

SCIENTIFIC NOTE

Invasive bullfrog *Lithobates catesbeianus* (Anura: Ranidae) in the Paraná state, Southern Brazil: a summary of the species spread

Manuela Santos-Pereira^{1,2} & Carlos Frederico Duarte Rocha¹

¹Departamento de Ecologia, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier, 524, Rio de Janeiro, 20550-013, RJ, Brazil.

²Corresponding author. E-mail: herpeto.pereira@gmail.com

Abstract. In this study, we summarize the available information about the invasion of the *Lithobates catesbeianus* in the Paraná state, Brazil, through search for published papers and inventory of the municipalities of the State that has active commercial frog farms. Occurrence of the *L. catesbeianus* in nature was recorded in eight studies and in 15 localities in the Paraná. We found a total of the 19 municipalities in the Paraná having commercial frog farms. The records of the *L. catesbeianus* invasions are relatively spread along of the Paraná. We encountered that from of the 15 records of the *L. catesbeianus* as invasive in 86.7% (or 13 from 15) of them were located at distances below 50km from the nearest municipality having frog farm, one were established at a distance of about 80km and one at a distance of approximately 130km from de nearest municipality having frog farm. These data suggest a consistent relationship of the occurrence of frog farms and the records of the invasions by *L. catesbeianus* along the geographic space of the Paraná state.

Keywords: *Lithobates catesbeianus*, exotic species, invasive species, Paraná state

Resumo. A Rã Touro invasora *Lithobates catesbeianus* (Anura: Ranidae) no estado do Paraná, sul do Brasil: um sumário da expansão da espécie. Neste estudo, nós reunimos informações disponíveis sobre a invasão de *Lithobates catesbeianus* no estado do Paraná no Brasil, através de trabalhos publicados e de um inventário dos municípios do Estado que tenham ranários ativos. A ocorrência de *L. catesbeianus* na natureza foi registrada em oito estudos e em 15 localidades no Paraná. Nós encontramos um total de 19 municípios no Paraná com ranários. Os registros de *Lithobates catesbeianus* estão relativamente espalhados ao longo do Paraná. Nós encontramos que dos 15 registros de *L. catesbeianus* como invasor, 86.7% (ou 13 de 15) deles ocorreram em locais com distâncias inferiores a 50km do município mais próximo possuindo fazenda comercial de criação de rãs, um deles estava a uma distância de cerca de 80km de município com criadouros e o outro a uma distância de aproximadamente 130km do município mais próximo possuindo criadouro. Estes dados sugerem uma relação consistente da ocorrência de ranários e os registros de invasões por *L. catesbeianus* ao longo do espaço geográfico do estado do Paraná.

Palavras-Chave: *Lithobates catesbeianus*, espécies exóticas, espécies invasoras, estado do Paraná

Invasion by exotic species has been considered the second most important cause of biodiversity erosion after habitat destruction (ROCHA *et al.*, 2011). *Lithobates catesbeianus* (SHAW, 1802) (Ranidae) popularly known as Bullfrog, is originally distributed in eastern North America (except Florida), Canada (Nova Scotia, Southern Quebec and Southern Ontario) and Mexico (Hidalgo State and Veracruz) but has been widely introduced in different countries of the Central (including Antilles) and South Americas, Europe and Asia (FROST, 2015) for farming purposes (raniculture) and is able to easily adjust to different environmental conditions (ROCHA *et al.*, 2011). The Bullfrog was named one of the hundred worrying invasive alien species (LOWE *et al.*, 2004) due to its high capacity for competition and predation (WU *et al.*, 2005) and as being a vector of infectious diseases such as chytridiomycosis, that is one of major causes of the global decline of amphibians (SCHLOEGEL *et al.*, 2005).

In the Brazil, *Lithobates catesbeianus* was introduced since 1930 by frog farms for production and commercialization as food (ROCHA *et al.*, 2011). Currently, the species has been recorded in several locations in 11 Brazilian states (Piauí, Rio Grande do Norte, Pernambuco, Alagoas, Bahia, Espírito Santo, Rio de Janeiro, Minas Gerais, São Paulo, Santa Catarina and Rio Grande do Sul) (DIXO & TRUTH, 2006; ROCHA *et al.*, 2011; BOELTER *et al.*, 2012) and Paraná (present study and references therein). Here we summarize available information on the invasion of the *L. catesbeianus* in the Paraná state.

To know the locations of the occurrence of the *Lithobates catesbeianus* in the Paraná, we have looked for studies conducted at that State providing species lists or species specific record of occurrence. We performed a search for published articles in the following databases: Web of Science, SciELO, Scopus and Google Scholar. We considered the following terms in our search: amphib* AND Paraná, anur* AND Paraná and frog* AND Paraná. We also considered records found in the Hórus Institute database. Additionally, we made an inventory of the municipalities of the Paraná state having active commercial frog farms (obtained at Cadastro de Empresas do Brasil 2015; <http://empresasdobrasil.com>) and related geographic location of frog farms with the location of those records of invasion of the *L. catesbeianus* obtained (Figure 1).

Until present *Lithobates catesbeianus* was recorded as invasive in the Paraná in eight studies (BERNARDE & MACHADO, 2001; 2002; CONTE & ROSA-FERES, 2006; ARMSTRONG & CONTE, 2010; BOTH *et al.*, 2011; AFFONSO & DELARIVA, 2012; LEIVA *et al.*, 2012; AFFONSO *et al.*, 2014) in a total of the 15 locations of the State (Figure 1; Tabela 1). We found a total of the 19 municipalities in the Paraná state having commercial frog farms (Figure 1). The records of the invasion by *Lithobates catesbeianus* in the Paraná is relatively spread along the State (Figure 1). We encountered that from of the 15 records of the *L. catesbeianus* as invasive in 86.7% (or 13 from 15) of them were located at distances below 50km from the nearest municipality having frog farm, one were established at a distance of about 80km from

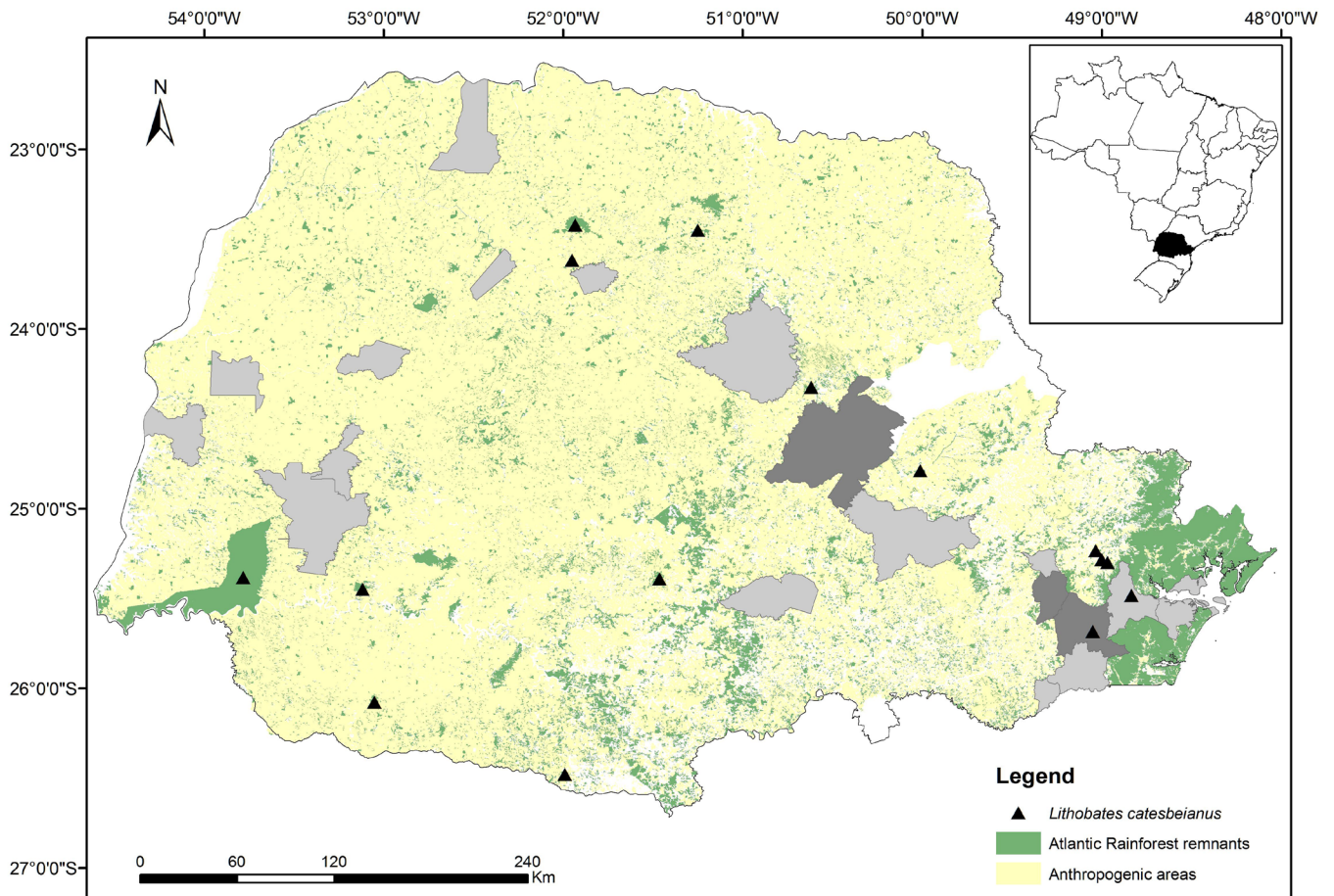


Figure 1. Locations with records of invasion by *Lithobates catesbeianus* in Paraná state, Southern Brazil (triangles; Municipalities of Bocaiúva do Sul, Campina Grande do Sul, Morretes, Quatro Barras, São José dos Pinhais, Foz do Iguaçu, Três Barras do Paraná, Itambé, Londrina, Maringá, Castro, Telêmaco Borba, Francisco Beltrão, Guarapuava and Palmas) and limits of municipalities having commercial frog farms (Agudos do Sul, Almirante Tamandaré, Curitiba, Morretes, Paranaguá, São José dos Pinhais, Tijucas do Sul, Cascavel, Corbélia, Marechal Cândido Rondon, Palotina, Bom Sucesso, Goioerê, Terra Boa, Irati, Ortigueira, Ponta Grossa, Tibagi and Paranavaí). In light gray municipalities having one frog farm and in dark grey municipalities having two frog farms. Map: Gisele Winck.

Table 1. Occurrence and habitats recorded for *Lithobates catesbeianus* in the invades areas in the Paraná State, Brazil, according to published studies. Temporary pond (TP), permanent weir (PW), lake (L), edge of forest fragment (EFF), open area (OA).

Locality	Longitude	Latitude	Habitat used	Source
Três Barras do Paraná	-53.116667	-25.450000	TP, PW in OA	Bernarde and Machado 2001
Londrina	-51.250000	-23.450000	-	Machado and Bernarde 2002
São José dos Pinhais	-49.050000	-25.683333	PW	Conte and Rossa-Feres 2006
Morretes	-48.833333	-25.483333	PW, L in OA	Armstrong and Conte 2010
Telêmaco Borba	-50.618067	-24.325003	-	Both <i>et al.</i> 2011
Francisco Beltrão	-53.051989	-26.077944	-	Both <i>et al.</i> 2011
Guarapuava	-51.462808	-25.390739	-	Both <i>et al.</i> 2011
Palmas	-51.990875	-26.480322	-	Both <i>et al.</i> 2011
Itambé	-51.950000	-23.616667	EFF	Affonso and Delariva 2012
Quatro Barras	-48.966667	-25.300000	-	Leivas <i>et al.</i> 2012
Campina Grande do Sul	-49.000000	-25.283333	-	Leivas <i>et al.</i> 2012
Bocaiúva do Sul	-49.033333	-25.233333	-	Leivas <i>et al.</i> 2012
Maringá	-51.933053	-23.421008	-	Affonso <i>et al.</i> 2014
Foz do Iguaçu	-53.817783	-25.460508	-	Instituto Hórus 2015
Castro	-50.011244	-24.789572	-	Instituto Hórus 2015

the nearest municipality with frog farm and one at a distance of approximately 130km from the nearest municipality having frog farm (Figure 1). These data are suggestive of a consistent relationship of the occurrence of frog farms and the records of the invasions by *L. catesbeianus* along the geographic space of Paraná state (Figure 1).

These data show that the invasion by *Lithobates catesbeianus* in environments of the Paraná took place in different localities and that the species is potentially spreading to new areas and that the real area of invasion of the Bullfrog in the State may be much larger than actually supposed. Studies in areas not yet sampled in the Paraná, possibly, will also register the occurrence of this exotic and invasive species in additional areas. Regarding to habitat use, it seems that, open and antropized/disturbed areas favors the species occurrence and invasion; possibly because invasion starts after some frogs escape from raniculture farms (ROCHA *et al.*, 2011) which usually are located in open environments. This scenario of invasion is worrying because, associated to the known damage to local native frog populations (and possibly to other sympatric organisms), there is also a lack of knowledge on possible negative effects to local communities and environment invaded which difficulties our understanding of the ecological processes governing such frog invasion. The first agent for the invasion of this species has been indicated as the man (ROCHA *et al.*, 2011), and our study accords with this assumption. However, to learn more about the adaptation of this species is necessary to understand their reproduc-

tive biology in the Paraná state and how this species escape from predator and/or on their predation on local species.

It is important that in the near future, plans for control, management and removal of the species from natural environments be developed and started, in order to stop the spread of the species in Paraná. Our study is indicative that in the control of the invasion of the *Lithobates catesbeianus* in the Paraná state special attention must be done to potential scape of frogs from farms.

ACKNOWLEDGMENTS

This study was supported by research grants from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (processes 304791/2010-5, 470265/2010-8 and 472287/2012-5) and from Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ) through “Cientistas do Nosso Estado” Program (process E-26/102.765/2012) to CFD. Rocha. M. Santos-Pereira receives PhD fellowship from CAPES. G. Winck kindly drawn the map.

REFERENCES

- AFFONSO, I.P. & DELARIVA, R.L. 2012. Lista comentada da Anurofauna de três Municípios da região Noroeste do Estado do Paraná, Brasil. **SaBios: Revista Saúde e Biologia** 7 (2): 102-109.
- AFFONSO, I.P.; CAFOFO, E.G.; DELARIVA, R.L.; ODA,

- F.H.; KARLING, L.K. & LOURENÇO-DE-MORAES, R. 2014. List of anurans (Amphibia: Anura) from the rural zone of the municipality of Maringá, Paraná state, southern Brazil. **Check List 10** (4): 878–882.
- ARMSTRONG, C.G. & CONTE, C.E. 2010. Taxocenose de anuros (Amphibia: Anura) em uma área de Floresta Ombrófila Densa no Sul do Brasil. **Biota Neotropica 10** (1): 39-46. <http://www.biotaneotropica.org.br/v10n1/pt/abstract?article+bn00610012010>.
- BERGER, L.; SPEARE, R.; DASZAK, P.; GREEN, D.E.; CUNNINGHAM, A.A.; GOGGIN, C.L.; SLOCOMBE, R.; RAGAN, M.A.; HYATT, A.D.; MCDONALD, K.R.; HINES, H.B.; LIPS, K.R.; MARANTELLI, G. & PARKES, H. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. **Proceedings of the National Academy of Sciences of the United States of America 95**: 9031–9036.
- BERNARDE, P.S. & MACHADO, R.A. 2001. Riqueza de espécies, ambientes de reprodução e temporada de vocalização da anurofauna em Três Barras do Paraná, Brasil (Amphibia: Anura). **Cuadernos de Herpetologia 14** (2): 93-104.
- BOELTER, R.A.; KAEFER, I.L.; BOTH, C. & CECHIN, S. 2012. Invasive bullfrogs as predators in a Neotropical assemblage: What frog species do they eat? **Animal Biology 62**: 397–408.
- 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.
- CADASTRO DE EMPRESAS DO BRASIL. 2015. Cadastro de Empresas do Brasil. Electronic Database available at: <http://empresadobrasil.com>. Accessed on: 20 may. 2015.
- CONTE, C.E. & ROSSA-FERES, D.C. 2006. Diversidade e ocorrência temporal da anurofauna (Amphibia, Anura) em São José dos Pinhais, Paraná, Brasil. **Revista Brasileira de Zoologia 23** (1): 162-175.
- CUNHA, E.R. & DELARIVA, R.L. 2009. Introdução da Rã-Touro, *Lithobates catesbeianus* (Shaw, 1802): Uma Revisão. **SaBios: Revista Saúde e Biologia 4** (2): 34-46.
- DIXO, M. & VERDADE, V.K. 2006. Leaf litter herpetofauna of the Reserva Florestal de Morro Grande, Cotia (SP). **Biota Neotropica 6**: 1-20. <http://www.biotaneotropica.org.br/v6n2/pt/abstract?article+bn00806022006>.
- FROST, D. R. 2015. Amphibian Species of the World: an Online Reference. Version 6.0. Electronic Database available at: <http://research>.

amnh.org/herpetology/amphibia/index.html>. American Museum of Natural History, New York, USA. Accessed on: 11 jun. 2015.

INSTITUTO HÓRUS 2015. Base de dados nacional de espécies exóticas invasoras, I3N Brasil, Instituto Hórus de Desenvolvimento e Conservação Ambiental. Electronic Database available at: <<http://i3n.institutohorus.org.br>>. Florianópolis, SC, Brazil. Accessed on: 11 jun. 2015.

LEIVAS, P.T.; LEIVAS, F.W.T. & MOURA, M.O. 2012. Diet and trophic niche of *Lithobates catesbeianus* (Amphibia: Anura). **Zoologia** **29** (5): 405–412.

LONGCORE, J.E.; PESSIER, A.P. & NICHOLS, D.K. 1999. *Batrachochytrium dendrobatidis* gen. et sp. nov., a chytrid pathogenic to amphibians. **Mycologia** **91**: 219–227.

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**. Auckland: The Invasive Species Specialist Group. 12 p.

MACHADO, R.A. & BERNARDE, P.S. 2002. Anurofauna da bacia do Rio Tibagi. pp. 297-306. *In*: Medri, M.E., Bianchini, E., Shibatta, O.A. & Pimenta, J.A. (Eds.). **A bacia do Rio Tibagi**. Londrina: ME Medri. 601 p.

ROCHA, C.F.D.; BERGALLO, H.G. & MAZZONI, R. 2011.

Invasive Vertebrates in Brazil, pp. 53-103. *In*: D. Pimentel (Ed.). **Biological Invasions. Economic and Environmental Costs of alien plant, animal and microbe species**. New York: CRC Press, Taylor & Francis. 449 p.

SCHLOEGEL, L.M.; PICCO, A.M.; KILTAPATRICK, A.M.; A DAVIES, 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**: 1420-1426.

WU, Z.; LI, Y.; WANG, Y. & ADAMS, M. J. 2005. Diet in introduced bullfrogs (*Rana catesbeiana*): Predation on and diet overlap with native frogs on Daishan Island, China. **Journal of Herpetology** **39**: 668-674.

Recebido: 11/11/2014

Revisado: 03/03/2015

Aceito: 07/07/2015

