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# Analysis of pairing-parturition- and interbirth-intervals in a colony of Common marmosets *(Callithrix jacchus)*

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## Abstract

Investigated the pairing-parturition-intervals (PPIs) and interbirth-intervals (IBIs) of marmoset females *(Callithrix jacchus)* with particular emphasis on prolongations. 28 PPIs and 166 IBIs of 31 females were considered. Comparison with endocrinological data of marmosets shows that conception usually takes place during the first or second ovarian cycle after pair formation. Our data indicate a two-peak-distribution of IBIs, that is 17 % of IBIs refer to conceptions during second or subsequent post-partum ovulation. About 45 % of these prolonged IBIs occur between the first and second, 21 % between the second and third delivery of each female. A relation was found between survival of the infants of the first and/or second litter in their native family and prolongation of the following IBI. The results are discussed in comparison with data from other colonies and with respect to the social system of marmosets.

## Introduction

Common marmosets have been kept and bred successfully under laboratory conditions for many years. Due to a mean gestation length of 144 days (Hearn 1983) and no delay in ovulation when lactating, conception usually occurs some days after birth (Lunn and McNeilly 1982). The interbirth-intervals are therefore usually 150 to 160 days (see e.g. Poole and Evans 1982; Box and Hubrecht 1987). However, a considerable fluctuation in the length of pairing-parturition-intervals and IBIs can also be observed (see e.g. Evans and Poole 1983; Phillips 1976). In *C. jacchus* prolongation of PPI has been reported to be due to the young age of females at pair formation (Evans and Poole 1983), but explanations for prolongations of IBIs are still lacking. In other Callitrichids it has been found that decreasing daylight and humidity might be involved in triggering the conception (Kirkwood et al. 1983; for *Saguinus oedipus*). Removal of the infants shortly after birth may cause a reduction of IBI (Wolfe et al. 1975; Kirkwood et al. 1983; for *Saguinus* sp.).

The present paper analyses a relatively large sample (n = 194) of PPIs/IBIs. The possible causes and consequences of prolongation are discussed.

## Material and methods

The marmosets were housed in cages or rooms of 1.0 m × 2.0 m × 2.5 m up to 5.0 m × 7.0 m × 3.0 m. The groups usually could not see each other, however, auditory and olfactory communication was possible. Housing conditions were maintained at a temperature of around 25 °C and 65 % humidity. In addition to daylight, a 12 hour light cycle was maintained using artificial lightning. All animals were fed twice daily; in the morning with a rice and porridge mixture with additional vitamins, protein and minerals; in the afternoon with fresh fruit and vegetables. Additionally the animals received crickets, mealworms, live newborn mice, boiled chicken and boiled veal. Unsweeted black tea was always available.

The data refer to 31 breeding females including six wild caught females. In order to exclude some possible influences of different social conditions only those families were taken into account, which

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*Table 1.* **Estimation of PPI and IBI ranges**

| | mean (days) | range (days) |
|---|---|---|
| gestation[1] | 144.0 ± 2.0 | 141–146 |
| post partum ovulation[1] | 10.5 ± 0.7 | 5– 17 |
| follicular phase[1] | 8.3 ± 0.3 | — |
| luteal phase[1] | 19.2 ± 0.6 | — |
| PPI – conception at: | | |
| first ovulation a.p. | — | 141–174 |
| second ovulation a.p. | — | 170–202 |
| IBI – conception at: | | |
| first ovulation p.p. | 154.5 ± 4.5 | 146–163 |
| second ovulation p.p. | 182.0 ± 4.9 | 174–191 |

[1]data published by HEARN (1983).
a.p. – after pair formation; p.p. – post partum.

were set up as pairs (no trios, or multi-male/multi-female groups). All females apart from one, were at least 18 months old when paired; the one exception was 15 months old. With the exception of one laboratory born and the wild caught females with unknown parity, all the other females were nulliparous. Except for one unintended pair formation (the male was 9.5 months old) all the other laboratory born males were no younger than 17 months.

Based on the endocrinological data published by HEARN (1983) we calculated expected PPI and IBI ranges by summing up the interval ranges of ovarian cycle and gestation period. These interval ranges were estimated from the mean values by Gaussian distribution. Depending on the conception date a number of discrete intervals, in which the IBIs should occur, could be found (during the first, second, or even later post-partum ovulation; table 1 and fig. 2, marked intervals). In contrast to the calculated IBIs, the expected intervals for PPIs overlapped in such a manner, that only an approximate determination was possible (table 1 and fig. 1, marked intervals).

The observed IBIs of all 31 breeding females were numbered chronologically. The intervals preceding abortions and premature births were excluded, whereas the IBIs between these events and the following births were included in the analysis. Additional information on the physical condition and illnesses of the animals, abortions, premature births as well as all disturbances (e.g. rehousing) to which the breeding groups were exposed, were used for a more detailed interpretation of the PPI and IBI data.

In order to examine a possible relationship between prolongation and seasonality in births, we looked for a correlation not only between the time of pair formation and first delivery but also the second delivery as well as the associated IBI and PPIs. Our hypothesis is, if there is an effectual seasonality in parturition, depending on the time of pair formation, a perceptible prolongation in PPI and IBI would be expected in order for the births to occur at the correct time of year.

Possible relationships of IBI length to group size (i.e. number of helpers) were examined by comparison of IBIs of successive deliveries of viable offspring.

## Results

### Pairing-parturition-intervals (PPIs)

Since two of the 31 females aborted and one female was already pregnant when paired, the data refer only to 28 deliveries. The lengths of the PPIs show a large spread between 144 and 402 days, however, most of the deliveries occured between 144th and 185th day after pair formation (fig. 1). 23 (82 %) of the observed deliveries occured during that interval. The respective females are likely to have conceived during the first or second ovulation after pairing (compare marked interval fig. 1). The prolongation of at least three of the remaining five PPIs (18 %) could possibly be related to disturbances in daily routine (n = 2) and to an unintended pair formation (n = 1, see above). A relationship between prolongation and seasonality could not be detected, as prolonged PPIs occured the whole year round (see also prolongations of IBIs).

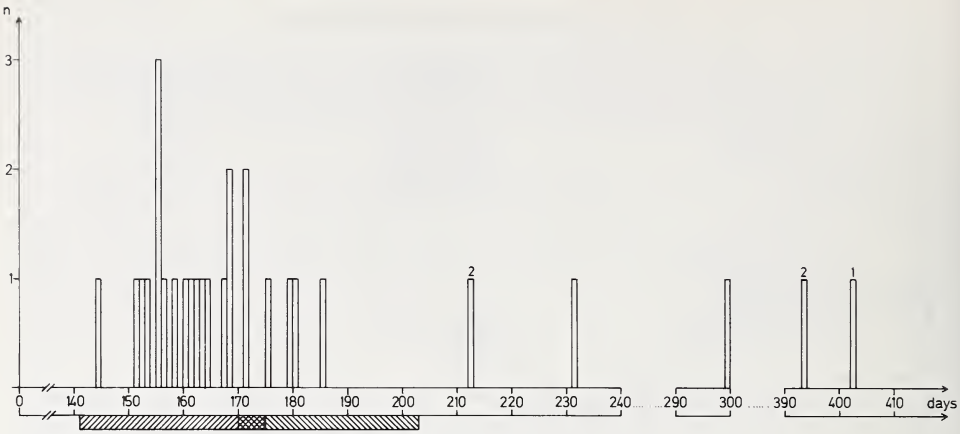


*Fig. 1.* Distribution of pairing-parturition-intervals

[1] – unintended pair formation (male 9.5 months old)

[2] – prolongation presumably caused by illness or disturbances

– conception at first ovulation after pair formation (estimated interval)

– conception at second ovulation after pair formation (estimated interval)

## Interbirth-intervals (IBIs)

The data refer to 166 deliveries excluding two abortions and one premature birth. 137 (83 %) of the IBIs could be allocated to the interval between day 147 and 167; most of which can be found between day 150 and 157 with maxima on the 152th and 155th day (fig. 2). A second minor concentration of IBIs occurs between 173 to 192 days (n = 15, 9 %). 14 (8 %) of the IBIs were longer than 196 days. These IBIs nearly totally agree with the two expected ranges of IBIs for conception after 1. the first ovulation (146 to 163 days) and 2. the second ovulation post partum (174 to 191 days; compare marked intervals fig. 2). In conclusion this means that only 17 % of all conceptions occured during the second or subsequent ovulation post partum.

## Prolongation of IBIs

One explanation for prolongation may be that regular breeding is interrupted or prevented by illnesses of the breeding pair or by external and/or social disturbances. The appendices in fig. 2 show that a considerable number of prolonged IBIs (n = 5, 17 %) may be influenced by such disturbances (n = 3) or occured after an abortion (n = 2). Nevertheless regular IBIs occured also after abortions (n = 3). Also no apparent relationship could be detected between prolongation and seasonality. Moreover, females which bred for several years in our facility gave birth the whole year round.

Apart from the possible influence of disturbances on IBI length, it is striking that 45 % (n = 13) of all prolonged IBIs (n = 29) were associated with the second delivery with a smaller peak in association with the third delivery (21 %, n = 6). This is also true for wild caught females, as two of the six females showed prolonged IBIs for their second delivery. This result was not caused by a possible bias due to different numbers of deliveries of different females. Table 2 shows the frequency of the IBI categories of 21 females which gave birth to at least five litters. The IBIs are listed according to the sequence of successive

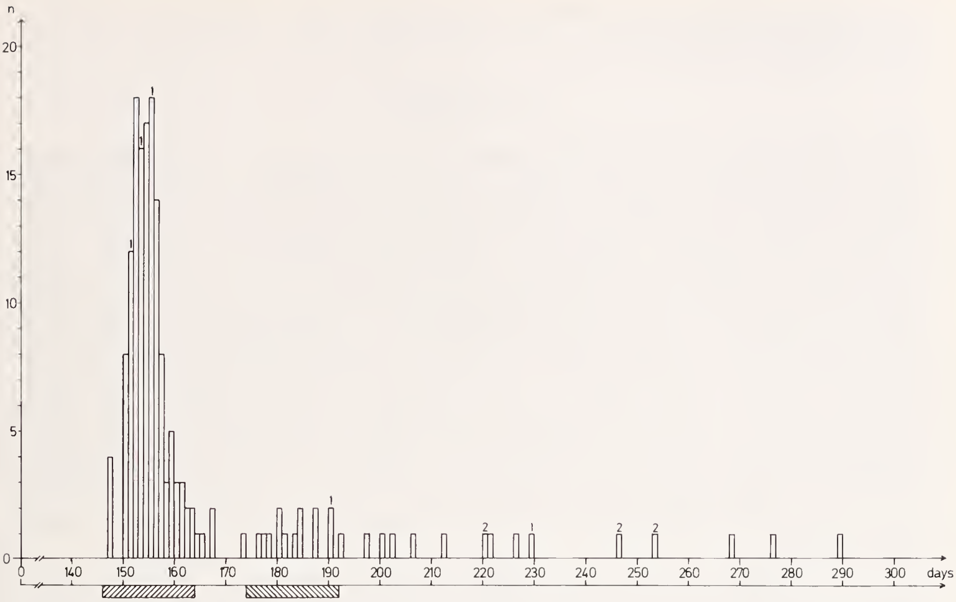


*Fig. 2.* Distribution of interbirth-intervals

[1] – one IBI after abortion
[2] – prolongation of one IBI presumably caused by illness or disturbances
– conception at first ovulation post partum (estimated interval)
– conception at second interval post partum (estimated interval)

deliveries of viable and reared offspring (litter 02 to litter 05) and are compared to those IBIs where all infants of a given litter died or were removed within 10 days ($IBI^{x}$). 41 % of IBIs of the second and 32 % of the third litter were prolonged. In comparison $IBI^{x}$ shows a prolongation of the IBIs rather similar to that of the fourth and fifth deliveries (6 to 17 %).

*Table 2.* **Frequencies of IBI categories of 21 females from litter 02 to 05**

| | | Ranges for IBIs (in days) 147–167 | 173–192 | >196 | Σn |
|---|---|---|---|---|---|
| litter 02 | n | 10[1] | 4 | 3[2] | 17 |
| | % | 58.8 | 23.5 | 17.7 | |
| litter 03 | n | 13 | 4 | 2 | 19 |
| | % | 68.4 | 21.1 | 10.5 | |
| litter 04 | n | 18 | 0 | 2[22] | 20 |
| | % | 90.0 | 0 | 10.0 | |
| litter 05 | n | 15[1] | 1 | 0 | 16 |
| | % | 93.7 | 6.3 | 0 | |
| $IBI^{a}$ | n | 10 | 2 | 0 | 12 |
| | % | 83.3 | 16.7 | 0 | |

[1] One IBI after abortion. – [2] One IBI presumably caused by illness or disturbances. – $IBI^{a}$ – all infants of a given litter died or were removed within 10 days after birth.

Overall this means that 72 % (n = 13) of prolonged IBIs of these 21 females occured in the second and third parturition.

## Discussion

Our data indicate that in the common marmoset a rather large proportion of conceptions occur during the first or second ovarian cycle of newly paired females. EVANS and POOLE (1983) found 50 % of all deliveries in their *C. jacchus* colony to occur between day 140 and 200 after pair formation. These authors explain the strikingly increased PPIs of the remaining females to be due to the young age of those females (< 18 months) when paired for the first time. We cannot comment on this interpretation. Our data confirm another observation of EVANS and POOLE (1983) that there is no relationship between the females' age at pair formation and the lengths of PPIs, if the paired females were older than 18 months. With the exception of the three prolonged PPIs in our sample which were probably caused by external factors, our data allow one to speculate that under normal conditions nearly all females would have given birth about 185 days following pair formation. This could also be true for females which live in their native groups until shortly before pair formation, since ovulation occurs almost immediately following the females' removal from their native family (ABBOTT 1984; EPPLE and KATZ 1984; EVANS and HODGES 1984).

As a consequence of this result it is not necessary to investigate further a possible seasonal dependence of deliveries in captive *C. jacchus* females. Although two breeding peaks have been observed in wild marmoset groups (HUBRECHT 1984; RYLANDS 1981), this may be altered by housing conditions in captivity. Nevertheless, if birth peaks are observed under laboratory conditions, one has also to examine other possible reasons apart from just seasonal dependence, i.e. more or less identical time of pair formation or synchronisation between breeding females as to ovulation cycles (see FRENCH and STRIBLEY 1987 for *Leontopithecus rosalia*).

In our colony most IBIs had a length of 150 to 157 days. The mean and median values for IBIs found in the literature generally range from 154 to 205 days (BOX and HUBRECHT 1987; HIDDLESTON 1978; LUNN and HEARN 1978; MCINTOSH and LOOKER 1982; PHILLIPS 1976; POOLE and EVANS 1982). However, as the observed IBIs of our *C. jacchus* colony and their expected intervals indicate a two (or more)-peak-distribution, the use of mean or median values are neither meaningful nor correct. Unfortunately we do not have enough data from our colony at present to undertake a more suitable statistical evaluation, which considers both the dependence and distribution (e.g. maximum likelihood). Apart from this, the rather regular IBIs and prolongation of IBIs seem comparable to other studies (e.g. BOX and HUBRECHT 1987). Our data show that the prolongations are regularly associated with the second and third deliveries of viable offspring. On the other hand, if infants are removed shortly after birth, the following IBI lengths are comparable to those of the fourth and fifth deliveries. This indicates a relationship between survival of the infants of the first two litters and prolongation of the following IBIs in wild caught as well as in laboratory born females (compare WOLFE et al. 1976 and KIRKWOOD et al. 1983 for *Saguinus* sp.). Newly paired marmosets are confronted with a strikingly new situation following parturition of their first young, as the parents will have to carry their infants during sexual and copulatory activities, whereas after the second delivery only unexperienced helpers are available. Both of these factors may possibly handicap the animals and prevent the female from conceiving during the first ovarian cycle post partum. Conception would be more probable during the second or later ovarian cycles, because at this time the infants are more independent and move around on their own. Therefore, the prolongation of the second and/or third IBI in the females' life may have a natural cause and should not be compensated by removal of the young.

On the other hand, if breeding pairs tolerate experienced related or unrelated conspecifics as helpers, they could possibly increase their potential time of reproduction by reducing the nonreproductive intervals. It has to be considered that this hypothesis cannot directly be extended to natural conditions.

Since wild marmosets have been observed to exhibit birth peaks (HUBRECHT 1984; RYLANDS 1981), a reduction of the nonreproductive interval would not necessarily result directly in a higher reproduction rate with a greater number of offspring. It has to be ensured that the births do not occur in a period of limited food resources which would result in higher infant mortality; therefore any reduction or prolongation of the nonreproductive interval leading to such an unfavourable time of birth would have to be avoided. In order to analyse these contrasting models it would be necessary to know firstly how long marmosets maintain their reproductive privilege in wild groups (to decide whether the regulation of the time of birth is associated to one or more females within a group) and secondly what the prerequisites for tolerance against strange conspecifics of either sex are. Although high turnover rates in *C. jacchus* groups had been observed (SCANLON et al. 1988) and new groups may be formed by more than one male and one female (FERRARI, pers. comm. 1988; for *C. flaviceps*), we urgently need more data to clarify the possible coherence between the presence of additional helpers, the tolerance against them and the reproductive benefits for the breeding animals.

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## Zusammenfassung

*Analyse von Verpaarungs-Geburt- und Intergeburten-Intervallen in einer Kolonie von Weißbüschelaffen (Callithrix jacchus)*

Untersucht wurden Verpaarungs-Geburten-Intervalle (PPIs) und Intergeburten-Intervalle (IBIs) von Weißbüschelaffen-Weibchen *(Callithrix jacchus)*. Für die Untersuchung standen 28 PPIs und 166 IBIs von 31 Weibchen zur Verfügung. Im Vergleich mit endokrinologischen Daten zeigt sich, daß die Weibchen normalerweise während des ersten oder zweiten ovarialen Zyklus' nach Verpaarung konzipierten. Die IBIs lassen eine zwei(oder mehr)-gipflige Verteilung vermuten, d. h. 17 % der IBIs lassen sich auf Konzeptionen bei der zweiten oder einer späteren Ovulation post partum zurückführen. Etwa 45 % dieser verlängerten IBIs folgen auf die erste Geburt, 21 % auf die zweite Geburt jedes Weibchens. Es kann eine Beziehung zwischen dem Überleben der Jungtiere des ersten und zweiten Wurfes und der Verlängerung der folgenden IBIs festgestellt werden. Die Ergebnisse werden im Vergleich mit anderen Untersuchungen und in Hinsicht auf das Sozialsystem der Marmosetten diskutiert.

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