Small Mammal Ecophysiology and Climate Change in Sarawak

Since 2014 researchers at IBEC have been using physiological ecology to help predict how Sarawak's small mammals will respond to climate change. Using equipment that measures metabolism and body temperatures in the lab and the field, students and researchers compile data on the energy use of small mammals under various climate scenarios.

Understanding how temperature and energy interact in tropical small mammals allows us to not only predict how they are likely to do with climate change but also answer important questions about the evolution of tropical mammals.

We are always looking for new students (FYP, MSc), for more information contact Ms. Cindy Peter (pcindy@unimas.my), Prof. Andrew Alek Tuen (aatuen@unimas.my) or Dr. Danielle Levesque (danielle.l.levesque@maine.edu) or visit https://umaine.edu/levesquelab/.

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ORIGINAL PAPER

Staying hot to fight the heat-high body temperatures accompany a diurnal endothermic lifestyle in the tropics

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Abstract
Much of our knowledge of the thermoregulation of endotherms has been obtained from species inhabiting cold and temperate climates, our knowledge of the thermoregulatory physiology of tropical endotherms is scarce. We studied the thermoregulatory physiology of a small, tropical mammal, the large treeshrew (*Tupaia tana*, Order Scandentia) by recording the body temperatures of free-ranging individuals, and by measuring the resting metabolic rates of wild individuals held temporarily in captivity. The amplitude of daily body temperature (~ 4 °C) was higher in treeshrews than in many homeothermic eutherian mammals; a consequence of high active-phase body temperatures (~ 40 °C), and relatively low rest-phase body temperatures (~ 36 °C). We hypothesized that high body temperatures enable *T. tana* to maintain a suitable gradient between ambient and body temperature to allow for passive heat dissipation, important in high-humidity environments where opportunities for evaporative cooling are rare. Whether this thermoregulatory phenotype is unique to Scandentians, or whether other warm-climate diurnal small mammals share similar thermoregulatory characteristics, is currently unknown.

Keywords Body temperature · Endothermy · Heterothermy · Scandentia · Thermoregulation · Tropics

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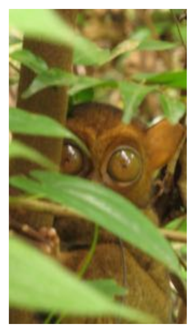

Searching for the Haplorrhine Heterotherm: Field and Laboratory Data of Free-Ranging Tarsiers

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The observation of heterothermy in a single suborder (Strepsirrhini) only within the primates is puzzling. Given that the placental-mammal ancestor was likely a heterotherm, we explored the potential for heterothermy in a primate closely related to the Strepsirrhini. Based upon phylogeny, body size and habitat stability since the Late Eocene, we selected western tarsiers (*Cephalopachus bancanus*) from the island of Borneo. Being the sister clade to Strepsirrhini and basal in Haplorrhini (monkeys and apes), we hypothesized that *C. bancanus* might have retained the heterothermic capacity observed in several small strepsirrhines. We measured resting metabolic rate, subcutaneous temperature, evaporative water loss and the percentage of heat dissipated through evaporation, at ambient temperatures between 22 and 35°C in fresh-caught wild animals (126.1 ± 2.4 g). We also measured core body temperatures in free-ranging animals. The thermoneutral zone was 25–30°C and the basal metabolic rate was 3.52 ± 0.06 W.kg^{-1} (0.65 ± 0.01 ml O_2.g^{-1}.h^{-1}). There was no evidence of adaptive heterothermy in either the laboratory data or the free-ranging data. Instead, animals appeared to be cold sensitive (T_b ~ 31°C) at the lowest temperatures. We discuss possible reasons for the apparent lack of heterothermy in tarsiers, and identify putative heterotherms within Platyrrhini. We also document our concern for the vulnerability of *C. bancanus* to future temperature increases associated with global warming.

Keywords: metabolism, primate thermoregulation, tropics, evolution, tarsiers

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Using thermoregulatory profiles to assess climate change vulnerability in an arboreal tropical bat: heterothermy may be a pre-adaptive advantage

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ABSTRACT: Many tropical endotherms are already confronted by ambient temperatures (T_a) close to their body temperature (T_b) and risk severe hyperthermia due to global warming. Tropical fruit bats play a vital role in the ecosystem and their absence could have dire consequences for ecosystem health. Many fruit bats have exposed roosting habits that increase their vulnerability to heat stress. We investigated the thermoregulatory capacity of wild caught lesser dog-faced fruit bats *Cynopterus brachyotis* from the Island of Borneo; a heterothermic 32 g foliage-roosting generalist bat. We determined the effect of T_a (21–36°C) on metabolism, T_b and evaporative cooling. We also measured the T_a and relative humidity (RH) at capture sites. The bats displayed a seemingly narrow thermoneutral zone of 30 ± 1°C, a basal metabolic rate of 5.60 ± 0.26 W kg^{-1} (1.01 ± 0.05 ml O_2 g^{-1} h^{-1}) and a normothermic T_b of 32.5 ± 0.3°C; all much lower than expected. Evaporative cooling was only effective at $T_a \leq 31$°C, above which heat storage became apparent. Bats typically entered torpor at $T_a < 25$°C and thermoconformed (i.e. allowed their T_b to fluctuate with T_a) at $T_a > 32$°C. The microclimate at capture sites remained cool (T_a = 24–25°C) and humid (RH > 90%). Our study supports the argument that tropical endotherms are susceptible to hyperthermia due to their low T_b. Further, we discuss the potential advantage of heterothermy in coping with short-term heatwaves. However, the future of these bats, and likely other low T_b species, depends primarily on their thermally buffered habitats, and decisive conservation action is required to protect thermal refugia.

KEY WORDS: Hyperthermia · Body temperature · Torpor · Global warming · Tropics · Fruit bats

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