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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 ($T_b \sim 31$°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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## INTRODUCTION

The capacity to become heterothermic conveys significant fitness benefits and promotes survivability (Geiser and Turbill, 2009; Geiser and Brigham, 2012; Lovegrove et al., 2014b; Nowack et al., 2015, 2016; Stawski et al., 2015; Lovegrove, 2017). These benefits may be derived either as a direct consequence of the reduction in energy expenditure and, in the case of hibernators specifically, the preservation of fat reserves during low resource availability (Lovegrove, 2000; Dausmann, 2014), or, indirectly by reducing the risk of predation due to decreased foraging effort (Bieber and Ruf, 2009; Stawski and Geiser, 2010; Bieber et al., 2014) as well as aiding in reproduction by manipulating foetal growth rate or by enhancing sperm storage (reviewed in Geiser and Brigham, 2012). However, whereas the benefits of heterothermy may be well documented, its origin remains hotly debated (Crompton et al., 1978; McNab, 1978; Bennett and Ruben, 1979; Hayes and Garland, 1995; Farmer, 2000; Koteja, 2000; Grigg et al., 2004; Kemp, 2006; Clarke and Pörtner, 2010; Lovegrove, 2012a,b, 2017).