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WIDESPREAD OCCURRENCE OF THE AMERICAN BULLFROG, *LITHOBATES CATESBEIANUS* (SHAW, 1802) (ANURA: RANIDAE), IN BRAZIL

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ABSTRACT. We report new records of *Lithobates catesbeianus* feral populations in Brazil. Data were based on fieldwork, natural history collection records, and literature and electronic database searches. *Lithobates catesbeianus* occurs in 130 municipalities of Brazil, including 55 presented for the first time in this work. Most records are from south and southeastern Brazil in the Atlantic Forest biome with climatic conditions that are favorable to the establishment of bullfrog populations. The wide and possibly expanding distribution of feral *L. catesbeianus* populations in Brazil poses a major conservation challenge and demands research on the invasion patterns.

KEYWORDS. Bullfrogs; distribution; Brazil; feral populations; biological invasion.

INTRODUCTION

The American bullfrog, *Lithobates catesbeianus* (Shaw, 1802), is native to the eastern United States and Canada but over the last century has been transported around the world to be cultured for human consumption. Bullfrogs are generalist predators, show high fecundity, and are strong competitors in both larval and adult phases (Bury and Whelan, 1987; Boelter and Cechin, 2007; Kaefer *et al.*, 2007) – life history traits typical of successful invasive species (Baker, 1974) – and populations are now established in nearly 40 countries in Africa, Asia, North, Central, and South America, and islands of the Mediterranean, South Pacific and Caribbean (Kraus, 2009). Invasive bullfrog populations have been linked either directly, through predation and competition, or indirectly, by inducing habitat use alteration and reducing feeding activity period or and metamorph sizes, to the decline of native amphibian populations in North America (Kats and Ferrer, 2003). Recently, attention has been devoted to the vector role of this species, which appears to be resistant to diseases that are lethal to other amphibians (Daszak *et al.*, 2004).

In South America, recent publications report the presence of invasive bullfrog populations in Argentina, Brazil, Colombia, Ecuador, Uruguay, and Venezuela (Santos-Barrera *et al.*, 2011). Ficetolla *et al.* (2007) and Giovanelli *et al.* (2008) showed that the climatic conditions of the southern Atlantic Forest

are favorable to the establishment of bullfrog populations, and during fieldwork in this region we found a high number of previously unknown bullfrog populations. Here, we present a new compilation of records of *Lithobates catesbeianus* in Brazil based on our samples, specimens deposited in Brazilian natural history collections, and the literature.

MATERIALS AND METHODS

We searched for bullfrogs at 90 sampling sites, both natural (*e.g.*, ponds, streams) and human-made (*e.g.*, dams), in 10 municipalities (Agudo, Blumenau, Chapecó, Dona Francisca, Guatambu, Indaial, Ivorá, Nova Erechim, Nova Palma, Pinhalzinho) in the states of Rio Grande do Sul and Santa Catarina, southern Brazil. Each site was marked using a GPS and visited at least three times in spring 2009 and spring and summer of 2010 to search for bullfrog egg clutches, tadpoles, and adults. We also conducted occasional surveys in localities of the states of Goiás, Paraná, Rio Grande do Sul, and Santa Catarina.

We complemented our own data with Brazilian *Lithobates catesbeianus* records obtained from published papers, internet databases, and unpublished dissertations and theses. Additionally, we queried curators of scientific collections regarding their bullfrog holdings (Appendix 1). We also received “expert information”, *i.e.*, unpublished data from professors

and PhD students. Often, we found multiple records in the same municipality. We standardized the data using municipalities as geographical units.

RESULTS

We obtained records of *Lithobates catesbeianus* in 130 Brazilian municipalities; of those, 55 are presented for the first time in this work (Table 1). We also obtained records of bullfrogs published after the most recent compilation by Giovanelli *et al.* (2008; Figure 1). Approximately 62% of the municipalities are in southern Brazil and 25% are in southeastern Brazil. The states of Rio Grande do Sul and Santa Catarina, southern Brazil, had the most records: 52 and 20 respectively. Northeastern and mid-western Brazil have just seven and nine records, respectively, and just one population is known in the northern region.

DISCUSSION

The increase in the number of known bullfrog localities is immediately evident in Figure 1. The number of municipalities with bullfrog records has doubled in the four years since the last compilation by Giovanelli *et al.* (2008). Most new records are from south and southeastern Brazil in the Atlantic Forest biome with climatic conditions that are favorable to the establishment of bullfrog populations (Ficetolla *et al.*, 2007; Giovanelli *et al.*, 2008). These are the same regions where we conducted field surveys and other researchers interested in bullfrog biology or bullfrog farming are located. This regional survey bias, combined with the lack of precise historical records, makes it difficult to assess whether the number of bullfrog populations has actually increased since the compilation by Giovanelli *et al.* (2008). We suspect that the species distribution is greater than we report, at least in Rio Grande do Sul and Santa Catarina states where we have focused our fieldwork. Most residents we interviewed claimed not to know that the bullfrog is non-native and some reported that they often introduce tadpoles to ponds where they raise fishes, while others reported that they had tried to rescue bullfrog tadpoles by transporting them from drying ponds to other water bodies.

Bullfrog farming began in Brazil in 1935 in Rio de Janeiro state and was promoted by the government beginning in the 1940s when tadpoles were donated to be reared even on small properties (Vizotto, 1984;

Agostinho, 2003). Scientific advances in aquaculture research in the 1970s were followed by the increase of bullfrog farming in the 1980s. In the early 1990s, it was estimated that there were 2000 bullfrog farms in Brazil (Lima and Agostinho, 1988), but the way the activity was structured was not profitable and several farms closed. This resulted in bullfrogs being released or abandoned, which is the most common beginning of bullfrog invasions, both in Brazil and other countries around the world.

The great distributional potential of *Lithobates catesbeianus* in South America is widely recognized

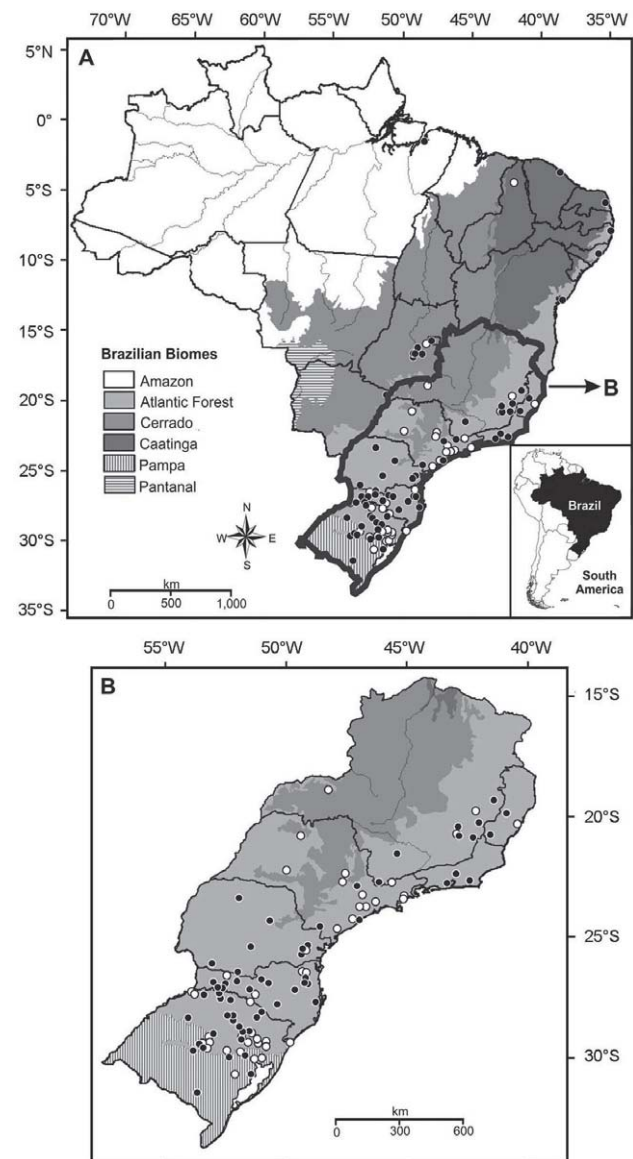


FIGURE 1. Spatial distribution of *Lithobates catesbeianus* invasive populations in Brazil (A). In B, the species distribution in south and southeastern regions appear in detail. White circles represent municipalities in which the bullfrog presence was already known in 2008 (Giovanelli *et al.* 2008), and the black circles represent the subsequent records reported herein.

TABLE 1. Occurrence points of *Lithobates catesbeianus* in Brazil. Coordinates are presented in decimal degrees.

Municipality	State	Biome	Longitude	Latitude	Source
Águas Mornas	Santa Catarina	Atlantic Rainforest	-48.823600	-27.693900	Present study (MCT 8172)
Agudo	Rio Grande do Sul	Atlantic Rainforest	-53.249920	-29.641570	apud.in Giovanelli <i>et al.</i> (2008)
			-53.279817	-29.498833	Present study
			-53.279150	-29.482066	Present study
Alegre	Espírito Santo	Atlantic Rainforest	-41.533100	-20.763600	Present study
Anápolis	Goiás	Cerrado	-48.952800	-16.326700	Present study
Aparecida de Goiânia	Goiás	Cerrado	-49.243900	-16.823300	Present study
Arroio do Tigre	Rio Grande do Sul	Atlantic Rainforest	-53.096130	-29.338650	apud.in Giovanelli <i>et al.</i> (2008)
Barão	Rio Grande do Sul	Atlantic Rainforest	-51.534560	-29.379320	apud.in Giovanelli <i>et al.</i> (2008)
Barracão	Rio Grande do Sul	Atlantic Rainforest	-51.454420	-27.676980	apud.in Giovanelli <i>et al.</i> (2008)
Belém	Pará	Amazon	-48.504400	-1.455800	Marinho, P. V. (<i>pers. comm.</i>)
Blumenau	Santa Catarina	Atlantic Rainforest	-49.065417	-26.920317	Dallacorte (2010)
			-49.119017	-27.003000	Present study
			-49.111650	-27.036783	Present study
			-49.112483	-27.037283	Present study
			-49.093667	-27.030350	Present study
			-49.086347	-27.053239	Present study
			-49.086600	-27.053783	Present study
Brasília	Distrito Federal	Cerrado	-48.010556	-16.035270	Rocha-Miranda <i>et al.</i> (2006)
Caçador	Santa Catarina	Atlantic Rainforest	-51.202085	-26.753441	Lot. C. L. (<i>pers. comm.</i>)
Camanducaia	Minas Gerais	Atlantic Rainforest	-46.144444	-22.755556	Present study (ZUEC 11542)
Campinas	São Paulo	Atlantic Rainforest	-22.811522	-47.063794	Pizzato, L. (<i>pers. comm.</i>)
Campos do Jordão	São Paulo	Atlantic Rainforest	-45.580080	-22.730460	apud.in Giovanelli <i>et al.</i> (2008)
Campos Novos	Santa Catarina	Atlantic Rainforest	-51.248600	-27.383990	Giovanelli <i>et al.</i> (2008)
Candiota	Rio Grande do Sul	Pampa	-53.683131	-31.481959	Bernardo-Silva, J. (<i>pers. comm.</i>)
Canela	Rio Grande do Sul	Atlantic Rainforest	-50.801870	-29.359920	apud.in Giovanelli <i>et al.</i> (2008)
Caratinga	Minas Gerais	Atlantic Rainforest	-42.140000	-19.790000	apud.in Giovanelli <i>et al.</i> (2008)
Catiporã	Rio Grande do Sul	Atlantic Rainforest	-51.700000	-29.016700	Present study (CFBH 20120, UFRGS 3926)
Caxias do Sul	Rio Grande do Sul	Atlantic Rainforest	-51.167540	-29.178370	apud.in Giovanelli <i>et al.</i> (2008)
Chapecó	Santa Catarina	Atlantic Rainforest	-52.619389	-27.185667	Lucas and Fortes (2008)
			-52.664667	-27.144917	Present study
			-52.652933	-27.143417	Present study
			-52.655833	-27.141717	Present study
Cocal de Telha	Piauí	Caatinga	-41.983330	-4.533330	apud.in Giovanelli <i>et al.</i> (2008)
Coimbra	Minas Gerais	Atlantic Rainforest	-42.800000	-20.866700	Silva <i>et al.</i> (2007)
Coronel Barros	Rio Grande do Sul	Atlantic Rainforest	-54.072797	-28.381386	Present study (UFRGS 4855, 4867)
Corupá	Santa Catarina	Atlantic Rainforest	-49.281810	-26.432660	Giovanelli <i>et al.</i> (2008)
Cotia	São Paulo	Atlantic Rainforest	-46.952450	-23.744130	apud.in Giovanelli <i>et al.</i> (2008)
Curitiba	Paraná	Atlantic Rainforest	-49.433333	-25.716667	apud. in Conte (2010)
Derrubadas	Rio Grande do Sul	Atlantic Rainforest	-53.855300	-27.266270	apud.in Giovanelli <i>et al.</i> (2008)
Dois Lajeados	Rio Grande do Sul	Atlantic Rainforest	-51.850000	-28.983300	Present study (UFRGS 2585)
Dom Feliciano	Rio Grande do Sul	Atlantic Rainforest	-52.110660	-30.697850	apud.in Giovanelli <i>et al.</i> (2008)
Dona Francisca	Rio Grande do Sul	Atlantic Rainforest	-53.358980	-29.626260	apud.in Giovanelli <i>et al.</i> (2008)
			-53.353367	-29.611983	Present study
			-53.353517	-29.611850	Present study
Dona Francisca	Rio Grande do Sul	Atlantic Rainforest	-53.377017	-29.593650	Present study
			-53.336350	-29.612167	Present study
			-53.338600	-29.607517	Present study
			-53.344383	-29.570567	Present study
Duque de Caxias	Rio de Janeiro	Atlantic Rainforest	-43.304460	-22.582420	apud.in Giovanelli <i>et al.</i> (2008)
Embu	São Paulo	Atlantic Rainforest	-46.831910	-23.236399	Giovanelli <i>et al.</i> (2008)
Encantado	Rio Grande do Sul	Atlantic Rainforest	-51.879890	-29.239840	apud.in Giovanelli <i>et al.</i> (2008)
Entre Rios do Sul	Rio Grande do Sul	Pampa	-52.732953	-27.528570	Present study (UFRGS 2555)

Municipality	State	Biome	Longitude	Latitude	Source
Erechim	Rio Grande do Sul	Atlantic Rainforest	-52.268920	-27.629560	apud.in Giovanelli <i>et al.</i> (2008)
Estrela	Rio Grande do Sul	Atlantic Rainforest	-50.980020	-28.100020	apud.in Giovanelli <i>et al.</i> (2008)
Estrela Velha	Rio Grande do Sul	Atlantic Rainforest	-53.153680	-29.172250	apud.in Giovanelli <i>et al.</i> (2008)
Faxinal do Soturno	Rio Grande do Sul	Atlantic Rainforest	-53.426750	-29.572950	Present study
			-53.426683	-29.573467	Present study
			-53.423433	-29.566400	Present study
			-53.423100	-29.580000	Present study
			-53.398817	-29.530483	Present study
			-53.398383	-29.530467	Present study
Fazenda Rio Grande	Paraná	Atlantic Rainforest	-49.250000	-25.616667	Conte and Rossa-Feres (2007)
Fortaleza	Ceará	Caatinga	-38.500000	-3.716700	Pacelli, G. (<i>pers. comm.</i>)
Francisco Beltrão	Paraná	Atlantic Rainforest	-53.099060	-26.064956	Present study
Frederico Westphalen	Rio Grande do Sul	Atlantic Rainforest	-53.400000	-27.366700	Present study (MCT 7469-7473)
Goiânia	Goiás	Cerrado	-49.266700	-16.666700	Present study
Gravataí	Rio Grande do Sul	Atlantic Rainforest	-50.990000	-29.950000	apud.in Giovanelli <i>et al.</i> (2008)
Guaíba	Rio Grande do Sul	Atlantic Rainforest	-51.320000	-30.110000	apud.in Giovanelli <i>et al.</i> (2008)
Guarapuava	Paraná	Atlantic Rainforest	-51.450000	-25.383300	Present study (ZUEC 16841)
Guatambu	Santa Catarina	Atlantic Rainforest	-52.779806	-27.088861	Lucas and Fortes (2008)
			-52.752267	-27.139967	Present study
			-52.751867	-27.163000	Present study
Hidrolândia	Goiás	Cerrado	-49.050000	-17.266700	Present study
Ibarama	Rio Grande do Sul	Atlantic Rainforest	-53.126920	-29.421140	apud.in Giovanelli <i>et al.</i> (2008)
Igrejinha	Rio Grande do Sul	Atlantic Rainforest	-50.800000	-29.580000	Giovanelli <i>et al.</i> (2008)
Indaial	Santa Catarina	Atlantic Rainforest	-49.255867	-26.931817	Present study
			-49.266217	-26.946867	Present study
			-49.265700	-26.946800	Present study
			-49.265217	-26.947800	Present study
Iporanga	São Paulo	Atlantic Rainforest	-48.583300	-24.583300	Present study (ZUEC 16905)
Ipuaçú	Santa Catarina	Atlantic Rainforest	-52.408060	-26.570670	Giovanelli <i>et al.</i> (2008)
Itarana	Espírito Santo	Atlantic Rainforest	-40.875278	-19.873889	Present study (MBML 5587)
Itatiaia	Minas Gerais	Atlantic Rainforest	-43.583300	-20.500000	Present study (CFBH-T 2674)
Ivorá	Rio Grande do Sul	Atlantic Rainforest	-53.527300	-29.482417	Present study
			-53.530467	-29.498517	Present study
			-53.530467	-29.492033	Present study
Jaraguá do Sul	Santa Catarina	Atlantic Rainforest	-49.100000	-26.480000	apud.in Giovanelli <i>et al.</i> (2008)
Joaçaba	Santa Catarina	Atlantic Rainforest	-51.524344	-27.158861	Present study
			-51.588928	27.160858	Present study
Lages	Santa Catarina	Atlantic Rainforest	-50.316700	-27.800000	Present study (MCT 10276)
Lajeado	Rio Grande do Sul	Atlantic Rainforest	-51.126920	-29.421140	apud.in Giovanelli <i>et al.</i> (2008)
Lebon Régis	Santa Catarina	Atlantic Rainforest	-50.666667	-26.853611	Lingnau (2009)
Macaíba	Rio Grande do Norte	Caatinga	-35.350000	-5.850000	Instituto Hórus (2011)
Maceió	Alagoas	Atlantic Rainforest	-35.745130	-9.625540	apud.in Giovanelli <i>et al.</i> (2008)
Manhuaçu	Minas Gerais	Atlantic Rainforest	-42.137461	-20.210497	Silva and Filho (2009)
Marau	Rio Grande do Sul	Atlantic Rainforest	-52.203853	-28.446708	Present study (CAUPF 1828-1834)
Marília	São Paulo	Cerrado	-49.945800	-22.213900	Giovanelli <i>et al.</i> (2008)
Maringá	Paraná	Atlantic Rainforest	-51.937225	-23.427731	Present study (CFBH 17180-17183, 17197-17198, 17227)
Mato Castelhana	Rio Grande do Sul	Atlantic Rainforest	-52.187369	-28.278672	Present study (CAUPF 1835-1844, 1853-1858)
Muçum	Rio Grande do Sul	Atlantic Rainforest	-51.869310	-29.165000	apud.in Giovanelli <i>et al.</i> (2008)
Muitos Capões	Rio Grande do Sul	Atlantic Rainforest	-51.183300	-28.316700	Gedoz, A. A. (<i>pers. comm.</i>)
Nonoai	Rio Grande do Sul	Atlantic Rainforest	-52.772433	-27.363242	Present study (UFRGS 2581, 4341)
Nova Erechim	Santa Catarina	Atlantic Rainforest	-52.899817	-26.869667	Present study
			-52.921350	-26.886633	Present study
			-52.925308	-26.881517	Present study
Nova Palma	Rio Grande do Sul	Atlantic Rainforest	-53.472230	-29.471450	apud.in Giovanelli <i>et al.</i> (2008)

Municipality	State	Biome	Longitude	Latitude	Source
		Atlantic Rainforest	-53.480000	-29.475083	Present study
		Atlantic Rainforest	-53.486400	-29.474150	Present study
Nova Petrópolis	Rio Grande do Sul	Atlantic Rainforest	-51.140000	-29.360000	apud.in Giovanelli <i>et al.</i> (2008)
Nova Roma do Sul	Rio Grande do Sul	Atlantic Rainforest	-51.406670	-28.999720	apud.in Giovanelli <i>et al.</i> (2008)
Palmas	Paraná	Atlantic Rainforest	-52.000000	-26.500000	Camargo-Neto, A (<i>pers. comm.</i>)
Pariquera-Açu	São Paulo	Atlantic Rainforest	-47.883300	-24.716700	Giovanelli <i>et al.</i> (2008)
Parnaíba	Mato Grosso do Sul	Cerrado	-51.195836	-19.671744	Present study (CFBH 20116)
Parnamirim	Rio Grande do Norte	Atlantic Rainforest	-35.260289	-5.906186	Instituto Hórus (2011)
Passo Fundo	Rio Grande do Sul	Atlantic Rainforest	-52.410000	-28.260000	Present study (CAUPF 2303)
Passos Maia	Santa Catarina	Atlantic Rainforest	-51.900000	-26.783333	Conte (2010)
Paulista	Pernambuco	Atlantic Rainforest	-34.883300	-7.950000	Instituto Hórus (2011)
Pedro de Toledo	São Paulo	Atlantic Rainforest	-47.231370	-24.287260	Giovanelli <i>et al.</i> (2008)
Peruíbe	São Paulo	Atlantic Rainforest	-46.994378	-24.316311	Present study (CFBH 12711)
Pinhalzinho	Santa Catarina	Atlantic Rainforest	-52.970167	-26.832067	Present study
			-52.969250	-26.831650	Present study
			-52.952550	-26.836350	Present study
			-52.952450	-25.839400	Present study
			-52.942600	-26.815383	Present study
			-52.938317	-26.812867	Present study
Piracicaba	São Paulo	Atlantic Forest/ Cerrado	-47.640000	-22.710000	apud.in Giovanelli <i>et al.</i> (2008)
Pomerode	Santa Catarina	Atlantic Rainforest	-49.175686	-26.740608	Present study
Ponte Nova	Minas Gerais	Atlantic Rainforest	-42.925003	-20.371067	Camargo-Filho <i>et al.</i> (2008)
Ponte Serrada	Santa Catarina	Atlantic Rainforest	-52.020528	-26.870203	Conte (2010)
Porto Alegre	Rio Grande do Sul	Atlantic Rainforest	-51.220000	-30.040000	apud.in Giovanelli <i>et al.</i> (2008)
Quatro Barras	Paraná	Atlantic Rainforest	-49.010140	-25.310060	Present study (CFBH 18142)
			-49.001490	-25.287120	Present study (CFBH 18150-18153)
Rio Claro	São Paulo	Atlantic Rainforest/ Cerrado	-47.571170	-22.354710	Giovanelli <i>et al.</i> (2008)
Rio do Sul	Santa Catarina	Atlantic Rainforest	-49.641967	-27.215347	Present study
Rio Pardo	Rio Grande do Sul	Atlantic Rainforest	-52.371653	-29.984625	Present study
Roca Sales	Rio Grande do Sul	Atlantic Rainforest	-51.871406	-29.289733	Present study (MCT 8435)
Salvador	Bahia	Atlantic Rainforest	-38.509344	-12.971672	Instituto Hórus (2011), Present study (UFBA, 4451)
Santa Cruz do Sul	Rio Grande do Sul	Atlantic Rainforest	-52.433710	-29.715770	apud.in Giovanelli <i>et al.</i> (2008)
Santa Maria	Rio Grande do Sul	Atlantic Rainforest/ Pampa	-53.828530	-29.695240	apud.in Giovanelli <i>et al.</i> (2008)
			-53.700000	-29.700000	Santos <i>et al.</i> (2008)
Santa Tereza	Rio Grande do Sul	Atlantic Rainforest	-51.745860	-29.168810	apud.in Giovanelli <i>et al.</i> (2008)
Santo Antônio do Descoberto	Goiás	Cerrado	-48.260300	-15.969680	Giovanelli <i>et al.</i> (2008)
São João do Polêsine	Rio Grande do Sul	Atlantic Rainforest	-53.443017	-29.621558	Present study
São José do Rio Preto	São Paulo	Cerrado	-49.379400	-20.819700	Giovanelli <i>et al.</i> (2008)
São José dos Pinhais	Paraná	Atlantic Rainforest	-49.195725	-25.530808	apud in Giovanelli <i>et al.</i> (2008)
São Luís do Paraitinga	São Paulo	Atlantic Rainforest	-45.133000	-23.346000	Giovanelli <i>et al.</i> (2008)
São Paulo	São Paulo	Atlantic Rainforest	-46.642900	-23.776140	Giovanelli <i>et al.</i> (2008)
Senador Canedo	Goiás	Cerrado	-49.083300	-16.716700	Present study
Serafina Correa	Rio Grande do Sul	Atlantic Rainforest	-51.932167	-28.712392	Present study (UFRGS 3445-3446, 3457-3458)
Silva Jardim	Rio de Janeiro	Atlantic Rainforest	-42.393500	-22.655589	Potsch, S. (<i>pers. comm.</i>)
Silvânia	Goiás	Cerrado	-48.610286	-16.665144	Bastos, R. (<i>pers. comm.</i>)
Suzano	São Paulo	Atlantic Rainforest	-46.299920	-23.569800	Giovanelli <i>et al.</i> (2008)
Tapes	Rio Grande do Sul	Pampa	-51.396614	-30.674347	Present study (UFRGS 3171)
Taquari	Rio Grande do Sul	Atlantic Rainforest	-51.860260	-29.801090	apud.in Giovanelli <i>et al.</i> (2008)
Telêmaco Borba	Paraná	Atlantic Rainforest	-50.583333	-24.283333	Machado (2004)
Tenente Portela	Rio Grande do Sul	Atlantic Rainforest	-53.760150	-27.375910	apud.in Giovanelli <i>et al.</i> (2008)

Municipality	State	Biome	Longitude	Latitude	Source
Teresópolis	Rio de Janeiro	Atlantic Rainforest	-42.966378	-22.412578	Potsch, S. (<i>pers. comm.</i>)
Torres	Rio Grande do Sul	Atlantic Rainforest	-49.755600	-29.348210	apud.in Giovanelli <i>et al.</i> (2008)
Triunfo	Rio Grande do Sul	Pampa	-51.718075	-29.942667	Present study (MCT 5614)
Tunas	Rio Grande do sul	Atlantic Rainforest	-52.991339	-29.126781	Bernardo-Silva, J., (<i>pers. comm.</i>)
Ubatuba	São Paulo	Atlantic Rainforest	-45.132530	-23.497280	Giovanelli <i>et al.</i> (2008)
Uberlândia	Minas Gerais	Cerrado	-48.279970	-18.900010	apud.in Giovanelli <i>et al.</i> (2008)
Varginha	Minas Gerais	Atlantic Rainforest	-45.100000	-22.333300	Present study (CFBH-T 7514)
Veranópolis	Rio Grande do Sul	Atlantic Rainforest	-51.560000	-28.940000	apud.in Giovanelli <i>et al.</i> (2008)
Viamão	Rio Grande do Sul	Atlantic Rainforest	-50.980000	-30.090000	apud.in Giovanelli <i>et al.</i> (2008)
Viçosa	Minas Gerais	Atlantic Rainforest	-42.882219	-20.754200	apud.in Giovanelli <i>et al.</i> (2008); Silva <i>et al.</i> (2009)
Vieiras	Minas Gerais	Atlantic Rainforest	-42.294728	-20.961692	Silva and Filho (2009)
Vila Flores	Rio Grande do Sul	Atlantic Rainforest	-51.551892	-28.868928	Present study (MCT 9933)
Vitória	Espírito Santo	Atlantic Rainforest	-40.412720	-20.331070	apud.in Giovanelli <i>et al.</i> (2008)
Xaxim	Santa Catarina	Atlantic Rainforest	-52.534097	-26.961517	Present study (MCT 9768)

(Ficettola *et al.*, 2007; Giovanelli *et al.*, 2008), given the fast reproductive potential in the subtropical region (Kaefer *et al.*, 2007) and the large variety of potential prey in invaded sites (Boelter and Cechin, 2007; Silva *et al.*, 2009). Scientists are united in calling for stronger policies and control programs to prevent, constrain, and eradicate bullfrog invasions in South America (Pereyra *et al.*, 2006; Boelter and Cechin, 2007; Laufer *et al.*, 2008; Silva *et al.*, 2011), but increasing market pressures are a challenge to any conservation initiative. If in the past bullfrog farming was unprofitable, the strong current global demand for frog legs and improvements in farm structure and technology have made bullfrog farming economically viable (De-Bernardi and Alderete, 1999; Warkentin *et al.*, 2007). We believe that frog leg production per se is not necessarily problematic, and the potential economic benefits of bullfrog farming must not be ignored. Instead, the problem lies in the absence of adequate biological and legal safeguards to prevent bullfrog escape or release.

The extensive and possibly expanding distribution of feral *Lithobates catesbeianus* populations in Brazil poses a major conservation challenge, and a lengthy list of research questions must be answered in order to meet it. Data are lacking on particular invasion histories, population densities, dispersal rates, spatial distribution at refined scales, infectious disease incidence, and the impact of invasive bullfrogs on natural ecosystems-especially native frog species, which may already be declining and are expected to be most negatively impacted by invasive anurans. These questions are inextricably linked to problems of public education, economics, and legal regulations, all of which must be addressed to resolve the problem of invasive bullfrogs.

RESUMO

Nós reportamos novos registros de populações na natureza de *Lithobates catesbeianus* no Brasil. Os dados foram baseados em trabalho de campo, registros de coleções científicas, literatura e bancos de dados eletrônicos. *Lithobates catesbeianus* ocorre em 130 municípios do Brasil, dos quais, 55 são apresentados pela primeira vez neste trabalho. Grande parte dos registros são das regiões sul e sudeste do Brasil, em áreas do bioma Mata Atlântica que apresentam condições climáticas favoráveis ao estabelecimento de populações da espécie. A ampla distribuição da espécie invasora, possivelmente em expansão, se apresenta como um grande desafio para a conservação e mostra a urgente necessidade de pesquisas sobre os padrões da invasão da espécie.

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LITERATURE CITED

- AGOSTINHO, C. A. 2003. Desenvolvimento de linhagem comercial de rã-touro (*Rana catesbeiana*): produção de plantel unissexual. *Boletim Técnico do Instituto da Pesca*, 34:7-11.
- BAKER, H. G. 1974. The evolution of weeds. *Annual Review of Ecology and Systematics*, 5:1-24.
- BARRASSO, D. A., R. CAJADE, S. J. NENDA, G. BALORIANI, AND R. HERRERA. 2009. Introduction of the American bullfrog *Lithobates catesbeianus* (Anura: Ranidae) in natural and modified environments: an increasing conservation problem in Argentina. *South American Journal of Herpetology*, 4:69-75.
- BOELTER, R. A. AND S. Z. CECHIN. 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.
- BURY, R. B. AND J. A. WHELAN. 1984. Ecology and management of the bullfrog. U.S. Department of the Interior, Fish and Wildlife Service, Washington, 23 pp.
- CONTE, C. E. 2010. Diversidade de anfíbios da Floresta com Araucária. Ph.D. dissertation, Universidade Estadual Paulista, Campus São José do Rio Preto, 123 pp.
- CONTE, C. E. AND D. C. ROSSA-FERES. 2007. Riqueza e distribuição espaço-temporal de anuros em um remanescente de Floresta de Araucária no sudeste do Paraná. *Revista Brasileira de Zoologia*, 24:1025-1037.
- DALLACORTE, F. 2010. Impacto da rã-touro-gigante (*Lithobates catesbeianus*) sobre a fauna nativa na zona de amortecimento e interior do Parque Nacional da Serra do Itajaí (PNSI), Blumenau, SC. Master dissertation, Universidade Regional de Blumenau, Blumenau, 145 pp.
- DASZAK, P., A. STRIEBY, A. A. CUNNINGHAM, J. E. LONGCORE, C. C. BROWN, AND D. PORTER. 2004. Experimental evidence that the bullfrog (*Rana catesbeiana*) is a potential carrier of chytridiomycosis, an emerging fungal disease of amphibians. *Herpetological Journal*, 14:201-212.
- DE-BERNARDI, L. A. AND J. M. ALDERETE. 1999. Rana toro, del bañado al criadero. *Revista de Alimentos Argentinos*, 12:1-4.
- FICETOLA, G. F., W. THUILLER, AND C. MIAUD. 2007. Prediction and validation of the potential global distribution of a problematic alien invasive species – the American bullfrog. *Diversity and Distributions*, 13:476-485.
- GIOVANELLI, J. G. R., C. F. B. HADDAD, AND J. ALEXANDRINO. 2008. Predicting the potential distribution of the alien invasive American bullfrog (*Lithobates catesbeianus*) in Brazil. *Biological Invasions*, 10:585-590.
- INSTITUTO HÓRUS. 2011. Base de dados de espécies exóticas invasoras no Brasil. www.institutohorus.org.br. Accessed 22 Feb 2011.
- KAEFER, I. L., R. A. BOELTER, AND S. Z. CECHIN. 2007. Reproductive biology of the invasive bullfrog *Lithobates catesbeianus* in southern Brazil. *Annales Zoologica Fennici*, 44:435-444.
- KATS, L. B. AND R. P. FERRER. 2003. Alien predators and amphibian declines: review of two decades of science and the transition to conservation. *Diversity and Distributions*, 9:99-110.
- KRAUS, F. 2009. Alien reptiles and amphibians: a scientific compendium and analysis. Springer, Netherlands, 563 pp.
- LAUFER, G., A. CANAVERO, D. NÚÑES, AND R. MANEYRO. 2008. Bullfrog (*Lithobates catesbeianus*) invasion in Uruguay. *Biological Invasions*, 10:1183-1189.
- LIMA, S. L. AND C. A. AGOSTINHO. 1988. A criação de rãs. Editora Globo, Rio de Janeiro, 187 pp.
- LINGNAU, R. 2009. Distribuição temporal, atividade reprodutiva e vocalizações em uma assembléia de anfíbios anuros de uma Floresta Ombrófila Mista em Santa Catarina, sul do Brasil. Ph.D. dissertation, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, 103 pp.
- LUCAS, E. M. AND V. B. FORTES. 2008. Frog diversity in the Floresta Nacional de Chapecó, Atlantic Forest of southern Brazil. *Biota Neotropica*, 8:0-0 online journal: www.biotaneotropica.org.br/v8n3/en/abstract?article=bn00508032008.
- MACHADO, R. A. 2004. Ecologia de assembléias de anfíbios anuros no município de Telêmaco Borba, Paraná, sul do Brasil. Ph.D. dissertation, Universidade Federal do Paraná, Curitiba, 128 pp.
- PEREYRA, M., D. BALDO, AND E. KRAUCZUK. 2006. La “rana toro” en la Selva Atlántica Interior Argentina: un nuevo problema de conservación. *Cuadernos de Herpetología*, 20:37-40.
- ROCHA-MIRANDA, F., M. MARTINS-SILVA, AND A. MENDONÇA. 2006. First occurrence of bullfrogs (*Rana catesbeiana*) in Federal District, Central Brazil. *Froglog*, 74:2-3.
- SANTOS, T., K. KOPP, M. R. SPIES, R. TREVISAN, AND S. Z. CECHIN. 2008. Distribuição temporal e espacial de anuros em área de Pampa, Santa Maria, RS. *Iheringia, Série Zoologia*, 98:244-253.
- SANTOS-BARRERA, G., G. HAMMERSON, B. HEDGES, R. JOGLAR, S. INCHAUSTEGUI, L. KUANGYANG, C. WENHAO, G. HUIGING, S. HAITAO, A. DIEMOS, D. ISKANDAR, P. P. VAN DIJK, S. MATSUI, B. SCHMIDT, C. MIAUD, AND I. MARTÍNEZ-SOLANO. 2009. *Lithobates catesbeianus*. IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4.
- SILVA, E., C. COSTA, AND R. N. FEIO. 2007. *Rana catesbeiana* (American Bullfrog). Prey. *Herpetological Review*, 38:443.
- SILVA, E. AND O. RIBEIRO-FILHO. 2009. Predation on juveniles of the invasive American Bullfrog *Lithobates catesbeianus* (Anura, Ranidae) by native frog and snake species in South-eastern Brazil. *Herpetology Notes*, 2:215-218.
- SILVA, E. T., E. P. REIS, R. N. FEIO, AND O. P. RIBEIRO-FILHO. 2009. Diet of the invasive frog *Lithobates catesbeianus* (Shaw, 1802) (Anura: Ranidae) in Viçosa, Minas Gerais state, Brazil. *South American Journal of Herpetology*, 4:286-294.
- SILVA, E. T., O. P. RIBEIRO-FILHO, AND R. N. FEIO. 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*, 6:1-10.
- WARKENTIN, I. G., D. BICKFORD, N. S. SODHI, AND C. J. A. BRADSHAW. 2009. Eating frogs to extinction. *Conservation Biology*, 23:1056-1059.
- VIZOTTO, L. D. 1984. Ranicultura. *Ciência e Cultura*, 36:42-45.

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APPENDIX 1

List of natural history collections consulted for *Lithobates catesbeianus* records: Coleção Célio F. B. Haddad, Universidade Estadual Paulista, Campus Rio Claro; Coleção de Amphibia da Universidade Federal da Bahia; Coleção de Anfíbios da Universidade de Passo Fundo; Coleção de Anfíbios da Universidade Federal do Rio de Janeiro; Coleção de Anfíbios do Museu de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul; Coleção de Anfíbios do Museu de Zoologia da Universidade Estadual de Campinas; Coleção de Anfíbios e Répteis do Instituto Nacional de Pesquisas da Amazônia; Coleção de Anfíbios Museu de Biologia Professor Mello Leitão; Coleção de Anfíbios, Universidade Estadual Paulista, Campus São José do Rio Preto; Coleção de Herpetofauna do Museu de Zoologia, Universidade Estadual de Londrina; Coleção de Herpetologia da Universidade Federal de Santa Maria; Coleção de Herpetologia da Universidade Federal do Ceará; Coleção de Coleção de Referência da Herpetofauna de Rondônia, Fundação Universidade de Rondônia; Coleção de Vertebrados do Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa; Coleção Herpetológica Alphonse Richard Hoge, Instituto Butantan; Coleção Herpetológica da Universidade Federal de Juíz de Fora; Coleção Herpetológica da Universidade Federal do Acre; Coleção Herpetológica da Universidade Federal do Rio Grande do Sul; Coleção Zoológica da Universidade Federal de Goiás.