

Preliminary inventory of the anuran fauna of the Mata Estrela Private Natural Heritage Reserve, in the Atlantic Forest of the State of Rio Grande do Norte, Brazil

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ABSTRACT

Tropical regions harbor the highest amphibian biodiversity, nevertheless, information on species composition is lacking in most areas yet these baseline data are essential to guide conservation strategies. The goal of the present study was to survey the anurans of a Private Natural Heritage Reserve named Mata Estrela, a fragment of about 26 km² in the Northern Atlantic Forest, Brazil. The study was carried out as an active census in June 2015. We found 27 anuran species assigned to five families: Bufonidae (2 spp.), Craugastoridae (1 sp.), Hylidae (11 spp.), Leptodactylidae (12 spp.) and Phyllomedusidae (1 sp.). All species are widespread in the Atlantic forest as well as in other South American ecoregions. Descriptions of local diversity such as this one are a fundamental baseline for conservation work and are especially needed in the northern limits of the Atlantic forest, for which there is still a huge lack of biological knowledge.

Key Words: Amphibians, Anurofauna, Species Richness, Diversity.

The Neotropical region harbours the highest amphibian diversity in the world (Baillie *et al.*, 2010). For example, South America hosts about three times more amphibian species than Africa (Wells, 2007), and Brazil leads in amphibian diversity worldwide

with ca. 14% of the over 8 000 current amphibian species (AmphibiaWeb, 2021). More than half of the Brazilian amphibian diversity is found in the threatened Atlantic Forest, characterized by a high degree of endemism with over 80% of anuran species

restricted to this ecoregion (Rossa-Feres *et al.*, 2017).

Originally the Atlantic Forest extended for ca. 1300 km² in the east coast of Brazil. Currently, however, only 11% of its original vegetation remains in very fragmented pieces (Ribeiro *et al.*, 2009; Tabarelli *et al.*, 2010). The northern Atlantic Forest is currently in its worst state of conservation, with most fragments covering less than 100 km², and almost half of the remaining forest is less than 100 m from the forest edges (Ribeiro *et al.*, 2009). The northern Atlantic Forest is presently in its most dire state of conservation (Ribeiro *et al.*, 2009). This scenario reinforces the need for amphibian surveys in the northern fragments as the rapid and ongoing decline of amphibians worldwide is mainly related to anthropogenic actions (Stuart *et al.*, 2004; Lips *et al.*, 2005; Verdade *et al.*, 2012). Recent efforts have been directed to uncover amphibian diversity in the northern Atlantic Forest (e.g. Santana *et al.*, 2008; Morato *et al.*, 2011; Pazinato *et al.*, 2013; Palmeira and Gonçalves 2015; Pereira *et al.*, 2016; Barbosa *et al.*, 2017; Leite-Filho *et al.*, 2017; Roberto *et al.*, 2017; Dubeux *et al.*, 2020), but some gaps still need to be filled. Understanding which species occur in a certain region is the first step for conservation management (Vilela *et al.*, 2018).

In this work, our objective was to carry out a rapid inventory of the anuran fauna in the private reserve of the Mata Estrela natural heritage, a fragment of Atlantic Forest located in the municipality of Baía Formosa, State of Rio Grande do Norte, Brazil.

The anuran survey was carried out in the Private Natural Heritage Reserve Mata Estrela (RPPN Mata Estrela) (06°22'53"South, 35°01'06"West; WGS 84; 34 m a.s.l.; Fig. 1), municipality of Baía Formosa, Rio Grande do Norte State, Brazil. This protected area is 20,35 km² and mainly covered by semideciduous forest (18,88 km²), sand dunes (0,82 km²) and lagoons (0,65 km²) (Govindin and Miller, 2015). The climate is classified as tropical with dry summers (according with Köppen criteria, Alvares *et al.*, 2013) and annual temperature and rainfall of 25.8 °C and 1504 mm, respectively (EMPARN, 2019). The vegetation is composed mainly by ombrophilous forest (Dorado *et al.*, 2006).

We sampled the study area for two nights (June 3 and 4, 2015). Individuals were located by active search (visual and acoustic encounter searches) in nocturnal transects in the middle of the forest lasting at least one hour each and in reproductive places such as puddles in roads, lakes and weirs.

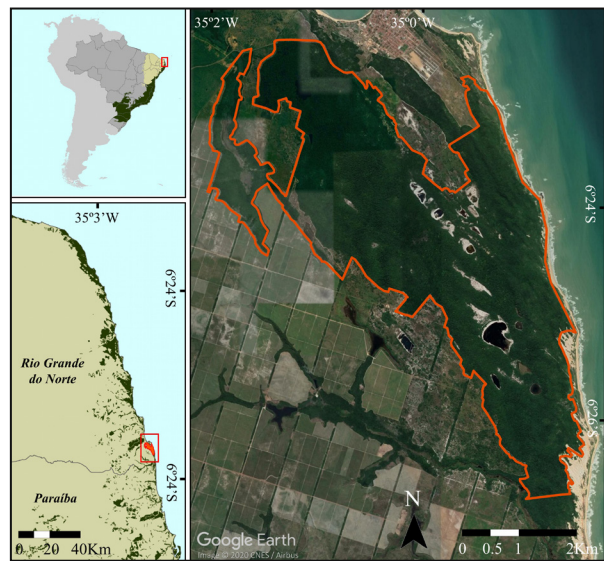


Figure 1. Satellite image of the Private Natural Heritage Reserve Mata Estrela (with boundaries shown in orange). Inset map is South America with rectangle showing the study area.

Two transects were carried out in the forest, one on the road at the edge of the forest and three around lakes and weirs. During each transect (between 17:00 – 23:00 h), 12 hours/collector were invested, where six observers walked slowly with headlights in search of frogs under the leaves or branches of bushes, moving litter and felling trunks and branches in all microhabitats suitable for the presence of frogs (Heyer *et al.*, 1994) (Fig. 2).

All observed individuals were registered, and at least five individuals of each species was collected (Collection authorization ICMBio/SISBIO 48770) and deposited in the *Coleção Herpetológica do Museu de História Natural of Universidade Federal de Alagoas* (MHN-UFAL) following the standard protocol of euthanasia and fixation (Resolução CFMV N°



Figure 2. Survey sites of Private Natural Heritage Reserve Mata Estrela, municipality of Baía Formosa, Rio Grande do Norte state, Brazil. A – C: lagoons; D: temporary pool.

1000 de 11 de maio de 2012). Morphological identification was performed using available literature, consulting specialists, and the taxonomy followed Frost (2021).

The conservation status of each species was based on the Red List of the International Union for the Conservation of Nature and Natural Resources (IUCN, 2022) and the *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (ICMBio, 2018). The geographic distribution of the observed anurans was obtained from Haddad *et al.* (2013) and Frost (2021).

In total, 1122 individuals of anurans of 27 species, eleven genera and five families were recorded visually (68.7%) and/or vocally (31.3%). One-hundred twenty one specimens were collected, to compose the witness material. Leptodactylidae and Hylidae were the most diverse families with twelve and eleven species, respectively, followed by Bufonidae (two species), Craugastoridae and Phyllomedusidae (one species each; Table 1; Figs. 3 – 5). The most abundant species was *Scinax nebulosus* (Spix, 1824) (119) and together with *Pseudopaludicola mystacalis* (Cope, 1887) (112), *Dendropsophus branneri* (Cochran, 1948) (89), *Pleurodema diplo-lister* (Peters, 1870) (82), *Scinax x-signatus* (Spix, 1824) (76), *Leptodactylus fuscus* (Schneider, 1799) (61), *Pristimantis ramagii* (Boulenger, 1888) (56), *Leptodactylus troglodytes* Lutz, 1926 (52), *Dendropsophus oliveirai* (Bokermann, 1963) (51), *D. nanus* (Boulenger, 1889) (45), *Leptodactylus macrosternum* Miranda-Ribeiro, 1926 (45), and *Pseudopaludicola pocoto* Magalhães, Loebmann, Kokubum, Haddad, and Garda, 2014 (45) were responsible for 74% of the records (n = 833) (Fig. 6). All species were classified as least concern according to ICMBio (2018) and IUCN (2022), except *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo and Bruschi, 2020”, which was not evaluated so far.

Only three anuran surveys are available for the Atlantic Forest fragments located less than 100 km from the RPPN Mata Estrela. The Guaribas Biological Reserve (REBio Guaribas, Paraíba) is 33 km south of the RPPN and has an area of 43,21 km², formed by several formations with a predominantly flat landscape, with fragments of savannah, Atlantic Forest, Semideciduous Seasonal Forest and tableland vegetation, where thirty-four species of frogs were recorded using drop traps and 9720 hours/person of active search (Mesquita *et al.*, 2018). Another survey in Paraíba was carried out in the Benjamim Maranhão Botanical Garden (Mata do Buraquinho),

88 km south of the Mata Estrela RPPN, an area of 5,15 km², comprising typical Atlantic Forest vegetation. Sixteen species of anurans were recorded in 60 days of sampling effort distributed over a year (August 2011 to July 2012, Leite-Filho *et al.*, 2017). At the Escola Agrícola de Jundiaí, state of Rio Grande do Norte, 70 km north of the Mata Estrela RPPN, it is characterized by direct contact between Caatinga and Atlantic Forest, 34 species of anurans were recorded during 11 months of active survey and is characterized by vegetation of Caatinga and Atlantic Forest (Magalhães *et al.*, 2013). Each of these locations have peculiarities that can influence their compositions (Moraes *et al.*, 2007; Gambale *et al.*, 2014). For example, the Mata do Buraquinho is isolated in a densely populated region, under great pressure from the surrounding communities (Santana *et al.*, 2008). A different situation from Mata Estrela and REBio Guaribas, which are in sugarcane plantation areas, despite having areas in contact with urbanized stretches, do not suffer to the same degree (Govindin and Miller, 2015; Mesquita *et al.*, 2018). On the other hand, the Escola Agrícola de Jundiaí, despite being outside the sugarcane plantation areas, is located in an important food production hub for the region (Marinho *et al.*, 2021). Hylidae and Leptodactylidae were the most diverse families in the RPPN Mata Estrela. This result was similar to other surveys in the northern Atlantic Forest, for example (Santana *et al.*, 2008; Palmeira and Gonçalves 2015; Leite-Filho *et al.*, 2017 and Melo *et al.*, 2018; Mesquita *et al.*, 2018; Dubeux *et al.*, 2020). Hylids have many morphological adaptations to several types of environments (the presence of adhesive discs in their fingers, for example) that allow them to explore a greater diversity of surfaces (Cardoso *et al.*, 1989). Leptodactylids are ecologically generalists that are resistant to open areas, with most species depending on the presence of water bodies for their reproduction (Coelho and Oliveira, 2010).

An investment of more days in the field, respecting seasonality, combined with other complementary methods for sampling anurans (such as drop traps), as well as in other available environments, not sampled in this study, may reveal greater species richness. In fact, nocturnal searching, especially in water bodies has been shown to be more efficient to record large numbers of anuran species because they are water dependent for their reproduction (Brassaloti *et al.*, 2010). Nevertheless some authors have recommended the use of more than one

Table 1. Species of anuran amphibians collected on 3 and 4 June 2015 at a Private Natural Heritage Reserve Mata Estrela, Baía Formosa, Rio Grande do Norte state, Brazil.

Species	Conservation status		Enviroments		Geographic distribution
	Forest	Open areas	Forest	Open areas	
BUFONIDAE					
<i>Rhinella granulosa</i> (Spix, 1824)	Least Concern (LC)		Sandy soil	Sandy soil and clayey	In the Brazil, Pará, Maranhão to Piauí, Ceará, and Alagoas, south to Rio Grande do Sul and Espírito Santo. Inland Paraguay to Amazonian and eastern Bolivia; and southwest to northern and central Argentina and northern Uruguay.
<i>Rhinella diptycha</i> (Cope, 1862)	Data Deficient (DD)		Sandy soil and clayey	Sandy soil and clayey, streams, temporary and permanent ponds and weirs edge	
CRAUGASTORIDAE					
<i>Pristimantis ramagii</i> (Boulenger, 1888)	Least Concern (LC)		Tree branch, edge vegetation of streams and vegetation of temporary ponds	Edge vegetation of temporary ponds and weirs	From RN to BA.
HYLIDAE					
<i>Boana albomarginata</i> (Spix, 1824)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds and vegetation in dams	In Brazil from RN to SC. Apart from Colombia to Guianas.
<i>Boana crepitans</i> (Wied-Neuwied, 1824)	Least Concern (LC)		Tree branches	Vegetation in temporary and permanent ponds and vegetation in dams	GO, MG, RJ, BA, SE, AL, PE and PB.
<i>Boana ranceps</i> (Cope, 1862)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds and vegetation in dams	Colombia, Venezuela, French Guiana, Paraguay, Argentina and Brazil in AL, AM, BA, CE, MG, MS, MT, MA, PA, PB, PE, PI, PR, RJ, RN, SE and SP.
<i>Boana</i> sp.	–		Tree branches	–	PE, AL, SE, BA, MG, ES, RJ, RN and PB.
<i>Dendropsophus branneri</i> (Cochran, 1948)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds	Colombia, Venezuela, Guianas, Trindade, Ecuador, Peru, Bolivia, Paraguay, Uruguay and Argentina. In all of Brazil.
<i>Dendropsophus minutus</i> (Peters, 1872)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds	Northeast to the extreme South of Brazil. Suriname, French Guiana, Paraguay, Argentina, Bolivia and Uruguay.
<i>Dendropsophus nanus</i> (Boulenger, 1889)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds.	From RJ to RN.
<i>Dendropsophus oliveirai</i> (Bokermann, 1963)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds	South, Central and Eastern of Brazil (PI, CE and AM), Bolivia, Paraguay, Argentina, Venezuela, Guiana and Suriname.
<i>Scinax fuscomarginatus</i> (A. Lutz, 1925)	Least Concern (LC)		–	Vegetation in temporary and permanent ponds	

<i>Scinax nebulosus</i> (Spix, 1824)	Least Concern (LC)	-	Vegetation in temporary and permanent ponds and vegetation in dams	Venezuela, Guianas and Bolivia. In Brazil, from low amazon river to Alagoas.
<i>Scinax x-signatus</i> (Spix, 1824)	Least Concern (LC)	-	Vegetation in temporary ponds	Colombia, Venezuela andd Suriname. Eastern, south and southeast of Brazil.
LEPTODACTYLIDAE				
<i>Adenomera hylaedactyla</i> (Cope, 1868)	Least Concern (LC)	-	-	Colombia, Venezuela, Guianas, Ecuador, Peru and Bolivia. From south to north, eastern and central of Brazil.
<i>Leptodactylus fuscus</i> (Schneider, 1799)	Least Concern (LC)	-	Herbaceous vegetation with soggy soil and edge of temporary ponds	Panama, Andes, Bolivia, Paraguay and Argentina; south to southeast of Brazil.
<i>Leptodactylus macrosternum</i> Miranda-Ribeiro, 1926	Least Concern (LC)	Sandy soil near temporary ponds	Sandy soil near temporary ponds and edge of dams	Colombia, Venezuela, Guianas, Bolivia, Trindade and Brazil.
<i>Leptodactylus mystaceus</i> (Spix, 1824)	Least Concern (LC)	Edge of temporary ponds	Herbaceous vegetation with soggy soil	Amazon to the southern limit of Brazil for Bolivia, Peru, Ecuador, Colombia, Venezuela and Guianas. Isolated records from Northeastern Brazil to the south of PN
<i>Leptodactylus natalensis</i> A. Lutz, 1930	Least Concern (LC)	-	Herbaceous vegetation with soggy soil and temporary ponds	Coastal region of Brazil: MA, RN to RJ
<i>Leptodactylus podicipinus</i> (Cope, 1862)	Least Concern (LC)	Herbaceous vegetation with soggy soil	Herbaceous vegetation with soggy soil and temporary ponds	Paraguay, Argentina, Bolivia and Uruguay. In Brazil, central part extending along the Madeira River and the Amazon River in the Amazon Basin.
<i>Leptodactylus troglodytes</i> A. Lutz, 1926	Least Concern (LC)	Herbaceous vegetation with soggy soil	Herbaceous vegetation with soggy soil and temporary ponds	Northeast Brazil to MG.
<i>Leptodactylus vastus</i> (Lutz 1930)	Least Concern (LC)	-	Edge of temporary ponds	Northeast Brazil
<i>Physalaemus cuvieri</i> Fitzinger, 1826	Least Concern (LC)	-	Herbaceous vegetation with soggy soil	Northeast, central and southern Brazil; Argentina, Paraguay, Bolivia and Venezuela.
<i>Pleurodema diplolister</i> (Peters, 1870)	Least Concern (LC)	Sandy soil near temporary pools	Sandy soil edge near temporary ponds and edge of dams	Northeast Brazil in the Caatinga region of MA, PB, TO, BA, GO and MG.
<i>Pseudopaludicola mystacalis</i> (Cope, 1887)	Least Concern (LC)	-	Herbaceous vegetation with soaked soil, edge of dams, edge of streams and temporary ponds.	South and east of Brazil. Bolivia, Paraguay, Argentina and Uruguay.
<i>Pseudopaludicola pocoto</i> Magalhães, Loebmann, Kokubum, Haddad & Garda, 2014	-	-	Herbaceous vegetation with soaked soil, edge of dams, edge of streams and temporary ponds.	Northeast Brazil in caatinga regions in the CE, PI, RN, PB and PE. An isolated log in the east of MG.
PHYLLOMEDUSIDAE				
<i>Pithecopus gonzagai</i> Andrade, Haga, Ferreira, Recco-Pimentel, Toledo, and Bruschi, 2020.	Not Evaluated (NE)	-	Vegetation in temporary and permanent ponds and vegetation of dams	RN, PB, PE, AL, CE, PI and MA.

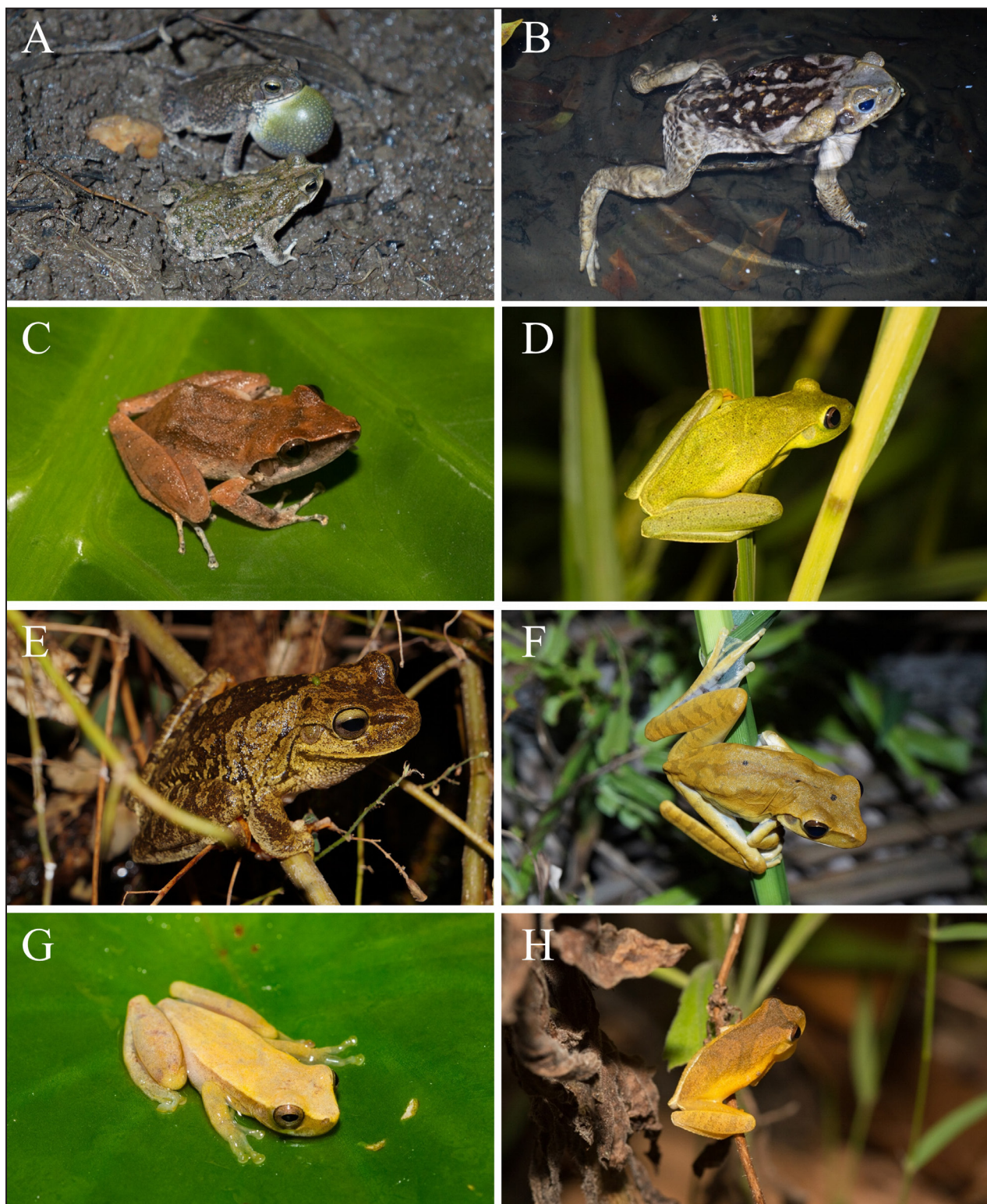


Figure 3. Anurans of the Private Natural Heritage Reserve Mata Estrela, municipality of Baía Formosa, Rio Grande do Norte State, Brazil. **A.** *Rhinella granulosa* (Spix, 1824). **B.** *R. diptycha* (Cope, 1862). **C.** *Pristimantis ramagii* (Boulenger, 1888). **D.** *Boana albomarginata* (Spix, 1824). **E.** *B. crepitans* (Wied-Neuwied, 1824). **F.** *B. raniceps* (Cope, 1862). **G.** *Dendropsophus branneri* (Cochran, 1948). **H.** *D. minutus* (Peters, 1872).

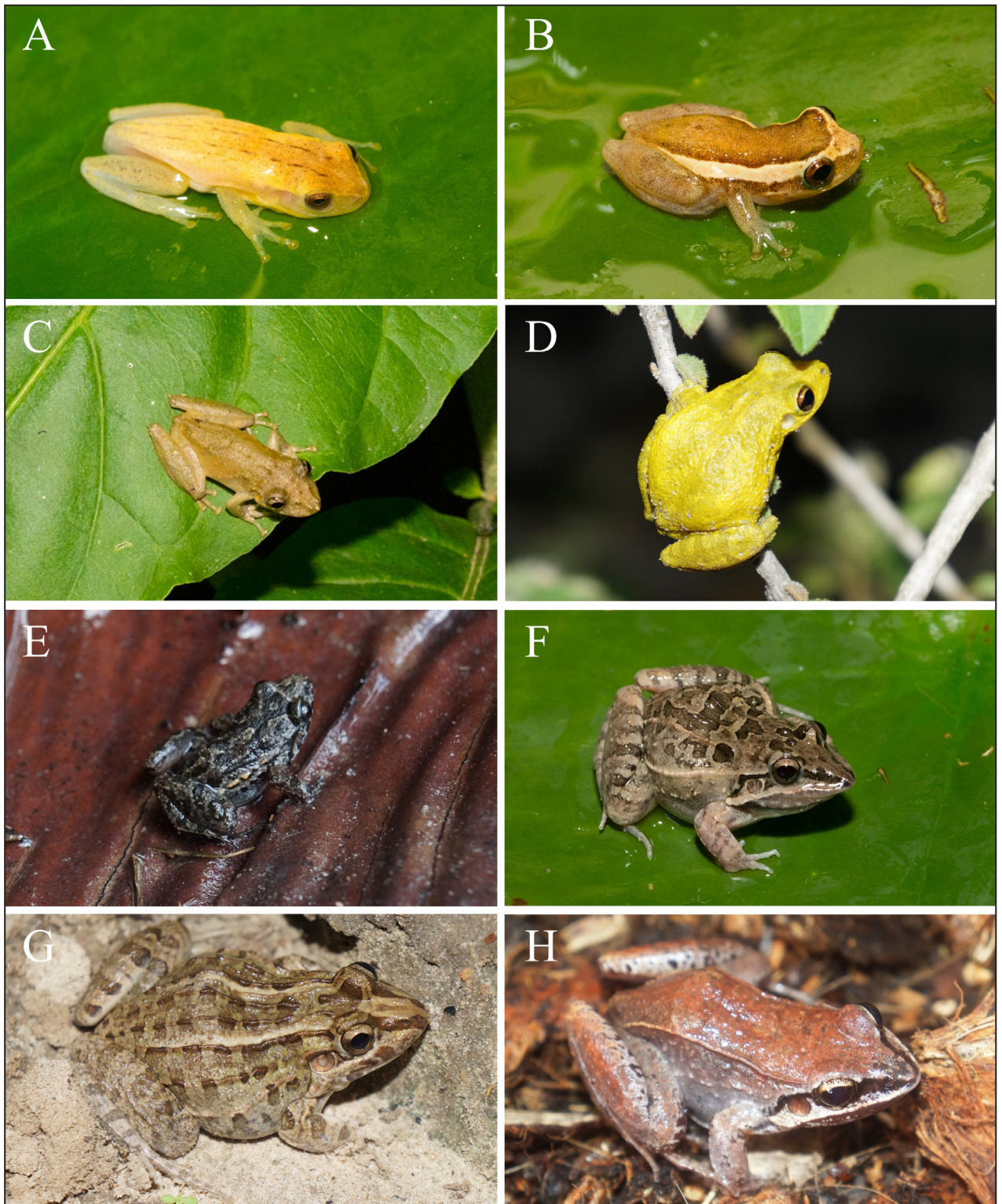


Figure 4. Anurans of the Private Natural Heritage Reserve Mata Estrela, municipality of Baía Formosa, Rio Grande do Norte State, Brazil. **A.** *Dendropsophus nanus* (Boulenger, 1889). **B.** *D. oliveirai* (Bokermann, 1963). **C.** *Scinax nebulosus* (Spix, 1824). **D.** *S. fuscovarius* (Lutz, 1925). **E.** *Adenomera hylaedactyla* (Cope, 1868). **F.** *Leptodactylus fuscus* (Schneider, 1799). **G.** *L. macrosternum* Miranda-Ribeiro, 1926. **H.** *L. mystaceus* (Spix, 1824).



Figure 5. Anurans of the Private Natural Heritage Reserve Mata Estrela, municipality of Baía Formosa, Rio Grande do Norte State, Brazil. A. *Leptodactylus natalensis* Lutz, 1930. B. *L. podicipinus* (Cope, 1862). C. *L. troglodytes* Lutz, 1926. D. *L. vastus* Lutz, 1930. E. *Physalaemus cuvieri* Fitzinger, 1826. F. *Pleurodema diplolister* (Peters, 1870). G. *Pseudopaludicola mystacalis* (Cope, 1887). H. *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo, and Bruschi, 2020.

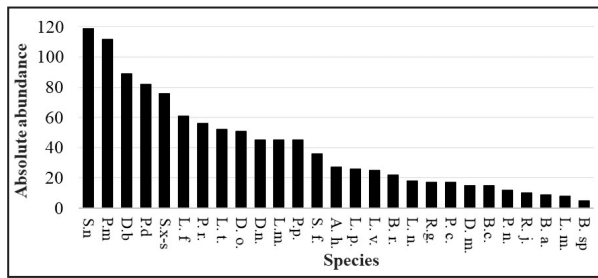


Figure 6. Total number of anurans recorded in the Private Natural Heritage Reserve Mata Estrela, municipality of Baía Formosa, Rio Grande do Norte State, Brazil between June 03 – 04, 2015 ($N = 1122$). *Scinax nebulosus*, *Pseudopaludicola mystacalis*, *Dendropsophus branneri*, *Pleurodema diplolister*, *Scinax x-signatus*, *Leptodactylus fuscus*, *Pristimantis ramagii*, *Leptodactylus troglodytes*, *Dendropsophus oliveirai*, *Dendropsophus nanus*, *Leptodactylus macrosternum*, *Pseudopaludicola pocoto*, *Scinax fuscocomarginatus*, *Adenomera hylaedactyla*, *Leptodactylus podicipinus*, *Leptodactylus vastus*, *Boana raniceps*, *Leptodactylus natalensis*, *Rhinella granulosa*, *Physalaemus cuvieri*, *Dendropsophus minutus*, *Boana crepitans*, *Pithecopus gonzagai*, *Rhinella diptycha* (Cope, 1862), *Boana albomarginata*, *Leptodactylus mystaceus*, *Boana* sp.

sampling method to optimize the area and increase the number of species recorded (Ribeiro-Júnior *et al.*, 2008; Condez *et al.*, 2009; Fonseca *et al.*, 2019).

Environmental impacts caused by anthropogenic actions comprise the majority of the responsibility for biodiversity loss. Private protected areas such as the RPPN Mata Estrela preserve essential environmental conditions to sustain populations of amphibians and other vertebrates dependent on forested habitats (e.g. *Alouatta belzebul* (Linnaeus, 1766), the Guariba monkey). Thus, the Mata Estrela RPPN can be considered an important area of the Atlantic Forest in its northern portion, with a good level of conservation.

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Literature cited

- Alvares, C.A.; Stape, J.L.; Sentelhas, P.C.; Gonçalves, J.L.M. & Sparovek, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711–728. DOI: 10.1127/0941-2948/2013/0507.
- AmphibiaWeb. 2021. <<https://amphibiaweb.org>> University of California, Berkeley, CA, USA. Accessed 16 July 2021.
- Baillie, J.E.M.; Griffiths, J.; Turvey, S.T.; Loh, J. & Collen, B. 2010. *Evolution Lost: Status and Trends of the World's Vertebrates*. Zoological Society of London. London.
- Barbosa, A.R. & Alves, I.T.L.S. 2014. Diversidade e uso de hábitat da anurofauna em um fragmento de um brejo de altitude. *Gaia Scientia* 8: 215–25.
- Barbosa, V.N.; Pereira, E.N. & Maranhão, E.S. 2017. Anfíbios da Estação Ecológica de Caetés Paulista, Pernambuco - atualização da lista de espécies. *Revista de Ciências Ambientais* 11: 39–49. DOI: 10.18316/rca.v11i2.3003.
- Brassaloti, R.A.; Rossa-Feres, D.C. & Bertoluci, J. 2010. Anurofauna da Floresta Estacional Semidecidual da Estação Ecológica dos Caetés, Sudeste do Brasil. *Biota Neotropica* 10(1): 275–291. DOI: 10.1590/S1676-06032010000100024.
- Cardoso, A.J.; Andrade, G.V. & Haddad, C.F.B. 1989. Distribuição espacial em comunidades de anfíbios (Anura) no sudeste do Brasil. *Revista Brasileira de Biologia* 49: 241–249.
- CFMV - Conselho Federal de Medicina Veterinária. 2012. Resolução do Conselho Federal de Medicina Veterinária Nº 1000 de 11 de maio de 2012. Dispõe sobre procedimentos e métodos de eutanásia em animais e dá outras providências. Available in: <<http://portal.cfmv.gov.br/lei/index/id/326>> Accessed on: 2 March 2020.
- Coelho, H.E.A. & Oliveira, R.S. 2010. Anurofauna de um fragmento de Mata Atlântica em Lauro de Freitas - Bahia. *Revista Virtual* 6: 52–60.
- Colwell, R.K. 2016. EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.10. User's guide and application published online. Available in: <http://viceroy.eeb.uconn.edu/estimates>. Accessed on: 2 March 2020.
- Condez, T.H.; Sawaya, R.J. & Dixo, M. 2009. Herpetofauna dos remanescentes de Mata Atlântica da região de Tapiraí e Piedade, SP, sudeste do Brasil. *Biota Neotropica* 9: 157–186. DOI: 10.1590/S1676-06032009000100018.
- Dorado, A.; Melero, M.G.; Gomes, E.P.C.; Damato, M. & Cavana, D. 2006. Unidades de vegetação da Mata Estrela, município de Baía Formosa – RN. In: Anais III Simpósio Regional de Geoprocessamento e Sensoriamento Remoto. Resumo expandido, Geonordeste, Aracaju, 1–5.
- Dubeux, M.J.M.; Gonçalves, U.; Nascimento, F.A.C. & Mott, T. 2020. Anuran amphibians of a protected area in the northern Atlantic Forest with comments on topotypic and endangered populations. *Herpetology Notes* 13: 61–74.
- EMPARN. 2019. Governo do Estado do Rio Grande do Norte. Empresa de Pesquisa Agropecuária do Rio Grande do Norte – EMPARN. Monitoramento Pluviométrico - Análise de chuvas no ano (RN). Available in: <<http://meteorologia.emparn.rn.gov.br:8181/monitoramento/2019.htm>>. Accessed on: 25 March 2020.
- Fonseca, W.L.; Silva, J.D.; Abegg, A.D.; Rosa, C.M. & Bernarde,

C. Palmeira *et al.* — Anurans in a fragment in the Northern Atlantic Forest

- P.S. 2019. Herpetofauna of Porto Walter and surrounding areas, Southwest Amazonia, Brazil. *Herpetology Notes* 12: 91-107.
- Frost, D.R. 2021. Amphibian Species of the World: An Online Reference. Version 6.1. Available in: <http://research.amnh.org/herpetology/amphibia/index.html>. Accessed on: 16 July 2021.
- Gambale, P.G., Woitovicz-Cardoso, M., Vieira, R.R., Batista, V.G., Ramos, J., Bastos, R.P. 2014. Composição e riqueza de anfíbios anuros em remanescentes de Cerrado do Brasil Central. *Iheringia, Série Zoologia* 104: 50-58.
- Gotelli, N.J. & Colwell, R.K. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4: 379-391.
- Govindin, J.L.S. & Miller, E.S. 2015. Práticas sociais e simbólicas: comunidade de pescadores e unidade de conservação em Baía Formosa/RN. *Sociedade & Natureza* 27: 125-139. DOI: 10.1590/1982-451320150109.
- Haddad, C.F.B. & Sazima, I. 1992. Anfíbios anuros da Serra do Japi: 188-211. In: Morellato, L.P.C. (ed.), História Natural da Serra do Japi: Ecologia e preservação de uma área florestal no Sudeste do Brasil. Editora da Unicamp/ FAPESP. Campinas.
- 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.
- Heyer, W.R.; Donnelly, M.A.; McDiarmid, R.W.; Hayek, L.C. & Foster, M.S. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution. Washington.
- ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade. 2018. Biodiversidade. Fauna Brasileira. Lista de Espécies Ameaçadas. Available in: <http://www.icmbio.gov.br/portal/biodiversidade/fauna-brasileira/lista-de-especies.html>. Accessed on: 20 March 2020.
- IUCN 2022. The IUCN Red List of Threatened Species. Version 2021-3. <<https://www.iucnredlist.org>> Accessed on: 27 April 2022.
- Júnior, A.P.P.; Campos, C.E.C. & Araújo, A.S. 2013. Composição e diversidade de anfíbios anuros do campus da Universidade Federal do Amapá. *Biota Amazônia* 3: 13-21. DOI: 10.18561/2179-5746/biotaamazonia.v3n1p13-21.
- Krebs, C.J. 1999. Ecological Methodology. Addison Welsey Educational Publishers. Inc.. Menlo Park. Califórnia.
- Leite-Filho, E.; Oliveira, F.A.; Eloi, F.J.; Liberal, C.N.; Lopes, A.O. & Mesquita, D.O. 2017. Evolutionary and Ecological Factors Influencing an Anuran Community Structure in an Atlantic Rainforest Urban Fragment. *Copeia* 105: 64-74. DOI: 10.1643/CH-15-298
- Lips, K.R.; Burrows, P.A.; Mendelson, J.R. & Parra-Olea, G. 2005. Amphibian population declines in Latin America: a synthesis. *Biotropica* 37: 222-226. DOI: 10.1111/j.1744-7429.2005.00029.x.
- Maffei, F.; Ubaid, F.K. & Jim, J. 2011. Anurofauna em área de cerrado aberto no município de Borebi, estado de São Paulo, Sudeste do Brasil: uso do habitat, abundância e variação sazonal. *Biota Neotropica* 11: 221-233. DOI: 10.1590/S1676-06032011000200023.
- Magalhães, F.M.; Dantas, A.K.B.P.; Brito, M.R.M.; Medeiros, P.H.; Oliveira, A.F.S.; Pereira, T.C.S.O.; Queiroz, M.H.C.; Santana, D.J.; Silva, W.P. & Garda, A.A. 2013. Anurans from an Atlantic Forest-Caatinga ecotone in Rio Grande do Norte State, Brazil. *Herpetology Notes* 6: 1-10.
- Marinho, J.R.D.; Souza, J.B.; Lira, V. M.; Paiva, L.L.; Danino, G.S.; Coutinho, P.W.R.; Mata, T.C.; Medeiros, D.C.; Lopes, D.A.; Demartelaere, A.C.F.; Junior, S.M.; Preston, H.A.F.; Mattos, K.M.C.; Nunes, S.K.S.; Silva, T.P.P.; Preston, W.; Silva, R.M. 2021. Economic analysis and financial viability the production *Manihot esculenta* (Crantz) in rural settlements the municipality Macaíba-RN. *Brazilian Journal of Development, Curitiba* 7: 43363-43404
- Melo, A.S.; Pereira, R.A.S.; Santos, A.J.; Shepherd, G.J.; Machado, G.; Medeiros, H.F. & Sawaya, R.J. 2003. Comparing species richness among assemblages using sample units: Why not use extrapolation methods to standardize different sample sizes? *Oikos* 101: 398-410. DOI: 10.1034/j.1600-0706.2003.11893.x.
- Morato, S.A.A.; Lima, A.M.X.; Staut, D.C.P.; Faria, R.G.; Souza-Alves, J.P.; Gouveia, S.F. & Silva, M.J. 2011. Amphibians and reptiles of the Refúgio de Vida Silvestre Mata do Junco, municipality of Capela, state of Sergipe, northeastern Brazil. *Check List* 7: 756-762. DOI: 10.15560/11015
- Moraes, R.A.; Sawaya, R.J.; Barrella, W. 2007. Composição e diversidade de anfíbios anuros em dois ambientes de Mata Atlântica no Parque Estadual Carlos Botelho, SP. *Biota Neotropica* 7:1-10.
- Oliveira-Filho, F.X.; Miranda, N.O.; Medeiros, J.F.; Silva, P.C.M.; Mesquita, F.O. & Costa, T.K.G. 2016. Compactação de solo cultivado com cana-de-açúcar em Baía Formosa, Rio Grande do Norte. *Revista Ceres* 63: 715-723. DOI: 10.1590/0034-737x201663050017.
- Palmeira, C.N.S. & Gonçalves, U. 2015. Anurofauna de uma localidade na Mata Atlântica setentrional, Alagoas, Brasil. *Boletim do Museu de Biologia Mello Leitao* 37: 149-171.
- Pazinato, D.M.M.; Silva, D.E.; Corrêa, L.L.C. & Cappellari, L.H. 2013. Diversidade de répteis em uma área da região central do Rio Grande do Sul, Brasil. *Perspectiva* 37: 115-122.
- Pereira, E.A.; Neves, M.O.; Hote, P.S.; Santana, D.J. & Feio, R.N. 2016. Anurans of the municipality of Barão de Monte Alto, state of Minas Gerais, southeastern Brazil. *Check List* 12: 1-13. DOI: 10.15560/12.5.1977.
- Pombal-Jr JP, & Gordo M 2004. Anfíbios anuros da Juréia: 243-256. In: Marques, O.A.V. & Duleba, W. (eds), Estação Ecológica Juréia-Itatins. Ambiente físico, flora e fauna Holos editora. Ribeirão Preto.
- Protázio, A.S.; Albuquerque, R.L.; Falkenberg, L.M. & Mesquita, D.O. 2015. Niche differentiation of an anuran assemblage in temporary ponds in the Brazilian semi-arid Caatinga: influence of ecological and historical factors. *Herpetological Journal* 25: 109-121.
- Ribeiro, M.C.; Metzger, J.P.; Martensen, A.C.; Ponzoni, F.J. & Hirota, M.M. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141-1153. DOI: 10.1016/j.biocon.2009.02.021.
- Ribeiro-Júnior, M.A.; Gardner, T.A. & Ávila-Pires, T.C.S. 2008. Evaluating the Effectiveness of Herpetofaunal Sampling Techniques across a Gradient of Habitat Change in a Tropical Forest Landscape. *Journal of Herpetology* 42: 733-749. DOI: 10.1670/07-097R3.1.
- Roberto, I.J.; Oliveira, C.R.; Araújo-Filho, J.A.; Oliveira, H.F. & Ávila, R.W. 2017. The herpetofauna of the Serra do Urubu mountain range: a key biodiversity area for conservation in the Brazilian Atlantic forest. *Papéis Avulsos de Zoologia* 57:

- 347–373. DOI: 10.11606/0031-1049.2017.57.27.
- Rossa-Feres, D.C.; Garey, M.V.; Caramaschi, U.; Napoli, M.F.; Nomura, F.; Bispo, A.A.; Brasileiro, C.R.A.; Thomé, M.T.C.; Sawaya, R.J.; Conte, C.E.; Cruz, C.A.G.; Nascimento, L.B.; Gasparini, J.L.; Almeida, A.P. & Haddad, C.F.B. 2017. Anfíbios da Mata Atlântica: lista de espécies, histórico dos estudos, biologia e conservação: 237–314. *In*: Monteiro-Filho, E.L.A. & Conte, C.E. (orgs), Revisões em Zoologia: Mata Atlântica Editora. UFPR. Curitiba.
- Santana, D.J.; Mangia, S.; Silveira-Filho, R.; Barros, L.C.S.; Andrade, I.; Napoli, M.F.; Juncá, F.A. & Garda, A.A. 2015. Anurans from the Middle Jaguaribe River Region, Ceará State, Northeastern Brazil. *Biota Neotropica* 15: 1–8. DOI: 10.1590/1676-06032015001715.
- Santana, G.G.; Vieira, W.L.; Pereira-Filho, G.A.; Delfim, F.R.; Lima, Y.C. & Vieira, K.S. 2008. Herpetofauna em um fragmento de Floresta Atlântica no estado da Paraíba, Região Nordeste do Brasil. *Biotemas* 21: 75–84. DOI: 10.5007/2175-7925.2008v21n1p75.
- Santos, A.J. 2004. Estimativas de riqueza em espécies: 19–41. *In*: Cullen Jr, L.; Rudran, R. & Valladares-Pádua, C. (orgs.), Métodos de estudos em biologia da conservação e manejo da vida silvestre. Universidade Federal do Paraná (UFPR). Curitiba.
- Santos, E.J. & Conte, C.E. 2016. Diversity of anurans in dry forest fragments of a subtropical region in Brazil. *Anais da Academia Brasileira de Ciências* 88: 1923–1940. DOI: 10.1590/0001-3765201620150698.
- Stuart, S.N.; Chanson, J.S.; Cox, N.A.; Youn, B.E.; Rodrigues, A.S.L. & Fischman, W.R.W. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306: 1788–1786. DOI: 10.1126/science.1103538.
- Tabarelli, M.; Aguiar, A.V.; Ribeiro, M.C.; Metzger, J.P. & Peres, C.A. 2010. Prospects for biodiversity conservation in the Atlantic Forest: Lessons from aging human-modified landscapes. *Biological Conservation* 143: 2328–2340. DOI: 10.1016/j.biocon.2010.02.005.
- Verdade, V.K.; Valdujo, P.H.; Carnaval, A.C.; Schiesari, L.; Toledo, L.F.; Mott, T.; Andrade, G.V.; Eterovick, P.C.; Menin, M.; Pimenta, B.V.S.; Nogueira, C.; Lisboa, C.S.; Paula, C.D. & Silvano, D.L. 2012. A leap further: the Brazilian Amphibian Conservation Action Plan. *Alytes* 29: 28–43.
- Vieira, W.L.S.; Arzabe, C. & Santana, G.G. 2007. Composição e distribuição espaço-temporal de anuros no Cariri paraibano, Nordeste do Brasil. *Oecologia Brasiliensis* 11: 383–396. DOI: 10.4257/oeco.2007.1103.08.
- Vilela, B.; Nascimento, F.A. & Vital, M.V.C. 2018. Impacts of climate change on small-ranged amphibians of the northern Atlantic Forest. *Oecologia Australis* 22: 130–143. DOI: 10.4257/oeco.2018.2202.03.
- Wake, D.B. & Vredenburg, V.T. 2008. Are we in the midst of the sixth mass extinction? A view from the world of amphibians. *Proceedings of the National Academy of Sciences* 105: 11466–11473. DOI: 10.1073/pnas.0801921105.
- Wells, K.D. 2007. The Ecology and behavior of amphibians. The University of Chicago Press, Ltd.. London.

