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Front cover: Adult male mantled howler (*Alouatta palliata*) at the Rio Salado, Cuero y Salado Wildlife Refuge, Honduras. Photo by Daniel Gonzalez-Socoloske.

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Articles

THE CONSERVATION STATUS OF *CALLICEBUS CAQUETENSIS* (PITHECIIDAE): A NEW SPECIES IN SOUTHERN CAQUETÁ DEPARTMENT, COLOMBIA

Javier García[1,2], Thomas R. Defler[2], Marta L. Bueno[2]

[1]*Fundación Herencia Natural, Bogotá D. C., Colombia*
[2]*Departamento de Biología, Universidad Nacional de Colombia, Bogotá D. C., Colombia*

Abstract

Moynihan (1976) mentioned an undescribed species of *Callicebus* between the ríos Caquetá and Orteguaza, Caquetá Department, Colombia. In August 2008, we confirmed the new species, which is phylogenetically related to *C. ornatus* and *C. discolor* to the north and south of the type locality respectively. We described this species as *Callicebus caquetensis* Defler *et al*., 2010 establishing its distribution through direct observations and information from local communities. Eighty-two animals were seen, including the holotype and paratype, which were collected. A review of historical archives of aerial photographs and satellite maps was carried out to assess the loss of the original vegetation of the area, and we found the habitat in an advanced state of fragmentation caused by extensive ranching and illegal crop cultivation. Existing coverage is now limited to small fragments of the original primary forest and secondary vegetation. We analyzed a Google Earth image of 75 km^2 of this primate´s habitat and found only 32% of forest and secondary forest vegetation remaining in 2002, the year the image was captured. We propose this Colombian endemic species should be considered as Critically Endangered (CR), (based upon the criteria A3c,d,e, C2 of the IUCN). We suggest that the Colombian and Caquetá governments and private individuals give special attention to this endemic primate, most importantly in the creation of reserves and in environmental education initiatives. This is probably the most endangered of Colombia's primates.

Key words: *Callicebus caquetensis*, endangered primates, endemics, Colombia

Resumen

Martin Moynihan (1976) fue el primero en mencionar la existencia de una nueva especie de *Callicebus* en el Departamento del Caquetá, Colombia. En Agosto del 2008 confirmamos la presencia de esta nueva especie, relacionada filogenéticamente con *Callicebus ornatus* y *Callicebus discolor* al norte y al sur de su localidad tipo (entre los ríos Orteguaza y Caquetá) y describimos la especie como *Callicebus caquetensis* Defler *et al*., 2010. La distribución de la especie fue establecida a través de entrevistas con la comunidad local y observaciones directas. Un total de 82 animales fueron observados, incluyendo el holotipo y el paratipo que fueron colectados. Una revisión histórica de fotografías aéreas y mapas satelitales fue llevada a cabo para evaluar la disminución de la cobertura vegetal original en el área; encontramos el hábitat en un avanzado estado de fragmentación causado por la ganadería extensiva y cultivos ilícitos. La cobertura existente esta relegada a pequeños bosques primarios y vegetación secundaria. Analizamos imágenes de Google Earth de 100 km^2 del hábitat de este primate y encontramos solo 32% de bosque original y bosque secundario en el 2002, año de captura de la imagen. Proponemos que esta especie debe ser considerada como Críticamente Amenazada (CR), (basados en los criterios A3c,d,e,C2 de la UICN). Sugerimos al gobierno nacional y del Caquetá que presten especial atención a este primate endémico, estabilizando reservas en la zona, estableciendo programas de ganadería sostenible, proyectos REDD y un programa de educación ambiental regional. Esta es probablemente la especie de primate más amenazada de Colombia.

Palabras Claves: *Callicebus caquetensis*, primates amenazados, endémico, Colombia.

Introduction

In 2010, we described a new species of titi monkey, *Callicebus caquetensis* Defler *et al*., 2010, from southern Caquetá Department, Colombia. To date it has been found only in forest patches on agricultural land that has been established in the region over past 50–60 years. This primate was mentioned by Moynihan (1976) from his travels in the piedmont of Colombia in 1969, although Hershkovitz (1990) made no mention of it. In 2008, the first author, a native of Caquetá, agreed to attempt field work where the titi monkey had been first observed by Moynihan (1976). The completely fragmented state of the forest was known to us from satellite images. An analysis of Colombian Amazonian forest cover by Defler (1992) indicated that about 70% of the forest had been lost in southern Caquetá by 1985. A further analysis was carried out with satellite images available to us from 2003. Caquetá is one of the principal colonization fronts in the Colombian Amazon, and in 1985 it was considered to be the Amazonian department that had suffered the most forest loss, with only about 29.4% left, and 79.6% under varying stages of conversion (Defler, 1992). An assessment of the status of this species was evidently a matter of urgency.

Field work in the area was made difficult by the fact that for past 50 years or so, the area where Moynihan (1976) described this primate has been a continual zone of conflict, with the presence of various insurgent groups on both ends of the political spectrum. Data collection in this region demanded careful preparation for all forays into the countryside, involving prior conversations with all possible contacts about the advisability of working in particular zones, and by carefully following the advice given. Despite this, it remained impossible to survey one of the most promising forest fragments for a possible reserve (described below). Field work was facilitated by the fact that the first author was a native of the nearby capital of Caquetá Department, Florencia, and was able to establish some local contacts through his family.

Cattle-raising and illicit cultivars are the main agricultural activities in the region. While cattle-raising has been supported in the past by the Colombian government and by the World Bank (Andrade & Ruiz, 1988), in the last three decades official support for colonization and cattle ranching has been reduced (Myers, 1980; República de Colombia, 1982; Jimeno, 1987; Jaramillo *et al.,* 1989).

Methods

The first author spent 22 days in April, 2008, 21 days in May, 2008 and 39 days in June–July 2010 for a total of 82 days of field work (García, 2008, 2010; García & Defler, 2009). García's field work involved contacting landowners using his family contacts to visit farms where small, forest patches remained. It is necessary to be connected to, and vouched for by, locals to guarantee personal security in this part of Colombia. The local people are very mistrustful of strangers. The study began at the village of Valparaíso, Caquetá, where Moynihan first observed the monkeys in 1969.

In the 2010 survey, García concentrated on the region to the west of the previous observations of 2008 and 2009, as well as the municipalities (*municipios*) of Albania, San José del Fragua and Curillo (see García, 2008; García & Defler, 2009 for details; in Colombia a *municipio* is more comparable to a county and often contains several different towns or cities; the term is not limited to one town as in the United States). Six additional groups were located (Fig. 1).

Google Earth allowed an overall view of the study area; it depicts the region using two different scales or resolutions for southern Caquetá. A baseline resolution of 15 m was used for the majority of the area, but it is not a scale easily analyzed for fragment sizes. A smaller percentage of area is depicted in a finer-grained resolution of 1 m, allowing analysis of forest condition and fragment area. Using a finer resolution, in an area centered around the coordinates 1°06'27.8"N, 75°32'57.6"W, 220 m altitude, we analyzed an image captured on 30 November, 2003 (10.7 km × 7.5 km or 75 km², and the latest image available to us) for the extent of fragmentation. With the results of the field work, and using the Google images, we identified six possible reserves for *C. caquetensis*.

Results and Discussion

During the 82 days of surveys, we detected 82 (including the holotype and paratype) animals with an average of four animals per group. Table 1 shows the breakdown per group for the 13 groups found, and the coordinates of where they were seen. The animals were detected at an altitudinal range of 190–270 m. Figure 1 shows the locations of the sightings made during 2008, 2009, and 2010. The point on the map marked *Callicebus torquatus* identifies a sighting of a *C. torquatus* group, suggesting that originally, when the forest was intact, *C. torquatus* and *C. caquetensis* were sympatric.

All observations were made in forest fragments, some of which were severely degraded. Moynihan (1976) reported seeing a group in a "medium-sized" patch of vegetation mostly less than 7 m in height, and he made a number of observations from "low second growth forest, except for land between a broad river on one side and patches of bamboo and abandoned crop fields on the other" (p.76). We delineated a square of land (Fig. 2) from the most recently available Google World image (30 November, 2003) of 11 km × 7.5 km (75 km²) and calculated the percentage of remaining forest there. Existing *Callicebus* habitat was in the form of fragments and tree-lined streams, and represented about 32% of the total area (about 26.4 km² of the total area) (1°07'45.74"N, 75°34'37.28"W, center of the rectangle) of vegetation that could sustain *Callicebus* at that time.

Figure 3 shows a group of interconnected fragments on the William Cuartas farm (1°8'17.9"N, 75°34'28.5"W) totaling about 2.5 km² of forest. Only one group of *C. caquetensis* was found there, even though this large fragment could evidently harbor more, since groups of the closely related *C. ornatus* have been observed in territories of 3.29 ha, 4.18 ha, and 3.5 ha in gallery forests in Meta and 14.2 ha in closed canopy forest (Defler, 2004; Mason, 1965, 1966). Robinson (1977) estimated densities for *C. ornatus* at about 5 individuals/km², which would suggest that this fragment could hold at least 12.5 animals (3–4 groups) of *C. caquetensis.*

Although there are no large blocks of forest in the area confirmed as the range of *C. caquetensis*, there are still possibilities for small reserves for this species and we suggest several here. An advantage of declaring several small reserves is the insurance against any large disaster in any one of them, since other small reserves will continue to protect the species. Presuming that *C. caquetensis* groups defend territory similar in size to those defended by *C. ornatus*, we believe that a fair population could be preserved in some of the larger available fragments between the Rios Orteguaza and Caquetá. Part of our future work will involve the development of proposals for the establishment of biological corridors to connect some of these reserves. Below are some suggestions for small reserves to protect *Callicebus caquetensis*.

1. El Dorado (*municipio* of Albania) contains *Mauritia flexuosa* palm forests combined with gallery forest close to a school (Institución Educativa Rural El Dorado) in El Dorado where environmental work could be carried out with the added advantage of security. The forest has easy access for the development of basic ecology or behavior projects. These forests might provide connections to forests along the Río Pescado, although they are

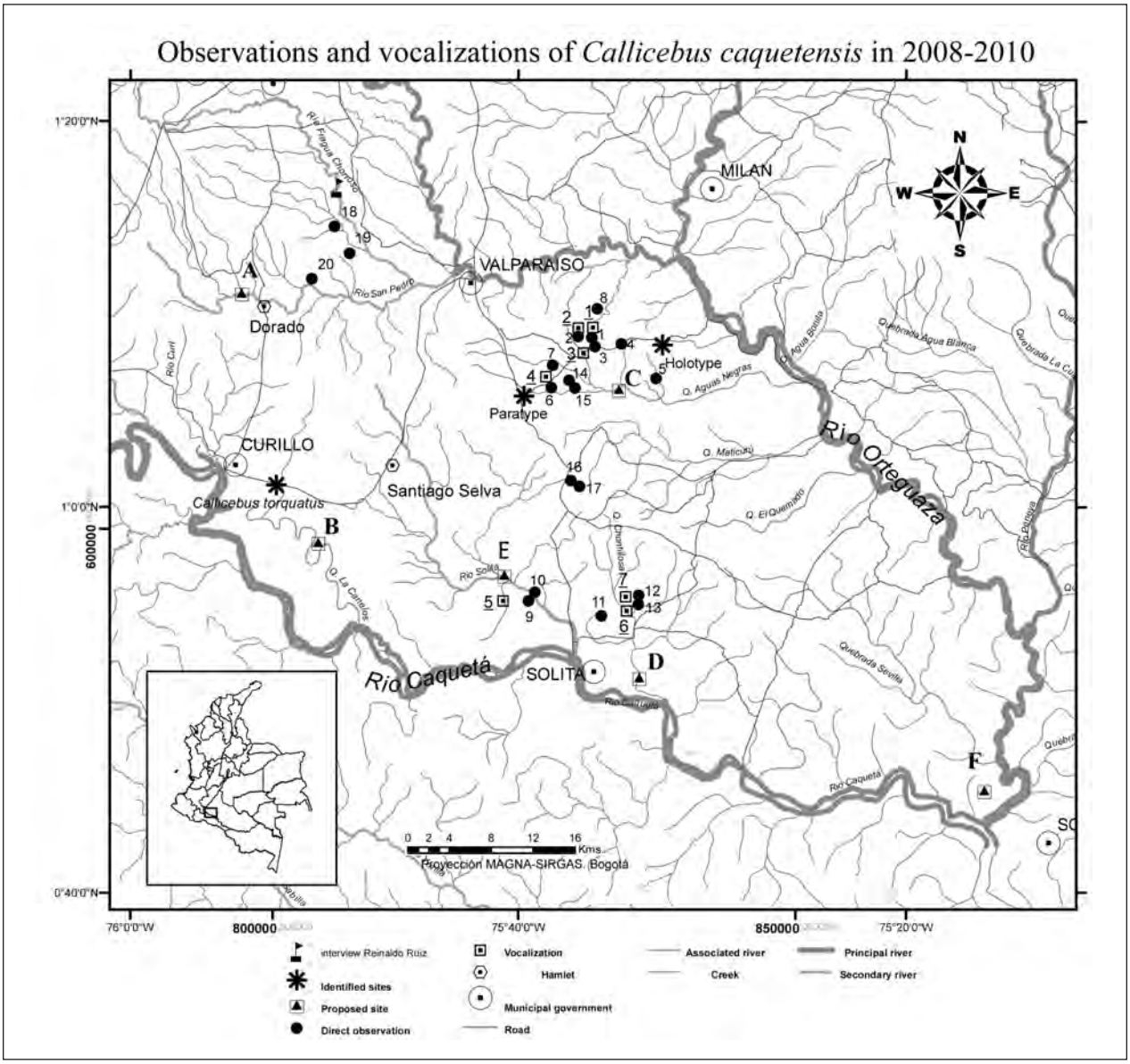

Figure 1. Map of observations of *Callicebus caquetensis* 2008–2010.

Table 1. Size, composition and location of *Callicebus caquetensis* and *Callicebus torquatus* groups observed in 2008–2009.

	M	F	Subad.	Juv.	Inf.	Total	Place	Coordinates
1	1	1	1	1	0	4	Nilson Barragán farm	01°08'38.3"N 75°36'00.4"W
2	1	1	0	2	1	5	Nilson Barragán farm	01°08'40.8"N 75°36'43.0"W
3	1	1	0	1	0	3	Alirio Santanilla farm	01° 08'09.4"N 75°35'51.4"W
4	1	1	0	1	1	4	Hacienda William Cuartas	01°08'17.90"N 75°34'28.5"W
5	1	1	1	0	1	4	Resbalón Creek	01°06'30.4"N 75°32'42.8"W
6	1	1	2	0	1	5	Hacienda Moisés Cruz	01°06' 54.4"N 75°37'27.3"W
7	1	1	0	1	1	4	Fidelino Peña farm	01° 07'11.0"N 75°38'01.1"W
8	1	1	2	1	1	6	Vereda la Florida*	01°10'07.92"N 75°35'43.86"W
9	1	1	1	0	1	4	La Solita Creek	0°54'57.42"N 75°39'15.76"W
10	1	1	1	0	0	3	La Solita Creek	0°55'05.2"N 75°39'00.6"W
11	1	1	0	0	1	3	Yaneth Soto farm	0°54'12.6"N 75°35'31.22"W
12	1	1	0	0	1	3	Doña Amparo farm	0°55'15.4"N 75°33'34.9"W
13	1	1	1	2	1	6	Edilberto Suárez farm	0° 54'47.8"N 75°33'36.3"W
14	1	1	1	1	1	5	Libardo Rojas farm	01°06'24.35"N 75°37'10.82"W
15	1	1		1	1	4	Libardo Rojas farm	01°06'12.27"N 75°36'58.80"W
16	1	1				2	Bello Diamante farm	01°01'13.09"N 75°37'5.26"W
17	1	1	1	2			**LOCATION**	01°01'06.87"N 75°37'1.02"W
18	1	1		1		3	Road along a creek, 4 km from Albania to Valparaiso	01°14'23.55"N 75°49'16.16"W
19	1	1	1		1	4	Forest road to Valparaiso	01°13'00.43"N 75°48'29.97"W
20	1	1		1		3	Hacienda Don Félix	01°11'39.84"N 75°50'27.34"W
Total observed						80	**Altitudes**	190–270 m
Average group size						4		
Holotype captured by locals							LOCATION	01°08'24.61"N 75°32'34.04"W
Paratype captured by locals							LOCATION	01°06'23.10"N 75°38'32.5"W
***Callicebus torquatus* group**							LOCATION	01°01'11.49"N 75°52'28.71"W

M: Adult male
F: Adult female

Figure 2. 75-km^2 quadrate analyzed for fragmentation and percent of forest cover (Image Google Earth, 2003).

Figure 3. Area around the Hacienda William Quartas (4 km × 2.75 km) showing ongoing fragmentation. (Image Google Earth, 2003).

extremely fragmented. Local people confirm that *C. caquetensis* eats *Mauritia flexuosa* fruits, just as has been observed for *Callicebus torquatus lugens* by Palacios *et al.* (1997) and *Callicebus t. lucifer* by TRD (unpubl. data).

2. Both *C. torquatus* and *C. caquetensis* occur in the forests of Canelo Creek. From the north it is easy to enter the area, although there are some security issues at this time. Canelo Creek flows into the Río Caquetá and would be important as a protective zone for that part of the river.

3. Aguas Negras Creek (*municipios* of Milán and Valparaiso) is a corridor that has sizeable forests along most of its length and may serve as habitat for *C. caquetensis*. South of it is a small forest of 90 ha, but it is being logged and will soon be ruined, although secondary vegetation probably would be attractive for this primate. Access to this forest is via the Río Orteguaza and Valparaíso.

4. One of the largest fragments that probably protects *C. caquetensis* is immediately east of the town of La Solita. Because of local security concerns it has not yet been possible to survey the fragment to determine if the species is there, although it has been confirmed nearby to the north. This fragment, about 17 km in length and 1–4 km wide, lies alongside the Río Caquetá. The species complex *C. ornatus*, *C. caquetensis*, *C. discolor*, and *C. cupreus* is particularly attracted to low-lying land alongside rivers, so the forest could be prime habitat for this small monkey (Defler, 2010). We have detected *Pithecia monachus*, *Lagothrix lagothricha lugens*, *Saimiri sciureus*, *Saguinus nigricollis hernandezi*, and *Cebus apella* in other, nearby fragments, and this large fragment might well protect small populations of *C. caquetensis* as well (García, 2008; García & Defler, 2009). The forest is probably scrubby, since lumbering in the region has long ago harvested the largest trees. *Callicebus* from this species group are also known to do well in scrubby and secondary vegetation, so we can surmise that this would be adequate habitat for *C. caquetensis* (Moynihan, 1976; Defler, 1994; Van Roosmalen *et al.*, 2002). This fragment is a prime choice for further evaluation in the future when the security situation improves.

5. Another possible reserve for this species could be established along La Solita Creek to the west of La Solita. *Callicebus caquetensis* has been registered there and, although the forest is not as extensive as to the east of La Solita, there is adequate vegetation along this creek for at least 6 km, and at its mouth the vegetation (probably seasonally flooded and attractive to this titi monkey) extends to a width of 5 km. To the north *C. ornatus* is very common in riparian (gallery) forests or forests along creeks and this preference is probably shared with *C. caquetensis*. The advantage of reserves being established in these two patches of large fragments is that they could be administered in part from the village of La Solita, situated between the two.

6. Other large fragments of forest still persist to the east, towards the mouth of the Río Orteguaza, where it flows into the Río Caquetá. The largest fragment (6 km × 4 km) is across the river from "Tres Esquinas", the Colombian air force base "Ernesto Esguerra" and village, where security might be stronger due to the military presence and where a reserve might be more easily protected. However, presently it is conjecture whether it contains *C. caquetensis*, since this part of the interfluvium of the Orteguaza and Caquetá has not been surveyed.

The species might be present in some other large fragments in this part of the interfluvium, but the fragments have not been surveyed, and they are isolated in terms of transportation and security. Forests along the right bank of the Río Orteguaza seem promising, since these are wide fragments and the forest following the right bank is continuous from just below Valparaíso. If this forest has not been cut

because it is low-lying and seasonally flooded, it is a good possibility for establishing reserves for *C. caquetensis*.

Reynaldo Ruíz (a colonist of the area) mentioned the historic presence of *C. caquetensis* in the floodplain of the Río Fragua (see Fig. 1), but it seems to be locally extinct there due to intense agricultural activities. This would be the westernmost point of its distribution and the point closest to the Cordillera de los Andes. Field work in 2010 confirmed the absence of the species west of the Río Pescado (*veredas* [= a subdivision of a *municipio* in Colombia], La Esperalda and Rochela, in the *municipio* of Morelia). We suppose that the western range extension of the species might prove to be more extensive than we have been able to demonstrate to date and this has important implications. Unfortunately the Agencia Nacional de Hidrocarburos of Colombia is planning extensive oil exploration in this western part of Colombia, but it is unclear whether such development will include safeguards for the conservation of the flora and fauna (<http://www.anh.gov.co/es/index.php?id=1>).

Cattle ranching is an important economic activity in the department of Caquetá, even though the soils are not appropriate (oxisols, poor in nutrients); one hectare of land can sustain an average of only 0.58 cattle (Ruiz *et al*., 2007). A study by the Colombian government concluded that Amazonian departments were not apt for this use due to the poor soils and environmental factors that favor persistent diseases which tend to decrease natality (PRORADAM, 1979). Paradoxically such use has been encouraged by the government. Lately the capacity of the land to sustain cattle production has begun to decrease and this forces land owners to convert what land is left into pasture (SINCHI, 2007). Conversion to cattle pastures involves clear cutting and burning, supplying a pulse of nutrients that can be assimilated by introduced grasses. But once the soils are leached and eroded, the maintenance of a healthy pasture becomes untenable, and further forest is cut. Forest recovery is seriously jeopardized and slow. Such is the process that gradually lays waste to enormous tracts of land, unproductive for crops or as cattle pasture. To illustrate the trend, one forest section where groups of *C. caquetensis* were observed in 2008 was found to be completely clear cut in 2010 (Fig. 4). Unfortunately the margins of rivers that maintain gallery forest so appealing to *Callicebus*, provide the most productive soils, and these forest are the first to be converted to grassland, even though this is prohibited by law (Article 4, Decree 2278, 1953). The fragmentation isolates these primates, and impedes dispersal. The environmental impacts of cattle ranching are numerous: negative influences of erosion and soil compaction, genetic uniformity from the grass monoculture, elimination of secondary vegetation using herbicides or uprooting, drying out of wetlands, construction of more roads, an increased demand for posts for fencing, corrals, contamination of water and soil using synthetic fertilizers and insecticides, as well as gas emissions produced by forest burning and the flatulence of the cattle.

In 2001, more than 50% of the territory of nine municipalities of Caquetá had been converted to grassland. Our calculation based on satellite images (2003) of 75 km² of land near Valparaiso yielded a conversion of 68%.

Figure 4. Pasture cut from former study forest. (Photo by Javier García).

Eighty-nine percent of La Solita had been converted by 2001; 98% of the municipality of Albania. Like other species of *Callicebus*, from this complex, *C. caquetensis* seems tolerant of human activities, and habituated animals readily move and probably disperse using very scarce vegetation or none at all. We saw a number of groups that seemed unconcerned by our presence. One animal was seen to pass over barbed wire from one patch of vegetation to another (Fig. 5). Another animal ate unconcernedly while being photographed (Fig. 6). Since primates are mostly ignored in this part of Colombia, the major pressure is forest conversion, although "poor", "broken-up", "isolated patches", "bamboo thickets", "dense vegetation, crowded and relatively low forests, thickets, and tangles" and secondary vegetation is sometimes used by this primate and by closely related species (Mason, 1965, 1966; Moynihan, 1976; Kinzey, 1981; Defler, 2004).

We believe that alternatives need to be supported that allow for a change in the mentality in this part of Colombia so heavily given to cattle ranching. But even though the low prices of milk and meat do not support successful cattle production, the frontier mentality in rural Colombia places a high premium on this activity, just as it does in so many other nations. Part of the solution in the area between the Ríos Orteguaza and Caquetá must be inclusion into national strategies such as the Project Sustainable Colombian Cattle-ranching supported by the Federación Colombiana de Ganaderos (FEDEGAN), see <http://portal.fedegan.org.co/TDR/100929%20TORs%20Contador%20para%20publicar.pdf>), international agreements such as the United Nations' Programa de REDD (Reducing Emissions from Deforestation and Forest Degradation, see <http://www.unredd.org/NewsCentre/87_million_approved_for_Global_Activities/tabid/1413/language/en-US/Default.aspx>) and financial support for communities that practice sustainable development in the region, as well as support for conservation priorities such as the *Workshop–90: Biological Priorities for Conservation in Amazonia* that identified conservation priorities, such as an endemic fish fauna in the Río Orteguaza (Rylands *et al.* 1991; Kress *et al.*, 1998). We would hope that organizations such as Parques Nacionales Naturales, Corpoamazonía, the Instituto de Investigaciones Amazónicas (SINCHI), the government of Caquetá and mayors of the different *municipios* would agree to consolidate the area as a biological corridor between the Colombian Amazon and the Andes, just as we soon hope to propose.

Illegal crops such as marijuana, poppy and coca have traditionally been a problem in this part of Colombia, although in the last decade coca plants have become dominant and continued to increase in Currillo, Milan, Solita and Valparaiso during the period 2008–2009 (SIMCI II, 2010; see <http://www.unodc.org/colombia/es/simci/simci.html>]). The opening of a coca plot usually takes place in the center of a patch of forest to avoid detection, thus, although promoting the permanence of some forest, contributes to its degradation and fragmentation (Fig. 7).

Herbicide is known to affect aquatic habitats and to cause malformation of tadpoles (Giesy, 2000; Chivian & Bernstein, 2008). Continuing fumigation of illegal crops with glyphosate causes environmental pollution and has never

Figure 5. *Callicebus caquetensis* negotiating barbed wire fence between two fragments. (Photo by Javier García).

Figure 6. *Callicebus caquetensis* eating a guava fruit. (Photo by Javier García).

Figure 7. Coca plantation in a forest fragment. (Photo by Javier García).

been evaluated in terms of its damage to arboreal fauna such as titi monkeys. Genotoxic, hormonal, and enzymatic effects of glyphosate in mammals have been reported, nevertheless (Lioi *et al.*, 1998; Peluso *et al.*, 1998; Daruich *et al.*, 2001). In rats, glyphosate has been found to decrease the activity of some detoxifying enzymes, cytochrome P-450, and monooxygenase activities and the intestinal activity of aryl hydrocarbon hydroxylase when injected into the abdomen (Hietanen *et al.*, 1983). The fact that this primate depends on vegetation that may often be sprayed with glyphosate around coca fields means that the animals are subjected to yet another environmental assault, which has never been evaluated—die-back of a part of their habitat due to spraying, the ingestion of affected fruits, or even being directly coated by the herbicide.

General poverty in southern Caquetá means that any conservation effort needs to be seen to provide economic advantages to the local communities. Socioeconomic conditions in southern Caquetá are difficult, and the rural population suffers from the lack of basic necessities (for example, inadequate housing with overcrowding, poor sanitation, poor structural integrity, and poor school attendance). The last national census of the Departamento Administrativo Nacional de Estadística (DANE) (2005: <http://www.dane.gov.co), showed this to be true for 54.59% of the rural population from the *municipios* of Milan, Valparaiso, Solita, Currillo, and Albania where we have found *C. caquetensis*. These conditions threaten the species in as much as many people use the forest fragments to satisfy basic needs, notably hunting for food. These problems urgently need to be addressed in order to guarantee a future for this endemic and endangered primate.

For the reasons above, we recommend that this species be classified as Critically Endangered (CR) on the *IUCN Red List of Threatened Species* applying a number of criteria. We believe that there has been a population reduction of more 80% in the last 10 years or three generations due to a reduction of the area of occupation, and the causes of the reduction have certainly not stopped, and they are affected by introduced taxa and contaminants A3(c,e). Population size is estimated to number fewer than 250 mature individuals, there is an estimated continuing decline of at least 25% within three years, and no subpopulation is estimated to contain more than 50 mature individuals—C1, 2a(i).

Conservation of *Callicebus caquetensis*

Our studies suggest that a variety of actions urgently need to be taken to ensure a future for this and other wildlife in the region.

1. Continued study is needed to clarify the conservation status of the species. The first author plans to do his master´s degree research on the region and on the species' conservation status.

2. One or two reserves need to be established immediately. We suggest six possible reserves in this paper.

3. The local people need to be convinced of the importance of preserving their local fauna. This small monkey evidently does not represent an important food source to local people, but this point must be researched in the future.

4. Political leaders and environmental agencies need to be brought into the conservation process to provide for socio-economic improvements with an understanding that the well-being of these local communities lies in the maintenance of healthy ecosystems for the provision of the natural resources they need.

5. Colombians need to hear about their newest and most endangered species of primate, and allies need to be identified to protect this animal and its habitat.

6. Before the possibilities are lost, a biological corridor must be established that connects the last relict forests of southern Caquetá with the east slopes of the eastern cordillera of the Andes, thus helping to protect a modicum of the region's wealth of biodiversity.

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A MORPHOLOGICAL ANALYSIS OF SOME SPECIES OF *CALLICEBUS,* THOMAS, 1903 (PITHECIIDAE - CALLICEBINAE)

Paulo Auricchio[1]

[1] *Departamento de Biologia, Campus Cinobelina Elvas, Universidade Federal do Piauí, Rodovia BR-135, km 03, Planalto Horizonte - 64900-000 – Bom Jesus – PI, email:. paulo.auricchio@ufpi.edu.br*

Abstract

A chromogenetic field analysis was performed with 25 of 29 of the known species of the genus *Callicebus*. Some species presented polymorphism, such as *C. moloch, C. hoffmansii* and *C. cupreus. C. bernhardi* presents the same distribution of color in chromogenetic fields as *C. moloch*, differing only in pigment amount, mainly in ventral surfaces, suggesting *C. bernhardi* is a junior synonym of *C. moloch*. *C. hoffmansii* presents two distinct phenotypes, but without a geographic barrier between them. *Callicebus cupreus*, *C. dubius* and *C. caligatus* are distinct species.

Key Words: Callicebus, taxonomy, phenotypical polymorphism

Resumo

Uma revisão taxonômica baseada nos campos cromogenéticos foi procedida em 25 das 29 espécies conhecidas do gênero *Callicebus*. Algumas espécies apresentaram polimorfismo como *C. moloch, C. hoffmansii e C. cupreus. Callicebus bernhardi* apresenta o mesmo padrão de distribuição de campos cromogenéticos de *C. moloch*, divergindo somente na quantidade de pigmentos, principalmente na face ventral da pelagem. Assim, *C. bernhardi* deve ser considerado sinônimo júnior de *C. moloch. C. hoffmansii* apresenta dois fenótipos distintos, porém não há uma barreira geográfica entre eles. *C. cupreus, C. dubius* e *C. caligatus* são espécies distintas.

Palabras Clave: *Callicebus*, taxonomia, polimorfismo fenotípico

Introduction

Although new species of *Callicebus* have been described from Brazil and Bolivia during the last decade, few taxonomic studies had been made on this genus during the same period. The first taxonomic review was performed by Elliot (1913), who recognized 22 monotypic species. This arrangement has been modified by several researchers, such as Tate (1939), Thomas (1927), Lönnberg (1939), Cruz-Lima (1945), Vieira (1955) and Cabrera (1958), who proposed more detailed taxonomic arrangements, defined geographical distributions and suggested phylogenetic relationships within the taxon. Hill (1960), influenced by those authors, proposed a more complete taxonomic arrangement. More recently, only Hershkovitz (1990), Kobayashi (1995) and Anselmo (1997) performed taxonomic studies of *Callicebus*. Hershkovitz (1990) based in skull, skeleton morphology and pelage color, recognized 13 species with 25 subspecific taxa, divided among four groups, as listed in Table 1.

Kobayashi (1995) carried a phenetic analysis based on metric skull characters, besides cariotype, pelage coloration and geographic distribution of 23 species and subspecies (*C. oenanthe, C. aureipalatti* and *C. coimbrai* were not included; the last two had not been described at that time). He recognized five species groups (Table 1) and stated these groups are independent lineages since the rates of character differentiation were not significantly different among the nearest related groups. Among these groups, Kobayashi (1995) pointed out a great differentiation rate between *personatus* and *torquatus*, while *donacophilus*, *cupreus*, *moloch* appear more closely related. Concerning the pelage color pattern of the *moloch* group, Kobayashi considered *donacophilus* and *personatus* groups as "no contrasting pattern", burnt yellow for *donacophilus* and blackish to yellowish for *personatus*; the *cupreus* group was defined as "weakly contrasting" and *moloch* and *torquatus* groups as "contrasting ventral surfaces" and "throat with white band", respectively. Roosmalen *et al.* (2002) described two new species (*C. stephennashi* and *C. bernhardi*), and considered five species groups: 1. *torquatus,* 2. *personatus,* 3. *moloch,* 4. *cupreus,* 5. *donacophilus.*

The great individual and population color variation in *Callicebus* raises several doubts and, sometimes, misunderstanding about the taxonomy of this genus. Aquino *et al.* (2008) found two distinctive populations of *Callicebus torquatus* in northeast Peru. Although several characteristics such as the shape of the hair tuft on the throat

(a characteristic of *torquatus* group), color tones on hands and the width of frontal band, seems to be different among those populations, the authors were not confident whether the two populations could be considered as different taxa or not. Heymann *et al.* (2002) also found problems with *Callicebus* phenotypical characterization, notably on the color of the hands. Moore (2009) tested the use of pelage color characters as diagnostic taxonomic markers across the geographic distribution of the *Callicebus* cupreus-group as an example. He found both a clinal variation along a geographic transect, as well as a localized intra-populational variation. He emphasizes that systematists should be careful while considering the relationship between intra-populational variation and geographic distribution. In this

Table 1. Taxonomic *status* synopsis of *Callicebus* as presented by some authors and this work (modified from Roosmalen, 2002).

Hershkovitz (1963)	Hershkovitz (1988, 1990)	Kobayashi (1995)	Groves (2001)	Roosmalen et al, 2002	Auricchio (2005)
	Group *modestus*		**Group** *modestus*		
	C. modestus		*C. modestus*		
	Group *donacophilus*	**Group** *donacophilus*	**Group** *donacophilus*	**Group** *donacophilus*	**Group** *donacophilus*
C. moloch donacophilus	*C. donacophilus donacophilus*	*C. donacophilus donacophilus*	*C. donacophilus*	*C. donacophilus*	*C. donacophilus*
	C. d. pallescens	*C. d. pallescens*	*C. pallescens*	*C. pallescens*	*C. pallescens*
	C. oenanthe		*C. oenanthe*	*C. oenanthe*	*C. oenanthe*
		C. modestus		*C. modestus*	*C. modestus*
	C. olallae	*C. ollalae*	*C. olallae*	*C. olallae*	*C. olallae*
C. m. moloch	**Group** *moloch*	**Group** *moloch*	**Group** *moloch*	**Group** *moloch*	**Group** *moloch*
	C. moloch	*C. moloch*	*C. moloch*	*C. moloch*	*C. moloch*
	C. cinerascens	*C. cinerascens*	*C. cinerascens*	*C. cinerascens*	*C. cinerascens*
C. m. hoffmannsi	*C. h. hoffmannsi*	*C. h. hoffmannsi*	*C. hoffmannsi*	*C. hoffmannsi*	*C. hoffmannsi*
	C. h. baptista	*C. h. baptista*	*C. baptista*	*C. baptista*	*C. baptista*
C. m. brunneus	*C. brunneus*	*C. brunneus*	*C. brunneus*	*C. brunneus*	*C. brunneus*
	C. caligatus			*C. bernhardi*	
	C. dubius	**Group** *cupreus*		**Group** *cupreus*	**Group** *cupreus*
C. m. cupreus	*C. cupreus cupreus*	*C. cupreus cupreus*	*C. cupreus cupreus*	*C. cupreus*	*C. cupreus*
C m. discolor	*C. c. discolor*	*C. c. discolor*	*C. c. discolor*	*C. discolor*	*C. discolor*
C. m. ornatus	*C. c. ornatus*	*C. c. ornatus*	*C. c. ornatus*	*C. ornatus*	*C. ornatus*
	C. personatus personatus		*C. personatus personatus*	*C. caligatus*	*C. caligatus*
			C. coimbrai		
	C. p. melanochir		*C. p. melanochir*	*C. dubius*	*C. dubius*
	C. p. nigrifrons		*C. p. nigrifrons*	*C. stephennashi*	*C. stephennashi*
	C. p. barbarabrownae		*C. p. barbarabrownae*		*C. aureipalatti*
	Group *torquatus*	**Group** *torquatus*	**Group** *torquatus*	**Group** *torquatus*	**Group** *torquatus*
C. torquatus torquatus	*C. torquatus torquatus*	*C. torquatus torquatus*	*C. torquatus torquatus*	*C. torquatus*	*C. torquatus*
C. t. lugens	*C. t. lugens*	*C. t. lugens*	*C. t. lugens*	*C. lugens*	*C. lugens*
	C. t. lucifer	*C. t. lucifer*	*C. t. lucifer*	*C. lucifer*	*C. lucifer*
	C. t. purinus	*C. t. purinus*	*C .t. purinus*	*C. purinus*	*C. purinus*
	C. t. regulus	*C .t. regulus*	*C. t. regulus*	*C. regulus*	*C. regulus*
C. t. medemi	*C. t. medemi*	*C. t. medemi*	*C. medemi*	*C. medemi*	*C. medemi*
		Group *personatus*		**Group** *personatus*	**Group** *personatus*
		C. personatus		*C. personatus*	*C. personatus*
		C. melanochir		*C. melanochir*	*C. melanochir*
		C. nigrifrons		*C. nigrifrons*	*C. nigrifrons*
		C. barbarabrownae		*C. barbarabrownae*	*C. barbarabrownae*
		C. coimbrai		*C. coimbrai*	*C. coimbrai*

article I present an analysis of the color pattern of all *Callicebus* specimens from the main Brazilian collections, in order to evaluate phenotypical polymorphism and the validity of these species using the color pattern of fur and hair as diagnosable characters.

Material and methods

I examined 455 dry skins of 25 species from 136 localities belonging to the following collections: Museu de Zoologia da Universidade de São Paulo (MZUSP - 194 specimens); Museu Nacional do Rio de Janeiro (MNRJ - 97); Museu Paraense Emílio Goeldi (MPEG - 130); Instituto Nacional de Pesquisas da Amazônia (INPA - 10); Instituto Pau Brasil de História Natural (IPBHN - 10; Universidade de Brasília (UnB - 1) and Centro de Primatologia do Rio de Janeiro (CPRJ – 4). Appendix I lists the specimens together with geographic coordinates, label identification and a review of identification as found after this analysis. One specimen of *C. pallescens* and one of *C. caligatus* were studied alive in captivity. Material of *Callicebus medemi, C. oenanthe, C. ollalae, C. modestus* and *C. auriepallati* were not available so these were excluded from this study.

Characters were chosen based on the pelage color of body parts or chromogenetic fields. Following Hershkovitz (1977), these are defined as any part of the pelage showing a particular color pattern from nearby areas, (for instance, the forearm, the back, one sub-apical band in a hair, etc), as shown in Figure 1. I could find chromogenetic fields characters only in pelage, not in hair, so the analysis focused on those. Each specimen was morphologically analyzed and

Table 2. Distinctive characters among *C. cupreus, C. caligatus* and *C. dubius.*

	***C. cupreus* phenotype 1 (most common)**	***C. caligatus***	***C. dubius***
Face	Reddish-cream	Dark reddish brown	Sideburns, sides of head and beard deep red
Forehead	reddish-cream (agouti hair banded with light stripes longer than dark ones)	Frontal Black stripe with no abrupt division with nape	transversal frontal band whitish, with a fine black line of superciliar vibrissae which connects the blackish ears
Crown	reddish-cream (agouti hair banded with light stripes longer than dark ones).	Black (rostral part)	brownish agouti; hairs with 4–5 pheomelanic bands, each alternated with eumelanic band.
Nape	reddish-cream (agouti hair banded with light stripes longer than dark ones).	Dark reddish brown -agouti. Each hair reddish brown with black tip	brownish agouti; hairs with 4–5 pheomelanic bands, each alternated with eumelanic band.
Back	reddish-cream (agouti hair banded with light stripes longer than dark ones).	Black	Brownish agouti. brownish agouti; hairs with 4–5 pheomelanic bands, each alternated with eumelanic band.
Lower back	reddish-cream (agouti hair banded with light stripes longer than dark ones), but washed with brown.	Dark reddish brown -agouti. Each hair reddish brown with black tip	Reddish -brown -agouti brownish agouti; hairs with 4–5 pheomelanic bands, each alternated with eumelanic band
External surface of fore legs and forearms	intense redish brown which can vary to orangish.	Dark reddish brown -agouti. Each hair reddish brown with black tip	Reddish
Back of Hands	Brown, not agouti	Black	Blackish agouti,
Fingers	Brown, not agouti	Black	Contrasting white
Back of Feet	Brown, not agouti	Black	Contrasting white
Base of tail	Reddish-cream (agouti hair banded with light stripes longer than dark ones), but washed with brown.	Black (20%)	Reddish-brown -agouti
Middle tail	Reddish-cream (agouti hair banded with light stripes longer than dark ones), but washed with brown.	Greyish, black/beige or burnt yellow (blackish hairs with 0.7 cm of whitish tip)	Blackish.
Tip of tail	Reddish-cream (agouti hair banded with light stripes longer than dark ones), but washed with brown.	Burnt yellow/ beige brush (INPA 4032)	Contrasting white brush
Ventral surface	Intense reddish brown which can vary to orangish.	Deep reddish-brown agouti. Each hair reddish-brown with black tip;	Hairs of throat blackish agouti; chest, belly and ventral surface of legs and arms reddish or reddish-brown; not banded.

assigned to different chromogenetic pattern groups by comparing the color pattern of 14 regions (shown in Figure 1, plus chest, belly and ventral surface of limbs), considering color tone variation as character states. This variation is due to the pigment present in hairs. Hershkovitz (1977) points out pheomelanin as the pigment responsible for yellows, browns and reds, depending on the amount of it deposited in the hair. Melanin is the pigment which gives black and gray colors to the hair. The analyses were performed by simple visual inspection, for example: when the character was crown with melanin pigment, states could be gray or black. Characters used in this study are listed in Table 2.

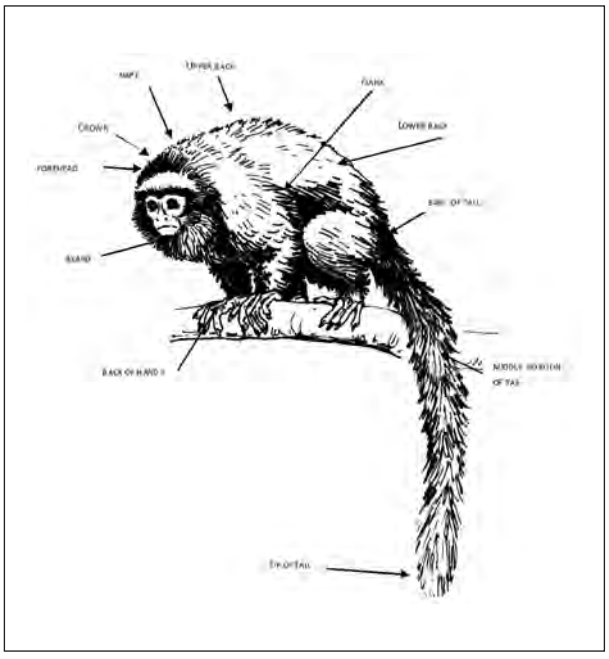

Figure 1. Pelage chromogenetic fields considered for this analysis.

Collecting sites were plotted (Fig. 2) and compared with bibliography. Although almost all *Callicebus* species were included in this analysis (25 of 29 species), only the ones with taxonomic problems are discussed in this paper. Table 3 lists these species and the number of specimens analyzed.

Results and Discussion

Morphological Analysis

1. *C. moloch/ C. bernhardi*

Pelage chromogenetic analysis shows *C. moloch* has great color tone variation on several chromogenetic fields, especially on the ventral surface, which ranges from yellow to reddish-brown. I could split the specimens into three phenotypes: "*normal phenotype", "red phenotype"* and *"light phenotype"*. The "normal phenotype" is the commonest (84% of the sample) and has a cream forehead, crown (banded

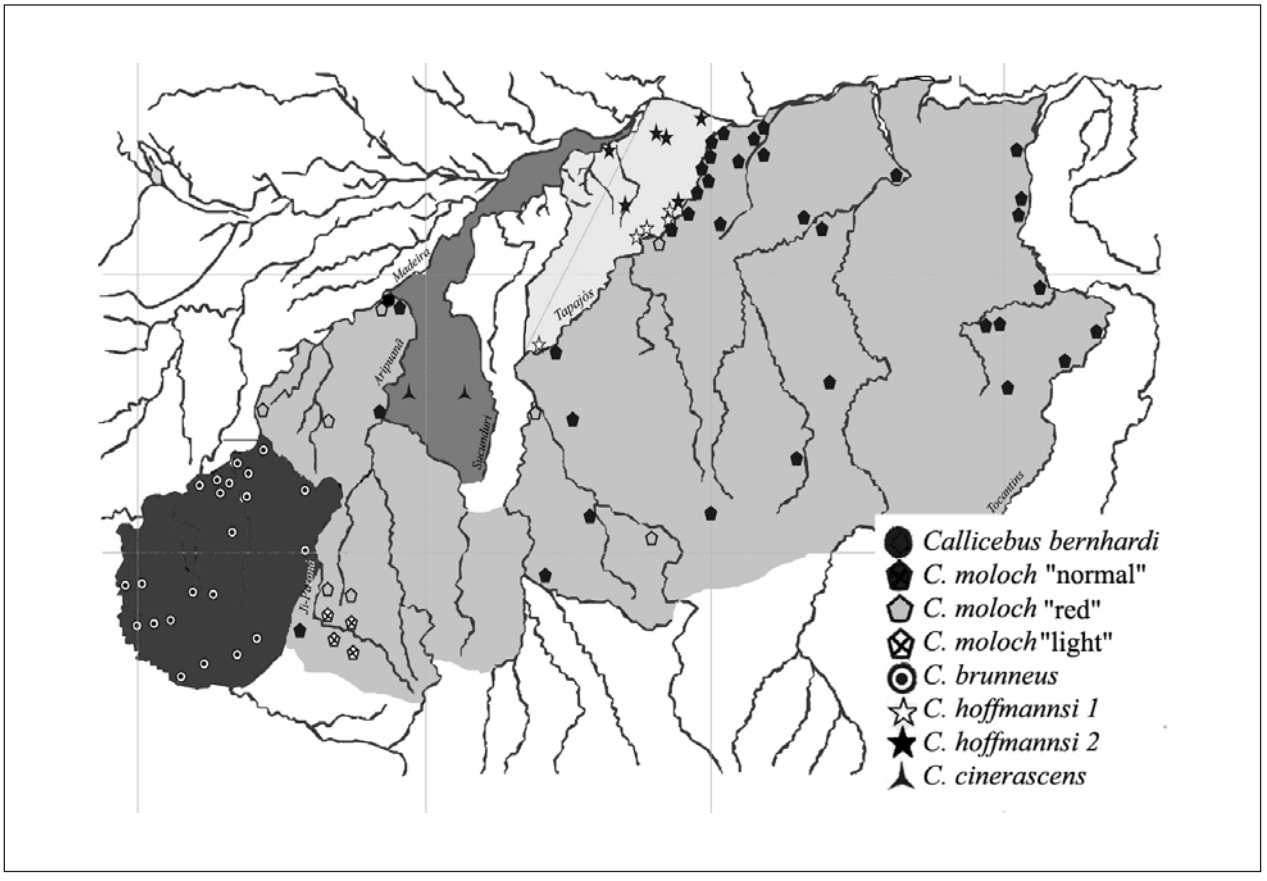

Figure 2. Map of collecting sites of *Callicebus* (*C. bernhardi, C. moloch* (3 forms), *C. brunneus*, *C. hoffmannsi* (2 forms) and *C. cinerascens*). Black arrow indicates a locality where all 3 phenotypes of *C. moloch* appear sympatric. Numbers refer to Appendix I localities.

hair showing light bands broader than dark ones) flanks, dorsal surface of limbs, feet and hands; lower-back light brown with a slight brown stripe along the middle back, slightly darker than the flanks, not washed with brown or it has very little amount of this pigment. The middle portion of tail is very dark (from dark brown to black) and the tip lightening to very light brown or dirty white. Beard, chest, belly and ventral surface of limbs are light orange-brown, more pigmented at the tip of hairs.

The general color pattern of all specimens follows the description above, but specimens IPBHN 207, 208, 209 (loc. 52, Ig Almas, Rio Juruena, extreme north of Apiacás, MT); MZUSP *18956* (loc.53 – RO, Nova Colina Polonoroeste); MZUSP 18964, 20253, *20255*, 20058, 20067 (loc.54 - RO, Nova Brasília Polonoroeste); MPEG 21972 (loc. 112 - PA, Ig. do Patauá, Município de Itaituba); MPEG 22000 (loc. 113 - PA, Apui, BR-230 Humaitá-Itaituba km 17) have the ventral pelage extremely pheomelanized of a live reddish-brown. These represent what I called *"red phenotype"*. A third phenotype, called here *"light phenotype"* has ventral parts much lighter, sort of a lime-yellow (specimens MZUSP 5198 and 5200 from loc. 82 – AM, Bom Jardim, right margin of Amazonas River); MPEG 22014, 22015, 22016, 22017 (loc. 109 – PA, UHE Tucuruí, Tocantins River); MPEG 245 (loc. 95 – PA, São João do Araguaia); MPEG 246 (loc. 94 – PA, Alto Iriri River, Xingu).

Roosmalen *et al.* (2002) described *C. bernhardi* and identified specimens MPEG 22996, 22997 (locality 50 - BR km 150 Apis-Humaitá, right margin of Marmelos River, AM); MPEG 24590 and 24591 (locality 55 - Alta Floresta, MT) as belonging to this taxon. Paratypes of *C. bernhardi* (INPA 4029 and 4033; locality 57 - AM River Mariepauá left aff. River Madeira) show the same chromogenetic pattern as *C. moloch*, with identical chromogenetic fields. These specimens differ only in color tone and pigment amount on the ventral surface, exactly as seen in the *"red phenotype"*. In Roosmalen *et al.* (*op. cit.*), diagnostic characters that distinguish *C. bernhardi* of *C. moloch* are described as follows: "*...by grayish forehead and crown, white ear tufts, and blackish tail with a distinct white pencil*". Actually, there is wide variation in forehead and crown color tone among all 183 specimens of the 3 phenotypes, from grayish to light red-brown, and the description above agrees perfectly with most specimens analyzed of "normal phenotype" as well.

Table 3. Material used for this study.

Species	Skins	Alive
C. moloch "normal phenotype"	154	
*C. moloch "red phenotype" / C. bernhardi**	20	
C. moloch "light phenotype"	9	
C. hoffmannsi	27	
C. brunneus	56	
C. dubius	1	
C. cupreus	70	
C. caligatus	2	1
TOTAL	**339**	**1**

Concerning the auricular tufts, none of 183 specimens of *C. moloch* (3 phenotypes) and those identified as *C. bernhardi* in INPA and MPEG that I could analyze, presented white auricular tufts (including *C. bernhardi* paratypes). Tails of all *"red phenotype"* specimens as well as *C. bernhardi* specimens are identical to *C. moloch*: black with a lighter tip. Drawings of *C. moloch* in Roosmalen *et al.* (2002) do not show a black tail and the whitish back of the hands, not matching all specimens analyzed. Thus, all specimens of the "*normal phenotype", "red phenotype", "light phenotype"* and those described as *C. bernhardi* show the same chromogenetic field pattern, differing, as mentioned, only in the amount of pigment (color tone) of the ventral surface.

Concerning the geographic distribution of *C. moloch* (all phenotypes), it is the broadest among all *Callicebus* species, occurring south of the Amazonas River, between the right margin of Madeira/Ji-Paraná Rivers to the left margin of Tocantins River. *C. moloch* is not found between the right margin of Aripuanã River and the left margin of Abacaxis River, where *C. cinerascens* is found (Noronha, *et al.* 2007). *Callicebus moloch* is found in Rondônia on both margins of the medium/upper Ji-Paraná River (Ferrari, *et al.* 2000), what is confirmed by specimens MZUSP 18956 (RO, Nova Colina Polonoroeste, right margin of Ji-Paraná River 10°48'S61°43'W, *"red phenotype";* MZUSP 18964, 20253, 20255, 20058, 20067 (RO, Nova Brasília Polonoroeste, right margin of Ji-Paraná River – 10°56'S61°20'W *"red phenotype",* and MPEG 19709, 19710, 19712, 19713 (Alvorada d'Oeste, BR 429 linha 64 km 87, left margin of Ji-Paraná River - 11°23'S62°18'W *normal phenotype.* Monção *et. al.* (2008) also assigned specimens they called *C. bernhardi* (here, "*red phenotype*") to 90 km west of Alto Alegre dos Parecis (Chapada dos Parecis, Rondonia).

Roosmalen (2002) states that there is a gap in the range of *Callicebus* at the southern portion of this region, between Sucunduri/Juruena River and Tapajós River. I could not find any specimens in Brazilian museums from this region. Wide rivers such as the Juruena / Teles Pires / Tapajós are no barriers isolating the three phenotypes of *C. moloch.* Gascon *et al.* (2000) observed that wide rivers are not always obstacles to put apart small mammals and frogs as well.

Localities for *C. bernhardi* indicated by Roosmalen *et al.* (2002) are: 51 (AM, Comunidade de Nova Olinda, right margin of Aripuanã River, Novo Aripuanã – holotype, INPA 3929 only skeleton) and 57 (AM, Mariepauá River, right tributary of Madeira River – paratypes of *C. bernhardi*). Specimens MNRJ 2480 and 2481 (from AM, right margin of São João do Aripuanã River) presents *"light phenotype*" and this locality is only 30 km straight line from locality 51 and 60 km from locality 57, mentioned

above, on the same bank of Aripuanã River. In the locality 109 (PA, UHE Tucuruí rio Tocantins) it is possible to find both *"light and normal phenotype*" as can be seen in specimens MPEG 21442, 21443, 22014, 22015, 22016, 22017, 22016 (normal phenotype) MPEG 22018 (light phenotype), one evidence of polymorphism. *"Red phenotype"* can be found far to the east from known localities of *C. bernhardi*. Specimens MPEG 21972 (locality 112- Ig. Patauá, Itaituba, PA), MPEG 22000 (BR 230 Itaituba, PA) and IPBHN 207, 208, 209 (locality 52- Ig. Almas, Juruena River, Apiacás, MT) are *"red phenotype"* (see Appendix I for coordinates). These localities are among others where phenotype can be *normal phenotype* or *light phenotype,* one more evidence of polymorphism.

One specimen from Alta Floresta (locality 55) MPEG 24590, label identificated as *C. bernhardi,* had its DNAmt sequenced and it is more similar to the sequence of IPBHN 207 (from Apiacás, MT), both *"red phenotypes"*. A phylogenetic analysis for *Callicebus* carried by me (to be published elsewhere) shows strong evidence for the three phenotypes of *C. moloch* to be considered a polymorphism of the same taxon. Also, *C. bernhardi* appears as sister group of *C. moloch*. It is possible to recognize a trend to a clinal variation along a east-west transect through the range of the species, with specimens from western localities showing more pigmented ventral parts (phenotype red) and specimens with lighter ventral parts (phenotype light) to the east. "Normal phenotype" is found throughout the range. Moore (2009) found similar results in *C. cupreus*. *C. hoffmannsi* showed similar south-north differences in ventral amount of pigments as can be seen bellow. Based on this, I suggest here *C. bernhardi,* Roosmalen *et al.* (2002), to be considered as a junior synonym of *C. moloch*.

2. *C. hoffmannsi*

Analysis of chromogenetic fields of *C. hoffmannsi* found two phenotypes differing only in the color tones of the ventral parts: *hoffmannsi 1,* yellow similar to that observed in typical *C. moloch*; and *hoffmannsi 2* which looks a very light lime-yellow. Pattern *hoffmannsi 2* is found north of pattern 1, the boundary between them set approximately by latitude 4ºS (Itaituba, Para) (Fig. 2). Despite color differences and non-overlapping ranges, I could not find any geographic barrier or an ecological feature supporting the possibility that *C. hoffmannsi* should be split into two taxa. So, I consider these two phenotypes as polymorphisms of the same species until other evidence of speciation arises.

3. *C. cupreus*

Callicebus cupreus also shows three phenotypes: **Phenotype 1:** forehead and crown reddish-cream (agouti hair banded with light stripes broader than the dark ones). Back and nape almost concolor with crown. Lower back similar, but washed with brown. Tail as back; arms, legs, chest, belly and ventral surface of an intense reddish brown, sometimes orangish. Back of hands and feet are brown, not agouti. **Phenotype 2:** specimens MZUSP11831 and 11832 from Pauini, AM, have arms, legs, chest and ventral surfaces orangish. **Phenotype 3** *C. cupreus* MZUSP7332 from Iquiri River, AM, holotype of *C. cupreus acreanus* and MZUSP5067 and 5068 from Santa Cruz do Eiru River have forehead and crown agouti-brown with black and cream, lighter than described for the phenotype 1, back as *moloch* and lower-back more brownish. Tail is dark-brown, gradually getting lighter to the tip, which is cream. Arms, legs, ventral surfaces and beard are dark reddish-brown, almost dark red.

Six specimens (MPEG 1587, 1588, 1605, 1608, 1609 and 1845) from Amazonas (Rio Javari, Estirão do Equador) are darker than the phenotype 3, described here. Phenotypes are distributed in four localities (Figure 2) that are inside the known distribution of *C. cupreus* and do not show a geographic pattern that could suggest an existence of more than one only taxon. As it was not possible to identify geographical limits that could indicate segregation among taxa, and it was not possible to perform a DNA analysis, definite considerations about the taxonomic status of *C. cupreus* must await, intra-specific color polymorphism being the best explanation for the observed pattern.

4. *C. cupreus, C. caligatus* and *C. dubius*

Grooves (2001) follows Hershkovitz (1990) in *Callicebus* taxonomy, but doubts him concerning some propositions. One of them considers *C. caligatus, C. dubius* and *C. cupreus* as synonyms. Roosmalen *et al.* (2002) described differences among these three species, considering all of them valid, a view I agree based on morphological grounds. All three show several distinctive characters, as pointed out by Roosmalen (2002) and revised here (shown in Table 2), such as the presence or absence of chromogenetic fields, e.g. frontal white and black stripes, tip of tail and white fingers.

Conclusions

C. bernhardi must be considered as a junior synonym of *C. moloch*, since the only difference between them is the amount of pigment in the hairs and it occurs in sympatry with *C. moloch* in several localityes. *C. hoffmannsii* shows two phenotypes with parapatric ranges, but without any defined geographic barrier that could support their assignment as two different taxa. Phenotype variation in *C. cupreus* is polymorphic, and do not show a geographic pattern that could support the idea of splitting it in more than one taxon; *Callicebus cupreus, C. dubius* e *C. caligatus* are distinct species since they present several distinctive characters and allopatric ranges.

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Appendix I

Collecting sites of all specimens analyzed. Label: Taxon indicated in label; Analysis = identification by the author of this article; Specimens = specimens' Number at collection; Listing numbers in bold are those cited in the map of Figure 2.

No	Collecting Locality	Coordinates	Label	Analysis	SPECIMENS
1	Colombia (loctip região de Villavicencio Rio Meta)	04°15'N 73°50'W	*C. ornatus*	*C. ornatus*	MNRJ 2486
2	Ecuador, Rio Anaray	00°30'S 76°22'W	*C. discolor*	*C. discolor*	MNRJ 3917
3	AM Ig. Iá Pq. Nac. Pico da Neblina	00°17'N 66°25'W	*C. lugens*	*C. lugens*	MNRJ 59657
4	AM, Barcelos, Rio Aracá Ig Jauari	00°10'S 63°05'W	*C. lugens*	*C. lugens*	MNRJ 67071
5	AM Ig. Japomeri, Rio Padauiri	00°00'S 64°00'W	*C. lugens*	*C. lugens*	CRB 2570 MNRJ 27070
6	RR Lago da Cobra dir. Rio Mucajaí	01°40'N 60°55'W	*C. torquatus*	*C. lugens*	MZ 9689, 9690
7	AM São Gabriel da Cacheira	00°07'S 67°04'W	*C. lugens*	*C. lugens*	INPA 4066
8	AM Rio Tootobi af.dir. rio Demini	01°40'N 63°34'W	*C. lugens*	*C. lugens*	MPEG 10018
9	AM Rio Mucajaí	02°45'N 62°00'W	*C. torquatus*	*C. lugens*	MPEG 1928, 1929, 1931,1932, 26374
10	PA 54 km S 150 km W de Altamira Gleba 61 lote 02	03°12'N 52°13'W	*C. torquatus*	*C. lugens*	MPEG20181 near Rio Uruará
11	AM, Rio Juruá	06°00'S 68°00'W	*C. regulus*	*C. regulus*	MZUSP 911; MZ911mounted
12	AM, Fonte Boa	02°33'S 66°02'W	*C. regulus*	*C. regulus*	MNRJ 2465, 21047, 25 899
14	AM Lg. Taoaria Grande, Rio Purus	6°30'S 64°15'W	*C. purinus*	*C. purinus*	MNRJ 2461
15	AM Lg. Ayapuá, R. Purus	04°28'S 62°08'W	*C. purinus*	*C. purinus*	MNRJ 2464, 2466, 2470
16	AM Porangaba mg.dir. rio Juruá Porto Walter	8°39'S 72°50'W	*C. cupreus*	*C. cupreus*	MPEG 22998 (black tail), 23000
17	AM Barro Vermelho mg.esq. rio Juruá Eirunepé	06°28'S 68°46'W	*C. cupreus*	*C. cupreus*	MPEG 23001
18	AM São Luiz do Mamoriá rio Purus	07°33'S 66°25'W	*C. cupreus*	*C. cupreus*	MPEG 270 (light colored)
19	Peru Iquitos Parque do MPEG	03°47'S 73°13'W	*C. cupreus*	*C. cupreus*	MPEG 253 (leucometopa), 672, 6874, 6875, 259
20	Peru Rio Marañons Iquitos	04°30'S 73°27'W	*C. cupreus*	*C. cupreus*	MPEG 677
21	AM Rio Javari Estirão do Equador	04°32'S 71°38'W	*C. cupreus*	*C. cupreus* 2	MPEG 1587, 1588, 1605, 1608,1609,1845
22	AC Rio Branco	9°57'S 67°48'W	*C. cupreus*	*C. cupreus*	MPEG 7102, 7103
23	AM Rio Jaquirana (Cach Jaquirana)	8°43'S 66°48'W	*C. cupreus*	*C. cupreus*	MPEG 8903
24	AM Lago Tefé Porto da Castanha	3°34'S 64°47'W	*C. cupreus*	*C. cupreus*	MPEG 13207, 13208, 13211
25	AM Santo Antonio do R. Eiru	07°10'S 70°25'W	*C. cupreus*	*C. cupreus*	MZUSP 4798,4805
26	AM Santa Cruz do R. Eiru	07°30'S 70°49'W	*C. cupreus*	*C. cupreus*	MZUSP 5054, 5057, 5062**,** 5064, 5066, 5067, 5068, 5069, 5070, 5071, 5072, 5073, 5076, 5077, 5081, 5082, 5085, 5086, 5087, 5088, 5089, 5090
27	AM Eirunepé	06°40'S 69°53'W	*C. cupreus*	*C. cupreus*	MZUSP 5052, 5055, 5056, 5058, 5059, 5060, 5061, 5063, 5065, 5074, 5075**,** 5078, 5079, 5080, 5083, 5084, 11534
28	AC Manoel Urbano	08°53'S 69°40'W	*C. cupreus*	*C. cupreus*	MZUSP 11237, 19542

No	Collecting Locality	Coordinates	Label	Analysis	SPECIMENS
29	AC Sena Madureira	09°04'S 68°44'W	*C. cupreus*	*C. cupreus*	IPBHN 820
30	AM, São Paulo de Olivença -Mata Juratuba	03°57'S 68°57' W	*C. cupreus*	*C. cupreus*	MNRJ 21049
31	AM Pauini	07°40'S 66°57'W	*C. cupreus*	*C. cupreus* 2	MZUSP 11831,11832
32	AC Iquiri	09°50'S 67°45'W	*C. cupreus*	*C. cupreus* 2	MZUSP 7332
33	RO EE Antonio Mugica Nava, Porto Velho esq Rio Madeira	09°24'S 64°56'W	*C. dubius*	*C. dubius*	*MZ (no number sat at time)*
35	AM Ig. Bacana marg. Oeste lago Jarí marg dir baixo Purus	04°00'S 61°20'W	*C. caligatus*	*C. caligatus*	INPA 4032; MZUSP 11722(unknown locality)
36	AM Humaitá Lábrea BR 230 km 41 mg.dir rio Ipixuna	07°30'S 63°23'W	*C. cupreus*	*C. caligatus*	MPEG 22011, 22012
37	AM Interfluvio R. Ipixuna e Mucuim no Purus	06°30'S 64°00'W	*C. stephennashi*	*C. stephennashi*	INPA 4030, 4031
38	AM médio e alto rio Purus	05°30'S 63°00'W	*C. stephennashi*	*C. stephennashi*	*INPA (no number sat at time)*
39	Bolivia Sta Cruz de la Sierra Provincia de Cercado	17°60'S 63°20'W	*C. donacophilus*	*C. donacophilus*	MNRJ 5537, 21059, 21060
40	MS Corumbá	19°00'S 57°38'W	*C. donacophilus*	*C. donacophilus*	MZUSP 3355, 3356, 3358, 3359, 3371
41	RO Alto Paraíso. Polonoroeste	09°37'S 63°27'W	?	*C. brunneus*	MZUSP 20075
42	RO Porto Velho	08°47'S 63°55'W	*C. brunneus*	*C. brunneus*	MZUSP 7798**,** 7799
43	RO Santa Bárbara	09°10'S 63°04'W	*C. brunneus*	*C. brunneus*	MZUSP 20141
44	RO Rio Machado Cach Nazaré	08°52'S 62°07'W	*C. brunneus*	*C. brunneus*	MZUSP 20432, 20433**,** 20434,20435; MPEG 22993, 22994, 22995
45	RO Pedra Branca	10°01'S 62°05'W	*C. brunneus*	*C. brunneus*	MZUSP 22897
46	RO Faz. Rio Candeias município Porto Velho	08°57'S 63°38'W	*C. brunneus*	*C. brunneus*	MPEG 10941,10942
47	RO UHE Samuel rio Jamari afl.dir. rio Madeira	08°40'S 63°25'W	*C. brunneus*	*C. brunneus*	**MPEG** 21686,21687, 21688, 21689, 21690, 21691, 21692, 21693, 21694,21695, 21696, 21697, 21698, 21699, 21700, 21701, 21702, 21703, 21704, 21705, 21706, 21707, 21710, 21711, 21748, 21795, 21943, 21944, 21945, 21946, 21947, 21948, 21949, 21954, 21955, 21956, 23035, **MNRJ** 28487, 28488, 28489
48	RO Calama margem direita Rio Ji-paraná	08°03'S 62°53'W	*C. moloch*	*C. brunneus*	MPEG 22006
49	PA Ig. Mundo novo margem direita do médio Rio Iriri	05°25'S 54°25'W	*C. moloch*	*C. moloch*	MPEG21836
50	AM BR-230 Humaitá-Apis km 150 mg.dir. rio Marmelos	07°45'S 61°44'W	*C. bernhardi*	*C. moloch* "red phenotype"	MPEG 22996, 22997
51	AM Com. Nova Olinda dir. R. Aripuanã Novo Aripuana	05°15'S 60°20'W	*C. bernhardi*	*C. moloch* "red phenotype"	INPA 3929 (holotype - only skeleton)
52	MT Apiacás Ig. Almas Rio Juruena	07°40'S 58°05'W	-	*C. moloch* "red phenotype"	IPBHN 207, 208, 209,
53	RO Nova Colina Polonoroeste	10°48'S 61°43'W	*C. moloch*	*C. moloch* "red phenotype"	MZUSP 18956
54	RO Nova Brasília Polonoroeste	10°56'S 61°20'W	*C. moloch*	*C. moloch* "red phenotype"	MZUSP 18964, 20253, 20255, 20058, 20067
55	MT Alta Floresta	09°52'S 56°04'W	*C. bernhardi*	*C. moloch* "red phenotype"	MPEG 24590, 24591
56	AM Com. Nova Olinda Rio Aripuanã	05°31'S 60°25'W	*C. bernhardi*	*C. moloch* "red phenotype"	INPA 3929

No	Collecting Locality	Coordinates	Label	Analysis	SPECIMENS
57	AM Rio Mariepauá aff. esq. Madeira	05°30'S 60°34'W	*C. bernhardi*	*C. moloch* "red phenotype"	INPA 4033 (paratype), 4029 (paratype)
58	AM Prainha Rio Aripuanã	07°16'S 59°19'W	?	*C. cinerascens*	MZUSP 11806, 11807**,** 11808, 11809, 11810, 11811, 11812
59	AM Prainha perto de Cipotuba m dir Rio Aripuanã.	07°16'S 60°20'W	?	*C. cinerascens*	INPA 4085
60	AM Lago do Batista marg dir R. Amazonas I. Tupinambarana	03°15'S 58°15'W	*C. baptista*	*C. baptista*	**MZUSP** 4802**,** 4957, 5141, 5145, 5161, 5162, 5163, 5164, 5168, 5170, 7168, 7169, 7173, 7174, **MNRJ** 5923, 5903, 6003
61	AM Tapaiuna marg dir R. Amazonas I. Tupinambarana	03°27'S 58°18'W	*C. baptista*	*C. baptista*	MZUSP 7166,7167,7171
62	Uíra Curapá	03°20'S 58°17' W	*C. baptista*	não visto	MGMvanR50
63	AM Parintins	02°50'S 56°45'W	*C. moloch*	*C. hoffmannsi*	MPEG 690
64	PA Fordlandia	03°47'S 55°35'W	*C. hoffmannsi*	*C. hoffmannsi* 1	MZUSP 11731, 11839
65	PA Itaituba marg esq R. Tapajós	04°18'S 56°05'W	*C. hoffmannsi*	*C. hoffmannsi* 1	MZUSP 3574, 3575, 3576
66	PA Brasilia Legal , marg esq R. Tapajós	03°55'S 55°35'W	*C. hoffmannsi*	*C. hoffmannsi* 1	MZUSP 11715, 11721, 11726
67	PA Vila Braga Tapajós	04°24'S 56°18'W	*C. hoffmannsi*	*C. hoffmannsi* 1	MPEG 251, MNRJ 2472
68	PA Jacareacanga 17km Rod. Transamazônica	06°15'S 58°00'W	*C. hoffmannsi*	*C. hoffmannsi* 1	IPBHN 444
69	PA Samauma R Tapajós	03°35'S 55°35'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MZUSP 11741, 11745
70	PA Aruã Rio Arapiuns marg esq R. Tapajós	02°40'S 55°50'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MZUSP 5091
71	PA Urucurituba marg esq Rio Tapajós	03°45'S 55°30'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MZUSP 10154, 10155, 11743, 11815, 11833, 19534
72	PA Santa Rosa Ilha de Urucurituba	03°48'S 56°33'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MZUSP 11834, 11835, 11836
73	PA Rio Arapiuns Santarém Tapajós	02°20'S 55°13'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MPEG 587
74	PA Vila Maripá, marg dir R Tapajós	02°39'S 55°57'W	*C. hoffmannsi*	*C. hoffmannsi* 2	MPEG 21444
75	PA Itaituba-Jacareacanga km 19	04°18'S 56°08'W	*C. hoffmannsi*	only skull	MPEG 8499, 8500, 8501, 8502
76	PA Monte Cristo marg dir R. Tapajós	04°05'S 55°38'W	*C. moloch*	*C. moloch*	MZUSP 3567, 3568, 3569, 11817
77	PA Taperinha	02°32'S 54°18'W	*C. moloch*	*C. moloch*	MZUSP 3570; MPEG 4733, 4734, 4735, 4736, 4737, 4738, 4739, 4740, 4743, 4744, 4745, 4746, 4747, 4748, 4749, 4750, 4751, 4752, 4753, 4754, 4755, 4756, 4757, 4758, 4759, 4760, 4761, 4762, 4763, 4764, 4765, 4766, 4767, 4768,4769, 4770, 4778
78	PA Santarém Faz Maruá	02°26'S 54°42'W	*C. moloch*	*C. moloch*	MZUSP 3571, 3572
79	PA Piquiatuba	03°03'S 55°07'W	*C. moloch*	*C. moloch*	**MZUSP** 5142,5153, 5155, 5156,5158, 5160, **MNRJ** 5981, 5979, 5980
80	PA Caxiricatuba R. Tapajós	02°36'S 54°56'W	*C. moloch*	*C. moloch*	MZUSP 5143, 5144, 5146, 5147, 5148, 5149, 5150, 5151, 5152, 5157, 5159, 5165, 5166, 5167, 5169, 24735
81	PA Foz do Curuá	02°23'S 54°05'W	?	*C. moloch*	MZUSP 5196, 5197, 5202
82	PA Bom Jardim dir Rio Amazonas	02°48'S 54°08'W	*C. moloch*	*C. moloch*	MZUSP 5198, 5200

No	Collecting Locality	Coordinates	Label	Analysis	SPECIMENS
83	Pa Cachimbo	09°22'S 54°58'W	*C. moloch*	*C. moloch*	MZUSP 8062
84	PA Fordlandia	03°47'S 55°23'W	*C. moloch*	*C. moloch*	MZUSP 10151, 10153,11716, 11717, 11718, 11719, 11720, 11723, 11724, 11725, 11727, 11728, 11729, 11730, 11732, 11733, 11734, 11735, 11736, 11737, 11738, 11739, 11740, 11742, 11744, 11813, 11814, 11816, 11837, 11838, 11840, 11841, 19690
85	PA Itapoama R. Tapajós	03°15'S 55°00'W	*C. moloch*	*C. moloch*	MZUSP 10152
86	PA Sto Antonio R. Tocantins	02°55'S 49°40'W	*C. moloch*	*C. moloch*	MZUSP 13472 (-= IPBHN 444 breast redish)
87	PA dir Rio Tapajós esq R. Mutuns	06°10'S 57°35'W	*C. moloch*	*C. moloch*	IPBHN 203
88	MT R. Arinos, aff dir R. Juruena	10°35'S 58 o00'W	*C. moloch*	*C. moloch*	MZUSP 11244 (SP Zoo), MNRJ 2915, 2923
89	PA Largo do Souza Rio Iriri	04°00'S 53°03'W	?	*C. moloch*	MZUSP 25441, 25442, 25443
90	PA Boca do rio Bacajá	03°25'S 51°48'W	?	*C. moloch*	MZUSP 25444, 25445
91	PA, Santarém, Rio Curuatinga, Aff Rio Curuauna	02°55'S 54°35'W	*C. moloch*	*C. moloch*	MNRJ 11590, 11593
92	PA, Alto Cururu	07°45'S 57°27'W	*C. moloch*	*C. moloch*	MNRJ 23867
93	PA, Rio Xingu	07°00'S 53°00'W	*C. moloch*	*C. moloch*	MNRJ 54834, 54835, 54836
94	PA Alto rio Iriri Xingu	08°20'S 53°30'W	*C. moloch*	*C. moloch* "light phenotype"	MPEG 246
95	PA São João rio Araguaia	06°14'S 48°23'W	*C. moloch*	*C. moloch* "light phenotype"	MPEG 245
96	PA Igarapé João Ribeiro mg.esq. rio Iriri	03°55'S 53°20'W	*C. hoffmannsi*	*C. moloch*	MPEG 21837, 21883
97	Luzilândia rio Araguaia Prox. Itaipava	06°41'S 48°50'W	*C. moloch*	*C. moloch*	MPEG 10932
98	PA Luzilândia rio Araguaia Xinguara	06°56'S 49°54'W	*C. moloch*	*C. moloch*	MPEG 10933, 10939
99	PA Serra Norte Carajás N1	06°0'S 50°16'W	*C. moloch*	*C. moloch*	MPEG 10943, 10944,11843
100	PA Serra Norte Carajás N2 área de manganês	06°00'S 50°00'W	*C. moloch*	*C. moloch*	MPEG 11832
101	PA 170 km S de Tucuruí Saúde mg.esquerda rio Tocantins	05°18'S 49°17'W	*C. moloch*	*C. moloch*	MPEG 12175, 12176
102	PA Santarém-Cuiabá Itaituba BR 165 zona Sul	04°05'S 54°55'W	*C. moloch*	*C. moloch*	MPEG 12627
103	PA Santarém Rod BR-163 km125 Flora do Tapajós. =78	03°27'S 55°10'W	*C. moloch*	*C. moloch*	MPEG 26406
104	MT Apiacás	09°30'S 57°05'W	*C. moloch*	*C. moloch*	*IPBHN 208, 209*
105	Alvorada d'Oeste BR 429 linha 64 km 87	11°23'S 62°18'W	*C. moloch*	*C. moloch*	MPEG 19709, 19710, 19712, 19713
106	AM, São João, R. Aripuanã	05°29'S 60°25'W	*C. moloch*	*C. moloch*	MNRJ 2480, 2481
107	PA, Santarém, Belterra = 80	02°39'S 54°57'W	*C. moloch*	*C. moloch*	MNRJ 5494
108	AM, Foz do Rio Castanho (R Roosevelt)	07°33'S 60°42'W	*C. moloch*	*C. moloch*	MNRJ 2482, 2484, 2485
109	PA UHE Tucuruí rio Tocantins	03°40'S 49°40'W	*C. moloch*	*C. moloch*	MPEG21442, 21443, 22014, 22015, 22016, 22017, 22016
109a	PA UHE Tucuruí rio Tocantins	03°40'S 49°40'W	*C. moloch*	*C. moloch* "light phenotype"	MPEG 22018

No	Collecting Locality	Coordinates	Label	Analysis	SPECIMENS
110	PA Mun Tucuruí Sítio Calandri acima da barragem mg esq Rio Tocantins	03°50'S 49°42'W	*C. moloch*	*C. moloch* "light phenotype"	MPEG 22015, 22016
111	PA, Ipanema, beira da Rodagem esquerda Santarém = 78	02°47'S 54°55'W	*C. moloch*	*C. moloch*	MNRJ 11588, 11591, 11592
112	PA Ig. do Patauá af. esq. Rio ?? Município de Itaituba	04°16'S 55°48'W	*C. moloch*	*C. moloch* "red phenotype"	MPEG 21972
113	PA, Apui, BR-230 Humaitá-Itaituba km 17	07°35'S 62°50'W	*C. moloch*	*C. moloch* "red phenotype"	MPEG 22000
114	(loctip 30 milles north Concepción, Paraguai)	22°50'S 57°27'W		*C. pallescens*	*Criad. Velho Jatobá*
115	Ba, Mirorós - Faz Conceição	11°24'S 42°17'W	*C. barbarabrownae*	*C. barbarabrownae*	UNB 1510
116	SE, Cristinapolis, Faz. Cruzeiro	11°28'S 37°45'W	*C. personatus*	*C. coimbrai*	MNRJ 30550
117	BA, (loctip Morro Dárara ou Faz Arara)	14°00'S 40°00'W	*C. melanochir*	*C. melanochir*	MZUSP 3884
118	MG Teófilo Otoni	17°52'S 41°28'W	*C. personatus*	*C. personatus*	MZUSP 2712, 2713, 2714
119	MG Baixo R. Suaçui	18°47'S 41°45'W	*C. personatus*	*C. personatus*	MZUSP 5839, 5931, 5932
120	ES Colatina	19°32'S 40°37'W	*C. personatus*	*C. personatus*	MZUSP 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227
121	ES Rio Doce	19°30'S 40°30'W	*C. personatus*	*C. personatus*	MZUSP 2409, 2410, 2411, 2412, 2413
122	ES Sooretama	19°00'S 40°00'W	*C. personatus*	*C. personatus*	MZUSP 11142, 11148, 111152, 111164, 11711, 11712, 11713, 11714, 11803, 11804, 11805
123	MG, Passos, Foz do Brejo, São João da Glória	20°42'S 46°37'W	*C. personatus*	*C. personatus*	MNRJ 21065, 21066, 25898
124	ES, São Domingos, Mata 10 de Agosto, Faz 10 de Agosto	19°08'S 40°38'W	*C. personatus*	*C. personatus*	MNRJ 21054, 21052, 21053
125	ES, Lagoa Juparaua, Sant´anna	19°22'S 40°07'W	*C. personatus*	*C. personatus*	MNRJ 2478
126	ES, Estrada Linhares, São Matheus km 54	19°15'S 40°05'W	*C. personatus*	*C. personatus*	MNRJ 21051
127	ES, Rio São José, Braço do Sul	19°05'S 40°40'W	*C. personatus*	*C. personatus*	MNRJ 54782, 54788
128	MG, Ituete, Rio Poço	19°25'S 41°18'W	*C. personatus*	*C. personatus*	MNRJ 11986
129	RJ Itatiaia	22°31'S 44°32'W	*C. nigrifrons*	*C. nigrifrons*	MZUSP 7426, 7427, 7428, 7429, 7430,19548
130	SP Serra da Cantareira	23°32'S 46°37'W	*C. nigrifrons*	*C. nigrifrons*	IPBHN 318
131	SP Itatiba	23°00'S 46°50'W	*C. nigrifrons*	*C. nigrifrons*	IPBHN 605, IPBHN 1016, IPBHN 1017
132	RJ, Itatiaia, Chevap - Funil	22°30'S 44°34' W	*C. personatus*	*C. nigrifrons*	MNRJ 25897
133	Cabeceiras do Paranatinga		*C. personatus*	*C. personatus*	MNRJ 3008
134			*C. personatus*	*C. personatus*	MNRJ 2479
135			*C. melanochir*	*C. melanochir*	MNRJ 11049
136			*C. purinus*	*C. purinus*	CPRJ 005

SEED DISPERSAL PATTERNS IN TWO CLOSELY RELATED HOWLER MONKEY SPECIES (*ALOUATTA PALLIATA* AND *A. PIGRA*): A PRELIMINARY REPORT OF DIFFERENCES IN FRUIT CONSUMPTION, TRAVELING BEHAVIOR, AND ASSOCIATED DUNG BEETLE ASSEMBLAGES

Katherine R. Amato[1*], Alejandro Estrada[2]

*[1] Program in Ecology, Evolution, and Conservation Biology, University of Illinois - Urbana/Champaign, email: amato1@illinois.edu, * Author for correspondence*
[2] Laboratorio de Primatología, Estación de Biología Tropical Los Tuxtlas, Instituto de Biología, Universidad Nacional Autónoma de México, email: aestrada@primatesmx.com

Abstract

Two-phased seed dispersal by primates and dung beetles is crucial for tropical rainforest regeneration. Two species of howler monkey exist in the tropical rainforests of southern Mexico: the mantled howler monkey (*Alouatta palliata*), and the black howler monkey (*A. pigra*). Differences between these species in foraging and traveling behavior, as well as associated dung beetle assemblages, may influence seed dispersal patterns. In this paper we present the results of a preliminary four-month study comparing the above aspects between a group of *A. palliata* (N = 15) in Los Tuxtlas, Veracruz and a group of *A. pigra* (N = 7) in Palenque National Park, Chiapas, Mexico. We observed each group in alternating months using focal sampling, fecal examination, and trapping of dung beetles. Results showed that the *A. palliata* group consumed more mature fruit, but both groups dispersed similar numbers of seeds over the study period (ca. 13,000 seeds). The total number of seed species collected from the feces of the *A. palliata* group was lower than for the *A. pigra* group (13 vs. 31 species). The *A. palliata* group had a larger home range (33 vs. 6.25 ha) and average day range (202 vs. 126 m). More dung beetles from more species were associated with the *A. palliata* group (357 v. 99 beetles, 16 v. 8 species). The *A. palliata* group attracted more ball-rolling dung beetles (75.1% of total), while the *A. pigra* group attracted more burrowers (80.8% of total). Our results suggest important differences between black and mantled howler monkeys of southern Mexico as seed dispersers and highlight the need to consider foraging and ranging patterns, as well as associated secondary dispersers, when assessing seed dispersal by primates.

Key Words: howler monkeys, seed dispersal, *A. palliata*, *A. pigra*, dung beetles, Mexico

Resumen

La dispersión por primates y cucarrones estercoleros es crucial para la regeneración del bosque tropical. Dos especies de monos aulladores existen en los bosques lluviosos del sur de Mexico: el mono aullador de manto (*Alouatta palliata)*, y el mono aullador negro (*A. pigra).* Las diferencias entre estas dos especies en el comportamiento de forrajeo y desplazamiento, así como los ensamblajes de cucarrones estercoleros asociados, pueden influenciar los patrones de dispersión de semillas. En este artículo presentamos los resultados de un estudio preliminar de cuatro meses, comparando estos aspectos entre un grupo de *A. palliata* (N = 15) en Los Tuxtlas, Veracruz, y un grupo de *A. pigra* (N = 7) en el Parque Nacional Palenque, Chiapas, Mexico. Observamos cada grupo durante meses alternos utilizando el muestreo focal, examinando muestras de heces, y coleccionando cucarrones estercoleros. Los resultados mostraron que el grupo de *A. palliata* consumió más frutos maduros, pero los grupos de ambas especies dispersaron un número similar de semillas durante el período de estudio (ca. 13,000 semillas). El número total de especies de semillas coleccionadas de las heces del grupo de *A. palliata* fue más bajo que aquel para el grupo de *A. pigra* (13 vs. 31 especies). El grupo de *A. palliata* tuvo un área de rango vital más grande (33 vs. 6.25 ha) así como un recorrido diario promedio mayor (202 vs. 126 m). Más cucarrones estercoleros de más especies estuvieron asociados con el grupo de *A. palliata* (357 v. 99 cucarrones, 16 v. 8 especies). El grupo de *A. palliata* atrajo más cucarrones estercoleros peloteros (75.1% del total), mientras que el grupo de *A. pigra* atrajo más estercoleros cavadores (80.8% del total). Nuestros resultados sugieren importantes diferencias entre los aulladores negros y aulladores de manto del sur de Mexico como dispersores de semillas y resaltan la necesidad de considerar el forrajeo y los patrones de movimiento, así como los dispersores secundarios asociados, cuando se evalúa la dispersión de semillas por parte de primates.

Palabras Clave: monos aulladores, dispersión de semillas, *A. palliata, A. pigra*, cucarrones estercoleros, Mexico

Introduction

Large frugivorous primates are important seed dispersers for many tropical tree species (Link and Di Fiore 2006). Although birds disperse a larger number of seeds, primates disperse the seeds of twice as many plant species as birds via endozoochory (Clark et al. 2001), and their ecological services are critical for recruitment of many medium- and large-seeded plant species (Ponce-Santizo and Andresen 2006; Stevenson and Aldana 2008; Stoner et al. 2007). Additionally, many seeds ingested by primates undergo two-phase dispersal. Dung beetles attracted to primate feces act as secondary dispersal agents by accidentally burying seeds along with feces at the deposition site or, if the beetles are ball-rollers, a short distance away (Vander Wall and Longland 2004; Vulinec et al. 2006). This behavior may allow some seeds to escape post-dispersal predation and may provide ideal microclimatic conditions, increasing the probability of seed germination and establishment (Nichols et al. 2008; Vander Wall and Longland 2004; Vulinec and Lambert 2009; Vulinec et al. 2006).

Two species of howler monkeys exist in the tropical forests of southern Mexico. The mantled howler monkey (*Alouatta palliata)*, which is found throughout Central America and into western South America, and the black howler monkey (*A. pigra),* which is endemic to the area shared by Mexico, Belize, and Guatemala (Ford 2006; Rylands et al. 2006). Behavioral studies generally report similar resource use and activity budgets for *A. palliata* and *A. pigra* (Estrada 1984; Pavelka and Knopff 2004), and the reported values of species richness for dung beetle populations associated with each primate species (*A. palliata*: 33 sp.; *A. pigra*: 29 sp.) are also similar (Estrada and Coates-Estrada 2002; Ponce-Santizo and Andresen 2006).

Many seed dispersal studies assume that all primates disperse seeds similarly (Gross-Camp et al. 2009; Nunez-Iturri et al. 2008), and only a few studies compare seed dispersal by closely related primate species in similar habitats (Knogge and Heymann 2003; Stevenson et al. 2002). However, based on differences in average body size (*A. palliata,* males: 4.5–9.8 kg, females: 3.1–7.6 kg; *A. pigra,* males: 11.1–11.6 kg, females: 6.2–6.6 kg, (Ford and Davis 1992) and group size (*A. palliata,* 5–16 indiv., average: 8 indiv.; *A. pigra*, 2– 12 indiv., average: 4 individuals, (Di Fiore and Campbell 2007; Van Belle and Estrada 2008), *A. palliata* and *A. pigra* may differ in seed dispersal patterns. In this paper, we report results from a short comparative study of *A. palliata* and *A. pigra* aimed at documenting daily travel patterns, seed species dispersed, and dung beetle species associated with howler monkey feces.

Methods

Data collection

The mantled howler monkey (*A. palliata*) was studied in a 2000 ha segment of the Los Tuxtlas Biosphere Reserve in the region of Los Tuxtlas, Veracruz (18°35'08.63"N, 95°04'26.99"W), and the black howler monkey (*A. pigra*) was studied in Palenque National Park (PNP) (~1800 ha; 17°29'12.02"N, 92°03'01.05"W), Chiapas, both in southeast Mexico (Fig. 1). At both sites vegetation is classified as tall, tropical rainforest, and the altitudinal gradient ranges from 150m to 500m above sea level (Estrada 1984; Estrada et al. 2002). Sampling was conducted in areas of continuous forest at both sites. Focal samples were collected for one group of *A. palliata* (N = 15) in Los Tuxtlas during March and May 2008, and for one group of *A. pigra* (N = 7) in PNP during February and April 2008 for eighteen days each month. We collected 135 and 120 hrs of continuous focal samples on the *A. palliata* group and *A. pigra* group, respectively. To control for differences in group size and observation time, all focal data for each species were pooled across individuals and an average focal observation for each species was calculated. We assumed that by alternating monthly observations for each howler group/species during the dry season (Estrada et al. 2002; Estrada and Coates-Estrada 2002) at both sites that, to a certain extent, we compensated for seasonal effects in the data. Additionally, sampling took place during the high-fruit season in both forests. In Los Tuxtlas, *A. palliata* consumes the most mature fruit between March and October (Estrada 1984; Estrada and Coates-Estrada 1991), and in PNP, *A. pigra* consumes the most mature fruit between March and July (Estrada and Muñoz, unpublished data). Studies of dung beetles in Los Tuxtlas have demonstrated that dung beetle populations during the same months (Estrada et al. 1993). No previous studies have examined the dung beetle population at PNP, but because the annual rainfall profile generally matches that observed at Los Tuxtlas (Estrada and Muñoz, unpublished data), seasonal fluctuations in the dung beetle population are likely similar to those in Los Tuxtlas.

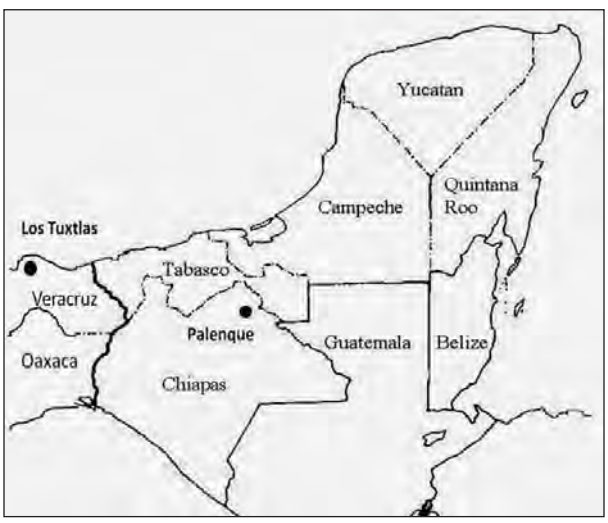

Figure 1. Location of study sites in southeast Mexico.

Focal samples were completed between 06:00 and 15:00 hrs each day to allow time for fecal sample processing. Each sample lasted between five and 15 min (avg.: 14 min ± 3). Focal individuals were chosen in a random order, and sampling was rotated until all individuals in the group were sampled. For each sample, the occurrence and duration of feeding (ingestion of plant material) and travel (group movement from one tree to another) activity was recorded. During feeding observations, the type of plant part ingested was recorded and identified to the species level. A scaled topographic map was used to estimate the distances traversed by the howlers. Total group biomass was estimated using the median body weight for each species (Ford and Davis 1992), and group biomass per hectare was calculated using the home range estimate from each map. Both groups were known to have only one neighboring group, and home range overlap was negligible. Only two *A. palliata* and three *A. pigra* intergroup interactions were observed during the study period.

Fecal samples were collected each day and examined for seeds. Seeds collected from the fecal samples were counted and, when possible, identified to species by comparison to the seed collection at the Los Tuxtlas field station and the National Herbarium housed at the Institute of Biology of the Universidad Nacional Autónoma de México. In the case of seeds < 1 mm in length occurring at high densities, the number of seeds in the sample was estimated by sample volume (seeds/30 mL feces).

Sampling of dung beetles was conducted at each site within the home range of the study groups using 10 pit-fall traps (15 cm in height × 5 cm width) baited with 60 g of feces from the howler species present. Traps were placed at 50 m intervals along a 500 m sinuous transect (Larsen and Forsyth 2005) and remained there for 24 hr. The traps were located about 1 m off of the main trail in ecologically similar locations at each site. Sampling was repeated three times per months at each site, and three distinct transects were used each month in an effort to fully represent each group's home range. Dung beetles encountered in the traps were counted and, when possible, identified to species by comparison of specimens with the dung beetle collection at the Los Tuxtlas field station.

Data analysis

Because individuals were sampled randomly, and no individual was sampled two times consecutively, focal samples were assumed to be independent. The proportion of time spent traveling and feeding on each resource during a given focal sample were compared between groups using a Kruskal-Wallis test with a Bonferroni correction (R Software). The amount of time dedicated to feeding on each mature fruit species was expressed as a percent of total mature-fruit consumption time. Total average distance traveled per day during the observation period was compared between howler monkey groups using a two-tailed, one-way ANOVA, after log-transformation (JMP 7.0). Since tree crowns as large as 50 m have been measured in the tropical forests of southeastern Mexico (Estrada and Coates-Estrada 1984), only daily movements of 50 m or more were considered as contributions to seed dispersal. Home range was calculated by using a gridded topographic map (50 × 50 m) of the study site to count the number of quadrants in which the group was present during monthly observations.

The number of seeds dispersed per day and the number of seeds per milliliter of fecal sample were compared using a two-tailed, one-way ANOVA (JMP 7.0). A chi-squared test was used to compare the total number of seeds dispersed, the number of large and small seeds dispersed, the total volume of feces produced, and the estimated biomass of each group. Shannon's diversity index (H') and Sorenson's similarity quotient were calculated to compare the dung beetle populations collected at each study site (Estrada and Coates-Estrada 2002).

Results

On average, both howler groups spent a similar percentage of time feeding on fruit during a focal sample (*A. palliata:* 9.27 % ± 5.05, *A. pigra:* 11.21 % ± 4.76; $\chi^2 = 0.81$, df = 1, p = 0.37; Table 1). Consumption of mature fruit accounted for 8.54 % ± 4.94 of an average focal sample for the *A. palliata* group and 5.28 % ± 2.96 for the *A. pigra*

Table 1. Average percent time individuals from the *A. palliata* and *A. pigra* groups spent consuming fruit and leaves during any given focal sample (N = 584 and 547 focal samples, respectively). Comparisons between groups were performed using a Kruskal-Wallis test with Bonferroni correction. Asterisks indicate significant p values. All medians = 0%.

	Alouatta palliata		*Alouatta pigra*		Kruskal-Wallis		
	Average	SD	Average	SD	χ^2	df	p
Fruit	**9.27**	**5.056**	**11.21**	**4.76**	**0.80**	**1**	**0.37**
Mature fruit	8.54	4.94	5.28	2.96	2.69	1	0.10
Young fruit	0.73	1.29	5.93	3.28	11.53	1	0.00069*
Leaves	**2.66**	**2.06**	**10.24**	**4.89**	**11.31**	**1**	**<0.00077***
Mature leaves	0.46	0.72	1.86	2.30	2.75	1	0.097
Young leaves	2.21	1.81	8.38	2.96	11.35	1	<0.00076*

group (Table 1). During the study period the *A. palliata* group consumed the mature fruits of a total of nine species (Table 2), while the *A. pigra* group consumed the mature fruits of four species (Table 3). *A. palliata* group was observed consuming mostly *Ficus* species (Moraceae) (*F. pertusa:* 17.33% of mature-fruit feeding time, *F. colubrinae*: 15.30%, *F. insipida:* 15.65 %) (Table 2), and *A. pigra* group mostly *P. armata* (Moraceae) (43.04%) (Table 3).

Overall, fewer fecal samples were collected from the *A. palliata group* (156 samples = 3230 mL) than from the *A. pigra* group (167 samples = 4800 ml, $\chi^2 = 307.0$, df = 1, $p = 0.0001$). More seeds were collected from the fecal samples of the *A. palliata* group (13,756 seeds) than the *A. pigra* group (13,162 seeds; $\chi^2 = 13.1$, df = 1, $p = 0.0003$), and fecal samples contained seeds from 13 and 31 species, respectively (Tables 2 and 3). Based on both focal and fecal sample data, the *A. palliata* group utilized 18 fruit species during the study period, and the *A. pigra* group utilized 33. The majority of seeds recovered from both groups were from *Ficus* species (*A. palliata, F. eugeniafolia:* 43.7 % of *Ficus* seeds, *A. pigra, F.* sp. 1: 43.9 %; Table 2, 3). However, the seeds collected from the two groups varied in size. The largest seed found in fecal samples of *A. palliata* was 21 mm in length (unknown sp. 10) (Table 2), and the largest seed found in fecal samples of *A. pigra* was 40 mm in length (*Inga* sp. 1) (Table 3). Most seeds measuring < 3 mm belonged to the *Ficus* genus, and both howler groups expelled more seeds measuring < 3 mm than seeds measuring > 3 mm (*A. palliata:* $\chi^2 = 13022.2$, df = 1, $p < 0.0001$; *A. pigra:* $\chi^2 = 10831.2$, df = 1, $p < 0.0001$). However, the percent of total seeds deposited that were greater than 3 mm was smaller for the *A. palliata* group (1.3%) than for the *A. pigra* group (4.6%). These seeds belonged to four and 11 plant species, respectively. Feces from *A. palliata* contained slightly more seeds/ml than those from *A. pigra* (4 ± 4 seeds/ml and 2 ± 3 seeds/ml respectively; $F_{1, 64} = 7.63$, $p = 0.007$). However, both groups deposited similar numbers of seeds per day (*A. palliata:* 458 ± 643 (± SD), *A. pigra:* 376 ± 1030 (±SD); $F_{1, 64} = 0.15$, p = 0.70).

The *A. palliata* group used a larger home range (12.5 ha) than the *A. pigra* group (6.25 ha) during the study period. Therefore, despite differences in group size, both groups accounted for similar howler monkey biomass/ha (*A. palliata:* 6.1 kg/ha, *A. pigra:* 7.7 kg/ha, $\chi^2 = 0.185$, df =1, p = 0.33).

Table 2. List of seed species collected from howler fecal samples and mature fruit species howlers were observed consuming in Los Tuxtlas (*A. palliata*). Quantity of seeds from each plant species is reported using the absolute number and the percent of total seeds collected in each site. Also shown is the percent of mature-fruit feeding time howlers devoted to consuming a particular species. Species recorded from focal samples only are highlighted in bold. Values for seed size marked with an asterisk were estimated in the field. Values without an asterisk were obtained from Croat (1978).

Species/Morphotype	Family	Lifeform	Type of Fruit	Percent Feeding Time	Number Seeds	Percent Total Seeds	Seed Size (mm)
Brosimum alicastrum	Moraceae	Tree	drupe	10.96	-	-	15
Coussapoa purpusii	Moraceae	Tree	drupe	drupe	-	-	-
Ficus pertusa	Moraceae	Tree	syconium	17.33	-	-	<1*
Ficus sp.	Moraceae	Tree	syconium	2.65	-	-	<1*
Ficus tecolutensis	Moraceae	tree	syconium	7.07	-	-	<1*
sp. 1	-	-	-	0.53	-	-	-
Ficus eugeniaefolia	Moraceae	tree	syconium	-	5679	43.70	<1*
Ficus colubrinae	Moraceae	tree (strangler)	syconium	15.30	3925	30.20	1*
Ficus insipida	Moraceae	tree	syconium	15.65	1647	12.67	2*
Ficus petenensis	Moraceae	tree (strangler)	syconium	-	1462	11.25	1*
Cecropia obstusifolia	Cecropiaceae	tree	drupe	0.88	808	6.22	2*
Poulsenia armata	Moraceae	tree	aggregate	15.83	116	0.89	4, 10*
sp. 10	-	-	-	-	37	0.28	21*
sp. 5					33	0.25	
sp. 11	-	-	-	-	26	0.20	3*
Cynometra vetusa	Fabaceae	tree	drupe	8.66	16	0.12	13*
Smilax sp.1	Smilicaceae	vine	berry	-	4	0.03	8*
sp. 13	-	-	-	-	2	0.02	3*
sp. 12					1	0.01	
Total Species = 18 Total Seed					**13,756**		

The average proportion of time spent traveling also did not differ between groups (*A. palliata:* 0.058 ± 0.055, *A. pigra:* 0.069 ± 0.018; $\chi^2 = 2.23$, df = 1, p = 0.13). During the study period, the *A. palliata* group traveled less than 50 m on 12 of the 34 days during which it was followed. The *A. pigra* group traveled less than 50 m on 15 of 34 days. Excluding these days, the *A. palliata* group had a marginally significantly larger day range (202 ± 149 m, range: 50–630 m) than the *A. pigra* group (127 ± 66 m, range 50–250m; $F_{1, 40} = 4.15$, $p = 0.048$).

At Los Tuxtlas, pit-fall traps captured 357 beetles belonging to 16 species (avg beetles/session = 59.50 ± 78.69), while in Palenque they captured 99 beetles belonging to eight species (avg. beetles/session = 16.50 ± 12.68) (Table 4). There was some evidence for higher dung beetle species

Table 3. List of seed species collected from howler fecal samples and mature fruit species howlers were observed consuming in Palenque (*A. pigra*). Quantity of seeds from each plant species is reported using the absolute number and the percent of total seeds collected in each site. Also shown is the percent of mature-fruit feeding time howlers devoted to consuming a particular species. Species recorded from focal samples only are highlighted in bold. Values for seed size marked with an asterisk were estimated in the field. Values without an asterisk were obtained from Croat (1978).

Species/Morphotype	Family	Lifeform	Type of Fruit	Percent Feeding Time	Number Seeds	Percent Total Seeds	Seed size (mm)
Brosimum alicastrum	Moraceae	tree	drupe	13.92	-	-	15
Ficus sp. 1	Moraceae	-	syconium	-	5599	43.87	<1*
Ficus sp. 9	Moraceae	-	syconium	-	3152	24.70	<1*
Ficus colubrinae	Moraceae	tree (strangler)	syconium	30.87	2670	20.92	1*
Poulsenia armata	Moraceae	tree	aggregate	43.04	459	3.60	4, 10*
Ficus pertusa	Moraceae	tree (strangler)	syconium	-	425	3.33	<1*
Ficus insipid	Moraceae	tree	syconium	-	379	2.97	2*
sp. 2	-	-	-	-	140	1.10	-
Ficus sp. 3	Moraceae	-	syconium	-	69	0.54	1*
Ficus sp. 2	Moraceae	-	syconium	-	40	0.31	1*
Ficus petenensis	Moraceae	tree (strangler)	syconium	-	38	0.30	1*
Cecropia obstusifolia					36	0.28	
sp. 6	-	-	-	-	33	0.26	8*
sp. 3	-	-	-	-	17	0.13	-
Ficus eugeniaefolia	Moraceae	tree	syconium	-	15	0.12	<1*
Ficus sp. 4	Moraceae	-	syconium	-	14	0.11	<1*
sp. 1	-	-	-	-	13	0.10	15*, 34*
Cynometra vetusa	Fabaceae	tree	drupe	12.15	11	0.09	13*
Ficus sp. 7	Moraceae	-	syconium	-	10	0.08	1*
Pseudolmedia oxyphyllaria	Moraceae	tree	drupe	-	10	0.08	10*
Dendropanax arboreus	Araliaceae	tree	berry	-	5	0.04	7, 5*
Ficus sp. 6	Moraceae	-	syconium	-	5	0.04	<1*
sp. 8	-	-	-	-	4	0.03	-
Cissus sp. 1	Vitaceae	vine	berry	-	3	0.02	9*
Ficus sp. 8	Moraceae		syconium	-	3	0.02	4*
sp. 4	-	-	-	-	3	0.02	-
Ocotea sp. 1	Lauraceae	tree	drupe	-	2	0.02	15*
sp. 5	-	-	-	-	2	0.02	-
Coussapoa purpusii	Cercropiaceae	epiphyte	aggregate	-	1	0.01	2*
Ficus sp. 5	Moraceae	-	syconium	-	1	0.01	2*
Inga sp. 1	Fabaceae	tree	legume	-	1	0.01	40
sp. 7	-	-	-	-	1	0.01	2*
Trichostigma octandrum	Phytolaccaceae	vine	drupe	-	1	0.01	5*
Total Species = 33 Total Seeds					**13,162**		

diversity at Los Tuxtlas (H' = 1.59, $E_{H'}$ = 0.57) than in Palenque (H' = 1.30, $E_{H'}$ = 0.63). Six dung beetle species were associated with both howler monkey groups, and Sorenson's quotient for dung beetles was 0.50. The most common beetle species associated with howler feces at Los Tuxtlas was *Canthon femoralis* (58.3 %; Table 4), and at PNP it was *Copris laeviceps* (56.6 %; Table 4). At Los Tuxtlas, most of the beetles captured were ball-rollers (75.1 %), while at PNP most were burrowers (80.8 %; Table 4). Also, at Los Tuxtlas 21.3 % of the beetles collected were nocturnal and 78.7 % were diurnal, while at PNP 62.6 % were nocturnal and 37.4% were diurnal (Table 4).

Discussion

Our behavioral and fecal samples data suggest that *A. palliata* and *A. pigra* differ somewhat in seed dispersal patterns despite being closely related. Previous studies report that *A. palliata* can incorporate between nine and 35 fruit species into its diet depending on the location, and in Los Tuxtlas, a year-long study documented 28 seed species in *A. palliata* feces (Estrada and Coates-Estrada 1991; Whencke et al. 2004). *A. pigra* utilizes 25 fruit species in fragmented forests in Belize, and a five-month study reported ten seed species in *A. pigra* feces in Guatemala (Marsh and Loiselle 2003; Ponce-Santizo and Andresen 2006). These data suggest that *A. palliata* is capable of consuming more seed species than the 18 documented in this study and that *A. pigra* consumes more seed species in PNP than in other locations. However, because this study directly compares the two species in similar forests during the same period of the year, the differences detected between *A. palliata* and *A. pigra* may indicate a potential distinction in plant-primate dynamics. Specifically, *A. palliata* appears to consume more mature fruit and disperse more total seeds while *A. pigra* appears to disperse a greater diversity of seeds.

Table 4. Dung beetle species collected in Los Tuxtlas (*A. palliata*) and Palenque (*A. pigra*). 60 traps were set in each site for 24 hours for a total of 1,440 trap hours at each site. Quantity of each beetle species is reported using the absolute number and the percent of total beetles collected in each site. Activity describes the time of day at which each species is active, and behavior describes fecal treatment.

Alouatta palliata				
Species	**Activity**	**Behavior**	**Number**	**Percent**
Canthon femoralis	diurnal	ball-roller	208	58.3
Copris laeviceps	nocturnal	burrower	52	14.6
Canthon euryscelis	diurnal	ball-roller	19	5.3
Deltochilum pseudoparile	nocturnal	ball-roller	12	3.4
Onthophagus batesi	diurnal	burrower	12	3.4
Canthon viridis vazquezi	diurnal	ball-roller	11	3.1
Dichotomius satanis	nocturnal	burrower	11	3.1
Neocanthidium martinezi	diurnal	ball-roller	7	2.0
Onthophagus rhinolophus	diurnal	burrower	7	1.0
Pseudocanthos perplexus	diurnal	ball-roller	5	1.4
Canthidium aff *ardens Bates*	diurnal	burrower	4	1.1
Canthon subhyalinus	diurnal	ball-roller	3	0.8
Canthidium perceptible	diurnal	burrower	2	0.6
Phanaeus chryseicollis	diurnal	ball-roller	2	0.6
Canthon sp.	diurnal	ball-roller	1	0.3
Copris lubgris	nocturnal	burrower	1	0.3
Total			**357**	
Alouatta pigra				
Species	**Activity**	**Behavior**	**Number**	**Percent**
Copris laeviceps	nocturnal	burrower	56	56.6
Onthophagus vatesi	diurnal	burrower	19	19.2
Canthon euryscelis	diurnal	ball-roller	15	15.2
Dichotomius satanis	nocturnal	burrower	4	4.0
Canthon femoralis	diurnal	ball-roller	2	2.0
Copris lubgris	nocturnal	burrower	1	1.0
Deltochilum gibbosum	nocturnal	ball-roller	1	1.0
Phanaeus endymion	diurnal	ball-roller	1	1.0
Total			**99**	

Differences in patterns of range-use and daily travel between the two howler groups also likely result in the production of different seed shadows (sensu Clark et al. 2005). Since both groups dispersed similar amounts of seeds per day, but the *A. palliata* group utilized a larger home range and day range than the *A. pigra* group, the seed shadow produced by the *A. palliata* group is likely less dense than that produced by the *A. pigra* group. These behavioral differences are unlikely to be a result of group size since group size in these species appears to be dictated by social constraints and not by food availability (Chapman and Pavelka 2005; Cowlishaw and Dunbar 2000; Van Belle and Estrada 2008). Similarly, because territory overlap among groups was minimal, these patterns are likely to remain constant across the entire territory. During the high-fruit season, seed dispersal patterns also appear to differ between howler species with regard to associated secondary dispersers. Previous research in the continuous forest of Los Tuxtlas described 20 dung beetle species associated with *A. palliata*, and a study of *A. pigra* in Guatemala documented 29 dung beetle species (Estrada and Coates-Estrada 1991; Ponce-Santizo and Andresen 2006). However, our data reveal a larger and more diverse dung beetle population associated with the *A. palliata* group than the *A. pigra* group, which may indicate a higher probability of secondary dispersal for seeds dispersed in *A. palliata* feces between February and May. Furthermore, most seeds dispersed by ball-rollers are less than 3 mm in length (Estrada et al. 1993; Vulinec et al. 2006). The *A. palliata* group was associated with more ball-rollers and dispersed fewer large seeds than the *A. pigra* group, and the *A. pigra* group was associated with more burrowers and dispersed more large seeds than the *A. palliata* group. Therefore, the effectiveness of seed dispersal by each howler species may depend on the interaction of seed size and secondary dispersal by dung beetles. The association of more diurnal dung beetles with the *A. palliata* group and more nocturnal dung beetles with the *A. pigra* group likely also influences patterns of secondary seed dispersal since a large proportion of diurnal dung beetles are ball-rollers which may move seeds up to 5 m from the initial deposit site while a large proportion of nocturnal dung beetles are burrowers which bury seeds on-site (Slade et al. 2007; Vulinec and Lambert 2009).

The subtle differences in howler seed dispersal behavior and associated dung beetle assemblages described in this study suggest an important distinction between black and mantled howler monkeys as seed dispersers. Further investigation of these differences in more groups of each species may broaden our understanding of how closely related primate species differing in associated secondary seed dispersal agents, among other features (e.g. body size and group size), may also differ in their contribution to the maintenance of plant diversity in their habitats. The participation of distinct dung beetle communities in processing the feces produced by each howler group during the high-fruit season also highlights the importance of dung beetles as secondary dispersers (Nichols et al. 2008). Recent studies have shown that the stability of this interface is altered by human-induced forest fragmentation and habitat isolation, which cause local declines in size or extinctions of primate and dung beetle populations (Andresen 2002; Estrada and Coates-Estrada 2002; Nichols et al. 2008; Ponce-Santizo and Andresen 2006). Such changes may result in significant modifications in patterns of recovery and distribution for many forest plant species. These modifications will have a strong impact on the persistence of primates in fragmented landscapes and on human livelihood and merit further investigation.

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Short Articles

Occorrência de Primatas No Parque Estadual do Ibitipoca e Entorno, Estado de Minas Gerais, Brasil

Denize Fontes Nogueira
Daniel da Silva Ferraz.
Aquila Fialho Oliveira
Fernanda Pedreira Tabacow
Sara Machado de Souza Amâncio
Fabiano Rodrigues de Melo

Introdução

A Mata Atlântica está sendo fortemente afetada pelos efeitos de fragmentação à semelhança das demais florestas tropicais do planeta. Depois da Amazônia, a Mata Atlântica é o bioma neotropical que apresenta a maior riqueza de espécies. Das cerca de 260 espécies de mamíferos que ocorrem no bioma (Mittermeier *et al*. 1998; Myers *et al*. 2000), 24 são primatas, sendo 17 endêmicas (Rylands *et al*. 1996; Mendes *et al.* 2003). Devido ao hábito arborícola, a destruição e a fragmentação da floresta, em alguns casos aliadas à caça, levaram cerca de 70% das espécies de primatas da Mata Atlântica à beira da extinção (Machado *et al*. 2008). Para agravar a situação, somente ¼ das áreas protegidas da Mata Atlântica tem área suficiente para sustentar populações viáveis de primatas (Chiarello 2000). O Estado de Minas Gerais, outrora amplamente coberto por florestas, tem registrado altos níveis estáveis de desmatamento na última década, resultando na redução da cobertura florestal de 47% para 33% de sua área total (Instituto Estadual de Florestas 2008). Embora esse cenário seja desfavorável para as espécies que dependem de florestas, levantamentos recentes têm localizado grupos remanescentes de primatas em várias áreas. A estimativa da população selvagem do muriqui-do-norte (*Brachyteles hypoxanthus*), espécie 'Criticamente Em Perigo', por exemplo, aumentou de 500 para mais de 900 indivíduos (Mendes *et al.* 2005). No entanto, a maioria de suas populações sobrevive em pequenos fragmentos florestais (Mittermeier *et al.* 1987; Strier 2000; Dias *et al*. 2005).

O Parque Estadual do Ibitipoca (PEIb) é um bom exemplo dessa paisagem fragmentada. A Floresta Ombrófila Densa Altimontana (Fontes *et al*. 1996) desta Unidade de Conservação (UC) e de seu entorno é habitada por cinco espécies de primatas: *Callicebus nigrifrons* (sauá), *Callithrix penicillata* (mico-estrela), *Alouatta guariba clamitans* (barbado), *Cebus nigritus* (macaco-prego) e *Brachyteles hypoxanthus* (muriqui-do-norte) (Hirsch *et al*. 1994; Fontes *et al*. 1996). Devido à carência de dados acerca da densidade e estado de conservação dos primatas no PEIb e nos fragmentos florestais de seu entorno, este trabalho visou descobrir novas populações remanescentes de muriquis, determinar parâmetros populacionais a fim de avaliar a necessidade de ampliação da área do PEIb ou de estabelecimento de um mosaico de UCs no seu entorno.

Metodologia

Área de estudo

O estudo foi realizado no Parque Estadual de Ibitipoca (Fig. 1) que é administrado pelo Instituto Estadual de Florestas-IEF, Estado de Minas Gerais, e em 22 fragmentos florestais localizados em propriedades particulares de seu entorno. O PEIb está localizado no município de Lima Duarte e faz divisa com os municípios de Bias Fortes a leste e nordeste e Santa Rita do Ibitipoca a noroeste. Os 22 fragmentos estão distribuídos em três regiões distintas: Mata do Patuá, Mata dos Luna e Mata Grande. A área dos fragmentos variou de 32 a 1600 ha.

O PEIb (21°42'32,3"S, 43°53'45,3"O; 1100-1782 m.a.n.m.; 1488 ha) faz parte do complexo da Serra da Mantiqueira situada nos municípios de Lima Duarte e Santa Rita de Ibitipoca, numa zona de transição entre a Mata Atlântica e o Cerrado (Hermann 2007). É considerada uma UC de alta importância biológica para a conservação de mamíferos da Mata Atlântica (Oliveira 2004; Biodiversitas 2005). A Mata Grande possui 70 ha (Rodela 1998) e compreende aproximadamente 47% da área total de Floresta Ombrófila

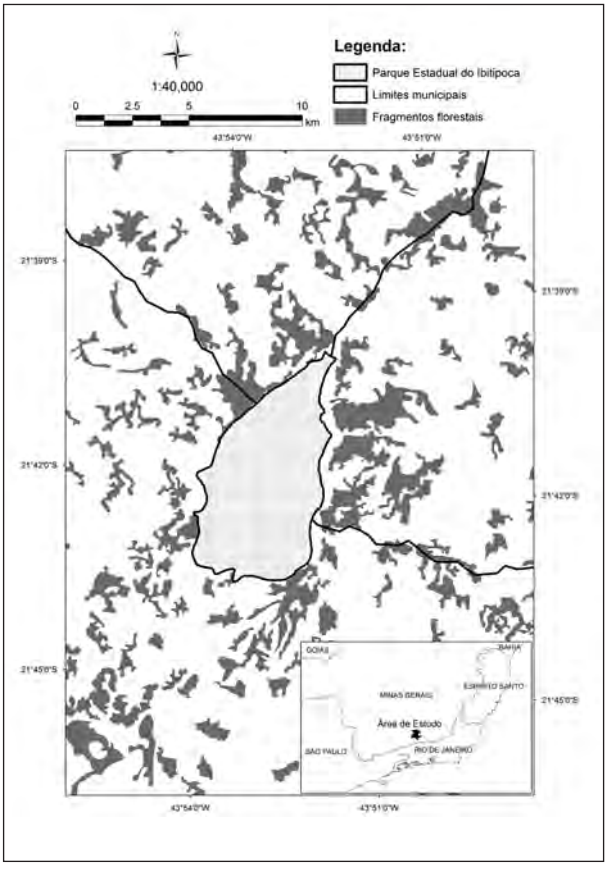

Figura 1. Cobertura vegetal na região do Parque Estadual do Ibitipoca, Lima Duarte, Estado de Minas Gerais, Brasil.

do PEIb (Oliveira 2003), representando um importante refúgio para espécies endêmicas e raras da fauna. A Mata do Patuá (21°42'26,4"S, 43°51'39,4"O) está localizada na base do morro do Gavião, paredão granítico que faz divisa com o PEIb, no município de Lima Duarte. O tipo fisionômico predominante é a Floresta Estacional Semidecidual Montana, na sua maior parte em estágio secundário de desenvolvimento devido a um intenso processo de corte seletivo. Próximos a este bloco de floresta, existem fragmentos em diversos estágios de regeneração, alguns dos quais encontram-se interligados nas cumeeiras dos morros por corredores de mata. A Mata dos Luna (21°38'42,5"S, 43°52'45,1"O) possui cerca de 32 ha e é caracterizada por Floresta Estacional Semidecidual Montana, a qual foi alterada por corte seletivo, embora possua áreas com árvores de grande porte (Araújo 2003). Está localizada a noroeste do PEIb no município de Santa Rita do Ibitipoca onde encontra-se isolada por áreas de atividade agropecuária.

As áreas de mata visitadas foram identificadas através da base cartográfica do IBGE (escala 1:50000), de imagens de satélite IKONOS e da indicação de proprietários e moradores. Treze campanhas de censo com duração de 5 a 7 dias (totalizando 60 dias de campo) foram realizadas no período de julho de 2004 a junho de 2006. Para localização dos grupos de primatas, foram percorridos transectos pré-existentes em bordas de mata, trilhas e estradas no interior do PEIb e nos fragmentos do entorno, a uma velocidade aproximada de 1,0 km/h conforme sugerido para o Método do Transecto Linear (Buckland *et al*. 1993). De forma oportunística foram registrados todos os avistamentos, vocalizações e fezes obtidos a pé ou a cavalo durante os deslocamentos entre os fragmentos. A utilização de *playback* também foi realizada durante as caminhadas. Entrevistas elaboradas na forma de roteiro também foram realizadas com a apresentação de fotografias das espécies da fauna com ocorrência comprovada para a área de estudo e a utilização de CD com gravação das vocalizações características de *B. hypoxanthus*, *C. nigrifrons*, *C. penicillata* e *A. g. clamitans*. A densidade de *B. hypoxanthus* foi calculada com base no número de indivíduos avistados dividido pela área total da Mata dos Luna (mapeamento total). Devido ao baixo número de avistamentos das demais espécies, foi calculado o índice de abundância relativa (taxa de encontro), expresso em número de indivíduos avistados por 10 km percorridos.

Resultados e Discussão

Foram obtidos 50 registros de primatas (13 no PEIb, 30 na Mata dos Luna e 7 na Mata do Patuá) distribuídos em cinco espécies: *C. nigrifrons* (18), *B. hypoxanthus* (17), *C. penicillata* (8), *A. g. clamitans* (6) e *C. nigritus* (1) (Tabela 1). *Brachyteles hypoxanthus* teve sua densidade estimada em 0,15 ind./ha, enquanto a taxa de encontro das demais espécies foi de 7,1 ind./10 km para *C nigrifrons*, 3,1 ind./10 km para *C. penicillata*, 2,4 ind./10 km para *A. g. clamitans* e 0,4 ind./10 km para *C. nigritus*. A riqueza de espécies encontrada está de acordo com o citado por vários autores (Hirsch *et al.* 1994; Fontes *et al.* 1996; Melo *et al.* 2002; Oliveira 2004; Hermann 2007). À semelhança de Melo *et al.* (2002) e Oliveira (2004), *B. hypoxanthus* foi registrado somente na Mata dos Luna, observação compatível com a hipótese de Oliveira (2004) e Hermann (2007) de que a espécie está extinta no PEIb. Além disso, o presente estudo constatou um declínio no tamanho populacional da espécie nesta localidade. Enquanto Oliveira (2003) relata a presença de um grupo composto por 10 indivíduos, Melo *et al.* (2004) registraram apenas sete indivíduos adultos (quatro machos e três fêmeas) no mesmo grupo. No levantamento de 2005 verificou-se que as fêmeas haviam desaparecido, permanecendo até 2009 apenas os quatro machos adultos (F. R. Melo, obs. pess.). Este resultado é compatível com o sistema social de *Brachyteles* spp., no qual as fêmeas subadultas dispersam de seus grupos natais e os machos são filopátricos (Strier 1992; Printes & Strier 1999). Devido à provável ausência da espécie nos fragmentos florestais do entorno da Mata dos Luna, o que inviabiliza a imigração de fêmeas para essa área, apenas estratégias de manejo visando a suplementação dessa população poderão evitar a sua extinção (Melo *et al*. 2004). A recente extinção da população do fragmento florestal de 44 ha da Fazenda Esmeralda, Rio Casca, é um testemunho dessa realidade. Inicialmente composto por 15 a 16 indivíduos, o grupo estudado por Fonseca (1985) e Lemos de Sá (1991) foi extinto em 2008 após a transferência do último indivíduo para o cativeiro (F. R. Melo, obs. pess.).

Tabela 1. Espécies de primatas encontradas nas três regiões de estudo e seus respectivos métodos de amostragem, Lima Duarte, Minas Gerais.

Área Selecionada	Espécies	Métodos de Amostragem	Total
Mata Grande (PEIb)	*A. g. clamitans*	Avistamento	3
	C. nigrifrons	Avistamento	5
	C. penicillata	Avistamento	4
	C. nigritus	Avistamento	1
Mata dos Luna	*B.hypoxanthus*	Avistamento Vocalização (playback)	17 1
	C. penicillata	Avistamento Vocalização (playback) Entrevista	3 9 2
	C. nigrifrons	Avistamento Vocalização (playback)	10 36
	A. g. clamitans	Vocalização espontânea	1*
Patuá	*C. penicillata*	Avistamento Entrevista	1 1
	A. g. clamitans	Entrevista Avistamento	1 3
	C. nigrifrons	Entrevista Avistamento	1 3

O registro de apenas três indivíduos de *C. nigritus* na área do PEIb também requer atenção, pois segundo Chiarello (2000) essa espécie é pouco discreta e possui alta taxa de encontro. Essa característica, por sua vez, pode tornar a espécie mais vulnerável à caça (Johns & Skorupa, 1987). Embora a espécie não esteja sob ameaça de extinção, ela é encontrada em baixas densidades na região e não foi citada para a área do PEIb nas entrevistas com os funcionários do Parque e os moradores da comunidade de Conceição do Ibitipoca. Registros semelhantes da espécie na Mata Grande, localizada no interior do PEIb, por Drumond (1989), Oliveira (2004) e Hermann (2007) reforçam as observações desta pesquisa.

Por fim, o pequeno tamanho populacional dessas espécies vivendo em fragmentos isolados compromete sua sobrevivência (Bernardo & Galetti 2004). Neste sentido, Chiarello & Melo (2001) sugerem que apenas fragmentos florestais > 20000 ha são capazes de manter populações viáveis de primatas em longo prazo. Portanto, os 32 ha da Mata dos Luna estão muito aquém do necessário para a manutenção de uma população mínima de 50 indivíduos. Consequentemente, os limites do PEIb são insatisfatórios para garantir a sobrevivência das espécies na região, o que reforça a necessidade de implantação de um mosaico de Unidades de Conservação no seu entorno. Desta forma, o incentivo à criação de Reservas Particulares do Patrimônio Natural (RPPN's) e Refúgios de Vida Silvestre Estaduais pode viabilizar o estabelecimento desse mosaico. Também é possível aumentar a conectividade estrutural entre os fragmentos por corredores de mata ciliar, a qual se encontra constituída por vegetação em estágio avançado de recuperação (D. F. Nogueira, obs. pess.). Corredores ecológicos entre a Mata do Luna e outros fragmentos com a mata do PEIb ampliariam a área de habitat disponível e poderiam restabelecer o fluxo gênico entre as populações isoladas, mitigando os efeitos da fragmentação florestal.

Denize Fontes Nogueira, Instituto Estadual de Florestas (IEF/MG). Rua Espírito Santo,495 – Centro Belo Horizonte, Minas Gerais – Brasil. CEP: 30166-030, e-mail: <denize.fontes@meioambiente.mg.gov.br>, **Daniel da Silva Ferraz, Aquila Fialho Oliveira, Fernanda Pedreira Tabacow, Sara Machado de Souza Amâncio** e **Fabiano Rodrigues de Melo***, CECO-Centro de Estudos Ecológicos e Educação Ambiental. Rua Caparaó, 122, Centro, Carangola/MG CEP: 36800-000, *Universidade Federal de Goiás, Campus de Jataí - Br 364, Km 192, nº 3.800, Parque Industrial, Jataí, Goiás 75801-615, e-mail: <frmelo@carangola.br>

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PREDATION OF ADULT PALMS BY BLACK-CAPUCHIN MONKEYS (*CEBUS NIGRITUS*) IN THE BRAZILIAN ATLANTIC FOREST

Carlos Rodrigo Brocardo
Henrique Santos Gonçalves
Valesca Bononi Zipparro
Mauro Galetti

Introduction

Neotropical primates affect plant population through mutualistic interactions, such as seed dispersal, and antagonist interactions such as seed predation and herbivory (Peres, 1993; Russo and Augspurger, 2004; Mourthé *et al*., 2008). Primates killing trees through herbivory is rarely documented (Rocha, 2000; Santos *et al*., 2007). The genus *Cebus* (Erxleben, 1777) is considered as having the widest diet plasticity among neotropical primates, eating leaves, seeds, fruits, invertebrates and even vertebrates (Fedigan, 1990; Galetti and Pedroni, 1994; Susan and Rose, 1994; Rose, 1996; Ludwig *et al*., 2005; Carretero-Pinzón *et al*., 2008; Freitas *et al*., 2008). In this paper, we documented the predation of two palm species through the consumption of palm heart (apical meristem) by black-capuchin monkey (*Cebus nigritus* Goldfuss, 1809).

Materials and methods

Our observations were carried out between June 2009 and June 2010 in "Carlos Botelho" State Park (CBSP) (24°06' and 24°14'S; 47°47' and 48°07'W), in São Paulo State, Brazil. The CBSP has an area of 37,644 ha of Atlantic Forest, and it is located in the Forest *Continuum* of Paranapiacaba massif. The annual average temperature varied

from 15 to 19 °C, and the annual precipitation varied from 1700 to 2400 mm (Instituto Florestal, 2008). The density of black-capuchin monkeys in this site is estimated at 10.5 (± 2.4 SE) individuals/km², and the average group size is 5.16 (± 0.55 SE) individuals (Galetti *et al*., unpub. data).

The records of palm heart predation (directly and indirectly) were taken during line transects of mammal survey (430 km, approach 500 hours) and during the displacements to line transects in the forest (about 200 field hours). Despite that the *C. nigritus* groups were not accompanied directly, the animals are relatively habituated to observers. The line transects surveys were carried monthly (10–15 days per month), when we encounter predation events, *ad libitum* observations were made (with binoculars or naked eye), each predation event was recorded by a single observer. We sampled adult trees through randomized 15 0.04-ha plots, and juvenile trees through 15 0.01-ha plots to estimate the capuchin-monkey palm predation (sampling tree adapted from Durigan, 2003). Chi-square analysis was used to estimate differences in predation intensity between seasons.

Results

We observed capuchin-monkeys preying upon palm hearts of *Euterpe edulis* Mart. in 14 occasions, being 12 times in the Winter (May – August), once in the Summer (November – February), and once in the Autumn (February – May). We recorded from one to four capuchin-monkeys (sub-adult and adult) feeding simultaneously on apical meristem, but each animal on a different palm. The group size in these events varied from 3 to 12 black-capuchin monkeys. Capuchin monkeys spend between 10 to 40 minutes (mean 25 ± 4 SE) to open the palm heart, varying principally with palm diameter. Initially, the monkeys bite the outer leaves, forcing them down using both hands, remaining supported with tail and posterior members on the palm stipe, then they repeat this process until liberate the apex of most leaves. After that, the animals bite the apex basis, to release it from the stipe, and consumed the apical meristem on other tree.

We found other 44 *E. edulis* killed by capuchins along the forest trails, of which 38 palms were killed in the Winter, four in the Summer, and two in the Autumn. The presence of recently signals permitted the identification of predation period (recently withdrawn leaves on the ground, recently destroyed apices and remains of consumed meristems; Fig. 1A and 1B). Other 12 palms were too old to determine the season of the predation (resting only the old destroyed apices). Considering direct and indirect observations of palms predation (only events where was possible determining the period of predation), the consumption of *E. edulis* differed significantly between seasons ($\chi^2 = 73.0$, $df = 2$, $p < 0.001$), being 10 times higher in the Winter than Summer, and 18 times greater than in the Autumn. The *E. edulis* palms killed had diameter at breast height from 8.6 to 15.4 cm (mean 12.8 ± 0.55 SE) and height from 7 to 20 m (mean 12.2 ± 0.94 SE). *E. edulis* is the most abundant arboreal plant in the study area, with a mean density of 93.3 (± 22.8 SE) adults/ha and 706.6 (± 90.7 SE) juveniles/ha. We estimated *E. edulis* adult mortality by capuchin monkeys at 1.7 (± 1.6 SE) individuals/ha per year (1.8 % of adult population).

Moreover, for the first time, we observed the predation of palm heart of *Geonoma gamiova* Barb. Rodr., an understory palm species, with height up to 4 m. Two adults *G. gamiova* were upon preyed by two adult capuchin monkeys (in the Winter). The process is similar to *E. edulis*, but beyond the animals supported on the palm, they supported in near lianas, taking for predation 8 minutes for a palm and 9 minutes for other.

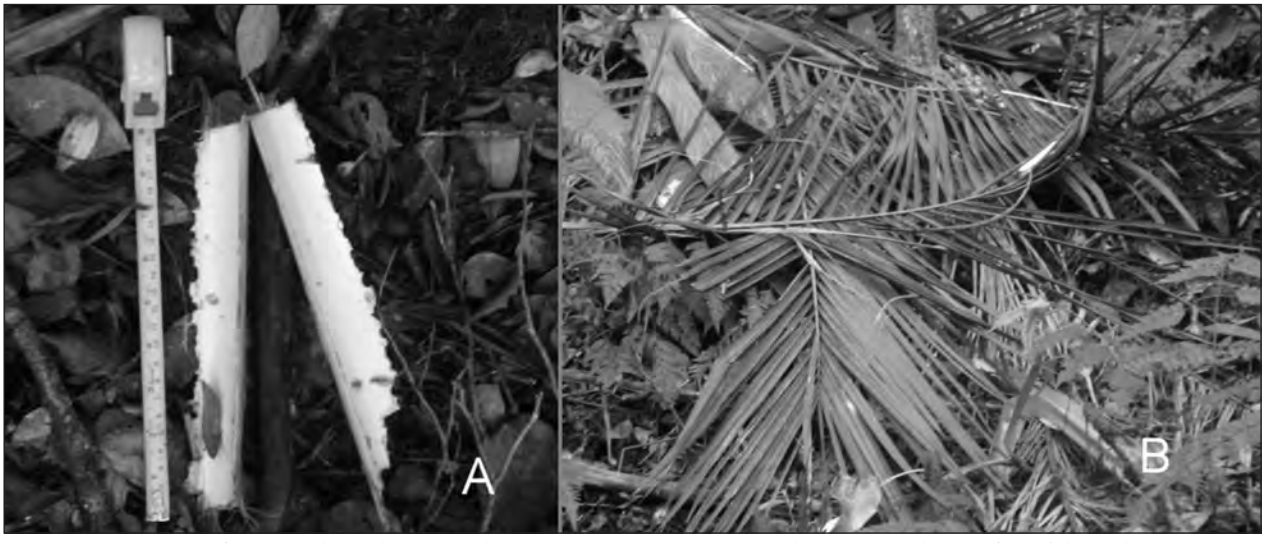

Figure 1. A) Remains of consumed apical meristem by *C. nigritus* in CBSP. B) Recently withdrawn leaves of *E. edulis* on the ground.

Discussion

The distribution of *E. edulis* and *C. nigritus* overlaps in most part of their occurrence in the Brazilian Atlantic Forest (Vilanova *et al*., 2005; Herderson, 2000) (Fig. 2A). But, the palm heart predation by capuchin monkeys has been reported in a few places (Fig. 2B). In others areas we have worked, as the Iguaçu National Park (Araucaria Forest and Semidecidual Atlantic Forest, 185,262 ha continuous area, Paraná state, Brazil) and Semidecidual Atlantic Forest fragments in São Paulo state ("Mata São José" and "Mata Santa Genebra", both approximately 250 ha), this behavior or predation signals were never recorded. It is possible that the use of this resource may be related to the group cultural inheritance, such as tool use and food-processing (Antinucci and Visalberghi, 1986; Rocha *et al*., 1998; Fragaszy *et al*., 2004; O'Malley and Fedigan, 2005; Canale *et al*., 2009). The group cultural inheritance in *Cebus* species, as well as other primate species, involves social learning, when the animals observe and interact with other group members, acquiring behaviors (Panger *et al*., 2002; Dindo *et al*., 2008; Dindo *et al*., 2009). The removal of the apical meristem demands dexterity and physical effort, being not accomplished by all members of a group, commonly this is done by some adults and sub-adults, and is observed for young animals.

Except humans, *C. nigritus* seems to be one of the only vertebrate able to prey upon apical meristem of adults *E. edulis*, since white-lipped peccaries (*Tayassu pecari* Link, 1795) prey upon apical meristem of saplings (F. Rocha-Mendes unp. data), and one of the few primates killing an arboreal plant (see Santos *et al*., 2007; Rocha, 2000). *E. edulis* is a palm with single stipe (differently of *Euterpe oleracea*), and removal of apical meristem leads to the death of individual. In forest fragments the main cause of mortality of *E. edulis* and *Geonoma brevispetha* (adult and juvenile palms) is the impact of meristem predation by black-capuchin monkeys (Souza and Martins, 2006; Santos *et al*., 2007; Portela, 2008; Portela *et al*., 2010). In areas where this behavior occurs, the capuchin monkeys may be helping to modeling the forest structure, similar to observed for ungulates (Silman *et al*., 2003; Wyatt and Silman, 2004; Beck, 2007). The palm heart predation by capuchins may have consequences for other species, especially birds, rodents and ungulates that depend on *E. edulis* fruits during the Winter (Galetti *et al*., 1999; Mikich, 2002). Nevertheless, this impact is much smaller than the one caused by human extraction, which may extirpate locally entire adult populations, being the higher threat to conservation of *E. edulis* (Galetti and Aleixo, 1998; Galetti and Fernadez, 1998; Pizo and Vieira, 2004).

Taira (2007) suggests that the consumption of palm heart in the Winter is an alternative source to insect scarcity, but not to fruit scarcity, which also occurs in the Winter at CBSP (Nakai, 2007). On the other hand, several papers concerning the diet of *C. nigritus* and congeners reported the use of alternative food resource in period of scarcity of fruits which normally constitute the main part of *Cebus* diet (Galetti and Pedroni, 1994; Peres, 1994; Freitas *et al*., 2008). Therefore, we suggest that palm heart of *E. edulis* and, at a lesser extent, of *G. gamiova*, might be considered as a fallback food of *C. nigritus*. Indeed, fallback foods are defined as "foods consumed during seasons when preferred foods are unavailable" (Altman, 1998) or as "foods

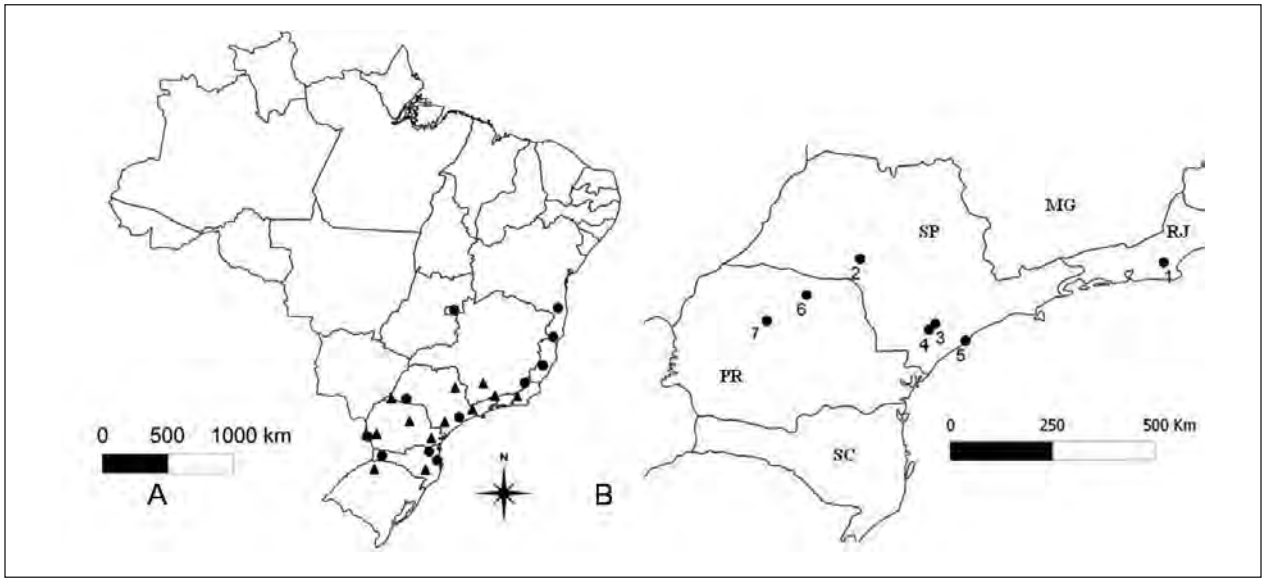

Figure 2. A) Distribution of *Cebus nigritus* (triangles) and *Euterpe edulis* (circles) in Brazil (adapted from Vilanova *et al*., 2005 and Herderson, 2000); B) Areas with records of apical meristem predation of *E. edulis* by *C. nigritus*: 1 –Poços das Antas Biological Reserve, fragment (Portela, 2008; Portela *et al*., 2010); 2 - Caetetus Ecological Station, fragment (R. Lázara pers. com.); 3 – CBSP, continuous (this paper, Taira, 2007); 4 –Intervales State Park, continuous (Zipparro and Galetti pers. ob.); 5 –Juréia-Itatins Ecological Station , continuous (P. Rubim pers. com.); 6 – "Mata" Doralice, fragment (Ludwig *et al*., 2005); 7 –Vila Rica do Espírito Santo State Park, fragment (Santos *et al*., 2007).

whose use is negatively correlated with the availability of preferred foods" (Marshall and Wrangham, 2007; reviewed in Lambert, 2009). *E. edulis* is known as a keystone-species, providing fruits and seeds for several animal species during the time of greatest shortage (Galetti *et al*., 1999; Mikich, 2002). The consumption of meristem apical by *C. nigritus*, especially in the Winter, highlights another aspect of importance of this palm.

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Carlos Rodrigo Brocardo*, **Valesca Bononi Zipparro** and **Mauro Galetti,** Laboratório de Biologia da Conservação, Universidade Estadual Paulista (UNESP), CEP 13.506-900. Av. 24 A, nº 1515, Rio Claro, São Paulo, Brazil, Henrique Santos Gonçalves, Laboratório de Biologia da Conservação, Universidade Estadual Paulista (UNESP) and Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) – RESEX Médio Purus, Lábrea, Amazonas, Brazil. *Author for correspondence. E-mail: <carlosbrocardo@hotmail.com>

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NOTEWORTHY RECORD OF A BLACK HOWLER MONKEY (*ALOUATTA CARAYA*) FROM THE CENTRAL DRY CHACO OF PARAGUAY

Anthony J. Giordano
Warren B. Ballard

Howler monkeys (*Alouatta*) comprise a diverse genus of neotropical primates that range from southern Mexico (*A. palliata*, *A. pigra*) to northern Argentina and southeastern Brazil (*A. guariba*, *A. caraya*) (Cortés-Ortiz *et al.*, 2003). Howler monkeys are the most folivorous of the Neotropical primates (Terborgh, 1983), and thus must forage for long periods to meet their high energetic demands. The southernmost distributed of the howler species, the South American black howler (*A. caraya*) has been reported to occur at the highest densities (Zunino and Rumiz, 1986; Bicca-Marques, 1990; Rumiz, 1990; Crockett, 1998). Considered principally an inhabitant of tropical lowland deciduous and semideciduous forests, black howlers are also known to frequent the gallery forests of the Rio Paraguay and Rio Paraná, as well as the seasonally inundated Pantanal in Brazil (Redford and Eisenberg, 1992; Crockett, 1998).

In Paraguay, black howlers are mostly associated with inland Atlantic forest fragments in the east and gallery forests of high rainfall in the Chaco (Stallings, 1985; Crockett, 1998). However, they have not been reported from the more xeric regions of the Chaco Boreal far from a major drainage system. Stallings and Mittermeier (1983: 161) found that *A. caraya* was "recorded from the higher forest [of the Chaco Boreal] but seemed to be rare in the region." However, they made no specific reference to geographic location, as howlers were not the primary subject of their discussion. Furthermore, they did not reference the time of year their primate observations were made. In conducting primate transects at Chaco Defensores National Park, Stallings *et al.* (1989) failed to record an observation of

A. caraya during the austral winter. Neither of these claims is surprising given that xeric regions of deciduous and semideciduous scrub forest likely act as barriers to the seasonal movements of a species that depends entirely on a low-quality, leafy forage. This is particularly true during the austral winter, when most such deciduous trees are devoid of leaves.

Here we describe an encounter with a solitary adult male black howler monkey of unknown age in the north-central Chaco of Paraguay. The encounter took place on a cool, overcast morning between 10:00 and 11:00 hours on 7 August, 2007. The solitary male was observed on private property approximately 130 km south of Chaco Defensores National Park (21° 41.176 South, 060° 09.234 West). The property is approximately 45,000 ha in expanse, >80% of which contains natural vegetation. In contrast, the majority of the surrounding properties have converted most of the natural vegetation into rangeland for livestock, and there is little opportunity for far-reaching habitat connectivity.

The howler was at the top of a short canopy tree (< 12–15 m) completely devoid of foliage. The tree was at the edge of a new clearing that had been opened up to create a cattle pasture and was isolated from other neighboring trees (i.e., the only access into the tree would have been from the base). We were able to observe it unobstructed, aided by binoculars, for approximately 20 minutes, while standing <2–3 meters from the trunk. During this time, the animal appeared completely undisturbed, and made no attempt to flee. On the contrary, it appeared indifferent to our presence and more concerned with that morning's cold temperature as it huddled over its extremities and moved very little. This observation occurred before the onset of a prolonged drought in the Paraguayan Chaco, and at the time when few trees were bearing leaves. Furthermore, the property owner, who observed the animal as well and had owned and managed the property for more than 20 years at the time of the observation, had never before seen the species on his property or anywhere else in the north-central Chaco. It was unclear where the animal had come from and what was sustaining it. We left to pursue other unrelated activities and returned less than 1 hour later to find the monkey gone, with no evidence as to where it had gone to. A subsequent, albeit anecdotal, inquiry among landowners found few to be familiar with this species. It would not be unreasonable to conclude that this male did not exist in isolation amidst such a sizeable region in the dry Chaco. Horwich (1998) remarked on the general adaptability of all *Alouatta* species, and we agree that *A. caraya* must be particularly adaptable to persist in such an ecosystem during a time of year when its limiting resources must be considered very scarce at best.

Anthony J. Giordano* and **Warren B. Ballard**, Department of Natural Resources Management, Texas Tech University, Box 42125, Lubbock, TX 79409 (AJG) and (WBB), *Author for correspondence: <species1@hotmail.com>

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PRELIMINARY OBSERVATIONS OF NAPO TAMARINS (*SAGUINUS GRAELLSI*) AND NOTES ON PRIMATES OF WILDSUMACO WILDLIFE SANCTUARY

E. Natasha Vanderhoff
Jonas Nillson

Wildsumaco Wildlife Sanctuary is a new reserve located on the eastern slopes of the Andes in Ecuador (400 hectares; 1400 m elevation; S 00° 40.28' W 77° 35.91'). The reserve consists of primary and secondary forest in a matrix of agricultural land. A top priority for the sanctuary and the affiliated Rio Pucuno Foundation is to conserve the remaining forest and biodiversity of the area. Research to date has focused on birds and mammals, especially carnivores. Primate surveys were conducted for 20 days and 3 nights from July 9–31, 2010. The Napo Tamarin (*Saguinus graellsi*) was

the only primate sighted during the survey and although troops were not habituated every attempt was made to gather data. Tamarins were followed for anywhere from 15 minutes to up to five hours. Tamarins used all levels of the forest, from the ground to the canopy (0–50m) and were seen foraging in both primary and secondary forest as well as along the main road that runs through the reserve (even crossing the road on the ground). Our preliminary data indicate that there are at least three troops, but there may be up to six. Average troop size was four individuals. Several intertroop encounters were observed and consisted of continuous loud chattering vocalizations lasting over 30 minutes in one instance. A number of calls were recorded and will be analyzed in the future. Foraging data gathered indicate that like most other tamarins, the individuals at this site have a mixed diet. Individuals were seen foraging on the flowers of *Inga* sp. and *Mucuna elliptica*, fruit of *Pourouma cecropiifolia* and an unkown liana, and palm exudates. During the study period a dead juvenile male was discovered with few marks. The specimen was measured (HB = 23 cm, T = 32.5 cm, HF = 6.5 cm, E = 2.4 cm) and deposited at Pontificia Universidad Católica del Ecuador in Quito. Although cause of death could not be determined, potential predators at the site include margays, tayras and several raptor species. In addition to the tamarins, four other species of primates have been observed in the reserve: *Aotus vociferans*, *Ateles belzebuth, Cebus albifrons,* and *Alouatta seniculus*. Although not in the reserve Woolly monkeys (*Lagothrix lagotricha*) do reside in the nearby Sumaco Galeras National Park. Researchers will continue to monitor primates at the site and more behavioral data will be collected in the future. The Wildsumaco Biological Field Station, a joint venture between the preserve, Francis Marion University and University of North Carolina Wilmington, will open in July 2011 and facilitate future primate studies in the area. For more information on primate studies at Wildsumaco please contact Natasha Vanderhoff (nvander4@ju.edu) or visit the website (http://www.riopucunofoundation.org/).

E. Natasha Vanderhoff, Department of Biology and Marine Science, Jacksonville University , 2800 University Blvd N., Jacksonville, FL 32211. **Jonas Nillson**, Wildsumaco Wildlife Sanctuary S.A., Pacto Sumaco, Ecuador.

News

Curso Métodos de Campo y Estrategias de Conservación

La Asociación Colombiana de Primatología en coordinación con la Universidad de Los Andes y el Laboratorio de Ecología de Bosques Tropicales y Primatología, los invitan a participar en el Primer Curso de Métodos de Campo y Estrategias de Conservación en Primatología del 10 al 22 de Julio de 2011, en el Parque Nacional Natural Cueva de Los Guácharos, Colombia. Para mayores informes entrar a http://cursoprimatologia2011.webs.com/

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The Institute of Tropical Ecology and Conservation offers the field course "Primate ethology and animal behavior" at the Bocas del Toro Biological Station, Panama. The purpose of this course is to give the student a foundation in primate ecology, primate behavior, field techniques and analytical tools in a tropical setting. The material covered is equivalent to a university upper level course in primate ecology. The course is available to college students, postbachs, graduate students or faculty. Registration deadline: November 20th, 2011. For more information go to: http://www.itec-edu.org/index.html

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Books

Atlas of Biodivesity Risk, edited by J. Settele, L. Peney, T. Georgiev, R. Grabaum & V. Grobelnik. 2010. Pensoft Publishers. 300pp. ISBN: 978-9546424464. This is the first book to describe and summarise the major pressures, impacts and risks of biodiversity loss at a global level. It identifies the main risks as global climate and land use change, environmental pollution, loss of pollinators and biological invasions. It also analyzes the impacts and consequences of biodiversity loss, with a strong focus on socio-economic drivers and their effects on society. *Contents:* 1. Biodiversity baseline information; 2. Research approaches for biodiversity and impacting factors; 3. Climate change impacts on biodiversity; 4. Land use change and their impacts; 5. Environmental chemicals and biodiversity; 6. Biological invasions; 7. Decline of pollinators and its impact; 8. Socio-economy and its role in biodiversity loss; 9. Combined biodiversity effects of major drivers and pressures; 10. The future of biodiversity and biodiversity research.

Primate Anti-Predator Strategies, edited by S. Gursky & K. A. I. Nekaris. 2010. Springer. 396pp. ISBN: 978-1441941909. This volume details the different ways that nocturnal primates avoid predators. It is a first of its kind within primatology, and is therefore the only work giving a broad overview of predation. *Contents:* 1. Predation and primate congnitive evolution – K. Zuberbühler; 2. Predation on primates: a biogeographical analysis – D. Hart; 3. Primates and other prey in the seasonally variable diet of *Cryptoprocta ferox* in western Madagascar – L. Dollar, J. U. Ganzhorn & S. M. Goodman; 4. Predation on lemurs in the rainforest of Madagascar by multiple predator species – S. M. Karpanty & P. C. Wright; 5. Predation, communication and cognition in lemurs - M. Scheumann, A. Rabesandratana & E. Zimmermann; 6. A consideration of leaping locomotion as a means of predator avoidance in prosimian primates – R. H. Crompton & W. I. Sellers; 7. Anti-predator strategies of cathemeral primates – I. C. Colquhoun; 8. Moonlight and behavior in nocturnal and cathemeral primates – L. T. Nash; 9. A comparison of calling patterns in two nocturnal primates, *Otolemur crassicaudatus* and *Galago moholi* as guide to predation risk – S. K. Bearder; 10. Predator defense by slender Lorises ans Pottos – K. A. I. Nekaris, E. R. Pimley & K. M. Albard; 11. The response of spectral trasiers toward avian and terrestrial predators – S. L. Gursky; 12. Talking defensively a dual use for brachial and gland exudates of slow and pygmy lorises – L. R. Hagey, B. G. Fry & H. F. Snyder; 13. Anti-predator strategies in diurnal prosimian – L. Gould & M. L. Sarther; 14. Howler monkeys and harpy eagles: a communication arms race – R. Gil-da-Costa; 15. Effects of habitat structure on perceived risk of predation and anti-predator behavior of vervet and patas monkeys – K. L. Enstam; 16. Predation risk and habitat use in Chacma baboons – R. A. Hill & T. Weingrill; 17. Reconstructing hominin interactions with mammalian carnivores – A. Treves & P. Palmqvist.

Primate Locomotion: Linking Field and Laboratory Research, edited by K. D'Août & E. E. Vereecke. 2010. Springer. 364pp. ISBN: 978-1441914194. This book brings together the two aspects of primate locomotion studies: laboratory studies based on biomechanics and energetics, and the field studies focused on behavior and ecology. *Contents: 1.* Introduction: primate locomotion, towards a synergy of in situ and ex situ research – Vereecke *et al.;* 2. Experimental and computational studies of bipedal locomotion in the bipedally-trained Japanese monkey – Ogihara *et al.;* 3. Scapula movements and their contribution to the three dimensional forelimb excursions in quadruped primates – Schmidt & Krause; 4. The kinematics of load carrying in great apes, implications for the evolution of human bipedalism – Watson *et al.;* 5. Field and experimental approaches to the study of locomotor ontogeny in *Propithecus verreauxi* – Wunderlinch *et al.;* 6. Comparisons of limb structural properties in habituated chimpanzees from Kibale, Gombe, Mahale and Taï communities – Carlson *et al.;* 7. Gait and kinematics of arboreal quadrupedal walk of free-ranging red howlers (*Alouatta seniculus)* in French Guiana – Youlatos & Gasc; 8. Implications of chimpanzee bipedal feeding for the evolution of hominid posture and locomotion – Stanford; 9. Linking in situ and ex situ approaches for studying primate locomotor responses to support stability – Stevens; 10. Leaping, body size, predation and energetic efficiency of locomotion - Blanchard *et al.*; 11. Translating primate locomotor biomechanical variables from the laboratory to the field – Schmitt.

Making Seed Identification Easier

Review of: Seeds of Amazonian Plants, by Fernando Cornejo and John Janovec, 2010. Princeton, Princeton University Press. ISBN 978-0-691-14647-8 (Paperback), 978-0-691-11929-8 (Hardcover). 155 pages, 750 colour illustrations, 2 b/w plates. Price: US-$ 35.00 (Pbk.), US-$ 75.00 (Hard.). <http://press.princeton.edu/titles/9139.html>.

Eckhard W. Heymann

"Wonderful" and "most helpful" are the two terms with which I can describe this book in the shortest possible ways. Published in the Princeton Field Guides series, this book provides high-quality colour photographs of seeds from many Amazonian plant genera, along with a short account of the principal characteristics and distribution of the respective genus. A clear and simple key that is comprehensible and thus useful also to non-botanists precedes

the descriptive part. Since many plant families possess specific seed characteristics that are easily recognized, the arrangement of families in alphabetic order makes it also possible to go strait to a family and then search for the correct genus. When I browsed through this book for the first time, I immediately recognized many seeds that my students and I had recovered from tamarin faeces and feeding residuals during field work in north-eastern Perú. This book will be useful to every primatologist working on the feeding ecology of or on seed dispersal and seed predation by New World monkeys and who needs to get a decent taxonomic identification of plants consumed, dispersed or preyed by their study subjects. Given the huge diversity of Neotropical plants, this guide cannot be comprehensive. The range of families and genera is certainly biased towards western Amazonia, where the field work was performed upon which this book is based. But many families and genera dealt with in this book have a very broad distribution, even ranging into Mesoamerica, so the book will be useful over a wider geographic area. As with van Roosmalen's "Fruits of the Guianan Flora" (which is also restricted to a specific area) "Seeds of Amazonian Plants" will at least help to get a first identification in the field in many if not in most cases. In sum, I highly recommend this book to Neotropical primatologists. "Seeds of Amazonian Plants" will make ecological field work on New World monkeys a bit easier.

Eckhard W. Heymann, Abteilung Verhaltensökologie & Soziobiologie, Deutsches Primatenzentrum, Kellnerweg 4, D-37077 Göttingen, e-mail: <eheyman@gwdg.de>.

Articles

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Meetings

2011

Joint Meeting of the International Ethological Conference and the Animal Behavior Society
The International Ethological Conference and the Animal Behavior Society will have a joint meeting this year at the Indiana University, Bloomington, Indiana, USA, from July 25 -30, 2011. For more information and registration go to: http://www.indiana.edu/~behav11

45th Congress of the International Society for Applied Ethology
The 45th congress of the International Society for Applied Ethology will take place in Indianapolis, USA, from July 31 to August 4, 2011. The general theme will be scientific evaluation of behavior, welfare and enrichment; and some of the specific topics: Zoo animal behavior, Laboratory animal behavior, Engineering environments & measurement technologies for science and welfare pain, distress & humane end-points. Abstract submission closes February 14th. For more information visit http://www.applied-ethology.org/isaemeetings.htm

10th International Conference on Environmental Enrichment
The 10th International Conference on Environmental Enrichment will take place in the Benson Hotel, Portland, Oregon, USA from August 14 to 19, 2011. The conference is sponsored by the Oregon National Primate Research Center and the Oregon Zoo. For more information go to http://bit.ly/icee2011

AP Summer Course Husbandry of Rescued Primates
The AP Summer Course, sponsored by the AAP, Sanctuary for Exotic Animals, will be held in the AAP Sanctuary for Exotic Animals at Almere, The Netherlands from August 21 to 26, 2011. For more information please visit http://www.aap.nl/english/aap-summer-course.html

2011 AAZK Conference
The AAZK Conference, sponsored by the American Association of Zoo Keepers, will take place in San Diego, California, USA, from August 24 to 28, 2011. For more information go to http://sdaazkconf.wordpress.com/

IV Congress of the European Federation for Primatology III Iberian Primatological Conference
The IV congress of the European Federation for Primatology and the III Iberian Primatological conference, sponsored by the APP-Associação Portuguesa de Primatologia, will take place in Almada, Portugal from September 14 to 17, 2011. For more information visit http://apprimatologia.com/Actividades/CEP2011.aspx

34th Meeting of the American Society of Primatologists
The meeting of the American Society of Primatologists will be held in Austin, Texas, USA, from September 16–19, 2011. Preliminary abstracts for symposia and workshops should be submitted by January 15, 2011. General abstracts deadline March 12, 2011. For more information go to http://www.asp.org/asp2011/index.htm

2012

III Congreso Colombiano de Primatología
La Asociación Primatológica Colombiana junto con la Universidad del Norte y la Fundación Proyecto Tití, organizarán el III Congreso Colombiano de Primatología dentro del marco del evento *Biodiversidad: Recurso Estratégico*, el cual se llevará a cabo en Abril de 2012, en la ciudad de Barranquilla Colombia.

XXVI Congress of the International Primatological Society
The XXVI congress of the International Primatological Society will be held at the World Trade Center, Veracruz, Mexico, from August 13–17, 2012. For more information visit http://www.citrouv.edu.mx/ips2012/

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Notes to Contributors

Scope

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

Submissions

Please send all English and Spanish contributions to: Erwin Palacios, Conservación Internacional – Colombia, Carrera 13 # 71-41 Bogotá D.C., Colombia, Tel: (571) 345-2852/54, Fax: (571) 345-2852/54, e-mail: <epalacios@conservation.org>, and all Portuguese contributions to: Júlio César Bicca-Marques, Departamento de Biodiversidade e Ecologia, Pontifícia Universidade Católica do Rio Grande do Sul, Av. Ipiranga, 6681 Prédio 12A, Porto Alegre, RS 90619-900, Brasil, Tel: (55) (51) 3320-3545 ext. 4742, Fax: (55) (51) 3320-3612, e-mail: <jcbicca@pucrs.br>.

Contributions

Manuscripts may be in English, Spanish or Portuguese, and should be double-spaced and accompanied by the text on CD for PC compatible text-editors (MS-Word, WordPerfect, Excel, and Access), and/or e-mailed to <epalacios@conservation.org> (English, Spanish) or <jcbicca@pucrs.br> (Portuguese). Hard copies should be supplied for all figures (illustrations and maps) and tables. The full name and address for each author should be included. Please avoid abbreviations and acronyms without the name in full. Authors whose first language is not English should please have their English manuscripts carefully reviewed by a native English speaker.

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

Short articles. These manuscripts are usually reviewed only by the editors. A broader range of topics is encouraged, including such as behavioral research, in the interests of informing on general research activities that contribute to our understanding of platyrrhines. We encourage reports on projects and conservation and research programs (who, what, where, when, why, etc.) and most particularly information on geographical distributions, locality records, and protected areas and the primates that occur in them. Text should be typewritten, double-spaced with no less than 12 cpi (preferably Times New Roman) font and 3-cm margins throughout, and should not exceed 12 pages in length (including references).

Figures and maps. Articles may include small black-and-white photographs, high-quality figures, and high-quality maps. (Resolution: 300 dpi. Column widths: one-column = 8-cm wide; two-columns = 17-cm wide). Please keep these to a minimum. We stress the importance of providing maps that are publishable.

Tables. Tables should be double-spaced, using font size 10, and prepared with MS Word. Each table should have a brief title.

News items. Please send us information on projects, field sites, courses, Thesis or Dissertations recently defended, recent publications, awards, events, activities of Primate Societies, etc.

References. Examples of house style may be found throughout this journal. In-text citations should be first ordered chronologically and then in alphabetical order. For example, "…(Fritz, 1970; Albert, 1980, 2004; Oates, 1981; Roberts, 2000; Smith, 2000; Albert *et al.*, 2001)…"

In the list of references, the title of the article, name of the journal, and editorial should be written in the same language as they were published. All conjunctions and prepositions (i.e., "and", "In") should be written in the same language as rest of the manuscript (i.e., "y" or "e", "En" or "Em"). This also applies for other text in references (such as "PhD thesis", "accessed" – see below). Please refer to these examples when listing references:

Journal article

Stallings, J. D. and Mittermeier, R. A. 1983. The black-tailed marmoset (*Callithrix argentata melanura*) recorded from Paraguay. *Am. J. Primatol.* 4: 159–163.

Chapter in book

Brockelman, W. Y. and Ali, R. 1987. Methods of surveying and sampling forest primate populations. In: *Primate Conservation in the Tropical Rain Forest,* C. W. Marsh and R. A. Mittermeier (eds.), pp.23–62. Alan R. Liss, New York.

Book

Napier, P. H. 1976. *Catalogue of Primates in the British Museum (Natural History). Part 1: Families Callitrichidae and Cebidae.* British Museum (Natural History), London.

Thesis/Dissertation

Wallace, R. B. 1998. The behavioural ecology of black spider monkeys in north-eastern Bolivia. Doctoral thesis, University of Liverpool, Liverpool, UK.

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Muckenhirn, N. A., Mortensen, B. K., Vessey, S., Fraser, C. E. O. and Singh, B. 1975. Report on a primate survey in Guyana. Unpublished report, Pan American Health Organization, Washington, DC.

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UNESCO. 2005. UNESCO Man and the Biosphere Programme. United Nations Educational, Scientific, and Cultural Organisation (UNESCO), Paris. Website: http://www.unesco.org/mab/index.htm. Accessed 25 April 2005. ("Acessada em 25 de abril de 2005" and "Consultado el 25 de abril de 2005" for articles in Portuguese and Spanish respectively).

For references in Portuguese and Spanish:

"and" changes to "e" and "y" for articles in Portuguese and Spanish respectively.

"In" changes to "Em" and "En" for articles in Portuguese and Spanish respectively.

"Doctoral thesis" changes to "Tese de Doutoramento" and "Tesis de Doctorado" for articles in Portuguese and Spanish respectively.

"MSc Thesis" changes to "Dissertação de Mestrado" and "Tesis de Maestría" for articles in Portuguese and Spanish respectively.

"Unpublished report" changes to "Relatório Técnico" and "Reporte no publicado" for articles in Portuguese and Spanish respectively.

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