Reproductive Patterns and Birth Seasonality in a South-American
Breeding Colony of Common Marmosets,
Callithrix jacchus

M. B. C. SOUSA

Universidade Federal do Rio Grande do Norte, Brasil

H. P. A. PEREGRINO

Bolsista de Desenvolvimento Regional

M. F. C. CIRNE and M. T. S. MOTA

Universidade Federal do Rio Grande do Norte, Brasil

ABSTRACT. We analyzed data on captive-born and wild-caught females housed under natural conditions in a colony located in northeastern Brazil. No differences in reproductive performance were found between captive-born and wild-caught females. Twins were the most frequent litter size, followed by triplets and singletons. No parity effect was observed, with similar infant survival for nulliparous and multiparous females. No significant departures in sex ratio were detected for births and mortality of the male and female infants. The age of the females at the time of pairing showed a negative correlation with pairing-parturition length, but did not affect infant survival. The prolongation in pairing-parturition interval (PPI) and interbirth interval (IBI) was related to birth seasonality. The births were clustered in the second half of the dry season and the beginning of the wet season (November–March), and the time of pairing and the time of infant birth influenced the PPI and IBI, respectively. The use of outdoor cages, which allowed the animals to be aware of the seasonal variations in photo-period and rainfall seems to be sufficient to time the reproductive activity, even when the animals are maintained on a constant food supply.

Key Words: Breeding colony; Birth seasonality; *Callithrix jacchus*; Interbirth intervals; Long-term studies.

INTRODUCTION

In recent years, the study of New World monkeys living under both natural conditions and in captivity, has contributed to clarifying various aspects of primate biology. In terms of the callitrichids, important features associated with the social control of reproduction (ABBOTT, 1984; BARRET et al., 1990; SALTZMAN et al., 1997, among others) as well as some mechanisms related to characteristics of parental care (see SNOWDON, 1996) have come to be better understood. The experimental use of these monkeys requires highly equipped colonies and at the same time efforts to improve the diet and housing conditions of the animals, in order to maintain an environment where they live as naturally as possible. Although the callitrichids are native to Central and South America, their high rate of reproduction in indoor conditions had been one of the reasons that these animals are used in experimental procedures in colonies spread throughout Europe, Asia, and North America. Therefore, basic factors that usually constrain breeding patterns in primates, such as seasonality and origin of the females – if from captivity or wild – have only poorly been investigated.

In colonies of tamarins, differences in reproductive potential between wild-caught and captive-born animals (*Saguinus oedipus*: TARDIF et al., 1984; SNOWDON et al., 1985; TARDIF et al., 1986) have been demonstrated. For common marmosets, *Callithrix jacchus*, no differences in

reproductive output between *wild-caught* and captive-born animals have been reported (TARDIF et al., 1984; POOLE & EVANS, 1982; BOX & HUBRECHT, 1987). EVANS (1983) explained these differences between genera as a consequence of a lower reproductive potential of the cotton-top tamarins in captivity, due to the longer interbirth interval, parental neglect, and high mortality after birth.

In relation to reproductive seasonality, the triggering mechanisms that are proposed to time reproduction are annual variation in photoperiod, and climatic factors such as variations in temperature and rainfall (BRONSON, 1988). For wild populations of callitrichids, the timing of reproduction seems adapted to synchronize birth peaks with the period of higher food availability (GOLDIZEN et al., 1988; DIETZ et al., 1994; DE LA TORRE et al., 1995; SAVAGE et al., 1996). In captivity, the occurrence of birth seasonality seems to depend on the characteristics of colony facilities. In colonies in which the animals are maintained in indoor enclosures no seasonality was detected (BOX & HUBRECHT, 1987; POOLE & EVANS, 1982), whereas in colonies which use outdoor cages, the births were seasonally restricted (ZIEGLER & STEIN, 1981; MCGREW & WEBSTER, 1995).

Since reproductive data for wild groups of callitrichids are frequently limited, either in terms of number of recordings or of follow-up time, the availability of systematic data on the reproduction of a captive population maintained under natural conditions over an extensive period of time, should help to clarify important aspects concerning environmental effects on the reproductive activity of these animals. Thus, in the present study we report systematic reproductive data recorded for six years (1990–1995) for *Callithrix jacchus* captive animals maintained under natural conditions in the same area in the native habitat of the species. Also, because the composition of our sample population is suitable, we compare the reproductive output of captive-born and wild-caught females. In this case, we expected if environmental factors other than food availability can act as proximal timing mechanism for reproduction, then seasonality should influence the distribution of births over the year in our captive groups just as it does in wild populations located in the same region (ARAÚJO, 1996).

MATERIALS AND METHODS

MAINTENANCE CONDITIONS

Husbandry

The animals used in this study were housed in the Núcleo de Primatologia of the Universidade Federal do Rio Grande do Norte, Natal, in the northeastern region of Brasil (5°47'42" S, 35°12'34" W). The Núcleo de Primatologia, has been successfully keeping a outdoor breeding colony of *Callithrix jacchus*, an endemic primate species from this region, since 1980. The animals are maintained in outdoor cages distributed in four separate buildings (blocks A, B, C, and D). Each building contains 20 individual cages measuring 1.0×2.0×1.0 m, built of brick (lateral walls) and wire mesh (front and back walls), with the roof partially covered with tiles. The cages are supplied with a nest-box, four boards attached to the side walls and a feeding shelf on the front door, plus branches, ropes, and a pot with a brush. In two of the four blocks the neighboring cages are connected in pairs through an opening in the side wall. These "double-cages" are occupied by families (the reproductive pair and their consecutive litters), and the individual cages are occupied by single animals or newly paired couples. In each building the animals maintain visual and olfactory contact with those in the neighboring cages. The

observation cages are similar to those described above, except for a one-way mirror located on the back wall, and the absence of visual contact between the animals.

During this time, in addition to the animals born in captivity, the colony has received a large number of wild-caught animals captured by IBAMA (Brazilian Environmental Institute), or as donations of animals previously maintained as pets.

Diet

The animals were fed twice a day; in the morning they received a mixture of fruits of the season, and in the afternoon a protein "porridge" consisting of milk, eggs, honey, bread, oil, vitamins, and minerals. In addition, pregnant and/or lactating females were supplemented with animal protein, cereals, raisins, and mealworms twice a week. Water was provided ad libitum.

DATA ANALYSIS

For our analysis, we used reproductive data from January 1990 to December 1995, on live born infants, abortions, and stillborns. The abortion category included any birth of a fetus not yet fully, as well as premature deliveries, or situations when the fetuses were not found (probably eaten by the mother or other group members) but there were signs of abortion (remains of fetal membranes, blood) in the nest-box, or in other parts of the cage. The full term young who died before birth were considered stillborn. In the category "perinatal mortality" we grouped the live born infants that died by the eighth day of life. The sex ratio was calculated based on the live born and stillborn infants whose sex was determined. The frequency of abortions, stillborns, perinatal mortality, the relative frequency of singletons, twins, triplets, and quadruplets and the sex ratio of captive-born and wild-caught female litters were compared by the Chi-square (χ^2) test. To assess the existence of a parity effect on the inter-birth interval (IBI) in days, i.e. significant variation in IBI length as a function of the number of litters produced, as well as the relationships between PPI (pairing/first parturition interval) length and the time (month) of pairing and also between the IBI length and the birth date of the previous litter, one-way analysis of variance (ANOVA) and the post-hoc Tukey's Honestly Significant Test (HST) were used. The influence of female age at the time of pairing on the PPI and on the percent of infants surviving per litter was analyzed by Pearson's Correlation test. For the analysis of the influence of female age at the time of pairing on the PPI length and on the first litter's infant survival, only the data concerning the animals for which we could calculate the age (captive-born females, and wild-caught females which had arrived to our colony as infants) were used. The level of significance was set at $p \leq 0.05$.

RESULTS

NUMBER OF INFANTS, LITTER-SIZE, SEX RATIO, AND INFANT MORTALITY

From January 1990 to December 1995, 153 litters were produced by 72 breeding females, (32 wild caught and 40 captive born of the first and subsequent generations), for a total of 327 infants. The wild-caught (WC) females produced a larger number of litters ($n=82$) than the captive-born (CB) females ($n=71$), probably because most WC females were already paired before the beginning of the study, while several CB females were paired during the study period. Both WC and CB females showed a similar distribution of the relative frequency of

Table 1. Number of infants and mortality rate for captive-born and wild-caught females.

Female origin	Litter size	Infants total (%)	Mortality		% of mortality
			Stillborn	Perinatal	
Captive-born	Singleton	7 (9.8)	0	2	28.6
	Twin	90 (63.4)	2	22	26.6
	Triplet	54 (25.3)	4	21	46.3
	Quadruplet	4 (1.4)	3	1	100
Wild-caught	Singleton	11 (13.4)	0	2	18.2
	Twin	104 (63.4)	3	28	29.8
	Triplet	57 (23.1)	2	34	63.1
	Quadruplet	0 (0)	0	0	

Table 2. Total number of births and mortality rate (up to the eighth day of life) per sex from 1990 to 1995, in *Callithrix jacchus*.

	Births			Deaths		
	Male	Female	Undetermined	Male	Female	Undetermined
Litters of captive-born females	64	63	25	17	16	25
Litters of wild-caught females	84	83	08	33	30	08
Total	148	146	33	50	46	33
%	45.2	44.6	10.1	38.7	35.6	25.6

singletons, twins, and triplets, with twins being the most frequent litter size for both CB and WC females (CB females: $\chi^2=90.5$, $df=3$, $p<0.01$; WC females: $\chi^2=89.5$, $df=3$, $p<0.01$) (Table 1). Only one case of quadruplets was recorded for one captive-born female, who had already given birth to three sets of triplets. Infant mortality for both CB and WC females was clumped in the first week of the infant's life. Perinatal mortality (30.8%) was significantly higher than the frequency of abortions and stillborns (8.5%) ($\chi^2=12.6$, $df=1$, $p<0.01$) (Table 1). The highest mortality rates occurred among triplets (54.7%), probably as a function of the female's inability to nurse more than two infants simultaneously. In fact, for all triplet deliveries at least one of the three infants died during the first week. With respect to the sex ratio, no significant deviation from the expected 1:1 frequency was observed (CB females: $\chi^2=0.47$, $df=1$, $p=0.49$; WC females: $\chi^2=0.32$, $df=1$, $p=0.56$) (Table 2). Also, no difference in the frequency of perinatal mortality was observed between males and females (CB females: $\chi^2=0.05$, $df=1$, $p=0.82$; WC females: $\chi^2=0.20$, $df=1$, $p=0.64$). Percent infant survival in the first litter was not significantly correlated with females age at the time of pairing ($r_s=0.02$, $p=0.90$).

PAIRING-PARTURITION AND INTER-BIRTH INTERVALS

The PPIs and IBIs were calculated excluding the intervals preceding abortions and premature births. Only the data for pairings starting in 1990 were considered for PPI calculation. For the females which were re-paired because of male death or fights with the partner, the period between two successive pairings was excluded from the IBI analysis. In the cases in which the re-paired female was not pregnant at the time of the next pairing, the data of the first reproduction after re-pairing were included in the PPI analysis. The observed pairing-parturition interval ranged from 145 to more than 600 days, but the most prolonged PPIs were recorded for two CB females paired when they were less than 15 months old, and for three WC females whose repro-

Fig. 1. **A.** Pairing-parturition interval of wild-caught females and captive-born females; **B.** inter-birth interval between successive litters for wild-caught (white bars) and captive-born (hatched bars) females.

ductive antecedents (illness, abortions) and age we could not specify. Indeed, those females reproduced only once, even though they were re-paired later with other males and their data were excluded from analysis, since they probably underwent reproductive impairment. Forty-six point eight percent (46.8%) of CB female conceptions and 42.8% of WC female conceptions occurred between 145 and 200 days after pair formation (Fig. 1A). CB females, for which we had the exact birth data, showed a significant negative correlation between female age at the time of first pairing and PPI prolongation ($r_s = -0.37$, $p = 0.054$).

Mean IBI ranged from 316.0 ± 25.7 days (1st to 2nd litter) to 219.0 ± 22.8 (2nd to 3rd litter) for CB females and from 244.3 ± 16.0 (1st to 2nd litter) to 198.6 ± 20.8 (3rd to 4th litter) for WC females. Considering a mean gestation length of 144 ± 2 days (HEARN, 1983), most conceptions occurred during the second or subsequent postpartum ovulations. There was no significant difference in mean IBI values among the subsequent litters of CB and WC females (CB females, One-way ANOVA: $F = 2.89$, $p = 0.078$; WC females: $F = 0.68$, $p = 0.56$). Because of the small number of records available to calculate the mean IBI value for the 5th litter of CB females ($n = 3$), this analysis was not performed (Fig. 1B).

REPRODUCTIVE SEASONALITY

One-way ANOVA showed a significant difference in PPI length between females paired during the last half of the dry season and those paired in the first half of the dry season (Fig. 2A). If

Fig. 2. Pairing-parturition (upper) and inter-birth (bottom) intervals during the dry and wet season.

* One-way ANOVA, $p < 0.01$.

the previous litter was born in the last half of the wet season or in the first half of the dry season, the IBI length for the subsequent litter was significantly shorter than the IBI following birth during the second half of the dry season (One-way ANOVA: $F = 5.41$, $p < 0.01$) (Fig. 2B).

As shown in Figure 3, most births occurred during the periods of longer daylight¹ and lower rainfall² (the end of the dry season and the beginning of the wet season — the period from November to March) (Fig. 3A, 3B). Moreover, in cases in which females had produced two sets of litters per year, the births were distributed in such a way that the second half of the wet season was avoided. The births occurred at the end of the dry season and at the beginning of the wet season (first litter), or at the beginning of the dry season (second litter) (Fig. 3C).

DISCUSSION

In general no marked differences in reproductive performance were found between CB and WC common marmoset females, in agreement with data reported by POOLE and EVANS (1982), and BOX and HUBRECHT (1987). Indeed, we found that the age of the females at the time of pairing showed a negative correlation with PPI length, although this did not affect infant survival. This fact reinforces the idea that callitrichid females had a low reproductive rate when paired younger than 18 months. This low reproductive output seems to be associated with physiological restraints such as anovulatory cycles and a high incidence of spontaneous abortions (ABBOTT, 1978; EVANS & POOLE, 1983; KÖNIG et al., 1990).

¹ Source: Instituto Astronômico e Geofísico of the Universidade de São Paulo (USP); ² Source: Estação Climatológica of the Universidade Federal do Rio Grande do Norte (UFRN).

Fig. 3. **A.** distribution of the total frequency of births (bars) and monthly photoperiod duration (line); **B.** distribution of the total frequency of births (bars) and rainfall (line) during a 6-year interval; **C.** frequency of births produced by females that had one litter per year (white bars) or two litters per year (first: black bars; second: hatched bars) over a 6-year period.

Our results also show that in our colony twins were the most frequent litter size for both captive-born and wild-caught females, in contrast to the data reported by POOLE and EVANS (1982), BOX and HUBRECHT (1987), and ROTHE et al. (1987) who found a higher incidence of triplet births. These last authors have argued that this increase in the frequency of triplet deliveries in captive populations may be a temporary effect and KILBORN et al. (1983) attributed this effect to the high amounts of protein in the diet of captive animals. Since we did not record any enhancement in the frequency of triplet deliveries along the years, even though in our colony the pregnant females were supplemented with animal protein, we suggest that the diet offered to captive animals is not the only factor influencing litter size. In fact, in our colony, some females which had successive triplet deliveries cannibalized their own offspring, probably because of mineral depletion. This suggests that triplet deliveries might be deleterious and that twinning in callitrichids probably evolved as a specialization from ancestors that had single births and not from those that had multiple ones (SOUSA et al., 1999).

With respect to the sex ratio, the expected 1 male: 1 female proportion was maintained for infant birth and perinatal mortality in the litters of both captive-born and wild-caught females. This is expected because factors such as predation and migration that constitute the main determinants of the sex biased composition observed in wild groups for adult animals (MOORE & ALI, 1984; DUNBAR, 1988) do not interfere at this age. Similar results were reported by ROTHE et al. (1987) and BOX and HUBRECHT (1987), for captivity conditions and also by ARAÚJO (1996) in a wild study.

The most interesting finding of the present study concerned the IBI and PPI prolongations. These intervals were longer in our colony than in the other colonies where the animals were maintained under much more controlled environmental conditions [POOLE & EVANS, 1982: mean IBI=154 days; BOX & HUBRECHT, 1987: mean PPI=166 days, mean IBI=158 days; KÖNIG et al., 1990: mean PPI (82%)=144 to 185 days, mean IBI=150 to 157 days]. The probable reason for reproductive seasonality in our colony is that the outdoor enclosures permit the animals to experience all environmental seasonal variations in photoperiod, temperature, and rainfall. However, food availability, another important factor that is frequently considered to influence birth seasonality in wild studies (FERRARI & LOPES FERRARI, 1989; GOLDIZEN et al., 1988; DIETZ et al., 1994; SAVAGE et al., 1996) cannot be tested in this study due to the regular food supply of these monkeys in captivity. Indeed, we cannot explain our results with basis in reproductive synchronism among females as found as occurring for *Leontopithecus rosalia* (FRENCH & STRIBLEY, 1987) since reproductive physiology studies have never reported this condition to occur for marmosets. Therefore, the existence of significant differences in PPI length as a function of time (month) of pairing, and in IBI length as a function of date of the previous litter birth in our results, appears to represent the way the animals in our colony adjust the births to a specific period of the year. This conclusion is supported by the fact that the period of birth peak recorded in our colony coincided with those reported for wild marmoset groups (*C. jacchus*), i.e. late October to November and late March to April (HUBRECHT, 1984) and 72.7% of births from October to March (DIGBY & FERRARI, 1994), and September and October for *C. humeralifer* (RYLANDS, 1981). Additionally, the delay in reproduction and the consequent IBI prolongations seem to be a common event in the wild. For example, DIETZ et al. (1994) observed that only 10 of 32 monitored reproductive *Leontopithecus rosalia* females had produced two litters per year on at least one occasion during a ten-year period study.

The birth seasonality demonstrated in our results, even with a constant food supply, suggests that the exposure to other environmental cues should be sufficient to time the reproductive activity of the animals and provide this biological rhythmicity. Seasonal variations in photoperiod, temperature, and rainfall should then act as proximate cues which set the endogenous rhythm to an appropriate time of year (called *zeitgebers*: ASCHOFF, 1954), even in the absence of the ultimate cause (variations in food availability).

One fact that supports this hypotheses is that the captive callitrichid populations which failed to show birth seasonality were those which were partially or totally prevented from being aware of seasonal variations in photoperiod and rainfall (MCGREW & WEBSTER, 1995). Indeed, chronobiological studies carried out in our laboratory demonstrated that although our colony is located near the equator, with an annual variation in day length of only 20–30 min, the rest/activity cycle of the groups showed a circannual variation. The daily activity length was shorter in the rainy winter than in the dry summer and since temperature fluctuated slightly and relative humidity was negatively related to it, the seasonality recorded was considered to be related to rainfall rates (MOREIRA et al., 1996).

Since females who had produced one litter/year as well as females who had produced two

litters/year showed a marked temporal organization of the births, even in the presence of a constant food supply, we suppose that photoperiod and/or rainfall or both, probably are the key environmental factors timing the reproductive activity of common marmosets, rather than availability of a specific food item. Biological rhythms are genetically determined in living organisms (FELDMAN, 1982), and during the evolutionary process of the timing of reproduction in callitrichids, different factors might be operating together under natural conditions. Under captive conditions, even with food availability being constant, we can speculate that other time clues such as rainfall and light-dark cycle might be strong enough to trigger and determine the annual distribution of births in these small primates.

In conclusion, our results demonstrated that under similar environmental conditions, there was no difference in reproductive patterns between wild-caught and captive-born *Callithrix jacchus* females, and that the reproductive activity of this species is seasonally distributed since the animals can be aware of environmental cues, such as variations in day-length and rainfall.

Acknowledgements. We wish to thank EDINÓLIA CÂMARA and ANTONIO BARBOSA DA SILVA for their technical assistance, and the anonymous referees for their valuable comments and criticism. This research was supported by grants from CNPq, a Brazilian Governmental Agency to the technological and scientific development (Grant No. 522660-95 and Grant No. 301. 309-84-1).

REFERENCES

- ABBOTT, D. H. 1978. The physical, hormonal and behavioural development of the common marmoset, *Callithrix jacchus jacchus*. In: *Biology and Behaviour of Marmosets*, ROTHE, H.; WOLTER, H. J.; HEARN, J. P. (eds.), Eigenverlag, Göttingen, pp. 99–106.
- ABBOTT, D. H. 1984. Behavioral and physiological suppression of fertility in subordinate marmoset monkeys. *Amer. J. Primatol.*, 6: 169–184.
- ARAÚJO, A. S. 1996. Influence des facteurs écologiques, comportementaux et démographiques sur la dispersion de *Callithrix jacchus*. Ph.D. thesis, Univ. de Paris, Nord, Paris.
- ASCHOFF, J. 1954. Zeitgeber der tierischen tagesperiodik. *Naturwissenschaften*, 41: 49–56.
- BARRETT, J.; ABBOTT, D. H.; GEORGE, L. M. 1990. Extension of reproductive suppression by pheromonal cues in subordinate female marmoset monkeys, *Callithrix jacchus*. *J. Reprod. Fertil.*, 90: 411–418.
- BOX, H. O.; HUBRECHT, R. C. 1987. Long-term data on the reproduction and maintenance of a colony of common marmosets (*Callithrix jacchus jacchus*). *Lab. Anim.*, 21: 249–260.
- BRONSON, F. H. 1988. Seasonal regulation of reproduction in mammals. In: *The Physiology of Reproduction*, KNOBIL, E.; NEILL, J. (eds.), Raven Press, New York, pp. 1831–1870.
- DE LA TORRE, S.; CAMPOS, F.; DE VRIES, T. 1995. Home range and birth seasonality of *Saguinus nigricollis graellsii* in Ecuadorian Amazonia. *Amer. J. Primatol.*, 37: 39–56.
- DIETZ, J. M.; BAKER, A. J.; MIGLIORETTI, D. 1994. Seasonal variation in reproduction, juvenile growth, and adult body mass in golden lion tamarins (*Leontopithecus rosalia*). *Amer. J. Primatol.*, 34: 115–132.
- DIGBY, L. J.; FERRARI, S. F. 1994. Multiple breeding females in free-ranging groups of *Callithrix jacchus*. *Int. J. Primatol.*, 15: 389–397.
- DUNBAR, R. I. M. 1988. *Primate Social Systems*. Croom Helm, London.
- EVANS, S. 1983. Breeding of the cotton-top tamarin *Saguinus oedipus oedipus*: a comparison with the common marmoset. *Zool. Biol.*, 2: 47–54.
- EVANS, S.; POOLE, T. B. 1983. Pair-bond formation and breeding success in the common marmoset *Callithrix jacchus jacchus*. *Int. J. Primatol.*, 4: 83–96.
- FELDMAN, J. F. 1982. Genetic approaches to circadian clocks. *Ann. Rev. Plant Physiol.*, 33: 583–608.
- FERRARI, S. F.; LOPES FERRARI, M. A. 1989. A re-evaluation of the social organization of the Callitrichidae with reference to the ecological differences between genera. *Folia Primatol.*, 52: 132–147.
- FRENCH, J. A.; STRIBLEY, J. A. 1987. Synchronization of ovarian cycles within and between social groups in golden lion tamarins (*Leontopithecus rosalia*). *Amer. J. Primatol.*, 12: 469–478.

- GOLDIZEN, A. W.; TERBORGH, J.; CORNEJO, F.; PORRAS, D. T.; EVANS, R. 1988. Seasonal food shortage, weight loss, and the timing of births in saddle-back tamarins (*Saguinus fuscicollis*). *J. Anim. Ecol.*, 57: 893–901.
- HEARN, J. P. (ed.). 1983. The common marmoset (*Callithrix jacchus*). In: *Reproduction in New World Primates*, MTP Press, Lancaster, pp. 181–215.
- HUBRECHT, R. C. 1984. Field observations on group size and composition of the common marmoset (*Callithrix jacchus jacchus*), at Tapacura, Brazil. *Primates*, 25: 13–21.
- KILBORN, J. A.; SEGHAL, P.; JOHNSON, L. D.; BELAND, M.; BRONSON, R. T. 1983. A retrospective study of infant mortality of cotton-top tamarins (*Saguinus oedipus*) in captive breeding. *Lab. Anim. Sci.*, 33: 168–171.
- KÖNIG, A.; RADESPIEL, U.; SIESS, M.; ROTHE, H.; DARMS, K. 1990. Analysis of pairing-parturition and interbirth-intervals in a colony of common marmosets (*Callithrix jacchus*). *Z. Säugetierkunde*, 55: 308–314.
- MCGREW, W. C.; WEBSTER, J. 1995. Birth seasonality in cotton-top tamarins (*Saguinus oedipus*) despite constant food supply and body weight. *Primates*, 36: 241–248.
- MOORE, J.; ALI, R. 1984. Are dispersal and inbreeding avoidance related? *Anim. Behav.*, 32: 94–112.
- MOREIRA, L. F. S.; MENEZES, A. A. L.; MARQUES, M. D. 1996. Activity onset and offset of *Callithrix jacchus* show seasonal variation in an equatorial region. In: *The XVIth Congress of the International Primatological Society and XIXth Conference of the American Society of Primatologists*. (abstracts)
- POOLE, T. B.; EVANS, R. G. 1982. Reproduction, infant survival and productivity of a colony of common marmosets (*Callithrix jacchus jacchus*). *Lab. Anim. Sci.*, 16: 88–97.
- ROTHER, H.; KÖNIG, A.; DARMS, K.; SIESS, M. 1987. Analysis of litter size in a colony of the common marmoset (*Callithrix jacchus*). *Z. Säugetierkunde*, 52: 227–235.
- RYLANDS, A. B. 1981. Preliminary field observations on the marmoset, *Callithrix humeralifer intermedius* (HERSHKOVITZ, 1977) at Dardanelos, Rio Aripuanã, Mato Grosso. *Primates*, 22: 46–59.
- SALTZMAN, W.; SCHULTZ-DARKEN, N.; ABBOTT, D. H. 1997. Behavioral and social correlates of escape from suppression of ovulation in female common marmosets housed with natal family. *Amer. J. Primatol.*, 41: 1–21.
- SAVAGE, A.; GIRALDO, L. H.; SOTO, L. H.; SNOWDON, C. T. 1996. Demography, group composition, and dispersal in wild cotton-top tamarin (*Saguinus oedipus*) groups. *Amer. J. Primatol.*, 38: 85–100.
- SNOWDON, C. T. 1996. Infant care in cooperatively breeding species. In: *Parental Care: Evolution, Mechanisms and Adaptive Significance*, ROSENBLATT, J. A.; SNOWDON, C. T. (eds.), Academic Press, San Diego, pp. 643–689.
- SNOWDON, C. T.; SAVAGE, A.; MCCONNEL, P. B. 1985. A breeding colony of cotton-top tamarins (*Saguinus oedipus*) in captivity. *Lab. Anim. Sci.*, 35: 477–481.
- SOUSA, M. B. C.; SILVA, H. P. A.; VIDAL, J. F. 1999. Litter size does not interfere with fertility in common marmoset, *Callithrix jacchus*. *Folia Primatol.*, 70: 41–46.
- TARDIF, S. D.; CARSON, R. L.; CLAPP, N. K. 1986. Breeding performance of captive-born cotton-top tamarin (*Saguinus oedipus*) females: proposed explanations for colony differences. *Amer. J. Primatol.*, 11: 271–275.
- TARDIF, S. D.; RICHTER, C. B.; CARSON, R. L. 1984. Reproductive performance of three species of Callitrichidae. *Lab. Anim. Sci.*, 34: 274–275.
- ZIEGLER, T. E.; STEIN, F. J. 1981. Reproductive data from a colony of marmosets (*Callithrix jacchus*). *Amer. J. Primatol.*, 1: 336.

— Received: September 9, 1997; Accepted: September 5, 1998

Authors' Names and Addresses: MARIA BERNARDETE CORDEIRO DE SOUSA, Departamento de Fisiologia, Universidade Federal do Rio Grande do Norte, P. O. Box 1511, 59072-970, Natal, RN, Brasil. e-mail: mdesousa@cb.ufrr.br; H. P. A. PEREGRINO, Bolsista de Desenvolvimento Regional, CNPq; M. F. C. CIRNE and M. T. S. MOTA, Departamento de Fisiologia, Universidade Federal do Rio Grande do Norte, P. O. Box 1511, 59072-970, Natal, RN, Brasil.