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RESEARCH ARTICLES

Reproductive Biology of Captive and Free-Ranging Spider Monkeys

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Records from 42 zoos and from long-term studies of wild populations were analysed to describe the reproductive biology of spider monkeys (*Ateles* spp.). Both data sets suggested that spider monkey females typically have their first infant between 7 and 8 years of age with an interbirth interval of approximately 32–36 months. Infant sex ratio for zoo populations was approximately 1 male to 1 female; infant sex ratios from wild populations were variable. Zoo records provided adequate sample size to suggest that interbirth interval was not influenced by the sex of the infant produced, and that the sex ratio and the probability of infant survival did not change with the number of infants the mother had produced. The findings of this study have implications with respect to the conservation of New World primate species. Since spider monkeys take a long time to reach sexual maturity and their interbirth interval is longer than that expected based on their body size, their populations may be slow to recover following disturbances. Thus, particular care should be taken for the protection of these species.

Key words: *Ateles*, births, interbirth interval, sex ratio

INTRODUCTION

Acquiring estimates of reproductive parameters for mammals in the wild is difficult. This problem is particularly accute when the study species is long-lived. Not only must individually recognizable animals be monitored for long periods, but logistical constraints often limit sample size. Such information is, however, essential for the development and implementation of effective conservation strategies. One means of obtaining information on a species' reproductive biology is by analysing records from zoos or captive colonies. However, caution must be used in the interpretations and application of these data, as some reproductive parameters may be altered by the living conditions in zoo environments.

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Spider monkeys (*Ateles* spp.) are one of the largest New World primates. They are of particular interest because they exhibit a relatively unique flexible social organization where animals form subgroups that frequently change size and composition [Klein, 1972]. In addition, spider monkeys have been classified as endangered throughout much of their geographic range [Wolfheim, 1983]. As a result, information on the reproductive biology of the species is particularly vital.

The objective of this study is to describe a series of reproductive parameters for both captive and free-ranging spider monkeys. Data on captive animals were derived from a survey of 42 zoo colonies, while the information from free-ranging populations was obtained both from the literature and from our 5-year study of the spider monkey of Santa Rosa National Park, Costa Rica.

MATERIALS AND METHODS

Captive Populations

A questionnaire was sent to all zoos listed in the International Zoo Yearbook [1971–1986] as having breeding colonies of any species in the genus *Ateles*. Information was requested concerning origin, age, weight, date of birth, reproductive history, sex of infants, and age at death. Forty-two zoos responded to the request. From the information provided the following variables were derived for each individual: sex, age (estimated or recorded), weight, and age at death (if applicable). In addition, the reproductive history of each female was determined, and information was extracted concerning age at first birth, interbirth interval, date of each birth, the sex of each infant, whether each infant survived to 1 year of age or to maturity, and the date of each infant's death (if applicable).

For questionnaires that were incomplete, a series of conservative criteria were established to exclude potentially erroneous or misleading data. Whenever there were gaps in the zoo records, information related to interbirth interval, mortality rate of infants, and sex of successive infants were extracted only up to the period when data were not recorded. If an infant was born into a colony, but its mother was unknown, subsequent data on all adult females in the colony were excluded. Since the length of the interbirth interval in spider monkeys is known to be dependent on the length of time females nurse young [Eisenberg, 1973], interbirth intervals for females that had infants that were hand-reared or that died prior to age 1 year were not included in the analysis of interbirth interval. Even employing these criteria, there were a number of instances in which the recorded interbirth interval did not appear to represent the typical breeding patterns. This might be expected if attendants were unaware of gaps in early records, or if the females were sick for an extended period. Thus, when the range of interbirth intervals were relatively continuous with the exception of some very long intervals, values following a 2-year gap in the data set were excluded from the analysis.

Free-Ranging Populations

Information concerning the reproductive biology of free-ranging spider monkeys were obtained from the literature [Carpenter, 1935; Klein, 1971, 1972; Eisenberg, 1973, 1976; Coelho et al., 1976; van Roosmalen, 1980; Milton, 1981; Symington, 1987a,b, 1988] and from our study of spider monkeys *(Ateles geoffroyi)* in Santa Rosa National Park, Costa Rica. In Santa Rosa, demographic data have been collected since 1983, involving 36 months of field observations [see Chapman, 1988;

Chapman et al., 1989, for a description of the study site and times]. Recognition of individuals was possible following the darting and tagging of animals, either as a result of collars and anklets placed on the animals (n = 13) or by their scars and pelage patterns (n = 22). It was estimated that 35 of the 42 individuals in the community could be reliably recognized.

Taxonomy

The taxonomy of the genus *Ateles* is poorly understood. Kellogg and Goldman [1944] conducted the last thorough taxonomic review and recognized four species. However, a number of recent studies have considered all spider monkeys to be members of a single species [for review, see Konstant et al., 1985]. This taxonomic confusion coupled with the fact that it is difficult to recognize the different species based only on coat color has inadvertently resulted in some hybridizations in captivity [Konstant et al., 1985]. As a result we take the conservative approach and describe the reproductive biology for the genus and do not attempt to compare species. However, based on field data, it seems unlikely that many of the reproductive parameters differ among species.

RESULTS

From the records provided by the zoos, information on 156 births were obtained. Seventy-four male infants and 82 female infants were born, producing an infant sex ratio of 1 male to 1.11 females. Of these 156 infants, 15 males and 25 females were reported to die before reaching maturity (mortality rate = 20.3% for males and 30.5% for females). Thus, the sex ratio of surviving infants was 1 male to 0.97 females.

Milton [1981] collected data on the reproductive parameters of a population of spider monkeys *(Ateles geoffroyi)* living on Barro Colorado Island (BCI), Panama and reported a sex ratio at birth of 1 male to 0.67 females (n = 15). Symington [1987b] documented a birth sex ratio of 1 male to 2.7 females for a population of black spider monkeys *(Ateles paniscus chamek)* in Manu National Park, Peru. Of the eight births recorded from Santa Rosa in 1987–1988, an equal number of males and females were produced. Infant mortality was reported in each of these studies; 1 out of 18 infants on BCI died [Milton, 1981], 8 out of 46 infants in Manu died [Symington, 1987a], and 3 of the 8 infants born in Santa Rosa died. Thus, the overall infant mortality rate for free-ranging spider monkeys was 17%.

Evidence from Santa Rosa suggests that male infants may suffer higher mortality rates than female infants. Juvenile males in Santa Rosa were 1.7 times more likely to receive aggression than immature females. In addition, of the six serious injuries observed, all involved young males [Chapman and Chapman, 1987], and identifiable immature males were five times more likely to disappear than females (presumably such males die, since their mothers were always present after their infants disappeared, and males do not disperse in this species [Chapman et al., 1989]). In other wild populations, documentation of wounding similarly suggests that males are more likely to be injured than females [Carpenter, 1935; Klein, 1972]. The mortality rate of infants born into zoo populations does not support this trend. Infant females had a 10% higher probability of dying than infant males.

The age at which females first gave birth in zoos ranged from 4 to 19 years of

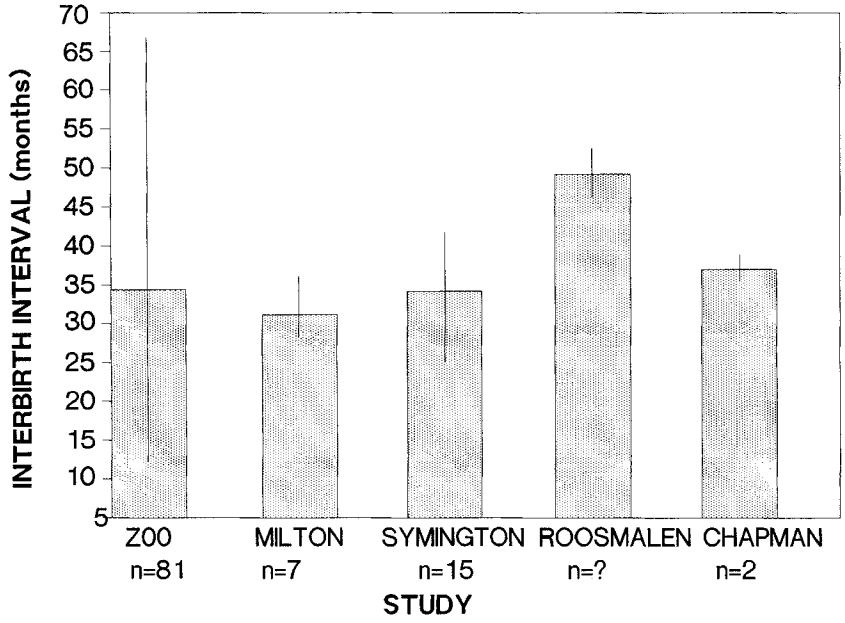

Fig. 1. The length of the interbirth interval (months) estimated for spider monkeys from zoo records, Milton [1981], Symington [1987a,b], van Roosmalen [1980], and this study.

age, with a mean of 7.8 years and a mode of 7 years. The only estimate of age at first birth from natural populations is 6.5 years, reported by Milton [1981]. At the time that Milton collected the data, a female that was 7.6 years old was pregnant with her first infant, and a 5.6-year-old female had not yet conceived.

Interbirth interval of a female entails the gestation period, lactation anestrus, and the period of time it takes to conceive. Eisenberg [1973] estimated that the gestation period of spider monkeys was approximately 230 days and observed that in captivity, females nursed for 18–20 months. Field estimates of the length of lactation anestrus and the duration of nursing vary. Based on observations of two females, Milton [1981] determined that spider monkeys nurse for 26 months. Similarly, Symington (1987b) estimated that females nurse for approximately 23 months (n = 19). However, van Roosmalen [1980] estimated that the period of lactation anestrus was 36 months (sample size not stated). These different estimates correspond to different estimates of interbirth interval. Milton [1981] estimated that the interbirth interval for spider monkeys was 32 months (n = 7, range 28–36 months, Fig. 1), while Symington [1987a] estimated it to be 34.5 months (n = 15, range 25–42 months), and van Roosmalen [1980] estimated it to be 46–50 months (sample sizes not stated). There are two cases from Santa Rosa in which the approximate dates of birth of an infant and its subsequent sibling were known. For these cases, the interbirth intervals were 37 and 36 months.

The mean interbirth interval of captive spider monkeys who had infants that survived to at least age 1 year was 34.5 months (n = 67). The length of time between births was not dependent on the number of infants the female had produced (1st interbirth interval = 1,019 days, n = 31, 2nd = 1,050 days, n = 19, 3rd = 1,194

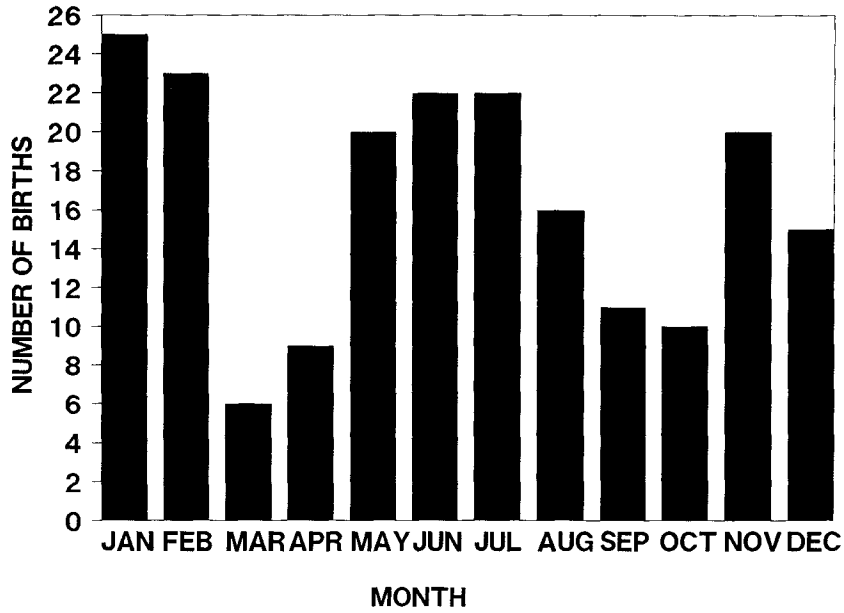

Fig. 2. The number of births of spider monkeys in each month of the year derived from zoo breeding records.

days, n = 11; F = 0.341, P = .713). Contrary to what has been suggested for wild populations [Symington, 1987b], there was no evidence to suggest that the interbirth interval following the birth of a son (1,118 days) was significantly longer than that following the birth of a daughter (1,002 days; F = 0.559, P = .457, n = 60). The mortality rate of infants born into zoos was 25.6%. The number of infants that died was independent of the number of infants a female had produced (χ^2 = 0.453, $P >$ .10, mortality rate 1st—27%, 2nd—24%, 3rd—28%, and 4th—18%). Similarly, sex ratio was independent of the number of infants that a female had previously produced (χ^2 = 3.53, $P >$ .05).

There was no clear evidence to suggest that spider monkeys in zoos exhibit a definite birth season (Fig. 2). However, one might not expect a birth season to be expressed under zoo conditions. Possible cues that may synchronize breeding such as seasonality in food availability have been removed, and often animals have been brought together from a wide geographical range, each with a potentially different birth season.

Evidence of birth seasonality from natural populations is contradictory. Some previous studies have suggested seasonality in births [Symington, 1987a, n = 46; Milton, 1981, n = 18; van Roosmalen, 1980; sample size not reported], while others have not [Klein, 1971, n = 6; Carpenter, 1935—examination of reproductive tracts and embryos of wild shot animals]. Two lines of evidence suggest that there is a birth peak in the spider monkey populations of Santa Rosa. First, there was an increase in the frequency with which females with clinging infants were observed, starting in July, peaking in August, and decreasing by February (Fig. 3). Corresponding to this,

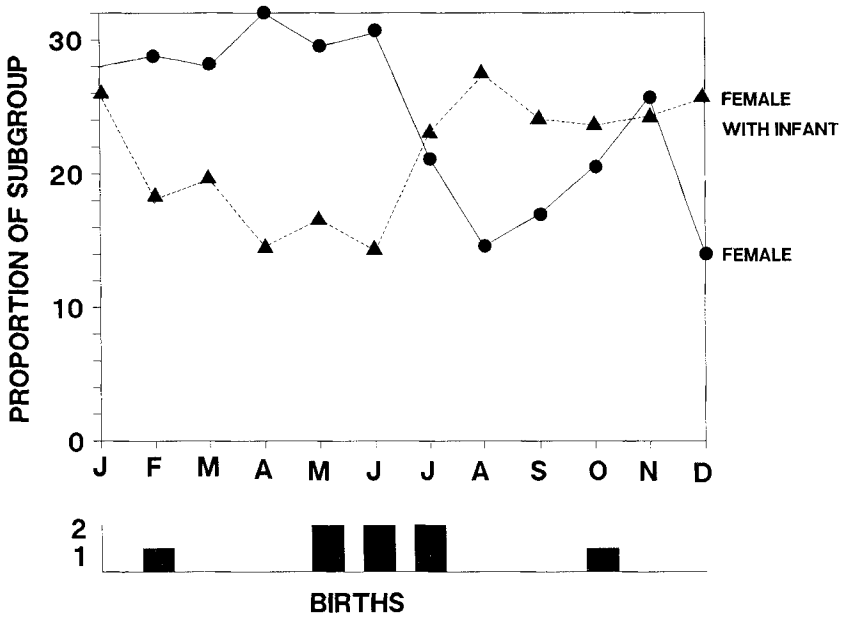

Fig. 3. The proportion of spider monkey subgroups in Santa Rosa National Park, Costa Rica comprising females and females with infants in each month of the year (note that when a female has an infant she changes categories). In addition, the bottom of the graph depicts the number of newborn infants in each month of the 1987–1988 field season.

there was a decrease in the number of adult females, since they were giving birth and thus being categorized as adult females with infants. Second, during the 1987–1988 field season, 12 consecutive months were spent observing the spider monkey community of Santa Rosa. During this field season eight infants were born (Fig. 3). Although this is a small sample, births were clustered between May and July, which is the start of the rainy season and a period when food is abundant. The bulk of the evidence from natural populations indicates some degree of birth seasonality.

There is considerable disagreement in the literature as to the extent of sexual dimorphism in weight for spider monkeys [for review, see Fedigan and Baxter, 1984]. Field observations suggest that males are larger than females [Symington, 1987a] (Chapman personel observations). If an adult is considered to be 7 years or older (approximately the age of female maturity), then contrary to that predicted from field observation, captive males were not significantly larger than captive females, but the weight difference was in the direction predicted ($F = 1.77$, $P = .097$; males 7.3 kg, females 6.7 kg, $n = 34$). However, by the age of 10 years, as predicted, males were significantly larger than females ($F = 3.41$, $P = .039$; males 7.5 kg, females 6.8 kg, $n = 26$).

Eisenberg [1981] documented that the maximum recorded age for captive *Ateles geoffroyi* was 18 years and for *A. fusciceps* was 24^+ years. From the information obtained from this survey of zoo records the maximum longevity for captive spider monkeys *(A. geoffroyi)* was 44 years (40 years at Taronga zoo, Sydney, Australia and estimated to have arrived at the zoo at 4 years of age; the animal is still alive).

DISCUSSION

Analysing the reproductive biology of captive spider monkeys has provided the sample size necessary to describe reproductive parameters that have been difficult to document from long-term studies of natural populations. Although estimates of the age at first birth from wild populations are based on small sample sizes, they are very similar to the estimate of 7–8 years obtained from the analysis of zoo records. Similarly, estimates of the interbirth interval from natural populations are close to those derived from zoo records. In natural populations, estimates of interbirth intervals vary from 32 to 50 months, but average approximately 36 months. In the zoo, interbirth interval was estimated at 34.5 months. With the large sample sizes obtained from zoo records, it was possible to conclude that interbirth interval is not influenced by the sex of the infant produced, and that sex ratio and the probability of the infant surviving does not change with the number of infants that the mother has produced. The only parameter for which zoo records and field data did not concur was seasonality. Zoo records did not suggest any definite seasonal pattern to the timing of births, while most long-term studies of natural populations suggest some degree of seasonality. These comparisons illustrate that the analysis of zoo records can provide support for observations of the reproductive biology of a species obtained from long-term studies in the wild; often providing much larger sample sizes than can feasibly be collected from monitoring natural populations. However, caution must be used in the application of the findings derived from zoo records to wild populations.

Information from both zoo records and natural populations provide evidence to indicate that spider monkeys are relatively slow in reaching sexual maturity and that, among primates, their interbirth interval is relatively long. To examine whether spider monkeys have an interbirth interval that is longer than would be expecting considering their body size, the data on interbirth interval and body weight of neotropical primate species were collected from Harvey et al. [1987] and the articles in Smuts et al. [1987]. For neotropical primates, interbirth interval and female body weight were strongly related ($r = 0.799$, $P < .001$, $n = 15$, Fig. 4). The duration of the interbirth interval for spider monkeys was considerably longer than that predicted based on its weight (Fig. 4). For instance, in comparison to spider monkeys, adult female howlers *(Alouatta palliata)* weigh approximately 6 kg, have a gestation period of 186 days, and have an interbirth interval of only 22.5 months ($n = 16$ [Glander, 1980]).

These findings have implications with respect to the conservation of spider monkeys. If a spider monkey population is reduced because of habitat alteration or hunting, it may be relatively slow to recover owing to a slow attainment of sexual maturity and a relatively long interbirth interval [see also Milton, 1981]. Thus, spider monkey populations may be very sensitive to disturbance, and particular care should be taken for the protection of these species.

CONCLUSIONS

1. Based on both analyses of zoo data and information derived from long-term studies of wild populations, it was estimated that spider monkey females will have their first infant between 7 and 8 years of age and tend to produce an infant once every 32–36 months.
2. Zoo records indicate that interbirth interval is not influenced by the sex of

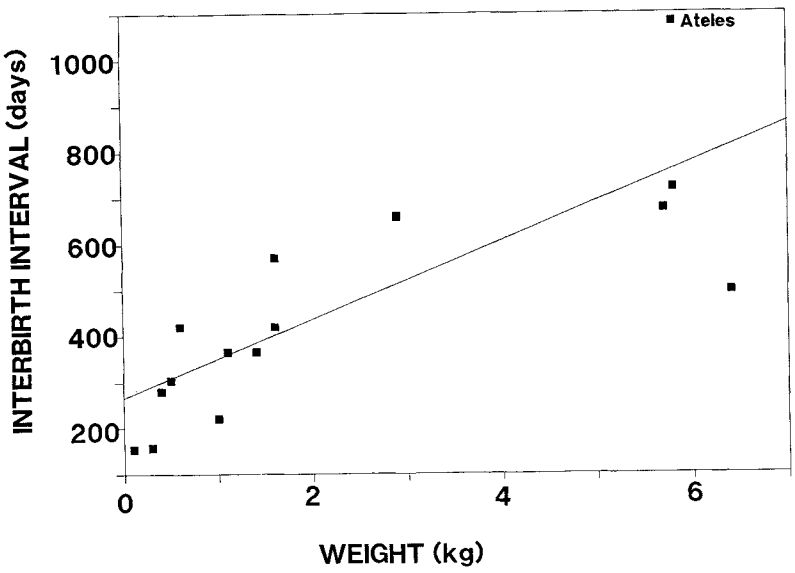

Fig. 4. The relationship between the interbirth interval (days) and female weight (kg) for a number of neotropical primate species.

the infant produced, and that the sex ratio and the probability of the infant surviving do not change with the number of infants that the mother has produced.

3. Long-term studies of natural populations suggest that there is a seasonal patterning to spider monkeys births, while zoo records do not indicate a definite seasonal patterning.

4. Spider monkeys have an interbirth interval that is longer than that predicted from their body weight. This suggests that their populations will be slow to recover from human disturbance and that particular care should be taken for the protection of this species.

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