Short Articles

FUR RUBBING BEHAVIOUR IN FREE RANGING BENI TITI MONKEYS *(PLECTUROCEBUS MODESTUS)* IN BOLIVIA

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Introduction

Fur rubbing is a mammalian behaviour in which a foreign substance is vigorously rubbed over some parts of the body with hands or feet (Baker, 1996; Huffman, 1997; Paukner and Suomi 2012). This behaviour has been observed in Neotropical primate species using distinct substances such as plant parts or insects, and has been related to distinct functions. Health benefits of fur rubbing were inferred as protection against mosquito blooms in rainy months and for healing wounds from fur rubbing observed in white-faced capuchin monkeys (*Cebus capucinus*), as insecticidal–repellent and fungistatic properties were found in one of those plant species used (*Piper tuberculatum*; Huffman, 1997; Palacios et al., 2009; Bazán-Calderón et al., 2011). Repellent functions were also suggested for plants used in fur rubbing by robust capuchins, *Sapajus apella* (Paukner and Suomi, 2008).

The repellent functions of fur rubbing seem valid when substances are spread over most of the individual's body as was observed in white-faced capuchin monkeys (*C. capucinus*; Baker, 1996). Nevertheless, Campbell (2000) related extensive fur rubbing behavior as a part of social interaction in spider monkeys (*Ateles geoffroyi*), when they applied foreign substances on some parts of their bodies. Potential changes in olfactory cues between individuals after applying pungent substances to fur could increase affiliative intragroup interactions. However, after unexpected aggressive interactions were observed in captive capuchin monkeys (*Sapajus apella*) after fur rubbing behavior, Paukner and Suomi (2008, 2012) hypothesized that the medicinal purposes of fur rubbing could be more relevant than group cohesion ones.

Fur rubbing has also been observed in some titi monkey species. Individuals of *Cheracebus torquatus* rubbed fur from throat to chest with a small ball of wadded unidentified leaves wetted with saliva (Defler, 2010). Similar behaviour was observed in *Plecturocebus donacophilus* using leaves of *Piper tuberculatum* (Ryan, 2011), a plant with insecticidal and fungicidal properties (Palacios et al., 2009; Bazán-Calderón et al., 2011). Recently, important efforts have been made to increase natural history knowledge and promote conservation actions for *Plecturocebus modestus*, an Endangered titi monkey species endemic to Bolivia (Veiga et al., 2008; Martinez and Wallace, 2010, 2016; Wallace et al., 2013). Here we report fur rubbing using plants observed in individuals of two groups of *P. modestus*, during a behavioral study of the species. We provide details regarding plant species used, individuals involved, and seasonal variations in the frequency of fur rubbing, as well as attempt to elucidate the probable function of this behaviour.

Methods

We conducted our study at San Miguel cattle ranch located in the southwestern portion of the Beni Department, Bolivia (13°57'5.49"S, 66°50'5.07"W). This site, selected according to available distributional information for *Plecturocebus modestus* (Felton et al., 2006; Martinez and Wallace, 2007; Wallace et al., 2013), is in the Llanos de Moxos ecosystem characterized by a landscape dominated by a grassland matrix where forest patches are immersed (Hanagarth, 1993). We selected two groups of *P. modestus* to be observed. The Maramacho group had four individuals (adult pair, one juvenile and one infant) inhabiting an area of large forest patches (>10 ha), and the Corral group had two adult individuals occurring in an area of small forest patches.

We sampled the occurrence of unusual behaviours such as fur rubbing by means of *ad libitum* sampling (Altmann, 1974), registering the duration of each fur rubbing event. We observed the focal groups all day from sunrise to sunset for 10 days per month, during 12 months (July 2010–June 2011) covering dry and wet seasons. We calculated absolute frequencies and time accumulated in fur rubbing for each focal group and individual. Plant species used in fur rubbing were collected and voucher specimens were identified at the Bolivian Herbarium in La Paz.

Results

In all our observations, fur rubbing consisted of an individual harvesting leaves of a plant that were then chewed for a short time, before the monkey rubbed the chewed plant mixture against its throat and chest with repeated energetic vertical movements. Titi monkeys used both hands for this task and chewed the leaves several times while they sat upright on branches, looking ahead. Although the behavioural display was similar between focal groups, the plant species used varied. Individuals of the Maramacho group used leaves of the herb *Piper callosum* (Piperaceae, collection number FZR-17816), while the Corral group used leaves of the vine *Tynanthus schumannianus* (Bignoniaceae, collection number FZR-17817). Leaves of both plant species had a mint smell and were dropped after fur rubbing. They were never eaten.

Most of the fur rubbing observed was performed by the Corral group in the small forest patches (18 events, 73 minutes, on 8 days), and both adult individuals performed this behaviour (Table 1). Fur rubbing was less frequent in the Maramacho group (3 events, 7 minutes, on 2 days) where only the adult male and juvenile female performed fur rubbing.

Table 1. Accumulated time and frequency of fur rubbing for each individual of focal groups of *Plecturocebus modestus* (rows in bold correspond to total time for each group).

Group	Individual	Age	Sex	Time accumulated [min] (number of events)		
				Total	Rain	Dry
CORRAL	Mandingo	Adult	Male	38(9)	31(7)	7(2)
	Natusha	Adult	Female	35(9)	35(9)	0(0)
				73(18)	**66(16)**	**7(2)**
MARAMACHO	Timoteo	Adult	Male	4(2)	4(2)	0(0)
	Lita	Juvenile	Female	3(1)	3(1)	0(0)
				7(3)	**7(3)**	**0(0)**
Total				**80(21)**	**73(19)**	**7(2)**
Observation time (hours)						
CORRAL				**1143.8**	**582.8**	**561.0**
MARAMACHO				**1235.7**	**619.0**	**616.7**

The adult male of the Maramacho group performed fur rubbing alone one time (15% of the fur rubbing group time), and once just before the juvenile female (85% of the accumulated group time). For the Corral group, most of the fur rubbing was performed by the adult pair simultaneously (5 of 8 days, 84.9% of accumulated group fur rubbing time), on two days the male fur rubbed alone (9.6% of fur rubbing time), and on one day the female fur rubbed alone (5.5% of fur rubbing time). Titi monkeys performed fur rubbing separately, without any kind of body contact between them, even in those cases when two individuals were engaged in this activity in close proximity. Fur rubbing was observed almost exclusively in the wet season except two events involving the adult male of Corral group (9.6% of accumulated group time, Table 1).

No special situations were observed on the days when the individuals of Maramacho group performed fur rubbing. On two of the days when individuals of the Corral group performed fur rubbing, we observed the adult male grooming the adult female, and on one day he tasted the female's urine. However, grooming was commonly observed in this group (37% of observation days) and although only three events of urine testing were observed during the study, none of these observations occurred just after fur rubbing; they occurred over a half an hour later.

Discussion

Plant species observed in fur rubbing by individuals of *Plecturocebus modestus* are used in traditional medicine by Amazonian people. Brazilian and Bolivian people prepare a tea or poultice with leaves and stem pieces of *Piper callosum* to treat digestive and diuretic illnesses, and fungistatic, insecticidal, and antilarval properties found in this plant suggest its use as repellent (Souto et al., 2012; Silva et al., 2017; Bolivian Herbarium database). Similarly, tea made with fruits and stem pieces of *Tynanthus schumannianus* is traditionally used for treatment of diarrhea in Bolivia, while active compounds for treatment of malaria were also found in fruits of this vine with no apparent use as repellent (Muñoz et al., 2000; Cansian et al., 2015). This plant is used also to treat conjunctivitis and as women's perfume (Bolivian Herbarium database). As Beni titi monkeys did not ingest the plants used in fur rubbing, some external function such as repellent seems feasible for *P. callosum*.

Several primate species have sternal glands whose secretions are used for scent marking (Ewer, 1968). Spider monkey (*Ateles geoffroyi*) fur rubbing was related to scent marking, rubbing the chest against a substrate that seemed to stimulate secretions of sternal glands (Campbell, 2000). As scent marking shares diverse types of information about an individual (such as identity, condition, and social rank), fur rubbing could be related to social interactions through chemical communication (NRC, 1998). Scent marking using the sternal gland was reported for *Plecturocebus moloch* and *Cheracebus torquatus*, rubbing their chest on branches, although with no clear function (Moynihan, 1966; Kinzey, 1981). Chest rubbing seemed to help re-establish friendly relationships between individuals of captive *C. torquatus* after prolonged separation (Fernandez-Duque et al., 1997). The fact that we did not observe any scent marking behaviour nor prolonged separations of groups' individuals

linked to fur rubbing, discards the scent marking function for fur rubbing in our groups of *Plecturocebus modestus*.

Capuchins and owl monkeys engage in social fur rubbing, with the participation of several individuals, using highly available rubbing materials such as mud, ants, or plant leaves, while solitary fur rubbing occurred with less abundant materials such as flowers or millipedes (Lynch et al., 2012). The same authors describe different levels of contact between individuals, such as rubbing on each other, or individuals rubbing their body against another whom already applied the rubbing substance. In our study, individuals performed fur rubbing with plants separately. Additionally, despite some coincidence of fur rubbing with grooming, there was not a direct relationship between the two behaviours that could suggest some social context for our fur rubbing observations.

Chemical communication could also help reproductive success, as was observed in sifakas (*Propithecus verreauxi*). Males of this species with stained chests caused by sternal gland secretions had higher copulation rates than males with clean chests (Dall'Olio et al., 2012). The only link we could report between fur rubbing and mating was when the Corral group male drank female's urine on the same day, but considerably later than the fur rubbing event. The assessment of females' fertility by male individuals based on drinking their urine has been reported for other mammals including the owl monkey *Aotus nancymaae* (Wolovich and Evans, 2007). Nevertheless, one isolated observation does not provide strong evidence for a link between mating behavior and fur rubbing.

Repellent functions, as well as usefulness against bacterial or fungal skin infections, were attributed to fur rubbing when substances were applied to almost the entire body, and especially during rainy season when risks of insects' bites and infections are higher (Huffman, 1997). This was observed in capuchin monkeys such as *Cebus capucinus* (Baker 1996), *Sapajus cay* (Giudice and Pavé, 2007), and *S. apella*, as well as distinct species of *Aotus* owl monkeys (Zito et al., 2003). In our case, the titi monkeys rubbed their throat and chest in a similar way as reported for *Cheracebus torquatus* (Defler, 2010), *Plecturocebus donacophilus* (Ryan, 2011), and *P. oenanthe* (Huashuayo-Llamocca and Heymann, 2017). The dense and long hair of titi monkeys, including *P. modestus* (Lönnberg, 1939; Martinez et al., 2013), would help prevent access to skin for biting insects, except for ventral zones with shorter and less dense hair, probably more vulnerable to insect bites. The marked occurrence of our fur rubbing observations during the wet season corresponds with the period of higher risk of insect bites due to increase of insect abundances (Huffman, 1997). Moreover, our focal groups occurred in ecotones of forest and savannahs with higher insect diversity than single habitats, including mosquito species that can be vectors of tropical diseases (Thongsripong et al., 2013). It is likely that a high abundance of mosquitos or other biting insects could be promoting the need of a repellent. Therefore, our observations of *P. modestus* treating their most vulnerable body areas with plant substances during the riskiest insect bite months suggest repellent as the most likely function of fur rubbing for this species.

We presented data on an uncommon behaviour observed in wild individuals of *Plecturocebus modestus*. Although we did not determine a conclusive function of fur rubbing, we provide valuable considerations for further research on the ecology of this endemic and threatened primate.

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GEOGRAPHICAL AND ALTITUDINAL RANGE EXTENSION OF WHITE-BELLIED SPIDER MONKEYS (*ATELES BELZEBUTH*) IN THE NORTHERN ANDES OF COLOMBIA

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Introduction

The geographic distribution of white-bellied spider monkeys (*Ateles belzebuth*) has been debated extensively, and there is no consensus on the historical continuity or discontinuity of its wild populations. Currently, white-bellied spider monkeys are known to have a disjunct distribution located across three regions: [1] the western piedmont of the Eastern Andes and the lowland rainforests of Colombia, [2] the forests in western Amazonia in Ecuador and Peru, as well as from [3] southern Venezuela and northwestern Brazil (Fig. 1). As mentioned by the IUCN Red List Assessment: "The distribution of this species is not well known and defies easy description" (Link *et al.*, 2019).

In Colombia, white-bellied spider monkeys are present in the lowland rainforests of Tinigua and Macarena National Parks, especially near the piedmont of the Eastern Andes. Some populations also occur in Guaviare and Caquetá departments, and a few "anecdotal" records have been documented in south-eastern Colombia. Nonetheless, Defler (2003) proposed that this handful of records in south-eastern Colombia actually correspond to isolated individuals, including two spider monkeys that were hunted by local persons given its rarity in the region. These spider monkeys are not present across a broad area of the Amazonian rainforests in Colombia (e.g. Amazonas department), nor are they found in northern Ecuador, north of the Cuyabeno River. Thus, based on reliable records, it seems that populations of white-bellied spider monkeys are divided into at least three disjoint populations (Fig. 1). The biogeographical, ecological and even anthropological drivers of this discontinuous distribution are still unknown.

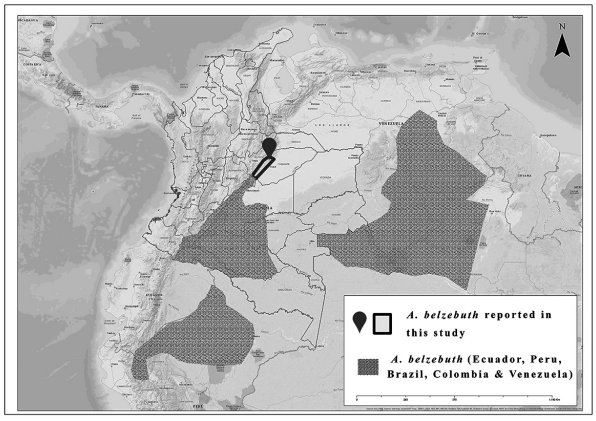

Figure 1. Geographical distribution of *Ateles belzebuth* (IUCN 2019). Shadow denotes reported populations and grey symbol denotes the northern population newly registered in this study.

The white-bellied spider monkey is classified as Endangered by the IUCN Red List (Link *et al.*, 2019) mainly due to the loss of habitat and the estimated reduction of its populations during the last decades. The demographic dynamics of white-bellied spider monkeys have been studied in the Ecuadorian and Colombian Amazon (Shimooka et al., 2008; Link et al. 2018) and it is clear that they have one of the slowest development cycles amongst living primates, with extended periods of infancy and sexual immaturity (Link et al., 2018). It has been proposed that their slow life history variables partly account for their high vulnerability to anthropogenic threats (Michalski & Peres, 2005). White-bellied spider monkeys also have long periods of development. Females begin reproducing only when they are approximately 7 – 9 years, most often have singletons (but see Link et al 2006), and have inter-birth intervals of approximately 30 – 36 months (Shimooka et al., 2008; Link et al., 2018). Spider monkeys also prefer undisturbed forests where they use large areas (160 – 400 hectares) to search for food, especially ripe fleshy fruits (Di Fiore et al., 2008). Spider monkeys' large body size makes them preferred hunting items for many indigenous and local communities, posing a strong threat on their wild populations (Franzen, 2008).

Here, we report on a previously unknown population of white-bellied spider monkeys living in the highland forests in the Eastern slope of the Eastern Andes in Colombia, in the departments of Casanare and Boyacá. This population accounts for the northern-most record of white-bellied spider monkeys in the Andes Piedmont in Colombia, and is present in highland forests that extend its altitudinal range to over 1,800 m. a.s.l. Given that in the Colombian Andes during the last centuries there has been a dramatic transformation of natural forests into agricultural fields and pastures for cattle ranching (Etter and van Wyngaarden, 2000; Armenteras et al., 2011), it is possible to