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Birth Intervals in *M. sylvanus* of Gibraltar

F. D. BURTON and L. A. SAWCHUK
University of Toronto

ABSTRACT. The length of the birth interval in *Macaca sylvanus* of Gibraltar was defined and one-year intervals were found to be normative. The effect of infant loss on the interbirth interval was assessed and found to have no influence.
Variability in the birth interval in comparable species is noted.

INTRODUCTION

The reproductive physiology of non-human primates is important in providing models for humans for the development of theoretical models in biology. The relationship of parity to birth cycle has more recently come under consideration (e.g., HADIDIAN & BERNSTEIN, 1979). Birth intervals closely reflect the actual reproductive performance and reproductive potential of a population (SCHULL & MACLURE, 1968) and are, therefore, of considerable interest.

The present report is concerned with the analysis of the length of intervals between successive births of *Macaca sylvanus* of Gibraltar. In Gibraltar, the population is free-ranging in its natural habitat and must rely on foraging as the animals are supplementally provisioned to only approximately one-third of their requirements (BURTON, 1972). Nevertheless, human influence is pervasive, as the population is regularly culled to conform to governmental regulation and as the population is encouraged through provisioning and chasing to free-range away from human settlement. Records go back to the early part of this century, affording documentation of basic population events. An earlier paper outlined essential demographic parameters of these monkeys (BURTON & SAWCHUK, 1974).

MATERIALS AND METHODS

The Gibraltar macaque population has been described by MACROBERTS (1970), MACROBERTS and MACROBERTS (1966) and BURTON (1972). The location and circumstances of the Middle Hill group have dramatically altered since 1970. At that time, they were still settled at Caroline's Battery, an area considerably closer to the town, on a plateau which afforded rich and variant foliage as well as sleeping sites away from the easterly wind. With the growing human population, and with the transfer of military land to the civilian population, that plateau became more frequented by towns-people, and was slated for development. The monkeys were, then, encouraged to remain at Middle Hill, and these efforts have been successful since 1972. Middle Hill does not afford the same diversity of flora. Indeed, although the olive grows at that height (426.7 m) it does not fruit. The number of nutritive resources are severely curtailed as is the amount of cubic space, since as the summit is a communications area, trees have been removed in favour of antennae, and what trees there are, are scrub forms. The time of relocation was accompanied by changes in leadership in the group too complex to detail here (BURTON, in manu.).

Table 1. Data on the reproductive performance of female macaques ($N = 35$) who had two or more offspring while resident at Gibraltar from 1935 to December 31, 1973.

	$\bar{x}$	S.D.	Min.	Max.
Age at 1st birth	4.99	1.13	2.9	7.9
Reproductive span	6.61	3.07	1.1	16.3
Longevity[1)]	11.58	8.60	5.0	22.3

1) Calculated by substracting the date of birth from either the date of loss, or as in the case of living females, from December 31, 1973.

Data on the reproductive performance of the Gibraltar macaque was based on British Army records spanning 40 years. During the period 1935 to December 31, 1973, a total of 35 females had birth intervals that were countable, that is, they had two or more successive births. Of these, 12 were born in Morocco and imported to Gibraltar during the latter part of the 1930's and early 1940's. The remaining 23 females were Gibraltar-born of these Moroccan females. Table 1 presents data on some of the reproductive parameters of the females sampled in the present study.

In addition to defining the length of the birth interval itself, a further objective here was to assess the effect of infant loss on the interbirth interval for *Macaca sylvanus* of Gibraltar. Following the work of TANAKA, TOKUDA and KOTERA (1970), infant loss is defined as postpartum loss of young which has occurred within one year minus the gestation period of the primate under investigation. The gestation period of the Gibraltar macaque has been estimated as approximately 163 days (MACROBERTS & MACROBERTS, 1966; BURTON & DEPELHAM, 1979) and thus, postpartum loss of young which has occurred within 202 days after birth is defined here as infant loss.

RESULTS

Table 2 presents data on the observed length and distribution of birth intervals for *Macaca sylvanus* of Gibraltar. A total of 177 recorded births yielded 155 countable interbirth intervals. The mean interval length was 431.716 days with a standard deviation of 165.941. The length of time between successive births ranged from 231 to 1,121 days. Of the 155 countable intervals, 132 (85.2%) of these clustered at one year. The two-year intervals accounted for 11.6% of the observed frequency and three-year intervals for 3.2%. As the "normative" birth interval was one year, it became apparent that infant loss would not significantly influence the length of the birth interval. The mean length of the 20 intervals where infant loss occurred within 202 days was 408.4 days. None of these losses were due to culling. The mean length of interbirth interval for infants surviving beyond 202 days was 435.2 days. As noted in Table 2, the distribution of birth intervals for the Gibraltar macaque deviated significantly from that of a normal curve with a distribution skewed to the right and highly leptokurtic. The observed heterogeneity in the interval length was reduced considerably when all two- and three-year intervals were removed from consideration. The adjusted mean interval was 369.012 days with a standard deviation of 39.012. As expected, removal of these cases did normalize the distribution with respect to skewness but did not significantly alter the leptokurtic nature of the distribution [$t_s = 4.906$ is greater than t .001 (131) $= 3.373$]. The departure from a normal distribution is a reflection of biological reality as among the Gibraltar monkeys, as in other macaques (BURTON & SAWCHUK, 1974) births and breeding are seasonal (LANCASTER & LEE, 1965).

Table 2. Frequency distribution of birth intervals for *Macaca sylvanus* (Gibraltar), based on the reproductive performance of 35 females.

Birth interval (days)	Absolute frequency (%)	Cumulative frequency (%)
231–259	1	0.6
260–288	6	4.5
289–317	1	5.2
318–346	21	18.7
347–375	52	52.3
376–404	33	73.5
405–433	11	80.6
434–462	4	83.2
463–491	3	85.2
608–636	2	86.5
637–665	1	87.1
666–694	3	89.0
695–723	7	93.5
724–752	4	96.1
782–810	1	96.8
1043–1071	2	98.1
1072–1100	1	98.7
1101–1129	2	100.0
	155	100.0

$\bar{x}$ = 431.716; S.D. = 165.941; median = 373.75; mode = 361; skewness = 2.491; t_s = 12.71*** ($p<0.001$); kurtosis = 6.180; t_s = 15.85*** ($p<0.001$).

A significant amount of heterogeneity in the length between successive births can be attributed to the occurrence of two- and three-year birth intervals. These 23 cases were examined for any systematic tendencies and the following observations can be reported. First, the longer birth intervals were associated exclusively with sequences involving livebirths only. With the exception of 1961, these departures from a one-year interval were randomly distributed through the study period. In that year, the reproductive performance of six adult females was disturbed suggesting a traumatic local environmental event. A further observation worth noting was that approximately 44% of these longer intervals occurred at the first interval, that is, between birth one and birth two. However, the remaining intervals varied irregularly with parity. The longer birth intervals also appeared to be related to group location, with 16 (69.57%) of the lengthier intervals attributable to females resident at Queen's Gate. The two- and three-year intervals were randomly distributed among the females studied and no familial tendencies for a longer birth interval were observed.

In Gibraltar, the data clearly show that the two samples of females differentially contributed to the sex ratio. The Moroccan born females produced more males than did the Gibraltar born females. They account for 61 of the 177 livebirths, of which 38 or 62.3% of Moroccan livebirths were male. The livebirth sex ratio of 1.65 from Moroccan females sharply contrasts with the 1.07 ratio of livebirths for the Gibraltar born females. These Moroccan females entered Gibraltar at a time when the total population had fallen below ten (in 1936, six, females of which two were adult, one adult male, and two others below 3 years) with a composition in favour of females. At the time when their offspring, the Gibraltar born females, began to breed, the population more closely approached the size and composition equilibrium that typifies it today. The difference in ratio may be attributable to random fluctuations as a function of a small sample size or may imply some breeding strategy responsive to group composition.

DISCUSSION

TANAKA, TOKUDA and KOTERA have analyzed interbirth interval in the Ohirayama population of *M. fuscata*, a wild population, which were transplanted from Yaku Island in 1957. The findings of this study suggest that two-year intervals are normative, and that one-year intervals occur only when infant loss has occurred. Of their sample of 168, there were 53 cases of 31.5% of one-year intervals, and 107 cases, or 63.7% of two-year intervals. That is, they found that two-year intervals occur regularly unless there has been an infant loss—a finding conflicting with our data. In addition, TANAKA, TOKUDA and KOTERA note that 40 cases of their 168 (or 23.8%) died under 185 days of age. In Gibraltar, there were only 20 cases of (12.9%) loss prior to 202 days, but 135 cases (87.1%) of survivorship past that postnatal term.

ROWELL (1972) reports one-year intervals for forest baboons in Uganda, and KOFORD (1965) reports for Cayo Santiago macaque that some females birth yearly, while others are highly variable, although actual intervals have not been calculated. Other authors, writing on macaques, describe yearly births but do not state the contribution per female per annum. HADIDIAN and BERNSTEIN in their recent study agree with KOFORD (1965) that cycles after birth will be advanced if there has been an infant death or reproductive failure. The segment of pregnancies that result in recorded stillbirths is too fragmentary to be separately calculated. Our findings based on infant loss up to 203 days post-partum, does not concur with the above and indicate that the interbirth interval is shortened. The influence of a loss prior to this period appears to be minimal as the mean difference amounts to no more than one month. Culling did not occur within the 203 days and does not effect this finding.

SUMMARY

An analysis of the length of the interval between successive births for the Gibraltar macaque yielded the following results:

1. One-year birth intervals are normative.
2. The observed distribution interbirth intervals deviates significantly from normality. The distribution exhibited positive skewness and was highly leptokurtic.
3. Infant loss appears to have little or no influence on the length of the birth interval.
4. There was no infant loss due to culling.
5. The difference in contribution made by founding females as opposed to that made by their daughters born in Gibraltar may imply some breeding strategy responsive to group composition.

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Authors' Names and Address: F. D. BURTON and L. A. SAWCHUK, *Social Sciences Division, Scarborough College, University of Toronto, 1265 Military Trail, West Hill, Ontario, M1C, 1A4, Canada.*