USE OF TORPOR IN A HIGH- AND MID-ELEVATION HUMMINGBIRD SPECIES IN SOUTHEASTERN ARIZONA

John L. Andrew[1], Donald R. Powers[1], and Susan M. Wethington[2]

[1]Biology Department, George Fox University, Newberg, OR 97132, USA; [2]The Hummingbird Monitoring Network, Patagonia, AZ 85624, USA.

INTRODUCTION

Studies have shown that hummingbirds enter nocturnal torpor when energy reserves fall below specific "threshold" levels (Hainsworth et al. 1997). Thus any ecological or physiological change that increases a hummingbird's energy costs could push energy reserves past their threshold requiring that torpor be used to balance their energy budget (e.g. Carpenter and Hixon 1988; Hiebert 1993; Powers et al. 2003).

Climate change has occurred in hummingbird habitats and recent studies suggest that these changes pose challenges that will likely increase hummingbird daily energy costs (La Sorte & Thompson 2007; Paresan 2006). Because hummingbirds are sensitive to environmental change and must respond quickly to address their energetic needs they are good candidates to be pioneer indicators to climate change (La Sorte 2009). If climate-induced increases in energy costs frequently push hummingbirds past their energy-storage thresholds then their first response might be increased torpor use (Powers et al. 2003).

To determine if climate change has made energy-budget management more problematic for hummingbirds we studied the frequency of torpor use by free-living broad-billed hummingbirds (*Cynanthus latirostris*; mid elevation) and broad-tailed hummingbirds (*Selasphorus platycercus*; high elevation) from populations within their historical range. No baseline data exists for "normal" torpor use in hummingbirds, but Powers et al. (2003) showed that access to a good quality food source might eliminate the need for torpor altogether. Thus, monitoring the frequency of torpor use might be a good strategy for tracking environmental changes that impact hummingbird energy budgets.

METHODS

Study Sites & Species. We studied two hummingbird species at two sites in southeastern Arizona during June 2012. Broad-tailed hummingbirds (*Selasphorus platycercus*; BTLH; M_b= 3.12-4.16 g; N=7) were captured on Mt. Lemon (high-elevation ~3,000 m) and broad-billed hummingbirds (*Cynanthus latirostris*; BBLH; M_b= 3.42-3.65 g; N=8,) were captured along Harshaw Creek in the Patagonia Mountains (mid-elevation ~1,300 m). Since measurements were made during breeding season, only males were used.

Figure 1. Male broad-tailed (left) and broad-billed (right) hummingbirds.

Experimental Protocol. Birds were captured close to dusk on the day measurements were made to allow for natural energy acquisition and storage (Powers et al. 2003). Just prior to measurement hummingbirds were allowed to feed ad libitum to ensure that all birds had a full crop at the start of their nocturnal fast (Calder & Calder 1990). Nighttime metabolic measurements (oxygen consumption; VO_2) were made using standard open-flow respirometry (Powers et al. 2003) at temperatures ranging from 5°-35° C. VO_2 was measured in real time and birds that exhibited VO_2 below normothermic values were considered to be in torpor. Measurements of VO_2 were made using a Sable Systems FoxBox Oxygen Analyzer. At the end of each trial birds were placed in a cage and allowed to feed ad libitum for ~1 h before being released.

RESULTS

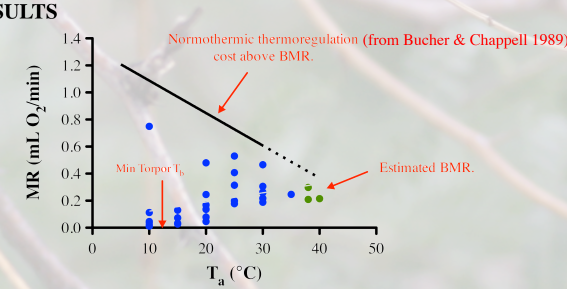

Figure 2. Minimal VO_2 measurements for BTLH.. Green circles indicate BMR. Blue circles indicate birds presumed to be in torpor. All birds entered torpor at 30 °C, ~4 hours into the metabolic trial, possibly indicating exhaustion of crop sugar and energy threshold passage (Powers et al. 2003). If the high torpor rate reflects torpor natural behavior then hummingbirds might be avoiding physiological issues associated with frequent hypothermia (Roth et al. 2010).

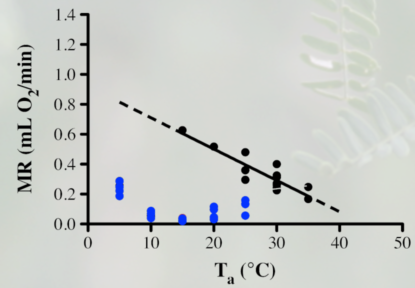

Figure 3. Minimal VO_2 for BBLH. Black circles indicate normothermic measurements, while blue circles are birds presumed to be in torpor. Most birds (50%) entered torpor at 25° C, approximately 3 hours into the metabolic trial. Torpor VO_2 begins to increase between 10 and 15 °C suggesting minimum T_b is in this range (similar to the 12 °C minimum T_b for BTLH; Bucher and Chappell 1989).

CONCLUSIONS

- Metabolic patterns during torpor suggest that minimum torpor T_b in BBLH is between 10 and 15 °C which is similar to that reported for BTLH (Bucher & Chappell 1989).
- Both high- and mid-elevation species regularly entered torpor at T_a below 25 °C. Consistent use of torpor at these relatively mild temperatures suggests that maintaining energy balance is a challenge for these species. Possible impact of climate change?
- Both species used torpor more frequency than expected. This might suggest that frequent use of nocturnal hypothermia by hummingbirds does not result in the physiological consequences seen in some mammals (Roth et al. 2010).

ACKNOWLEDGEMENTS

Funding was provided by NASA (10-BIOCLIM10-0094) and the Richter Scholar Program at George Fox University. We thank Katie Langland for her assistance in the field.