CIRCADIAN ORGANIZATION IN THE REGULATION OF LOCOMOTOR ACTIVITY AND REPRODUCTION IN RATTUS EXULANS

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ABSTRACT

The role of the circadian time-keeping system in regulation of locomotor activity and certain aspects of reproduction has been investigated in wild Polynesian rats, Rattus exulans.

Locomotor activity is under circadian control and data are consistent with a general model of the pacemaker mechanism as a weakly interacting population of circadian oscillators. Experimental studies and field observations indicate that the action of light in entrainment of this rhythm is primarily non-parametric.

Female R. exulans continue to ovulate during prolonged periods in constant conditions and undergo a pattern of change in vaginal cytology through the estrous cycle which closely resembles that of laboratory R. norvegicus. These findings are consistent with the hypothesis that the estrous cycle in R. exulans is regulated by a similar circadian mechanism to that controlling the timing of ovulation, and hence the duration of estrous cycle, in laboratory rats.

Female R. exulans do not exhibit regular fluctuations in either the period of the activity rhythm or intensity of the active phase in association with the estrous cycle. Ovariectomy also has no significant effect on the period of the activity rhythm and no discernible effect on the distribution or intensity of activity. It is therefore concluded that there is no feedback action of the ovaries or estradiol on the circadian pacemaker regulating locomotor activity in R. exulans, which thus differs from laboratory rodents. This proposition is further supported by the observation that there are no significant changes in either period or variability of the activity rhythm in association with the degenerative changes that occur in the female reproductive system in old age. The adaptive significance of these findings is considered.

Field studies on breeding patterns of R. exulans throughout its distribution provide several lines of indirect evidence in support of the hypothesis that the onset of breeding in this species in temperate latitudes is regulated by seasonal changes in photoperiod. Accelerated attainment of puberty occurs in juvenile females collected during the non-breeding part of the year and housed in LD 16:8. Juvenile females collected at the same times but housed in LD 8:16 for an identical duration remain immature. Groups of mature females collected during the breeding

season do not show a differential response to these light regimes. These results are discussed in relation to field data on breeding patterns in the population from which experimental animals were collected. It is concluded that the onset of breeding in this population is controlled primarily by a photoperiodic mechanism regulating the attainment of reproductive maturity in females.

Information on the physiological organization of circadian systems in mammals is reviewed, with particular emphasis on the relationships between locomotor activity rhythms, the estrous cycle, and the effects of photoperiod on reproductive function in rodents.

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SYMBOLS AND ABBREVIATIONS

τ	The period of an overt circadian rhythm in conditions of constant light intensity and temperature. In this study $\bar{\tau}$ is the mean period calculated over 10 consecutive cycles.
CT	Circadian time. A relative time scale in which one unit = $24/\tau$.
$\Delta\phi$	The steady-state phase shift produced in an overt rhythm by a perturbation. $+\Delta\phi$ indicates a phase advance. $-\Delta\phi$ indicates a phase delay.
T	The period of a zeitgeber cycle.
ψ	The phase angle in steady-state entrainment between an overt circadian rhythm (or the pacemaker driving it) and the zeitgeber cycle. In this study ψ is measured between activity onset and the onset of the dark phase of the LD cycle.
LL	Constant light.
DD	Constant darkness.
LD	x:y x hours of light alternating with y hours of darkness.

See also:

Aschoff, J., K. Klotter and R. Wever, 1965. Circadian vocabulary. In: Circadian Clocks (ed. J. Aschoff), North-Holland Publishing Co. Amsterdam.

Halberg, F., 1973. Chronobiologic glossary. Int. J. Chronobiol. 1, 31 - 64.

FRONTISPIECE

Adult female *Rattus exulans*.
(Photograph courtesy of Professor C.R. Austin.)