The Relationship Between Hibernation Temperature and Immune Competence in Big Brown Bats (*Eptesicus fuscus*)

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Introduction

Bats have evolved a variety of physiological and behavioral mechanisms to survive and thrive in hyper-variable environments. For insectivorous temperate bats, like Big Brown Bats (*Eptesicus fuscus*), the combined challenge of cold temperatures and lack of food is met by autumnal fattening followed by altered thermoregulatory balance and metabolic processes during hibernation. Despite the obvious metabolic benefits of prolonged torpor, hibernating mammals are known to arouse to euthermic temperatures periodically during the winter.

Many hypotheses have been put forth to explain this paradox, but none have clearly revealed why mammals expend stored energy to warm their bodies for relatively short periods of time. One possibility is that these periodic arousals play a significant role in the maintenance of immune competence, as suggested by the work of Prendergast et al. (2002) in ground squirrels and Sulkin & Allen (1974) in both Big Brown Bats and Little Brown Bats *(Myotis lucifugus*). In this study, we tested the hypothesis that bats arouse during hibernation in order to modulate their immune competence, and the immune functions will be altered by the hibernation temperatures.

Methods

- Bats were housed in environmental chambers at 4°C and 8°C, and in a flight cage ~20°C.
- In each condition, bats were assigned to one of the following experimental groups: control, disturbance control, and immune challenged.
- Data loggers (iBBats) attached to each bat recorded body temperature every 30 min for 9 weeks (Fig. 1).

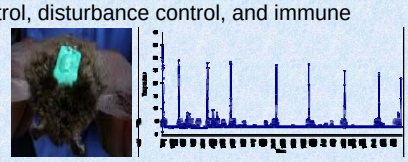

Figure 1. Illustration of iBBAT data logger and example of data obtained for one bat

- The complexity of immune responses was captured by assessing multiple measures of immune function, such as wound healing, bacterial killing activity, and levels of natural antibodies.

Results

- Bats housed at 8°C aroused more frequently, achieved higher body temperatures during arousal bouts, and spent more time over the study period at euthermic temperatures than bats housed at 4°C. (Fig. 2 and 3)

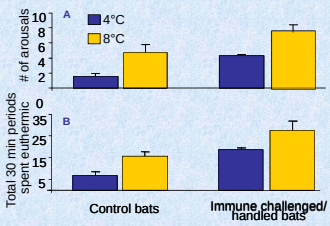

Figure 2. Arousal patterns in hibernating Big Brown Bats. (A) Number of arousals over a 9 week period. (B) Total time spent euthermic over this period, as measured by the number of recordings (taken at 30 min intervals) at euthermic temperatures.

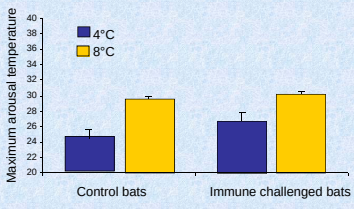

Figure 3. Maximum arousal temperatures (average) exhibited by each group of bats.

Results continued

- Bats housed at 8°C showed greater bactericidal activity (a measurement of constitutive innate immunity) than bats housed at 4°C, suggesting greater immune competence in bats hibernating at the warmer temperature (Fig. 4).

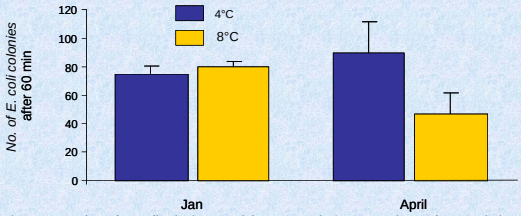

Figure 4. Number of *E. coli* colonies remaining on Tryptic Soy Agar plates after 60 min incubation with bat plasma.

- Bats housed at euthermic temperatures were able to heal wounds in their wing membranes (made with 3 mm biopsy punch) within 3 weeks after creation, whereas bats housed at either hibernation temperature showed **no wound healing** even after three months of wound creation (Fig. 5).

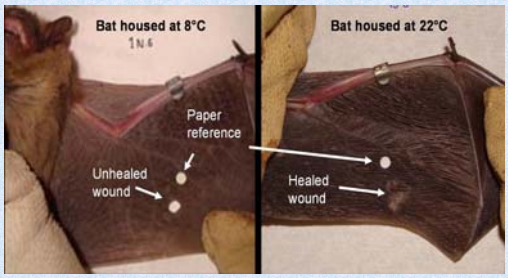

Figure 5. Photo documentation of 3 mm biopsy wounds.

Discussion

Several studies suggest that immune responses in bats are qualitatively and quantitatively different from those of other mammals in that bats exhibit delayed responses to some pathogens (Calisher et al., 2006; Reeder et al., unpublished data; Sulkin & Allen, 1974). Our preliminary results also indicate that immune function is compromised in hibernating bats compared to non-hibernating bats, with bats maintained at higher hibernation temperatures exhibiting higher compliment activity in plasma.

In light of the emergence of “White Nose Syndrome” in bats in the North-eastern USA, in which significant number of bats are dying during the winter, understanding how bat immune systems function is critical. Future studies will examine immune competence in greater detail in both Little Brown Bats and Big Brown Bats.

References

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Acknowledgements

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