A 3-year study of an annual rhythm in plasma androgen levels in male rhesus monkeys (*Macaca mulatta*) in a constant laboratory environment

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Like many other non-human primates (Lancaster & Lee, 1965; Michael & Zumpe, 1971), rhesus monkeys in the wild (Vandenbergh & Vessey, 1968) and in captivity (Michael & Keverne, 1971; Michael, Zumpe, Plant & Evans, 1975; Robinson, Scheffler, Eisele & Goy, 1975) exhibit seasonal changes in sexual behaviour. In the northern hemisphere there is a peak in ejaculatory activity in the late autumn and early winter followed by a decline in late winter and spring when, in the wild, most fertile females are pregnant. However, pregnancy is not the sole cause of the decline in sexual activity.

Pairs of intact monkeys in which the females were sterilized by ligation of the oviducts (Michael & Keverne, 1971) and pairs in which the females were ovariectomized and treated s.c. with 10 µg oestradiol benzoate/day (Michael et al., 1975) showed the seasonal changes characteristic of intact animals in the wild. It seemed, therefore, that the annual behavioural rhythm might be in part dependent on changes within the male of the pair. In two studies (Plant, Zumpe, Sauls & Michael, 1974; Robinson et al., 1975), each of which included 1 complete year, well-marked seasonal changes occurred in the plasma testosterone levels of male rhesus monkeys, with maxima in the autumn and winter months. A notable feature of our preliminary results was the occurrence of an autumnal increase although animals were maintained in a constant photoperiod. These studies have now been extended for a 3-year period during which environmental conditions were rigorously controlled to assess the extent to which long-term rhythms in plasma androgen levels are dependent on known exteroceptive factors.

Four adult male rhesus monkeys were obtained from India 6 months before the start of the study. The animals were housed in a well-controlled laboratory environment with a constant photoperiod (lights on at 06.15 h, off at 20.15 h) and at constant temperature (68–74°F) and had free access to food and water. Males were tested with ovariectomized, oestrogen-treated (10 µg oestradiol benzoate/day s.c.) females for 1 h each day on Monday to Friday throughout the study period, and some of the behavioural results are reported elsewhere (Michael & Zumpe, 1976). Blood samples were taken weekly at 08.00 h and plasma testosterone levels were determined by a new computerized, semi-automated technique that allowed all samples from each male to be analysed simultaneously (Bonsall, Baumgardner & Michael, 1976). Because of its cross-reactivity with the testosterone antiserum (Michael, Setchell & Plant, 1974), dihydrotestosterone contributed to the plasma levels reported here.

The results of assays on 577 samples collected over the 3-year period, plotted as combined monthly means for all males, are shown in Text-fig. 1(e). The within- and between-animal variations are illustrated in Text-figs. 1(a)–1(d). Despite the variability, all males showed evidence of seasonal testosterone rhythms in 1973 and 1975. Males 142 and 144 showed only small increases in the autumn of 1974, and Male 144, with low testosterone levels throughout, showed an irregular pattern.

These findings extend our earlier results and demonstrate the remarkable persistence of the annual androgen rhythm in males subjected to a constant photoperiod, temperature and food supply, and to a constant behavioural testing routine with ovariectomized oestrogen-treated females. There appeared to be a trend towards lower levels in the combined means with the passage of time and a small drift in the timing of the annual peaks: September–October in 1973, October–November in 1974 and October–December in 1975. Although these differences were not conspicuous or shown by all males, they perhaps reflected the lack of periodic stimulation by exteroceptive factors. Gordon,
Text-fig. 1. Annual changes in plasma androgen levels in male rhesus monkeys maintained in the laboratory in constant photoperiod and temperature. Columns show monthly means ± S.E.M. for each male (a, Male 142; b, Male 159; c, Male 148; d, Male 144) and for all males combined (e). N = total number of samples/month.

Rose & Bernstein (1976) recently reported an annual rhythm in plasma testosterone levels in a social group of male rhesus monkeys maintained with intact females in an outdoor enclosure. The timing and magnitude of the autumnal androgen peaks were very similar to those reported here. However, the spring and summer levels in the socially living males were considerably lower (200 ng/100 ml) than those in our laboratory (500 ng/100 ml) where oestrogenized, receptive females were available to the males throughout the year. These results appear to exclude changes in the photoperiod and in ambient temperature as principal factors in determining the long-term endocrine rhythms reported here, but the animals may be utilizing other channels of information about environmental events, and the findings do not prove that the rhythm is an endogenous one.

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References


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