

## Dynamic colour change in the lizards *Pelturagonia nigrilabris* and *P. spiniceps* from Borneo

Hayden R. Davis<sup>1,\*</sup>, Kyra S. Woytek<sup>1</sup>, Izneil Nashriq<sup>2</sup>, Aaron M. Bauer<sup>3</sup>, and Indraneil Das<sup>2</sup>

Colour change in reptiles occurs under many circumstances, including gradually over the lifetime of an individual, seasonally, diurnally, or even instantaneously in response to stimuli (Gans and Crews, 1992; Johnston, 1994; Carpenter, 1995; Greenberg, 2003; Stuart-Fox and Moussalli, 2009; Zug et al., 2009; Krohn and Rosenblum, 2016; Harvey et al. 2017, 2021; Beltrán, 2019). Depending on the taxonomic group, these changes can be triggered by various factors both internal, such as an individual's nutrient or hormone levels (Calisi and Hews, 2007), and external, such as temperature (Langkilde and Boronow, 2012; Krohn and Rosenblum, 2016) or light intensity (Tao et al., 2018). While the mechanisms vary by taxa, colour change serves a variety of functions including substrate matching (Norris and Lowe, 1964), sexual selection (LeBas and Marshall, 2000; Stuart-Fox and Ord, 2004; Chen et al., 2012; Quah et al., 2012), anti-predation (Jayasekara and Dharmarathne, 2018), social signalling (Vinegar, 1972; Stuart-Fox and Moussalli, 2008; Ligon, 2014; Batabyal and Thaker, 2017; Harvey et al., 2021), and crypsis (Stuart-Fox et al., 2004), among others. Despite numerous thoroughly studied examples, the phenomena of colour change remain poorly understood for many taxonomic groups.

The Old World lizard family Agamidae is both a genetically and morphologically diverse radiation that includes the subfamily Draconinae, a group endemic to South and Southeast Asia. This subfamily includes *Draco*, the only extant lizard group with well-developed

patagia for gliding (Colbert, 1967), and groups such as *Acanthosaura* and *Calotes*, which often have large dorsal spines and highly variable and bright colouration (Manthey, 2010; Pal et al., 2018). However, other members of Draconinae, such as *Pelturagonia*, display much more conservative morphological features with inconspicuous colouration.

Until recently, species of *Pelturagonia* on the Southeast Asian island of Borneo were assigned to *Phoxophrys*, but a study based on morphological and molecular data resulted in a revised taxonomy (Harvey et al., 2019). This updated taxonomy recognized *Pelturagonia* as endemic to Borneo and its nearby islands, with little known about the natural history of its constituent species. Although Harvey et al. (2019) provided a thorough morphological examination of the genus, most of the specimens examined were from museum collections. As such, notes on colouration for many of the species were based on prior records or preserved specimens. While the genus is known for being cryptically coloured, intraspecific colouration can vary considerably within a species (Das, 2004).

One species of the genus, *Pelturagonia nigrilabris* (Peters, 1864), is a small- to medium-sized lizard (maximum SVL 84 mm) restricted to forests in the lowlands and foothills of Borneo (Harvey et al., 2019). Similar to other species in the genus, *P. nigrilabris* is characterized by cryptic colouration, typically greenish brown. Although the original species description was limited and without colouration data (Peters, 1864), Boulenger (1885) examined the type specimen and indicated that it was light brown with blackish bands on each side, some whitish enlarged scales, and brown labial areas. Additional colouration information was added by de Rooij (1915), who noted that the tail was banded. However, the geographic range reported by de Rooij for *P. nigrilabris* overlapped with the subsequently described *P. borneensis* (Inger, 1960), indicating that some of her colouration notes may have been taken from *P. borneensis* specimens. A more recent species account reported that *P. nigrilabris* was predominantly brownish with occasional marbling and light-coloured vertebral bands, or green

<sup>1</sup> Department of Biology and Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington 98195, USA.

<sup>2</sup> Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.

<sup>3</sup> Department of Biology and Center for Biodiversity and Ecosystem Stewardship, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085, USA.

\* Corresponding author. E-mail address: hrdavis1@uw.edu