ergy-saving hypothermia reduces flight ability in mourning dove

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Introduction

Overwintering birds are frequently exposed to thermal challenges that can quickly decrease energy reserves, thus leading to an increase in the risk of starvation. During these periods of energetic hardship, many avian species use nocturnal hypothermia to conserve energy that would otherwise be lost remaining warm throughout the night (McKechnie & Lovegrove 2002). However, a cool body temperature (T_b) may limit a bird's ability to monitor the environment and may slow their response to a potential threat. Thus, birds likely trade-off between the benefits of energy-saving hypothermia and the potential costs of reduced behavioral responsiveness to predators (Welton et al. 2002).

Our study organism, the mourning dove (*Zenaida macroura*), is frequently exposed to energetic challenges and high predation during winter (Roth & Lima 2003), making them an ideal species for such a study. Our preliminary work has also demonstrated that doves routinely use nocturnal hypothermia when energetically stressed during food deprivation; doves typically drop their T_b by 2 °C on control nights with food available *ad libitum* with an approximate 4 °C and 7 °C drop in T_b following one and two days of food deprivation, respectively (Carr & Lima, unpublished data). These drops in body temperature can lead to significant energy savings during periods of energetic stress. However, the flight muscles also cool significantly, potentially leading to slower muscle contractions and reduced flight ability.

In this study, we tested the flight ability of hypothermic mourning doves to examine how these energy-saving drops in nighttime T_b influence a bird's ability to escape from a potential threat. The behavior of hypothermic birds has not been examined in detail (but see Laurila & Hohtola 2005) and testing flight ability while hypothermic will provide valuable insights into potential trade-offs between energy-conservation and predation risk. This research will also provide the ground-work for future tests of hypothermia under different levels of perceived risk to further examine potential mechanisms behind these behavioral responses.

Methods: Body temperature monitoring

- All doves were wild caught in Vigo County and housed in environmental control chambers at 5°C and a 10L:14D light cycle.

- Subcutaneous implantation of temperature-sensitive radio-transmitters and the application of weight backpacks were conducted simultaneously using isoflurane anesthesia 48 h after capture.

- Birds were allowed to recover for 5 days with *ad libitum* food and vitamin-supplemented water before the onset of a 2-day food-deprivation period.

- T_b was monitored continuously and remotely using a data-logger to minimize disturbances.

Methods: Hypothermic flight tests

- Flight tests were conducted approx. 3 hours after lights-off when birds were hypothermic on the first or second night of food deprivation.

- Weights (~15% of body mass) were added to backpacks immediately prior to flight to better-detect flight costs associated with hypothermia.

- Flight ability was determined by flight speed, height and distance.

Flight #1: ~2130h ☾ (+) weight, cool T_b
Flight #2: ~2130h ☾ (-) weight, cool T_b
Flight #3: ~2200h ☾ (+) weight, warm T_b

Results: Body temperature monitoring

- Doves dropped their nighttime T_b progressively lower throughout the food deprivation period (**Figure 1**).

- Birds had no apparent difficulty maintaining normothermic daytime T_b, supporting the energy-conserving nature of nighttime hypothermia (**Figure 1**).

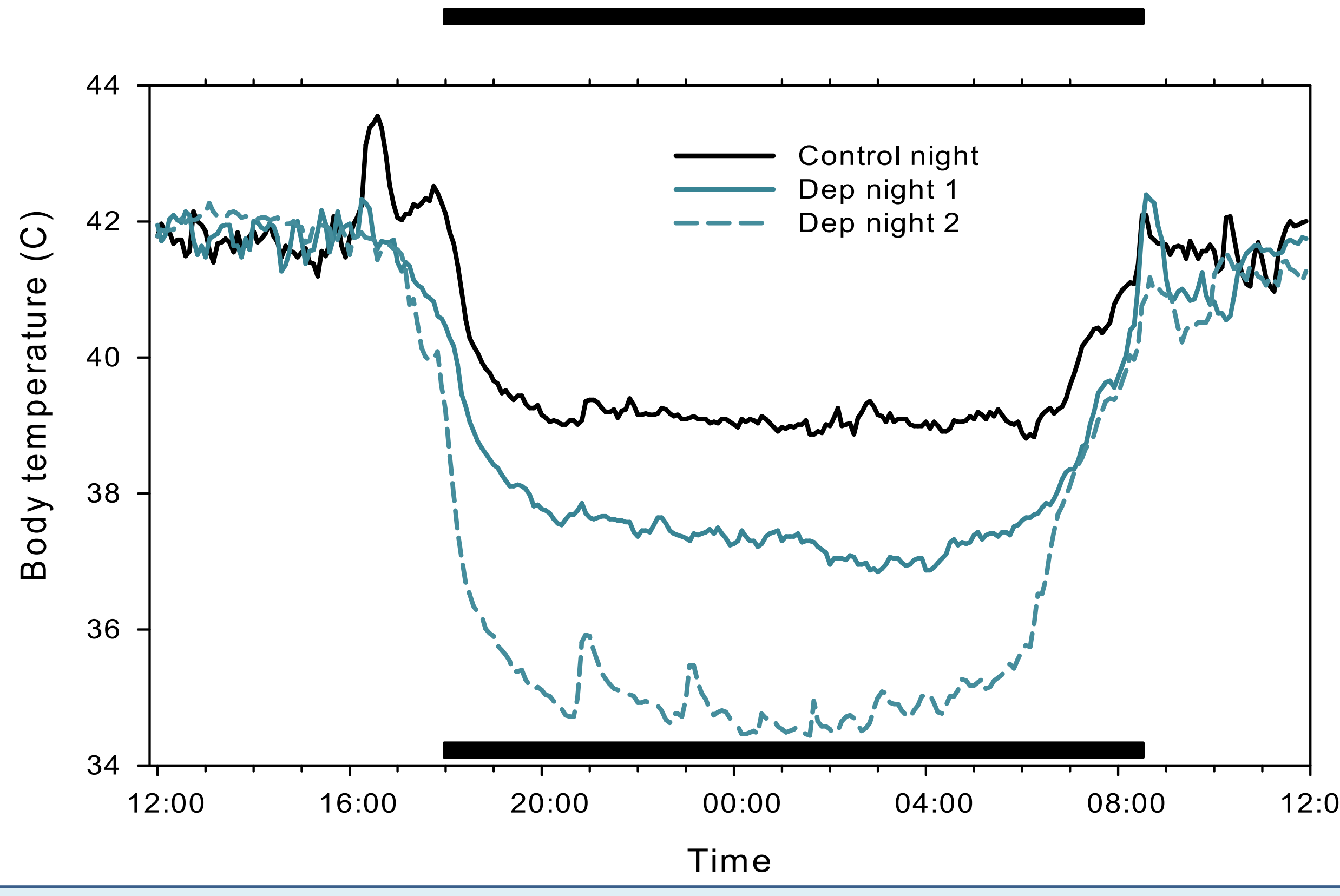

Figure 1. Body temperature profile for an individual mourning dove during a 2-day food deprivation period. Black bars indicate periods of darkness.

Results: Hypothermic flight tests

- Hypothermia resulted in a reduction in overall flight ability (**Table 1**).

- Birds exhibited the **worst** flight ability during **Flight #1** (cool T_b with weight addition). The **best** flight ability was recorded during **Flight #3** (warm T_b with weight addition). See **Table 1**, **Figure 2.**

Table 1. Average flight performance of four doves during hypothermic flight tests. One dove (MODO #8) was tested on both the first and second deprivation nights.

	Speed (m/s)	Height (m)	Distance (m)
Flight #1	0.73	0.36	2.71
Flight #2	1.84	1.02	6.54
Flight #3	2.57	1.41	6.54

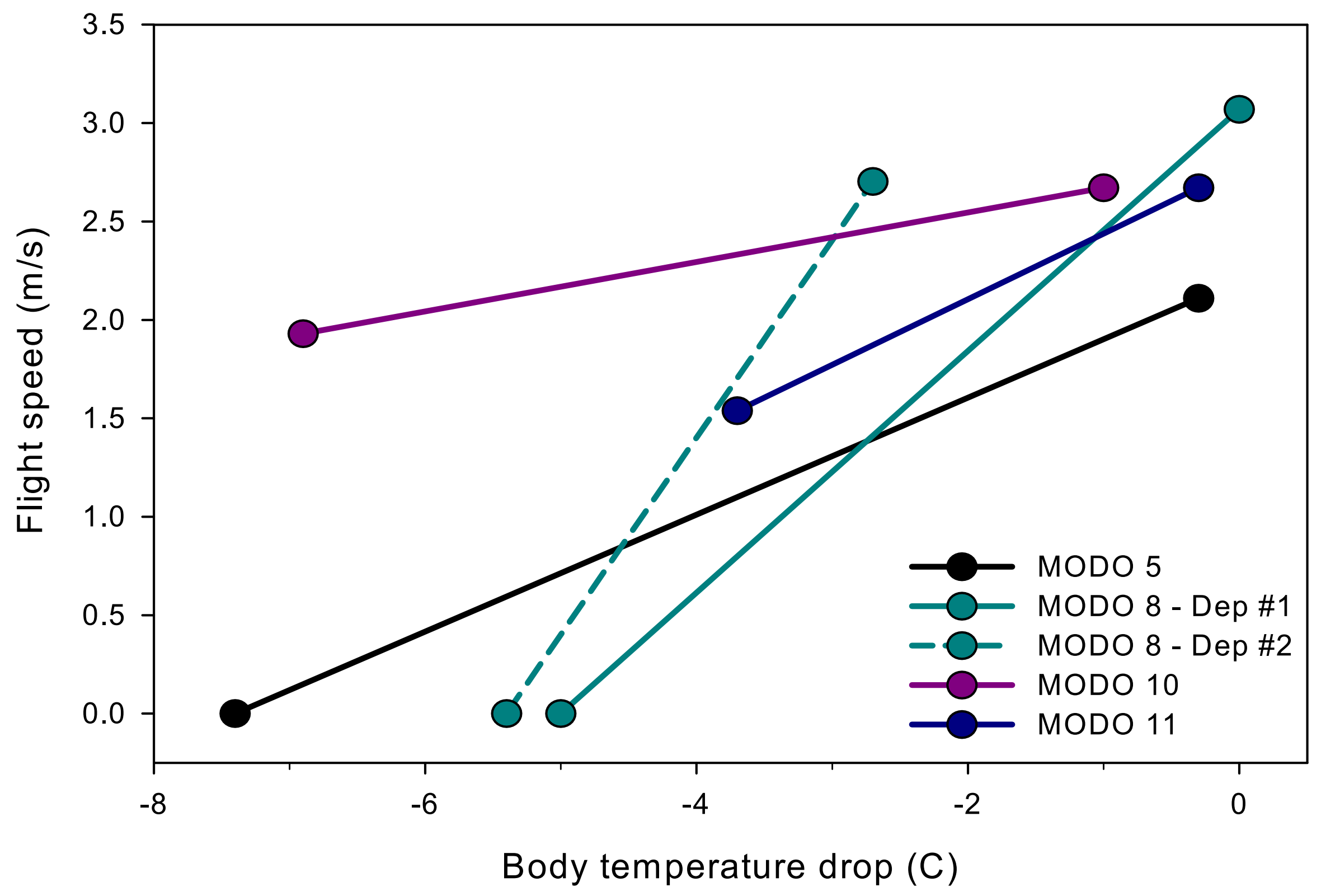

Figure 2. Flight speed of 4 mourning doves during flights #1 and #3 (cool T_b and warm T_b with weight addition, respectively). Body temperature drop indicated the deviation from average daytime T_b for each bird.

Discussion

- Mourning dove reductions in T_b closely resemble those observed in our pilot work, demonstrating the appropriateness and **repeatability of deprivation-induced hypothermia**.

- We observed an overall **reduction in flight ability associated with hypothermia**. This reduction in flight performance **will likely lead to an increase in predation risk**, thus supporting a potential trade-off between energy-conservation and predation risk.

- The strongest flight performance occurred during Flight #3 when birds were carrying additional weight, but had near-normothermic body temperatures. This indicates that **poor flight ability is likely due to hypothermic T_b and not weight addition or poor condition associated with food deprivation.**

- This research will be continued next winter to obtain the necessary sample size for data analysis.

Future work

- **A direct test of the hypothermia-predation trade-off** will provide insight into how perceived levels of environmental risk effect the depth and use of avian hypothermia.

- **Determining the underlying mechanism** behind hypothermia induction, which may be dictated by circadian rhythm or simply determined by periods of light and darkness, will clarify key factors in regulating the onset and arousal from hypothermia.

- **Comparative analyses of the hypothermia-predation trade-off** in taxonomically widespread avian species will compare thermoregulatory responses to predation across a wide range of habitats, diets and depth of hypothermic responses.

References

Laurila, M. & Hohtola, E. 2005: The effect of ambient temperature and simulated predation risk on fasting –induced nocturnal hypothermia of pigeons in outdoor conditions. J Therm Biol. **30**, 392-399.

McKechnie, A. E. & Lovegrove, B. G. 2002: Avian facultative hypothermic responses: a review. Condor **104**,705-724.

Roth, T. C. & Lima, S. L. 2003: Hunting behavior and diet of Cooper's hawks: an urban view of the small-bird-in-winter paradigm. Condor **105**, 474-483.

Welton, N. J., Houston, A. I., Ekman, J. & McNamara, J. M. 2002: A dynamic model of hypothermia as an adaptive response by small birds to winter conditions. Acta Biotheor. **50**, 39-56.

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