

EFFICIENCY OF DEATH FEIGNING: ANTIPREDATOR MECHANISMS IN *PRISTIMANTIS RAMAGII* (ANURA: STRABOMANTIDAE) DURING A PREDATION ATTEMPT BY *CHIRONIUS FLAVOLINEATUS* (SERPENTES: COLUBRIDAE)

EFICIÊNCIA DA TANATOSE: MECANISMO ANTIPREDATÓRIO EM *PRISTIMANTIS RAMAGII* (ANURA: STRABOMANTIDAE) DURANTE UMA TENTATIVA DE PREDÇÃO POR *CHIRONIUS FLAVOLINEATUS* (SERPENTES: COLUBRIDAE)

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Resumo.— Este estudo documenta o comportamento de tanatose do sapinho-de-folhigo-da-Paraíba (*Pristimantis ramagii*) em condições *ex-situ*, quando confrontado com uma tentativa de predação pela cobra-cipó não venenosa (*Chironius flavolineatus*). Apesar de predado pela serpente, o mecanismo antipredação do anuro foi eficiente para evitar a predação enquanto realizado. Nossas descobertas comprovam a ocorrência desse comportamento em *P. ramagii* e ressaltam o significado adaptativo da tanatose no aumento da sobrevivência das presas durante encontros predatórios em condições naturais.

Palavras-chave.— Cobra-cipó, dieta, herpetofauna, presa, tática de defesa.

Abstract.— This study documents the death feigning behavior in the Paraíba Robber Frog (*Pristimantis ramagii*) in *ex-situ* conditions when confronted with a predation attempt by the non-venomous snake Boettger's Sipo (*Chironius flavolineatus*). Despite being preyed on by the snake, the amphibian's antipredator mechanism was efficient in avoiding predation while executed. Our findings state the occurrence of this behaviour in *P. ramagii* and underscore the adaptive significance of death feigning in enhancing prey survival during predatory encounters in natural conditions.

Keywords.— Boettger's sipo, defensive tactics, diet, herpetofauna, prey.

Death feigning, commonly referred to as thanatosis or tonic immobility, is a well-documented antipredator strategy observed across various vertebrate species (Whitman et al., 1986; Giannico, 2014; Muscat et al., 2016; Motte et al., 2018; Pochron & Thompson, 2019; Ferreira et al., 2019). This behavior is evolutionarily advantageous as it can increase an individual's chances of evading predators by inhibiting attacks or preventing subsequent predatory attempts (Miyatake et al., 2004). Death

feigning does not occur spontaneously but is typically triggered by specific stimuli associated with predation threats (Greene, 1988; Miyatake et al., 2004).

Death feigning is characterized a mechanism of posture sympleiomorphic in Anura (Ferreira et al., 2019). During this behavior the individual may fully opening their eyes, partially opening their mouths, and relaxing their limbs to simulate

death more convincingly (Toledo et al., 2010). This behavior serves as an effective secondary defense strategy for many species (Sazima, 1974; Toledo et al., 2011; Lourenço-de-Moraes et al., 2016; Ferreira et al., 2019). The interaction between predator and prey during death feigning typically follows an escalated sequence of approach, detection, identification, and a reduction in interaction through the prey's antipredator mechanism (Lourenço-de-Moraes et al., 2016). The interaction concludes with either the prey's escape and survival or the predator's subjugation and consumption of the prey (Humphreys & Ruxton, 2018).

During a study on the predation behavior and diet of the non-venomous snake *Chironius flavolineatus* Boettger, 1885, we offered amphibians of the species *Pristimantis ramagii* (Boulenger, 1888) as prey and observed the thanatosis (death-feigning) behavior of the frog during a predation attempt by the snake *C. flavolineatus*. The snake was captured on November 30, 2018, at 17:30, and the frog on December 11, 2018, at 15:50, both from the same urban forest patch in Jacaraú municipality (6° 39' 36.90" S, 35° 15' 04.40" W), in the state of Paraíba, northeast Brazil. The specimens were collected by hand and housed in a glass terrarium (50 cm x 50 cm x 40 cm) in the animal ecology laboratory at Universidade Federal da Paraíba, Campus IV, under permits SISBIO N°65652-1 and CEUA-UFPB 2485280119. The death feigning behavior and predation attempt were recorded using a Xiaomi® Mijia 1080p smart IP wireless camera.

During an experiment on the feeding behavior of *Chironius flavolineatus* in captivity, an individual of *Pristimantis ramagii* was introduced to the terrarium. The frog is a common species in the northeast Atlantic Forest (Pereira-Filho et al., 2023). It is listed as least concern in The IUCN Red List of Threatened Species (IUCN,

2023) and does not appear on the National List of Threatened Species of Extinction of Brazil (Portaria MMA nº 148, 7 June 2022). There are reports in the literature of *Pristimantis ramagii* in the diet of *Chironius flavolineatus* (Arruda et al., 2024) and being preyed upon by other snake species, such as *Dendrophidion atlantica* and *Leptodeira annulata* (Santos et al., 2018; Lima et al., 2019).

Upon introduction to the terrarium, the frog exhibited escape behavior, including jumping and colliding with the terrarium walls. At the first sign of movement from the snake, the frog immediately adopted death feigning behavior, turning onto its back with its belly facing up and remaining completely immobile with eyes opened (Fig. 1B). This state lasted for 3 min 20 s. During this period, the snake foraged throughout the terrarium and encountered the frog three times without detecting it (Fig. 2 A-F). After the last encounter, the frog made slight movements with its forelimbs and cranial region, preparing for a potential escape (see Ferreira et al., 2019). These movements triggered a predatory response from the snake, leading to the frog's capture and ingestion immediate (Fig. 2 G-H).

Macdonald (1973) noted that active prey is more likely to be targeted by snakes compared to inactive prey. Anurans can maintain the death feigning posture with their bellies facing upwards for up to 5 min before resuming normal behavior and attempting to escape (Toledo et al., 2011; Lourenço-de-Moraes et al., 2016; Ferreira et al., 2019). In this study, the frog remained immobile for over 3 min in a controlled environment, demonstrating the efficacy of death feigning as a survival strategy in *ex-situ* conditions. The snake only detected the prey after it began to move, underscoring the importance of immobility in evading predators. It is important to make it clear that the



Figura 1. Indivíduos recolhidos na área de estudo. A) *Chironius flavolineatus*; B) *Pristimantis ramagii* em posição natural; C) *P. ramagii* durante a simulação de morte. Fotos: A) Vanessa do Nascimento Barbosa, B) e C) Ricardo Lourenço-de-Moraes.

Figure 1. Individuals collected in the study area. A) *Chironius flavolineatus*; B) *Pristimantis ramagii* in natural position; C) *P. ramagii* during death feigning. Photos: A) Vanessa do Nascimento Barbosa, B) and C) Ricardo Lourenço-de-Moraes.

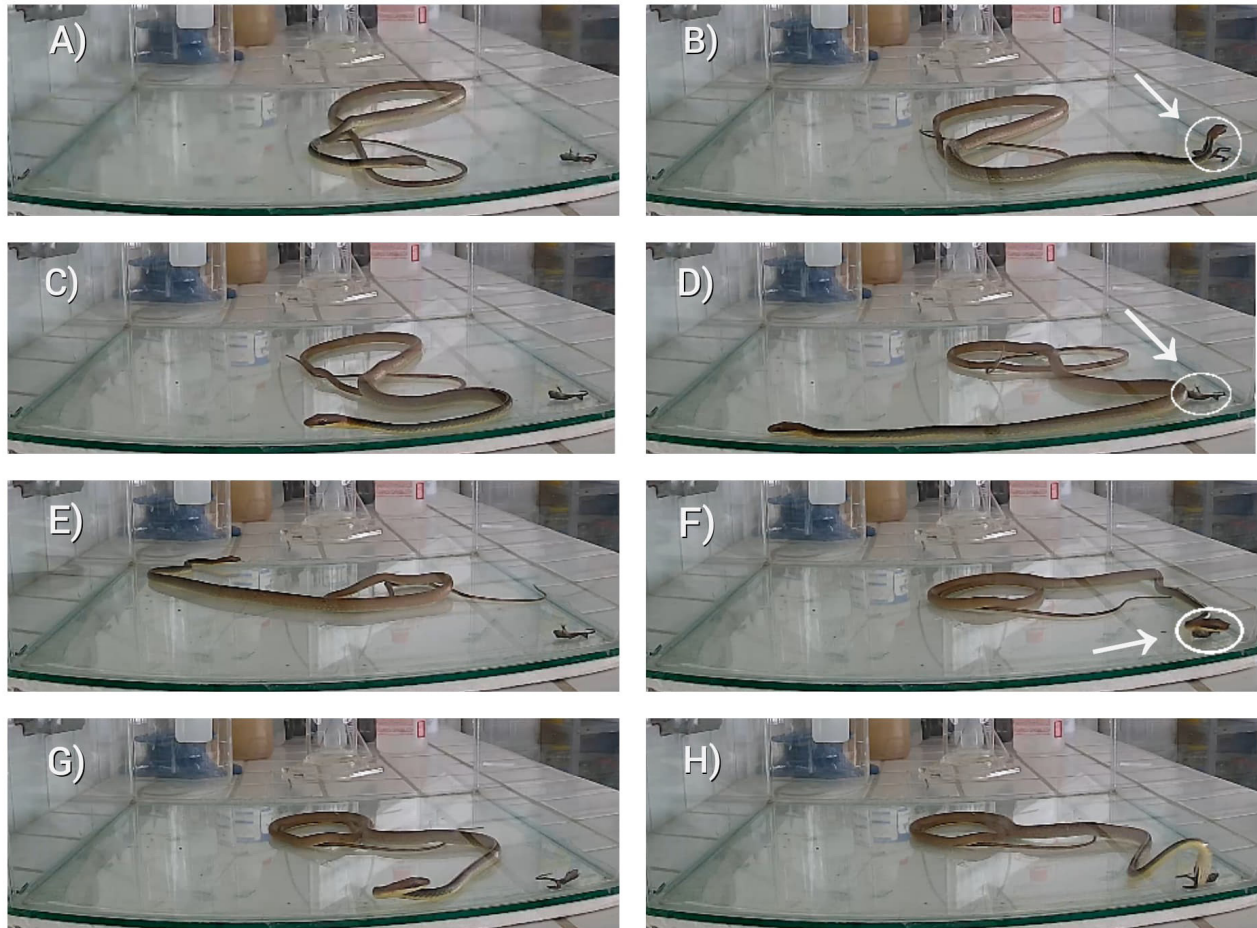


Figura 2. Comportamento de tanatose de *Pristimantis ramagii* e tentativa de predação por *Chironius flavolineatus* registrado em condições de cativeiro em 12 de dezembro de 2018, às 11:00. A) Início da simulação de morte exibida pelo sapo; B) Primeiro contato da serpente com o sapo; C) Serpente forrageando na parte frontal do terrário; D) Segundo contato entre os espécimes; E) Serpente forrageando na parte de posterior do terrário; F) Terceiro contato entre os espécimes; G) O sapo movimentando cuidadosamente suas patas traseiras; H) Ataque predatório e ingestão da presa pela serpente.

Figure 2. Death feigning behavior of *Pristimantis ramagii* and predation attempt by *Chironius flavolineatus* recorded in captivity conditions on December 12, 2018, at 11:00. A) initial death feigning displayed by the frog; B) Snake's first contact with the frog; C) Snake foraging in the front part of the terrarium; D) Second contact between the specimens; E) Snake foraging in the rear part of the terrarium; F) Third contact between the specimens; G) Frog slightly moving its hindlimbs; H) Predatory strike and prey ingestion by the snake.

behavior of death feigning normally occurs in synergy with the mechanisms of camouflage and release of odoriferous secretion that blends in with the environment (Lourenço-de-Moraes et al., 2016; Ferreira et al., 2019). Thus, the effectiveness of this behavior in a natural environment should be higher when compared to the experiment in the present study. Our observations highlight the effectiveness of death feigning in natural predation scenarios and emphasize its role as an evolutionary survival mechanism for less protected species (Humphreys & Ruxton, 2018).

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