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# AGE-SEX DIFFERENCES IN THE SOCIAL BEHAVIOR OF ZOO-HOUSED COLOMBIAN BLACK SPIDER MONKEYS (*Ateles fusciceps rufiventris*)

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**ABSTRACT.** Spider monkeys (*Ateles* spp.) live in multi-male multi-female groups with conspicuous sex differences in ranging patterns, association preferences and social strategies. Behavioral studies in populations under human care can provide a unique opportunity to build on our current understanding of their social behavior. Here, we studied sex differences in social behavior of one group of 18 black spider monkeys (*Ateles fusciceps rufiventris*) at the Wakatá Biopark, in Colombia. We conducted 20-min focal animal samples and recorded the focal animal's activity and the rates and duration of their main social behaviors. Overall, we found no differences between sexes in the time spent in each activity, but adults rested more than juveniles who spent more time socializing. We found behavioral differences between the sexes with males showing a higher frequency of aggressive displays, chest rubbing, tail wrapping, and emitted long distance vocalizations more often than females. Grooming was mostly directed towards males, embraces were mostly between male-male dyads, and females were the most frequent recipients of aggression. Although relations amongst male spider monkeys have been suggested to be egalitarian, our results suggest that a single male in the study group received a larger proportion of grooming from females and was most often involved in unique social behaviors (e.g., chest rubbing). We suggest that these subtle behaviors, largely overlooked in the wild, might play a role in male-male relations and male reproductive strategies.

**RESUMEN. COMPORTAMIENTO SOCIAL DE LOS MONOS ARAÑA (*Ateles fusciceps rufiventris*) EN EL BIOPARQUE WAKATA EN COLOMBIA.** Los monos araña (*Ateles* spp.) viven en grupos multimacho-multihembra con evidentes diferencias en el uso del espacio y las preferencias sociales entre machos y hembras. Los estudios sobre este género bajo cuidado humano ofrecen la oportunidad de ampliar nuestro conocimiento sobre su comportamiento. Estudiamos las diferencias en el comportamiento social entre machos y hembras de un grupo de 18 monos araña (*Ateles fusciceps rufiventris*) en el Bioparque Wakatá, en Colombia. A través de muestreos de animal focal de 20 minutos, registramos las tasas de actividad y la duración de sus principales comportamientos. No encontramos diferencias en el tiempo que machos y hembras emplean en las diferentes actividades a lo largo del día, pero sí encontramos que los machos tienen una mayor frecuencia de comportamientos agresivos y emiten más frecuentemente vocalizaciones de larga distancia. El acicalamiento fue principalmente dirigido hacia los machos y los abrazos también fueron más frecuentes entre diadas de machos, mientras que las hembras fueron las principales receptoras de agresión. Nuestros resultados evidencian que uno de los machos del grupo recibió la mayor cantidad de acicalamiento y fue el que tuvo mayores tasas de frotarse alimentos en el pecho. Sugerimos que estos comportamientos sutiles, y difíciles de observar en vida silvestre, pueden jugar un rol importante en la regulación de relaciones sociales entre los machos de *Ateles* y sus estrategias reproductivas. Concluimos que los estudios ex situ son importantes para entender el comportamiento social de los primates y definir criterios de manejo de sus poblaciones.

**Key words:** Aggression, captivity, ex situ, platyrrhines, social interactions.

**Palabras clave:** Agresión, ex situ, interacciones sociales, parque zoológico, platyrrinos.

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## INTRODUCTION

Spider monkeys have a high degree of fission-fusion dynamics (Aureli et al. 2008) and extremely flexible grouping patterns, as they live in groups of “stable” composition that are most often divided into smaller subgroups that can vary both in size and composition during short temporal intervals (Symington 1988; Aureli & Schaffner 2008; Link 2011). Male spider monkeys are philopatric, while females disperse from their natal groups and join other groups after reaching sexual maturity (Shimooka et al. 2008; Di Fiore A. et al. 2009; Link et al. 2018). Studies on wild spider monkeys have documented a relatively high occurrence of affiliative behaviors and low rates of aggression between adult males (Aureli & Schaffner 2008) and lower quality relations between female-female dyads compared to male-male relations (but see Ramos-Fernandez et al. 2009). Also, several studies have found that female directed aggression initiated by adult males is common and might play a role on indirect social control as well as on male mating strategies (Fedigan & Baxter 1984; Link et al. 2009; Slater et al. 2008, 2009).

The nature of social relations between male spider monkeys is still far from understood. In the wild, contest competition amongst males is rarely seen, and male-male aggression is extremely rare, even in the presence of estrous females (Slater et al. 2008; Abondano & Link 2012; Gibson 2010). Nonetheless, coalitionary aggression from adult males to subadult males can lead to lethal attacks (Campbell 2009; Valero et al. 2006), and similar outcomes from aggression might occur in the context of inter-group encounters and aggression Aureli et al. (2006), (Link 2011). Although males cooperate in territorial defense, competition between them for reproductive opportunities seems to be subtle and indirect (Gibson 2010). Thus, relations amongst males in a social group seem to be largely egalitarian and tolerant, and mechanisms that may influence the establishment of dominance may be nonexistent or difficult to observe and record.

Research on populations under human care has provided ample evidence that this condition drives changes in the behavior of animals when compared to their behavior in the wild (Fernandez et al. 2009).

For example, some studies have described the behavioral responses of primates to ex situ conditions, such as the size of the enclosure (Ross et al. 2009), population density (Guzmán & Stevenson 2011), enrichment of habitat and the number of visitors (Davis et al. 2005). However, they may well play a complementary role in the study of animal behavior. For example, studies of zoo-housed populations could provide an ideal setting for the study of subtle behaviors rarely seen in the wild, as for example female dominance in mouse lemurs (Radespiel & Zimmermann 2001), or allow investigators to control for social and ecological variables that may influence an individual’s activity and social behavior.

The main objective of this study was to describe the sex differences in the social behavior of a group of zoo-housed black spider monkeys, in order to: [1] Build on our current knowledge of the behavioral flexibility of these primates, [2] better understand the behavior of spider monkeys under human care, and [3] provide data that can help improve the design and implementation of rehabilitation strategies, captive population management, and reintroduction of individuals into the wild. In order to achieve these goals, this study seeks to determine sex differences in the time spent on different activities, in rates of affiliative and agonistic behaviors, and to compare these results with those obtained in field studies on *Ateles*.

## METHODS

### Study Site and Focal Subjects

This study was conducted with one zoo-housed group of black spider monkeys (*Ateles fusciceps rufiventris*) at the Wakatá Biopark, in the municipality of Tocancipá near the city of Bogotá, Colombia. Data collection took place from January to June of 2013. The enclosure consists in two islands (850 m<sup>2</sup>), surrounded by water, which are connected through several aerial ropes, and with a few artificial structures where monkeys can go inside and shelter. The study group consisted of 18 individuals: six adult males, seven adult females, two juvenile females, one juvenile male and two infants, one of each sex. We considered adult individuals to be at least five years of age, juveniles between 2 and 5 years, and infants less than two years of age.

### Data Collection

At the start of the study, we conducted a pre-sampling stage of five days at the zoo, where we individually identified all

group members based on physical characteristics and age-sex categories. Characteristics used to individually identify group members included the color of the hair around the ears, shape of the face, presence or absence of white chin hair, body size, scars, and ano-genital marks (Arango et al. 2008). During this preliminary sampling period, we also constructed a detailed ethogram for the study group based on comprehensive field protocols that have been made for wild spider monkeys (Link & Di Fiore unpublished) and complemented with “novel” behaviors observed in the captive population throughout the study.

After the pre-sampling stage we conducted behavioral sampling on the activity patterns and social behavior, including all adults, juveniles and infants. We collected behavioral data using focal animal sampling (Altmann 1974), with a rotating set of 20-min focal samples conducted once on each of the 18 individuals during each sampling day. In order to control for the time of day when each animal was selected as a focal animal, we established a pre-defined schedule in which individuals were sampled evenly across hours of the day. During each day, the order of the focal animals was randomized, ensuring that for each rotation of 18 days, none of the individuals repeated the time of the day when it was sampled. Two complete sampling cycles of 18 days each were completed during this study.

During each focal sample, we collected instantaneous point records every two minutes on the main activity of the focal animal and other group members that were in proximity (within two meters) or in contact with the focal animal. Activities included the following categories: feeding, resting, moving, social interactions (e.g., grooming, embrace, aggressions, social play) (Abondano & Link 2012). All the behaviors not belonging to these categories were included in the category “other”. Likewise, during the entire focal sample and within the 2-min instantaneous records, all social behaviors were recorded continuously (e.g., aggression, grooming, etc.). Those behaviors that could be registered instantaneously (e.g., threat, chase) were classified as events, and those that had time duration were recorded and classified as states (e.g., grooming or play).

The rates of behavioral states such as grooming, embracing, tail wrapping, social play and aggression were calculated for all possible dyads in the group. We also recorded the duration of time in proximity as the time spent within a distance of 2 m between the focal animal and its nearest neighbor. Grooming was recorded as the duration of time in which an individual used his hand or mouth to manipulate the hair of another group member (Abondano & Link 2012). Embraces were events when an individual placed both arms around another individual. Tail wrapping was reported when two individuals joined their tails and intertwined them. We also reported all aggressive interactions including chases (when an individual rapidly followed another individual making it move from its original position) (Link et al. 2009), lunges (when one individual directed its arm violently to another individual) and threats (an individual bares its teeth toward another one) (Abondano & Link 2012).

## Data Analyses

Activity budgets were estimated for each individual based on the observed time spent in each activity (feeding, resting, moving, social and other). To compare differences between

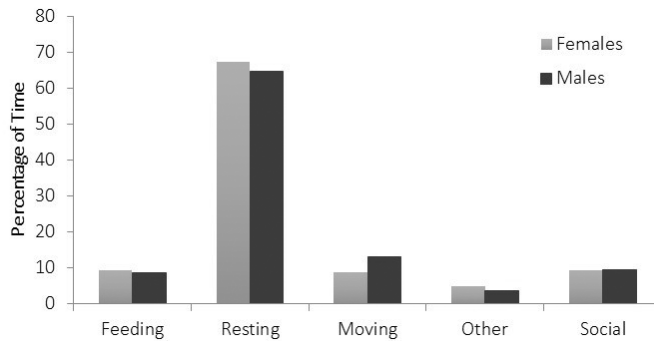
sexes for each activity we used a t-test, adjusting the level of significance through a Bonferroni correction with a p-value of  $P < 0.01$  (Slater et al. 2009). In order to reduce the lack of independence of our behavioral data, each focal sample was treated as a single data point. For social behavioral states, the percentage of time each dyad spent in a given state was calculated from the time the individuals began interacting until the end of the interaction. Mean percentage of time each subject spent in grooming or in proximity to another individual was calculated across all its dyads. Percentage data were normalized using the arcsine transformation (Fowler et al. 1998; Slater et al. 2009) and in order to look for significant differences in the behavior of males and females we used a one-way ANOVA, followed by post-hoc Tukey test. For events such as embraces, tail wrapping, genital presentation and aggressions we calculated hourly rates by adding the rates of all the possible dyads, and calculated the total number of times each type of event took place as well as its directionality (e.g. male to female, female to female or female to male).

## RESULTS

We collected a total of 648 focal samples (36 on each group member,  $N = 18$  individuals), including 252 samples of adult females and 216 samples of adult males, 468 samples corresponded to adults, 108 samples to juveniles and 72 to infants. There were no differences in proportion of time males and females invested in different activities (resting,  $p = 0.476$ ; moving,  $p = 0.186$ ; feeding,  $p = 0.693$ ; other,  $p = 0.616$ ; social activities,  $p = 0.998$ ; see Fig. 1).

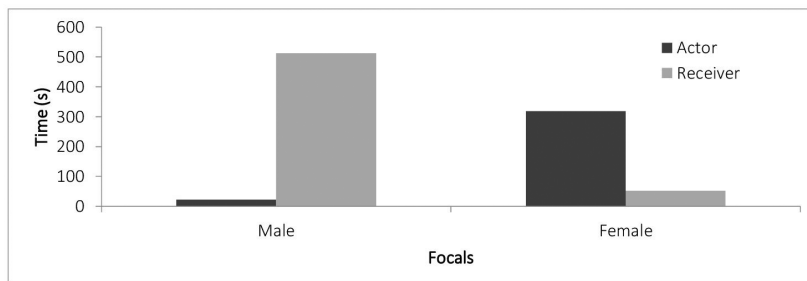
There were no differences in the time adults and infants spent in different activities (feeding,  $p = 0.397$ ; resting,  $p = 0.657$ ; moving,  $p = 0.176$ ; social,  $p = 0.486$ ; other,  $p = 0.649$ ). Nonetheless, we found differences in the proportion of time juveniles and adults spent in different activities. They spent a similar proportion of time in activities such as feeding ( $p = 0.176$ ), moving ( $p = 0.154$ ), and other ( $p = 0.151$ ), but differences were found in resting ( $p = 0.036$ ) and socializing ( $p = 0.013$ ). Adults rested more than juveniles, and juveniles spent more time socializing compared to adults. These differences also occurred between juveniles and infants as infant behavior seemed strongly influenced by adult behavior.

There were no differences in the proportion of time males and females spent in contact or in proximity. Also, there were no differences in the proportion of time males and females were actors and receivers of grooming (Table 1). Although the average percentage of time spent grooming was roughly equal for males and females, females initiated more grooming towards males and received more grooming from females (Fig. 2a). Also, females had a larger number of grooming partners than males (Fig. 2b).

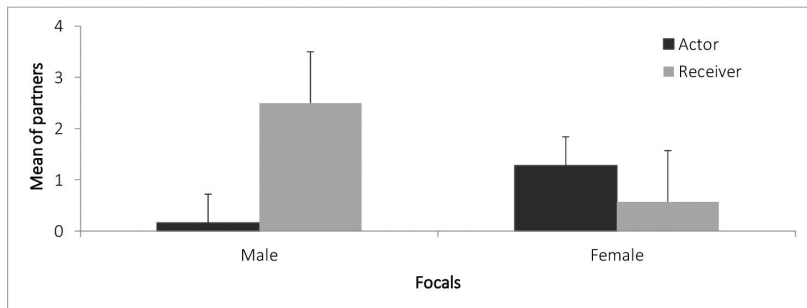


**Fig. 1.** Mean percentage of daily activity budget for male and female black spider monkeys.

2a.



2b.



**Fig. 2.** a) Time in seconds spent on grooming by males and female spider monkeys. b) Mean of partners that interacted in grooming.

Almost all members of the group were involved in grooming for a similar amount of time (the average percentage of time spent grooming was 0.025%,  $N = 13$  individuals). None the less, one adult male (MAY) spent a much higher proportion of time grooming with other group members, and interestingly, most of the grooming was directed towards him (Fig. 3). This particular male was also the one that was most frequently involved in chest rubbing behaviors throughout the study period.

Adult males were the most frequent or unique initiators of several social behaviors. For example, males initiated 24 out of 26 displays (rough movements towards the observer, visitors at the zoo or other members of the group). Also, chest rubbing with fruits and long distance calls were uniquely initiated by males (Fig. 4). We observed that the majority of embraces occurred between males, and that males were most often the initiators of embraces. Out of twenty-three embraces observed, males embraced

**Table 1**

Mean ( $\pm$ SE) of percentage of time (seconds) spent in social interactions by male and female black spider monkeys.

	Male Actor		Female Actor		One-way ANOVA	
	Male receives	Female receives	Male receives	Female receives	F	P
Contact (% time)	15.3 $\pm$ 4.0	13.2 $\pm$ 2.5	14.8 $\pm$ 3.6	15.2 $\pm$ 3.2	0.576	0.64
Proximity (% time)	17.2 $\pm$ 3.9	15.4 $\pm$ 2.8	16.6 $\pm$ 3.8	17.4 $\pm$ 4.0	0.415	0.74
Grooming (% time)	0.41 $\pm$ 0.46	0.16 $\pm$ 0.15	0.2 $\pm$ 0.16	0.3 $\pm$ 0.21	1.325	0.29

with other males on ten occasions, and six times were towards females, while females only initiated seven embraces (5 towards males and 2 towards females). Also, males were the most frequent actors in presenting themselves to be smelled, initiating 111 genital presentation events while females only started them on 41 occasions. The majority of aggression was directed toward females. On 27 out of 33 aggressions, females were the target of aggression both from females (N= 13 events) and males (N = 14 events) while aggression against males was very low especially in male-to-male dyads where it only occurred on one occasion. Finally, during this study, we recorded an unusual behavior in spider monkeys in which individuals intertwine their tails while resting or moving together (but see Van Roosmalen & Klein 1988). These tail-wrapping events were more common among male-to-male dyads (7 out of 8 events), and were absent in female-to-female dyads. Only a single tail-wrapping event took place between a male-female dyad.

## DISCUSSION

The results of this study suggest that the nature of social interactions amongst spider monkeys at the Wakatá Biopark is similar to that reported on wild populations of spider monkeys (Aureli & Schaffner 2008). Overall, aggression is rare and more often directed from males to females (Slater et al. 2008; Link et al. 2009). Also, males seem to have close social bonds and affiliative behaviors such as embracing which are more common amongst them (Fedigan & Baxter 1984). Nonetheless, we noticed the appearance of unusual behaviors such as chest rubbing (with fruits) and tail-wrapping which have been documented in only but a few early studies on spider monkeys (Klein & Klein 1977; Van Roosmalen & Klein 1988). We note that although chest rubbing might have social implications, we consider it is a

self-directed behavior which still needs to be further investigated. Also, one male was the recipient of most grooming from other group members and most often initiated chest rubbing behaviors.

Zoo-housed spider monkeys spent different proportion of time in their main activities when compared to previous results from wild populations. As expected, spider monkeys at Wakatá Biopark spent a much higher proportion of time resting than wild populations (Slater et al. 2009; Abondano & Link 2012). In this study, spider monkeys spent on average approximately 70% of their time resting, and divided the rest of their time between feeding, moving and socializing. Wild populations of spider monkeys spend roughly half of their time resting and about 20 to 25% both feeding and moving, and only spend a minor proportion of time in social behaviors and other activities (Slater et al. 2009; Di Fiore et al. 2011; Abondano & Link 2012). These differences in the activity budget of wild vs. populations under human care clearly evidence the fact that zoo-housed populations are provisioned, they are fed on a fix time schedule every day and the energy required to search for food is negligible.

Also, both males and females spent a similar proportion of time in different activities in this study, suggesting that the spatial constrains and fixed feeding schedules might reduce potential differences between the sexes in their allocation of time to find food, partners or reproductive opportunities. Although differences in activity patterns between males and females in the wild are not striking, and overall, they tend to spend similar proportions of time in each activity, several studies have found subtle, but significant, differences in the time males and females spend feeding or socializing (Di Fiore et al. 2011). Finally, this study found that juveniles tended to spend a larger proportion of time in playing and social activities than adults, as seen in wild spider

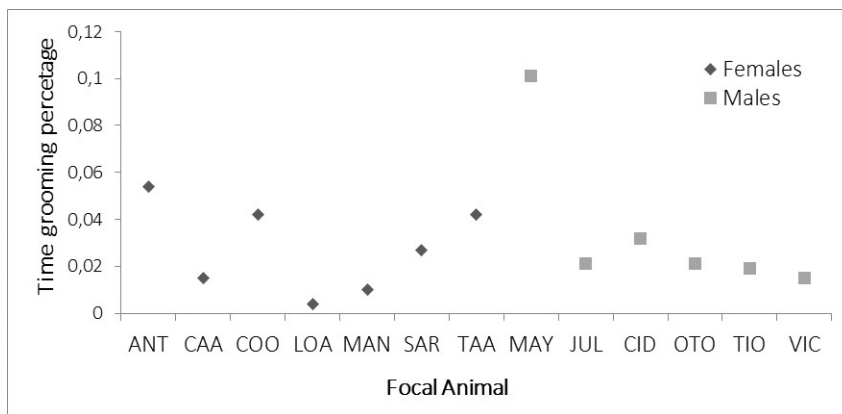


Fig. 3. Percentage of time each individual spent grooming with other group members.

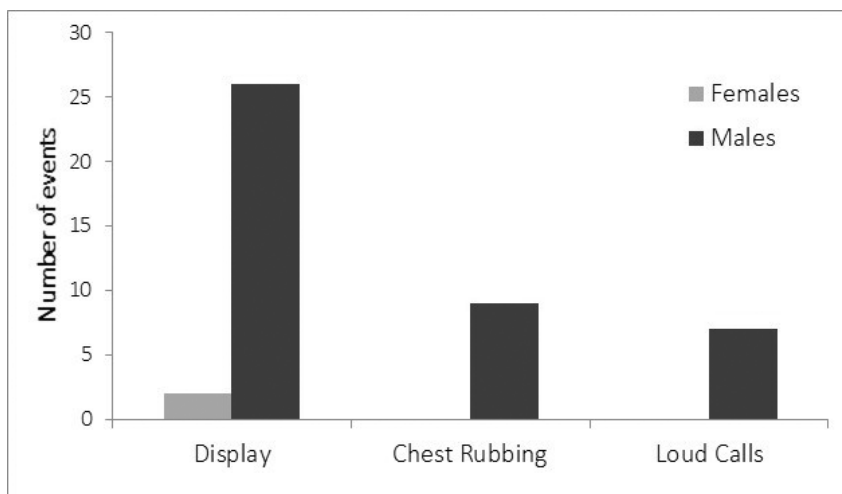


Fig. 4. Number of observations in which male and female black spider monkeys initiated social displays (DIS), chest rubbing using fruits or leaves (RUB), or long calls (VLC).

monkeys, and other wild primates (Shanee & Shanee 2011).

There were no differences in the time males and females spent in proximity and grooming with other group members and both females and males initiated and received grooming in a similar proportion. Nonetheless, females initiated more grooming towards males and received more grooming from females. Also, males received grooming from more partners than females. Unexpectedly, a single adult male was the recipient of a larger proportion of grooming from most other group members. This is interesting as most (if not all) studies of wild spider monkeys have had practical challenges in identifying dominance relations between the group's

males, or even finding males with higher social "centrality" (Ramos-Fernandez et al. 2009). This particular male was also the most frequently involved in chest rubbing and other social behaviors suggesting a probable role as leader or central member of the group.

Most behaviors that were not directed at other group members, such as displays (directed to the observers), chest rubbing and long calls, were almost exclusively initiated by males. Although these behaviors may play a role in the subtle patterns of male-male competition, or may be subject to female choice, this still needs to be studied more thoroughly. Also, given that territorial behaviors such as boundary patrols and deep incursions into

neighboring territories are initiated by male spider monkeys (Aureli et al. 2006; Link 2011), displays to observers may be evidencing male participation in behaviors related to group defense. Interestingly, the nine independent chest rubbing events were only displayed by three of the adult males, and more than half of these events were initiated by “May”, who was the male that also received more grooming in the study. In fact, chest rubbing in other male atelines (e.g., woolly monkeys) has been associated with the presence of estrous females and the occurrence of sexual behaviors (Di Fiore et al. 2006).

Patterns of aggression in our study group seem to follow those patterns reported in multiple studies of wild spider monkeys (Fedigan & Baxter 1984; Slater et al. 2009; Link 2011; Abondano & Link 2012). Most of the aggression was initiated by male spider monkeys (although females also initiated an important proportion of aggression) and almost exclusively targeted to females (see Fedigan & Baxter 1984). We suggest that male-to-female low intensity aggression (e.g., chases) might play a role in the maintenance of social relations of males with each of the group’s females (Link 2011) and might even act as a form of courtship and influence female sexual preferences (Slater et al. 2009). Similar to what has been observed in the wild, male-to-male aggression was extremely rare in this study, but it is noteworthy that when it happens, it can escalate to lethal aggression (Campbell 2006; Valero et al. 2006). Overall, these results are similar to the results reported by Slater et al. (2009) and Link et al. (2009) who found that males are more involved in affiliative behaviors than females, and that females receive more aggressions than males. Finally, there was only scant data on aggressive behaviors and thus it was not possible to test for dominance relations between male or female spider monkeys. Nonetheless, the fact that in natural conditions aggressions between male spider monkeys are very rare is in accordance with the results of this study, although in zoo-housed groups, male-male aggression is more common than amongst other sex dyads and more injurious than inter-sexual aggression or female-female aggression (Davis et al. 2009).

Several behaviors observed in populations under human care seem to reinforce the hypothesis that male spider monkeys have strong social bonds between them. Not only was aggression between males quite rare, but male-male dyads were more frequently involved in embracing (Schaffner et al. 2012). Also, tail wrapping—an unusual behavior observed during field studies—was common among male-to-

male dyads, and was not present in female-to-female dyads. Probably this set of social behaviors, although less frequently displayed than in many other primate societies, still play a role in the maintenance and strengthening of social bonds.

This study provides evidence that life in zoos has profound effects on the activity and behavior of spider monkeys and changes their activity budgets and social relations within a group. We found differences in the behavior of spider monkeys when compared with studies in the wild. Spider monkeys adapt to living in zoos by changing several aspects of their behavior, but also maintain key aspects of their sociality when kept under human care. This study contributes to our current knowledge of the behavioral flexibility of spider monkeys and helps us understand the behavior of *Ateles* living under human care, providing relevant information for the design and implementation of rehabilitation strategies, captive population management, and reintroduction of individuals into the wild.

## CONCLUSIONS

Studies that describe the social behavior of spider monkeys under human care are still scant. Even though expected changes in feeding behavior, ranging patterns and social behavior may emerge in zoological facilities, they may also help to detect and study how group members interact with each other, and identify subtle and inconspicuous behaviors that may be overlooked in the wild and may well play an important role in the regulation of social relations in primate societies. In this study, male to female aggression was common while male-male aggression was extremely rare. Also, adult males seemed to have closer bonds and were involved in actives such as embracing more often than any other age-sex dyad. Interestingly, one of the males was the recipient of a larger amount of grooming and at the same time was involved in chest rubbing behaviors and other affiliative behaviors with all other group members. We suggest that some of these behaviors, rarely seen in the wild, might outline the behavioral mechanisms used by male (and female) spider monkeys to shape the nature of their social relations and the establishment and maintenance of social bonds.

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