WORK SCHEDULES IMPACT SLEEP SCHEDULES in foraging honey bees

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INTRODUCTION

Shift work tests humans' capacity to be flexible when scheduling both work and sleep. Honey bees (*Apis mellifera*) shift their foraging schedules depending on resource availability and are known to exhibit sleep behavior (Kaiser 1988). No study has been conducted to test the plasticity of sleep within individual honey bees, despite the importance of colony-level plasticity in the face of a changing environment.

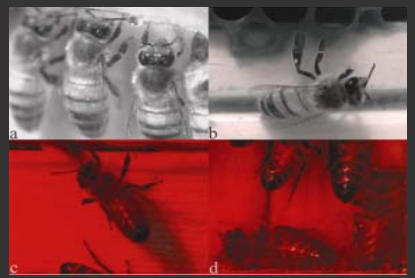
Hypothesis

Sleep schedules of foraging honey bees depend on the timing of resource availability

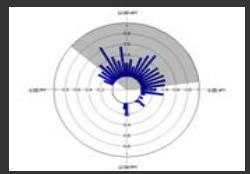
Predictions

Temporal shifts in availability of nectar will correspondingly shift foragers' sleep cycles

Bees trained to forage early in the morning will experience earlier sleep onset or earlier waking than bees trained to forage late in the afternoon



Worker honey bees displaying typical sleep postures, with limbs and body drooping in the direction of gravity. Bees exhibit a sleep-state with immobile antennae while (a) in groups, (b) isolated, (c) dangling motionless from tarsal claws, or (d) leaning against the observation hive wall or floor.



Circadian sleep cycle of foragers (2005; Klein in prep). Proportion of observations during which bees were in a sleep state with no antennal motility (considered deepest sleep state; *n*=10 bees, avg. across 72h). Gray area = time between sunset and sunrise.

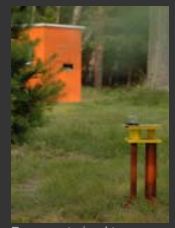
Kaiser, W. 1988. J. Comp. Phys.A. 163:565-584.

METHODS

We brought two colonies of honey bees to a biological station which lacked naturally occurring hives and had very few natural food resources. We trained individually marked bees to forage at a feeder with sugar water for two consecutive mornings (6:45-9 AM) and examined behaviors suggestive of sleep (posture; relative immobility, distinguishing motility states of the antennae) every 30min for 24h starting on the third morning. On days four and five we blocked the hive entrance until 4 PM, shifting the period during which food was made available to bees to the late afternoon (4-7 PM) and reexamined sleep signs exhibited by the same individual bees across a second 24h period. Additionally, foraging attempts were measured by numbers of bees that attempted to exit the hive by 9 AM (in trial 1).

Cranberry Lake Biological Station, Adirondacks State Forest, NY, USA.

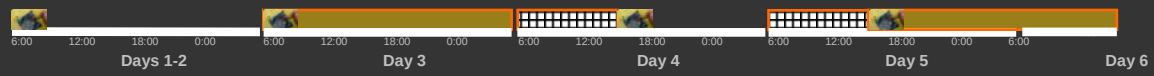
Hut with observation hive of honey bees.



Foragers trained to a scented sucrose solution.

Foragers individually marked dorsally and ventrally with paint.

Bees in observation hive examined under ambient light (day) or red light (night).



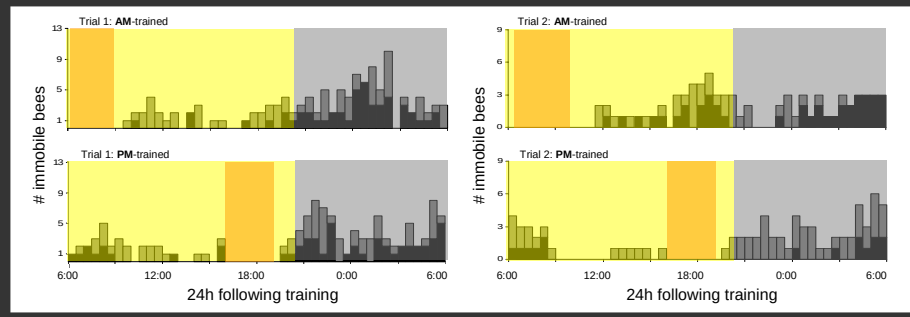
Schedule of training and resource availability. Bees visited early morning food source Day 1-3; behavior observed in hive for 24h on Day 3. Same bees then trained to afternoon food source on Day 4 (blocked from exiting hive until afternoon availability) and observed for 24h on Day 5-6.

RESULTS

Resource availability appears to impact sleep schedules in foraging honey bees

Total time devoted to each behavior does not appear to change; only the timing of behavior is changed

Fewer bees attempted to forage early when trained to a late afternoon resource



Sleep schedules of foragers belonging to two colonies (Trials 1&2) that had been trained to an early morning food source and later to late afternoon food source. Gray background represents period between sunset and sunrise. Orange areas represent resource availability periods. Gray bars = hourly total number of immobile bees; black bars = the portion of each hourly total of bees that exhibited no antennal motion.

Although the numbers of observations of sleep signs exhibited by foragers did not differ between morning and afternoon treatments in either colony (*P*= .83 & .60, matched-pairs analysis), the *timing* of sleep differed within bees. No sleep was observed during periods of resource availability, but bees did sleep at other times of the day (and night, as expected).
Also, more bees attempted to exit the hive by 9am when trained in the morning than in the afternoon (n = 25 versus 15).

CONCLUSION

Shifting temporal availability of food resources shifted the sleep schedules of foraging honey bees, suggesting that plasticity in timing of foraging is matched by plasticity in timing of sleep. A correlation between resource availability and sleeping schedules demonstrates, for the first time, temporal plasticity of sleep in an insect under ecologically relevant conditions.

Sleeping aids

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