Female Reproductive Advertisement and Social Factors Affecting the Sexual Behavior of Captive Spider Monkeys

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Introduction

The transmission of messages about the reproductive condition of females is extremely widespread among mammals. Female urogenital signals, particularly those arising during estrus, play the most important role in the chemical signaling of many primate species. Genital scent-marking behavior by females, sniffing and mouthing of female genitalia by males, and even tasting of female urine and vaginal discharges are preludes to sexual arousal by male primates (Epple *et al.*, 1993). As with other chemical signals, female urogenital signals derive from many sources. Besides urine there are specific secretions of the reproductive tract and the accessory sex organs which may be modified by the action of microorganisms inhabiting the vagina. Many species also possess well developed skin glands in the anogenital region (e.g., labial gland, circumgenital glands) which further contribute to the chemical ambience of the genital region of female primates. Five chemical signaling materials have been identified in the female: (1) Urine components. (2) Materials from the upper reproductive tract, such as oviducal, endometrial, and cervical mucus. There are cyclic changes in the cervical lipids (hydrocarbons, glycerides, cholesteryl esters, free fatty acids and phospholipids [Singh *et al.*, 1972]). (3) Materials from the vaginal walls. The vagina is rich in glands and receives exfoliated cells from its surface and transudates of blood plasma. It is also rich in glucose that is transformed into glycogen by enzymes which are stimulated by high estrogen levels (Singh *et al*, 1972). (4) Secretions of the vulval glands (also called Bartholin's glands). The functions of these secretions are unknown. (5) Materials from the activity of resident vaginal microflora. In human females, lactobacilli and facultative and strict anaerobes have been identified in the vaginal tract. These bacteria are known to use glycogen as a substrate, producing a wide variety of volatile fatty acids such as acetic acid. In the rhesus monkey, acetic and isovaleric acids are known to dominate female vaginal odor (Michael *et al.*, 1972; Larsen *et al.*, 1977).

The effects of vaginal secretions as monitored by male *Macaca mulatta* were first studied by Michael & Keverne (1968). In platyrrhines, anogenital inspection by males has been described in the dusky titi (*Callicebus moloch*, Moynihan, 1966), the night monkey (*Aotus trivirgatus*, Moynihan, 1976), spider monkeys (*Ateles geoffroyi* and *A. belzebuth*, Klein, 1971; Eisenberg & Kuehn, 1990; Chapman & Chapman, 1990) and the woolly spider monkey (*Brachyteles arachnoides*, Milton, 1985).

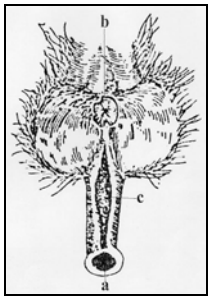

Figure 1: External genitalia of female *Ateles geoffroyi* illustrating the a) *glans clitoridis*, b) *anus* and c) *sulcus retroglandis* adapted from Hill (1963)

The clitoris of the female spider monkey has been a subject of curiosity due to its enormous length (*Figure 1;* Hill, 1963). This structure is a soft flabby structure more or less resembling the penis but longer (4.7 cm in *Ateles belzebuth*). Hill (1963) made a detailed description of the clitoris, emphasising its *sulcus retroglandis* and the pigmented horseshoe-shaped *glans clitoridis* located at its caudal tip. No studies have been able to explain the evolutionary mechanisms that have favored such a large clitoris in female spider monkeys. Some authors suggest that, because the frugivorous genus *Ateles* tends to forage individually, females use small quantities of urine retained in the perineal groove (*sulcus retroglandis*) of the clitoris to leave scent traces in the trees to advertise their reproductive condition (Klein, 1971). Milton (1985) suggests that females travel more when receptive, depositing urine in various places. There is a lack of information concerning the vaginal components that could serve as pheromones in spider monkeys. Hodges *et al.* (1981) identified estriol, estradiol, and estrone in female spider monkey urine, with estrone in the highest concentrations.

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No studies have been carried out to evaluate the influence of familiarity upon the reproductive performance of spider monkeys in captivity, although they are a very common species of primate in Mexican zoos. Also, the effect of length of the external genitalia of females has not yet been evaluated in the sociosexual context.

Objectives

The aims of this paper are to evaluate (1) the role of olfactory inspection (clitoris grasping and sipping of urine) of female spider monkey external genitalia as precopulatory sexual behavior by the adult male; (2) the effect of clitoris size upon female sexual attractiveness; and (3) the effect of familiarity between group members on the occurrence of sexual behavior.

Because of the small male sample size (N=2 males), comparisons of male behavior were not possible; therefore, statistical differences were only evaluated among females (as receivers of male sexual behavior).

Materials and Methods

Subjects: Observational data were collected for 15 months from two groups of nine captive black-handed spider monkeys (*Ateles geoffroyi; N* = 18) housed at the Centenario Zoo at Mérida, Yucatán, Mexico. The study subjects belong to the subspecies *A. g. yucatanensis* (Dubach, personal communication). Spider monkeys of this species are found in forest patches and in protected rain forest natural reserves of the Yucatan Peninsula.

The two groups studied have different histories. One was a **newly formed group**, composed of nine wild-caught, unrelated animals of various ages which had been kept as pets since infancy. They had been confiscated by wildlife officials and given to the Zoo. They were kept in individual quarantine before being incorporated into a group. This study began five months later.

The other group studied was an **established group,** composed of nine captive-born animals that are currently breeding. Unfortunately, there are no records on how long the animals have been together, birth dates, or general reproductive profiles. Paternity tests were performed by the Department of Genetics of the Chicago Zoological Society to determine the group's kinship.

Each group was composed of seven females, one adult male, and one juvenile male. This coincidental similarity between the two groups made it possible to control for group composition.

Because birth dates were not known, age was determined by correlating individuals' eye skin pigmentation (ESP) with age categories. The skin that surrounds the eyes lacks pigmentation in newborns and infants (Eisenberg, 1976). According to Eisenberg, this lack of pigmentation persists until over 14 months of age in *Ateles geoffroyi*. As the juvenile matures, the face gradually becomes pigmented, except for the skin around the eyes, which can still be pink at 19 months of age. Further development sees the accumulation of more melanin in the dermis and epidermis of the skin surrounding the eyes, forming more and more dark brown freckles.

Each animal was assigned to an age class based on this criterion. Using ESP as a method to approximate age has several possibilities for error including individual variation, size range of age categories, and observational error. However, in the absence of birth records, this indirect measure of approximate age was useful.

Subject environment: During this study the monkeys were housed in basic, temporary accommodations away from the public. Animals from the established group were housed together and never mixed with unfamiliar animals.

Housing: The two groups of black-handed spider monkeys lived in two neighboring enclosures (each 34.8 m^2 – or 4.35 m^2 per animal), separated by wire mesh. These enclosures are furnished throughout with ropes and tree trunks that enable the monkeys to move in a three-dimensional environment. The sand floors of the cages are renewed every 3-6 months and perches and walls are disinfected every month. Due to the tropical climate of the Yucatan Peninsula, which has an average temperature of 25°C, the animals do not require night enclosures. If isolation of an animal is required, the feeding section is adapted to this purpose. The cages are provided with shelters just above the main perch, where the monkeys normally cluster together hiding from the rain.

Husbandry: As mentioned above, feeding takes place in a special section of the enclosures. This 5 m^2 feeding section has a cement floor, over which the keepers disperse fruit. This cement floor is routinely washed prior to feeding. Water is provided here in a bowl.

Food is provided twice a day and consists of a variety of fruits and vegetables (bananas, oranges, papaya, watermelon, carrots, tomatoes, lettuce). Twice a week the animals are provided with freshly cut *Brosimum alicastrum*, a natural food resource for *Ateles* in Yucatan. In the evening, commercial dog food or cooked rice or oats is supplied, sometimes with honey or milk and vitamins added. Pregnant and lactating females are supplied with vitamin and mineral supplements; and, as a preventive measure, all monkeys are dewormed every six months with Albendazol (Zentel).

Methods of behavioral sampling: Four sampling methods were utilized: focal animal sampling, scan sampling, *ad libitum* sampling, and continuous sampling (Altmann, 1974). Focal samples were used for adult females and

males. This enabled us to quantify social relationships and compute frequencies of behavior (Dunbar, 1975). The daily data for each individual was collected randomly to avoid bias.

Sexual behavior was recorded using focal and *ad libitum* sampling. Animals were followed for 30 focal minutes. When a male was observed inspecting females' genitals and/or animals were observed attempting copulation (leg lock or female sitting on male's lap), I left the focal subject and changed to *ad libitum* continuous sampling, to record as many instances of sexual behavior as possible.

Behaviors sampled: The sexual behaviors recorded were defined as follows:

a) Inspecting behaviors

grasp: Male approaches female, manipulates her clitoris, squeezes the *glans clitoridis*, and smells his hand.

sip: Male sips the urine of a female shortly after she has urinated.

b) Copulatory behaviors

lap sit: Receptive female approaches male and initiates mounting by sitting on the male's lap.

leg lock: Male places his hind legs over the female's thighs. Usually both animals are sitting down.

thrust: Intromission.

Because the animals were inactive during the middle of the day when temperatures were highest, sampling was restricted to the periods between 08:00-12:00 and 16:00-17:00, when the animals were most active.

A total of 208 hours of focal observations were taken from the newly formed group and 242 hours from the established group. Four instances of complete copulation and one copulation attempt by a male were recorded through *ad libitum* sampling in the established group. No complete or incomplete copulation was recorded in the newly formed group.

Two males were not included in the focal samples (Bart and Marcos). Marcos was a juvenile and Bart an infant when I started this study. Their participation in the social network was very limited, and they spent most of the time playing. Bart was still very dependent on his mother and clinging to her at the time I started to collect the focal samples.

Evaluating the relationship between genital grasping as a form of genital inspection and copulation: Frequencies (events/min) of males actively grasping the external genitals of females and mounting were correlated using Spearman Rank coefficients.

Evaluating the relationship between clitoris size, age, and female sexual attractiveness: While the animals were anesthetized for blood collection (for DNA fingerprinting), they were weighed and measured and female clitoris lengths were obtained.

To test for the relationship between clitoris size and sexual attractiveness (measured by the number of times the males grasped females' genitals and/or sipped females' urine), the residual of clitoris length, regressed on body weight, was correlated with ESP and frequency with which males performed these behaviors. The purpose of using these residuals was to control for body weight (body weight in kg regressed against clitoris length in cm).

In the newly-formed group, Doris was excluded from the sample, as her clitoris size seemed to differ greatly from the *Ateles geoffroyi* average length reported in the literature (4.7 cm). Doris's clitoris was smaller than those of the rest of the females; we thought she belonged to another species of *Ateles*. However, the karyotype profiles revealed that Doris, like the rest of the animals studied, belongs to *Ateles geoffroyi yucatanensis* (Dubach, personal communication). The reason for the small size of her clitoris remains unknown.

Results

a) Inspection and sexual behavior: In this study, only the adult male from the established group (Loco) actively manipulated the clitorises of females. This behavior was also accompanied by sniffing his hand after the manipulation. *Figure 2* shows two peaks of clitoris inspection by Loco in a period of 14 months. These peaks coincided with incidents of mounting, in April and in August, suggesting that female genital inspection by males precedes copulation. Loco also sipped the urine of females. Damian, the adult male in the new group, neither grasped the clitoris of females nor copulated with them, but he did sip the urine of one female (Vicky) shortly after she deposited urine. I included this form of genital inspection when correlating age with sexual performance, as pheromones from the *sulcus retroglandis* can be flushed out with urine.

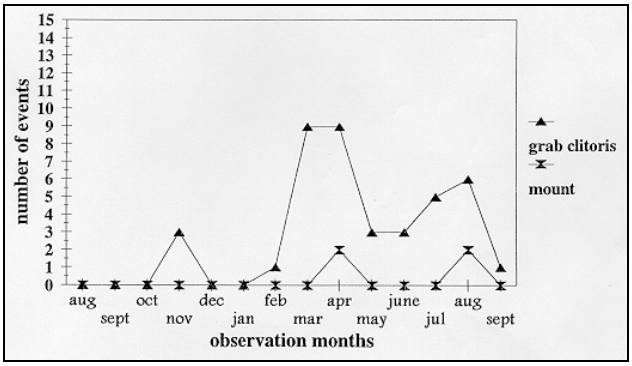

Figure 2: Female genital manipulation and mounting by Loco (Established group).

This difference in grasping by males between the two groups (Mann-Whitney-U Test, Z=-2.44, 2-tailed p= 0.01,

N=13) suggests that the social environment might have an important effect upon females' sexual attractiveness. Another possible reason for this is that there may be differences in sexual interest between the males, and elusive behavior by females, because adapting to the entirely new social context could have been very stressful for the animals of the newly formed group.

The clitorises of three females in the established group (Guera, Emma, and China) were almost always grasped preceding copulation. Another female, Flaca, gave birth in August, 1995. Prior to the birth of her infant, Loco (the adult male) was seen grasping her genitals on two occasions; once in January, eight months prior to delivery, and once in April. Considering that the gestation period of *Ateles* is 226 days (Robinson & Janson, 1987), an unobserved copulation must have taken place sometime at the end of January of that same year. This suggests that her genitals were also grasped close to when copulation took place.

Another female worth commenting on is Faby. Loco grasped her clitoris at a very high rate. Two frequency peaks of grasping were observed, in April and in July, the periods when Loco copulated with the other females. But even though Loco grasped her genitals frequently, he was never seen attempting to copulate with her.

Lisa and Lucrecia, who had not reached sexual maturity when this study was carried out, were never observed being inspected or mounted by Loco.

b) Clitoris size, age category (ESP) and female attractiveness: To evaluate the relationships between: (1) age and clitoris size, (2) age and frequency with which females are inspected by males (by grasping or sipping), and (3) clitoris size and genital grasping, the residuals of the regression between clitoris length and body weight, and absolute clitoris length were correlated with ESP and frequency of clitoris grasping by a male (see *Table 1*).

Age and clitoris size: The results suggest that age category of the females, based upon eye skin pigmentation, is not significantly correlated to clitoris length/body weight residual (r_s=.06, p=0.84, N=13). Absolute clitoris size was also not significantly correlated with frequency of genital inspection (r_s= -.04, p=0.89, N=13). These results suggest that clitoris size is not a function of female age.

Age and genital inspection: For the male of the established group there was a non-significant relationship between total frequency (events/minute) of both sipping and grasping and age of females (ESP) (r_S=1.65, 2-tailed p=0.61), and a non-significant relationship between frequency of just sipping and age (r_S=0.49, 2-tailed p= 0.61). However, there was a significant relationship between frequency of grasping and age (r_S=1.94, 2-tailed p=0.04). Presumably Loco is obtaining chemical signals related to the reproductive condition of adult females through this grasping. Damian showed a non-significant relationship between frequency of sipping and age, (r_S=0.49, 2-tailed p=0.04), suggesting that he is not obtaining chemical information on her reproductive condition.

Females	Absolute clitoris length (cm)	Clitoris residual	Male grasps (events/ min.)	*Age category (ESP)
Newly formed group				
Quita	4.5	1.21	0	1
Mona	6	0.08	0	1
Gringa	5	-1.32	0	2
Gorda	6	0.37	0	2
Vicky	5.1	0.51	0	1
Susi	5.3	1.45	0	1
Established group				
Guera	4	-0.62	0.002	2
Flaca	5	0.41	0.001	2
Lucrecia	4	-0.62	0	0
Faby	4.1	-0.46	0.1	2
Lisa	4	-0.58	0.0005	1
China	4.2	-0.68	0.01	2
Emma	5	0.39	0.001	2

Table 1: Variables utilized to evaluate female sexual attractiveness. ***** 0= not pigmented, 1= partially pigmented, 2= pigmented

Clitoris size and genital inspection: Neither clitoris length/body weight residual nor absolute clitoris length was significantly correlated with Loco's genital grasping (clitoris length/body weight residual with genital grasping: r_s=.-10, p=0.72, N=13, absolute clitoris length and genital grasping: r_s= -.22, p=0.46, N=13).

Discussion

The females of the established group were inspected more by a male than the females of the newly-formed group. One of the reasons for this is that the females of the established group seemed to be advertising their reproductive cycles, and therefore to be more attractive to their male, Loco. Older females were inspected more than younger females, suggesting that the difference in clitoris grasping is a function of the females' age. Also, the results obtained seem to suggest that an increase in frequency of female genital grasping by the male precedes copulation.

The differences between groups, in males actively grasping the genitals of females, could be explained by the fact that it was stressful for the animals of the recently convened group to be in a new situation, surrounded by unfamiliar animals, in their own and the established group. It might be that the adult females of the newly formed group were reproductively suppressed due to that social

stress, and therefore were not advertising reproductive cycles (Dunbar, 1980).

Another possible explanation is that learning might be a factor for the development of pre-copulatory behaviors in male spider monkeys. In wild conditions sub-adults join all-male bands (MacFarland 1990), and probably learn how to approach and inspect females as they wander within their natal group's range. In this study the male of the newly formed group, Damian, approached a certain female, probably attracted by her scent. He then indirectly inspected this female by sipping the urine she had deposited. The lack of familiarity among the members of this group may explain why Damian was reluctant to directly inspect the genitals of females. It is also possible that, at the same time, the females were reluctant to be directly inspected by a relatively unfamiliar conspecific.

Because clitoris size did not seem to be related to female sexual attractiveness, the function of such a large structure remains unknown.

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