

## Anuran hotspot at Brazilian Atlantic rainforest invaded by the non-native *Lithobates catesbeianus* Shaw, 1802 (Anura: Ranidae)

Rodrigo Barbosa FERREIRA<sup>1,2,\*</sup> and Caio Simão de LIMA<sup>3</sup>

1. Department of Wildland Resources and Ecology Center, Utah State University, Logan, UT 84322-5230, USA.
  2. Museu de Biologia Prof. Mello Leitão, Av. José Ruschi, 4, Centro, CEP 29650-000, Santa Teresa, Espírito Santo, Brasil.
  3. Departamento de Ciências Biológicas, Centro de Ciências Humanas e Naturais, Universidade Federal do Espírito Santo, Av. Marechal Campos, 1468, Campus de Maruípe, Vitória, Espírito Santo, 29040-090, Brasil.
- \* Corresponding author, R.B. Ferreira, E-mail: [rodrigoecologia@yahoo.com.br](mailto:rodrigoecologia@yahoo.com.br)

Received: 26. February 2012 / Accepted: 18. August 2012 / Available online: 01. September 2012 / Printed: December 2012

**Abstract.** Herein we report for the first time the occurrence of the non-native frog *Lithobates catesbeianus* (Bullfrog) in the municipality of Santa Teresa, Espírito Santo, Brazil. The establishment of this generalist-habits species represents a remarkable risk to the native fauna of Santa Teresa, which harbours one of the highest species richness of amphibians in the world.

**Key words:** *Lithobates catesbeianus*, invasive species, distribution, Santa Teresa, threat.

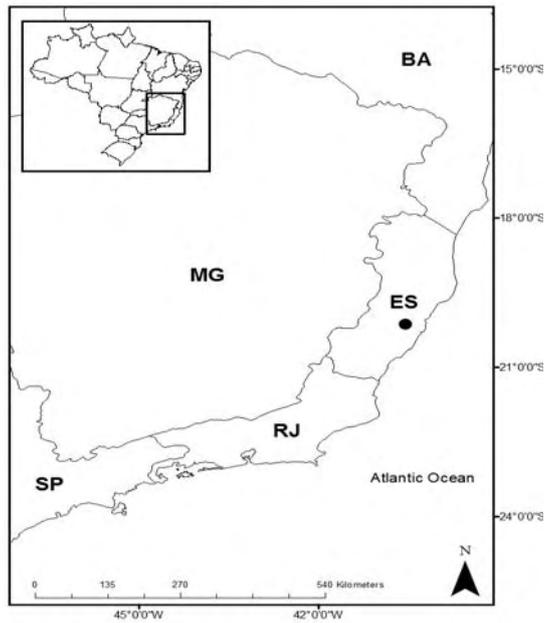
*Lithobates catesbeianus* Shaw, 1802, popularly known as American bullfrog, is originally distributed throughout eastern of North America (Bruening 2002). In the last century, American bullfrogs have been widely introduced in several countries for aquaculture purposes related to its potential alimentary trade, and also as biological control agent and as ornamental species (Laufer et al. 2008). In Brazil this species was primarily introduced in the south in 1935, and intensive breeding began on frog farms (Fontanello & Ferreira 2007, Silva et al. 2011). Nowadays bullfrog populations are widely spread over Brazil, with population occupying several states across southern and south-eastern regions (Borges-Martins et al. 2002, Santos-Barrera et al. 2009). Nori et al. (2011) modelled the distribution of bullfrog under different climatic conditions for the years 2050 and 2080 in South America and called attention to the vulnerability of the Atlantic rainforest to the invasion of this species. Brazilian Atlantic rainforest and Brazilian savanna are currently the main biomes colonized by this frog. I general this spread began after the individuals reached natural environment due to the ineffective frog's maintenance and isolation in captivity by the farmers. Besides intentional release also happened after farmers noticed the low economic gains in trading this frog (Fontanello 1994, Silva et al. 2010).

*Lithobates catesbeianus* possess several ecological attributes that facilitates its adaptation into new environments. Large body size, high population density and capacity to effectively dispersead being habitat and diet generalist have been pointed out by several authors as effective traits

responsible for its success (see Crayon 2009). Once colonized a natural environment that harbours native species, bullfrog can interfere in the local community structure, mostly due to predation and competition (Kiesecker & Blaustein 1998, Lowe et al. 2000, Ficetola et al. 2007, Garwood et al. 2010). Lowe et al. (2000) considered this species as one of the most harmful invasive frog species in the world, which causes a variety of ecological damages to the native fauna.

Herein we report for the first time the presence of *L. catesbeianus* in the natural environment of Santa Teresa municipality, state of Espírito Santo (Fig. 1; 19°56'09"S, 40°35'59"W, 655 m a.s.l.). In October, November, and December 2008, one individual of this species was observed by the author C.S.L. and Herika R. Rangel in a natural environment during field surveys at the "Museu de Biologia Mello Leitão" in this municipality (Fig. 2A). This young individual measured 80 mm in snout-vent length and was observed occupying only a little pond surrounded by rocks (Fig. 2B).

In the only compilation of anurans inhabiting Santa Teresa, Rödder et al. (2007) listed 102 species. However *L. catesbeianus* was not reported occurring in this municipality. In a recent list of frogs of Espírito Santo State, Almeida et al. (2011) reported the presence of a bullfrog in the municipality of Itarana which is 30 km from Santa Teresa. However this individual was collected in a frog farm (*Criadouro do Paulo Cezar Miller*) according to the information on the voucher tag. It is possible that our reported individual dispersed from this breeding facility in Itarana. Furthermore, a recent prediction of the potential distribution of *L. cates-*



**Figure 1.** First record of *Lithobates catesbeianus* in the wild at the anuran hotspot, Santa Teresa municipality, south-eastern Brazil. [States: Bahia (BA), Espírito Santo (ES), Minas Gerais (MG), Rio de Janeiro (RJ), and São Paulo (SP).]



**Figure 2.** A. Individual of bullfrog observed in Santa Teresa, south-eastern Brazil; B. habitat used by this bullfrog during our field survey. Photos: Caio Lima.

*beianus* in Brazil did not assign Santa Teresa as one of the highest suitable region for the establishment of this species (Giovannelli et al. 2008). These authors, however, considered the southern and south-eastern states, inserted in the Brazilian Atlantic rainforest, as the most sensitive areas for bullfrog establishment. Previous papers report bullfrog for the other states of Brazilian south-eastern region (Rio de Janeiro, Salles et al. 2009, São Paulo, Guix 1990, Minas Gerais, Silva et al. 2009, Silva et al. 2010). Both et al. (2011) in a compilation of all records for Brazil mentioned the presence of bullfrog in the municipality of Alegre, Espírito Santo state. In a report of general public

interest, the Brazilian online database for non-native species (see Instituto Hórus 2011) provides a record of bullfrog for municipality of Vitória, capital of Espírito Santo. This database was used by three studies (Giovannelli et al. 2008, Ferreira et al. 2010, Both et al. 2011). Giovannelli et al. (2008) included this species in their spatial modelling analysis, while Ferreira et al. (2010) listed this species in their inventory of amphibians of Vitória. The municipality of Santa Teresa is 60 km north from Vitória and 145 km north from Alegre, which led us to believe that these introductions occurred from different sources. The high number of permanent water bodies in these three municipalities

led us to suggest that they are suitable for bullfrog establishment and even for their spread. Although the finding of viable population(s) at these municipalities would not be surprising, there is no evidence of an established population yet.

As there is no study addressing ecological impacts of bullfrog on the local native community in Santa Teresa municipality, we recommend further study to reduce the lack of local information. Santa Teresa is considered the municipality harbouring one of the highest richness of anurans in the world (see Rödder et al. 2007, Almeida et al. 2011). Even more worrying is the fact that *L. catesbeianus* is relatively more resistant to infestation by ranaviruses and chytridiomycosis and represents an important carrier of these pathogens (see Daszak et al. 2004, Schloegel et al. 2009). The establishment of bullfrog in Santa Teresa is especially concerning because of its potential harm to the local anuran fauna, particularly to species that are endemics to this municipality (15 species).

Bullfrogs are trophic generalists, feeding on a great variety of organisms, even larger than themselves, but this species focus its feeding strategy on frogs. Three studies conducted in Brazil recently showed that anurans make up a large part of adult bullfrogs' diet in invaded areas (Boelter & Cechin 2007, Silva et al. 2009, Silva et al. 2011). Potentially the most threatened native frogs by bullfrog in Santa Teresa might be those with microspatial overlap as noticed by Silva et al. (2011) for certain regions of Brazilian Atlantic rainforest and by Batista (2002) for a population in the Brazilian Savanna.

It is likely that *L. catesbeianus* is still in the early stage of naturalization in Santa Teresa. This stage has been considered the most important to effectively control the spread of non-native species (Manchester & Bullock 2000). Therefore we strongly recommend state and local policy makers to implant a control program to eradicate this species from the wild. We consider this management strategy as the only opportunity to control bullfrog spread in Santa Teresa as well as in Vitória. Shooting adults has been considered to have a positive effect for certain regions (Dobledee et al. 2003). We also suggest that information should be transmitted to the local farmers notifying them about this harmful invasive frog. These acts might also be accompanied by an encouragement of the farmers to manually collect bullfrogs for alimentary purposes (Casali et al. 2005, Nóbrega et al. 2007).

Farming of bullfrog is a growing activity in Brazil, but lacks regulation upon the captivity management. Following the national scenario, bullfrog farms have been expanding the production in Espírito Santo state, which consequently suggest that the potential spread of bullfrog is likely ongoing through this pathway. Therefore we suggest that a control program should be urgently implemented for active and inactive farms in order to prevent bullfrog escapes, or releases by strictly regulating and monitoring farms' surroundings.

**Acknowledgements.** We would like to thank Hérika R. Rangel and Juliana Peres for providing some data and help with field work, João Gabriel R. Giovanelli and Cecília Waichert for the helpful comments on the manuscript, Reuber Brandão and Fabiano Lanschi for providing valuable information. We also thank Museu de Biologia Mello Leitão for providing access to the study area and lodging during study period.

#### References

- Almeida, A.P., Gasparini, J.L., Peloso, P.L.V. (2011): Frogs of the state of Espírito Santo, southeastern Brazil- The need for looking at the coldspots. *Check List* 7(4): 542-560.
- Batista, C.G. (2002): *Rana catesbeiana* (Bullfrog). Effects on native anuran community. *Herpetological Review* 33(2): 131.
- Boelter, R.A., Cechin, S.Z. (2007): Impacto da dieta de rã-touro (*Lithobates catesbeianus* - Anura, Ranidae) sobre a fauna nativa: estudo de caso na região de Agudo, RS, Brasil. *Natureza e Conservação* 5: 45-53.
- Borges-Martins, M., Di-Bernardo, M., Vinciprova, G., Measey, J. (2002): Geographic distribution. *Rana catesbeiana*. *Herpetological Review* 33(4): 319.
- Both, C., Lingnau, R., Santos-Jr., A., Madalozzo, B., Lima, L.P., Grant, T. (2011): Widespread occurrence of the American Bullfrog, *Lithobates catesbeianus* (Shaw, 1802) (Anura: Ranidae), in Brazil. *South American Journal of Herpetology* 6(2): 127-134.
- Bruening, S. (2002): *Rana catesbeiana*. *Animal Diversity Web*. <[http://animaldiversity.ummz.umich.edu/site/accounts/information/Rana\\_catesbeiana.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Rana_catesbeiana.html)>, accessed at: 2011.04.11>
- Casali, A.P., Moura, O.M., Lima, S.L. (2005): Rações comerciais e o rendimento de carcaça e subprodutos de rã-touro. *Ciência Rural* 35(5): 1172-1178.
- Crayon, J.J. (2009): Ecology *Lithobates catesbeianus*. *Global Invasive Species Database*. <<http://www.issg.org/database/welcome/>>, accessed at: 2011.05.23>.
- Daszak, P., Strieby, A., Cunningham, A.A., Longcore, J.E., Brown, C.C., Porter, D. (2004): Experimental evidence that the bullfrog (*Rana catesbeiana*) is a potential carrier of chytridiomycosis, an emerging fungal disease of amphibians. *Herpetological Journal* 14(4): 201-207.
- Dobledee, R.A., Muller, E.B., Nisbet, R.M. (2003): Bullfrogs, disturbance regimes, and the persistence of California red-legged frogs. *Journal of Wildlife Management* 67(2): 424-438.
- Ferreira, R.B., Silva-Soares, T., Rödder, D. (2010): Amphibians of Vitória, an urban area in south-eastern Brazil: first approximation. *Salamandra* 46(4): 187-196.

- Ficetola, G.F., Thuiller, W., Miaud, C. (2007): Prediction and validation of the potential global distribution of a problematic alien invasive species – the American bullfrog. *Diversity and Distribution* 13(4): 476-485.
- Fontanello, D. (1994): Histórico da Ranicultura no Brasil. pp. 3-6. In: Lima, S.L., Figueiredo, M.R.C., Moura, O.M. (eds.), *Diagnóstico da Ranicultura: problemas, propostas de soluções e pesquisas prioritárias*. Viçosa, Associação Brasileira de Estudos Técnicos em Ranicultura.
- Fontanello, D., Ferreira, C.M. (2007): Histórico da Ranicultura Nacional. *Aquicultura*. <<http://www.aquicultura.br/historico.htm>, accessed at: 2011.06.23>
- Garwood, J.M., Ricker, S.J., Colin, W.A. (2010): Bullfrog Predation on a Juvenile Coho Salmon in Humboldt County, California. *Northwestern Naturalist* 91(1): 99-101.
- Giovanelli, J.G.R., Haddad, C.F.B., Alexandrino, J. (2008): Predicting the potential distribution of the alien invasive American bullfrog (*Lithobates catesbeianus*) in Brazil. *Biological Invasions* 10(5): 585-590.
- Guix, J.C. (1990): Introdução e colonização de *Rana catesbeiana* Shaw, 1802 em um pequeno vale no município de Suzano (SP), sudeste do Brasil. *Grupo Estudos Ecológicos, Série Documento* 2: 32-34.
- Hórus (2011): Instituto Hórus de Desenvolvimento e Conservação Ambiental. < [http://www.institutohorus.org.br/download/fichas/Rana\\_catesbeiana.htm](http://www.institutohorus.org.br/download/fichas/Rana_catesbeiana.htm), accessed at: 2011.03.20>
- Kiesecker, J.M., Blaustein, A.R. (1998): Effects of introduced bullfrog and smallmouth bass on microhabitat use, growth, and survival of native red-legged frogs (*Rana aurora*). *Conservation Biology* 12(4): 776-787.
- Laufer, G., Canavero, A., Núñez, D., Maneyro R. (2008): Bullfrog (*Lithobates catesbeianus*) invasion in Uruguay. *Biological Invasions* 10(7): 1183-1189.
- Lowe, S., Browne, M., Boudjelas, S., De Poorter, M. (2000): 100 of the World's worst invasive alien species. A selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG), Auckland.
- Manchester, S.J., Bullock, J.M. (2000): The impacts of non-native species on UK biodiversity and the effectiveness of control. *Journal of Applied Ecology* 37(5): 845-864.
- Nóbrega, I.C.C., Ataíde, C.S., Moura, O.M., Livera, A.V., Menezes, P.H. (2007): Volatile constituents of cooked bullfrog (*Rana catesbeiana*) legs. *Food Chemistry* 102(1): 186-191.
- Nori, J., Urbina-Cardona, J.N., Loyola, R.D., Lescano, J.N., Leynaud, G.C. (2011): Climate change and American bullfrog invasion: What could we expect in South America? *PLoS ONE* 6(10): e25718.
- Rödder, D., Teixeira, R.L., Ferreira, R.B., Dantas, R.B., Pertel, W., Guarneire, G.J. (2007): Anuran hotspots: the municipality of Santa Teresa, Espírito Santo, southeastern Brazil. *Salamandra* 43(2): 91-110.
- Salles, R.O.L., Weber, L.N., Silva-Soares, T. (2009): Amphibia, Anura, Parque Natural Municipal da Taquara, municipality of Duque de Caxias, state of Rio de Janeiro, southeastern Brasil. *Check List* 5(4): 840-854.
- Santos-Barrera, G., Hammerson, G., Hedges, B., Joglar, R., Inchaustegui, S., Kuangyang, L., Wenhao, C., Huiqing, G., Haitao, S., Diesmos, A., Iskandar, D., van Dijk, P.P., Matsui, M., Schmidt, B., Miaud, C., Martínez-Solano, I. (2009) *Lithobates catesbeianus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <[www.iucnredlist.org](http://www.iucnredlist.org), accessed at 2012.02.24>
- Schloegel, L.M., Picco, A.M., Kilpatrick, A.M., Davies, A.J., Hyatt, A.D., Daszak, P. (2009): Magnitude of the US trade in amphibians and presence of *Batrachochytrium dendrobatidis* and ranavirus infection in imported North American bullfrogs (*Rana catesbeiana*). *Biological Conservation* 142(7):1420-1426.
- Silva, E.T., Reis, E.P., Feio, R.N., Ribeiro-Filho, O.P. (2009): Diet of the invasive frog *Lithobates catesbeianus* (Shaw, 1802) (Anura: Ranidae) in Viçosa, Minas Gerais State, Brazil. *South American Journal of Herpetology* 4(3): 286-294.
- Silva, E.T., Reis, E.P., Santos, P.S., Feio, R.N. (2010): *Lithobates catesbeianus* (American Bullfrog) - Diet. *Herpetological Review* 41(4): 475-476.
- Silva, E.T., Ribeiro-Filho, O.P., Feio, R.N. (2011): Predation of native anurans by invasive bullfrogs in southeastern Brazil: spatial variation and effect of microhabitat use by prey. *South American Journal of Herpetology* 6(1): 1-10.