Measuring Circadian Entrainment in Five Species of Lemurs

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Eulemur mongoz
Lemur catta
Variegated black-and-white ruffed lemur
Ring-tailed lemur

Background
There are nearly 100 species of lemurs in Madagascar, each of different sizes, colorations, and diets (Mittermeier et al. 2010). Lemur species also differ in terms of their photic niche, some are nocturnal, some are diurnal and some are cathemeral (active both day and night). Very little is known, however, about the relationship between lemur behavior and their 24-hour light-dark exposure patterns. Certainly circadian entrainment, relating proximate light-dark exposure and activity-rest patterns, has never been measured in lemurs (Rea et al. 2014).

Methods
Four individuals of each of five species of lemurs (Eulemur mongoz, Lemur catta, Propithecus coquereli, Varecia rubra and Varecia variegata variegata) housed at the Duke Lemur Center (DLC) in Durham, North Carolina, were fitted with a Daysimeter-D pendant that contained light and accelerometer sensors (Figure 1). The DLC is a unique facility, not only because it houses over 15 species of lemurs, but also because most of the animals may roam at will between the carefully maintained DLC facility and a large outdoor reserve. Circadian entrainment can be quantified using phasor analysis where the synchrony between the measured proximal light-dark exposure pattern and the measured activity-rest pattern is determined (Rea et al. 2010). Phasor analysis provides two outcome measures — phasor magnitude is the degree to which the light-dark and activity-rest patterns are correlated and phasor angle reflects the temporal, or phase relationship, between the two patterns.

Results
Common as well as species-specific light exposure and behavior patterns were observed (Figures 2a-6b).
• All five species were more active between sunrise and sunset.
• All five species demonstrated an anticipatory increase in their pre-sunrise activity that peaked at sunrise with all but V. rubra showing a reduction within an hour.
• All five species reduced activity during mid-day.
• Four of the five species reduced activity after sunset, but P. coquereli began reducing their activity about two hours before sunset.
• Average phasor magnitudes and angles are included in each panel (Figures 2a-6b). Like normal humans working daylight (i.e., not night- or rotating-shift humans), the lemurs were entrained to their diurnal photic niche (phasor magnitudes > 0.3). Unlike normal humans that have positive phasor angles, however, the unrestricted lemurs exhibit negative phasor angles which result from their advanced activity-rest patterns relative to their light-dark exposure patterns. Interestingly, the two L. catta restricted to the indoor environment exhibited positive phasor angles.
• Two animals of one species (L. catta) were restricted to indoor environment while the other two were not (Figure 6b). Phasor magnitudes were nearly identical despite limited exposure to daylight in the restricted animals, but phasor angles were not, suggesting a significant change in circadian phase angle with different absolute light exposure levels.

Conclusion
The Daysimeter-D offers new opportunities for research into the behavior, proximal light exposure patterns, and circadian entrainment of lemurs and for deeper insight into the promotion of health and well-being of these endangered strepsirrhine primates.

References