

## BEHAVIORAL ECOLOGY AND CONSERVATION STATUS OF SPIDER MONKEYS IN THE *OTOCH MA'AX YETEL KOOH* PROTECTED AREA

Gabriel Ramos-Fernández<sup>1</sup>, Laura G. Vick<sup>2</sup>, Filippo Aureli<sup>3</sup>, Colleen Schaffner<sup>4</sup> and David M. Taub<sup>5</sup>

<sup>1</sup>Pronatura Península de Yucatán, A.C. Calle 17 #188<sup>a</sup> x 10, Col. García Ginerés, Mérida, Yucatán 97070, México, e-mail <ramosfer@sas.upenn.edu>.

<sup>2</sup>Anthropology Department, Peace College, 15 Peace St., Raleigh, NC 27604, USA.

<sup>3</sup>School of Biological and Earth Sciences, John Moores University, Byrom St., Liverpool L3 3AF, UK.

<sup>4</sup>Psychology Department, Chester College of Higher Education, Parkgate Rd., Chester CH1 4BJ, Cheshire, UK.

<sup>5</sup>Medical University of South Carolina, 268 Calhoun Street, Charleston, SC 29425, USA.

### Introduction

Habitat destruction is the greatest threat to the survival of the extant primates of the Yucatán peninsula, the black-handed spider monkey (*Ateles geoffroyi*) and the black howler monkey (*Alouatta pigra*). Most of their habitat has been destroyed by slash-and-burn agriculture and the accidental fires associated with it (reviewed in Challenger, 1998). Spider monkeys are particularly vulnerable to the effects of habitat fragmentation, because they occur in low numbers, occupy wide home ranges, have low fecundity rates and rely on a patchy food resource such as ripe fruit (Meffe and Carroll, 1994). We report the results of an eight-year study on the behavioral ecology of spider monkeys living in a fragmented habitat in the northeastern Yucatán peninsula. Specifically, we include those results that help evaluate the viability of the population and provide guidelines for

the design of conservation strategies that help ensure the permanence of this and other remaining populations of the species throughout the Yucatán peninsula. We also include a brief description of our different research lines.

### Study Site

The study site has been recently declared as the *Otoch Ma'ax Yetel Koooh* protected area by Mexican Federal authorities (*Diario Oficial de la Federación*, 5 June 2002; see Fig. 1). Of the 53.67 km<sup>2</sup> declared as protected, 7.7 km<sup>2</sup> consist of old-growth, semi-evergreen, medium forest distributed in patches of varying size. Trees in this forest are up to 25 m in height. Local communities have protected this fragment from slash-and-burn agriculture because of their interest in the permanence of the spider monkey population as a source of income from tourist visits. In addition, approximately 29 km<sup>2</sup> within the protected area consist of 30-50 year old successional forest, that the local people call *kelenché* (Maya for "young tree or forest"). Maximum tree height in this forest does not exceed 10 m. The rest of the vegetation within the protected area consists of fields used for slash-and-burn agriculture and young forest regenerating after this process. Because spider monkeys use both the medium forest and the *kelenché*, the conservation challenge is to preserve a large enough area of each of these two types of forest in the context of their continuous use by the local communities.

### Population Size

A line transect census carried out in 1997-1998 (Ramos-Fernández and Ayala-Orozco, 2003) revealed a very high density of spider monkeys in the medium forest (87 ind/km<sup>2</sup> ± 2.2 confidence interval at 95%) and a low but significant density in *kelenché* (6.3 ind/km<sup>2</sup> ± 5.6). Thus, the area of each vegetation type mentioned above would contain 648 individuals in medium forest and 183 individuals in *kelenché*. Clearly, because spider monkeys use these two vegetation types differently (see below), the estimation for *kelenché* should be taken with care.

The population density of spider monkeys found in medium forest is higher than any other reported for *Ateles geoffroyi* (Costa Rica: 6-9 ind/km<sup>2</sup> in Freese, 1976,

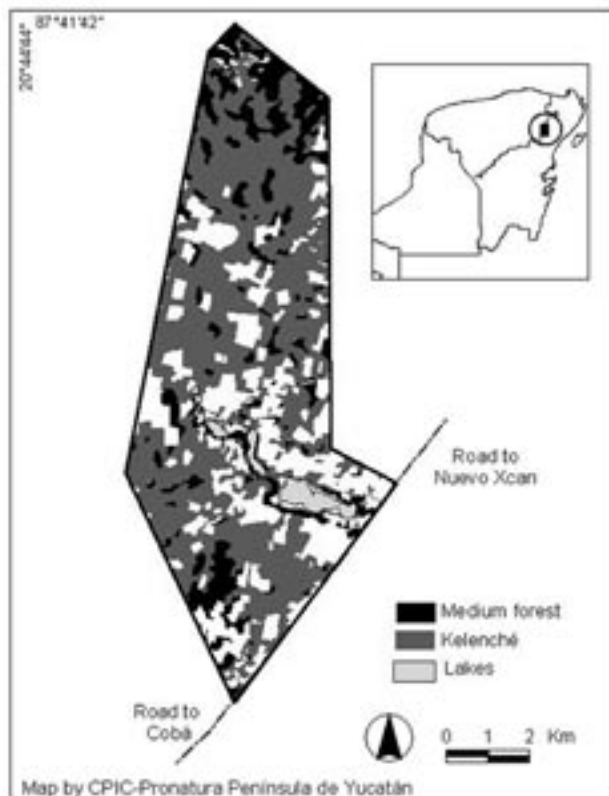


Figure 1. *Otoch Ma'ax Yetel Koooh* protected area in the state of Yucatán, Mexico.

25 ind/km<sup>2</sup> in Chapman, 1990, and 49 ind/km<sup>2</sup> in McDaniel, 1994; Guatemala: 45 ind/km<sup>2</sup> in Coelho *et al.*, 1976 and 26 ind/km<sup>2</sup> in Cant, 1978). This study is comparable to McDaniel's (1994) in that her site also consisted of fragments of old-growth forest within a matrix of cattle ranches and regenerating vegetation in Guanacaste National Park, Costa Rica. In fact, higher densities of forest-dwelling animals are the expected temporary outcome of a partial decrease in the available habitat area (Lovejoy *et al.*, 1986).

## Demography

Two groups of spider monkeys living in the main medium forest fragment around the Punta Laguna lake (2 km wide) have been studied continuously since January 1997. For an average of six daily hours, instantaneous scan samples have been taken at 20-minute intervals by four local assistants. In each sample, the location, subgroup size and activity of each visible monkey is noted, as well as the plant species and part eaten. In January 1997, the two groups contained a total of 19 and 34 individuals, respectively. By December 1999, the same two groups contained 16 and 41 individuals, respectively. As of December 2002, these groups contained 20 and 40 individuals. Table 1 shows the composition of the groups in terms of age and sex classes in January 1997, December 1999 and December 2002.

In the six-year period between January 1997 and December 2002, we registered a total of 36 births from known females in both study groups. Also, we ceased obtaining records on 30 known individuals, who we noted as "disappeared". We were able to confirm eight of these disappearances as deaths: six of them were dependent infants, at least one of whom died as a consequence of an attack by an adult male on the infant's mother (Vick *et al.*, in prep.). Two others were adult males, who possibly died as a consequence of adult male attack. At the same time, 17 of the "disappeared" individuals were subadult females that probably emigrated from the study groups. In addition, during this period, two adult females immigrated into each of the study groups. The mean inter-birth interval for eight adult females that gave birth at least twice during the period between January 1997 and December 2002 is 32 months

( $\pm 6$  SD, range 24 to 46). These values are comparable to those found by Milton (1981) in *A. geoffroyi* at Barro Colorado Island in Panamá ( $32 \pm 3$  SD, range 28 to 36), as well as those found by Symington (1987) in *A. chamek* at Manú, Perú ( $34.5 \pm 5.8$  SD, range 25 to 42). Thus, even though the density of spider monkeys appears abnormally high and could be the result of a "crowding effect" due to habitat destruction (Lovejoy *et al.*, 1986), the demographic parameters found here appear normal and there has even been an increase in the total number of monkeys in the two study groups.

## Ranging Behavior

Spider monkeys in both groups were found, in the majority of the observations, in areas of medium forest. However, in about half of the observation days, at least one subgroup traveled as far as 5 km into the successional forest, where monkeys fed on several, widely-spaced trees and always returned to sleeping sites located within the medium forest. The Eastern group's home range, defined by the minimum polygon enclosing all locations where monkeys were observed in 1997 through 2000 (Ramos-Fernández and Ayala-Orozco, 2003) consisted of 0.95 km<sup>2</sup>, from which 0.29 km<sup>2</sup> corresponds to medium forest and 0.66 km<sup>2</sup> to minimum successional forest. Similarly, the Western group ranged in a total area of 1.66 km<sup>2</sup>. Their medium forest occupation and minimum successional forest occupation was estimated at 0.29 and 1.37 km<sup>2</sup>, respectively. These figures are close to the lower limit of those reported in other studies of *Ateles* (Klein and Klein, 1977 for *A. belzebuth*, 2.6 and 3.9 km<sup>2</sup> in two groups; Van Roosmalen, 1985 for *A. paniscus*, 2.2 km<sup>2</sup>; Symington, 1987 for *A. chamek*, 2.3 and 1.5 km<sup>2</sup> in two groups; Chapman, 1990 for *A. geoffroyi*, 1.7 km<sup>2</sup>; McDaniel, 1994 for *A. geoffroyi*, 1.4 km<sup>2</sup>; Nunes, 1995 for *A. belzebuth*, 3.2 km<sup>2</sup>; Wallace, 1998 for *A. chamek*, 2.9 km<sup>2</sup>).

## Diet

Spider monkeys consume fruits and leaves from a wide variety of species (Van Roosmalen and Klein, 1988). In this study, monkeys foraged on a total of 55 species, although 85% of their total foraging time from January 1997 through

**Table 1.** Age and sex composition of the two study groups in January 1997, December 1999 and December 2002.

Age category	Sex	Eastern Group			Western Group		
		January 1997	December 1999	December 2002	January 1997	December 1999	December 2002
Infant	F	2	3	2	3	6	7
	M	3	1	3	4	4	3
Juveniles <sup>1</sup>	F	4	2	4	5	7	5
	M	2	2	0	1	3	2
Adults	F	7	5	7	14	15	13
	M	1	3	4	7	6	10
Total	F	13	10	13	22	28	25
	M	6	6	7	12	13	15

<sup>1</sup> Juveniles were independently moving monkeys that had not yet reached adult size.

December 2000 was devoted to consuming the fruit of the following species: *Ficus cotinifolia*, *Ficus ovalis*, *Manilkara zapota*, *Metopium brownei*, *Protium copal*, *Malmea* spp., *Guazuma ulmifolia*, *Sideroxylon capiri*, *Spondias mombin*, as well as the fruit and leaves of *Brosimum alicastrum* and *Enterolobium cyclocarpum*. Of these species, *G. ulmifolia* and *M. brownei* are more abundant in *kelenché* than in medium forest.

### Management Recommendations

According to the reports of the local people, most of the medium forest in the protected area was lost due to an accidental fire in 1969, after the passing of Hurricane Beulah. Indeed, most of the vegetation in the area consists of 30-year old *kelenché*. Fire clearly did not damage the fragments of medium forest that we find today, which contain a majority of trees that are several hundred years old. Our results on the inter-birth intervals, together with the increase in the size of the study groups during the six years of continuous study, suggest that the population is healthy. A similar situation was found by Strier (1991) in a group of muriquis (*Brachyteles arachnoides*) in Minas Gerais, Brazil, which after an unknown disturbance grew in size from 22 to 43 individuals in eight years of study.

Indeed, as the *kelenché* regenerates, it provides increasingly more fruit for the monkeys. A possible outcome of this is that the study groups' home range will continue increasing into the *kelenché* and that the population will continue to grow within the next few years. As of now, discussions concerning the management of the *Otich Ma'ax Yetel Kooh* protected area by all interested parties are taking place. In these, the committee formed by this paper's authors will suggest the following management recommendations to the local communities and Federal authorities, in order to preserve the population of spider monkeys in the area: 1) protect the totality of the remaining medium forest and an area of *kelenché* three times as large that joins the two largest patches of medium forest in the north (around Madera Lake) and south (around Punta Laguna; see figure); and 2) implement a thorough fire prevention and control program, especially in those years after the passing of hurricanes.

### Other Studies

Research on spider monkeys in the *Otich Ma'ax Yetel Kooh* protected area includes the following projects, with the initials of the main authors responsible also noted:

1. *Socialization process in immature spider monkeys* (LGV and DMT). This project aims to determine how the behavior of peers and adults helps channel the ontogeny of behavior toward age- and gender-appropriate patterns. In particular, the interest lies in understanding the process by which integration into the male hierarchy occurs (Riss and Goodall, 1997; Nishida and Hosaka, 1996) and the process of immigration into non-natal groups by females (Strier,

2000). More generally, this project can provide information about general socioecology, social behavior, and developmental milestones to the general data bank for the entire project, for the use of future behavioral research and to promote wise conservation policy and ecotourism.

2. *Regulation of social relationships and social structure* (FA and CS). This project aims to examine how social relationships between sexually mature individuals are regulated in the fission-fusion societies of spider monkeys. The project has two main objectives: 1) to examine the mechanisms for conflict management (see Aureli and de Waal, 2000 for a review) used by wild populations of spider monkeys. In particular, the possible sex and age differences in the use of such mechanisms will be investigated; 2) To determine the social and ecological factors influencing conflict and cooperation between group members. These factors could be related to mating strategies and counter-strategies, seasonal changes in fruit productivity, and distance from food sources, sleeping trees and community boundaries.
3. *Feeding ecology and social structure* (FA, CS and GRF). This project attempts to integrate knowledge on the social aspects outlined in the above-mentioned projects with knowledge on ecological pressures in order to understand how and why social relationships are established and maintained in the fission-fusion societies of spider monkeys. Critical ecological pressures are those related to the availability and distribution of food and other critical resources (e.g., sleeping trees) and the influence of neighboring communities and potential predators (Sterck *et al.*, 1997; Isbell and Young, 2002).
4. *Secondary forest regeneration and its utilization by spider monkeys* (GRF). This project aims at determining the role that *kelenché* and the regeneration of forest in general play in the feeding ecology of spider monkeys in the protected area, exploring the possible long-term changes in the monkeys' use of this type of forest. Through the use of geographic information systems, this project could help to predict the different scenarios in the management of the protected area, including changes in the fallow period of the traditional slash-and-burn agriculture, accidental fires, etc. (e.g., Menon *et al.*, 2001).

Ultimately, these projects, aided by genetic and hormonal studies planned for the future, would provide specific guidelines for managing other similar areas where primate conservation is of interest and where low levels of slash-and-burn agriculture can be maintained.

### References

- Aureli, F. and de Waal, F. M. B. (eds.). 2000. *Natural Conflict Resolution*. University of California Press, Berkeley.
- Cant, J. G. H. 1978. Population survey of the spider monkey, *Ateles geoffroyi*, at Tikal, Guatemala. *Primates* 19: 525-535.

- Challenger, A. 1998. *Utilización y Conservación de los Ecosistemas Terrestres de México: Pasado, Presente y Futuro*. CONABIO, UNAM, Sierra Madre, México.
- Chapman, C. A. 1990. Association patterns of spider monkeys: The influence of ecology and sex on social organization. *Behav. Ecol. Sociobiol.* 26: 409-414.
- Coelho Jr., A. M., Bramblett, C. A., Quick, L. B. and Bramblett, S. S. 1976. Resource availability and population density in primates: A socio-bioenergetic analysis of the energy budgets of Guatemalan howler and spider monkeys. *Primates* 17: 63-80.
- Freese, C. 1976. Censusing *Alouatta palliata*, *Ateles geoffroyi* and *Cebus capucinus* in the Costa Rican dry forest. In: *Neotropical Primates: Field Studies and Conservation*, R. W. Thorington Jr. and P. G. Heltne (eds.), pp.4-9. National Academy of Sciences, Washington, DC.
- Isbell, L. A. and Young, T. P. 2002. Ecological models of female social relationships in primates: Similarities, disparities and some directions for future clarity. *Behaviour* 139: 177-202.
- Klein, L. L. and Klein, D. J. 1977. Feeding behaviour of the Colombian spider monkey. In: *Primate Ecology*, T. H. Clutton-Brockh (ed.), pp.153-181. Academic Press, London.
- Lovejoy, T. E., Bierregaard Jr., R. O., Rylands, A. B., Malcolm, J. R., Quintela, C. E., Harper, L. H., Brown Jr., K. S., Powell, A. H., Powell, G. V. N., Schubart, H. O. R. and Hays, M. 1986. Edge and other effects of isolation on Amazon forest fragments. In: *Conservation Biology: The Science of Scarcity and Diversity*, M. E. Soulé (ed.), pp.257-285. Sinauer Associates, Sunderland, MA.
- McDaniel, P. 1994. The social behavior and ecology of the black-handed spider monkey (*Ateles geoffroyi*). Ph.D. Dissertation, University of Saint Louis, Saint Louis, Missouri.
- Meffe, G. K. and Carroll, C. R. 1994. *Principles of Conservation Biology*. Sinauer Associates, Sunderland, MA.
- Menon, S., Pontius, R. G., Rose, J., Khan, M. L. and Bawa, K. S. 2001. Identifying conservation priority areas in the tropics: A land-use change modeling approach. *Conserv. Biol.* 15: 501-512.
- Milton, K. 1981. Estimates of reproductive parameters for free-ranging *Ateles geoffroyi*. *Primates* 22: 574-579.
- Nishida, T. and Hosaka, K. 1996. Coalition strategies among adult male chimpanzees of the Mahale Mountains, Tanzania. In: *Great Ape Societies*, W. C. McGrew, L. F. Marchant, and T. Nishida (eds.), pp. 114-134. Cambridge University Press, New York.
- Nunes, A. 1995. Foraging and ranging patterns in white-bellied spider monkeys. *Folia Primatol.* 65: 85-99.
- Ramos-Fernández, G. and Ayala-Orozco, B. 2003. Population size and habitat use of spider monkeys at Punta Laguna, México. In: *Primates in Fragments: Ecology and Conservation*, L. K. Marsh (ed.), pp.191-209. Kluwer Academic/Plenum Press, New York.
- Riss, D. C. and Goodall, J. 1997. The recent rise to the alpha rank in a population of free-living chimpanzees. *Folia Primatol.* 27: 134-151.
- Van Roosmalen, M. G. M. 1985. Habitat preferences, diet, feeding strategy and social organization of the black spider monkey (*Ateles p. paniscus*) in Surinam. *Acta Amazonica* 15: 1-238.
- Van Roosmalen, M. G. M. and Klein, L. L. 1988. The spider monkeys, genus *Ateles*. In: *Ecology and Behavior of Neotropical Primates*, Vol. 2, R. A. Mittermeier, A. B. Rylands, A. F. Coimbra-Filho and G. A. B. da Fonseca (eds.), pp.455-537. World Wildlife Fund, Washington, DC.
- Sterck, E. H. M., Watts, D. P. and van Schaik, C. P. 1997. The evolution of female social relationships in nonhuman primates. *Behav. Ecol. Sociobiol.* 41: 291-309.
- Strier, K. B. 1991. Demography and conservation of an endangered primate, *Brachyteles arachnoides*. *Conserv. Biol.* 5: 214-218.
- Strier, K. B. 2000. *Primate Behavioral Ecology*. Allyn and Bacon, Needham Heights, MA.
- Symington, M. M. 1987. Ecological and social correlates of party size in the black spider monkey, *Ateles paniscus chamek*. Ph.D. Dissertation, Princeton University, Princeton, NJ.
- Wallace, R. B. 1998. The behavioural ecology of black spider monkeys in northeastern Bolivia. Ph.D. Dissertation, University of Liverpool, Liverpool, UK.