



## ECOGEOGRAPHIC PATTERNS OF MORPHOLOGICAL VARIATION IN ELEPAIOS (*CHASIEMPIS* SPP.): BERGMANN'S, ALLEN'S, AND GLOGER'S RULES IN A MICROCOSM

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**ABSTRACT.**—Animals often exhibit predictable geographic variation in morphology, and such ecogeographic patterns reflect local adaptation to varying environmental conditions. The most common of these patterns are termed Bergmann's, Allen's, and Gloger's rules. I studied morphological variation in the Hawaii Elepaio (*Chasiempis sandwichensis*) and the Oahu Elepaio (*C. ibidis*), forest birds endemic to the Hawaiian Islands. I measured body size and plumage color of 223 live elepaios captured at 36 sites on Hawaii and 132 live elepaios captured at 23 sites on Oahu, and I examined 132 museum specimens from an additional 22 locations on Hawaii. I used multiple regressions to examine relationships of elepaio body size and plumage color to elevation and annual rainfall on each island. Size of Hawaii Elepaios varied among sites and was related to elevation and rainfall. Wing chord, tail length, and body mass had positive relationships with elevation, as predicted by Bergmann's rule. Proportional bill length and proportional tarsus length were inversely related to elevation, as predicted by Allen's rule. In Hawaii Elepaios, 17 of 20 plumage color variables were related to rainfall. Elepaios in wetter areas were more heavily pigmented and had fewer and smaller white markings, as predicted by Gloger's rule. Plumage color of Oahu Elepaios showed similar but weaker patterns and only two of 20 plumage characters were related to rainfall. All body-size and plumage-color measurements had smoothly clinal distributions, with no large gaps with respect to elevation or rainfall. Putative subspecies of the Hawaii Elepaio differed in mean value of several plumage characters, but there was overlap in plumage color among subspecies and variation within them, and none of the three subspecies was diagnosable from both other subspecies by any plumage character using the 75% rule. Elepaios differed morphologically among sites only a few kilometers apart because of their sedentary behavior and the steep gradients in temperature and elevation and limited climatic variation of the tropical environment of the Hawaiian Islands. Morphological variation in elepaios is smoothly clinal because there are few dispersal barriers and elepaios inhabit areas with a range of climates and vegetation. Although my results did not support the designation of subspecies within the Hawaii Elepaio, morphological and underlying genetic variation is important, and conservation of elepaios with varying phenotypes would preserve evolutionary potential and ability to adapt to climate change. *Received 28 July 2010, accepted 28 July 2011.*

**Key words:** *Chasiempis*, ecogeographic variation, elepaio, environmental gradients, local adaptation, morphological variation, subspecies diagnosis.

### **Patrones Ecogeográficos de Variación Morfológica en *Chasiempis* spp.: Las Reglas de Bergmann, Allen y Gloger en un Microcosmos**

**RESUMEN.**—Frecuentemente los animales presentan un patrón de variación geográfica en la morfología que es predecible, reflejando la adaptación local a las diversas condiciones ambientales. De estos patrones, los más comunes son las reglas de Bergmann, de Allen y de Gloger.

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