

## **Challenging ecogeographical rules: Phenotypic variation in the Mountain Treeshrew (*Tupaia montana*) along tropical elevational gradients**

### **ABSTRACT**

Bergmann's and Allen's rules were defined to describe macroecological patterns across latitudinal gradients. Bergmann observed a positive association between body size and latitude for endothermic species while Allen described shorter appendages as latitude increases. Almost two centuries later, there is still ongoing discussion about these patterns. Temperature, the common variable in these two rules, varies predictably across both latitude and elevation. Although these rules have been assessed extensively in mammals across latitude, particularly in regions with strong seasonality, studies on tropical montane mammals are scarce. We here test for these patterns and assess the variation of several other locomotory, diet-associated, body condition, and thermoregulatory traits across elevation in the Mountain Treeshrew (*Tupaia montana*) on tropical mountains in Borneo. Based on morphological measurements from both the field and scientific collections, we found a complex pattern: Bergmann's rule was not supported in our tropical mountain system, since skull length, body size, and weight decreased from the lowest elevations (<1000 m) to middle elevations (2000–2500 m), and then increased from middle elevations to highest elevations. Allen's rule was supported for relative tail length, which decreased with elevation, but not for ear and hindfoot length, with the former remaining constant and the latter increasing with elevation. This evidence together with changes in presumed diet-related traits (rostrum length, zygomatic breadth and upper tooth row length) along elevation suggest that selective pressures other than temperature, are playing a more important role shaping the morphological variation across the distribution of the Mountain Tree shrew. Diet, food acquisition, predation pressure, and/or intra- and inter-specific competition, are some of the potential factors driving the phenotypic variation of this study system. The lack of variation in body condition might suggest local adaptation of this species across its elevational range, perhaps due to generalist foraging strategies. Finally, a highly significant temporal effect was detected in several traits but not in others, representing the first phenotypic variation temporal trends described on tree shrews.