# CONTRACTING BEHAVIOR IN THE GIANT GLADIATOR FROG *BOANA BOANS* (HYLIDAE) AND THE EMERALD CRYSTAL FROG *ESPADARANA PROSOBLEPON* (CENTROLENIDAE)

## COMPORTAMIENTO DE CONTRACCIÓN EN LA RANA GLADIADORA GIGANTE *BOANA BOANS* (HYLIDAE) Y LA RANA DE CRISTAL ESMERALDA *ESPADARANA PROSOBLEPON* (CENTROLENIDAE)

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**Resumen.**– Los anuros presentan diversos comportamientos anti depredadores, tanatosis (también conocida como inmovilidad tónica), donde los anuros fingen estar muertos, y contracción (o encogimiento). A diferencia de la tanatosis, durante el encogimiento los anuros suelen permanecer con los ojos cerrados, las extremidades contraídas cercanas al cuerpo. Al tratar de estirar alguna de sus patas, el animal la regresa hacia su cuerpo, generalmente cubriendo algún órgano vital. En este trabajo reportamos el comportamiento de encogimiento observado por primera vez en la rana gladiadora gigante (*Boana boans*), y la rana de cristal esmeralda (*Espadarana prosoblepon*). Estos reportes son importantes, ya que contribuyen en el entendimiento de la ecología y comportamiento de estas especies y de los anuros en general.

**Palabras clave**.– Antidepredador, defensa, depredador, evitación, protección, toxinas.

**Abstract.**– Anurans exhibit several anti-predator behaviors, including thanatosis (also known as tonic immobility) where anurans pretend to be dead, and contracting (or shrinking). In contrast to thanatosis, contracting anurans usually remain with their eyes closed and their limbs contracted close to the body covering vital organs. If one attempts to stretch a limb from a contracted position , it pulls it back to the body after release. Here, we report for the first time, observations of contracting behavior in the Giant gladiator frog (*Boana boans*), and the Emerald glass frog (*Espadarana prosoblepon*). These records are important since they contribute towards the understanding of ecology and behavior of these species and anurans generally.

**Keywords**.– Antipredator, avoidance, defense, predator, protection, toxins.

Different groups of post-metamorphic anuran have evolved a variety of creative ways to avoid predators, which have been grouped into numerous categories by different authors. These include the use of visual systems, such as aposematic coloration to warn potential predators of danger; cryptic coloration that provides camouflage to go unnoticed by predators; and behavioral systems, such as adopting postures that make them appear larger and more intimidating, feigning death, or contracting to avoid suffering more damage than they would receive in a fight (Toledo et al., 2011; Ferreira et al., 2019). These last two behaviors can be confused by a human observer due to the immobility of the specimen, but they have been well defined by Toledo et al., (2010). When anurans pretend to be dead, a behavior called thanatosis or tonic immobility, they show no movement even when touched, usually keeping their eyes open and their limbs loose. In contrast to thanatosis, when anurans engage in contracting or shrinking behavior, they usually keep their eyes closed and their front and hind limbs bent and close to the body. If an observer attempts to stretch any of the animal's legs, the animal will immediately force it back close to the body,

usually covering its vital organs with its hind legs and its head with its hands. Formal recording of these mechanisms helps to improve knowledge of the natural history of the species and the behavioral mechanisms involved (Guerra et al., 2018). In this paper we report defensive contracting behavior in both the Giant Gladiator Frog *Boana boans* (Linnaeus, 1758), which, although previously reported for the genus *Boana* (Ferreira et al., 2019; Toledo et al., 2010), had not been previously reported in *B. boans*, and the Emerald Glass Frog *Espadarana prosoblepon* (Boettger, 1892), making this the second record of this behavior in the family Centrolenidae. *Boana boans* is a large tree frog belonging to the family Hylidae. Males can measure between 80 and 118 mm in cloacal length, and females between 84 and 110 mm (Rodriguez & Duellman, 1994). They have a wide distribution in South America, mainly in the Amazon basin, and in Central America where they are only found in the central and eastern areas of Panama, with an altitudinal distribution ranging from 0 to approximately 1,000 m a.s.l. (La Marca et al., 2010).

*Espadarana prosoblepon*, of the family Centrolenidae, is a small frog, with a snout-cloaca length between 26.7 and 29.6 mm in males and females 29.5–31.8 mm in females. Its distribution extends in Central America from eastern Honduras, Nicaragua, Costa Rica, Panama, and in South America along the Pacific slope of the Andes in Colombia and Ecuador, from sea level to 1,900 m a.s.l. (Guayasamin et al., 2020).

Ferreira et al., (2019) reported on defense behaviors of many species throughout different regions of the world, classifying the most representative species in each of them, with the *Boana* genus being among the most representative for charge, contraction, mouth gape, death feigning, production of slippery secretions, kick, puncture, and distress calls. Some of these behaviors have been documented for *B. boans*, among wish distress calls (Hödl & Gollmann, 1986; Rocha & López-Baucells, 2014; Arrivillaga & Levac, 2019), mouth gape (Lima et al., 2005), limb stretching and leaping (Rocha and López-Baucells, 2014), body inflation and jump away (Arrivillaga & Levac, 2019), have previously been reported.

For the Centrolenidae family, reported defensive behaviors are very rare, but include cloacal discharge (Vockenhuber, 2008; Escobar-Lasso & Rojas-Morales, 2012), crouching down and body-raising (Escobar-Lasso & Rojas-Morales, 2012; Pedroso-Santos, 2021), body inflation (Escobar-Lasso & Rojas-Morales, 2012), odour secretion (Escobar-Lasso & Rojas-Morales, 2012), noxious secretion (Rueda-Almonacid, 1994), thanatosis or feigning death (Toledo et al., 2011; López-Molina et al., 2023), distress call (Souza et al., 2016), contraction or shrinking (López-Molina et al., 2023), bite (Toledo et al., 2011) and kick (Vockenhuber et al., 2008), these last two are exclusive to individuals of this group during parental care. *E. prosoblepon* is known to produce acrid or pungent odors as a defense against predators when captured (Guayasamin et al., 2020).

During two field trips to the Cocobolo Nature Reserve, Province of Panama, Republic of Panama (Fig. 1), a general survey was carried out and two males of *B. boans* were captured for identification. The first individual (Fig. 2A) was found on 5 August 2022, at 21:00 h., in the highest part of the reserve (9.32° N, 79.205167° W), at about 721 m a.s.l., perched about two meters high on a sapling. The second individual (Figure 2B) was found on 7 January 2023, at about 22:40 h. on the banks of the Mamoní River (9.289517° N, 79.206517° W), at about 235 m a.s.l., calling on the trunk of a small bush at about one meter above the ground. When both individuals were captured, they adopted a contracting posture, which was very similar in both individuals: bringing their hind legs close to the body, apparently protecting the abdominal area, placing their hands next to the head with the palms facing outwards and the head bent forward, and the eyes closed until they returned to their normal posture (Fig. 2). When the animals' legs were stretched out both individuals immediately pulled them back into the contracting position, close to the body. The first individual found was placed on the ground after adopting the contracting posture, where it remained for approximately four minutes. The second individual was held by hand and, unlike the first individual, it had inflated its lungs, looking more rounded with its legs slightly apart than what was observed in individual 1. It remained in this position for about a minute and a half.

In addition to these reports for *B. boans*, during field sampling on 23 November 2022, carried out in the Pixbae creek (8.8151° N, 80.469467° W), near the community of Cutevilla, province of Coclé, Panama (Fig. 1), at about 64 m a.s.l., a male *E. prosoblepon* was found at approximately 1730 h. When captured for identification, it immediately adopted a contracting posture, bringing its hind legs close to its body. However, unlike *B. boans*, it did not bring its hands to the sides of its head, but placed them close to the gular and thoracic regions, with the palms facing outwards. The head was not tilted forward and the eyes remained open, in addition to not appearing to have inflated the lungs (Fig. 3), this individual produced a pungent or plant-like odor when captured, similar to that described previously for *E. prosoblepon* (Guayasamin et al., 2020) and other species in the family Centrolenidae, wich have been reported at the date *Centrolene quindianum*, *C. savagei*, *Nymphargus grandisonae* (Escobar-Lasso & Rojas-Morales, 2012) and *N. pijao* (López-

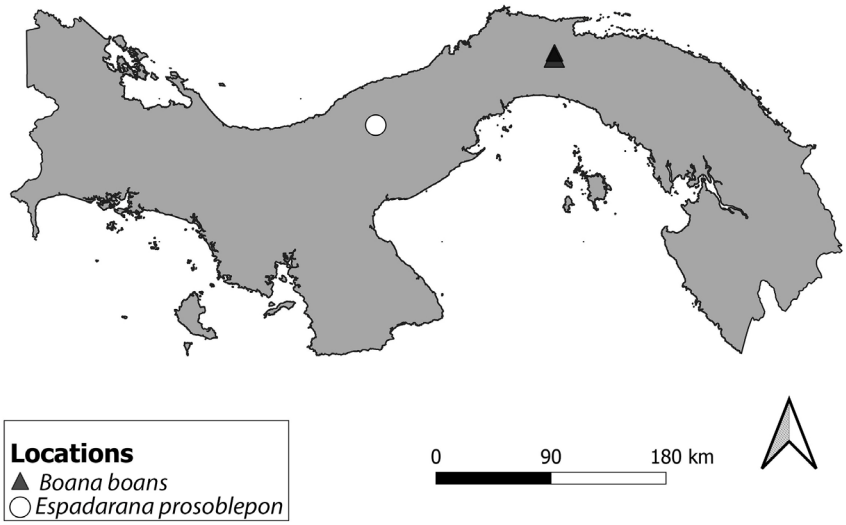


**Figura 1.** El Istmo de Panamá con las localizaciones donde los animales fueron observados. Los triángulos negros muestran la localidad de la Reserva Natural Cocobolo, provincia de Panamá, donde los individuos de *B. boans* fueron observados. El circulo blanco muestra la localidad donde el individuo de *E. prosoblepon* fue encontrado. Elaboración: Erick Barría.

**Figure 1.** The Isthmus of Panama with the locations where the animals were observed. The black triangles show the locality of the Cocobolo Nature Reserve, province of Panama, where the individuals of *B. boans* were observed. The white circle shows the locality where the *E. prosoblepon* individual was found. Made by: Erick Barría.


**Figura 2.** Individuos de *Boana boans* encontrados en la Reserva Natural Cocobolo mostrando el comportamiento de contracción, acompañado por la protección de los ojos, bajando la barbilla (A y B) e inflando el cuerpo (B). Foto: Erick Barría.

**Figure 2.** Individuals of *Boana boans* found in the Cocobolo Nature Reserve showing contracting behavior, accompanied by eye protection, chin-tucking (A and B) and puffing up the body (B). Photo: Erick Barría.

**Figura 3.** Individuo de *Esparadana prosoblepon* mostrando el comportamiento de contracción, colocando las piernas cerca del estómago y las manos cubriendo la región gular y torácica. Foto: Erick Barría

**Figure 3.** Individual of *Esparadana prosoblepon* showing contracting behavior, placing the legs close to the belly and the hands covering the gular and thoracic region. Photo: Erick Barría.

Molina et al., 2023). This behavior in *E. prosoblepon* was very brief, lasting approximately 30 seconds.

The contracting behavior of *B. boans* reported in this study was accompanied by other behaviors as described by Toledo et al., (2011). Some of these are also behaviors that have not been previously reported for this species, such as eye protection, usually with the chin bent towards the abdomen or other similar positions, covering the head, eyes, and eardrum with the forearms and hands – behaviors that usually occurs when the frogs are in a motionless position (observed in the two individuals of *B. boans* ). Another behavior previously reported for *B. boans* is "chin-tucking", which is characterized by bending the chin towards the pectoral region; and body inflation (Arrivillaga & Levac, 2019), also known as "lung inflation" (Ferrante et al., 2014), which consists of filling the lungs with air and thus increasing the size of the frog. The main possible function of contracting and eye protection is to prevent damage during subjugation and to prevent ingestion. Likewise, the main possible function for "body inflation" and "chin-tucking" is to prevent underplaying, modifying their appearance to make themselves look larger than they are, fooling predators into deciding that the prey is too big to eat. This behavior is very likely to help intimidate predators (Toledo et al., 2011; Caro, 2014; Ferreira et al., 2019) and may have been carried out to make it more difficult for a possible predator to ingest the individual (Arrivillaga & Levac, 2019). The sequence of all these behaviors may represent a more complex behavior (Guerra et al., 2018), and the simultaneous use of several defense strategies appear to increase the probability that a frog will be able to escape from a predator (Toledo et al., 2011). In addition, anurans may respond differently to several types of predators, using different predator avoidance strategies within the same species, or a combination of these strategies (Ferrante et al., 2014). This could be seen in the differences observed between two individuals of *B. boans*, in which only one of them performed "body inflation" when held in the hand by the researcher.

In contrast to the combination of different physical defensive strategies observed in *B. boans*, we assume that *E. prosoblepon* only performed contracting to protect the vital organs with the legs, since no other postural elements were observed. Toledo et al., (2010) suggested that contracting behavior is characteristic of frogs with the ability to produce toxins in the skin or release secretions, reporting that 80 % of contracting anurans released skin secretions. Ferreira et al., (2019) classify these secretions into four types: adhesive, odoriferous, slippery, and noxious. According to this classification, the secretions produced by *B. boans*, for instance, can be classified as noxious, since they are known to produce certain skin peptides with a dual function. They can also serve as a first line of immunity against bacterial, protozoan and fungal infections, but the cytotoxic activity of these peptides may have an anti-predator function, as they can cause irritation and pain in the oral mucosa of predators (Raaymakers et al., 2017; Conlon et al., 2023). These peptides may be acting alongside other toxins that weaken the cell membranes of predators, facilitating the permeability of the toxins and allowing them to act more quickly (König et al., 2015; Raaymakers et al., 2017).

No such studies of toxin secretion have been conducted for the family Centrolenidae, but the skin secretions that produce pungent or plant-like odors when trapped can be categorized as odoriferous-type secretions (Ferreira et al., 2019), which can function as a kind of chemical camouflage (Toledo et al., 2011), or to cause irritation to the mucous membranes of potential predators. It has also been speculated that if predators learn that unpalatable prey is associated with some odor, they may avoid prey with that odor in the future. (Williams et al., 2000; Ferreira et al., 2019).

As suggested by López-Molina et al., (2023), these behaviors may not be rare in the species of our study. However, there is a need for an effort to publish each particular behavior, as they help us better understand the ecological species strategies when faced to the danger posed by predators.

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