



Developmental conditions promote individual differentiation of endocrine axes and behavior in a tropical pinniped

Eugene J. DeRango¹ · Jonas F. L. Schwarz¹ · Friederike Zenth² · Paolo Piedrahita³ · Diego Páez-Rosas^{4,5} · Daniel E. Crocker⁶ · Oliver Krüger¹

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Abstract

Between-individual variation in behavior can emerge through complex interactions between state-related mechanisms, which include internal physiological constraints or feedback derived from the external environment. State-related conditions can be especially influential during early life, when parental effort and exposure to social stress may canalize consistent differences in offspring hormonal profiles and foster specific behavioral strategies. Here, we unravel how relevant state variables, including sex, somatic condition, local population density, and maternal traits, contribute to within-cohort differences in stress, sex, and thyroid hormone axes in dependent Galapagos sea lions with the primary goal of understanding downstream effects on boldness, docility, habitat use, and activity. Pups within denser natal sites had higher levels of cortisol and thyroid T4, a prohormone and proxy for metabolic reserves, likely as an adaptive physiological response after exposure to increased numbers of conspecific interactions. Furthermore, considering maternal effects, mothers in better body condition produced pups with higher testosterone yet downregulated basal cortisol and thyroid T4. This hormonal profile was correlated with increased boldness toward novel objects and attenuated stress responsiveness during capture. Intriguingly, pups with increased thyroid T3, the biologically active form, maintained faster somatic growth and were observed to have increased activity and extensively explored surrounding habitats. Collectively, these findings provide comprehensive evidence for several links to hormone-mediated behavioral strategies, highlighted by variation in socio-environmental and maternally derived input during a foundational life stage.

Keywords Galapagos sea lion · Hormones · Maternal effects · Metabolism · Personality

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✉ Eugene J. DeRango
eugene_joseph.derango@uni-bielefeld.de

- ¹ Department of Animal Behaviour, Bielefeld University, Morgenbreede 45, 33615 Bielefeld, Germany
- ² University of Freiburg, Freiburg, Germany
- ³ Facultad de Ciencias de la Vida, Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador
- ⁴ Galápagos Science Center, Universidad San Francisco de Quito, Isla San Cristóbal, Galápagos, Ecuador
- ⁵ Dirección Parque Nacional Galápagos, San Cristóbal, Isla San Cristóbal, Galápagos, Ecuador
- ⁶ Department of Biology, Sonoma State University, Rohnert Park, CA, USA

Introduction

The concept that many aspects of behavior are highly variable across individuals within most species is now deeply rooted into modern ecological studies (Wolf et al. 2007). Although behavior can acutely change in response to environmental stimuli, individuals often exhibit consistent differences in average behavioral phenotypes over time or within and across contexts (deemed animal ‘personalities’) (Sih et al. 2004). Traits such as boldness (i.e., risk-taking), exploration, or sociability seem functionally distinct but are often linked through correlations known as behavioral syndromes (Réale et al. 2007). The structure of these traits may underlie how animals occupy specific niches within their habitat (Dingemanse and Wolf 2010; Wolf and Weissing 2010). For example, bold animals may utilize more risk-intense environments, which in turn could result in receiving higher rates of agonistic interactions or even predation. Although