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Signatures Of Sleep In A Paper Wasp

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Introduction

The study of sleep within invertebrates has received recent attention, most notably within fruit flies (*Drosophila melanogaster*), honey bees (*Apis mellifera*), and crayfish (*Procambarus clarkii*). I assembled a set of behavioral and physiological criteria that have served as "sleep signs" in the literature, and investigated these criteria in social paper wasps (Class Insecta, Order Hymenoptera, Family Vespidae: *Polistes flavus*).

Methods

Three complete colonies of *Polistes flavus* were collected from the Sonoran Desert (Pima Co., AZ, USA), and reared under ambient light and temperature conditions. Members of each colony (mean = six wasps) were individually marked, and observed and tested for sleep signs, including exhibiting a specific posture during (1) extended, (2) recurrent, and (3) reversible bouts of relative immobility (twitching of antennae or tarsi discounted), as well as displaying a (4) decreased body temperature relative to the surrounding temperature, along with (5) increased arousal threshold during these periods, and (6) a homeostatic regulatory mechanism. Videotaping, behavior-recording software, and CO2 metabolic measures (with Allen Gibbs) were implemented to address the first two criteria. Infrared imagery and accompanying software enabled specific behaviors to be correlated with relative body temperatures. Individually housed wasps were perturbed with a sonicator at different times under red light to quantify arousal threshold and reversibility. Sleep deprivation experiments, in which wasps were made to locomote every five minutes for 12 hour periods (day versus night versus control), served as tests for a homeostat.

Results

Polistes flavus paper wasps spent extended periods (criteria 1, 2) from dusk until several hours after sunrise in a relatively motionless state, with bodies usually contacting the substrate, antennae lowered, and with occasional limb-dangling in the direction of gravity. During these states, wasps typically engaged in discontinuous ventilation, versus active-state rapid cycling ventilation, as measured by CO2 expired. The more time wasps remained immobile, the lower were their metabolic rates ($P<.0001$, $n = 12$ wasps). Relative body temperatures were lower (4) when wasps remained immobile than when locomoting or grooming (ca. 2.5 and .9 degrees C differences, respectively). Wasps could be aroused (3, 5) from this state with an increasing vibratory stimulus. When disturbed at five minute intervals during sleep deprivation (6), wasps more quickly returned to an immobile state as the night progressed ($P=.01$, n = four wasps, one colony), although the night's disturbance did not appear to create a greater propensity (n = three colonies) to become quiescent the following day relative to controls and daytime perturbation treatments.

Conclusions

Polistes flavus, by the criteria outlined above, appear to engage in sleep. Additional work to fortify this assertion should include increasing sensitivity of the homeostat measure, testing for habituation during sleep deprivation, and reversing sleep schedules. Paper wasps can have small populations and reside on open, easily manipulated and observed nests, making them candidates for future study within certain social contexts of sleep.