

Continuous light abolishes the maternal entrainment of the circadian activity rhythm of the pups in the field mouse

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Summary. 12:12-h cycles of presence and absence of mother mouse act as a 'zeitgeber' and entrain the circadian rhythm of locomotor activity in the pups of *Mus booduga* under continuous darkness or continuous dim light. Continuous higher illumination of 15–25 lx abolishes this impressive maternal entrainment.

Keywords. Maternal entrainment; freerun; period; circadian pacemakers; *Mus booduga*.

Most studies on circadian behaviors in mammals have been restricted to adult animals in which the pathway of entrainment by environmental light and darkness (LD) is exclusively through the eyes^{2,3}. In the infants of mice and rats the mother further acts as a transducer and coordinates the timing (phase) of the developing biological clock to her own clock time which, in turn, is entrained by ambient lighting⁴⁻⁶. We reported previously for *Mus booduga* that cycles of presence and absence of the mother mouse (PA cycles) entrain the circadian locomotor activity rhythm of pups both in continuous darkness (DD) and in continuous dim light (LL)⁷. However, some of our experiments (unpublished data) revealed that entrainment to PA cycles in LL

of 3-10 lx was somewhat wobbly. LL is known to bring about radical alterations in circadian features⁸ and even induce arrhythmia, split rhythms, etc.⁹⁻¹¹. It has also been reported from this laboratory that social cues which synchronized the circadian flight activity rhythm of members of a colony of *Hipposideros speoris* bats in DD failed to do so in LL of 10–20 lx¹². We therefore performed experiments to investigate whether LL of appropriately high intensities would in any manner impair the maternal entrainment of the circadian activity rhythm of pups. **Materials and methods.** Pregnant mice *M. booduga* (17 in number) were captured from the fields around the University campus. Seven of them were maintained in DD and the other 10

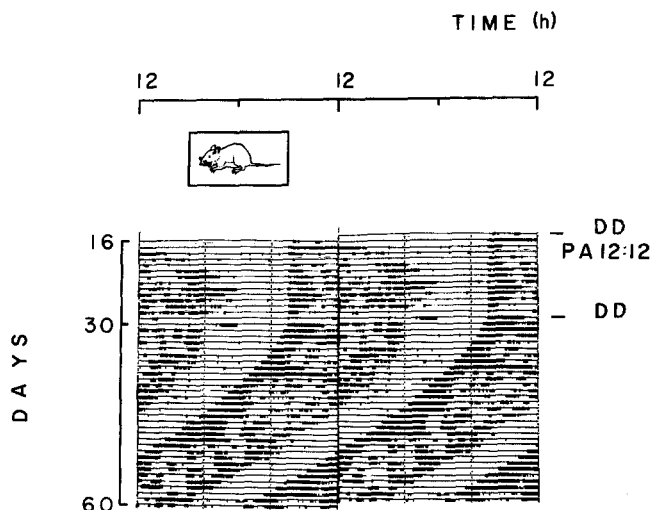


Figure 1. Continuous record of wheel running activity of a pup: days 16–30, DD and PA cycles of mother 12:12-h; days 31–60, DD. The record has been duplicated for easy visual estimation. Presence of the mother: 18.00–06.00 h. The presence of the mother is indicated by a bar.

animals in LL of 15–25 lx (incandescent light). They littered 2–8 pups each. Two pups of either sex were selected from a litter and placed in plastic boxes of 21 × 15 × 13 cm. Starting on day 5 of the pups' life, mothers were alternately presented and removed for 12 h thereby creating PA cycles of 12:12 h. Thus each of the two pups would be with the mother for one half of the cycle. On day 16 the pups were introduced into activity running wheels and the locomotor activity was recorded using an A620 X Esterline Angus Event Recorder. The PA cycles were continued but the mother was tethered by a 10-cm aluminium chain barring her from entering the running wheel. The mother/infant interactions thus took place in the nesting cage attached to the wheels. Food and water were provided ad libitum.

Results and discussion. Figure 1 illustrates an ideal case of maternal entrainment of the circadian rhythm in the locomotor activity of a pup in DD. In this behavioral entrainment the presence of the mother is apparently construed by the pup as subjective day and her absence as subjective night. The pup ran the wheel during subjective night. This entrainment of the pups by PA cycles has been reported by us earlier⁷. Figure 2 shows that this impressive maternal entrainment is abolished by higher LL and the circadian activity rhythm of pups freeruns with a τ of > 24 h in spite of PA cycles. The loss of such entrainment is obviously due to the action of light. Light is known to have dramatic effects on the endocrine system¹³. While the physiological basis underlying the ability of LL to abolish entrainment by PA cycles is not known, light probably uncouples the circadian pacemakers by altering the hormonal profiles^{14,15}. This is, of course, at best a conjecture. Earlier findings of other authors that the effectiveness of maternal entrainment of infant rhythms can be markedly manipulated by LD cycles^{16,17} and our present report that maternal entrainment can even be totally abolished by higher intensities of LL are of obvious interest for human maternity ward situations.

A further feature of interest in figure 2 is that the onset of activity of the pups on day 16 coincides with the time at which the mother was removed in the preceding days. This finding suggests that the pups did entrain to the PA cycles for the first 14–16 days notwithstanding higher LL intensities. Our explanation follows the law of parsimony: higher LL does not impair the maternal entrainment of locomotor activity rhythm of pups because light perception in these mammals is solely through the eyes^{2,3} which open only around 12–14 days¹⁸.

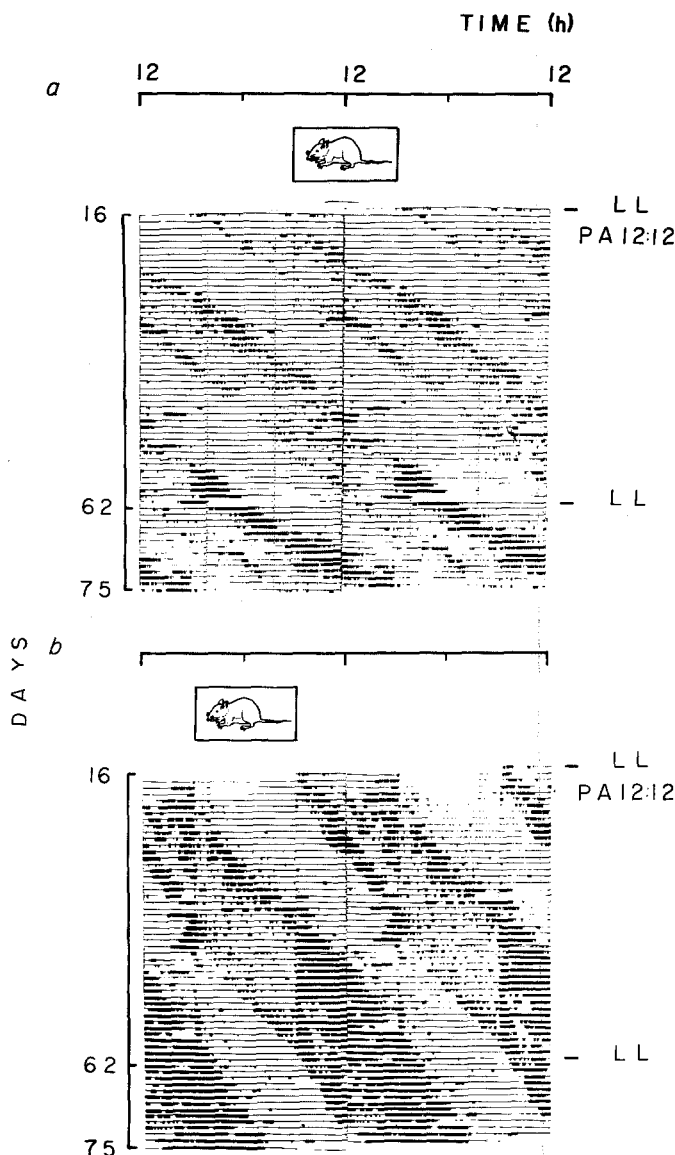


Figure 2. Continuous record of wheel running activity of the pups: a and b Days 16–62, LL and PA cycles of mother 12:12 h; days 63–75, LL. The record has been duplicated for easy visual estimation. Presence of mother τ with pup a) 06.00–18.00 h; pup b) 18.00–06.00 h. The presence of mother is indicated by a bar. The activity rhythm freeruns with a period (τ) of > 24 h (a τ = 24.61; b τ = 24.49). The periods of activity rhythms are not significantly different both during and after PA cycles.

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