Census of primates in the *Jungla de los Monos* proposed Conservation Concession, El Tambo, San Martin, Peru

Nestor Allgas
Neotropical Primate Conservation

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ABSTRACT

The highly deforested Alto Mayo region lies within the Peruvian department of San Martin, which experiences one of the highest levels of deforestation and fragmentation in the country. It is home to, amongst others, the Critically Endangered and endemic San Martin titi monkey (*Plecturocebus oenanthe).* Historically San Martin was home to at least 19 primate species, and at least 14 of these persist in the Alto Mayo Valley. We surveyed primate populations in the "Jungla de Los Monos" a locally protected remnant of the naturally diverse primate community of the Alto Mayo in one of the last remaining mid-elevation seasonally flooded forests in the region. We recorded evidence of seven primate species in the area, *Lagothrix lagothricha* was suggested to be present by local villagers but we found no evidence of its persistence. By far the most common species was *Saimiri macrodon*. Only one detection of *Plecturocebus oenanthe* was made in the forest interior. The area holds a surprisingly high diversity and density of primates considering its proximity to population centres. Conservation of the area should be made a regional priority, especially as we found evidence of anthropogenic hunting and disturbance.

Introduction:

Historically, San Martin had one of the most diverse primate faunas in Peru; at least fourteen species remain (Shanee et al. 2013). With NPC's assistance, the community of El Tambo is protecting 257 ha of seasonally flooded forest, and the neighbouring community of Santa Elena is protecting 1612 ha (Fig 1). These areas are home to at least 7 species of primate (Table 1), including the CR San Martin titi monkey *(Plecturocebus oenanthe*, IUCN 2011). We carried out diurnal line transect surveys and nocturnal point surveys in the area of El Tambo during the wet and dry seasons to estimate densities and biomass of the different primate species found. We also mapped occurrences of the area's San Martin titi monkeys (*P. oenanthe*) and its capuchin monkeys (*Cebus yuracus* and *Sapajus macrocephalus*). It was reported locally that capuchins are often aggressive towards titi monkeys, with reports of capuchins even killing titi monkeys.

This survey was carried out to help the development of conservation and research projects in the local area, particularly to enhance the protected status of the two reserves. Preliminary observations prior to the start of the study suggested high primate densities in the area. Such high densities and diversity are rarely still found in the Alto Mayo valley. In order to empirically study the effects of local conservation efforts in relation to the threats linked with such small relict forest areas, it is vital to obtain baseline data.

Table 1) Species expected at the study sight and recorded during field work.

Species	Red list status	CITES Appendix	DS004-2014MINAGRI	Recorded during surveys
Alouatta seniculus	LC	II	-	Yes
Aotus cf. nancymaae	VU	II	-	Yes
Cebus yuracus	NT	II	-	Yes
Plecturocebus oenanthe	CR	II	CR	Yes*
Leontocebus leucogenys	VU	II	-	Yes
Lagothrix lagotricha	EN	II	EN	No**
Sapajus macrocephalus	LC	II	-	Yes
Saimiri cf. macrodon	LC	II	-	Yes

*Not recorded during transect surveys.

**Reported by local guides; not confirmed.

Methods:

The study site is located near the village of El Tambo, between the Romero and Negro rivers, and approximately 10 km north of the city of Rioja. We carried out diurnal surveys using line transect methodology (Peres 1999; Plumptre and Cox 2006; Marshall et al. 2008; Buckland et al. 2010a; Buckland et al. 2010b). Transect walks were carried out by researchers and local co-investigators trained by the principal investigators. Eight transects were opened, measured and tagged with foresters' tape, totalling 7,500 meters (avg 0.94 km/transect). Depending on the weather conditions each transect was walked 4x monthly for 4 months during the dry season and 4 months during the wet season. Two transects were walked each day. Transects were sampled twice between 7:00 and 9:00 am and twice between 4:00 and 6:00 pm, at ~ 1km/h on all walks to increase chances of detection. Repeat samples were made no less then 72 hours apart to ensure independence and avoid pseudo-replication. Habitat characterization and phenological data were recorded separately.

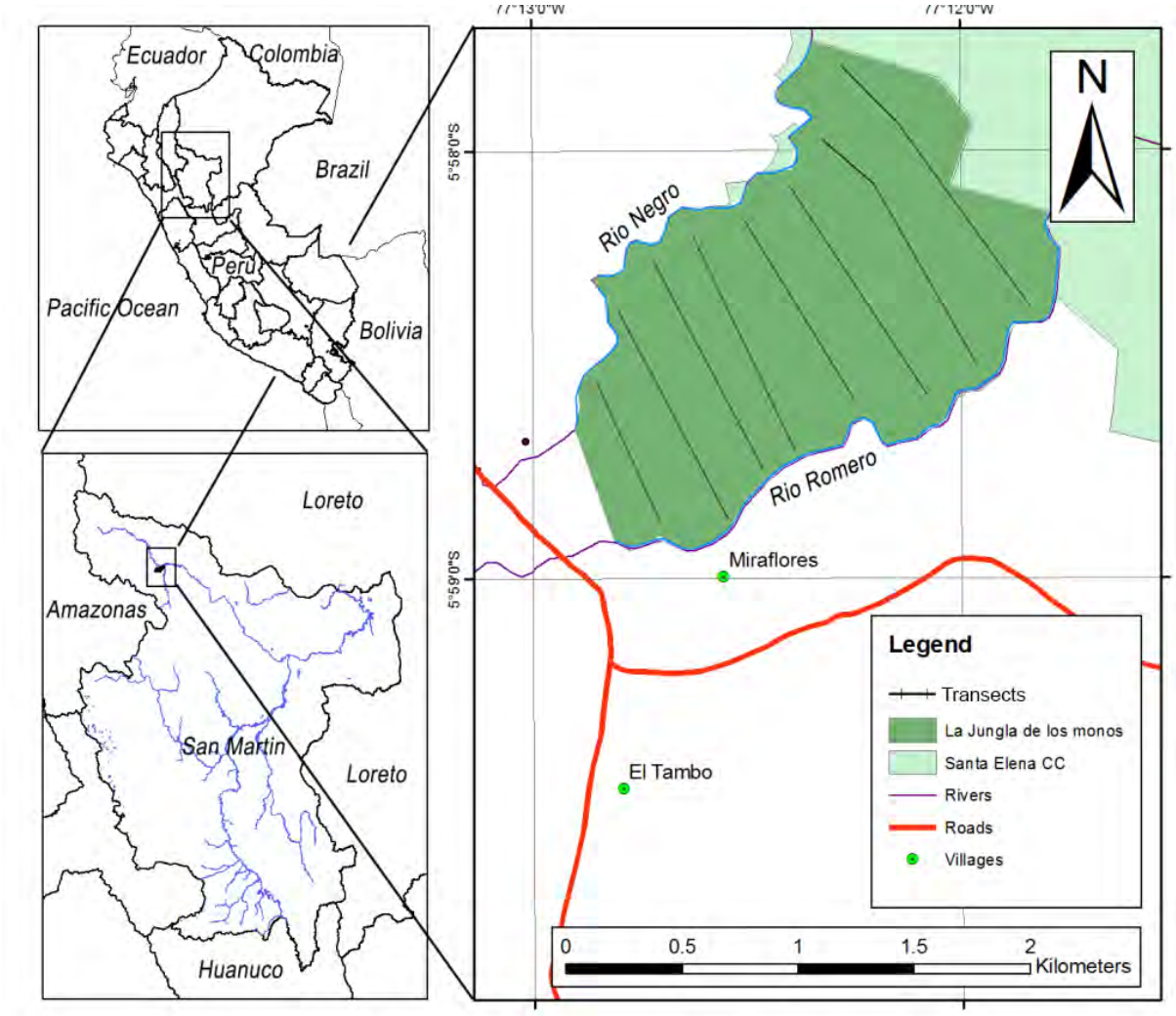

Figure 1 Map showing study sight location within Peru and transects used in surveys.

Nocturnal surveys were also carried out to sample the presence/density of *Aotus* cf. *nancymaae* using fixed point sampling methods along the same transects used in diurnal surveys. Points were located at 200m intervals along each transect and observations were made starting at 7pm for 20 minutes on each point, sampling one transect per night and repeating each transect twice a month.

Data recorded included: date, start and end times, climatic condition, species identity, group size, sighting location, perpendicular distance from the approximate group centre to transect (or point in case of nocturnal surveys), group spread, activity, height in tree, food type (if eating), age and sex of any mammal species and primate groups. Distances were measured using a laser range finder or estimated by eye, angles were measured with a compass/protractor. The locations of detections were recorded with hand-held GPS units. Mixed-species associations, *ad-lib* behavioural observations, and vegetation features were also recorded.

Density estimates were made using Distance 7.2 software [Thomas et al. 2009] for the primate community as a whole (Biomass) and for individual species. We also used Krebs' [1999] formula:

$$Group\ density = G_t/(L_t 2(ESW))$$

wherein *Gt* = total number of sightings, *Lt* = total sampling effort, and *ESW* = estimated strip width (calculated as the average adjusted perpendicular distance). Crude biomass estimates were calculated using the formula:

$$Bio_c = W*D$$

where Bio_c = crude biomass, *W* = average adult body weight (kg) and *D* = population density of species (/km^2). We used average adult body weights from published studies and assumed that half the members of each group were immature individuals and that immature individuals weigh half that of mature individuals (Ford and Davis 1992; Peres 1993; Ford 1994; Boinski 1999; Lu 1999).

We made habitat descriptions using point-quarter method [Krebs 1999] on the same transects as census walks (Fig 1). Samples were taken every 50 meters along each transect. At each point we established four quadrants, divided between the cardinal compass points. We used a radial cut-off distance of 25m around each point, not sampling trees at greater distances. In each quadrant we measured the distance from the centre to the nearest tree and a second measurement from the first tree to its nearest neighbour (Allgas et al. 2016). We included all trees of trunk diameter at breast height (DBH) > 10cm, recording DBH, height and crown spread for each.

Interspecific interactions observed during transect walks or *ad-lib* were recorded. We also made additional presence/absence surveys of *P. oenanthe* in surrounding riverine forests and forest fragments.

Results:

Diurnal Primate Surveys

We made a total of 173 good transect walks, totalling a distance of 274.7 km of repetitions. We detected primates on 287 occasions. The most commonly encountered species were *Saimiri macrodon* and *Alouatta seniculus.* The species with the lowest encounter rates were *P. oenanthe,* only one detection, and *Aotus cf. nancymaae*, with 2 detections during diurnal transect surveys.

Table 2) Results of primate densities using Krebs (1999) formula.

Species	Detections (n)	Avg Gp	Strip width	Gp/Km^2 (Ha)	Ind/Km^2 (Ha)
A. seniculus	92	6.11	43.3	7.74 (0.08)	47.28 (0.47)
L. leucogenys	28	5.86	33.72	3.02 (0.03)	17.72 (0.18)
S. macrodon	97	18.95	44.66	7.91 (0.08)	149.81 (1.50)
C. yuracus	22	7.91	42.96	1.86 (0.02)	14.75 (0.15)
S. macrocephalus	47	6.26	45.30	3.78 (0.04)	23.65 (0.24)
Primates		3.00	43.08	24.26 (0.24)	256.43 (2.56)

Using Krebs (1999) formula, densities of primates varied widely (Tables 2). *Saimiri macrodon* was by far the most common species with almost 150 individuals/km^2, followed by *Alouatta seniculus* with just under 50 individuals/km^2. Overall primate density was 256.43 individuals/km^2, using Krebs (1999) formula, with an estimated biomass of 563.70 kg/km^2 (Table 3). Over half of the primate biomass was made up by *A. seniculus*, with a further quarter made up by *S. macrodon* (Table 3).

Table 3) Density and biomass results for primates recorded during surveys using Krebs (1999) formula.

Species	Ind/Km^2 (Ha)	Avg body weight (Kg)	Biomass (Kg/km^2)
A. seniculus	47.28 (0.47)	6.5	307.32
L. leucogenys	17.72 (0.18)	0.39	6.91
S. macrodon	149.81 (1.50)	0.94	140.82
C. yuracus	14.75 (0.15)	2.7	39.83
S. macrocephalus	23.65 (0.24)	2.91	68.82
Primates	256.43 (2.56)	-	563.70

The data were entered into Distance 7.2 Program (Buckland et al. 1993) for further analyses. We calculated primate density and individual densities for each species separately (Table 4). We fit different models to the data and used Delta AIC, AIC and Coefficient of Variance values to evaluate which model fit best (Burnham and Anderson 1998, 2003; Burnham et al. 2011). As with estimates using Krebs (1999) method, densities varied widely between primate species, but estimates were constantly higher using Distance program than with Krebs (1999) method. Again, the species found at the highest density was *S. macrodon* (Table 4), accounting for roughly one third of all primates at the study sight (Table 5), and over half of all primate biomass made up by *A. seniculus* (Table 5).

Table 4) Model parameters and results of primate densities using Distance.

Species	Key function	Series expansion	Strip width	Ind/Km^2 (Ha)	Delta AIC	AIC	Coefficient of Variance
A. seniculus	Half Normal	Cosine	30.46	64.758 (0.65)	0.00	296.93	0.148
L. leucogenys	Half Normal	Cosine	23.29	26.727 (0.27)	0.00	78.01	0.272
S. macrodon	Half Normal	Cosine	30.52	220.738 (2.21)	4.82	326.49	0.136
C. yuracus	Hazard Rate	Simple Polynomal	38.99	16.599 (0.17)	0.00	72.97	0.270
S. macrocephalus	Hazard Rate	Simple Polynomal	38.8	28.074 (0.28)	0.00	147.94	0.184
Primates	Hazard Rate	Simple Polynomal	33.67	333.145 (3.33)	1.11	920.35	0.098

Table 5) Density and biomass results for primates recorded during surveys using Distance.

Species	Ind/Km^2	Avg body weight (Kg)	Biomass (Kg/km^2)
A. seniculus	64.758	6.5	420.93
L. leucogenys	26.727	0.39	10.42
S. macrodon	220.738	0.94	207.49
C. yuracus	16.599	2.7	44.82
S. macrocephalus	28.074	2.91	81.70
Primates	333.145	-	765.36

Nocturnal Primate Surveys

We carried out nocturnal surveys at 12 points along 4 transects. We did not encounter *Aotus* cf*. nancymaae* during any of the night surveys (Although we did record the species during diurnal surveys, see above), probably due to the low number of points surveyed and the disturbance (splashing and falling) caused during night walks. In the end, due to the extreme difficulty of night surveys along flooded transects and the lack or willingness on the part of the guides we had to abandon night surveys, instead using funding to carry out extra diurnal walks and additional presence absence work with *P. oenanthe*. We hope to be able to complete night surveys at a later date.

Habitat description

A total of 508 trees were sampled between the 8 transects (average 63.5 per transect), these represented a total of 47 morphotypes (species identification is still not complete). Average tree height was 18.28 (± 3.43) m, average DBH was 109.19 (± 16.57) cm, average crown projection was 6.23 (± 0.87) m and average relative tree diversity score was 0.26 (± 0.09). No significant differences were found in habitat characteristics between transects (All $p > 0.05$).

Table 6) Details of habitat characteristics for each transect.

Transect	Average Distance to nearest tree (m)	Average tree height (m)	Average DBH (cm)	Average crown projection (m)	Relative tree diversity*
A	3.30	15.23	98.7	6.62	0.19
B	2.54	25.76	97.89	5.44	0.26
C	4.04	20.05	113.52	6.68	0.38
D	3.12	18.14	135.52	6.65	0.20
E	2.44	18.55	125.68	7.53	0.32
F	2.97	16.47	118.68	6.35	0.18
G	2.72	15.52	93.07	4.7	0.21
H	2.37	16.58	90.49	5.87	0.43
Average	2.94 (± 0.55)	18.29 (± 3.43)	109.19 (± 16.57)	6.23 (± 0.87)	0.26 (± 0.09)

*Number of different morphotypes (as surrogate measure for species) registered divided by number of trees sampled.

Plecturocebus oenanthe

One of the principle aims of this survey was to evaluate the density of the local population of the endemic and Critically Endangered San Martin titi monkey (*P. oenanthe*). Unfortunately, we were only able to record the presence of this species once on the transects. We did observe the species on several occasion in forests along the river banks when travelling towards the study site. One of the hypotheses we hoped to examine in this study was the possibility that the risk of agonistic encounters with capuchin monkeys (*Sapajus macrocephalus* and *Cebus yuracus*) would much reduce encounters with *P. oenanthe* in areas where the capuchins are present. This hypothesis may be at least partially supported as we found capuchins throughout the study area, and only once encountered *P. oenanthe* in the forest interior. Conversely, we did find *P. oenanthe* along river banks, where we did not observe capuchins. However, previous studies suggest titi monkey densities are higher in secondary and riverine forests (Mark 2003; van Kuijk et al. 2015). Therefore, our observations could just be because *P. oenanthe* prefer edge forest, whereas capuchins prefer forest interior, and it is not a case of competitive or aggressive exclusion.

Additionally, we made several presence/absence surveys of *P. oenanthe* in surrounding forest patches. Of 7 patches surveyed we found the species present in 5. We also recorded the presence of *P. oenanthe* in several riverine forests along the borders of the “La Jungle de los Monos” reserve and nearby rivers.

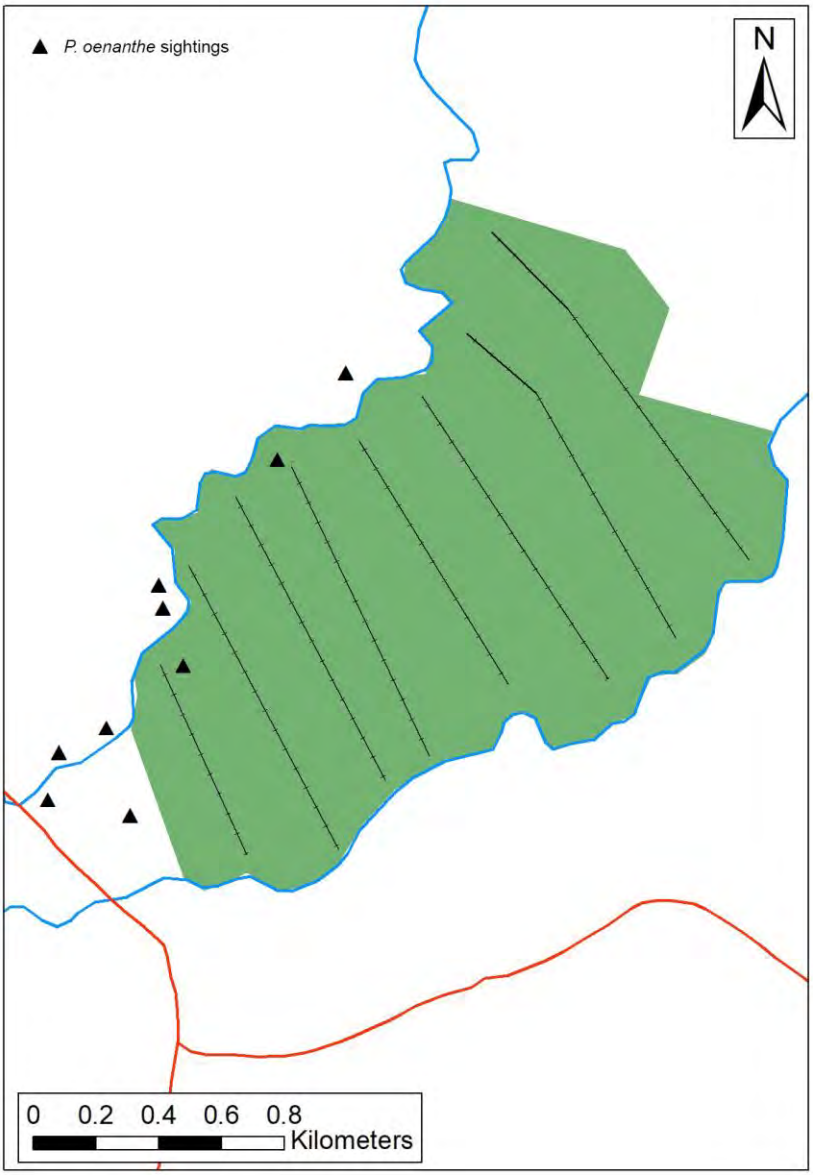

Figure 2 Map of study site showing locations of *P. oenanthe* sightings.

Interspecific Associations

Interspecific associations were recorded for all primate species (except *Plecturocebus oenanthe* and *Aotus nancymaae*). By far the most common species parings were between *Saimiri macrodon* and *Sapajus macrocephalus* (Table 7). The only species pairs not observed were *Leontocebus leucogenys* and the two capuchin species, or between the two capuchin species themselves (Table 7).

Table 7) Number of observations of species pairs in interspecific association.

	Alouatta seniculus	*Cebus yuracus*	*Leontocebus leucogenys*	*Saimiri macrodon*	*Sapajus macrocephalus*
Alouatta seniculus		2	1	3	1
Cebus yuracus	2		-	**5**	-
Leontocebus leucogenys	1	-		4	-
Saimiri macrdon	3	**5**	4		**14**
Sapajus macrocephalus	1	-	-	**14**	

By far the most common species found during this study was *Saimiri macrodon* at almost double the density of previous studies (Table 8) even with lower average group sizes then other studies (Table 9). All other species were found at densities within the range of those in the published literature (Table 8). Group sizes found during this study were generally at the lower end of published group sizes (Table 9).

Table 8) Comparative density estimates between this study and density ranges found in the literature.

Species	Ind/Km^2 (This study)	Ind/Km^2 (Literature review)
A. seniculus	47.28	25-54
L. leucogenys	17.72	2.4-68
S. macrodon	149.81	8-80
C. yuracus	14.75	1-15.8
S. macrocephalus	23.65	5.8-40

Table 9) Comparative average group sizes between this study and those found in the literature.

Species	Average Group size (This study)	Average Group size (Literature review)
A. seniculus	6.11	2-16
L. leucogenys	5.86	5-10
S. macrodon	18.95	25-54
C. yuracus	7.91	8-35
S. macrocephalus	6.26	6-23

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