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ORIGINAL PAPER

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

Danielle L. Levesque[1,2] · Andrew Alek Tuen[2] · Barry G. Lovegrove[3]

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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

Abbreviations

BMR	Basal metabolic rate
C_{dry}	Dry thermal conductance ($mO_2 \cdot °C^{-1} \cdot h^{-1}$)
C_{wet}	Wet thermal conductance ($mO_2 \cdot °C^{-1} \cdot h^{-1}$)
EHL	Evaporative heat loss (W)
EWL	Evaporative water loss ($mg \cdot g^{-1} \cdot h^{-1}$)
HI	Heterothermy index
MHP	Metabolic heat production (W)
RMR	Resting metabolic rate
T_a	Ambient temperature (respirometer temperature or environmental temperature)
T_b	Core body temperature
T_{lc}	Lower limit of the TNZ
T_{sub}	Subcutaneous temperature
TNZ	Thermoneutral zone
O_2	Volumetric rate of oxygen consumed by the animal ($mO_2 \cdot h^{-1}$)

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✉ Danielle L. Levesque
danielle.l.levesque@maine.edu

[1] Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

[2] School of Biology and Ecology, University of Maine, Orono, ME 04469, USA

[3] School of Life Sciences, University of KwaZulu-Natal, P/Bag X01, Scottsville 3209, South Africa

Introduction

Endotherms use physiological and biochemical processes to maintain body temperatures (T_b) at elevated, and relatively constant levels (Bartholomew 1972). By providing the means to maintain high levels of performance over a wider range of environmental temperatures, the evolution of endothermy allowed mammals and birds to radiate into environments that had previously posed challenges for temperature-dependent ectothermic species (Crompton et al. 1978; Bennett and Ruben 1979; Lovegrove 2017). However, the capacity to generate heat does not mean that vertebrate endotherms operate entirely independent from environmental temperatures (Heinrich 1977; Angilletta Jr et al. 2010). At rest, most endotherms are capable of

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