can have effects on behavior and ecology of populations. For example, in muriquis (*Brachyteles arachnoides*), increases in population size have been found to lead to increases in home range size (Strier, 1993). A low proportion of juveniles or infants may indicate reproductive problems in the population (Colishaw & Dunbar, 2000; Lynch Alfaro *et al.*, 2014) and sex ratio imbalances in a group or a population can have a dramatic effect on the future number of breeding males or females (Dunbar, 1988). Modelling of changes in sex ratios on the viability of populations in muriquis (*Brachyteles arachnoides*) have shown that slight deviations in the sex ratio of neonates in favor of males can lead to drastic reductions in population size (Strier, 1993 – 1994). Other studies have shown that changes in demography can lead to changes in levels of competition for mates or even patterns of sex-biased dispersal (Strier, 2003; Jones, 2005; Strier, 2007). Age composition can have a significant effect on the viability of a population. A group made up of mainly young or old females will have a lower birth rate than a group of females in their reproductive prime (Strum & Western, 1982).

Previous studies have highlighted inherent difficulties with the use of spot counts and direct observation as a means of assessing group demography in arboreal primates

(Williamson & Fiestner, 2011), especially in areas where troops are not fully habituated to human presence (Strier, 2007). In order to overcome these issues, alternative methods can be utilized. Motion-activated camera traps are an effective non-invasive method for monitoring primates (Kierulff *et al.*, 2004; Tan *et al.*, 2013; Pebsworth & LaFleur, 2014). Camera traps have been used successfully to confirm species presence (Lhota *et al.*, 2012; Bezerra *et al.*, 2014), provide information on activity patterns (Tan *et al.*, 2013; LaFleur *et al.*, 2014) and investigate life history (Galvis *et al.*, 2014). In this paper, we report how video camera trapping was used to provide the first information on group composition for wild Hooded Capuchins (*Sapajus cay*) in Paraguay.

Methods

Study Site

This study was carried out at Reserva Natural Laguna Blanca (RNLB), San Pedro, Paraguay (23°49'52.0"S 56°17'42.2"W). RNLB is a private nature reserve in eastern Paraguay and is home to two groups of Hooded Capuchins. This 804 ha reserve is located in the transitional zone between the Cerrado and Atlantic Forest ecoregions. The reserve contains a small fragment of 243 ha of young secondary Upper Paraná Atlantic Forest, characterized by deciduous, mesophytic, broadleaf plants (Lowen *et al.*, 1996). Departamento San Pedro experiences average yearly temperatures of 23 to 24°C, and an average yearly rainfall of approximately 1400 mm (Cartes, 2008). The forest fragment has a history of selective logging until 2010 when it was classified as a reserve.

Data Collection

A provisioning station was constructed in an area of the forest where the capuchins were regularly observed. The station consisted of a 2 m high, 0.72 m² triangular platform positioned 50 cm from a *Chrysophyllum gonocarpum* tree (Fig. 1). A Primos Truth Cam Ultra 46 HD Trail Cam (www.trailcampro.com) was secured to the tree with a durable canvas strap. The camera has a 13.72 m detection range and uses an infrared sensor to detect body heat and motion. The camera was set to record 60 seconds of 1,280x720p HD footage per trigger with a 5-second delay between each trigger. Each 60-second video was automatically marked with a date and time stamp.

The platforms were baited with between 5 and 10 kg of whole ears of corn for a preliminary period of 16 trap days between March 10th 2015 and May 30th 2015. A trap day was defined as a full 24-hour period in which the video camera trap was set. During this time, two visits were recorded at the station but the videos were not used in this analysis. For 24 camera trap days between July 4th 2015 and the 4th August 2015, two 106SS model Tomahawk traps were tied to the platform; with the door secured in the open position by plastic cable zipties, and facing the camera trap. Corn pieces and whole bananas were placed



Figure 1. Provisioning Station. a. Video camera trap, b. Baited Tomahawk traps, c. 2 m high, 0.72 m² triangular platform.



Figure 2. Camera trap frames of adult, subadult, juvenile, and infant *S. cay*. 2A is the largest adult male, he has a very robust lower jaw and smaller tufts than the adult female (2B). 2C and 2D show subadult individuals. 2C has a thinner pointed black cap than 2D and 2D has pink marking under her eyes. 2E shows a juvenile who is smaller than the subadults in comparison to the Tomahawk traps. 2F shows the group's only infant being carried by the same female shown in 2B.

both inside the traps and loose in the center of the platform. The Tomahawk traps were baited with 6 kg of bananas and halved ears of corn twice per week and videos were retrieved from the SD memory card on a continuous basis when the station was re-baited.

Data Analysis

All videos in which a capuchin appeared were reviewed on a frame-by-frame basis. Screen shots were taken at all opportunities when the face and body of individuals were clearly visible. Individual identities were assigned to monkeys on each screenshot based on a variety of physical characteristics including: 1) body size, shape, size, and color of tufts 2) shape of the black cap on forehead 3) shape and

coloration of black and white facial masks and 4) distinctive scars or wounds.

A sex was assigned to an individual when a clear image of their genitalia was obtained. Individuals with robust facial features, complete adult dentition, and the largest relative body sizes were scored as “adults” (Fig. 2A and 2B) (Fragazy *et al.*, 2004). The presence of elongated nipples, indicative of lactation, was used to score the age and sex of one smaller adult female. “Subadults” were classified as individuals approaching adult body size but lacking the characteristic robust facial features and tufts of the adults (Fig. 2C and 2D). “Juveniles” were classified as individuals that were less than three quarters of the average adult size, not including tail length (Fig. 2E) (Oliveira & Langguth, 2006; Bezerra *et al.*, 2014). “Infants” were classed as only those individuals observed being carried by an adult (Fig. 2F).

Results

Over the 24 trap days during which the station was baited the capuchins visited the platform on 11 occasions. A total of 319 videos were obtained, resulting in 196 videos in which at least one capuchin appeared (61.44%). Each individual appeared in the videos at least once during the 11 visits. A group of 18 individuals containing 3 adult males, 5 adult females, 5 subadults (2 females), 4 juveniles (2 males) and 1 infant was identified.

Discussion

Demographic comparisons of wild primate species across forest fragments can be used to monitor the health and life histories of different populations. Rapid and cost effective assessments are necessary to establish baseline demographic information for future spatial and temporal comparisons across populations of a single species. These assessments can be used to compare population densities, reproductive parameters, patterns of natal dispersal, and group fission and fusion events across multiple species (Lynch Alfaro *et al.*, 2014). Our results provide the first detailed demographic information of a group of wild hooded capuchins (*Sapajus cay*) in Paraguay.

The group size of 18 individuals in Reserva Natural Laguna Blanca is higher than the only previous estimate for *Sapajus cay* in Paraguay (average group size: 7 (Stallings, 1985)), though the total group size is more comparable to the average group size across the genus (Table 2). Group sizes and compositions of the eight *Sapajus* species can vary within and across different habitat locations (Tables 1 and 2). The variability of group sizes across the genus may be indicative of site-specific factors such as variable predation rates, access to supplemental food sources, and anthropogenic disturbances such as hunting and agricultural encroachment (Cullen *et al.* 2000; Fragazy *et al.*, 2004; Hankerson & Dietz, 2014; Izar *et al.*, 2012).

Though few natural potential predators exist in the area, the capuchins were hunted by local people (mainly for meat and infants for the pet trade (Ayala, pers. com.)) until the reserve was granted protected status in 2010. Predation has been found to reduce the number of individuals in a group (Irwin *et al.*, 2009; Hankerson & Dietz, 2014) and affect group composition by increasing the number ratio of adult males to adult females (Hill & Lee, 1998). Even the loss of

one individual per year from the group can have important consequences for group demographic structure (Fragaszy *et al.*, 2004). A reduction in the number of breeding females would likely have a large impact on the future of the group, as the percentage of juveniles and infants in the group is already below the mean for the genus (Table 2).

Table 1. Study results and mean group size and composition across the genus *Sapajus*.

Species	Group Size	-	No. of Adult Males	No. of Adult Females	No. of Subadults	No. of Juveniles	No. of Infants	Source
<i>S. cay</i>	18	-	3	5	5	4	1	This study
Species	Mean Group Size	Group Size Range	Mean No. Males	Mean No. Females	Mean No. Subadults	Mean No. Juveniles	Mean No. Infants	
<i>S. cay</i> (Paraguay)	12.5	7-18	-	-	-	-	-	Stallings, 1985; This Study
<i>S. cay</i> (Brazil)	20.5	20-21	6	6	2	7.5	-	Pinto, 2006; Fernandes Jr., 2013;
<i>S. macrocephalus</i>	8.3	2-21	1.8	2.1	0.65	2.8	0.8	Klein & Klein, 1976; Izawa, 1980; Defler, 1982; Soini, 1986; Rylands <i>et al.</i> , 2013
<i>S. libidinosus</i>	21.8	6-45	3.4	7	1.25	5	2.5	Freitas <i>et al.</i> , 2008; Izar <i>et al.</i> , 2011; Massaro <i>et al.</i> , 2012; Carretero-Pinzón, 2013; Falótico & Ottoni, 2013
<i>S. nigritus</i>	20.6	7-44	2.4	5.6	2.6	6.8	2.5	Lynch & Rímoli, 2000; Di Bitetti & Janson, 2001; Lynch-Alfaro, 2007; Izar <i>et al.</i> , 2011; Garber <i>et al.</i> , 2012; Janson <i>et al.</i> , 2012; Liebsch & Mikich, 2015
<i>S. xanthosternos</i>	14	9-27	2	3	4	4	1	Canale <i>et al.</i> , 2013
<i>S. robustus</i>	15.7	8-23	2	4	1	-	-	Martins, 2010; Mittermeier <i>et al.</i> 2015
<i>S. flavius</i>	40.2	7-77	10	15	-	37	7	Pontes <i>et al.</i> , 2013; Rodrigues, 2013; Bastos <i>et al.</i> , 2015; Mittermeier <i>et al.</i> 2015

Table 2. Study results and percentage group composition across the genus *Sapajus*.

	% Adult Males	% Adult Females	% Subadults	% Juveniles	% Infants
<i>S. cay</i> (Paraguay)	16.67	27.78	27.78	22.22	5.56
<i>S. cay</i> (Brazil)	29.9	29.9	9.91	36.6	-
<i>S. macrocephalus</i>	9.09- 25	20- 50	0 – 20	22.22– 60	0 – 31.25
<i>S. libidinosus</i>	7.14 - 17.78	21.43 - 35.56	0- 21.43	22.22-42.86	17.39- 33.33
<i>S. nigritus</i>	9.52 – 17.86	25 -62.5	0-25	0 -39.28	0-21.43
<i>S. xanthosternos</i>	14.29	21.43	28.71	28.57	7.14
<i>S. robustus</i>	13.3	26.67	6.67	-	-
<i>S. flavius</i>	24.8	37.3	-	92.04	17.4

Species classification based on Lynch Alfaro *et al.* (2012).

Access to supplemental food sources can increase the size of populations. In Parque Nacional de Brasília, Brasília, Brazil, the capuchins have become accustomed to being fed by tourists and their population has increased exponentially (Fragaszy *et al.*, 2004). In Japanese macaques (*Macaca fuscata*) access to supplementary food sources, in the form of human rubbish dumps, has been found to decrease feeding competition and increase female fertility, leading to increases in group size (Asquith, 1989; Muruthi *et al.*, 1991). The forest fragment of RNLB is bordered on two sides by a large crop field. The capuchins have been seen raiding the crops during the season when corn is grown (Pers. obs.). Though the lack of information from various sites across Paraguay prevents a definitive answer, it may be that the group size in RNLB is related to this supplemental food access.

Within Paraguay, encroachment of soy plantations and cattle farming have had devastating effects on the country's native forest and as a result it is becoming more important to assess wildlife populations in isolated fragments (Huang *et al.*, 2007). With less than 13% of this forest remaining (WWF, 2015), continued habitat fragmentation surrounding RNLB and across Paraguay has the potential to further isolate remaining populations of *Sapajus cay*. Habitat fragmentation can have significant impacts on group demographic structure. Initially, habitat fragmentation can lead to unnaturally high densities of primates, increasing feeding competition within and between groups (Strier, 2007). Decreases in available habitat can affect dispersal patterns. For example, red howler monkeys living in small forest fragments show increased rates of female dispersal, leading to an increased troop density within the fragment (Crockett, 1996). In contrast, mantled howler monkeys (*Alouatta palliata*) have been found to remain in their natal groups causing group size to increase as habitat decreases (Crockett, 1998). In RNLB the 414 ha forest fragment is home to two groups of hooded capuchins. At present, there is no information available for the home ranges of this species but home ranges of *Sapajus nigritus* in Iguazú National Park, Argentina have been found to average 161.77 ha (range=81±293 ha, n=7) (Di Bitetti, 2001). If *S. cay* have similar home ranges to *S. nigritus* then the troop density in RNLB is not abnormally high. The higher number of individuals in the group compared to Stallings (1985) average group size of 7 may be a result of the isolated nature of the forest fragment. However, as the forest at RNLB only became cut off from surrounding fragments within the last 10–15 years (Ayala, pers. comm.) future monitoring will be required to establish long term effects of habitat fragmentation on the group's demographic structure.

We have demonstrated that video camera trapping has great potential for rapid demographic assessment of semi- or unhabituated arboreal primates in areas of rugged terrain or with non-sexually dimorphic species. Using tomahawk traps made the food items harder to access, forcing the capuchins to remain within sight of the video camera for long

periods of time to obtain a food reward. These extended visits produced sufficient videos to identify individuals and made determination of sex possible for the majority of subjects. Though we had success over the course of this study, long-term provisioning of wild primates has been known to alter behavior, development and demographic structure (Asquith, 1989; Lyles & Dobson, 1988; Fedigan, 2010), therefore, the use of a baited provisioning platform is recommended only for short-term assessments and not long-term studies of demographic changes.

This novel information on the group composition of wild *Sapajus cay* population in Paraguay provides a baseline from which changes in group structure can be monitored, facilitating future studies on the effects of living in the remnants of the Paraguayan Atlantic Forest, a topic of increasing importance to the conservation of wild primates (Lynch Alfaro *et al.*, 2014).

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MAKING USE OF CAPUCHINS' BEHAVIORAL PROPENSITIES TO OBTAIN HAIR SAMPLES FOR DNA ANALYSES

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Abstract

Genotyping wild and captive capuchins has become a priority and hair bulbs have high quality DNA. Here, we describe a method to non-invasively collect fresh-plucked strands of hair that exploits capuchins' manual dexterity and propensity to grasp and extract food. The apparatus consists of a transparent tube baited with food. Its extraction requires the monkey to place its forearm in contact with double-sided tape applied on the inner surface of the tube entrance. The "tube" method, successfully implemented with captive (N=23) and wild (N=21) capuchins, allowed us to obtain hair bulbs from most individuals and usable genomic DNA was extracted even from a single bulb.

Keywords: Hair collection; DNA; non-invasive method; *Sapajus*

Resumen

Establecer el genotipo de capuchinos silvestres y en cautiverio se ha convertido en una prioridad y los bulbos capilares tienen AND de alta calidad. Describimos un método no invasivo para coleccionar hebras de cabello recién arrancadas que aprovecha la destreza manual de los capuchinos y su propensión a agarrar y extraer alimento. El aparato está compuesto por un tubo transparente cebado con alimento. Su extracción requiere que el mono ponga su antebrazo en contacto con cinta de doble faz que se ha acondicionado en la superficie interior de la entrada del tubo. El método del "tubo", exitosamente implementado con capuchinos cautivos (N=23) y silvestres (N=21), nos permitió obtener bulbos capilares de la mayoría de individuos y AND genómico utilizable fue extraído aún de un solo bulbo.

Palabras clave: Colección de pelo; ADN; método no invasivo; *Sapajus*

Introduction

Genetic material is a fundamental tool for population genetics and conservation biology, since it allows determining species identification, reproductive success, inbreeding, population size, dispersal and migration (Sunnucks, 2000). Recent phylogenetic and biogeographic evidence indicate distinct evolutionary histories of the two radiations of capuchin monkeys, *Cebus* (untufted or gracile capuchins) and *Sapajus* (tufted or robust capuchins) and a higher number of species than previously recognized (Lynch Alfaro *et al.*, 2012 a, b). As a consequence, captive capuchins of uncertain geographic origin cannot be ascribed to a given species without being genotyped to identify the species and the hybrids. Therefore, genotyping wild and captive capuchins has become a priority for both wild and captive capuchins (Lynch Alfaro *et al.*, 2014).

Samples of fresh-plucked strands of hair have relatively high concentrations of high-quality DNA that preserves well at room temperature if kept dry and produces fewer artifacts during amplification than DNA isolated from other tissues (e.g. Morin *et al.*, 1994; Taberlet and Bouvet, 1994; Valderrama *et al.*, 1999; Améndola-Pimenta *et al.*, 2009). Hair is also suitable to study heavy metal bioaccumulation (e.g., Malvandi *et al.*, 2010), feeding and dietary variations (e.g., Oelze, 2015), and hormone levels (e.g., Fourie and Bernstein, 2011). Consequently, a number of non-invasive methods to collect fresh hair from wild nonhuman primates exploiting species' spontaneous behaviors have been developed. For example, researchers took advantage of the fact that apes build nests and collected shed hair for DNA analyses (e.g., Morin *et al.*, 1994; Jeffery *et al.*, 2007), or of the proclivity of some species to manipulate food wrapped in duct tape to get their hair (Valderrama *et al.*, 1999).

In this study, we describe and test the effectiveness of a new non-invasive method to collect fresh-plucked strands of hair from wild and captive capuchin monkeys that exploits capuchins' manual dexterity, proclivity to manipulate foods/objects and strong natural propensity to exploit resources that need to be extracted from a substrate (Fragaszy *et al.*, 2004). We also evaluate the productivity of the method in terms of bulbs obtained for DNA extraction.

Methods

Subjects

The method was tested with wild and captive tufted capuchin monkeys. The former, 21 (out of 23; Table 1) wild bearded capuchins (*Sapajus libidinosus*) living in one social group at Fazenda Boa Vista (hereafter FBV) in the State of Piauí (Brazil; Visalberghi and Fragaszy, 2013). The latter were 23 captive-born tufted capuchins (*Sapajus* spp.; Table 2) derived from individuals of different geographical origin. These individuals were housed at the Primate Center of the ISTC-CNR in Italy. They belonged to four groups, each housed in an indoor–outdoor enclosure (indoor: 5 m² × 2.5 m high; outdoor: 40–130 m² × 3 m high). Water was freely available at all times. Fresh fruit, vegetables and monkey chow were provided in the afternoon after testing. This study complied with protocols approved by the Italian Health Ministry (DM133/2014 C to E. Visalberghi) and by SISBIO (Number: 51258-1) and adhered to the ASP Principles for the Ethical Treatment of Non Human Primates.

Apparatus and Procedure

FBV, Piauí, Brazil. We presented four transparent acrylic tubes of different lengths and diameters. The four tubes were 18, 18, 27, and 34 cm long, with inner diameters of 3.3, 2.6, 2.6, and 2.0 cm, respectively. The inner diameter of tubes 3 and 4 were obtained by using PVC-adapters in tubes with larger inner diameters (Fig. 1). One end of the tube was open. Small food items were placed inside the tube at a variable distance from the opening. Food items were sufficiently small to allow the monkey to easily move the hand inside the tube when holding the food during retrieval. Finally, if necessary, the depth of the tube was adjusted by inserting in the tube blocks (circular blocks made of the rachis of the local *buriti* palm) and/or pebbles so that the food was within the subject's reach but far enough to require it to insert the arm fully.

Double-sided tape (19 mm width) (Pattex extra strong Henkel Italia SPA ©) was attached to the inner circumference of the tube at the opening (Fig. 1). To allow removal of the tape after the hair was collected, one cm of the tube circumference was left bare. Immediately prior to use, the protective covering of the exposed surface of the tape was removed. Finally, the tube was fastened with two straps to a tree trunk or thick branch; each strap was 3 cm from the end of the tube (Fig. 2). A firm anchorage prevented the monkeys from dislodging the tube. Wooden wedges were

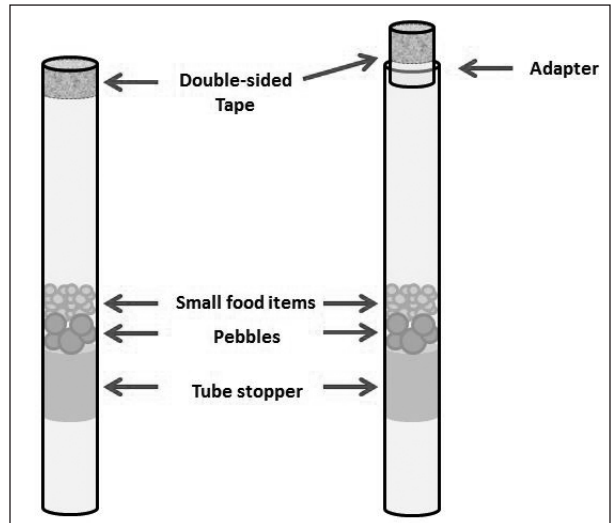


Figure 1. Schematic representation of the tube apparatus baited with small food items. Double-sided tape was applied on the inner surface of the tube entrance. The inner diameter of the tube could be reduced by tightly inserting a PVC-adapter inside the tube. One ending of the tube is blocked to change its depth as necessary to fit the individual's arm length. Pebbles were also used for the same purpose.

sometimes useful for this purpose. Tubes were placed so that a monkey could see the food inside the tube from its opening and could easily introduce its arm into the tube (see video at <https://vimeo.com/162360240>). The tube was oriented to increase the probability that the dorsal surface of the monkey's arm contacted the tape because the dorsal surface has longer hairs than the volar surface, and has a greater density of hair.

The tubes were baited with pieces of palm nuts (common in the diet of the capuchins living in FBV). To retrieve them the monkey had to place the full length of its arm inside the tube one or more times. The food items were located inside the tube at different distances. When the distance was short, the reward could be obtained by large individuals with some effort and high probability of hairs sticking to the tape. To collect the hairs of the smaller individuals the food had to be positioned further away from the opening. The tubes were located at 8–12 m from one another and each was closely monitored by at least one observer to detect the presence of hair(s) on the tape after an individual reached inside the tube (one or more times). If this were the case, the tube was removed, and the tape was carefully detached from the tube inner surface, attached to a clean paper sheet, covered with protective film and stored in a plastic bag marked with the date and subject's identity. Hair samples were collected in an area frequently visited by the group and used for field experiments (Visalberghi and Fragaszy, 2013), or opportunistically in other locations. The latter option was adopted for peripheral individuals. The hairs left in the tube by a single monkey were collected; when certain identification of the source of hairs on the tape could not be made, the samples were discarded. Before starting hair collection capuchins were familiarized with



Figure 2. The tubes were fastened to tree trunks or branches by means of two straps located close to the extremities of the tube. A firm anchorage was necessary to prevent monkeys from dislodging the tube (from a video taken by Luca Antonio Marino).

the tubes by exploring them (Fig. 3a, b). Testing occurred between 7.00 and 16.00. We presented the tubes on days without rain because wet hair does not adhere to the tape.

The number of hair bulbs of each sample collected in FBV was counted at the Department of Experimental Psychology, University of São Paulo using a stereo-microscope (Nikon AxioCam MRm Zeiss, SMZ 745T).

Primate Center of the CNR. Tubes 1, 2, and 3 were used (see previous section). The tubes were baited with small pieces of peanuts that required the monkey to reach into the tube one or more times to retrieve. Hair samples were collected from a single individual while the individual was separated briefly from the group for this purpose. Captive capuchins housed at the Primate Center of the CNR are familiar with tubes. Testing occurred between 9.30 and 15.15.

To evaluate the quality of genomic DNA from the hair bulb samples of the 23 captive capuchins was extracted



Figure 3. Before starting hair collection, young capuchins were allowed to explore the tubes together (A) and, only after they became more confident, each individual was opportunistically attracted to the tube for sample collection when no other individuals were nearby (B) (Photos V. Truppa).

using NucleoSpin® Tissue (Macherey Nagel, MN) and Chelex® 100 (Sigma) at two amounts of resin (5% and 20%) and their yield of genetic material assessed (see Table 2). Amount and purity of DNA extracted were evaluated using the optical reader Multi-Mode Microplate Readers (Biotek).

Results

FBV, Piauí. Data collection was carried out during 12 days for about 40 min per day. Seventy-four hair samples were collected from 21 individuals tested, including infants (Table 1). The individuals from whom we did not obtain hair were an adult female and a 6 month-old infant. An average of 3.4 samples (range 1-7 samples) was obtained per individual, yielding an average number of 8.8 usable bulbs per individual (range 0->35).

Primate Center of the CNR. Data collection was carried out during 5 days during a total of 3-4 hours. Fifty-one samples were collected from all the 23 individuals tested (Table 2). An average of 2.1 samples (range 1-4 samples) was obtained per individual, yielding an average number of 6.9 usable bulbs (range 0-20). The number of bulbs collected and the mean yield from each individual in relation to the DNA extraction methods are reported in Table 2. Usable genomic DNA was extracted even from a single bulb hair.

Table 1. Number of hair samples and hair bulbs collected from wild capuchins at Fazenda Boa Vista.

Subject	Sex	Age class*	N samples	N bulbs
Jatobá	M	Adult	5	13
Mansinho	M	Adult	5	9
Teimoso	M	Adult	3	2
Piaçava	F	Adult	2	7
Teninha	F	Adult	2	6
Chuchu	F	Adult	1	2
Dita	F	Adult	3	1
Amarelinha	F	Adult	7	8
Tomate	M	Adult	2	17
Catu	M	Adult	2	1
Doree	F	Adult	7	15
Pamonha	F	Adult	5	8
Coco	M	Juvenile	6	35
Taís	F	Juvenile	2	>35
Presente	M	Juvenile	5	15
Chani	F	Juvenile	1	0
Cachaça	M	Juvenile	2	3
Titia	F	Juvenile	1	0
Patrícia	F	Infant	6	5
Divina	F	Infant	1	0
Donzela	F	Infant	6	8
MEAN			3.4	8.8

* Age class was assigned in this way: Adults (individuals older than 5 years); Juveniles (individuals between 18 months and 5 years); Infant (individuals below 18 months).

Discussion

Both wild and captive capuchins were attracted by the tubes and their contents. Our non-invasive method to collect fresh-plucked strands of hair, including the hair bulb, proved to be effective and simple. The number of samples obtained depended primarily on the subject's propensity for inserting its forearm inside the tube to retrieve the food and, in wild individuals, from social constraints. Sampling was easy for high-ranking capuchins, especially males, and more difficult for subordinates (because dominant individuals tended to monopolize access to the tube) and young infants (because of their reluctance to venture to a tube alone). Finally, peripheral individuals were relatively difficult to encounter/detect but since they were often alone or far from dominant individuals, samples were easily collected out of view of the rest of the group.

Our "tube" method uses materials that are easy to find, inexpensive and reusable (with the obvious exception of the tape and the bait); it also guarantees easy retrieval of the sample with low risk of contamination. Moreover, and in contrast with methods requiring shooting (e.g., Valderrama

et al., 1999, 'shooting tape' method; Améndola-Pimenta *et al.*, 2009), or traps (Stone *et al.*, 2015), our method does not disturb monkeys and is safe also for very young ones. In addition, food extraction requires the individual contacting the sticky tape with the volar part of the hand (rich in hair) and not with the hand and mouth as it happens when the food is wrapped in tape attached to a tree limb, or in tape-covered food baskets, or wrapped directly with inverted tape, as done by Valderrama *et al.* (1999). In short, our "tube" method seems ideal to obtain the high quality DNA contained in hair samples and thus to contribute to the very much needed genotyping of both wild and captive capuchins (Lynch Alfaro *et al.*, 2014). Finally, as described for humans (Higuchi *et al.*, 1988), capuchins' usable genomic DNA can be extracted from a single bulb hair.

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Table 2. Number of hair samples and hair bulbs collected from captive capuchins at the CNR. For each subject the method of extraction and the yield of DNA extraction (expressed in nanogram/microliter) are reported.

Subject	Sex	Age class	N samples	N bulbs	Extraction	ng/μl
Peonia	F	Adult	2	10	MN	2
Rucola	F	Adult	1	9	MN	2
Penelope	F	Adult	1	nr	MN	1
Vispo	M	Adult	4	nr	MN	2
Cognac	M	Adult	1	9	MN	2
Robiola	F	Adult	3	7	MN	5
Paprica	F	Adult	3	5	MN	2
Carlotta	F	Adult	2	1	Chelex 5%	12
Robin Hood	M	Adult	1	10	Chelex 5%	18
Ulisse	M	Juvenile	3	1	Chelex 5%	5
Cammello	M	Adult	2	3	Chelex 5%	9
Robinia	F	Adult	2	10	Chelex 5%	9
Brahms	F	Adult	3	5	Chelex 5%	7
Totò	M	Juvenile	1	10	Chelex 5%	32
Rame	F	Adult	1	8	Chelex 5%	10
Pepe	M	Adult	2	15	Chelex 5%	14
Roberta	F	Adult	3	3	Chelex 5%	4
Quincy	F	Adult	1	3	Chelex 5%	10
Pacajà	F	Adult	2	20	Chelex 20%	22
Saroma	F	Adult	2	10	Chelex 20%	8
Robot	M	Adult	3	5	Chelex 20%	7
Virginia	F	Adult	2	1	Chelex 20%	9
Sandokan	M	Adult	3	0	na	na
MEAN			2.1	6.9		8.7

(nr = not recorded; na = not applicable)

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SHORT ARTICLES

ROPE BRIDGES: A STRATEGY FOR ENHANCING HABITAT CONNECTIVITY OF THE BLACK HOWLER MONKEY (*ALOUATTA PIGRA*)

Edwin Hernández-Pérez

Introduction

The development of linear infrastructure such as roads, highways and power lines is an important element in social and economic development (Delgado et al., 2004; Beckmann et al., 2010). However, like almost any human activity, it causes negative impacts on wildlife (Seiler, 2001; Santos and Tellería, 2006; Taylor and Goldingay, 2010). Habitat fragmentation is one of the main effects caused by the implementation of this infrastructure, creating linear clearings and forest edges which isolate wildlife populations (Delgado et al., 2004; Laurance et al., 2009; Beckmann et al., 2010). This is the case of primates like the black howler monkey (*Alouatta pigra*), an endangered species restricted to southern México and northern Guatemala and Belize (IUCN, 2008; SEMARNAT, 2010). This species has been affected due to poor connectivity of forest patches through its range in southern Mexico, particularly in Tabasco and Campeche states (Pozo-Montuy and Bonilla-Sánchez, 2008; Pozo-Montuy et al., 2008). For arboreal primates, forest fragmentation prevents free movement of primates through the landscape matrix (Isabirye-Basuta and Lwanga, 2008). In addition, this can lead them to adopt unusual behaviors such as movement on the ground to reach another fragment in search of food, sleeping sites or mates (Pozo-Montuy and Serio-Silva, 2007; Martínez-Mota et al., 2007). Such movements on the ground increase the probability of predation, disease transmission from other wild or domestic animals, or road kills (Martínez-Mota et al., 2007; Pozo-Montuy and Bonilla-Sánchez, 2008). Because of that, several methods to mitigate the impacts of fragmentation have been proposed, such as canopy bridges (Gregory et al., 2013) and rope bridges (Valladares-Padua et al., 1995; Weston et al., 2011), which can connect fragments allowing primate movement. The use of both types of bridges has been documented for several arboreal mammals in Belize, Peru, Brazil and Australia (Lyon and Horwich, 1996; Turbher and Ayarza, 2005; Weston et al., 2011; Gregory et al., 2013; Zimmerman Teixeira et al., 2013). Canopy bridges have been implemented in tropical evergreen forest, where tall trees (15-35 m high) allow binding of canopy (Turbher and Ayarza, 2005; Gregory et al., 2013). In southern Mexico, the dominant vegetation type is medium stature forest (sub-perennial and semi-deciduous forest; Rzendowsky, 2006), which makes it almost impossible to form canopy bridges. Nevertheless, rope bridges have been implemented for spider monkeys (*Ateles geoffroyi*) in Punta Laguna, Quintana Roo and for

black howler monkeys in Balancán, Tabasco, both locations in Mexico. However, their efficiency and functionality are unknown.

This paper reports the use of one rope bridge by a troop of black howler monkeys between two fragments of habitat in Palizada, Campeche, Mexico. This contribution provides critical information on the behavioral flexibility and adaptability of this species to use artificial devices like the rope bridges.

Methods

Study Area

The study site, Environmental Management Unit "Rancho San Román" (UMA; acronym in Spanish), is a private ranch located within the wildlife protected area "Laguna de Términos", 16 km southwest from Palizada, Campeche, Mexico (N 18°6'46.09", W 92°5'35.20"). The predominant climate in the region is warm humid with a mean annual temperature of 27°C (INEGI, 2009). There is a rainy season with an annual average rainfall above 1,500 mm (INEGI, 2009). The main types of vegetation in the UMA are low flooded forest and gallery forest surrounded by grassland for livestock, plots of fruit trees (mango, orange and zapote) and ecotourism cottages (Hernández-Pérez et al., 2014).

Implementation of the Rope Bridge

Prior to installation of the bridge, a study was conducted to report on the feeding behavior of a troop of black howler monkeys (one adult male, one adult female, one young female and one infant) in the rainy season (August-October; Hernández-Pérez et al., 2014). In this study six crossings between patches (places where one or more individual came to the ground and moved to another patch) were documented. Two of those patches (15 m apart) were connected by an electric power line which sometimes was used by the troop to cross. Due to the damages to the electrical infrastructure caused by the troop of monkeys, the UMA owners decided to remove the power line, which caused the monkeys to begin to move on the ground more frequently. Therefore, on October 16, 2014 the rope bridge was constructed in the location of the previous power line. The goal was to avoid movement of monkeys on the ground, which could cause them to be attacked by dogs or be killed by a vehicle, as the patches are separated by a dirt road.

The bridge was made using silk rope of 15 mm diameter and wooden rods (50 cm long and 3x1 cm thick). The wooden rods were placed 20 cm from each other, on two parallel lines of rope and fixed with wires. The bridge was tied to the trunks of the trees nearest to the fragment edge, at a height of 3 m from the ground. Two poles were placed in T-shape to stabilize the bridge and to prevent twisting. The bridge had a length of 20 m.



Figure 1. Male black howler monkey (*Alouatta pigra*) using a rope bridge in Rancho San Román UMA, Palizada, Campeche, Mexico. Foto: José D. Cú-Vizcarra.

Monitoring of Troop

After the rope bridge installation, we followed the troop for three months looking for the monkey troop's habituation and any sign of use of the bridge. *Ad libitum* data were taken (Martin and Bateson, 1986), recording only behaviors that indicate the use of the bridge, for example, to get to the bridge, sit still watching the bridge, touch it, etc. The observations did not follow a defined schedule, and were made only when the troop moved towards place where the bridge was located. This was in the morning between 8:00 and 10:00 h, and in the afternoon between 17:30 and 19:00 h. We totaled 127 hours of observation.

Results

During the first month, after the rope bridge installation, we did not observe any curiosity or interest in the bridge by the monkeys. However, in November, the adult male began to show interest in the bridge, getting as close as about 1 to 2 m to the bridge at moments, followed by the rest of the troop (adult female, young female and infant), until the rest came one meter from the bridge. It was not until January 11, 2015, we observed for first time the adult male crossing the rope bridge (Fig. 1), and after few days the rope bridge was used by all individuals in the troop. The rope bridge was used by monkeys on average of two times per day, approximately, between 9:00-10:00 h and 17:00-18:00 h. We document that the bridge was used for travel between patches, we did not observe other uses by the monkey troop, but by gray squirrels (*Sciurus aureogaster*) which were observed feeding on the bridge. Besides howler monkeys and gray squirrels, the bridge was used by another species, the common opossum *Didelphis marsupialis*.

Discussion

Habitat fragments near roads and highways are the first to disappear, due to edge effects (Bonilla-Sánchez et al., 2011) that reduce the fragment area and its functionality and increase the isolation of wildlife populations (Forman et al.,

2002). The installation of rope bridges could help to mitigate this effect, until native trees are planted to form live fences that naturally connect fragmented areas. Live fences have been used in response to fragmented landscapes, creating corridors of trees that connect several habitat fragments and facilitate reforestation (Chacón-León, 2006). However, the planting of trees to connect patches of habitat is not always possible. For example, it is impossible to plant trees in road areas like dirt roads highly frequented by people, paved roads and highways. Therefore, rope bridges can become relevant to maintain connectivity, as they are an inexpensive tool in manufacturing and installation. In addition, they function as an ideal substrate for the movement of the monkeys and other arboreal wildlife, preventing them from coming to the ground where they are vulnerable to hazards.

Cuarón (1995) mentioned that the use of rope bridge in open areas can cause negative effects like predation of small primates by raptors, because they are exposed. This author, suggests some modifications, such giving the bridge a "roof", mesh on the sides and natural vines to camouflage, or to take a tubular shape to avoid predation. However, these modifications may attract other predators such as snakes, and also could be used as nesting sites for birds and mammals (like rats and mice). Moreover, the howler monkeys are considered one of the largest primate species of America (CONABIO, 2011), and the largest raptor (*Harpia harpyja*) is absent from our study area, making it unlikely that howlers would suffer predation by raptors when using of the rope bridges.

This study demonstrates the functionality of rope bridges by an *Alouatta pigra* troop in a fragmented habitat at Palizada, Campeche, Mexico. In general, we recommend following up and evaluating various artificial bridge types and designs under different conditions (dirt roads, paved roads, distance between habitat fragments, target species as the spider monkeys, etc.), in order to know the impact and functionality for primate populations, and in their conservation.

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EVIDENCE OF ALBINISM IN THE WHITE-FACED MONKEY *CEBUS CAPUCINUS IMITATOR* ON COIBA ISLAND, REPUBLIC OF PANAMA

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Introduction

Increased rates of abnormal coloration (Fortes et al., 2008), including albinism (Camargo et al., 2014), have been linked to low genetic diversity resulting from isolation, inbreeding depression, and high density of populations. Other potential determinant characteristics for albinism include: 1) low-quality habitat and diet, 2) pollution, or 3) follicular damage (Camargo et al., 2014). Albinism is caused by a single genetic mutation that inhibits melanocyte production of melanin compounds, which are transported via melanosomes into keratinocytes of the epidermis and hair follicles (Caro, 2005; Prado-Martínez et al., 2013). Albinism is differentiated from leucism by a total absence of pigmentation in the whole body (white to yellowish color) and eyes with red or pink coloration (Abreu et al., 2013). Albinism has been documented in numerous mammals (Peles et al., 1995; Ramírez and Arana, 2005; Abreu et al., 2013), including human and non-human primates (Hu et al. 1980, Veiga 1994, and Prado-Martínez et al., 2013). Albinism is considered rare in nature (McCardle, 2012) due to the low rate survivorship of albinos (Caro, 2005), possibly due to greater risk of predation (Owen and Shimmings, 1992). However, there is trivial support for differences in fitness of albino and normal colored mammals (Owen and Shimmings, 1992; Brewer et al., 1993). Hence, documentation of albino animals is important to provide indirect evidence of underlying genetic variability (Jehl 1985) and implications for viability of those populations (Prado-Martínez et al., 2013).

White-faced monkeys *Cebus capucinus* are medium-sized (3–4 kg) omnivorous primates found throughout a variety of forest types in Central America and the coastal areas of Colombia and Ecuador (Rylands et al., 2006). Normal phenotypic characteristics of the species include black pelage on the main body, with yellow-cream fur on the head, chest and shoulders (Rylands et al., 2006). The subspecies *C. c. imitator* is common across its range, from Nicaragua, Costa Rica, to the west part of the Panama Canal (Boubli et al. 2012), as well as on Coiba Island, Panama (Figure 1; Hershkovitz, 1949), which has around 600 individuals (1.3 ind/km², 10.8 ind/group; Méndez-Carvajal, 2012).

Methods

From 12 Mar–3 Jul 2015 we deployed 32 Bushnell® HD eight megapixel cameras equipped with an infrared sensor in three general areas across Coiba Island, Panama (Fig. 1). We deployed each camera facing a trail or area with conspicuous wildlife activity. The objective of the survey was to estimate the diversity and density of terrestrial mammals on the island.

Results

On 25 Mar and 3 Apr 2015, an albino white-faced monkey (*C. c. imitator*) was photographed (Fig. 2) by a camera deployed in the central-western region of the island (Fig.1). These were the only photographs of an abnormally-colored monkey during the survey. In each photograph, the albino white-faced monkey was observed with one other white-faced monkey with normal pigmentation, as seen in the lower right corner of Figure 2. We suggest this monkey exhibits evidence of albinism based on a lack of pigment across the entire body. Although the photograph limits detection of red or pink eye color, lack of pigmentation in the hands and feet indicate this monkey was albino and not leucistic (Abreu et al., 2013).

Discussion

This evidence of albinism in *C. c. imitator* is the only record for this species and of the first documented occurrence of albinism in wild populations of Cebidae. Veiga (1994)

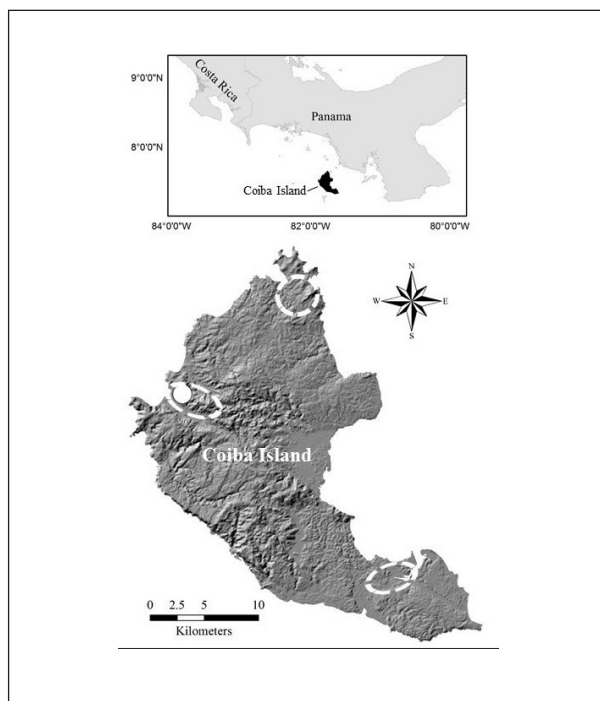


Figure 1. Photograph location (white dot) where an albino white-faced monkey *C. c. imitator* was photographed within a camera survey area (dashed ovals) on Coiba Island, Panama. April 2015.



Figure 2. Albino white-faced monkey (*C. c. imitator*) photographed by a remote camera on Coiba Island, Panama, April 2015.

suggested albinism in the brown capuchin monkey, *C. apella*, but her record is speculative because it was based on a second-hand report. Bicca-Marques (1988) stated an albino *C. apella* was obtained from the Roca Sales region of Brazil for transfer to a zoo, but did not state if the monkey was of captive or wild origin. Although our observation may be an anomalous case of albinism, there is a possibility that *C. c. imitator* on Coiba Island may be experiencing reduced gene flow, as suggested for other mammals (Fortes et al., 2008; Camargo et al., 2014). Coiba Island retains mostly pristine forest and is relatively large compared to most Pacific islands, but it has been isolated from the mainland of Panama for about 10,000 to 12,000 years (ANAM, 2009). This span of isolation may have led to a loss of gene flow for *C. c. imitator*, possibly leading to greater occurrence of albinism, as shown in the lowland gorilla *Gorilla gorilla gorilla* (Prado-Martinez et al., 2013). Also, primates on Coiba Island have fewer predators (only raptors) than populations on the mainland, which could decrease risk of albino individuals being removed from the population by predation (Owen and Shimmings, 1992).

Beside population density estimates of Milton and Mittermeier (1977) and Méndez-Carvajal (2012), little is known about the ecology and genetic structure of *C. c. imitator* on Coiba Island. Their low density (Méndez-Carvajal 2012) combined with presence of albinism on Coiba Island emphasizes that further research is needed to understand the genetic structure of this population. Genetic research is especially needed to assess the long-term viability of this population and build upon ongoing primate monitoring on Coiba Island (Méndez-Carvajal, 2012). Research on this population could also increase overall knowledge of the prevalence, causes, and fitness consequences of albinism in wild animal populations.

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- en 2013 en Iquitos nos motivó a organizar otro simposio, que se realizó del 20 al 23 octubre 2015 en las instalaciones de la Universidad Nacional Amazónica de Madre de Dios (UNAMAD) en Puerto Maldonado, ciudad ubicada en una región (Madre de Dios) que es un “hotspot” de biodiversidad en general y de primates en particular; era el lugar indicado para llevar a cabo el 3^{er} simposio. Así como en los simposios anteriores, este no solo atrajo científicos y estudiantes peruanos, sino también de Colombia, Ecuador, México, EE.UU., España, Inglaterra, Italia y Alemania, y contó con más de 200 participantes.
- El simposio fue inaugurado el 20 de octubre con palabras de bienvenida del Dr. Miguel Nicolás Peralta Rosario, rector de la UNAMAD, y los organizadores principales, Fanny M. Cornejo Fernández y Eckhard W. Heymann. En un discurso de bienvenida, Patricia C. Wright (Stony Brook University, New York, EE.UU.) recapituló sus experiencias cuando realizó uno de los primeros estudios primatológicos de campo en el Perú y el primero sobre monos nocturnos, en 1980-1982 en la Estación Biológica Cocha Cashu, y compartió sus experiencias en establecer un programa de investigación y conservación de primates en Madagascar. La inauguración fue completada con una conferencia magistral a cargo de Anthony B. Rylands (Conservation International, New York, EE.UU.) sobre la importancia de la taxonomía para la conservación de los primates neotropicales.
- Como en los simposios anteriores, contamos con invitados científicos de reconocimiento internacional para impartir las conferencias magistrales. Leandro Jerusalinsky (Centro Nacional de Pesquisa e Conservação de Primates Brasileiros, João Pessoa, Brasil) expuso sobre los avances y desafíos en la conservación de primates en Brasil. Varun Swamy (San Diego Global Institute for Conservation Research, San Diego, EE.UU.) enfatizó la importancia de los primates en la regeneración de bosques amazónicos y reseñó los impactos negativos de la caza de primates para la regeneración. Liliana Cortés-Ortiz (University of Michigan, Ann Arbor, EE.UU.) presentó resultados de los primeros estudios sobre la diversidad genética en los monos aulladores rojos del Perú. Laura K. Marsh (Global Conservation Institute, Santa Fé, EE.UU.) actualizó el estado de conocimiento sobre los efectos de fragmentación sobre poblaciones de primates. Andrés Link (Universidad de Los Andes, Bogotá, Colombia) resumió e integró los conocimientos sobre competencia y cooperación en monos arañas.
- Durante del simposio se hicieron 20 presentaciones orales y 23 en posters. Las mejores presentaciones orales (“Premio Pekka Soini”) y posters (“Premio Jaime Moro Sommo”) de estudiantes y científicos jóvenes fueron premiadas con los libros “Primates in Fragments” de Laura K. Marsh, donados por Springer Science+Business Media, y “The Smallest Anthropoids” de Susan M. Ford, Leila M. Porter y Lesa C. Davis, donados por Leila M. Porter. Además, el primer puesto en posters fue premiado con un viaje de 4 días al Refugio Amazonas, y el de presentaciones orales, con un

3^{ER} SIMPOSIO “PRIMATOLOGÍA EN EL PERÚ”

Fanny M. Cornejo
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El gran éxito del 1° y 2° simposio “Primatología en el Perú”, realizados en 2011 en Lima (Cornejo & Heymann 2011) y



Figura 1. Ganadores de la competencia de orales. De izquierda a derecha, Pedro E. Perez Peña, Rosario Huashayo Llamocca, Manuel Fonseca, Mariana Hernández González y Julian León Ortega. Foto: Noel Rowe.



Figura 2. Ganadores de la competencia de posters. De izquierda a derecha, Eder Murrieta Villalobos, Claudia Nolasco, Citlalli Morelos Juárez y Maribel Taco. Foto: Noel Rowe.



Figura 3. Guía de Identificación de Bolsillo “Primates de Perú” / Pocket Identification Guide “Monkeys of Peru” y unos de los autores de la guía durante su presentación (de izquierda a derecha, Eckhard W. Heymann, Fanny M. Cornejo Fernández, Liliana Cortés-Ortíz, Stephen Nash, Laura K. Marsh y Anthony B. Rylands). Foto: Noel Rowe.

viaje al Tambopata Research Center; ambos premios fueron donados por Rainforest Expeditions. Los ganadores en presentaciones orales fueron, de acuerdo al puesto ocupado: Pedro E. Pérez Peña, Manuel Fonseca y Rosario Huashayo Llamocca, y Mariana Hernández González; se entregó una mención de honor a Julian León Ortega (Fig. 1). En posters, de acuerdo al puesto ocupado: Citlalli Morelos Juárez, Claudia Nolasco y Maribel Taco; se entregó una mención de honor a Eder Murrieta Villalobos (Fig. 2).

Un punto culminante del simposio fue la presentación al público de la Guía de Bolsillo para la identificación de los “Primates de Perú” / Pocket Identification Guide “Primates of Peru” (Fig. 3). Esta guía presenta ilustraciones y mapas de distribución de las 54 especies y subespecies actualmente reconocidas en el Perú. Su elaboración se inició durante del 2° simposio en Iquitos en noviembre 2013; su impresión fue posible gracias a la subvención de Conservation International, Deutsches Primatenzentrum, Yunkawasi y el Servicio Nacional Forestal y de Fauna Silvestre del Ministerio de Agricultura del Perú. Con esta guía se dispone de una herramienta para promover la conservación de primates en el Perú a nivel nacional, regional y local.

En una mesa redonda dedicada a la diversidad de primates del Perú, se presentaron y discutieron resultados de estudios sobre una posible nueva especie de *Callicebus* (Edgardo M. Rengifo y colaboradores), sobre las relaciones evolutivas y la diversidad de los monos nocturnos *Aotus* (Fanny M. Cornejo y Liliana Cortés-Ortiz), sobre *Pithecia* como un modelo para la importancia de taxonomía en la conservación (Laura K. Marsh) y, sobre perspectivas para analizar la diversidad genética de *Callimico* y *Cebuella* (Leila M. Porter y colaboradores). En otra mesa redonda, representantes del Servicio Forestal y de Fauna Silvestre – SERFOR, presentaron los nuevos reglamentos para investigación científica de fauna silvestre en el Perú. SERFOR también organizó un taller para la elaboración de la estrategia nacional para la conservación de primates en el Perú.

- Asociado con el simposio, se realizaron varios talleres y cursos:
- Rehabilitación, manejo y liberación de primates (Raúl Bello).
- Ilustración científica como herramienta para la primatología (Stephen Nash & Lucille Betti-Nash).
- Métodos de observación etológica y ecológica (Eckhard W. Heymann).
- Primatología de campo (organizado por Mrinalini Watsa y Gideon Erkenswick, dictado por Eckhard W. Heymann).

Al final del simposio se discutió la constitución de una asociación primatológica en el Perú. Como conclusión

unánime se consideró que existe la necesidad de contar con dicha asociación y 24 participantes del simposio fundaron la Asociación Peruana de Primatología y eligieron una junta ejecutiva que va a adelantar los procesos legales y técnicos para la inscripción formal de la asociación.

Finalmente, durante de la clausura del simposio se invitó al 4° simposio, que tendrá lugar en 2017 en la ciudad de Piura. Se puede encontrar más información sobre los simposios, la Asociación Peruana de Primatología y cómo adquirir las guías de bolsillo en www.monosperu.org.

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RECENT PUBLICATIONS

BOOKS

Primates Colombianos en Peligro de Extinción, editado por Deffler Thomas R, Stevenson Pablo R, Bueno Marta L, Guzmán Caro Diana C. 2015. Asociación Primatológica Colombiana. Este libro compila diversas investigaciones realizadas en años recientes sobre algunos de los taxones de primates más amenazados de Colombia, incluyendo temas sobre historia natural, bienestar, hábitat, comportamiento

y ecología. Así mismo, este libro proporciona información valiosa sobre las acciones de conservación necesarias para promover la supervivencia de las poblaciones de primates colombianos. *Contenido:* 1) Aspectos sobre la conservación de los primates colombianos: ¿Cuál es el futuro?- Deffler TR; 2) El Proyecto Tití: Medidas efectivas para la conservación del tití cabeciblanco (*Saguinus oedipus*) – Savage A, Guillen Monroy R, Soto Rojas L, Vega Abello J; 3) Diagnóstico sobre el comercio de monos nocturnos *Aotus* spp. en la frontera entre Colombia, Perú y Brasil – Maldonado AM; 4) La sistemática de los platirrininos y el registro fósil – Tejedor MF, Muñoz-Saba Y; 5) Estado de conservación en Colombia de uno de los primates más amenazados con la extinción: el mono araña café (*Ateles hybridus*) – Link A, de Luna G, Burbano-Girón J; 6) Microfilaria en titís cabeciblancos (*Saguinus oedipus*) - Geiszler-Monsalve D, Chacón Pacheco J, Betancur Hurtado C, Monsalve Buriticá S, Carrascal JC; 7) Efectos del entorno social en la frecuencia de vocalizaciones e interacciones sociales en monos churucos en cautiverio – Álvarez AM, Guzmán-Caro DC, Millán JF, Stevenson PR; 8) Gusano de cabeza espinosa (*Prosthenocheilus elegans*) en el tití gris (*Saguinus leucopus*): Reporte de caso – Pérez J, Peña J, Soler-Tovar D; 9) Caracterización del hábitat de tres grupos de tití gris (*Saguinus leucopus*) en un paisaje transformado por actividades agropecuarias en Victoria, Caldas – Pérez-Pinzón ZV, Cabrera-Amaya DM, Montenegro OL, Sánchez Palomino P; 10) Densidad poblacional y disponibilidad de hábitat de *Callicebus ornatus*, un tití endémico Colombiano - Carretero-Pinzón X; 11) Densidad de una población introducida del tití cabeciblanco (*Saguinus oedipus*) en el Parque Nacional Natural Tayrona y su relevancia en la conservación de la especie en Colombia - García-Villarreal S, Amaya-Espinel JD; 12) Densidad, uso de hábitat y estado de conservación de una población de *Saguinus leucopus* en un bosque premontano de Colombia - Sánchez-Londoño JD, Santamaría M, Devenish C, Mendoza H, Forero F, Medina S, Franco AM; 13) Modelos predictivos de distribución para los micos atelinos (*Lagothrix* y *Ateles*) en Colombia - Rodríguez-Bolaños A, González-Caro S, Etter A, Stevenson PR; 14) Distribución potencial y disponibilidad de hábitat del tití gris (*Saguinus leucopus*): un primate endémico de Colombia y en peligro de extinción – Roncancio N, Acosta Castañeda A, García Loaiza LM, Ríos Franco CA; 15) Comparaciones de la densidad poblacional y estructura grupal de la marimonda café o del Magdalena (*Ateles hybridus*), Serranía de San Lucas (Bolívar) - Roncancio N, Gómez-Cadenas K, Quintero F; 16) Conservación de *Saimiri sciureus albigena*, una subespecie de mono ardilla endémica de Colombia - Carretero-Pinzón X, Ruiz-García M, Deffler TR; 17) Análisis preliminar de la pérdida y fragmentación del hábitat de *Callicebus caquetensis* – García J, Deffler TR; 18) Repertorio vocal de los monos araña café (*Ateles hybridus*) – León J, Link A; 19) Dieta de los churucos colombianos (*Lagothrix lagothricha lugens*) en relación con la productividad de frutos en el Parque Nacional Natural Cueva de los Guácharos – Cifuentes EF, Ramírez MA, León J, Galvis N, Vargas S, Stevenson PR; 20) ¿Por qué los monos atelinos dispersan

semillas? –Ramírez MA, Stevenson PR; 21) Procesos eco-sistémicos provenientes del papel de los monos churucos (*Lagothrix lagothricha*) como dispersores de semillas – Stevenson PR, Guzmán-Caro DC.

Primate Behavior and Human Origins, by Glenn E. King. 2015. Routledge. 450 pp. ISBN: 978-1138853164. This book demonstrates the theoretical perspectives and concepts that are applied to primate behavior, and explores the relevance of non-human primates to understanding human behavior. It provides a thorough overview of the primate order. The chapters cover common features and diversity, and touch on ecology, sociality, life history, and cognition. Written in an engaging and approachable style, this is an invaluable resource for students of primate behavior as well as human evolution.

Conservation Psychology: Understanding and Promoting Human Care for Nature, by Susan Clayton, Gene Myers. 2015. Wiley Blackwell. 344 pp. 978-1118874608. Understanding how people think about, experience, and interact with nature is crucial for promoting environmental sustainability as well as human well-being. Conservation psychology is the field that explores connections between the study of human behavior and the achievement of conservation goals. This book summarizes theory and research on ways in which humans experience nature; it explores people's conceptions of nature and environmental problems, their relationship with nature, and their moral lenses on nature; and examines ways to encourage conservation-oriented behavior at both individual and societal levels. Sections cover human perceptions of environmental problems, examples of community-based conservation, and a "positive psychology" perspective that emphasizes the relevance of nature to human resilience.

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information visit: <https://www.nc3rs.org.uk/events/2016-primate-welfare-meeting-%E2%80%93-cumulative-severity-and-lifetime-experience-nhps-research>

APV WORKSHOP

The Association of Primate Veterinarians 2016 workshop will be held Wednesday, October 26 through Saturday, October 29, 2016 in Charlotte, North Carolina. For more information visit: <https://www.primateteves.org/workshop>

MEETINGS

PSGB WINTER MEETING 2016

The PSGB Winter Meeting 2016 (actually early in 2017) will be held at Durham University, hosted by Primatology@Durham. The meeting is part of Durham Anthropology's 50th Birthday, and the Evolutionary Anthropology Research Group's 20th birthday celebrations. For more information visit: http://www.psgb.org/meeting_detail.php?ID=psgb-winter-meeting-2016-2017-01-10

26TH CONGRESS OF THE INTERNATIONAL PRIMATOLOGICAL SOCIETY AND 39TH MEETING OF THE AMERICAN SOCIETY OF PRIMATOLOGISTS

The 39th meeting of the American Society of Primatologists will be held jointly with the 26th Congress of the International Primatological Society in Chicago, Illinois, August 21–27, 2016. All details, including submission deadlines, are available on the joint meeting website: <http://www.IPSChicago.org>.

2016 PRIMATE WELFARE MEETING – CUMULATIVE SEVERITY AND LIFETIME EXPERIENCE OF NHPS IN RESEARCH

The NC3Rs Primate Welfare Meeting is a key international event for researchers, veterinarians, technologists and others involved with the care and use of non-human primates (NHPs). This year's meeting will be held in central London on Monday 10 October 2016 and is focused on the lifetime experience of NHPs used in research and methodologies and frameworks for assessing cumulative severity* in long-term research programmes. For more

Notes to Contributors

Scope

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

Contributions

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

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

Short articles. These manuscripts are usually reviewed only by the editors. A broader range of topics is encouraged, including such as behavioral research, in the interests of informing on general research activities that contribute to our understanding of 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.

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 Doutorado" 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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