Uma publicação da Sociedade Brasileira de Herpetologia

SEÇÃO VOL. 15
História Natural e Conservação NUM. 01

Notes on defensive behaviors in three Amazonian anurans

Natalia S. Campos[1,2*], Thiago Silva-Soares[2]

1 Júlio de Mesquita Filho State University of São Paulo (UNESP), Faculty of Sciences, Department of Biological Sciences, Laboratory of Evolutionary Biology and Systematics of Modern Tetrapods (LaBesta), 17033360 Bauru, São Paulo, Brazil.

2 Últimos Refúgios Institute, Department of Herpeto Capixaba, 29070-030 Vitória, Espírito Santo, Brazil.

*Corresponding author:
natalia.biocampos@gmail.com

Editora de Área: Ariadne Sabbag
Submetido em 09/07/2025
Aceito em 10/02/2026
DOI: 10.5281/zenodo.18599636

Resumo

A Amazônia abriga uma elevada diversidade de anuros, os quais desempenham papel fundamental na manutenção do equilíbrio ecológico, atuando como presas para invertebrados e diversos grupos de vertebrados. Esses animais desenvolveram adaptações fisiológicas, morfológicas e comportamentais antipredatórias, que têm sido estudadas principalmente em espécies da Mata Atlântica, resultando em lacunas significativas de conhecimento sobre os táxons amazônicos. Neste estudo, descrevemos observações comportamentais de três espécies de anuros amazônicos, *Adelphobates quinquevittatus, Dendropsophus marmoratus* e *Rhaebo guttatus*, em resposta à aproximação e ao manuseio por seres humanos. Esses registros de história natural fornecem dados de referência sobre os repertórios comportamentais dessas espécies.

Palavras-chave

Biodiversidade amazônica; Ecologia de anuros; Interações predador-presa; Mecanismos antipredatórios.

ABSTRACT

The Amazon hosts a high diversity of anuran amphibians that play a crucial role in maintaining ecological balance by serving as prey for a variety of predators, including invertebrates and vertebrates. These amphibians have developed physiological, morphological, and behavioral antipredatory adaptations, which have been primarily studied in Atlantic Forest species, resulting in significant knowledge gaps regarding Amazonian taxa. This study presents behavioral observations of three Amazonian anuran species, *Adelphobates quinquevittatus*, *Dendropsophus marmoratus*, and *Rhaebo guttatus*, in response to human approach and handling. These natural history records provide baseline data on the behavioral repertoires of these species.

Keywords

Amazon biodiversity; Anuran ecology; Antipredatory mechanisms; Predator-prey interactions.

Throughout their life cycle, anurans are vulnerable to predation by both vertebrates and invertebrates, particularly spiders and snakes, which exert strong selective pressures on their behavior and morphology (Duellman & Trueb, 1994). In response to these pressures, anurans have evolved a wide range of antipredatory behavioral, ecological, physiological, and morphological strategies that increase survival by reducing detection, deterring attacks, or facilitating escape (Brodie & Brodie, 1999; Toledo et al., 2011). These mechanisms may occur singly or in combination, and vary across species, populations, and even sexes (Williams et al., 2000; Toledo et al., 2005). However, the majority of studies reporting these defenses have focused on Atlantic Forest species, where research efforts have historically been concentrated (Haddad et al., 2013; Ferreira et al., 2019). As a result, important aspects of natural history remain poorly understood for many Amazonian taxa (Ferreira et al., 2019).

Adelphobates quinquevittatus (Steindachner, 1864) (Dendrobatidae) is a diurnal species that inhabits leaf litter or fallen logs on the forest floor, and is found in well-preserved forest areas in Brazil (southern Amazonia, particularly in the Madeira River drainage), as well as in Bolivia and Peru (Bernarde, 2007; Bernarde & Macedo, 2008; Silva et al., 2018; Medeiros et al., 2021). It is characterized by a black dorsum with longitudinal stripes and orange limbs marked with black spots (Caldwell & Myers, 1990; Martins & Haddad, 1990). Species within this genus are characterized by exposed aposematic coloration, bright hues such as red, blue, orange, and yellow covering most of the body (Ferreira et al., 2019).

Dendropsophus marmoratus (Laurenti, 1768) (Hylidae) is distributed throughout the Amazon Basin, occurring in Brazil (Acre, Rondônia, Pará, and Mato Grosso), as well as in Colombia, Ecuador, Peru, Bolivia, southern Venezuela, Guyana and Suriname (Bokermann, 1964; Kohler, 1995; Gomes & Peixoto, 2009; Ouboter & Jairam, 2012; Cole et al., 2013; Metcalf et al., 2020; Camper et al., 2021). The species is nocturnal and arboreal, usually found on leaves and branches in tropical forests and in clearings near forests (Rodríguez & Duellman, 1994). It is characterized by a slightly tuberculate dorsum with coloration ranging from grayish bronze to greenish bronze, marked with black, dark brown, or reddish spots often with olive-green areas along the dorsolateral surfaces. The axillary region, groin, and posterior surface of the thighs display yellow-orange pigmentation with black spots or markings (Duellman, 1978).

Rhaebo guttatus (Schneider, 1799) (Bufonidae) is distributed across Bolivia, Peru, Ecuador, Colombia, Suriname, Venezuela, the Guianas and the eastern and central Amazon in Brazil, typically found on the ground, along riverbanks, or among the leaf litter on the forest floor (Duellman, 1997; Lotters et al., 2000; Bustamante et al., 2005; Bernarde et al., 2011; Ouboter & Jairam, 2012; Metcalf et al., 2020; Taucce et al., 2022). It is a large, terrestrial and nocturnal species that produces yellow-orange skin secretions. This is an important characteristic that distinguishes them from other frogs, which usually have white secretions (Frost et al., 2006).

Documenting defensive behaviors is critical for advancing our understanding of predator–prey interactions, population dynamics, and the evolutionary processes driving phenotypic plasticity under selective pressure. In this context, the present study describes behavioral observations exhibited by three Amazonian anuran species in response to human approach and handling. We discuss these behaviors in the context of potential defensive strategies, while noting that their confirmation as antipredator mechanisms requires further studies under natural conditions.

MATERIAL AND METHODS

Observations of *R. guttatus* were conducted during a field expedition in January 2009 along BR-319, in the Reunidas region, municipality of Manicoré, state of Amazonas, northern Brazil, at approximately 3:00 p.m. (5°31’26”S 62°08’17”W, WGS 84; elev. 44 m a.s.l.). On 26 November 2013 at 5:45 p.m., another individual of *R. guttatus* was observed exhibiting defensive behavior in the Flona Tapirapé-Aquiri, municipality of Parauapebas, state of

Pará, in a forested area (5°49'40.22" S, 50°31'25.54" W, WGS 84; elev. 221 m a.s.l.). *Adelphobates quinquevittatus* and *D. marmoratus* were observed displaying defensive behaviors during a field expedition conducted between 21 and 26 November 2013 in the municipality of Comodoro, state of Mato Grosso, central-west Brazil (13°47'27" S, 60°27'47" W, WGS 84; elev. 189 m a.s.l.). Both individuals of *R. guttatus* exhibited defensive behavior under natural field conditions; the other species were captured and transported to the field laboratory, where they were photographed after displaying behavioral responses to handling and human approach.

RESULTS

Rhaebo guttatus. During the first encounter with the individual from Amazonas, as TSS approached while the toad was hopping, it emitted an audible expiratory sound, described here as an "air sound," consistently produced during expiration each time it moved or jumped (see video: https://www.herpetocapixaba.com.br/herpetovideos). In addition to this acoustic response, the individual displayed the behaviors described below.

The second individual was encountered in Parauapebas, state of Pará, at dusk (approximately 5:45 p.m.), moving on the forest floor. Upon the approach of TSS, both individuals exhibited a set of defensive behaviors previously reported in the literature, including body inflation, escape movements, elevation of the anterior portion of the body by the forelimbs, and orientation of the parotoid glands toward the observer (Fig. 1A).

Adelphobates quinquevittatus. The adult was taken to the laboratory at 7:30 a.m., and, when handled for photographic documentation at 9:32 p.m., exhibited death feigning behavior; contraction of the limbs with the belly turned upwards (Fig. 1B).

Dendropsophus marmoratus. The species exhibited a series of responses to our manipulation for photographic documentation. Initially, at 6:16 p.m., the individual contracted its limbs and flexed its head ventrally with the belly upwards, exhibiting its ventral aposematic coloration (Fig. 1C). At 6:18 p.m., the individual displayed immobility, then performed an evasive jump. When an attempt was made to capture the individual by hand, it inflated its body while bracing itself against the substrate (Fig. 1D).



Figure 1. Defensive behaviors exhibited by *Rhaebo guttatus*, *Adelphobates quinquevittatus* and *Dendropsophus marmoratus*: (A) *R. guttatus*: elevation with tilting of the body supported by the forelimbs, and orientation of the parotid glands toward the observer (B) *A. quinquevittatus*: contraction; (C) *D. marmoratus*: contraction; and (D) *D. marmoratus*: body inflation. Photos by TSS.

DISCUSSION

For *R. guttatus*, we observed a behavioral repertoire previously described for bufonids, including escape, body inflation, elevation of the body by the forelimbs, and orientation of the parotid glands toward the observer (Jared et al., 2011). The orientation of the parotid glands is a preparatory phase for the voluntary ejection of venom, as proper orientation can increase the accuracy and effectiveness of chemical defense by ensuring that the secretion directly hits the predator (Jared et al., 2009, 2011), although the ejection itself was not observed in the present record.

In addition, during the escape response, the individual emitted an audible expiratory sound five times while jumping. Sounds produced in contexts of disturbance, handling, or escape have been discussed in the literature as defensive acoustic emissions, often broadly referred to as defensive calls (Toledo & Haddad, 2009; Toledo et

al., 2015). Amphibian calls are commonly classified into three categories: warning calls, which act as intimidating deterrents toward potential predators; alarm calls, produced during escape or predation events and potentially attracting interference; and distress calls, emitted when the animal is already captured, representing a last attempt to startle the predator into releasing it (Toledo & Haddad, 2009; Toledo et al., 2015).

The sound recorded here was emitted during an active escape attempt, simultaneously with evasive jumping behavior, and may be interpreted as an alarm-type defensive acoustic emission. To our knowledge, this represents the first record of an air-expelled sound associated with defensive behavior in *Rhaebo guttatus*. This combined occurrence of an expiratory sound and evasive jumping represents a previously undocumented component of the defensive repertoire of this species.

Adelphobates quinquevittatus exhibited distinct defensive behaviors in response to human handling or approach. The limb contraction displayed is a behavior previously documented in other anuran families, such as Hylidae and Bufonidae (Ferreira et al., 2019). This posture has been associated with hindering ingestion, death feigning, enhance the display of aposematic coloration, or facilitate the spread of skin secretions (Toledo et al., 2011). To our knowledge, this is the first published record of this posture not only for the species, but also for the genus *Adelphobates* and the family Dendrobatidae. Members of the family Dendrobatidae, commonly known as poison frogs, possess aposematic coloration and potent chemical defenses in the form of skin alkaloids (Daly et al., 2002; Saporito et al., 2007). In our observations, the individual no toxin secretion was observed, but limb contraction resulted in a more prominent exposure of its ventral pattern. The recorded behavior had the immediate visual effect of enhancing the display of its coloration, constituting a new behavioral record for the family Dendrobatidae that is similar to postures observed in other anuran families.

Dendropsophus marmoratus exhibited a sequence of behaviors consistent with known antipredatory categories for anurans. Behaviors such as body inflation, immobility, contraction and evasive jumps are commonly reported as antipredatory tactics for other species of the genus, serving to intimidate the predator, avoid detection by visually oriented predators or to increase the distance from predators that rely on chemosensory cues (Duellman & Trueb, 1994; Ferreira et al., 2019). Postures that reveal the ventral coloration, enhancing the display of aposematic coloration, are often described as hidden aposematism, used as a misleading signal to confuse or alert potential predators to the presence of toxins or lack of palatability (Ferreira et al., 2019). This study provides the first description of these behaviors for *D. marmoratus*.

In summary, we documented behaviors in *A. quinquevittatus*, *D. marmoratus*, and *R. guttatus* that are consistent with putative antipredatory strategies reported in the literature on anurans. These observations serve primarily as a record of natural history, providing a baseline description of behaviors that may inform future research on the antipredatory mechanisms of these Amazonian anurans. Documenting these behaviors is important for understanding predator-prey dynamics in poorly studied regions such as the Amazon, where such data are scarce or not previously reported. Continuous observations are essential to reveal the full range of defensive behaviors in neotropical amphibians.

REFERENCES

Bernarde P.S. 2007. Anfíbios e répteis: Introdução ao estudo da herpetofauna brasileira. Anolis Books, Curitiba.

Bernarde P.S., Macedo L.R. 2008. Riqueza de anuros no Parque Estadual Mata dos Godoy, Londrina, Paraná, Brasil. *Biota Neotropica* 8:125–133.

Bernarde P.S., Machado R.A., Turci L.C.B. 2011. Herpetofauna da área do Igarapé Esperança na Reserva Extrativista Riozinho da Liberdade, Acre – Brasil. *Biota Neotropica* 11:117–144.

Bokermann W.C.A. 1964. Notes on treefrogs of the *Hyla marmorata* group with description of a new species (Amphibia, Hylidae). *Senckenbergiana Biologica* 45:243–254.

Brodie E.D., Brodie E.D. Jr. 1999. Predator-Prey Arms Races: Asymmetrical selection on predators and prey may be reduced when prey are dangerous. *Biociências* 49:557–568. doi: https://doi.org/10.2307/1313476.

Bustamante M.R., Menéndez-Guerrero P.A., Cisneros-Heredia D.F. 2005. Geographic distribution: *Bufo guttatus. Herpetological Review* 36:331.

Caldwell J.P., Myers C.W. 1990. A new Amazonian poison frog of the genus *Dendrobates* (Anura: Dendrobatidae). *American Museum Novitates* 2988:1–15. doi: http://hdl.handle.net/2246/5075.

Camper J.D., Torres-Carvajal O., Ron S.R., Nilsson J., Arteaga-Navarro A.F., Knowles T.W., Arbogast B.S. 2021. Amphibians and reptiles of Wildsumaco Wildlife Sanctuary, Napo Province, Ecuador. *Check List. The Journal of Biodiversity Data* 17:729–751. doi: https://doi.org/10.15560/17.3.729.

Cole C.J., Townsend C.R., Reynolds R.P., MacCulloch R.D., Lathrop A. 2013. Amphibians and reptiles of Guyana, South America: illustrated keys, annotated species accounts, and a biogeographic synopsis. *Proceedings of the Biological Society of Washington* 125:317–578.

Daly J.W., Garraffo H.M., Spande T.F., Clark V.C. 2002. Alkaloids from frog skin: the discovery of epibatidine and the potential for developing novel non-opioid analgesics. *Natural Product Reports* 19:105–117. doi: https://doi.org/10.1039/a900728h.

Duellman W.E. 1978. The biology of an equatorial herpetofauna in Amazonian Ecuador. University of Kansas Museum of Natural History, Kansas.

Duellman W.E., Trueb L. 1994. Biology of amphibians. Johns Hopkins University Press, Baltimore and London.

Duellman W.E. 1997. Amphibians of La Escalera region, southeastern Venezuela: Taxonomy, ecology, and biogeography. *Scientific Papers* 2:1–52.

Ferreira R.B., Lourenço-de-Moraes R., Zocca C., Duca C., Beard K.H., Brodie E.D. 2019. Antipredator mechanisms of post-metamorphic anurans: a global database and classification system. *Behavioral Ecology and Sociobiology* 73:1–21. doi: http://dx.doi.org/10.1007/s00265-019-2680-1.

Frost D.R., Grant T., Faivovich J., Bain R.H., Haas A., Haddad C.F.B., Wheeler W.C. 2006. The amphibian tree of life. *Bulletin of the American Museum of Natural History* 297:1–291. doi: https://doi.org/10.1206/0003-0090(2006)297[0001:TATOL]2.0.CO;2.

Gomes M.R., Peixoto O.L. 2009. Geographic distribution: *Dendropsophus marmoratus. Herpetological Review* 40:445.

Haddad C.F.B., Toledo L.F., Prado C.P.A., Loebmann D., Gasparini J.L., Sazima I. 2013. Guia dos Anfíbios da Mata Atlântica: Diversidade e Biologia. Anolis Books, São Paulo.

Jared C., Antoniazzi M.M., Navas C.A., Katchburian E., Freymüller E., Tambourgi D.V., Rodrigues M.T. 2009. Parotoid macroglands in toads (*Rhinella jimi*): Their structure and functioning in passive and active defense. *Toxicon* 54:197–207. doi: https://doi.org/10.1016/j.toxicon.2009.03.029.

Jared C., Antoniazzi M.M., Navas C.A., Katchburian E., Freymüller E., Tambourgi D.V., Rodrigues M.T. 2011. Head co-ossification, phragmosis and defence in the casque-headed tree frog *Corythomantis greeningi*. *Journal of Zoology* 285:189–195. doi: https://doi.org/10.1017/S0952836904005953.

Köhler J. 1995. Erstnachweis von *Hyla marmorata, Leptodactylus syphax und Phrynopus pervianu*s für Bolivien. *Weinstadt* 17:6–8.

Laurenti J.N. 1768. Specimen Medicum, Exhibens Synopsin Reptilium Emendatum cum Experimentis Circa Venena et Antidota Reptilium Austriacorum. Joan. Thom. nob. de Trattnern., Austria.

Lötters S., Riva I., Reichle S., Soto G. 2000. First records of *Bufo guttatus* from Bolivia with comments on

Bufo glaberrimus (Amphibia: Bufonidae). *Bonner Zoologische Beiträge* 49:75–78.

Martins M., Haddad C.F.B. 1990. On the occurrence of *Dendrobates quinquevittatus* (Steindachner) in Brazil (Amphibia, Anura, Dendrobatidae). *Memórias do Instituto Butantan* 52:53–56.

Medeiros L.A., Ribas C.C., Lima A.P. 2021. Genetic diversification of *Adelphobates quinquevittatus* (Anura: Dendrobatidae) and the influence of Upper Madeira River historical dynamics. *Evolutionary Biology* 48:269–285. doi: https://doi.org/10.1007/s11692-021-09536-y.

Metcalf M.F., Marsh A., Pacaya E.T., Graham D., Gunnels C.W. 2020. Herpetofauna of the Santa Cruz Forest Reserve in the Peruvian Amazon Basin. *Herpetology Notes* 13:753–767.

Ouboter P.E., Jairam R. 2012. Amphibians of Suriname. Brill, Leiden.

Rodríguez L.O., Duellman W.E. 1994. Guide to the frogs of the Iquitos region, Amazonian Peru. Asociación de Ecología y Conservación, Kansas.

Saporito R.A., Donnelly M.A., Jain P., Garraffo H.M., Spande T.F., Daly J.W. 2007. Spatial and temporal patterns of alkaloid variation in the poison frog *Dendrobates pumilio. Biochemical Systematics and Ecology* 35:877–885. doi: https://doi.org/10.1016/j.toxicon.2007.06.022.

Schneider J.G. 1799. Historia Amphibiorum Naturalis et Literarariae. Fasciculus Primus. Continens Ranas, Calamitas, Bufones, Salamandras et Hydros in Genera et Species Descriptos Notisque suis Distinctos. Friederici Frommanni, Jena.

Silva F.R., Almeida-Neto M., Prado V.H.M., Haddad C.F.B., Rossa-Feres D.C. 2018. Humidity levels drive reproductive modes and phylogenetic diversity of amphibians in the Brazilian Atlantic Forest. *Journal of Biogeography* 45:1667–1677. doi: https://doi.org/10.1111/j.1365-2699.2012.02726.x.

Steindachner F. 1864. Batrachologische Mittheilungen. *Verhandlungen des Zoologisch-Botanischen Vereins in Wien* 14:239–288.

Stuart S.N., Hoffmann M., Chanson J.S., Cox N.A., Berridge R.J., Ramani P., Young B.E. 2008. Threatened amphibians of the world. Lynx Edicions, Spain; IUCN, Switzerland and Conservation International, USA.

Taucce P.P.G., Costa-Campos C.E., Carvalho T.R., Michalski F. 2022. Anurans (Amphibia: Anura) of the Brazilian state of Amapá, eastern Amazonia: species diversity and knowledge gaps. *European Journal of Taxonomy* 836:96–130. doi: https://doi.org/10.5852/ejt.2022.836.1919.

Toledo L.F. 2005. Predation of juvenile and adult anurans by invertebrates: current knowledge and perspectives. *Herpetological Review* 36:395–400.

Toledo L.F., Haddad C.F.B. 2009. Defensive vocalizations of Neotropical anurans. *South American Journal of Herpetology* 4:25–42. doi: https://doi.org/10.2994/057.004.0104.

Toledo L.F., Sazima I., Haddad C.F.B. 2011. Behavioural defences of anurans: an overview. *Ethology Ecology and Evolution* 23:1–25. doi: https://doi.org/10.1080/03949370.2010.534321.

Toledo L.F., Martins I.A., Bruschi D.P., Passos M.A., Alexandre C., Haddad C.F.B. 2015. The anuran calling repertoire in the light of social context. *Acta Ethologica* 18(2):87–99. doi: 10.1007/s10211-014-0194-4.

Williams C.R., Brodie E.D. Jr., Tyler M.J., Walker S.J. 2000. Antipredator Mechanisms of Australian Frogs. *Herpetological Journal* 34:431–443. doi: https://doi.org/10.2307/1565367.

Video Caption

Video. Escape response in Rhaebo guttatus showing synchronization between audible expiratory sounds while jumping.



Natalia S. C. is a Brazilian biologist from the state of Espírito Santo. She is currently pursuing her Master's degree in Biodiversity at São Paulo State University (UNESP). She is a member of both the Laboratory of Evolutionary Biology and Systematics of Current Tetrapods (LaBESTA) and the Herpeto Capixaba Project. Her research interests focus on the ecology, natural history, and conservation of Neotropical anurans.



Thiago S. S. is a Brazilian biologist from Espírito Santo, with a Master's degree (2010) and a PhD (2015) in Zoology (Herpetology) from the National Museum, Federal University of Rio de Janeiro. He is the founder of Herpeto Capixaba, a research and conservation initiative focused on Brazilian amphibians and reptiles, currently affiliated with the Instituto Últimos Refúgios. His research interests include taxonomy, natural history, species distribution, and conservation of Neotropical herpetofauna..