signatures of sleep in the paper wasp *Polistes flavus*

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INTRODUCTION

Sleep may significantly define the behavior, ecology and evolution of animals, both vertebrate and invertebrate. To understand sleep’s potential roles within a community, both an individual and its entire society must be examined.

Paper wasps (Hymenoptera: Vespidae: Polistinae) are cosmopolitan foragers, visual predators, and architects, forming societies atop their paper cities. We experimentally tested colonies of paper wasps, primarily Polistes flavus (Cresson, 1866), for signs of sleep. Observational studies of caged wasps preceded experiments testing circadian metabolic rates, arousal thresholds, behavior-dependent thoracic temperatures, and the existence of a homeostat regulating sleep.

METHODS

Collection and maintenance

Four colonies of *P. flavus* (mean = five adult wasps) were collected from the Skokomish River (Pima County, Arizona, USA) during the summer of 2001. Wasps were individually marked with unibeaded felt-drying pens, and reunited with their mates in transparent cages. All wasps were maintained under ambient light and temperature conditions, accepting red light for nocturnal viewing and moderate heating during the late fall. Wasps were transferred to a temperature and light-controlled laboratory prior to experiments measuring metabolic rates and arousal thresholds.

Statistical analyses

Proportional statistics of continuous variables are reported as ± standard error means. Proportional data are presented in their raw, untransformed states, but were arc sine square root transformed for all statistical analyses.

EXTENDED, RECURRING PERIODS OF IMMOBILITY

Wasp immobility was assessed via behavioral activity by behavioral recording of wasps every ten minutes.

Circadian immobility was analyzed in darkness, between periods of ambient lighting in four colonies for four evenly-distributed three hour periods each day for four days.

INCREASED AROUSAL THRESHOLDS were elicited by a vibratory stimulus, and were determined by individually housed active wasps in a dark environmental control room.

HOMEOSTATIC REGULATION of sleep was tested via sleep deprivation on three colonies across three 50 hour weekends. Wasps were disturbed every five minutes (night, day, or not at all) and were censused every 15 minutes when not being disturbed. In addition, wasp temperature was monitored every 30 minutes throughout a night of disturbance.

DECREASED BODY TEMPERATURES of wasps were measured during the dark periods using an infrared camera with accompanying software. Temperature differences were calculated by subtracting the average temperature surrounding each wasp from its average thoracic temperature.

CONCLUSIONS

Results from the suite of sleep signs support the hypothesis that *Polistes flavus* wasps exhibit a sleep state, opening up prospects for studying social aspects of sleep in paper wasps.

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