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FIRST RECORD OF CONTRACTING AND THANATOSIS BEHAVIOUR IN THE GENUS *NYMPHARGUS* (ANURA: CENTROLENIDAE)

PRIMER REGISTRO DE LOS COMPORTAMIENTOS DEFENSIVOS CONTRACCIÓN Y TANATOSIS EN *NYMPHARGUS* (ANURA: CENTROLENIDAE)

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Resumen.– En los últimos años, las ranas de cristal han sido especies modelo para diversos estudios relacionados a su ecología, evolución, sistemática, entre otras características asociadas. Sin embargo, en cuanto a comportamientos defensivos son pocos los estudios que describen las estrategias antipredatorias que pueden exhibir. En este trabajo documentamos dos comportamientos defensivos que no se habían reportado para el género *Nymphargus* y uno de ellos, es el primer reporte formal para la familia Centrolenidae.

Palabras Clave.– Centroleninae, Colombia, comportamiento defensivo, depredador-presa.

Abstract.– In recent years, the glass frogs have been model species for diverse studies related to ecology, evolution, and systematics, among other associated characteristics. However, regarding defensive behaviours few studies describe the antipredatory strategies that they can exhibit. In this work, we document two defensive behaviors that have not been reported for the genus *Nymphargus* and one of these, is the first record for the Centrolenidae family.

Keywords.– Centroleninae, Colombia, defensive behavior, predator-prey.

The glass frogs (Anura: Centrolenidae) are a family of Neotropical anurans that include 164 species distributed from Mexico to northern Argentina (Frost, 2023). In recent years, the studies to understand the systematic, diversity, natural history, and evolution of some traits of this charismatic family have increased, being one of the relatively best documented amphibian group in the Neotropical region (Guayasamin et al., 2009; Delia et al., 2020; Guayasamin et al., 2020; Duarte-Marín et al., 2022). However, despite the incredible increase in studies that allow us to understand several aspects of glass frogs, few studies document their defensive behaviors against a potential predator.

Ferreira et al. (2019) compiled all the information related to antipredatory mechanisms reported for anurans and only seven species of glass frogs have at least one description or report of defensive behavior. Predation events by vertebrates (snakes) and invertebrates such as arachnids, crustaceans, and insects have been recorded in this family (Villa, 1977; Hayes, 1983; Vockenhuber et al., 2008; Delia et al., 2010; Hertz & Lotzkat, 2010; Delia et al., 2017). Thus, it is essential to document their defensive behaviors because they permit us to understand the ecology and evolution of predator-prey interactions. The objective of this work is to describe two defensive behaviors not previously reported in *Nymphargus pijao* Montilla, Arcila-Pérez, Toro-Gómez, Vargas-Salinas & Rada, 2023, an endemic glass frog of Colombia distributed in the slopes of the Cordillera Occidental and the western slope of Cordillera Central between 1480 and 2430 m.a.s.l. (Frost, 2023; Montilla et al. 2023).

Previously, the populations that correspond to *Nymphargus pijao* were misassigned to the species *N. griffithsi*, but based on evidence related to advertisement call, natural history, molecular information, internal and external morphology in adults and tadpoles, describe this new species (see Arcila-Pérez et al. 2017; Montilla et al. 2023). In particular, *N. pijao* presents a truncated snout in lateral and dorsal view, SVL in males: 22.1-27.3 mm - SVL in females: 24.6-28.6 mm, its dorsal coloration

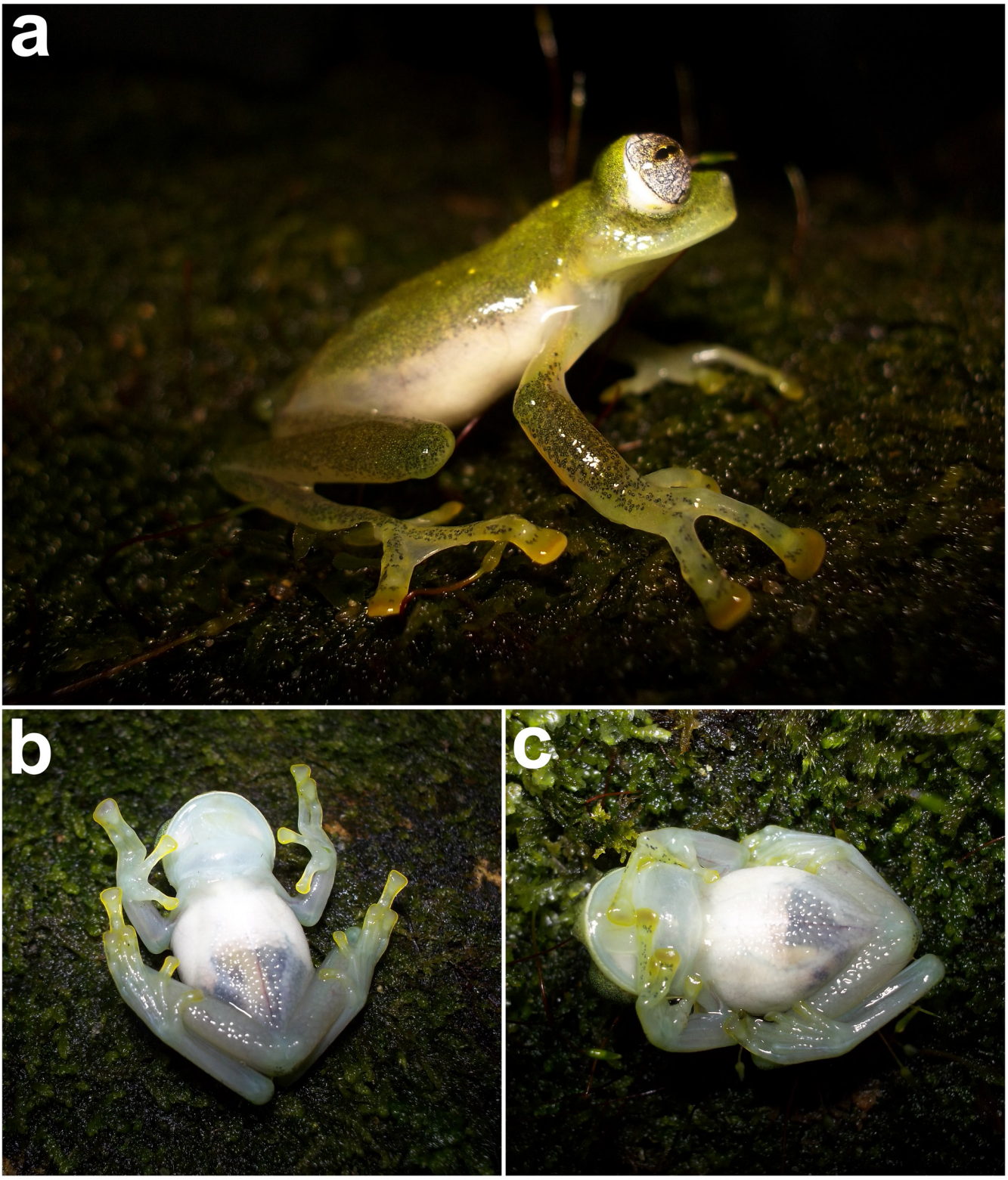

Figura 1. Individuos de *Nymphargus pijao* en diferentes posturas: a) posición "natural", b) desplegando el comportamiento de tanatosis y c) de contracción.
Figure 1. Individuals of *Nymphargus pijao* in different postures: a) "natural" position, b) displaying thanatosis, and c) contracting behavior.

is green with tiny clusters of melanophores and green-yellowish spots, green bones, absence of membrane on the outer fingers, white peritoneum in more than half and translucent visceral (not covered by iridophores) and differs from *N. griffithsi* by the absence of humeral spine (present in *N. griffithsi*, Montilla et al. 2023).

We observed three individuals of *N. pijao* in two nights on November 2020 at the "Cascadas de Río Verde" Nature Reserve, municipality of Córdoba, department of Quindío, Colombia (4.403918° N, 75.658302° W, elevation 2,404 m.a.s.l.). Individuals were captured and manipulated for 60-120 s, and their response was registered. All individuals remained motionless before being captured (Fig. 1a). During one minute, two of these bowed their heads, bent their limbs to contract them to their bodies, and remained immobile despite repeated manipulation attempts. In addition, when trying to separate one of the limbs, the individuals quickly returned the limb to its initial position (Fig. 1b). Furthermore, the remaining individual had a similar behavior but did not bow their head, flipped onto-back, had half-closed eyes, and did not shrink its limbs. Finally, we tried to repeat the same procedure with the other individuals and we noticed that when moving the limbs, they did not show any sign of resistance (Fig. 1c).

Based on these characteristics and as proposed by Toledo et al. (2010), such behaviors are known as contracting (or shrinking) and thanatosis (or death feigning). Both behaviors have been recorded in more than 20 anuran families, where the Hylidae, Bufonidae, and Leptodactylidae families have been the most representative ones (Ferreira et al. 2019). In Centrolenidae, our observations of contracting behavior are the first reports for this family and in the case of thanatosis, it is the first record for the genus *Nymphargus* since Toledo et al. (2010) reported it in *Vitreorana uranoscopa* (as *Hyalinobatrachium uranoscopum*).

Moreover, various explanations have been given for how these behaviors would work against a potential predator (see Brodie Jr, 1977; Toledo et al., 2010). Sazima (1974) suggests that contracting behavior would prevent serious injury to the frog's body since its position protects vital body parts (e.g., limbs) in the subjugation phase (sensu Toledo et al., 2010). In addition, it has been found that most of the species that present this behavior synergistically release secretions (Toledo et al., 2010), and in our case, we noticed that the three individuals when handled had a plant-like odor. In Centrolenidae, these odors only have been reported in *Centrolene quindianum*, *C. savagei*, and *N. grandisonae* (Escobar-Lasso & Rojas-Morales, 2012). Toledo et al. (2011) suggest these odors could act like a chemical camouflage or mimicry). About thanatosis, remaining immobile could promote a disinterest in potential predators that require stimuli related to movement to feed, implying a possible survival to a particular predation event (Edmunds, 1974; Toledo et al., 2010). Finally, we suggest that these behaviors are not unusual in glass frogs, but a more focused effort is required to document such defensive strategies, and the odor secretion released by *N. pijao* needs to be described and chemically characterized.

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