

Daylight Dimmer than Starlight Entrainsthe Circadian Rhythm of a Bat

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We report here an accidental finding which we later investigated at some length. The microchiropteran bat, *Hipposideros speoris* of the Madurai region (9°58'N, 78°10'E) roosts in a cave where darkness seems to be absolute and humidity and temperature are constant. These bats seem to entrain their circadian rhythm in flight activity by daily sampling of light just prior to flying out to forage at dusk [1] and through 'social cues' [2]. In the course of experiments investigating the flight activity of these bats, it was found that they entrained perfectly to sunset time in spite of the supposed absolute darkness within the cave. Apparently, light was streaming in, since solitary bats of this species in solitary caves

free run when darkness is absolute and continuous [2]. Careful scrutiny revealed a crack in the uneven ceiling of the cave through which very dim light in the range of 10^{-4} lux streamed in. Due to the inclination of the crack the light came in for just about 90–100 min during the midday hours. Light intensity was measured (with a UDT/40 X Optometer on the log scale) where it shone the brightest on the floor of the cave.

Two experiments were performed with 4 and 3 bats, respectively. All these bats entrained. Figure 1 shows the pattern of entrainment of two bats used in the first experiment over periods of 39 days (Fig. 1a) and 35 days (Fig. 1b), respectively, to the

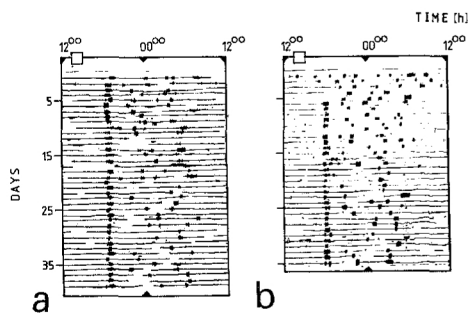


Fig. 1. Entrainment in the flight activity rhythm in 2 male *Hipposideros speoris* inside a natural cave for 39 days (a) and 35 days (b) in response to ca. 1.5 h of light of 0.0001–0.0006 lux streaming in at midday hours (box at top). Aktogram raw data; blotches: flight; horizontal traces: rest. Onset of activity every day coincided with local sunset time

very dim light of 0.0001–0.0006 lux over ca. 1.5 h. The second experiment confirms that the entrainment was indeed effected only by the dim light. Figure 2 shows entrainment in 2 bats during the first 18 days. Then the light leak was plugged. One bat began the free run immediately (Fig. 2a) with a period < 24 h and the other (Fig. 2b) took 2 weeks before free running with a period > 24 h. The free run establishes that the bat rhythm is circadian in nature and the entrainment was exclusively due to the dim light that came in before the plugging.

The lowest light intensity entraining the circadian rhythm of sensitivity of the median eye of a scorpion, reported by Fleissner [3], was 0.00025 lux over 16 h as against

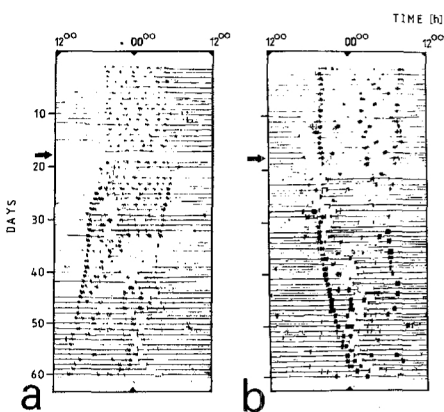


Fig. 2. Pattern of activity of 2 male *Hipposideros speoris* for a period of 60 days in the natural cave. Entrainment ensues for 18 days (a) and 33 days (b). The light leak was fixed on day 18 (arrow). In one bat, the rhythm free ran immediately (a), in the other, it free ran after day 33 only

our 0.0001–0.0006 lux available over only about 1.5 h. It should, however, be pointed out that in our experiment the light intensity at the level of the cages, positioned approximately 4 m away from the site of measurement, was beyond the sensitivity of our optometer. Our natural daylight was about 5–30% of the starlight obtaining in Madurai.

Another interesting feature of the entrained rhythm was its phase angle: though the light was sighted during midday, the bats started activity 6 h later (-90°), coin-

ciding with sunset. The 1.5-h light pulse might have acted as subjective midday and the ψ -value of -90° may have an adaptive significance.

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