

DISTRIBUTION, HABITAT AND STATUS OF THE WHITE-COATED TITI MONKEY (*CALLICEBUS PALLESCENS*) IN THE CHACO - CHIQUITANO FORESTS OF SANTA CRUZ, BOLIVIA

Damián I. Rumiz^{1,2}

¹Museo de Historia Natural Noel Kempff-Mercado

²Chiquitano Forest Conservation Foundation (FCBC), P.O. Box 5300, Santa Cruz de la Sierra, Bolivia, <confauna@scbbs.net>

Abstract

In order to review the distribution and status of the Chacoan or white-coated titi monkey in Bolivia, I examined 60 available records of *Callicebus* and the vegetation types where they occurred in southern Santa Cruz. Based on the color pattern of photographed individuals, their location and basic ecological data, I characterized the range of *Callicebus pallescens* as extending from the Río Parapetí, across most of the Kaa Iya Park up to the Pantanal of Rio Negro, and inhabiting semiarid Chaco forests (475 mm of rainfall) with tree-like cacti, dry transitional Chaco and Chiquitano forests (<625-800 mm), up to subhumid seasonally flooded riverine forests of the Pantanal (1,000 mm). In the subhumid and humid forests North of Kaa Iya and near Santa Cruz city, *C. pallescens* is replaced by the gray titi monkey *C. donacophilus*, which can be recognized by a darker and more contrasting color pattern. However, the geographic limit between the two species is poorly known and confounded by current deforestation. Likewise, the identity of *Callicebus* from the eastern Chiquitano forest and Pantanal in the Bolivia-Brazil border is also confusing and needs to be studied.

Key Words: abundance, *Callicebus donacophilus*, dry forest, gray titi monkey, Kaa-Iya Park, Pantanal

Resumen

A fin de revisar la distribución y el estatus del sahuí, tití blanco o chaqueño en Bolivia, examiné 60 registros de ocurrencia de *Callicebus* y sus tipos de vegetación en el sur de Santa Cruz. En base al patrón de color de individuos fotografiados, su ubicación geográfica e información ecológica caractericé la distribución de *Callicebus pallescens* como extendida desde el río Parapetí, a través del Parque Kaa-Iya, hasta el pantanal del río Negro, y habitando bosques chaqueños semiáridos (475 mm de lluvia) con cactus arbóreos, bosques secos transicionales chaqueños y chiquitanos (<625-800 mm) hasta bosques ribereños subhúmedos estacionalmente inundables del pantanal (1,000 mm). En los bosques subhúmedos y húmedos cercanos a la ciudad de Santa Cruz, *C. pallescens* es reemplazado por el tití gris boliviano, *C. donacophilus*, que puede ser reconocido por su patrón de color más oscuro y contrastante. Sin embargo, el límite entre estas dos especies no está bien conocido y se enmascara por la creciente deforestación. También, la identidad de las formas de *Callicebus* del bosque chiquitano oriental y el pantanal en la frontera de Bolivia y Brasil es confusa y necesita ser aclarada.

Palabras Clave: abundancia, bosque seco, *Callicebus donacophilus*, Parque Kaa-Iya, Pantanal, sahuí boliviano

Introduction

Titi monkeys (genus *Callicebus*) from the south of the Amazon were considered once as a single species (*Callicebus moloch*), reaching Bolivia with several subspecies of which *C. moloch donacophilus* was the southern-most (Hershkovitz, 1963). Later, these subspecies were upgraded to full species (Hershkovitz, 1990) and *Callicebus donacophilus* was recognized as having two subspecies itself, *C. d. donacophilus* in central Bolivia and *C. d. pallescens* in southern Santa Cruz department (Anderson, 1997). The southern subspecies was later considered a full species *C. pallescens* [Thomas 1907] by van Roosmalen *et al.* (2002), and its distribution was estimated as covering the full width of southern Santa Cruz into western Mato Grosso in Brazil and the Chaco in Paraguay (Veiga *et al.*, 2008a; Martínez

and Wallace, 2010; Smith, 2012). Despite the advances in recognizing the white-coated titi monkey (*C. pallescens*) as an inhabitant of the Chaco and Pantanal dry forests, little is known about its ecology and habitat choice (Martínez and Wallace, 2010; Ayala, 2011). Moreover, their habitat and distribution records are often uncertain because the species is not identified as the white-coated or the Bolivian gray titi monkey (*C. donacophilus*). The Bolivian gray (or white-eared) titi monkey lives in wet but seasonal forests from southern Rondonia in Brazil through the departments of Beni, the east of Cochabamba and the north of Santa Cruz in Bolivia (Veiga *et al.*, 2008b), reaching patches of the drier Chaco-Chiquitano transitional forest around Santa Cruz city (Pyritz *et al.*, 2010). However, along the estimated range limit between these two species there is a wide

expanse of dry forest habitats where the presence, absence or identity of titi monkeys is uncertain.

In order to review the distribution and status of the Chacoan or white-coated titi monkey in Bolivia, I examined the available records of *Callicebus*, new field observations, photos and vegetation types where they occur in southern Santa Cruz. Based on the color pattern of the individuals, their geographic location and available ecological data, I characterize the distribution range of *C. pallescens*, propose a range limit with *C. donacophilus* and identify uncertainties on the current knowledge of these species.

Study sites and Methods

Wildlife surveys conducted mainly by researchers from Wildlife Conservation Society (WCS) and the Museo Noel Kempff Mercado (MNKM) have produced records of titi monkeys within and around the Kaa Iya National Park during the last 15 years. This park is the largest in Bolivia and encompasses 3.5 million hectares of alluvial plains and eroded peneplains (250–450 m a.s.l.), with a few isolated sandstone hills rising 200 m or more above the plains (Cerro Cortado 600 m, Cerro San Miguel 840 m). Two Ramsar sites partially overlap the park, the Parapetí River-Isoso “Bañados” (Isoso floodplain or inland delta) in

the west, and the Palmar de las Islas-Salinas de San José in the east, on the border with Paraguay. Mean temperature is 24–26° across the region but rainfall decreases sharply from 1,000 mm and 3 months per year in the NE of the region to 400 mm and 10 dry months in the SW corner of the park (Fig. 1). This results in semi-arid, dry, and sub-humid bioclimatic ombrotypes (Navarro and Maldonado, 2002) that affect the vegetation and fauna.

Main vegetation types of Kaa Iya park are associated with Chaco landscape systems (Navarro and Ferreira, 2008) such as the alluvial plain dry forests of the Parapetí and Grande rivers in the SW, the distinct riverine vegetation complexes along these rivers, and the transitional forests towards the Chiquitano region on alluvial plains to the N and on sandstones to the E. At the eastern border of the park, vegetation types have more affinity with the Brazilian Cerrado, and include transitional and distinct Chiquitano dry forests and scrublands that are more mesic (humid) than those of the Chaco. Further E and NE from the park, Chiquitano and Chaco forests continue as riverine strips and patches into the flooded Pantanal. A digital vegetation map of Santa Cruz (scale 1:100,000; Navarro and Ferreira, 2008) and field descriptions of at least 20 sites were used to define the forest types associated to the *Callicebus* records compiled in this study.

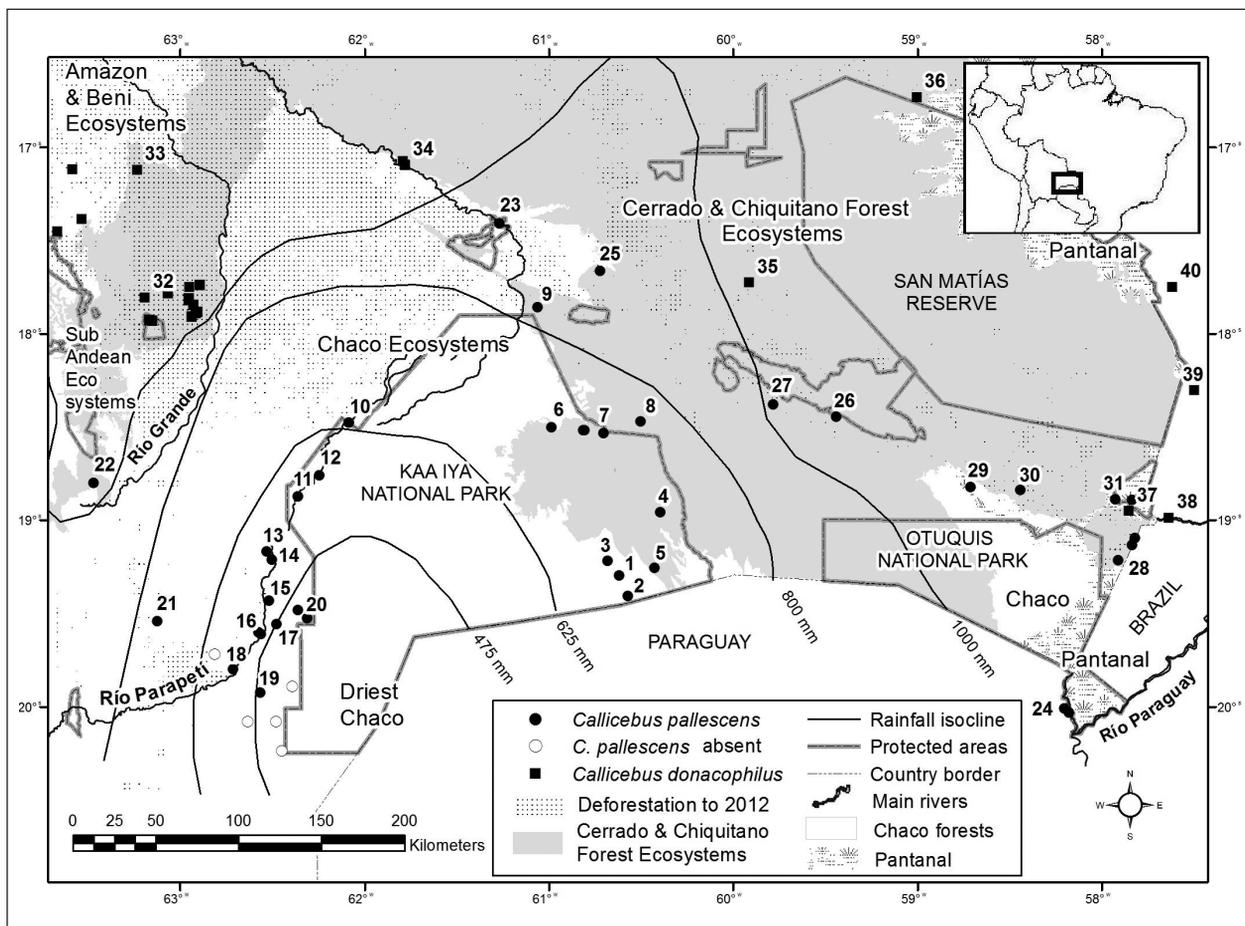


Figure 1. *Callicebus* records, protected areas, rainfall isoclines, deforestation and mayor landscape systems in southern Santa Cruz, Bolivia (ecosystems adapted from Navarro and Ferreira, 2008).

The range of *C. pallescens* was assessed by mapping 60 titi monkey localities in southern Santa Cruz and neighboring Pantanal, based on previous reviews, verification of original observations with WCS and MNKM researchers, and examination of recent images and sightings (see Table 1 for sources). However, most sources either did not identify the titi monkey species or referred it to as *C. moloch*. To become capable of identifying these species, I examined skins of *C. donacophilus* at MNKM and observed wild individuals around Santa Cruz city. I could not examine museum specimens of *C. pallescens* because there are none in Bolivia. I followed the descriptions published for these species (Hershkovitz 1990, Anderson 1997, van Roosmalen *et al.* 2002) and discussed them with observers and photographers to assess the identity of new sightings, photographs and videos. Because no specimens were collected for this study, the most reliable identifications of *C. pallescens* were those records contiguous to the collection localities of specimens identified as such by Anderson (1997). Images or sightings from these and other areas that showed *C. pallescens* with diagnostic features (uniform light color, relatively long pelage and lack of contrasting white ears) were also considered reliable identifications for this species. Undefined titi monkey observations that occurred near others identified as *C. pallescens* were assumed to be of this species, but those that were both undefined and distant from reliable records were labeled as 'suspected' *C. pallescens*. Localities marked as of *C. donacophilus* reflected their sources and were not corroborated except when stated as such in the text.

Results and discussion

Identification and distribution of Callicebus records

Forty out of the 60 titi monkey locality records were mapped in Figure 1 and listed in Table 1 after removing or grouping some points to avoid cluttering. Sources of these records included review papers (Hershkovitz, 1990; Anderson, 1997; Martínez and Wallace, 2010), broad wildlife surveys (Parker *et al.*, 1993; Cuéllar and Noss, 1997; Miserendino *et al.*, 1998; Navarro *et al.*, 1998; Ayala and Noss, 2000; Arispe and Rumiz, 2002; Brooks *et al.*, 2002; Cuéllar *et al.*, 2003; Maffei, 2005), specific primate studies (Justiniano, 2004; Thurley, 2009; Pyritz *et al.*, 2010; Ayala 2011), unpublished photos and related personal communications (Table 1). The presence of *C. pallescens* was supported by collected specimens in two sites (# 15 and 22) and by new photos and a video in nine sites (# 1, 2, 7, 8, 10, 14, 23, two in 24), while undefined observations in 21 sites and local reports in nine other sites completed the 'assumed' and 'suspected' localities for this species. *C. donacophilus* was assigned to 19 localities based on three collection sites (two near #32, one in 37), 14 direct observations as defined by their authors, and photographs that I reviewed from three sites (near #32 and 33).

Sightings assigned to *C. pallescens* with high reliability include Ravelo (#1), Palmar de las Islas (#2), Sol de Mayo,

camp Tucavaca and nearby points (#6, 7, 8), and community sites along the Parapetí river (#13 through 19). From Ravelo and Palmar there are photos and a video that show the long and uniformly colored pale buff pelage of the individuals (Fig. 2), as well as in Sol de Mayo (Fig. 3) and Tucavaca (Fig. 4). The photograph from Paraboca in the Parapetí river (Fig. 5) shows the same light color of the individuals sighted in nearby riparian communities, including the locality # 15 where three specimens were collected in the 1980's and assigned then to *C. donacophilus pallescens* by Anderson (1997). Sightings and a photo from the Rio Negro in the Otuquis Pantanal (#24, Verónica Zambrana, pers. comm.) also matched *C. pallescens* descriptions, as well as the photos available from the nearby Paraguayan



Figure 2. *C. pallescens* at Ravelo (#1), Martin Thurley.



Figure 3. *C. pallescens* in #8, Rosario Arispe.

Table 1. Localities, type of evidence and source of 40 records of titi monkeys from southern Santa Cruz, Bolivia mapped in Figure 1, with the species assigned by this study or its original author in the case of *C. donacophilus*.

No.	Locality	Type of evidence and source	Coordinates	Assigned species
1	Fortín Ravelo	Photos, counts: Justiniano, 2004; Thurley, 2009	19°18'S 60°37'W	<i>Callicebus pallescens</i>
2	Palmar de las Islas	Obs.: Navarro <i>et al.</i> , 1998; Thurley, 2009; video, S. Angulo, R. Montaña, pers. comm.	19°24'S 60°34'W	<i>C. pallescens</i>
3	Salina San José	Obs.: Cuéllar <i>et al.</i> , 2003	19°13'S 60°41'W	<i>C. pallescens</i>
4	El Cruce	Obs.: Navarro <i>et al.</i> , 1998	18°57'S 60°24'W	<i>C. pallescens</i>
5	Santa Adriana	Obs.: Navarro <i>et al.</i> , 1998	19°15'S 60°26'W	<i>C. pallescens</i>
6	Camp Tucavaca	Photos, counts: Justiniano, 2004; Maffei, 2005	18°31'S 60°48'W	<i>C. pallescens</i>
7	S. Lucia pond	Photos: D. Alarcón pers. comm.	18°32'S 60°42'W	<i>C. pallescens</i>
8	Sol de Mayo	Photos, obs.: Arispe pers. comm.	18°28'S 60°30'W	<i>C. pallescens</i>
9	San Ignacito	Obs.: Navarro <i>et al.</i> , 1998	17°51'S 61°03'W	Suspected <i>C. pallescens</i>
10	Cupesí - Charata	Counts: Miserendino <i>et al.</i> , 1998 Photos: D. Alarcón, pers. comm.	18°29'S 62°05'W	Assumed <i>C. pallescens</i>
11	La Madre	Counts: Cuéllar and Noss, 1997	18°52'S 62°22'W	Assumed <i>C. pallescens</i>
12	Curuyuqui	Local report: Parker <i>et al.</i> , 1993	18°46'S 62°14'W	Assumed <i>C. pallescens</i>
13	Kuarirenda	Counts: Ayala, 2011	19°10'S 62°32'W	<i>C. pallescens</i>
14	Paraboca	Photos: L. Acosta, pers. comm.	19°13' S 62°30'W	<i>C. pallescens</i>
15	Guirapembi	Specimens: Anderson, 1997	19°26'S 62°31'W	<i>C. pallescens</i>
16	La Brecha	Counts: Ayala, 2011	19°37'S 62°34'W	<i>C. pallescens</i>
17	Isiporenda	Obs.: Noss and Cuéllar, 2000	19°33'S 62°29'W	<i>C. pallescens</i>
18	Karapari	Counts: Ayala, 2011	19°48'S 62°42'W	<i>C. pallescens</i>
19	Perforación	Local report: Parker <i>et al.</i> , 1993	19°55'S 62°34'W	Assumed <i>C. pallescens</i>
20	Cerro Cortado, Cerro Colorado	Counts: Ayala and Noss, 2000; Noss and Cuéllar, 2000	19°32'S 62°19'W	<i>C. pallescens</i>
21	Tacuarembó, Charagua	Obs.: L. Acosta and R. Strem, pers. comm.	19°32'S 63°20'W	Suspected <i>C. pallescens</i>
22	Río Grande	Specimen: Anderson, 1997	18°48'S 63°28'W	<i>C. pallescens</i>
23	Laguna Concepción	Photo: A. Mamani and L. Acosta, pers. comm. 2011	17°25'S 61°16'W	Suspected <i>C. pallescens</i>
24	Río Negro, Pantanal	Photos: V. Zambrana, pers. comm. 2008; Smith, 2012	20°02'S 58°10'W	<i>C. pallescens</i>
25	Quituniquiña	Loc. rep.: Arispe and Rumiz, 2002	17°40'S 60°43'W	Suspected <i>C. pallescens</i>
26	Urucú	Loc. rep.: Arispe and Rumiz, 2002	18°23'S 59°47'W	Suspected <i>C. pallescens</i>
27	Quituniquiña	Loc. rep.: Arispe and Rumiz, 2002	18°27'S 59°26'W	Suspected <i>C. pallescens</i>
28	Mutun	Local report: Parker <i>et al.</i> , 1993	19°13'S 57°54'W	Suspected <i>C. pallescens</i>
29	Guayacanes	Local report: Parker <i>et al.</i> , 1993	18°49'S 58°42'W	Suspected <i>C. pallescens</i>
30	Sunsas farm	Obs.: L. Acosta, pers. comm.	18°50'S 58°26'W	Suspected <i>C. pallescens</i>
31	Lag. Cáceres	Loc. rep.: Arispe and Rumiz, 2002	18°57'S 57°51'W	Suspected <i>C. pallescens</i>
32	Around Santa Cruz city	Specimens, photos, obs.: Anderson, 1997; Pyritz <i>et al.</i> , 2010; K. Dingess, pers. comm.	16 sites near 17°48'S 63°11'W	<i>Callicebus donacophilus</i>
33	Mineros	Photos: D. Alarcon, pers. comm.	17°07'S 63°13'W	<i>C. donacophilus</i>
34	San Miguelito	Counts: Rumiz <i>et al.</i> , 2000	17°01'S 61°31'W	Assumed <i>C. donacophilus</i>
35	San Juan de Chiquitos	Obs.: Brooks <i>et al.</i> , 2002	17°47'S 59°56'W	Assumed <i>C. donacophilus</i>
36	Candelaria	Obs.: Brooks <i>et al.</i> , 2002	16°46'S 58°56'W	Assumed <i>C. donacophilus</i>
37	Puerto Suárez	Specimen: Anderson, 1997	18°56'S 57°49'W	<i>C. donacophilus</i>
38	Corumbá	Specimens: Hershkovitz, 1990; Auricchio, 2010	19°00'S 57°38'W	<i>C. pallescens</i> or <i>C. donacophilus</i>
39	Santa Teresa	Counts: Tomas <i>et al.</i> , 2010	18°18'S 57°30'W	<i>C. aff. donacophilus</i>
40	Acurizal	Specimen: Hershkovitz, 1990	17°45'S 57°37'W	<i>C. pallescens</i>

Pantanal (Smith, 2012). According to all our photos, the color pattern of *C. pallescens* individuals agreed with the published descriptions of the species, although their faces were not as white as in the drawing from van Roosmalen *et al.* (2002).



Figure 4. *C. pallescens* in # 7, Daniel Alarcón.



Figure 5. *C. pallescens*, Río Parapeti #13, Luis Acosta

Records from transect censuses east of Ravelo (#4, 5), on the Isoso flood plain (#10, 11) and near the hills of Cerro Cortado and Cerro Colorado (#20) were originally identified as *Callicebus moloch*, but surely correspond to *C. pallescens* according to pictures taken in or near these sites. Recent sightings and pictures of light colored titi monkeys from the riverine forest of Laguna Concepción (#23, Ana Mamani and Luis Acosta, pers. comm.) are suspected to be this species, as well as undefined sightings (# 9, 30) and local reports of titi monkeys (# 25-31) extended further east. An old (1980) collecting site of *C. pallescens* on the lower slopes of the Andes (# 22; Anderson, 1997) could not be verified with newer data, and its closest recent record was an undefined sighting of titi monkeys in the Charagua hills (# 21; Rosa Strem, Luis Acosta, pers. comm.). Square dots near Santa Cruz city (around # 32) included two collecting sites of *C. donacophilus* (Anderson, 1997), subsequent reviews (Martínez and Wallace, 2010) and several recent sightings nearby that can be confidently assigned to the gray titi monkey (Pyritz *et al.*, 2010; Dingess, unpublished; Rumiz pers. obs.). *C. donacophilus* showed a buffy or brownish agouti pelage in the upper and outer parts of head, body and limbs, darker than in *C. pallescens*, but with the tail base noticeably paler and ear tufts markedly whitish (Fig. 6 from #32, Fig. 7 from #33). Square dots at # 34 most probably correspond to sightings of the same form (Rumiz *et al.*, 2000) and would represent the easternmost record of the gray titi monkeys (Veiga *et al.*, 2008b; Martinez and Wallace, 2010), unless we accept that this species was also seen on the gas pipeline to Cuiabá (#35, 36; Brooks *et al.*, 2002) and may reach the Brazilian Pantanal. In fact, a specimen from Puerto Suárez on the eastern Bolivian border (# 37) was considered by Anderson (1997) to be *C. d. donacophilus*, as well as another five specimens from Corumbá (# 38) in western Brazil mentioned as *C. donacophilus* by Auricchio (2010). However, it seems that the same five specimens from Corumbá in the Museum of São Paulo, plus another specimen from Acurizal further N (#40), had been originally examined and assigned to *C. d. pallescens* by Hershkovitz (1990) in



Figure 6. *C. donacophilus* near Santa Cruz city (#32), Daniel Alarcón.

his seminal paper. A recent field transect study conducted nearby (Santa Teresa # 39; Tomas *et al.*, 2010) identified the titi monkeys as 'aff. *donacophilus*.'

Dry forest types and the occurrence of Callicebus pallescens

According to the latest classification and mapping of Santa Cruz vegetation (Navarro and Ferreira, 2008), the compiled titi monkey localities included a variety of forest types belonging to the Chaco, Chiquitano and Pantanal biogeographical provinces, belonging to semi-arid, dry, and subhumid bioclimatic ombrotypes (Figure 1). The available data on the occurrence and abundance of white coated titi monkeys were grouped in different situations according to climate, sites and forest types (Table 2). From these, three best known areas with titi monkey populations are described below in order of increasing humidity. *C. pallescens* was found living in one of the driest Chaco forests (semiarid ombrotype, <475 mm of rainfall), such as in the foothills of Cerro Cortado and Cerro Colorado (#20), but apparently only in forest patches with large trees and tree-like cacti. Encounter rates along transects run through mixed dry forests were very low since monkeys were absent in shorter stature forest (Cuéllar and Noss, 1997, Ayala and Noss, 2000; Noss and Cuéllar, 2000). Several sites in the driest SW corner of Kaa Iya had no titi monkeys (open dots in Fig. 1), and at least one of them had *Aotus* but not *Callicebus* (Justiniano, 2004). It is possible that titi monkeys occur only in the taller/denser patches of these dry Chaco forests and they may be found near other hills to the east within Kaa Iya, but they are absent in the driest Chaco of western Paraguay (Stallings *et al.*, 1989; Brooks, 1996).

The Chaco riverine, hydrophytic, and seasonally flooded forests along the Parapetí river (# 11-18) harbor abundant *C. pallescens* and three other primate species (Ayala and Noss, 2000; Ayala, 2011) despite their upper - semi-arid ombrotype (475-625 mm of rainfall). The influence of the river and a shallow water table allow the existence of dense 'algarrobo' (*Prosopis chilensis*; Fabaceae) forests, where titi monkeys were found at densities of 3.5, 6.2 and



Figure 7. *C. donacophilus* North of Santa Cruz de La Sierra (#33), Daniel Alarcón.

10.4 groups/km². Riverine habitats extend downstream into less dry ombrotypes allowing the connectivity of *Callicebus* populations of northern Kaa Iya and the Chiquitano forests. Outside the park, however, deforestation is intense and threatens this corridor.

White coated titi monkeys occur in the transitional Chaco-Chiquitano forests of Ravelo and Palmar (#1, 2, 3) under a lower-dry ombrotype (625-800 mm of rainfall), and reach a high density of 15.3 groups/km² at the tall foothill forest of Cerro San Miguel (Thurley, 2009). They are absent or less abundant in low stature forests nearby, but occur further north and east suggesting a continuous distribution in eastern Kaa Iya park. Within the same climate type but in the tall transitional Chiquitano forest, *C. pallescens* is common and was found at a relatively high abundance (#6; 1.8 groups encountered / 10 km walked; Justiniano, 2004; Maffei, 2005). South of Palmar de la Islas, in northern Paraguay, titi monkeys are also present at several sites (Brooks, 1996; Smith 2012) and were abundant in the tall forest of Agua Dulce (Stallings *et al.*, 1989). Further east in Bolivia and Paraguay, extending up to the Pantanal, these forests become more mesic (>800 mm), include more Chiquitano species, and also harbor titi monkeys.

The occurrence and abundance of primate species through the dry Chaco seems to depend on the relatively tall and more diverse forest patches that grow associated to well drained and richer soils (Stallings *et al.*, 1989). In Kaa Iya, *Callicebus* and other monkeys occur mainly in tall Chaco forests around the Parapetí river, old river channels, isolated hills, and in the Chiquitano transitional forest. It is likely that size of the trees, availability of tree holes and other shelters, and water-rich foods (such as succulent leaves, flowers and fruits of arboreal cacti) become the key habitat features for *C. pallescens* (and for *Aotus*). In humid Chiquitano forest patches near Santa Cruz city (Pyritz *et al.*, 2010), forest maturity, surrounding forest area and understory density have been identified as factors affecting diversity and abundance of primates, although only the high understory density seemed to have a significant and negative effect on the abundance of *C. donacophilus*. Field studies are needed to identify and conserve the main habitat features that allow these monkeys to survive in these extremely dry forests.

Subhumid forests and the range of C. pallescens and C. donacophilus

C. pallescens was confirmed to occur in the subhumid ombrotype forests (>1,000 mm) of the Otuquis Pantanal of Bolivia and Paraguay, and it is the 'suspected' form – although no good images are available – that occurs in the Chiquitano forests north and northeast of Kaa Iya under sub humid and upper-dry (800-1,000 mm) ombrotypes. This area (sites # 9, 23, 25-35) has been considered partially within the range of *C. pallescens* (Veiga *et al.*, 2008a), while further north of it there would be a hiatus in *Callicebus* distribution since the range of *C. donacophilus* (#32,

33) had not reached east of the río Grande (Veiga, *et al.*, 2008b). Points # 23, 25, 34-36, however, show that titi monkeys are present in these subhumid Chiquitano habitats, north of the accepted range of *C. pallescens*, and that they are connected westward through forests to the range of *C. donacophilus* (#32, 33). Therefore, this northeastern population may belong to *C. pallescens*, connected with the Paraguayan Pantanal and Chaco populations (Hershkovitz, 1990; van Roosmalen *et al.*, 2002; Veiga *et al.*, 2008a), or to *C. donacophilus*, according to the labeling of Pantanal specimens from Bolivia (#37: Anderson, 1997) and Brazil (#38: Aurichio, 2010). However, a current habitat connection between titi monkey populations does not prove a species' identity, furthermore if the phenotypes are not well defined and the karyotypes from these locations are unknown. *C. pallescens* from the dry Chaco looks quite different from *C. donacophilus* from the humid Amazon and Beni forests, but some photographed individuals seem 'intermediate' in their diagnostic color features. To better characterize these phenotypes it is necessary to assess the individual variation of southern *C. donacophilus* color patterns, considering age and sex differences in known groups around Santa Cruz city, and to collect specimens and more photos of potential *C. pallescens* in the subhumid transition southward into the Chaco.

The old collecting site of *C. pallescens* near the upper Rio Grande (#22) falls on a marked gradient of dry to humid forests on the Andean slopes, and it is only one hundred kilometers from *C. donacophilus* localities on the same forested slopes further north. This suggests that both species may come in contact on the sub Andean forests (around 18°20'S, 63°30'W), and also along the humid to dry lowland forest gradient of the Beni-Chaco alluvial plains near the Rio Grande, which is currently being lost to agriculture. It would be important to verify if titi monkey phenotypes in these transitions are 'intermediate' or defined for either species. The scarce data available on the karyotype of *C. donacophilus* (Minezawa and Borda, 1985) and *C. pallescens* (Dumas, 2005) suggest that differences in the number of bi-armed and acrocentric chromosomes, although both species have $2n=50$, would prevent fertile interbreeding. This can only be verified by collecting geo-referenced genetic samples of these little known species and by identifying the phenotypes of the peripheral Chaco populations.

Summary and conclusions

Callicebus pallescens is the titi monkey species occurring in the Kaa Iya and Otuquis parks of Bolivia, and neighboring areas in Paraguay. It can be identified and distinguished in the field from *C. donacophilus* by its longer pelage, lighter color and little or no contrasting white ears. However, more images, new specimens and genetic samples should be analyzed to assess its phenotypic variation and relationships with *C. donacophilus*. White-coated titi monkeys occur in a variety of Chaco and Chiquitano forests, ranging from semiarid Chaco forests (475 mm of rainfall), to dry

transitional Chaco and Chiquitano forests (625-800 mm), and up to subhumid Pantanal riverine forests in southeastern Santa Cruz (>1000 mm). In the subhumid and humid forests north and northwest of the Chaco, *C. pallescens* is replaced by the gray titi monkey (*C. donacophilus*), but the geographic limit between the two species is not clearly known. Moreover, additional records of titi monkeys in the Chiquitano forests fall outside the known range of both species, and likewise the Pantanal records on the Bolivia-Brazil border, their identity needs to be verified. Surveys are needed to assess remnant populations in the threatened forest north of Kaa Iya and Otuquis parks, for which park guards and biologists should be trained with visual aids to recognize the primate species in the field and to take pictures, specimens or genetic samples if opportunities arise.

Acknowledgments

I want to thank the biologists and technicians who collected the original field data on monkeys and habitats, especially Luis Acosta, Sixto Angulo, Rosario Arispe, Johnny Ayala, Joaquín Barrientos, Erika Cuéllar, Rosa Leny Cuéllar, Ciro Justiniano, Leo Maffei, Romer Miserendino, Rossy Montaña, Gonzalo Navarro, Jorge Segundo, Martin Thurley and Veronica Zambrana, who also provided images and descriptions. Daniel Alarcón kindly contributed his great pictures, while Louise H. Emmons, Leo Maffei, Andrew Noss, Rob Wallace and an anonymous reviewer provided useful comments to the manuscript. This study was funded through Wildlife Conservation Society and additional donors such as US Fish and Wildlife, Kaa Iya Foundation, Shared Earth and Ramsar, under agreements with the Museo Noel Kempff Mercado, Capitanía del Alto y Bajo Isoso, Servicio Nacional de Areas Protegidas, and Viceministerio de Medio Ambiente y Agua, Bolivia.

References

- Anderson, S. 1997. Mammals of Bolivia, taxonomy and distribution. *Bull. Am. Mus. Nat. Hist.* 231: 1-652.
- Arispe, R. and Rumiz, D. I. 2002. Una estimación del uso de los recursos silvestres en la zona del Bosque Chiquitano, Cerrado y Pantanal. *Rev. Boliv. Ecol. Conserv.* 11: 17-36.
- Aurichio, P. 2010. A morphological analysis of some species of *Callicebus*, Thomas, 1903 (Pitheciidae, Callicebinae). *Neotrop. Primates* 17: 47-58.
- Ayala, J.M. 2011. Estudio de la comunidad de primates en el Alto y Bajo Isoso (Gran Chaco), Santa Cruz, Bolivia. Master's thesis in Ecology and Conservation. Universidad Mayor de San Andrés, La Paz.
- Ayala, J. and Noss, A. J. 2000. Censo por transectas en el Chaco Boliviano: limitaciones biológicas y sociales de la metodología. In: *Manejo de fauna silvestre en Amazonía y Latinoamérica*, E. Cabrera, C. Mercolli and R. Resquin (eds.), pp. 29-36. CITES Paraguay, Fundación Moises Bertoni, University of Florida. Asunción, Paraguay.

- Brooks, D. M. 1996. Some observations of primates in Paraguay. *Neotrop. Primates* 4: 15–19.
- Brooks, D.M., Tarifa, T., Rojas, J.M., Vargas, R.J. and Arambar, H. 2002. A preliminary assessment of the mammalian fauna of the eastern Bolivian panhandle. *Mammalia* 65: 509–520.
- Cuéllar, E. and Noss, A.J. 1997. Conteo de huellas en brechas barridas: un índice de abundancia para mamíferos. *Ecología en Bolivia* 30: 55–67.
- Cuéllar, E. and Noss, A.J. 2003. *Mamíferos del Chaco y la Chiquitania*. Wildlife Conservation Society. Editorial FAN, Santa Cruz, Bolivia.
- Cuéllar, E., R. Montaña, Hesse, A., Azurduy H., Dosapei, T., and Peña, R. 2003. Biodiversidad de la Salina Ravelo (19° 17' 44" S, 60° 37' 10" W) Parque Nacional Kaa Iya del Gran Chaco. Unpublished report # 96, CABI/WCS, Santa Cruz, Bolivia.
- Hershkovitz, P. 1963. A systematic and zoogeographic account of the monkeys of the genus *Callicebus* (Cebidae) of the Amazonas and Orinoco river basins. *Mammalia* 27: 1–79.
- Hershkovitz, P. 1990. Titi, New World monkeys of the genus *Callicebus* (Cebidae, Platyrrhini): A preliminary taxonomic review. *Fieldiana Zool. NS* 55: 1–109.
- Justiniano, C. 2004. Los monos en dos zonas del Parque Nacional Kaa-Iya del Gran Chaco. In: *II Congreso de investigadores en recursos naturales del Parque Nacional Kaa-Iya y zonas de influencia*. R.L. Cuéllar (ed.), pp. 21–22. CABI, WCS, Santa Cruz, Bolivia.
- Maffei, L. 2005. Informe final de los trabajos de investigación realizados en el campamento de Tucavaca, Gasoducto Bolivia-Brasil. Unpublished report, CABI/WCS, Santa Cruz, Bolivia.
- Martinez, J. and Wallace, R. B. 2010. Pithecidae. In: *Distribución, ecología y conservación de los mamíferos medianos y grandes de Bolivia*, R.B. Wallace, H. Gomez, Z. Porcel and D.I. Rumiz (eds.), pp.307–330. Centro de Ecología Difusión Fundación Simón I. Patiño, Santa Cruz de la Sierra, Bolivia.
- Miserendino, R., Cuéllar, E. and Noss, A.J. 1998. Diversidad de los mamíferos en el Izozog y el Area Natural de Manejo Integrado del Gran Chaco, Santa Cruz, Bolivia. *Ecología en Bolivia* 31: 17–31.
- Navarro, G., Guerrero, J., Gonzáles, L., Hurtado, J.C., Santivañez, J. L., Cuéllar, E., Rojas J. M. and Fuentes, A. 1998. Tipificación y caracterización de los ecosistemas del Parque Nacional Kaa-Iya del Gran Chaco (Departamento de Santa Cruz, Bolivia). Documento Técnico # 38, WCS-CABI, Santa Cruz, Bolivia.
- Navarro, G. and Maldonado, M. 2002. *Geografía ecológica de Bolivia. Vegetación y ambientes acuáticos*, Centro de Ecología Simón I. Patiño, Departamento de Difusión. Cochabamba, Bolivia.
- Navarro, G. and Ferreira, W. 2008. *Mapas de vegetación, potencial forestal ecológico y protección de la vegetación del departamento de Santa Cruz*. Gobierno Departamental Santa Cruz, Santa Cruz de la Sierra. <http://www.santacruz.gob.bo/turistica/mapas/descargas/index.php?IdMenu=30067>. Accessed 26 August 2012
- Noss, A. and Cuéllar, E. 2000. Índices de abundancia para fauna terrestre en el chaco boliviano: huellas en parcelas y en brechas barridas. In: *Manejo de fauna Silvestre en Amazonia y Sudamérica*, Cabrera, E., C. Mercolli and R. Rasquin (eds), pp. 73–82. CITES Paraguay, Fundación Moises Bertoni, University of Florida. Asunción, Paraguay.
- Parker, T.A., III, Gentry, A.H., Foster, R.B., Emmons, L.H. and Remsen, J.V., Jr. 1993. The Lowland Dry Forests of Santa Cruz, Bolivia: A Global Conservation Priority. Conservation International, *RAP Working Papers* 4.
- Pyritz, L. W., Büntge, A. B., Herzog, S. K. and Kessler, M. 2010. Effects of habitat structure and fragmentation on diversity and abundance of primates in tropical deciduous forests in Bolivia. *Int. J. Primatol.* 31: 796–812.
- Rumiz, D.I., Fuentes, A. F., Rivero, K., Santivañez, J.L., Cuéllar, E., Miserendino, R., Fernández, I., Maffei, L., and Taber, A.B. 2002. La biodiversidad de la Estancia San Miguelito, Santa Cruz, Bolivia: Una justificación para establecer reservas privadas de conservación. *Ecología en Bolivia, Documentos, Serie Biodiversidad* 1: 1–68.
- Smith, P. 2012. Fauna Paraguay. Mammalogy. Dusky titi, *Callicebus pallescens* <<http://www.faunaparaguay.com/callicebuspallescens.html>>. Accessed 17 April 2012.
- Stallings, J. R., West, L., Hahn, W. and Gamarra, I. 1989. Primates and their relation to habitat in the Paraguayan Chaco. In: *Advances in Neotropical Mammalogy*, K. H. Redford and J. F. Eisenberg (eds.), pp. 425–442. Sandhill Crane Press, Gainesville, Florida.
- Thurley, M. 2009. Primate species *Callicebus pallescens* in the Bolivian Chaco Chiquitano Transitional Dry Forest. Bachelor thesis, University of Applied Sciences Eberswalde, Germany.
- van Roosmalen, M.G.M., van Roosmalen, T., and Mittermeier, R. 2002. A taxonomic review of the titi monkeys, genus *Callicebus* Thomas, 1903, with the description of two new species, *Callicebus bernhardi* and *Callicebus stephennashi* from Brazilian Amazonia. *Neotrop. Primates* 10: 1–52.
- Veiga, L.M., Wallace, R.B. and Velilla, M. 2008a. *Callicebus pallescens*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Accessed 27 June 2010.
- Veiga, L.M., Wallace, R.B. and Ferrari, S. F. 2008b. *Callicebus donacophilus*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Accessed 27 June 2010.