

10 Population density and habitat availability of *Callicebus ornatus*, a Colombian endemic titi monkey

Densidad Poblacional y Disponibilidad de Hábitat de Callicebus ornatus, un Titi Endémico Colombiano

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ABSTRACT

The distribution, habitat loss, density, fragmentation and their influence on group sizes of *Callicebus ornatus* were evaluated between 2004 and 2011 in an area around San Martín de los Llanos, Meta, Colombia. The distribution of the species in official conservation areas is about 49,074,79 km²; however, the total area is highly fragmented by agricultural crops and other activities. As a result, the actual area available for this primate species is less than 39,404,454 km² (35% of habitat reduction, data from 2001 to 2008). The density values of *C. ornatus* were estimated to vary between 57.94 ind/km² and 1.073 ind/km² for five fragments, that varied in size between 16 ha and 1050 ha. Although there was no strong correlation with the size of the fragment, there is a tendency for higher densities in smaller fragments. Group sizes also showed a tendency to be high (4 to 5 individuals) in smaller fragments. These results are probably caused by low dispersion to adjacent areas and few refuge locations in intervened areas, although other studies have argued that the absence of competitors in small fragments may also affect titi population densities.

Key words: *Callicebus ornatus*, estimated density values, group sizes

RESUMEN

La distribución y pérdida de hábitat, densidad y fragmentación y su influencia en los tamaños de grupo de *Callicebus ornatus* fueron evaluados entre el 2004 y 2011 en un área alrededor del municipio de San Martín de los Llanos, Meta. La distribución conocida de la especie en áreas de conservación protegidas por la ley es de alrededor de 49,074,79 km², sin embargo esta área es altamente fragmentada debido a la agricultura y otras actividades. Como resultado de esto, el área real disponible para esta especie de primate es de alrededor de 39,404,454 km² (35 % de reducción del hábitat, desde 2001 - 2008). Los valores de densidad de *C. ornatus* fueron estimados entre 57.94 ind/km² y 1.073 ind/km² para cinco fragmentos que varían en tamaño entre 16 ha a 1050 ha. Aunque no existe una correlación fuerte con el tamaño del fragmento, existe una tendencia hacia altas densidades en fragmentos pequeños. Los tamaños de los grupos mostraron una tendencia a ser más altos (4 a 5 individuos) en fragmentos pequeños. Estos resultados probablemente son causa de una baja dispersión a áreas adyacentes y pocos

refugios ubicados en áreas intervenidas, aunque otros estudios han sugerido que la ausencia de competidores fuertes en pequeños fragmentos puede incrementar la densidad de los titis.

Palabras claves: *Callicebus ornatus*, valores de densidad estimados, tamaño grupal

INTRODUCTION

Titi monkeys (genus *Callicebus* sp.) are Neotropical primates with high diversity and not well resolved taxonomy (Hershkovitz, 1990; Groves, 2001; Defler, 2010). In Colombia, there are six species of titi monkeys (Van Roosmalen *et al.*, 2002; Groves, 2000, 2005; but see Defler, 2010), two of which are endemic and endangered: *Callicebus ornatus* (Vulnerable –VU– according to IUCN criteria; Defler, 2010) and *Callicebus caquetensis* (in Critical Risk –CR–; García *et al.*, 2010). *C. ornatus* is classified as vulnerable due to a small distribution area, which includes from the north of upper Guayabero River from the Cordillera Oriental to the Ariari River. The main population extends up the piedmont forest at least to the Upia River. Eastern limits are poorly defined and probably do not extend beyond the Metica River (Fig. 1). The forests in the distributional range have a long history of fragmentation (Stevenson y Aldana, 2008).

Fragmentation produces different effects on primate populations depending on fragment shape, size and isolation between them (Chapman *et al.*, 2003; Hobbes y Yates, 2003; Marsh, 2003). Colombian primates living in areas of colonization, agriculture and/or increased livestock are most threatened. In the last five years fragmentation has increased due to illegal crops and incentives for palm oil plantation (*Phoenix dactylifera*; Instituto von Humboldt, 2011; Fedepalma, 2011).

The main threats for *C. ornatus* are fragmentation and habitat loss, especially due to palm oil plantations in Meta department, which is the main producer of palm oil in the country (Fedepalma, 2011) and to increased petroleum explorations. The species' estimated distribution area is of 60.000 km². This study assessed the distribution of *C. ornatus* and habitat loss, as well as population densities and the effect of fragment size on group size in five areas within its distribution.

METHODS

Distribution and habitat loss

The distribution of *C. ornatus* was reviewed and recalculated using satellite images. I confirm actual distribution based on direct observations, and reports of other researchers and local people. The values for the area distribution were calculated using Google Earth tools and data from Vazquez y Serrano (2010) and Lasso and collaborators (2010). Deforestation areas were calculated based on data from 2001 to 2008 published on Parques Nacionales Naturales de Colombia (2005), Tobón and Resterpo (2009) and Murcia and collaborators (2010).

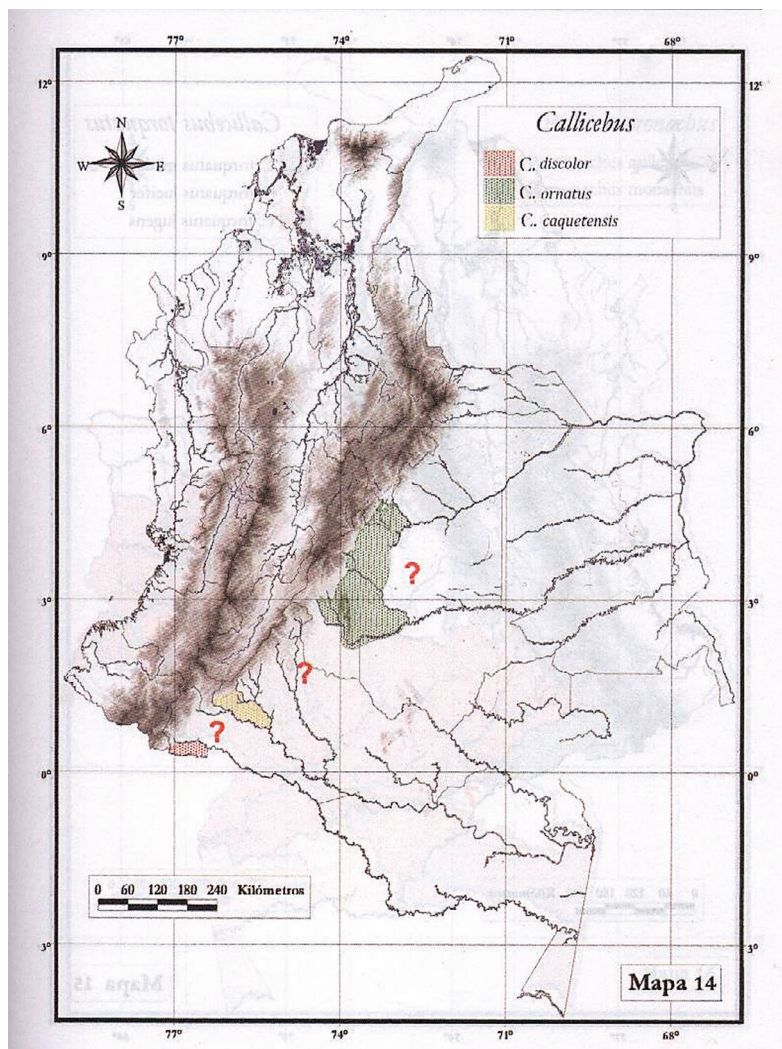


Figure 1. *Callicebus ornatus* distribution in Colombia (from Defler 2010; interrogation symbols means areas where *Callicebus* species are unknown).

Densities estimates and effects of fragment size on group size

Population data was recorded from 2004 to 2011 in small fragments of different sizes and from a large fragment from 2008 to 2011 near of San Martín de los Llanos, Meta in the Colombian Llanos Orientales (Fig. 2; Carretero-Pinzón, in press). Estimated density values for small fragments were calculated using the ecological density formula: the number of individuals divided by the available or sampled area (Soini, 1986). The estimated density value for the largest fragment (1050 ha) was calculated with the software Distance 6.0

(Thomas *et al.*, 2002) and the population data was collected in all fragments, between 6:00 and 12:00, and from 14:00 to 18:00. All groups observed were followed at each fragment for at least 15 minutes to determine group composition. The number of individuals in the group and their individual identification within the troop were also analyzed and individuals were identified and differentiated between troops in small fragments. Fragmentation influence on group size of *Callicebus ornatus* was analyzed by linear regression considering all group sizes recorded in all fragments surveyed on San Martín area (Fig. 2).



Figure 2. Fragments sampled, 2004 – 2011, near of San Martín town with *Callicebus ornatus* (Red dots are fragments where populations surveys were made; yellow dots are fragments where *C. ornatus* presence was recorded by observations or by vocalizations).

RESULTS AND DISCUSSION

Distribution and habitat Loss

Table 1 shows the national parks and conservation areas protected by Colombian law, which overlap with the distribution of *C. ornatus*. A total area of 49.074,79 km² is likely to have populations of *C. ornatus*, however deforestation in these areas in the last decade has reduced it to 39.404,454 km² (35 % of habitat reduction mainly due to illegal crops inside of National Parks). Not all these areas are forests; some of these are a mixture of forest fragments and agriculture and/or livestock lands. For example, areas in the Integrated Management District (DMI acronym *in spanish*) Ariari – Guayabero, DMI Macarena Norte and DMI Macarena Sur are zones with people living inside of La Macarena National Park and with a high proportion of agriculture, livestock, illegal crops and social unrest (Vasquez and Serrano, 2009). Such threats make management difficult because of multiple pressures on *C. ornatus*' populations. Other areas have some small zones where it is possible to find the species in small fragments, such as around the town of Villavicencio, where its presence is reported by local people (Carretero-Pinzón, 2011).

Table 1. Natural parks and conservation areas protected by Colombian laws likely to have *Callicebus ornatus*.

Department	Nearest town	GPS Point	Estimated area (km2)	Height	Protection status	C. ornatus presence	Deforestation (km2)***
Meta	La Uribe - La Macarena	2°22'47.52"N 74°04'36.27"W	2234.5	500 m	PNN Tinigua *	Yes	1838
Meta - Caquetá	La Uribe - San Vicente del Caguan La Macarena - Mesetas - Puerto Concordia - San Juan de Arama - Puerto Rico	2°45'17.76"N 74°41'15.97"W	2979.78	500 m	PNN Cordillera los Pichahos*	Yes	2729.28
Meta	Lejanías - El Castillo - Vista Hermosa - Granada - Fuente de Oro - San Juan de Arama - Puerto Lleras - Cubarral - Mesetas - Puerto Rico - La Macarena - San José del Guaviare	2°34'47.88"N 73°39'54.48"W	6280.52	100 - 1500 m	PNN Sierra de La Macarena*	Yes	2.009.766
Meta - Guaviaré	Mesetas - San Juan de Arama - Vista Hermosa - Puerto Rico	3°45'27.56"N 73°51'23.28"W - 2°03'41.86"N 73°57'35.06"W	23558.57	200 - 3500 m	DMI Ariari - Guayabero *	Yes	1780.79
Meta		3°22'08.05"N 74°07'32.74"W	3481.54	200 - 2000 m	DMI Macarena Norte*	Yes	
Meta	La Macarena	2°03'41.86"N 73°57'35.06"W	393.05	200 m	DMI Macarena Sur*	Yes	1312.5
Meta	Villavicencio	4°09'03.12"N 73°40'41.37"W	14.52	470 - 1330 m	RFP Honda Stream - Parrado and Buque spouts*	Yes	?
Meta	Villavicencio	4°11'23.96"N 73°37'09.24"W	7.31	450 - 830 m	RFP Vanguardia Hill - Vanguardia spout and stream*	?	?
Meta - Cundinamarca	Castilla la nueva - San Carlos de Guaroa - Acacias - Villavicencio - Restrepo - Cumaral - Medina - Paratebueno - Cabuyaro - Barranca de Upiá - Ubala - Santa María - San Luis de Gaceno - Puerto López	3°41'N 72°45'W - 4°57'N 73°53'W	10125	160 - 1400 m	Conservation Nominated Area Alto Río Meta**	Yes	?
TOTAL AREA			49074.79				
*Data from Vasquéz & Serrano (2010); PNN = Parque Nacional Natural (National Natural Park); DMI = Distrito Integral de Manejo (Integrated Management District); RFP = Reserva Forestal Protectora (Protected Forestal Reserve); REH = Reserva ecológica e hídrica (Ecological and hidric reserve); RF = Reserva forestal (Forestal reserve);							
ZUPIS = Zona de utilidad pública e interés social (Public utility and social) interest area							
***Data from Lasso et al (2010)							
**Data from Parques Nacionales Naturales de Colombia (2005); Tobón & Restrepo (2009) and Murcia et al (2010)							

Table 2 shows some private natural reserves that probably have *C. ornatus* populations (210,62 km²) and where its presence has been confirmed (71,092 km²). However the future of private reserves is uncertain because every owner has the right to change his land use depending on circumstances and wishes, which does not guarantee its long-term permanence. These forests are highly important as conservation tools in zones with human pressure on this and other species of endemic primates of the region such as *Aotus brumbacki* and *Saimiri sciureus albigena*. Outside the areas previously mentioned, it is possible to find *Callicebus* populations living in small fragments linked by fence rows, such as around the San Martín area.

Table 2. Areas of private natural reserves with and without confirmed presence of *Callicebus ornatus* (data available through Nodo Orinoquía website (<http://nodorinoquia.com/>)).

Department	Name	Town	Area (km ²)	<i>C. ornatus</i> Presence
Meta	Caño Quenane	Villavicencio	0.29	?
	La casa de la abuela	San Martín	0.01	No
	Las Unamas	San Martín	37.832	Yes
	Rancho Camana	Restrepo	0.025	?
	Rey Zamuro	San Martín	15.525	Yes
	Kaliawirinae	Cumaral	0.04	?
	La Reseda	Puerto López	0.8095	?
	Aguas Calientes	Paratebueno	43.449	?
	El Paraíso	Restrepo	0.0379	?
	Nakua	Villavicencio	0.0439	?
	La Esperanza	Villavicencio	0.3785	?
	Mata Redonda	San Martín	15.525	Yes
	Floresta	Cumaral	0.195	?
	El Jardín del Comino	Villavicencio	0.3	?
	Altamira	Acacias	0.35	Yes
	El Socay	Acacias	0.13	Yes
	Manaco6	San Martín	0.9	?
	El Caduceo	San Martín	1.73	Yes
	El Toruno	Puerto Gaitán	132.15	?

Density estimates and effects of fragment size on group size

Table 3 summarized the estimated values of density and abundances in different fragments. Densities reported for *C. ornatus* are variable, with higher densities having been previously reported in small fragments (Mason, 1966: 400 ind/ km²; Wagner et al., 2009: 192,2 ind/ km²) and lower densities in continuous forest (8 ind/ km²; Polanco-Ochoa and Cadena (1993)). Densities reported here are lower than densities for the same species reported by other authors for small fragments (Wagner et al., 2009; Mason, 1966). The density

estimated for the largest fragment (1050 ha) is lower than that found in continuous forest at Tinigua National Park (8 ind/km²; Polanco-Ochoa y Cadena, 1993). Higher densities in small fragments may be a reflection of space restriction and refugees from other perturbed areas and could indicate crowded populations. However, as suggested by Wagner and collaborators (2009), the presence of strong competitors such as capuchin and howler monkeys in large fragments may also affect the population density of titi monkeys. When data from line transect censuses were combined with vocalizations of differentiated groups, the same density value of 2.95 ind/ km² (13 groups) were found in the largest fragment. This suggests that this fragment size showed similar conditions to that found in continuous forest for this species (8 ind/ km²; Polanco-Ochoa y Cadena, 1993). However it does not mean that 1050 ha is the minimal fragment size for a *C. ornatus* population in good condition and with natural population densities.

Table 3. Density and abundance of *Callicebus ornatus* in different size fragments, near of San Martín town.

Fragment area (Ha)	Density (ind/ km ²)	Abundance (individual numbers)
16	7.25*	3
21	57.94*	11
46.5	15.63*	5
186	16.66**	31
1050	1.073***	31****
*Based on direct counts (average from 2004- 2009, Carretero-Pinzón, in press)		
**Based on direct counts of differentiated groups (Carretero-Pinzón, data from 2009 - 2011)		
***Calculated with Distance 6.0 (SE: 0.26; AIC: 156.25)		
****Data based on differentiated groups		

Average group size showed a relatively weak relationship to fragment size (Fig. 3; R²: 12.45; standard error: 387.6; p>0.05). It is possible that in small isolated fragments there is an extended permanence of immatures in natal groups because of low opportunities for dispersion and a high predation risk and low probability of new group formations; however, more surveys are necessary to confirm this hypothesis. Dispersing individuals are reported by local people crossing large extensions of pastures (E. Enciso, comp. pers.) and use of fence rows are reported only on one occasion by Carretero-Pinzón and collaborators (2010). Predation by domestic dogs on titi monkeys has been reported (P.R. Stevenson, comp. pers). Another species of titi monkey (*C. caquetensis*) has been reported using wire fences to cross from one fragment to another in a highly fragmented area (García *et al.*, 2010). This behavior reflects high pressure on this primate that, despite their cryptic behavior, shows some plasticity in fragmented areas. An increase of fragmentation and

isolation could lead to local extinction unless this region implements education and connectivity programs.

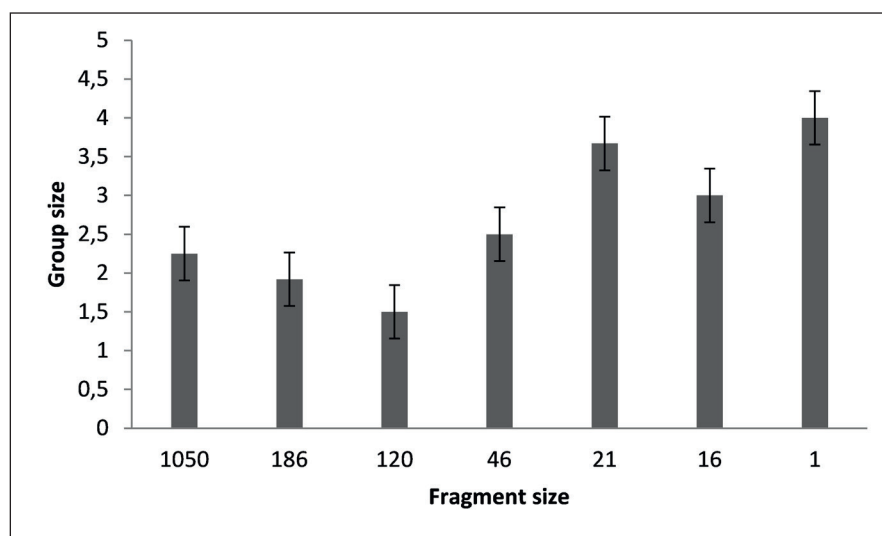


Figure 3. Relationship between fragment size and average of group size of *Callicebus ornatus* in forest patches in San Martín, Meta (Colombia).

In conclusion, the areal of *C. ornatus* has been reduced at least 35 % (current distributional area of 39.404,454 km²). Reduction has occurred as a result of an increment in the fragmentation by palm oil plantation, illegal crops and extractive activities resulting in habitat loss. This endemic species faces local extinction in some fragments despite its ability to survive in secondary forest (Defler, 2010), its cryptic behavior and its charismatic image. If conservation actions leading to prevent local extinction do not begin, it is possible that the species will change its endangered status from VU to Endangered. More studies to understand the absence of *C. ornatus* in fragments of different sizes, its habitat needs, use of space, dispersal habits and other demographic characteristics are needed for effective conservation of this species.

Acknowledgements

The author is most grateful to the local farmers for their support over the last eight years of work in the San Martín area, Colombian Llanos. Thanks to APR and TRD for their comments. Collection of ecological data was possible with private support (2004 to 2007). Idea Wild gave equipment for this and other projects during the past years. Work in 2009 was supported by IEA Grants (Conservación Internacional – Colombia, Fundación Omacha and Fondo para la Acción Ambiental).

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