REPTILES & AMPHIBIANS

Death-Feigning in Two Species of *Bothrops* Wagler 1824 (Squamata: Viperidae) in the *Bothrops atrox* Clade

Lucas Aosf[1], Bryan da Cunha Martins[2], and Rafael Scherrer Mathielo[3]

[1]Instituto de Manejo da Biodiversidade (IMBio), Rua Álvares Cabral, 247 - Campo Do Galvão, 12505-070, Guaratinguetá, São Paulo, Brasil (lucasaosf@gmail.com)
[2]Universidade Federal do Amazonas, Av. Rodrigo Octavio, Manaus, Amazonas, 69067-005, Brasil
[3]Universidade Federal do Espírito Santo, Rod. Gov. Mário Covas, BR-101 - Km 60, Litorâneo, São Mateus, Espírito Santo, 29932-540, Brasil

Snakes display a wide range of defensive or anti-predator behaviors that include erratic movements, tail vibration (which involves rattles in some species), hissing or expulsion of air, dorsoventral flattening, defensive strikes, and simulation of death (e.g., Greene 1988; Sazima and Abe 1991). Death-feigning is an antipredator mechanism in which animals assume a relatively immobile, often inverted posture for periods that can vary from seconds to hours (Humphreys and Ruxton 2018). The efficacy of this mechanism appears to be related to the tendency of some predators to attack moving prey (e.g., Edmunds 1974; Gregory et al. 2007), diverting the predator's interest, or directing the attack toward other nearby and/or moving prey (e.g., Segovia 2018). Most records of this behavior involve nonvenomous snakes, which account for over 15% of all records of death-feigning (Fuentes et al. 2021). Until now, however, this behavior has been documented in only two species of Lanceheads (*Bothrops* spp.): *B. jararacussu* and *B. erythromelas* (dos Santos and da Silva Muniz 2012; Muscat and Entiauspe-Neto 2016). We herein report two new records of death-feigning in *Bothrops leucurus* and *B. moojeni*.

The White-tailed Lancehead (*Bothrops leucurus*), which occurs in coastal areas from the state of Espírito Santo to Paraíba (Nogueira et al. 2019; Costa et al. 2021), is a terrestrial species with a varied diet that includes amphibians, reptiles (including snakes), birds, and mammals (Fagundes et al. 2009; Baptista et al. 2016; Castro and Oliveira 2017; Dubeux et al. 2019). Despite its abundance, limited information addresses ecology and behavior apart from sparse records on diet and one study of reproductive biology (Barros et al. 2014). Because of its phylogenetic proximity to the Common Lancehead (*Bothrops atrox*), the behavior of the two species is thought to be similar (Carrasco et al. 2023).

The Brazilian Lancehead (*Bothrops moojeni*) is widely distributed throughout the morphoclimatic domain of the Cerrado (Leloup 1984; Campbell and Lamar 1989; Borges and Araújo 1998), but also occurs in the Pantanal and ecotones between the Cerrado and Atlantic Forest (Nogueira et al. 2019). Systematic research indicates that *B. moojeni* populations in the southeastern and central Brazilian Cerrado constitute a monophyletic group within the *atrox* species group



Figure 1. A young White-tailed Lancehead (*Bothrops leucurus*) death-feigning in an ecotone between Cerrado and Caatinga in the Municipality of Jacinto, Minas Gerais, Brazil. Photograph by Lucas Aosf.



Figure 2. An adult Brazilian Lancehead (*Bothrops moojeni*) death-feigning in the Municipality of Pirapora, Minas Gerais, Brazil. Photograph by Daniel Rubens Silvares de Matos.

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(Carrasco et al. 2023). However, little is known about the ecology and behavior of this species and closely related congeners (Martins and Gordo 1993; Martins et al. 2002; Sazima 1992; Valdujo et al. 2002).

We recorded death-feigning in *B. leucurus* on 16 July 2021 in the Municipality of Jacinto, State of Minas Gerais, southeastern Brazil (-16.15831, -40.24869; elev. 160 m asl). The event, which lasted four minutes (0934–0938 h), occurred when a young individual that was found and handled adopted the death-feigning posture upon touching the ground after an attempted escape (Fig. 1). We observed death-feigning in *B. moojeni* at 1550 h on 30 November 2022 in the Municipality of Pirapora, State of Minas Gerais, southeastern Brazil (-17.33769, -44.94675; elev. 483 m asl) when an adult, initially located in a 1.8-m tall bush, feigned death after handling (Fig. 2). Upon assuming the death-feigning position, this individual exhibited distress by simultaneously moving erratically and gaping. Video recordings of both snakes have been deposited in the Jacques Vielliard Neotropical Fonoteca (FNJV), Audiovisual Collections Museum of Biological Diversity (MDBio), Institute of Biology (IB), UNICAMP (ZUEC-VID1324–6) and also are available on the Zenodo platform (Aosf et al. 2024).

We herein have added two more species of viperids to the list of snakes known to engage in death-feigning. Although the idea that venomous snakes resort to this behavior might seem unnecessary, envenomation of a predator might not act immediately, taking longer than necessary to cause pain or some type of functional impairment, so that envenomation alone would be an inadequate defense against potential predators (Ward-Smith et al. 2020). Furthermore, resistance of some predators, such as opossums (*Didelphis* spp.), to snake venom (Oliveira and Santori 1999), could render envenomation of little use. Therefore, even venomous species might have to resort to alternative defensive behaviors that could include fleeing and feigning death (e.g., Glaudas et al. 2005).

Although records of death-feigning in snakes are relatively scarce compared to other reptilian taxa, some examples illustrate its widespread ecological and evolutionary importance. In North American species, such as *Heterodon nasicus* and *Thamnophis elegans*, and Eurasian species, such as *Natrix tessellata*, the propensity of this behavior appears to be influenced by factors that include predation pressure, body size, temperature, and handling intensity (Gregory and Gregory 2006; Gerald 2008; Durso and Mullin 2014; Golubović et al. 2021). Similarly, Fuentes et al. (2021) described this behavior in Panamanian snakes, including *Leptodeira annulata* and *Dipsas catesbyi*, demonstrating that it occurs in arboreal and nocturnal taxa. Together with our new records in *Bothrops*, these examples highlight that thanatosis is widespread among snakes, although its frequency and ecological correlates remain poorly understood.

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