International Journal of Primatology, Vol. 14, No. 5, 1993

Sexual Dimorphism in Canine Length of Woolly Spider Monkeys (*Brachyteles arachnoides*, E. Geoffroy 1806)

Rosa M. Lemos de Sá,[1] Theresa R. Pope,[2] Thomas T. Struhsaker,[2] and Kenneth E. Glander[2]

Received February 21, 1992; revised April 30, 1992; accepted May 21, 1992

*We measured canine teeth from 28 woolly spider monkeys (*Brachyteles arachnoides*) to assess sexual dimorphism and population differences. The specimens are from the Brazilian states of Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, and São Paulo. We found strong sexual dimorphism in canine length for individuals belonging to populations south of 22°00′ latitude but no sexual dimorphism in canine length from individuals of populations north of 21°00′ latitude. Canine length did not vary among females of northern and southern populations. However, southern males had significantly longer canines than northern males. This geographical difference in canine morphology, together with the presence or absence of thumbs and published accounts of differences in genetics and social structure between northern and southern populations, suggests that *Brachyteles arachnoides* may be composed of at least two subspecies, which appear to be separated by the rivers Grande and Paraiba do Sul and the Serra da Mantiqueira.*

KEY WORDS: *Brachyteles*; canine; sexual dimorphism; subspecies.

[1]Department of Wildlife and Range Sciences, University of Florida, Gainesville, Florida 32611.
[2]Department of Biological Anthropology and Anatomy, Duke University, Durham, North Carolina 27706.

0164-0291/93/1000-0755$07.00/0

INTRODUCTION

The woolly spider monkey (*Brachyteles arachnoides*) is a highly endangered species threatened by habitat destruction. It is restricted to the Atlantic coastal forest of Brazil, most of which has been destroyed (Fonseca, 1983, 1985). Only small isolated populations of *Brachyteles* exist today (Mittermeier *et al.,* 1987).

Several studies of *Brachyteles* have been carried out in the past 10 years (Fonseca, 1983, 1985; Milton, 1984, 1985a, b; Strier, 1987a–c, 1989, 1991a, b; Mittermeier *et al.,* 1987; Lemos da Sá, 1988; Lemos de Sá and Strier, 1992) in order to comprehend its behavior and ecology and develop effective conservation management programs.

Lemos de Sá and Glander (1993), noticed a sexual difference in canine length between two geographically isolated populations of *Brachyteles.* Previous studies of sexual dimorphism documented no interpopulational difference in dentition (Zingeser, 1973, Kay *et al.,* 1988). We present data on sexual dimorphism in canine length, based on measurements of museum specimens and live monkeys in the field.

METHODS

In September 1990, 12 individuals, including 8 adults, of *Brachyteles arachnoides* were captured via darts loaded with Telazol (Fonseca *et al.,* 1991). Ten subjects were from Fazenda Esmeralda, Minas Gerais, Brazil, and two were from Fazenda Barreiro Rico, São Paulo, Brazil.

The subjects were measured, weighed, marked, and then released (Lemos de Sá and Glander, 1993). We measured canine tooth length (longest length from tip of canine to cingulum) with a vernier caliper.

During this procedure we noticed an apparent geographical difference in canine tooth length among subjects from Minas Gerais and São Paulo.

In order to examine the geographical difference in canine length further, we measured the canine length of 14 adults in the Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, and 6 adults in the Museu Nacional (MN), Rio de Janeiro, Brazil. We used tooth wear to determine age and excluded canines that were broken or worn heavily. We divided the data into two distinct geographical regions: north of 21°00′S and south of 22°00′S latitude. The northern region includes the states of Bahia, most of Minas Gerais and Espírito Santo, while the southern region includes the states of Rio de Janeiro and São Paulo (Fig. 1).

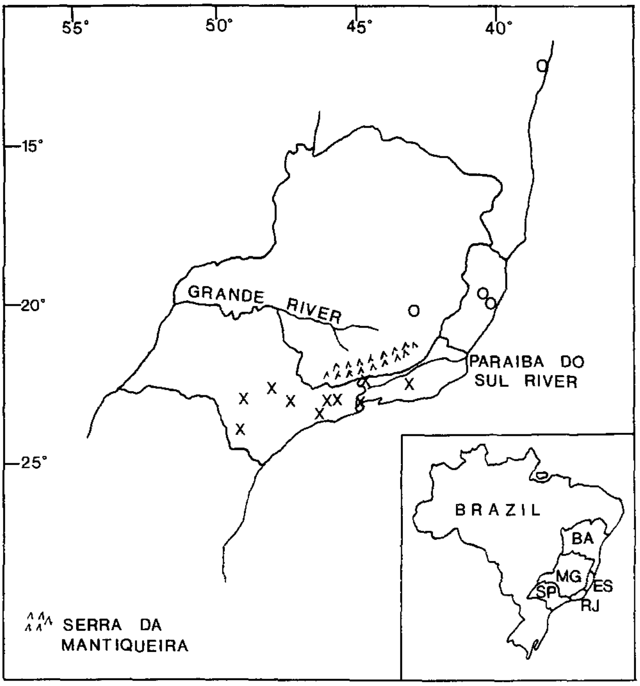

Fig. 1. Localities where measured specimens were collected, designated O for northern localities and X for southern localities. Three possible geographical barriers separating northern (O) and southern (X) populations of *Brachyteles arachnoides* are Grande River, Paraiba do Sul River, and Serra da Mantiqueira.

RESULTS AND DISCUSSION

Tooth length varied considerably in males and females of the northern populations (Table I, Fig. 2). However, there was no statistically significant difference between adult male and adult female canine length (Mann–Whitney two-tailed test; n = 5 females and 7 males; p = 0.465 and 0.144 for upper and lower canines, respectively). Figure 2 shows the wide range of tooth length in males and females.

In contrast, the southern populations demonstrated sexual dimorphism in canine length (Table II, Fig. 3). Adult males had significantly longer canines than adult females (Mann–Whitney two-tailed test; n = 7 females and 9 males; p = 0.0006 and 0.0015 for upper and lower canines, respectively). When asterisked values from Table II were excluded (those animals classed to sex based on skull size and the cingulum based on average ratio), this difference remained significant (Mann–Whitney, two-tailed test; $n = 4$ females and 8 males; $p = 0.0066$ and $p = 0.0066$ for upper and lower canines, respectively).

Females from northern and southern populations were not significantly different in canine length (Mann–Whitney, two-tailed test; $n = 5$ from northern and 7 from southern populations; $p = 0.626$ and 0.745 for

Table I. Upper and Lower Canine Length of Adult Male and Female *Brachyteles arachnoides* from Localities North of 21°00'S Latitude[a]

Sex	Canine length (mm)		ID	State	Source
	Upper	Lower			
Female	4.6	5.4	10	M.G.	Lemos de Sã & Glander
Male	5.0	5.9	03	M.G.	Lemos de Sã & Glander
Female	6.0	4.4	08	M.G.	Lemos de Sã & Glander
Male	6.8	8.8	China	M.G.	Lemos de Sã (unpu.)
Female	7.2	5.7	07	M.G.	Lemos de Sã & Glander
Male	7.6	7.6	3533	M.G.	MZUSP
Female	8.4	7.6	11102	E.S.	MZUSP
Male	8.5	6.2	01	M.G.	Lemos de Sã & Glander
Male	8.7	6.6	02	M.G.	Lemos de Sã & Glander
Male	9.0	7.8	2236	E.S.	MZUSP
Male	9.7	8.8	11180	E.S.	MZUSP
Female*	9.8	8.0	3830	B.A.	MZUSP

[a]M.G., Minas Gerais; E.S., Espírito Santo; B. A., Bahia; MZUSP, Museu de Zoologia da Universidade de São Paulo.

*Animals classed as adults based on complete dentition exhibiting at least moderate wear, and sex based on skull size.

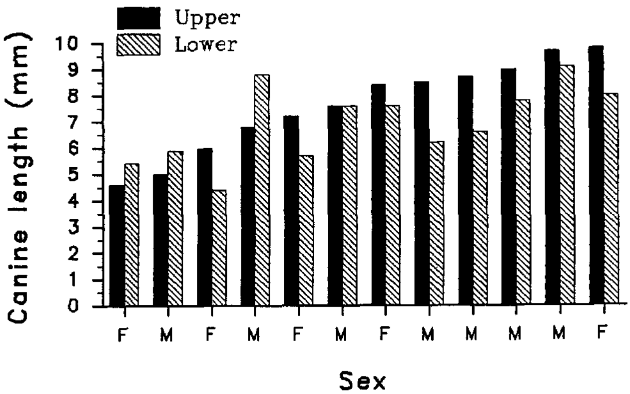

Fig. 2. Canine length of male and female *Brachyteles arachnoides* from localities north of 21°00'S.

Table II. Upper and Lower Canine Length of Adult Male and Female *Brachyteles arachnoides* from Localities South of 22°00′S Latitude[a]

Sex	Canine length (mm)		ID	State	Source
	Upper	Lower			
Female*	4.0	3.9	1689	S.P.	MZUSP
Female*	6.0	5.0	1158	S.P.	MZUSP
Female	6.5	5.9	12	S.P.	Lemos de Sã & Glander
Female*	6.6	5.7	1159	S.P.	MZUSP
Female	7.5	6.7	1425	R.J.	MN
Female	7.6	6.1	1424	R.J.	MN
Female	7.7	6.6	8513	R.J.	MN
Male	8.2	7.6	2940	S.P.	MZUSP
Male	8.3	8.3	1864	S.P.	MZUSP
Male	8.8	9.0	1863	S.P.	MZUSP
Male	9.1	—	9962	R.J.	MZUSP
Male	9.6	7.6	2717	R.J.	MN
Male	9.9	7.1	11	S.P.	Lemos de Sã & Glander
Male	10.4[b]	9.0	6482	S.P.	MZUSP
Male	11.2	9.5	1422	R.J.	MN
Male*	11.3	6.6	7422	S.P.	MZUSP
Male	12.5	10.2	1426	R.J.	MN

[a]S. P., São Paulo; R. J., Rio de Janeiro; MZUSP, Museu de Zoologia da Universidade de São Paulo; MN Museu Nacional.
[b]Value determined by (total canine length) × (mean ratio for male upper canines of total canine to length of canine from tip to cingulum) = 14.0 mm × 0.74.
*Animals classed as adults based on complete dentition exhibiting at least moderate wear, and sex based on skull size.

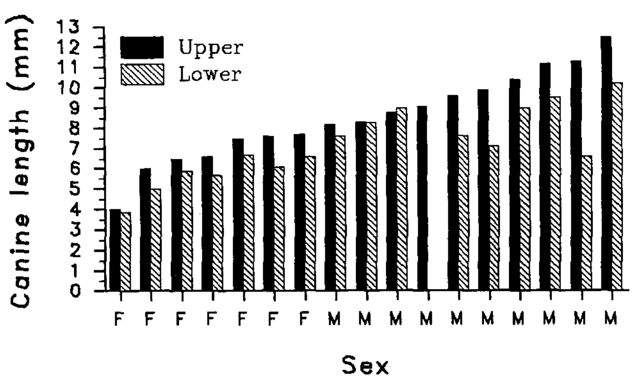

Fig. 3. Canine length of male and female *Brachyteles arachnoides* from localities south of 22°00′S.

upper and lower canines, respectively). However, males from southern populations had significantly longer upper canines than males from the north (Mann–Whitney two-tailed test; $n = 7$ and 9 for northern and southern males, respectively; $p = 0.025$). Lower canines were not significantly different among males of northern and southern populations (Mann–Whitney two-tailed test; $n = 7$ and 9 for northern and southern males, respectively; $p = 0.204$).

Previous workers who found no sexual dimorphism in canine lengths, (Zingeser, 1973; Milton, 1985a, Kay *et al.,* 1988; Rosenberger and Strier, 1989), may have dealt only with northern populations or combined specimens, regardless of their geographical origins. In addition to sexual dimorphism in canine length, we also observed other differences between northern and southern populations. All age classes of southern animals had black faces and genitalia. In contrast, although northern animals are born with black faces and genitalia, the skin of these areas becomes mottled pink and black by adulthood (Nishimura, 1979; Assumpção, 1983). Five muriquis (2 captured and 3 museum) from the south lacked thumbs, while all 24 muriquis (10 captured and 14 museum) from the north had thumbs. Analysis of DNA and allozymes also clearly indicates major differences between the two populations (Pope, 1993). These interpopulational differences may be due to separation by geographical barriers. Three possible barriers are the rivers Grande and Paraiba do Sul and the Serra da Mantiqueira (Fig. 1).

In addition, there appears to be a difference in grouping patterns between northern and southern groups. Strier (1987a, b), and Lemos de Sá (1988), who studied northern populations, showed that groups traveled daily as a cohesive unit of 12–26 animals, but Assumpçáo (1983) and Milton (1984, 1985a) described a fluid social structure in southern populations, with typical daily associations of 5–7 individuals occurring primarily between females and their offspring.

Given the sexual differences in canine length between these two populations, one expects corresponding differences in the degree and or form of competition between males for mates (Kay *et al.,* 1988). Two social groups have been studied at two different sites in the north. As might be expected from the absence of sexual differences in canine length, males within these groups did not overtly compete aggressively for estrous females. Females regularly mated with two or more males during estrus (Strier, 1986, 1987a–c; Lemos de Sá, 1988). Strier (1987c) observed 47 copulations among 7 males and 8 females, during a period of 13 months. The high degree of indifference among males during copulations suggested exceptionally low levels of male competition for access to females. However, female preference for some males may reflect a dominance hierarchy among males (Strier, 1987c).

In contrast, the longer canines of males in the southern populations would lead one to predict greater degrees of overt aggression and competition between males for mates. Unfortunately, the sample and available information for this population are sparse. Only one group of seven individuals (all females and immatures) was studied in the south for <1 year. This study concentrated on females only. All data on sexual behavior (n = 31 copulations) were from one female, collected during approximately 54 days over a 4-month period. More than one-third of all observed copulations occurred on one day (Milton, 1985a). As many as four different males copulated with this female within a single 12-hr sample period. Sometimes two or more males copulated with her within 15 min of one another. Based on this, Milton (1985a) concluded that there was little intermale aggression for sexual access to the receptive female. However, she also reported that opportunities for copulation with ovulating females may be few and far between. In fact, among her study animals, there was only one estrous female available for at least nine males. In contrast to her conclusion, Milton (1985a) further notes that (1) there appeared to be a well-defined dominance hierarchy among the males that was based in part on body size; (2) ". . . on occasion a single large adult male monopolized the estrous female for several hours and his presence clearly discouraged other males from approaching her to copulate"; (3) some males copulated more with the female than others and some, particularly smaller males, were displaced to the periphery of the mating aggregation and were not observed to mate; and (4) on at least one occasion a copulation was interrupted when another male threatened the copulating male. All of these observations suggest that, given the limitations of the sample, intermale aggression for mates may prove to be greater in the southern than in the northern populations of *Brachyteles*. This would be predicted from the population differences in sexual dimorphism in canine length.

The morphological, genetic, and social differences between northern and southern populations suggest that there are at least two geographically separated subspecies of *Brachyteles arachnoides*. Conservation management should maintain viable populations of both of them.

ACKNOWLEDGMENTS

We thank Drs. Karen B. Strier and Gustavo A. B. da Fonseca for their participation. Thanks to Sr. José Carlos Reis de Magalhães and to Dr. Antônio Cuppertino Teixeira for their permission to capture the animals on their farm and for their conservation efforts. We would also like to thank Dr. P. E. Vanzollini from the Museu de Zoologia da Universidade de São Paulo and Dr. A. Langguth from the Museu Nacional for providing the specimens for measurement. This work was funded by Wildlife Preservation Trust International and by Conservation International.

REFERENCES

Assumpção, C. T. (1983). Ecological and behavioral information on *Brachyteles arachnoides. Primates* 24(4): 584-593.

Fonseca, G. A. (1983). *The Role of Deforestation and Private Reserves in the Conservation of the Woolly Spider Monkey* (Brachyteles arachnoides), M.Sc. thesis, University of Florida, Gainesville.

Fonseca, G. A. (1985). Observations on the Ecology of the muriqui (*Brachyteles arachnoides* E. Geoffroy 1806). *Primate Conserv* 5: 48-52.

Fonseca, G. A., Lemos de Sá, R. M., Pope, T. R., Glander, K. E., and Struhsaker, T. T. (1991). A pilot study of genetic and morphological variation in the muriqui (*Brachyteles arachnoides*) as a contribution to a long term conservation management plan. Unpublished report to Conservation International and Wildlife Preservation Trust International.

Kay, R. F., Plavcan, J. M., Glander, K. E., and Wright, P. C. (1988). Sexual selection on canine dimorphism in New World monkeys. *Am. J. Phys. Anthropol.* 77: 385-397.

Lemos de Sá, R. M. (1988). *Situação de uma População de mono-carvoeiros,* Brachyteles arachnoides, *em Fragmento de Mata Atlântica (M.G.), e Implicações para sua Conservação,* M.Sc. thesis, Universidade de Brasília.

Lemos de Sá, R. M., and Glander, K. E. (1993). Capture techniques and morphometrics for the woolly spider monkey, or muriqui (*Brachyteles arachnoides*, E. Geoffroy 1806). *Am. J. Primatol.* 29: 145-153.

Lemos de Sá, R. M., and Strier, K. B. (1992). A preliminary comparison of forest structure and use by two isolated groups of woolly spider monkeys (*Brachyteles arachnoides*). *Biotropica* 24: 455-459.

Milton, K. (1984). Habitat, diet and activity patterns of free-ranging woolly spider monkeys (*Brachyteles arachnoides* E. Geoffroy 1808). *Int. J. Primatol.* 5: 491-514.

Milton, K. (1985a). Mating patterns of woolly spider monkeys, *Brachyteles arachnoides*: implications for female choice. *Behav. Ecol. Sociobiol.* 17: 53-59.

Milton, K. (1985b). Urine washing behavior in the woolly spider monkey. *Z. Tierpsychol.* 67: 154-160.

Mittermeier, R. A., Valle, C. M. C., Alves, M. C., Santos, I. B., Pinto, C. M. A., Strier, K. B., Veado, E. M., Constable, I. D., Paccagnella, S. G., and Lemos de Sá, R. M. (1987). Current distribution of the muriqui in the Atlantic forest region of eastern Brazil. *Primate Conservation* 8: 143-148.

Nishimura, A. (1979). In search of woolly spider monkey. *Reports of New World Monkeys*, Kyoto University Primate Research Institute, pp. 21-37.

Pope, T. R. (1993). Genetic variation in remnant populations of the woolly spider monkey: Implications for conservation. *Conserv. Biol.* (submitted for publication).

Rosenberger, A. L., and Strier, K. B. (1989). Adaptive radiation of ateline primates. *J. Hum. Evol.* 18: 717-750.

Strier, K. B. (1986). *The Behavior and Ecology of the Woolly Spider Monkey, or Muriqui* (Brachyteles arachnoides *E. Geoffroy 1806*), Doctoral dissertation, Harvard University, Cambridge, MA.

Strier, K. B. (1987a). Ranging behavior of woolly spider monkeys, or muriquis, *Brachyteles arachnoides. Int. J. Primatol.* 8: 575-591.

Strier, K. B. (1987b). Activity budgets of woolly spider monkeys, or muriquis (*Brachyteles arachnoides*). *Am. J. Primatol.* 13: 385-395.

Strier, K. B. (1987c). Reprodução de *Brachyteles arachnoides*. In de Mello, M. T. (ed.), *A Primatologia no Brasil, Vol. 2,* Universidade de Brasília, Brasília, Brasil.

Strier, K. B. (1989). Effects of patch size on feeding associations in muriquis (*Brachyteles arachnoides*). *Folia Primatol.* 52: 70-77.

Strier, K. B. (1991a). Diet in one group of wooly spider monkeys, or muriquis (*Brachyteles arachnoides*). *Am. J. Primatol.* 23: 113-126.

Strier, K. B. (1991b). Demography and conservation of endangered primates. *Conserv. Biol.* 5: 214-218.

Zingeser, M. R. (1973). Dentition of *Brachyteles arachnoides* with reference to Alouattine and Atelinine affinities. *Folia Primatol.* 20: 351-390.