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Letter from the editors

Welcome to the 2017 edition of Canopy, the in-house journal of the MSc in Primate Conservation at Oxford Brookes University.

This edition contains a compilation of articles pertaining to the Neotropics. Central and South America are home to the world's richest biodiversity hotspots, ranging from the woodland-savanna of Brazil's Cerrado region to the snow-capped mountains of the Tropical Andes. Parts of the Amazon are still untouched. The Neotropics are characterized by high levels of endemic flora and fauna, including about 165 species of New World monkeys. Large howler monkeys' distinctive call can be heard for miles, while tiny squirrel monkeys are barely distinguishable from the foliage. Unfortunately, 40% of these species are categorized as globally threatened due mainly to hunting and the loss of their natural habitat (IUCN, 2008). Additionally, climate change is affecting both the landscapes and food availability in Neotropical regions, which could severely impact its primate species. Recently, drought conditions have allowed fires to ravage the forests of Peru, with a devastating impact on both primate and human populations.

We have included for your enjoyment articles discussing the conservation and welfare of Neotropical primates. It is crucial to understand how primates adapt to both natural landscapes and captive situations so that wild populations can be conserved for posterity.

We hope that this edition of Canopy draws your attention to these issues, as it explores some of the most fascinating and threatened mammals in the world. We would like to thank everyone who contributed to the success of this issue, including the organizations that supported the research presented here.

Sincerely,
The editors

Ellie Darbey, Kelsey Frenkiel, Nicholas James, Marina Ramon & Magdalena Svensson

Letter from the Course Leader

Welcome to volume 17 of Canopy, the official journal of the MSc Primate Conservation at Oxford Brookes University. As the Year of the Monkey comes to a close, many steps forward have been taken to help ensure a future for primates. Several of Oxford Brookes staff and former students took part in IUCN Red List workshops for every group of primates ranging from Neotropics, to African mainland, Madagascar and Asia. Although many taxa are now listed as Endangered or Critically Endangered, it is wonderful to see the network of Oxford Brookes staff and alumni striving to reverse these trends, especially through the creation of active field projects in countries as wide ranging as Peru, Colombia, Costa Rica, Madagascar, Nigeria, Kenya, Central African Republic, Uganda, Thailand, India, Laos PDR and Indonesia to name but a few. Primate Conservation staff and students attended some vital meetings this year, including the joint International Primatological Society / American Society of Primatologists meeting held in Chicago, USA, where staff and students also took part in the President's roundtable on illegal wildlife trade and primates as pets. Oxford Brookes is also now the home to *Folia Primatologica*, the official journal of the European Federation of Primatology, with myself as co-editor-in-chief, alongside Christophe Soligo from University College London. Combined all of these achievements highlight Oxford Brookes as a Centre for Excellence in Primate Conservation.

The MSc course may be entering its 17th year, but many other changes have occurred in the Primate Conservation programme at Oxford Brookes too. Our PhD programme is now flourishing with more than 20 students registered to study aspects of primate ecology, evolution, and conservation issues in general, and we have just validated a new MRes programme in Primatology and Conservation. Our primate conservation lab has moved to the Gibbs Building, where it is a hub of activity, and houses wonderful collections of books donated by Dr David Chivers, and the late Dr Alison Jolly, Cyril Rosen and Tess Lemmon.

This issue of Canopy focuses on Neotropical primates. This issue features work by several students who conducted important research on South and Central America's rare primates. These students follow in the footsteps of some of our alumni who continue to work in the

Neotropics, offering continued collaboration for students wishing to work in their areas of expertise. Recently Dr Sam Shanee, who completed both his MSc and PhD at Oxford Brookes University, became a Research Associate of our Faculty. His NGO Neotropical Primate Conservation, co-run with Noga Shanee, also an Oxford Brookes' alumna, remains a leader in the preservation of Peru's threatened primates. Fellow alumnus Pedro Mendez is also continuing his efforts to preserve Panama's primates, and to facilitate this, founded the Panamanian Primate Conservation Society. Bolivian primatologist Jesus Martinez recently published one of a series of papers on Bolivia's rare titi monkeys – research that had direct impact on the Red List assessment for these species. I hope you enjoy reading the work of our students and feel inspired to visit our lab, attend our Monday evening seminar series (or give a talk yourself), or even consider joining our of our postgraduate programmes. Best wishes for 2017!

Professor Anna Nekaris

Course Leader, MSc Primate Conservation

Modelling occupancy for the Critically Endangered brown-headed spider monkey (*Ateles fusciceps fusciceps*) in Tesoro Escondido, NW Ecuador

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When primates occur in difficult terrain it is often hard to meet the assumptions set by traditional sampling methods such as line transect sampling. Occupancy modelling is a presence/absence survey technique that is based on fixed point sampling and has been used to study primates living in difficult terrain (lemurs; Guillera-Arroita *et al.,* 2010; Keane *et al.,* 2012; gibbons; Neilson *et al.,* 2013; owl monkeys; Campbell, 2010; Sclater's monkey; Baker *et al.,* 2011). Occupancy refers to the number of sites that are being occupied by a species (Guillera-Arroita *et al., 2*010). Occupancy models both occupancy and detectability (MacKenzie *et al.,* 2006) and by modelling detectability eliminates false absences that can occur in presence-absence surveys (MacKenzie *et al.,* 2006) when animals are not encountered during the survey period but occupy the survey area.

We quantified the occurrence and distribution of the Ecuadorian brown-headed spider monkey (*Ateles fusciceps fusciceps*; Figure 1) by using presence absence surveys and occupancy modelling. *A. f. fusciceps* is endemic to northwest Ecuador (Peck *et al.,* 2011) and is one of the most threatened primate species. An 80% reduction in its historic distribution due to agricultural expansion (Tirira, 2004) and logging have placed it on the Primates in Peril the world's 25 most endangered primates list (Mittermeier *et al.,* 2012). Additionally, it is listed by the IUCN as Critically Endangered, as a result of an 80% decline in population size over the last 45 years (Cuarón *et al.,* 2008). Identifying areas of conservation priority is imperative for this species to enable future conservation action, as it is found in several unprotected areas, including Tesoro Escondido, the site of this study.

The aim of this investigation was to identify which habitat factors affect the presence of *A. f. fusciceps* in Tesoro Escondido to aid conservation in the area. Tesoro Escondido has been identified by previous studies as an area of importance for the survival of these spider monkeys (Moscoso Rosero, 2010; Peck *et al.,* 2011). Additionally, due to the presence of commercial logging companies in lands surrounding the cooperative, the investigators were interested to see the effects of sustainably logged areas on the usage of those areas by *A. f. fusciceps*.

We hypothesized that the spider monkeys would prefer areas of lower elevation (Shanee, 2009), and that logging would be the strongest predictor of presence in an area, as previous studies have shown that spider monkeys prefer mature primary forest (Aldana *et al.,* 2008) and tend to disappear from disturbed forest (Asensio *et al.,* 2012).

Tesoro Escondido is a cooperative located in the Canande watershed, part of the Cotacachi-Cayapas Ecological Reserve (RECC) buffer zone in Esmeraldas Province, NW Ecuador. The cooperative spans an area of 30km^2. The lowland evergreen forests are interspersed with selectively logged forest and deforested areas.

Figure 1. A male *A. f. fusciceps*

71 sites in the cooperative were visited 5 times for 10 minutes. Sites were deemed to be occupied if *A. f. fusiceps* were sighted or were heard at a distance ≤50m. A detection history (Hi) was created by assigning a 1 to sites that were occupied and a 0 to those that were not (Guillera-Arroita *et al.,* 2010). Detection histories for each occupancy site were combined to create a maximum likelihood model. The modelling program PRESENCE 5.6 was used to run all the models. PRESENCE uses the maximum model likelihood to obtain values of occupancy and detectability (Bailey & Adams, 2005).

Covariates were then added to the model to determine what factors affect presence for the brown-headed spider monkey. Covariates included: altitude, forest, tree diameter at breast height (DBH), tree density, climate, and canopy connectivity. Data on covariates were collected from all 71 sites on one visit except for data on climate which was collected during all visits and a median value for each site was entered into the model.

To determine the correct model, the models were ordered using the Akaike Information Criterion (AIC; MacKenzie *et al.,* 2006). The model with the lowest AIC value is the model that best explains the pattern observed. . The top 8 models were selected as having less than 4 AIC units difference from the top ranking model (Campbell, 2010; Guillera-Arroita *et al.,* 2010).

ΔAIC refers to Akaike difference. This is the difference between one model and the next one down. Models with ΔAIC <2 have greater support (MacKenzie *et al.,* 2006). The summing of ΔAICs allows the determination of which covariate is the best indicator of occupancy and which of detectability (Campbell, 2010; Guillera-Arroita *et al.,* 2010). After 99 hours and 30 minutes of surveying, *A. f. fusciceps* was seen on 32 occasions and heard at a distance of <100m three times.

This includes repeated sightings of some groups. The animals were detected at sites between 6:34 in the morning and 15:12 in the afternoon. *A. f. fusciceps* were detected at 23 out of 71 sites in Tesoro Escondido, giving a naïve occupancy estimate of 0.3239. The model in which occupancy and detectability were kept constant (ψ(.)p(.)), gave an occupancy estimate of 1.0 and a detectability estimate of 0.0676. An occupancy value of 1.0 indicates that all occupancy points should have been occupied or used by the spider monkeys, and that a lower naïve occupancy value means that not all animals were detected. Detectability could have been influenced by forest structure, observer error or time of site visit. To test the effect of habitat characteristics on ψ and p, habitat covariates were modelled for 5 site repeats. The top 8 ranked models are presented in Table 1. The model in which occupancy was affected by forest and altitude, whilst keeping detectability constant, came out on top (Table 1).

Table 1: Occupancy models of *A. f. fusciceps* in Tesoro Escondido for the 8 top-ranking models. **AIC**: Akaike Information Criterion, **ΔAIC**: Akaike difference, **AICw**: Akaike weight, **N**: Number of parameters.

Model	AIC	ΔAIC	AIC w	N	Ψ
Ψ(FOR, ALT),p(.)	175.26	0	0.0827	4	0.845
Ψ(CAN, DEN),p(CAN)	175.85	0.59	0.0615	5	0.873
Ψ(ALT, DEN),p(.)	176.09	0.83	0.0546	4	0.859
Ψ(FOR, ALT),p(CLI)	177.16	1.9	0.032	5	0.845
Ψ(DEN, DBH),p(ALT)	177.18	1.92	0.0317	5	0.901
Ψ(FOR, ALT),p(DBH)	177.26	2	0.0304	5	0.845
Ψ(CAN,DEN),p(ALT)	177.44	2.18	0.0278	5	0.873
Ψ(ALT,DEN),p(DEN)	177.88	2.62	0.0223	5	0.873
Ψ(.),p(.)	179.65	4.39	0.0092	2	1.0

Models names comprise the covariate that was modelled for the probability of occupancy (Ψ) and the probability of detecting (*p*) spider monkeys. Covariates of the top models included: presence/ absence of forest disturbance as a result of logging (FOR), altitude (ALT), canopy connectivity (CAN), tree density (DEN), tree diameter at breast height (DBH) and climate (CLI). Models in which covariates were kept constant were denoted by (.).

Tree density and altitude came out of the model as the most important indicators of spider monkey presence in Tesoro Escondido.

Sites of all tree densities and elevations were occupied by *A. f. fusciceps*. Altitude was the main indicator of the probability of detecting *A. f. fusciceps* (Figure 2).

With increasing altitude, the ability to detect the spider monkeys decreased. Beyond 600m, detectability dropped around 4% (Figure 2). Brown-headed spider monkeys are difficult to study as they live in challenging terrain; making traditional line transect surveys more challenging.

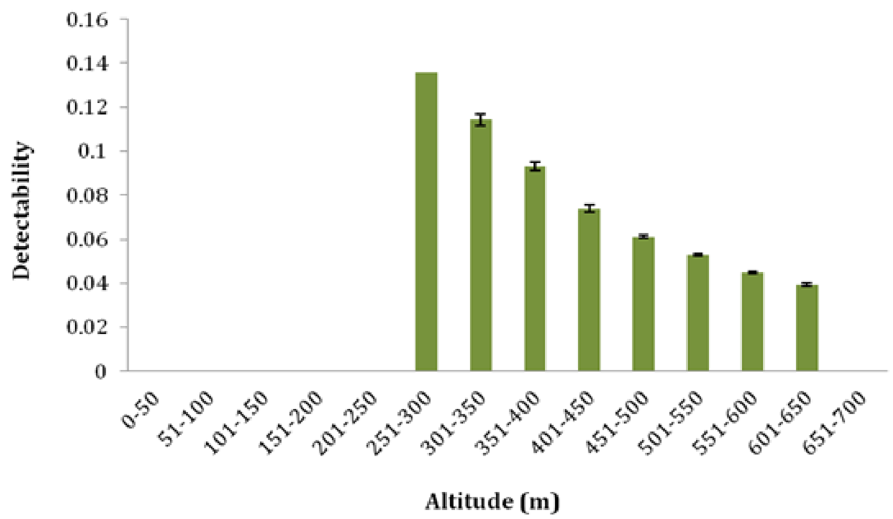

Figure 2. The probability of detection of *A. f. fusciceps* in Tesoro Escondido, northwest Ecuador May-July 2013, in relation to altitude. Error bars represent standard error bars. Probabilities of detection were taken from the model Ψ(.),p(ALT).

Additionally, Peck *et al.* (2011) noted that play-back methods may underestimate primate abundance. Recently, occupancy modelling has proven to be a useful technique to study arboreal mammals in difficult terrain (Campbell, 2010; Neilson *et al.,* 2013). It was thus aimed to test a novel method to determine the factors that affect habitat use by these spider monkeys to aid future conservation efforts in the area. Occupancy modelling revealed that all sites in Tesoro Escondido should be occupied by brown-headed spider monkeys. This would make Tesoro Escondido a site of high conservation priority for the future survival of this species.

The model showed that detectability was low and only 5 repeats per site are needed in future to determine the presence of spider monkeys at sites in and around Tesoro Escondido.

Modelling occupancy with covariates showed that altitude was an important indicator of site use by *A. f. fusciceps*. Spider monkeys range from sea level to 1800 m.a.s.l. (Shanee, 2009). The model revealed that the brown-headed spider monkeys were using all the tested sites in Tesoro Escondido within an altitudinal range of 287-634 m.a.s.l., thereby showing no preference for the lower sites. Additionally, tree density was also an important indicator of site occupancy. At lower tree densities (fewer trees per hectare), more sites were occupied. Primary forest is characterised by having lower tree densities due to the higher number of large trees. This suggests that *A. f. fusciceps* prefers primary forest which is in line with other members of the *Ateles* genus (Aldana *et al.,* 2008). However, as the animals were found at all sites, this indicates that they also use logged forest and secondary forest. It is believed that this is due to the lack of hunting in the cooperative that is often associated with logging practices. The lack of hunting pressure and the high density of *A. f. fusciceps* (Peck *et al.,* 2011), indicate that Tesoro Escondido is a site of high conservation priority for the future survival of this species.

It is suggested that future conservation efforts incorporate occupancy modelling to investigate where other populations of *A. f. fusciceps* are located, especially when surveying areas in which they are being hunted (Baker *et al.,* 2011) and line transects may not be as applicable due to the difficult terrain (Neilson *et al.,* 2013). For example, surveying the RECC (in which the terrain is challenging and hunting occurs) for the possible development of a habitat corridor between Tesoro Escondido and RECC.

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Behaviour and social networks of rehabilitant mantled howler monkeys (*Alouatta palliata*)

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Howler monkeys are the most studied New World primate genus in the wild. Within their habitat, they are threatened by deforestation, urban and infrastructure expansion, poaching, and the illegal wildlife trade. Hunters regularly seize mothers to acquire their infants, depriving them of natural social learning processes. These are essential for developing survival and behavioural skills, such as for foraging or predator avoidance. Once confiscated, these naïve orphaned animals must undergo a lengthy rehabilitation process to improve their welfare and chances of reintroduction and survival in the wild (Guy *et al.,* 2013). Within rehabilitation centres, however, limited research has been done on mantled howler monkeys (*Alouatta palliata*). They do not thrive in captivity, despite their ability to adapt to many different environments in the wild (Neville *et al.,* 1988). A sensitive gastrointestinal tract and complex microbiota contribute to this (Pastor-Nieto, 2015). Moreover, mantled howler monkeys are susceptible to many viral, bacterial, and parasitic infectious diseases that are zoonotic and anthropozoonotic. An infection with the majority of these diseases is associated with stress, improper management, and inadequate captive conditions (Pastor-Nieto, 2015). Specialist veterinarians however, are rare.

The inability of mantled howler monkeys to cope with captivity is also reflected by their absence in any of the 960 zoos and aquaria across 86 countries present in the database of the International Species Information Service (ISIS, 2016). Guidelines not only for best practice rehabilitation, but also for disease prevention and management are urgently needed.

In order to address this issue, I evaluated the effects of group rehabilitation on the behaviour of rehabilitant mantled howler monkeys, by assessing the relationship between the rehabilitants' proximity to one another and the performance of naturalistic behaviours. I experienced the difficulty of keeping mantled howler monkeys in captivity first hand when three study subjects died during a disease outbreak. I assessed how the behaviour and social network of the remaining rehabilitants were affected by this. Additionally, I provided guidelines on disease prevention and management in Central and South American rescue and rehabilitation centres, in particular those housing howler monkeys.

My research took place at an *in situ* rehabilitation centre in Panama where I and other interns collected data on two infants, four juveniles, and one subadult individual during daily bush outings. During these bush outings, the animals were allowed to forage and move at will within forest areas to regain familiarity with their natural habitat. This process appears to be crucial to prepare animals for release as it provides them with essential learning experiences, promotes the acquisition of natural behaviours including locomotion and food selection, and decreases human attachment (Ongman *et al.*, 2013).

The individuals seemed to benefit from proximity to conspecifics with knowledge of food distributions, in terms of finding and identifying palatable food items. They appeared to gain independence from humans with an increasing age but spent very limited amount of time within the canopy, putting them at risk of predation from ground predators.

The disease outbreak caused setbacks to the rehabilitation success; the animals were at greater risk of predation and dependence on humans and were less likely to acquire dietary knowledge as well as develop social skills.

Infant mantled howler monkey during a bush outing. Photograph: McKensey Miller

Most social network measures decreased post-outbreak but associations with humans increased. Rehabilitants' activity budgets also differed from those of wild mantled howler monkeys. The structure of the social network appeared to be influenced by the dependence of the study subjects on humans.

The inability to find food in natural environments and to travel on flexible substrates is often referred to as the reasons for failure among rehabilitation and release programs (Britt & Iambana, 2003; Stoinski *et al.*, 2003). It could, furthermore, be detrimental to the release success if the animals seek human contact at the expense of exhibiting naturalistic species-specific social behaviours. Investigating factors that have the potential to promote the performance of naturalistic behaviours is essential to define best practice rehabilitation guidelines. Group rehabilitation may potentially be such a factor. It seemed to encourage some naturalistic behaviour and may decrease stress. It also provided security while discouraging reliance on humans which should be a primary goal of rehabilitation (IUCN/SSC 2013).

There is an urgent need for longer-term research on howler monkeys in captivity with larger and more diverse samples. The behaviour and group compositions of rehabilitant individuals should be quantitatively assessed to understand the key factors that predict rehabilitation success, individual progress, and eventually release success.

Disease management protocols and communication between parties are also in dire need of development. Further publications will hopefully raise awareness and improve the survival rates of mantled howler monkeys in rehabilitation centres by minimising the disease threat.

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Tourist-monkey interactions at Iguazú National Park, Argentina

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Tourism to natural areas can impact wild primates in a variety of ways, such as increasing levels of aggression (Fuentes & Gamerl, 2005) or increasing stress levels (Maréchal *et al.,* 2011). It can also alter primates' activity budgets (Saj *et al.,* 1999), ranging patterns (Sabbatini *et al.,* 2008) and habitat use. Problems associated with tourism are exacerbated when animals are provisioned (Orams, 2002). Therefore, proper understanding of primate-tourist interactions is essential for the development of appropriate management strategies to ensure that wild populations and humans can coexist.

This study focused on interactions between tourists and a group of black capuchin monkeys (*Sapajus nigritus*) at Iguazú National Park (25°40'S, 54°30'W) in Argentina. The monkeys regularly visit a hotel within the park where they may receive handouts, or enter empty rooms to search for food. These interactions pose potential dangers for visitor safety and may impact the monkeys' behaviour and health.

Data were collected from May 1st to July 21st 2013, for a total of 83 days. The group was followed for approximately eleven hours each day, resulting in a total of 820 hours of observation. Data on tourist-monkey interactions were collected using ad libitum sampling (Martin & Bateson, 2007). The mean number of individual interactions for each sex and for three age classes were calculated, including juveniles (1-5 years), subadults (6-10 years) and adults (>10 years). Infants (<1 year) were excluded from the analysis. Interactions in which monkeys actively participated were considered direct interactions, while interactions in which tourists participated, but monkeys did not respond, were considered indirect interactions.

I used a two-way ANOVA test to determine the influence of age and sex class on individual interactions. Statistical analyses were carried out using SPSS 17. Significance levels were set at $p<0.05$, and standard errors are reported for all mean values.

The mean number of total interactions per individual was 20.8(±2.8), with a range of 0-48 interactions per individual. There was a mean of 10.6(±1.5) direct interactions per individual, with a range of 0-29. Subadult males had the highest interaction rate of all age/sex classes, with a total mean of 40(±3.1) interactions, and a mean 20.4(±1.7) direct interactions. Sex had a significant effect on the number of direct interactions ($F_{1, 22} = 4.499$, $p = 0.049$), with males involved in more direct interactions than females. Age also had a significant effect on the number of direct interactions ($F_{2, 22} = 5.300$, $p = 0.016$), with subadults involved in more direct interactions than both juveniles and adults. Subadult males participated both in more indirect and direct interaction than any other age/sex class (Figure 1).

The highest number of interactions occurred at the hotel. The monkeys obtained food at the hotel more often than at any other location, accounting for 52.7% of all feeding events. Bread, biscuits and potato chips were the most commonly consumed foods.

Individuals in the group vary widely in their propensity to interact with tourists. Subadult males interact with tourists more often than other age/sex classes. Most interactions in which the monkeys receive food occur at the hotel, and the hotel exerts a greater influence on the behaviour of the group than other tourist areas do.

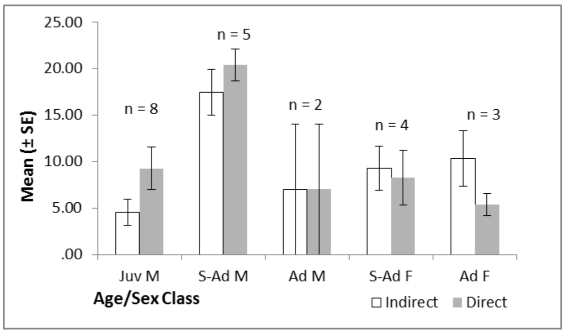

Figure 1. Mean (±SE) individual interactions per age/sex class

If these patterns persist, it is likely that the numbers of tourist-monkey interactions will increase, particularly as juvenile males in the group grow into subadults. This raises the possibility that monkeys will become physically aggressive towards people, with the risk of injuries for visitors (Fuentes *et al.,* 2007). The consumption of human foods could also have a negative effect on the health of the monkeys (Kuhar *et al.,* 2013).

Figure 2. A subadult male black capuchin feeds on potato chips on the hotel balcony

Educational material and the imposition of fines should be used to discourage visitors to the park from feeding monkeys. Park authorities and the hotel management should work to reduce the availability of foods at the hotel, by ensuring that doors and windows to rooms are locked and food in hotel rooms is stored in secure containers.

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An assessment of enrichment strategies for sanctuary housed spider monkeys (*Ateles geoffroyi*)

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It has been well documented that primates raised as pets experience a variety of physical and psychological conditions, serving as surrogate children or props in entertainment or fashion. The welfare implications of these conditions are diverse (Lee & Priston, 2005). The Endangered black-handed spider monkey, *Ateles geoffroyi*, is among the most commonly hunted species for the live pet trade and human consumption within Mexico (Estrada *et al.,* 2004; Cuaron *et al.,* 2008). As these practices mainly involve juvenile spider monkeys, pet spider monkeys are commonly donated or abandoned at the onset of sexual maturity (approximately four years of age, Eisenberg 1976). The high number of private sanctuaries in primate-range countries is further evidence of the primate pet trade problem (Nijman *et al*., 2009; Soulsbury *et al*., 2009). Concerns have been raised about the welfare standards attained in these unregulated institutes (Mapel, 2003; Carter & Kagan, 2010). Private sanctuaries are frequently ill-informed on how to recognize and alleviate signs of poor captive welfare (Brent, 2007) despite the established relationship between inadequate environmental conditions and ill-health of primates (Dawkins, 1990). Enrichment has been shown to improve captive wellbeing, as environmental stimulation normalizes brain development resulting in appropriate species-typical behaviour (Lukas *et al.,* 2001). Although contemporary zoos have shifted from basic facilities to naturalistic enclosures more compatible with species-typical needs (Mun *et al.,* 2013), private sanctuaries are often unable to invest in facilities of this type (Carter & Kagan, 2010).

From May- July 2014, I conducted research within a private spider monkey sanctuary, Ecoparque el Fenix, in Campeche, Mexico, home to 20 spider monkeys obtained from the illegal pet trade. Limited financial resources had resulted in a variety of captive housing conditions, classified as follows: social housing (one group of eight monkeys housed within a large communal outdoor enclosure, 10m x 10m x 13m, [length, width, height]), free range conditions (4 monkeys allowed to range within the park boundaries) singularly housed (two adult males singularly housed in joint neighbouring enclosures, 6m x 4m x 4m each), and tree tethered (five individuals tethered with rope to trees). In order to improve immediate welfare concerns I coordinated the construction of an enrichment program whereby all monkeys were provided access to elevated physical enrichments, including shelters, platforms, and rope furnishings. I collected behavioural data using cyclytic scan observation methods of 30 second intervals in 45 minute samples, thus each monkey was observed every three minutes for nine days on either side of enrichment installation (Martin & Bateson, 2008). The aim of the study was to determine the effectiveness of enrichments upon promoting species-typical behaviour in relation to space use, locomotion, and social structures. I applied a variety of analytical techniques to the collected data including non-parametric statistics and social network analysis (SNA) to compare behaviour before and after enrichment provisioning.

In agreement with Herbert & Bard (2000), I found ropes, suspended branches, and wooden planks were effective primate enrichments. Such items promoted the use of *Ateles* functional assets as observed by the expression of quadrupedal locomotion, suspension, and clambering, which are all species-typical behaviours (Youlatos, 2008). Adults favoured shelters and platforms, whereas infants preferred flexible structures such as rope and hanging furnishings (Figure 1), which were most effective for grappling and play. Terrestrial activity and resting near ceased in all cases, indicative of a uniform preference for elevated space use.

Figure 1. Free ranging female infant black-handed spider monkey on a recycled tire suspended by rope.

Social network analysis revealed that all individuals sought proximity to group members at higher rates after environmental changes. Enrichment pathways ensured means of escape from any negatively perceived social encounters, and ex-pets were observed alone more than captive-raised individuals. Social network analysis further confirmed that infants played a significant role in social structures, with infant handling a desirable activity amongst juvenile and adult females. Locomotion, space-use and social deficits were found to relate most significantly to current housing type in both measurements, with enrichments proving least effective for tree-tethered groups followed by single-housed and free-ranging individuals. In comparison, the socially-housed group expressed higher rates of species-typical locomotive and social behaviour, and enrichment use.

It is paramount that rehabilitation is not hampered by inadequate housing restricting social and locomotive facilitation. Increased research within range-country sanctuaries would be beneficial to attain an idea as to the common housing and enrichment strategies currently employed within non-accredited facilities. This would ensure that enrichments are fulfilling the objective to promote species-typical behaviour. As highlighted here, inappropriate housing alone may reduce the likelihood of enrichment meeting this objective.

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Behaviour and ranging patterns of the Endangered and endemic Bolivian titi monkeys (*Plecturocebus olallae* and *P. modestus*)

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Knowledge about the ecological needs of species is a key conservation priority in the face of the effects of human activities on tropical forests (Holl & Capelle, 1999; Wright, 2005; FAO, 2012). Due to their great dependence of these habitats, Primates suffer severely from anthropogenic impacts, such as forest fragmentation (Isabirye-Basuta & Lwanga, 2008). Nevertheless, researchers have also found that some species, such as certain titi monkey species (traditionally known as genus *Callicebus*), show tolerance and even some kind of preference for disturbed habitats (Estrada & Coates-Estrada, 1996; Bicca-Marques, 2003; Arroyo-Rodríguez *et al.,* 2013; Benchimol & Peres, 2013). This unexpected response could be crucial knowledge for the conservation of this group of neotropical primates. Although their high diversity has been quite well documented there is still a general dearth of ecological information about them (Bicca-Marques & Heymann, 2013; Byrne et al., 2016).

For example, up until recently no information was available for the endemic titi monkeys of Bolivia, *Plecturocebus olallae* and *P. modestus* (both formerly known as *Callicebus olallae* and *P. modestus*, respectively [Byrne *et al.,* 2016]) since they were discovered almost 80 years ago (Lönnberg, 1939). Recent studies by the Wildlife Conservation Society (WCS) showed their Endangered condition and ecological needs, informing conservation in the face of serious habitat loss (Veiga *et al.,* 2008a; 2008b; Martinez & Wallace, 2009a; 2009b; 2010). I led a WCS team conducting a behavioural ecology study of both species to obtain information about behaviour, ranging patterns and diet. We assessed variations between species and groups living in different habitats as a way to evaluate tolerant and generalist features attributed to titi monkeys (Pyritz *et al.,* 2010; Benchimol & Peres, 2014). We aimed to provide conservation knowledge, thereby contributing to the understanding of how primates respond to habitat disturbances.

Our study was made at two private cattle ranches in the south-western part of the Beni Department in Bolivia: La Asunta to observe *P. olallae* (2007-2008), and San Miguel for *P. modestus* (2010-2011). We selected groups living in gallery and fragmented forest for *P. olallae*, and groups living in light and heavily fragmented forest for *P. modestus*. We used continuous scan sampling with an interval of 10 minutes to categorize primate behaviour: resting, moving, feeding, social interactions, territorial calls, and other. Movement of groups were recorded by means of a continuous sampling (Altman, 1974; Martin & Bateson, 1993). In the last case, the grid count method was used using cells of 25x25m as location units. We observed the monkeys during 10 days per month (approx. 6:30 to 18:30) during one year for each species, enabling assessments of variations between dry and wet seasons. To improve our comparisons, two teams observed the two groups simultaneously at each site. The information collected was analysed using both parametric and non-parametric statistical analyses (Siegel & Castellan, 1988).

We found resting as the most registered behavioural category (around 60%) followed by moving (25%) and feeding (10%) in both *P. olallae* and both *P. modestus* groups. Non-adult individuals were more engaged in social activities than adults, because of their involvement in playing and grooming. Primate activity decreased towards midday apparently due to higher temperatures. Peaks of moving and feeding occurred in the morning and the afternoon. Similar patterns were reported for other titi monkey species (Kinzey, 1981; Bicca-Marques & Heymann, 2013). We observed relatively less moving in *P. olallae*, particularly in the group inhabiting the more fragmented forest due to the highly patchy forest in this area. The *P. olallae* area was a more closed understory, including a spiny bromeliad species (*Bromelia serra*) that hindered the displacements of terrestrial animals inside forest patches, reducing titi monkey interactions with them. We consider this as a source of behavioural variation as compared to *P. modestus* that inhabited a region with more open forests, perhaps explaining their less shy behaviour as they were able to interact with other animals. The *P. modestus* groups dedicated more time to move and less to feed during the wet season, apparently related to a typical high intake of fruits in that period.

Our estimations of home ranges (approx. 7-10 ha) and daily distance covered (approx. 400-800 m) were within the range reported for most titi monkey species (Kinzey, 1981; Bicca-Marques & Heymann, 2013). Similar home ranges for the *P. modestus* groups, despite their different group sizes (four and two individuals), suggests an apparent lack of food resources in the most fragmented forest. The comparison of monthly home ranges revealed that groups of both species occupied more border areas of their forest patches than transition and core areas. Transition zones were an apparent reservoir of fruit during the wet season, except for the group *of P. olallae* at gallery forest who suffered a reduction in these areas by flooding. Flooding affected the observation of this group and caused extremely high estimates of distance/hour travelled. On the other hand, longer distances travelled by the *P. modestus* group in more fragmented forests suggested a lack of resources in this forest type. No meaningful variations were found in the groups' displacement between weather seasons. Our assessment of the time that groups spend on different grid cells showed that groups in fragmented habitats spend more time in border zones of patches, than groups in more continuous forests. A direct positive relationship was found in the number of plants source of food per cell and the time monkeys spent feeding in the cell, although this relationship was inverted for *P. olallae* during the wet season. Our observations also suggested few intraspecific interactions between groups, even in groups not occurring in heavily fragmented forests.

We provide information to partially support the generalist ecological style of titi monkeys, considered to make them tolerant to habitat disturbance (Pyritz *et al.,* 2010; Benchimol & Peres, 2014). Nevertheless, the group differences found do show how habitat differences promote different ecological responses that need to be understood in more detail. Thus, our work provides relevant knowledge for the design of conservation strategies for *P. olallae* and *P. modestus* (Martinez & Wallace, 2010; Porter *et al*., 2013). Both face imminent threats and this work contributes to previous efforts to preserve these endemic species and the associated biodiversity.

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Preliminary study on the effects of a hunting community on the Peruvian black spider monkey (*Ateles chamek*)

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The Amazon is the largest rainforest in the World, covering about 40% of South America (Butler, 2014; World Wildlife Fund, 2015) and one of the fastest changing ecosystems in the world (Redmond, 2008). Human-induced pressure on the Amazon has been increasing as a result of human development, which is now threatening the local flora and fauna. One of these threatened species is the Peruvian black spider monkey (*Ateles chamek*), a species classified as Endangered by the IUCN (Wallace *et al.,* 2008) and included in the Appendix II of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES). *Ateles chamek* occurs in three countries: Bolivia, Brazil and Peru (Figure 1). The species is listed as Vulnerable by the Peruvian government in the Supreme Decree No. 34-2004-AG (2004). This decree prohibits hunting, capturing, ownership, transportation, and exportation for commercial purposes (Heymann, 2004). Enforcement of environmental legislation in Peru is, however, lacking (Environmental Investigation Agency, 2015). Many studies show that *A. chamek* (the largest primate in south-eastern Peru) is one of the favoured hunting targets of the people living in the Amazon (Parry *et al.,* 2009), including the research area (Schulte-herbrüggen & Rossiter, 2003). I hypothesised that spider monkeys would spend more time travelling and less time feeding, resting, and socialising the closer they were to the community of Lucerna. I also expected the spider monkeys to be found at higher levels in areas closer to the local community and at lower levels for further distances. The study area is situated along the Las Piedras river, within the Madre de Dios section of Peru at the Las Piedras Amazon Centre and its surroundings (-12.0709367 S, -69.5005917 W) (Figure 1).

The study site is located between 200 and 300m above sea level and mostly contains floodplain forest and terra firme forest. The research took place from the 5th of May till the 26th of July, this period being part of the dry season in the Madre de Dios region.

Data were collected on the first animal seen (group size, sex-ratio, forest level use (0-10, 10-20 and 20+ meters), reaction to the observer, distance to observer and the behaviour of the focal animal. Whenever the group could be followed, additional data were then collected every 5 minutes. Data were collected using instantaneous focal data sampling (Altmann, 1974). The focal animal was followed until out of sight for more than ten minutes, until it was no longer possible to follow, or until it settled in a tree for sleeping. The behavioural categories used were travelling, resting, foraging, socialising, and other. We collected data in two distance categories with the community Lucerna being the central point. We surveyed a hunted and a non-hunted site.

The activity budgets were calculated by combining the frequency of behaviour in all samples. To find out what influenced the activity budget the data were further analysed in SPSS using Fisher Exact tests (FET) and Mann-Whitney tests (U).

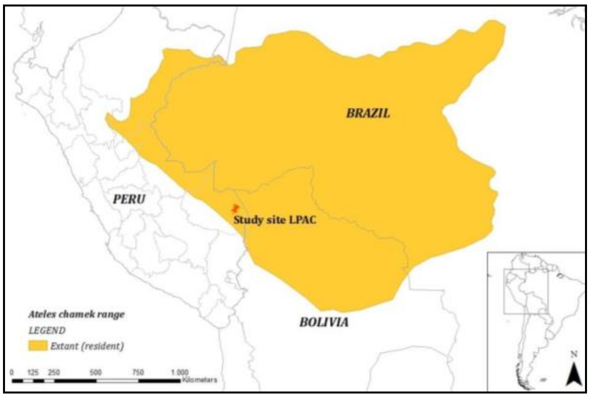

Figure 1. Peruvian black spider monkey (*Ateles chamek*) range and location of the study site the Las Piedras Amazon Centre, Madre de Dios, Peru.

The dependent variable was the behaviour and the independent variable was the distance to Lucerna. The distance to the community was also analysed for its effect on forest level use, reaction to observer, and distance from observer.

I was only able to collect data for a total of 13 hours and 15 minutes of which only 20 minutes were collected in the second distance category (5-10km) and 0 minutes in the hunted site. We were not able to sample males and females equally as we encountered more females than males (3:10 male to female ratio). In total we collected data on 39 spider monkey encounters (some individuals were encountered more than once), in 25 groups spread over 20 days. The average group size of *A. chamek* in this study was 3.08 (SD 1,71) individuals.

The activity budget for *A. chamek* comprised of 38,46% travelling, 35,90% resting, 10,26% foraging, 2,56% socialising and 12,82% other. (In 100% of the cases that other behaviour was recorded, vocalising was their main behaviour). I further analysed the data and compared them for the two distance categories from the community Lucerna (0-5km and 5-10km). The activity budget did not significantly differ between the two distance categories (p = 0,367 FET).

After combining all encounters, I found that *A. chamek* were encountered above 20 metres (canopy) 58,97% of the time, between 10 and 20 metres for 38,46% of the time, and beneath 10 metres 2,56% of the time. (There was only one encounter during which *A. chamek* was underneath 10 metres. This was when the animal came down to drink from a stream.) There was no significant difference between forest level use between the two distance categories (p = 0,190 FET). The average distance to the observers was 28,29 metres (SD 9,83). There was no significant difference in the distance to observer between the distance categories (U = 89,500, N = 38, p = 0,158).

I expected that the spider monkeys would travel more but rest, feed, and socialise less the closer they were to Lucerna (Gill *et al.,* 2001). There is, however, no significant difference found in activity budgets between the two distance categories from the community. There has been little research on activity budget changes due to hunting by humans. But in a study on the effect of logging on Malaysian primates, they found that the primates would rest more and travel and feed less (Johns, 1986). Nijman (2001) writes that behavioural changes are most likely species-specific and this can therefore be different for spider monkeys. I could not compare the activity budgets between the hunted and non-hunted site. Further research on the population in the hunted site is necessary to eliminate the hypothesis that differences in activity budgets are due to hunting. The average group size is 3.08 individuals (SD 1.71) which is not unusual (McFarland Symington, 1988; Apaza-Quevedo *et al.*, 2008).

There is no difference found in forest level use for *A. chamek* and we could therefore conclude that the species do not alter their forest level use due to hunting. The spider monkeys overall spent most time in the canopy >20m (58.97%). There is one sighting underneath >10m (2.56%) when the animal was believed to be drinking from a stream. These findings comply with other studies (van Roosmalen, 1985; Wallace, 2008).

More data need to be gathered on the spider monkeys in the hunted site to be able to reject the theory that hunting impacts spider monkey behaviour.

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