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Article

Anuran amphibians in state of Paraná, southern Brazil

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Abstract: The state of Paraná, located in southern Brazil, was originally covered almost entirely by the Atlantic Forest biome, with some areas of Cerrado savanna. In the present day, little of this natural vegetation remains, mostly remnants of Atlantic Forest located in the coastal zone. While some data are available on the anurans of the state of Paraná, no complete list has yet been published, which may hamper the understanding of its potential anuran diversity and limit the development of adequate conservation measures. To rectify this situation, we elaborated a list of the anuran species that occur in state of Paraná, based on records obtained from published sources. We recorded a total of 137 anuran species, distributed in 13 families. Nineteen of these species are endemic to the state of Paraná and five are included in the red lists of the state of Paraná, Brazil and/or the IUCN. Two anuran species were categorized as Near Threatened by the IUCN and 27 species were listed as Data Deficient in one or more lists. According to IUCN 49.6% of the anuran species recorded had their population trends stable, 19% in declined, only 1.4% is increased and 20.4% had your population trends unknown. We also recorded the occurrence in Paraná of the exotic invader anuran *Lithobates catesbeianus*. We consider our list of species to be a relatively reliable estimate of the anuran diversity of the Brazilian state of Paraná, although new species records are expected, mainly because there are many regions that have not yet been sampled.
Keywords: *Atlantic Forest, checklist, Cerrado, inventory, species richness.*

Anfíbios anuros do estado do Paraná, sul do Brasil

Resumo: O estado do Paraná, localizado no sul do Brasil, originalmente possuía praticamente toda sua área coberta pelo bioma Mata Atlântica com algumas porções do bioma Cerrado. Atualmente, pouco resta das formações destes biomas, sendo a maior parte remanescentes florestais de Mata Atlântica, localizados na região costeira do Estado. Apesar de haver estudos sobre anuros no estado do Paraná, até então nenhum deles proveu uma lista dos anuros com ocorrência no Estado, o que pode dificultar o conhecimento sobre a potencial diversidade de anuros e restringir medidas de conservação. A partir dessa lacuna, elaboramos uma lista das espécies de anuros com registro para o Paraná, a partir de dados de estudos publicados. Registramos um total de 137 espécies de anuros, pertencentes a 13 famílias. Dentre estas, 19 espécies de anuros são endêmicas do estado do Paraná e cinco encontram-se relacionadas sob algum grau de ameaça de extinção na lista vermelha do estado do Paraná, do Brasil e/ou da lista global da IUCN. Duas espécies de anuros foram categorizadas como Quase Ameaçada pela IUCN e 27 espécies foram listadas como Dados Insuficientes nestas listas. De acordo com a IUCN, 49,6% das espécies de anuros registradas apresentaram tendências populacionais estáveis, 19% diminuíram, apenas 1,4% aumentaram e 20,4% apresentaram tendências de sua populações desconhecidas. Registramos também a ocorrência do anuro exótico e invasor *Lithobates catesbeianus* para diferentes áreas do estado do Paraná. Consideramos nossa lista de espécies uma estimativa relativamente confiável da diversidade de anuros do estado brasileiro do Paraná, embora sejam esperados novos registros de espécies, principalmente porque existem muitas regiões que ainda não foram amostradas.
Palavras-chave: *Mata Atlântica, lista de espécies, Cerrado, inventário, riqueza de espécies.*

Introduction

Currently 6836 species of anuran amphibians are known to exist worldwide (Frost 2017). Just under a sixth (15.2%; 1039 species) of this total is found in Brazil (Segalla et al. 2016). This high species richness is partly related to the continental dimensions of the country and its considerable variation in altitude, as well as the enormous variety of tropical and subtropical habitats and ecosystems found in the different Brazilian biomes (Araújo et al. 2009), which provide a diversity of environments appropriate for anuran populations. In the Brazilian state of Paraná, most of these ecosystems are associated with the Atlantic Forest biome, although some areas of the Cerrado biome are also found in the state. Both these biomes have been classified as world biodiversity hotspots (Myers et al. 2000). Based on the modeling of the distribution data available for anuran species, Toledo & Batista (2012) estimated that as many as 147 anuran species may potentially occur in the state. Crivellari et al. (2014) recently listed the anurans that occur in the southern grasslands of Paraná, citing a total of 61 species. Up until now, however, no complete list of the anurans known to occur in the state of Paraná has been published.

While species lists for the country as a whole or for its different political divisions are important for the understanding of their biodiversity and provide an additional tool for the development of conservation measures, knowledge on the diversity of most groups of animals, through studies that provide species lists, is still incipient for most Brazilian states. Currently, lists of anuran amphibians are only available for the Brazilian states of Alagoas (Almeida et al. 2016), Espírito Santo (Almeida et al. 2011), Piauí (Roberto et al. 2013), Rio de Janeiro (Rocha et al. 2004), Rio Grande do Sul (Machado & Maltchik 2007), and São Paulo (Rossa-Feres et al. 2011), less than a quarter (23.1%) of the total number of Brazilian states.

In the present study, we estimated the number of anuran taxa that occur in the Brazilian state of Paraná based on a compilation of published records. We identified the endemic species, the taxa listed as threatened, near threatened and data deficient and the population trend of each species (*sensu* IUCN 2017). We also mapped the localities in Paraná where anuran inventories have been conducted.

Material and Methods

To identify the anuran species that occur in the Brazilian state of Paraná, we considered data obtained from papers published in journals based on a search of the Web of Science, Scielo, Scopus, and Google Scholar databases. The search terms used to identify the papers were amphib* AND Paraná, anur* AND Paraná and frog* AND Paraná. We consulted the papers cited as references in these articles. We terminated the search in November 06, 2017. We also did a supplementary search on the website SpeciesLink (2017) to know if there was still some anuran species collected in the state of Paraná that had not been registered by us through the publications accessed. To identify the endemic species of the Paraná state and the Atlantic Forest, we analyzed the known geographic distribution of each recorded species by Frost (2017). The current conservation status of each species was obtained from the Red List of Threatened Fauna of the state of Paraná (Segalla & Langone 2004), the Red List of Threatened Brazilian Fauna (MMA 2014), and the online version of the IUCN Red List of Threatened Species (IUCN 2017). The IUCN website was accessed to know the population trends of the anurans recorded in the present study (IUCN 2017). We followed the taxonomic nomenclature of Frost (2017).

Results

Based on the combined database (Table 1), we recorded 137 anuran species for the state of Paraná, belonging to 13 families: Hylidae (n = 58 species), Leptodactylidae (26), Brachycephalidae (15), Bufonidae (12), Cycloramphidae (7), Hylodidae (5), Odontophrynidae (5), Mycrohylidae (3), Hemiphractidae (2), Alsodidae (1), Centrolenidae (1), Craugastoridae (1), and Ranidae (1).

The Hylidae family was the richest in species (58 species, 42.3% of the total), while Alsodidae, Centrolenidae, Craugastoridae, Hemiphractidae and Ranidae were the least diverse, each one represented by a single species (0.7% of the total) (Table 1). The most diverse genus was *Boana*, with 13 species, 9.5% of the total recorded for the state. The most frequently recorded species in published studies were *Boana faber* (Wied-Neuwied, 1821) and *Scinax fuscovarius* (Lutz, 1925), each one recorded in 18 studies, and *Dendropsophus minutus* (Peters, 1872) and *Ischnocnema henselii* (Peters, 1870), both recorded in 17 studies. By contrast, out of 137 recorded species, 32 (23.3%) were cited in only a single study, nine of them (28.1%) are endemic to Paraná, and a further eight (25%) are also found only in the neighboring states of Santa Catarina or São Paulo.

Out of 137 species recorded in this study (Table 1), 19 (13.9%) are endemic to the state of Paraná: Brachycephalidae: *Brachycephalus brunneus* Ribeiro, Alves, Haddad & Reis, 2005 (Pico Caratuva, Campina Grande do Sul municipality), *B. coloratus* Ribeiro, Blackburn, Stanley, Pie & Bornschein, 2017 (Serra da Baitaca, Piraquara municipality), *B. curupira* Ribeiro, Blackburn, Stanley, Pie & Bornschein, 2017 (Serra do Salto, São José dos Pinhais municipality), *B. ferruginus* Alves, Ribeiro, Haddad & Reis, 2006 (Pico do Marumbi, Morretes municipality), *B. izecksohni* Ribeiro, Alves, Haddad & Reis, 2005 (Pico Caratuva, Campina Grande do Sul municipality), *B. leopardus* Ribeiro, Firkowski & Pie, 2015 (Serra do Araçatuda, Tijucas do Sul municipality; Morro dos Perdidos, Guaratuba municipality), *B. pernix* Pombal, Wistuba & Bornschein, 1998 (Quatro Barras, Morretes and São José dos Pinhais municipality), *B. pombali* Alves, Ribeiro, Haddad & Reis, 2006 (Pico da Igreja, Guaratuba municipality), *B. tridactylus* Garey, Lima, Hartmann & Haddad, 2012 (Pico do Morato, Guaraqueçaba municipality), *Ischnocnema paranaensis* (Langone & Segalla, 1996) (next to Pico do Paraná, Antonina municipality) and *I. sambaqui* (Castanho & Haddad, 2000) (Guaraqueçaba and Morretes municipality); Bufonidae: *Dendrophryniscus stawiarskyi* Izecksohn, 1994 (Bituruna municipality), *Melanophryniscus alipioi* Langone, Segalla, Bornschein & de Sá, 2008 (Campina Grande do Sul municipality) and *M. vilavelhensis* Steinbach-Padilha, 2008 (Ponta Grossa municipality); Cycloramphidae: *Cycloramphus duseni* (Anderson, 1914) (Ipiranga municipality) and *C. mirandaribeiroi* Heyer, 1983 (São João da Graciosa, Morretes municipality); Hylidae: *Bokermannohyla langei* (Bokermann, 1965) (Morretes municipality) and *Boana jaguariaivensis* (Caramaschi, Cruz & Segalla, 2010) (Jaguariaíva municipality); Leptodactylidae: *Physalaemus insperatus* Cruz, Cassini & Caramaschi, 2008 (Guaratuba municipality).

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Table 1. Anuran amphibians in the state of Paraná, southern Brazil, including geographical distribution in Brazil, endemism for the state of Paraná (both sensu Frost 2017), and conservation status [according to Red List of Threatened Fauna of the state of Paraná (Segalla & Langone 2004), Red List of Threatened Brazilian Fauna (MMA 2014), and the IUCN Red List of Threatened Species (2017)]. Population trend of anurans follows IUCN (2017): S = stable, D = decreasing, I = increasing and U = unknown. Source of records: 1, Affonso & Delariva (2012); 2-3, Affonso et al. (2011, 2014); 4, Alves et al. (2006); 5, Antonucci et al. (2011); 6, Armstrong & Conte (2010); 7, Baldo et al. (2008); 8, Benarde & Anjos (1999); 9, Bernarde & Machado (2001); 10, Bokermann (1965); 11, Bornschein et al. (2015a); 12, Bornschein et al. (2015b); 13, Bornschein et al. (2016b); 14, Caramaschi & Cruz (2002); 15, Caramaschi & Rodrigues (2007); 16, Caramaschi et al. (2010); 17, Castanho & Haddad (2000); 18-19, Clemente-Carvalho et al. (2009, 2011); 20, Condez et al. (2016); 21, Conte & Machado (2005); 22-23, Conte & Rossa-Feres (2006, 2007); 24-25, Conte et al. (2005, 2010); 26, Costa et al. (2009); 27, Crivellari et al. (2014); 28, Cruz (1990); 29, Cruz et al. (2008); 30, Cunha et al. (2010); 31, Figueiredo et al. (2014); 32, Fontoura et al. (2011); 33, Gambale et al. (2014); 34, Garey & Hartmann (2012); 35-36, Garey et al. (2012a, 2012b); 37-38, Heyer (1978, 1983); 39, Heyer & Heyer (2004); 40, Hiert & Moura (2010); 41, Hiert et al. (2012); 42, Izecksohn (1993); 43, Langone & Segalla (1996); 44, Langone et al. (2008); 45, Leivas & Hiert (2016); 46, Lima et al. (2010); 47, Lingnau & Bastos (2007); 48, Lingnau et al. (2008); 49, Machado & Bernarde (2002); 50, Machado et al. (1999); 51, Marcelino et al. (2009); 52, Miranda et al. (2008); 53-55, Moresco et al. (2009, 2013, 2014); 56, Nazaretti & Conte (2015); 57, Nunes et al. (2012); 58, Oda & Landgraf (2012); 59, Oda et al. (2015); 60, Oliveira et al. (2010); 61, Pederassi et al. (2015); 62, Pie et al. (2013); 63, Pimenta et al. (2014); 64, Pombal et al. (1998); 65, Prado & Pombal (2008); 66, Ribeiro et al. (2015); 67, Ribeiro et al. (2017); 68, Sá & Langone (2002); 69-70, Sá et al. (2007, 2014); 71, Santos-Pereira & Rocha (2015); 72-74, Santos-Pereira et al. (2011, 2015, 2016); 75, Steinbach-Padilha (2008); 76-77, Toledo et al. (2007, 2012); 78, Thomé et al. (2012); 79, Trein et al. (2014); 80, Vieira et al. (2012); 81, Winkelmann & Noleto (2015). *considered the anuran species as "aff.". **considered the anuran species as "cf.".

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
ANURA							
Alsodidae							
Limnomedusa macroglossa (Duméril & Bibron, 1841)	Southern		CR		LC	S	9, 22
Brachycephalidae							
Brachycephalus brunneus Ribeiro, Alves, Haddad & Reis, 2005	PR (Pico Caratuva, Campina Grande do Sul)	X			DD	U	13, 18, 19, 32, 62
Brachycephalus coloratus Ribeiro, Blackburn, Stanley, Pie & Bornschein, 2017	PR (Serra da Baitaca, Piraquara)	X					67
Brachycephalus curupira Ribeiro, Blackburn, Stanley, Pie & Bornschein, 2017	PR (Serra do Salto, Malhada District, São José dos Pinhais)	X					67
Brachycephalus ferruginus Alves, Ribeiro, Haddad & Reis, 2006	PR (Pico Marumbi, Morretes)	X			DD	U	4, 13, 18
Brachycephalus hermogenesi (Giaretta & Sawaya, 1998)	RJ, SP and PR				LC	S	30*, 72, 74
Brachycephalus izecksohni Ribeiro, Alves, Haddad & Reis, 2005	PR (Pico Caratuva, Campina Grande do Sul)	X			DD	U	13, 18, 19, 62
Brachycephalus leopardus Ribeiro, Firkowski & Pie, 2015	PR (Serra do Araçatuba, Tijucas do Sul and Morro dos Perdidos, Guaratuba)	X					13, 66
Brachycephalus pernix Pombal, Wistuba & Bornschein, 1998	PR (Quatro Barras, Morretes and São José dos Pinhais)	X	CR	CR	DD	U	18, 19, 22, 62, 64
Brachycephalus pombali Alves, Ribeiro, Haddad & Reis, 2006	PR (Pico da Igreja, Guaratuba)	X			DD	U	4, 13, 18, 19, 62
Brachycephalus sulfuratus Condez, Monteiro, Comitti, Garcia, Amaral & Haddad, 2016	SP, PR and SC						20
Brachycephalus tridactylus Garey, Lima, Hartmann & Haddad, 2012	PR (Pico do Morato, Guaraqueçaba)	X					11, 13, 34, 36, 74
Ischnocnema henselii (Peters, 1870)	Southern				LC	U	6*, 8, 9, 21, 22, 23, 25, 27, 30*, 34, 45, 49, 50, 72, 73, 74
Ischnocnema paranaensis (Langone & Segalla, 1996)	PR (Next to Pico do Paraná)	X	EN		DD	U	12, 43

Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Ischnocnema sambaqui (Castanho & Haddad, 2000)	PR (Guaraqueçaba and Morretes)	X	DD		DD	U	6, 17, 22, 74
Ischnocnema cf. *spanios*					DD	U	74
Bufonidae							
Dendrophryniscus berthalutzae Izecksohn, 1994	PR and SC				LC	D	34, 74
Dendrophryniscus leucomystax Izecksohn, 1968	RJ, SP, PR and SC				LC	D	34, 74
Dendrophryniscus stawiarskyi Izecksohn, 1994	PR (Bituruna)	X	DD		DD	U	42
Melanophryniscus alipioi Langone, Segalla, Bornschein & de Sá, 2008	PR (Campina Grande do Sul)	X			DD	U	27, 44
Melanophryniscus tumifrons (Boulenger, 1905)	PR and RS				LC	U	14
Melanophryniscus vilavelhensis Steinback-Padilha, 2008	PR (Ponta Grossa)	X					27, 75
Rhinella abei (Baldissera, Caramaschi & Haddad, 2004)	Southern				LC	U	6, 21, 22, 23, 27, 30, 34, 45, 72, 74, 78
Rhinella henseli (Lutz, 1934)	Southern				LC	U	27, 78
Rhinella hoogmoedi Caramaschi & Pombal, 2006	CE to PR				LC	U	34, 74
Rhinella icterica (Spix, 1824)	RS to BA, MG and GO				LC	S	6, 21, 22, 23, 27, 30, 34, 45, 49, 74
Rhinella ornata (Spix, 1824)	ES, RJ, SP and north PR				LC	U	56, 78
Rhinella schneideri (Werner, 1894)	CE to RS				LC	I	1, 3, 5, 8, 22, 56, 58
Centrolenidae							
Vitreorana uranoscopa (Müller, 1924)	Southeastern and Southern		DD		LC	D	6, 8, 9, 22, 27, 30, 34, 45, 49, 50, 74
Craugastoridae							
Haddadus binotatus (Spix, 1824)	BA to RS, MS				LC	S	8, 9, 22, 27, 34, 49, 50, 72, 74
Cycloramphidae							
Cycloramphus cf. *asper*			DD		DD	D	74
Cycloramphus bolitoglossus (Werner, 1897)	PR and SC		DD		DD	D	21, 22, 23, 38
Cycloramphus duseni (Andersson, 1914)	PR (Ipiranga)	X	DD		DD	U	38
Cycloramphus eleutherodactylus (Miranda-Ribeiro, 1920)	RJ, SP and PR		DD		DD	U	38
Cycloramphus lutzorum Heyer, 1983	SP and PR		DD		DD	D	38, 46
Cycloramphus mirandaribeiroi Heyer, 1983	PR (São João da Graciosa)	X	DD		DD	U	38, 74

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Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Cycloramphus rhyakonastes Heyer, 1983	PR and SC		DD		LC	U	38
Hemiphractidae							
Gastrotheca microdiscus (Andersson, 1910)	SP, PR and SC		DD		LC	D	15, 74
Fritziana gr. *fissilis*					LC	S	34, 74
Hylidae							
Aplastodiscus albosignatus (Lutz & Lutz, 1938)	GO, MG, RJ, SP and PR				LC	D	21, 22, 23, 27, 30, 45, 74
Aplastodiscus ehrhardti (Müller, 1924)	SP, PR and SC				LC	D	6, 22, 24
Aplastodiscus perviridis Lutz, 1950	Central, Southeastern and Southern				LC	S	8, 9, 21, 22, 23, 26, 45, 49, 50
Boana albomarginata (Spix, 1824)	PE to SC				LC	S	6, 30, 34, 74
Boana albopunctata (Spix, 1824)	Central, Southeastern and Southern				LC	S	1, 3, 8, 21, 22, 27, 45, 49, 50, 56, 75
Boana bischoffi (Boulenger, 1887)	RJ to RS				LC	S	6, 21, 22, 23, 27, 30, 45, 51
Boana caingua (Carrizo, 1991)	MS, SP and Southern				LC	S	27
Boana faber (Wied-Neuwied, 1821)	PE to RS				LC	S	1, 3, 6, 8, 9, 21, 22, 23, 27, 28, 34, 45, 49, 50, 55, 74, 80
Boana jaguariaivensis (Caramaschi, Cruz & Segalla, 2010)	PR (Jaguariaíva)	X					16
Boana leptolineata (Braun & Braun, 1977)	PR and RS				LC	S	27, 40, 41
Boana prasina (Burmeister, 1856)	MG, RJ, SP and PR				LC	S	8, 9, 21, 22, 23, 27, 45, 49, 50, 56
Boana pulchella (Duméril & Bibron, 1841)	Southern				LC	S	27
Boana raniceps (Cope, 1862)	Southeastern (except ES) and PR				LC	S	1, 3, 22, 33, 49, 50, 56
Boana semiguttata (Lutz, 1925)	PR and SC			EN	LC	S	22, 49
Boana semilineata (Spix, 1824)	AL to SC				LC	S	34, 74
Boana cf. *stellae*					LC	S	27
Bokermannohyla circumdata (Cope, 1871)	BA, Southeastern, PR and SC				LC	D	21, 22, 23, 27
Bokermannohyla hylax (Heyer, 1985)	SP and PR				LC	D	6, 30, 34, 74
Bokermannohyla langei (Bokermann, 1965)	PR (Morretes)	X	DD		DD	U	10
Dendropsophus anceps (Lutz, 1929)	BA to PR		CR		LC	S	22, 25, 56

Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Dendropsophus berthalutzae (Bokermann, 1962)	ES, SP and PR				LC	S	6, 30, 34, 74
Dendropsophus elegans (Wied-Neuwied, 1824)	BA to SC				LC	S	6, 30, 34, 74
Dendropsophus microps (Peters, 1872)	BA to RS				LC	S	6, 22, 23, 27, 30, 34, 49, 74
Dendropsophus minutus (Peters, 1872)	Brazil				LC	S	1, 3, 6, 8, 9, 21, 22, 23, 27, 30, 34, 45, 49, 50, 56, 74, 75
Dendropsophus nahdereri (Lutz & Bokermann, 1963)	Southern				LC	S	22, 25, 30
Dendropsophus nanus (Boulenger, 1889)	Brazil				LC	S	1, 3, 8, 22, 49, 50, 56
Dendropsophus sanborni (Schmidt, 1944)	Southern				LC	S	21, 22, 23, 27, 49, 56
Dendropsophus seniculus (Cope, 1868)	MG, ES, RJ and PR				LC	S	34, 74
Dendropsophus werneri (Cochran, 1952)	Southern				LC	S	30, 34, 52, 60, 74
Itapothihyla langsdorffii (Duméril & Bibron, 1841)	SE, BA, Southeastern, PR and RS						74
Julianus uruguayus (Schmidt, 1944)	PR and SC				LC	S	22, 27, 49
Lysapsus limellum Cope, 1862	MT and PR				LC	S	3
Ololygon argyreornata (Miranda-Ribeiro, 1926)	ES, RJ, SP and PR				LC	S	6*, 34, 74**
Ololygon aromothyella Faivovich, 2005	PR and RS				DD	U	27
Ololygon berthae (Barrio, 1962)	Southern				LC	S	21, 22, 23, 34*, 49, 56, 74*
Ololygon catharinae (Boulenger, 1888)	Southeastern and Southern				LC	S	22, 23, 27**
Ololygon littoralis (Pombal & Gordo, 1991)	SP, PR and SC				LC	D	6, 34, 35, 74, 77
Ololygon aff. *perpusilla*					LC	S	6, 34, 74
Ololygon rizibilis (Bokermann, 1964)	SP and PR				LC	D	6, 22, 23, 27, 30, 31
Phasmahyla guttata (Lutz, 1924)	RJ, SP, ES and PR		DD		LC	D	28
Phyllomedusa distincta Lutz, 1950	SP, PR and SC				LC	D	6, 22, 23, 27, 30, 34, 45, 74
Phyllomedusa tetraploidea Pombal & Haddad, 1992	SP and PR				LC	S	1, 3, 8, 9, 22, 27, 49, 50, 56, 81
Pithecopus rusticus (Bruschi, Lucas, Garcia & Recco-Pimentel, 2015)	PR and SC						27
Pseudis cardosoi Kwet, 2000	Southern				LC	S	25, 27

Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Scinax alter (Lutz, 1973)	BA, MG, ES, RJ and PR				LC	S	6*, 30
Scinax fuscomarginatus (Lutz, 1925)	Southern, Central, Southeastern, Northeast, Southern AM				LC	S	56
Scinax fuscovarius (Lutz, 1925)	Southeastern and PR				LC	S	1, 3, 6, 8, 9, 22, 23, 27, 30, 33, 34, 45, 49, 50, 56, 59, 74
Scinax granulatus (Peters, 1871)	Southern				LC	S	25, 27, 53
Scinax imbegue Nunes, Kwet & Pombal, 2012	SP, PR and SC						57
Scinax nasicus (Cope, 1862)	MT, MS, GO, MG, SP, PR, SC and RS				LC	S	61
Scinax perereca Pombal, Haddad & Kasahara, 1995	SP, PR and RS				LC	U	6, 8, 9, 21, 22, 23, 27, 30, 34, 45, 49, 50, 56*, 74
Scinax squalirostris (Lutz, 1925)	MS, Southeastern and PR				LC	S	21, 22, 27, 49
Scinax tymbamirim Nunes, Kwet & Pombal, 2012	RJ to RS						57, 74**
Sphaenorhynchus caramaschii Toledo, Garcia, Lingnau & Haddad, 2007	Southern, Southeastern and BA				LC	S	27, 76
Sphaenorhynchus surdus (Cochran, 1953)	Southern				LC	S	21, 22, 23, 27
Trachycephalus dibernardoi Kwet & Solé, 2008	Southern				LC	U	22, 23, 25, 27
Trachycephalus mesophaeus (Hensel, 1867)	BA to RS				LC	D	6, 30, 34, 74
Trachycephalus typhonius (Linnaeus, 1758)	Southern				LC	S	1, 3, 22, 49
Hylodidae							
Crossodactylus caramaschii Bastos & Pombal, 1995	SP, PR and SC				LC	S	27**, 63, 74
Crossodactylus schmidti Gallardo, 1961	Southern				NT	D	3
Hylodes cardosoi Lingnau, Canedo & Pombal, 2008	SP and PR				LC	U	48, 74, 80
Hylodes aff. *asper*					LC	S	34, 74
Hylodes heyeri Haddad, Pombal & Bastos, 1996	SP and PR				DD	D	6, 22, 26, 30, 34, 47, 74**
Leptodactylidae							
Adenomera araucaria Kwet & Angulo, 2002	Southern				LC	S	25
Adenomera cf. *bokermanni*					LC	S	6*, 34*, 74**
Adenomera marmorata Steindachner, 1867	RJ to SC				LC	S	21, 22, 23*, 27*, 30**, 34, 72, 73, 74

Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Adenomera nana (Müller, 1922)	PR and SC				LC	U	25, 27
Leptodactylus flavopictus Lutz, 1926	ES to SC				LC	D	70
Leptodactylus furnarius Sazima & Bokermann, 1978	TO, BA, Central, Southeastern and PR				LC	S	7, 37, 39, 70
Leptodactylus fuscus (Schneider,1799)	Brazil				LC	S	1, 3, 8, 22, 27, 33, 49, 50, 56, 70
Leptodactylus gracilis (Duméril & Bibron, 1840)	Southern				LC	S	22, 27, 49, 70
Leptodactylus labyrinthicus (Spix, 1824)	Central, Southeastern and PR				LC	S	22, 27, 49, 50, 56, 70
Leptodactylus latrans (Steffen, 1815)	MG, BA, SP and PR				LC	S	1, 3, 27**, 30**, 34, 45, 56, 70, 74
Leptodactylus mystaceus (Spix, 1824)	Norte, Northeast, Central, MG, SP and PR				LC	S	2, 3, 70
Leptodactylus mystacinus (Burmeister, 1861)	Central, Southeastern and Southern				LC	S	1, 3, 9, 22, 27, 49, 50, 55, 70
Leptodactylus notoaktites Heyer, 1978	SP, PR and SC				LC	S	6, 22, 23, 27, 30, 34, 45, 69, 70, 74
Leptodactylus plaumanni Ahl, 1936	Southern				LC	S	27, 70
Leptodactylus podicipinus (Cope, 1862)	Northern, Central and PR		DD		LC	S	3, 22, 49, 56, 70
Physalaemus cuvieri Fitzinger, 1826	Northeast, Central and Southern				LC	S	1, 3, 6, 8, 9, 21, 22, 23, 27, 33, 45, 49, 50, 54, 55
Physalaemus gracilis (Boulenger, 1883)	Southern				LC	S	9, 21, 22, 23, 27*, 45*, 49, 75
Physalaemus insperatus Cruz, Cassini & Caramaschi, 2008	PR (Guaratuba)	X			DD	U	29
Physalaemus lateristriga (Steindachner, 1864)	SP, PR and SC						27, 45
Physalaemus maculiventris (Lutz, 1925)	RJ, SP, PR and SC		DD		LC	D	30
Physalaemus nanus (Boulenger, 1888)	SP and Southern				LC	S	27
Physalaemus nattereri (Steindachner, 1863)	Central, Southeastern and SC				LC	D	3, 56
Physalaemus olfersii (Lichtenstein & Martens, 1856)	MG, ES, SP and PR				LC	S	6**, 22, 23, 30, 34*, 74*
Physalaemus spiniger (Miranda-Ribeiro, 1926)	SP and PR				LC	D	34, 72, 74, 77
Pleurodema bibroni Tschudi, 1838	Southern				NT	D	27**, 79
Scythrophrys sawayae (Cochran, 1953)	PR and SC		DD		LC	D	22

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Continued Table 1.

TAXON	Geografic Distribution in Brazil	Endemism	Red lists			Population trend (IUCN)	Source of record
			Paraná	Brazil	Global (IUCN)		
Microhylidae							
Chiasmocleis leucosticta (Boulenger, 1888)	SP, PR and SC		DD		LC	S	22, 30
Elachistocleis bicolor (Guérin-Méneville, 1838)	Southern				LC	S	3**, 6, 22, 23, 50, 56
Elachistocleis cf. *cesarii*							1
Odontophrynidae							
Odontophrynus americanus (Duméril & Bibron, 1841)	Southern				LC	S	3, 21, 22, 23, 27, 49, 50, 56
Proceratophrys avelinoi Mercadal de Barrio & Barrio, 1993	PR and RS				LC	U	8, 9, 22, 23*, 49, 50, 68
Proceratophrys brauni Kwet & Faivovich, 2001	Southern				LC	D	27
Proceratophrys boiei (Wied-Neuwied, 1824)	Southeastern, PR and SC				LC	S	6, 21, 22, 23, 27, 30, 34, 45, 72, 74
Proceratophrys subguttata Izecksohn, Cruz & Peixoto, 1999	PR and SC				LC	D	65
Ranidae							
Lithobates catesbeianus (Shaw, 1802)	Brazil				LC	I	1, 3, 6, 9, 22, 27, 45, 49, 71

We recorded a total of 24 anuran species whose type locality is in the state of Paraná (Figure 1). Nineteen of these species are endemic to the state, and 15 (except *B. leopardus*, *B. pernix*, *I. sambaqui*, and *B. jaguariavensis*) are known only from the type locality (Figure 1).

We also reported the occurrence of the exotic invader anuran *Lithobates catesbeianus* (Shaw 1802) (Ranidae), known as the bullfrog. We found five studies that recorded the occurrence of this anuran species in the state of Paraná (Table 1).

Five (3.6%) anuran species are listed as threatened in the red lists of Paraná, Brazil and/or IUCN (Table 1): *Brachycephalus pernix*, *Dendropsophus anceps* (Lutz, 1929), *Limnomedusa macroglossa* (Duméril & Bibron, 1841), *Boana semiguttata* (Lutz, 1925) and *Ischnocnema paranaensis*. *Brachycephalus pernix* is classified as Critically Endangered (CR) in Paraná and Brazil and *L. macroglossa* only in Paraná, while *B. semiguttata* and *I. paranaensis* are listed as Endangered (EN) in Brazil and in Paraná, respectively. Moreover, *Crossodactylus schmidti* Gallardo, 1961 and *Pleurodema bibroni* Tschudi, 1838 are listed as Near Threatened (NT) by the IUCN. A further 27 species (19.2% of the total) are listed as Data Deficient (DD) in Paraná and/or by the IUCN. Two of the species endemic to Paraná (*B. pernix* and *I. paranaensis*) are listed as Critically Endangered, corresponding to 10.5% of the anuran species endemic to the state.

Based on IUCN (2017), the population trends of 68 (49.6%) anuran species recorded in the present study are stable (Table 1). Most of these species belongs to the family Hylidae (40 species, 58.8% of the total number of registered species), representing 69% of the recorded hylids, and Leptodactylidae (17 species, 25.0% of the total number of registered species), representing 65.4% of the recorded leptodactylids. By contrast, 26 species (19% of the total number of registered species) have declining populations, including nine hylids (15.5% of hylid species) and five leptodactylids (19.2% of leptodactylids species), and two species have increasing populations (1.4% of the total number of registered species), *Rhinella schneideri* (Werner, 1894) and *Lithobates catesbeianus.* A further 28 (20.4%) species recorded for Paraná have unknown population trends, nine species from the family Brachycephalidae (6.6% of the total number of registered species, 60% of the brachycephalids) and seven species from the family Bufonidae (5.1% of the total number of registered species, 58.3% of the bufonids). The remaining 11 anuran species (8.1% of the total number of registered species) have yet to be assessed by the IUCN. Two recently described anuran species (*Brachycephalus coloratus* and *B. curupira*) have not yet been assessed by the IUCN and therefore, we have not been able to access their population trends.

In our supplementary search of the SpeciesLink database (Table 2), we recorded 24 anuran species belonging to seven families: Hylidae (n = 9 species), Leptodactylidae (5), Hylodidae (4), Bufonidae (2), Centrolenidae (2), Allobatidae (1) and Mycrohylidae (1). These species included 10 anurans not identified in our literature search: *Allobates brunneus* (Cope, 1887), *Vitreorana eurygnata* (Lutz, 1925), *Aplastodiscus cochranae* (Mertens, 1952), *A. leucopygius* (Cruz & Peixoto, 1985), *Boana polytaenia* (Cope, 1870), *Ololygon brieni* (De Witte, 1930), *Crossodactylus gaudichaudii* Duméril & Bibron, 1841, *Leptodactylus chaquensis* Cei, 1950, *Physalaemus biligonigerus* (Cope, 1861) and *Pseudopaludicola falcipes* (Hensel, 1867).

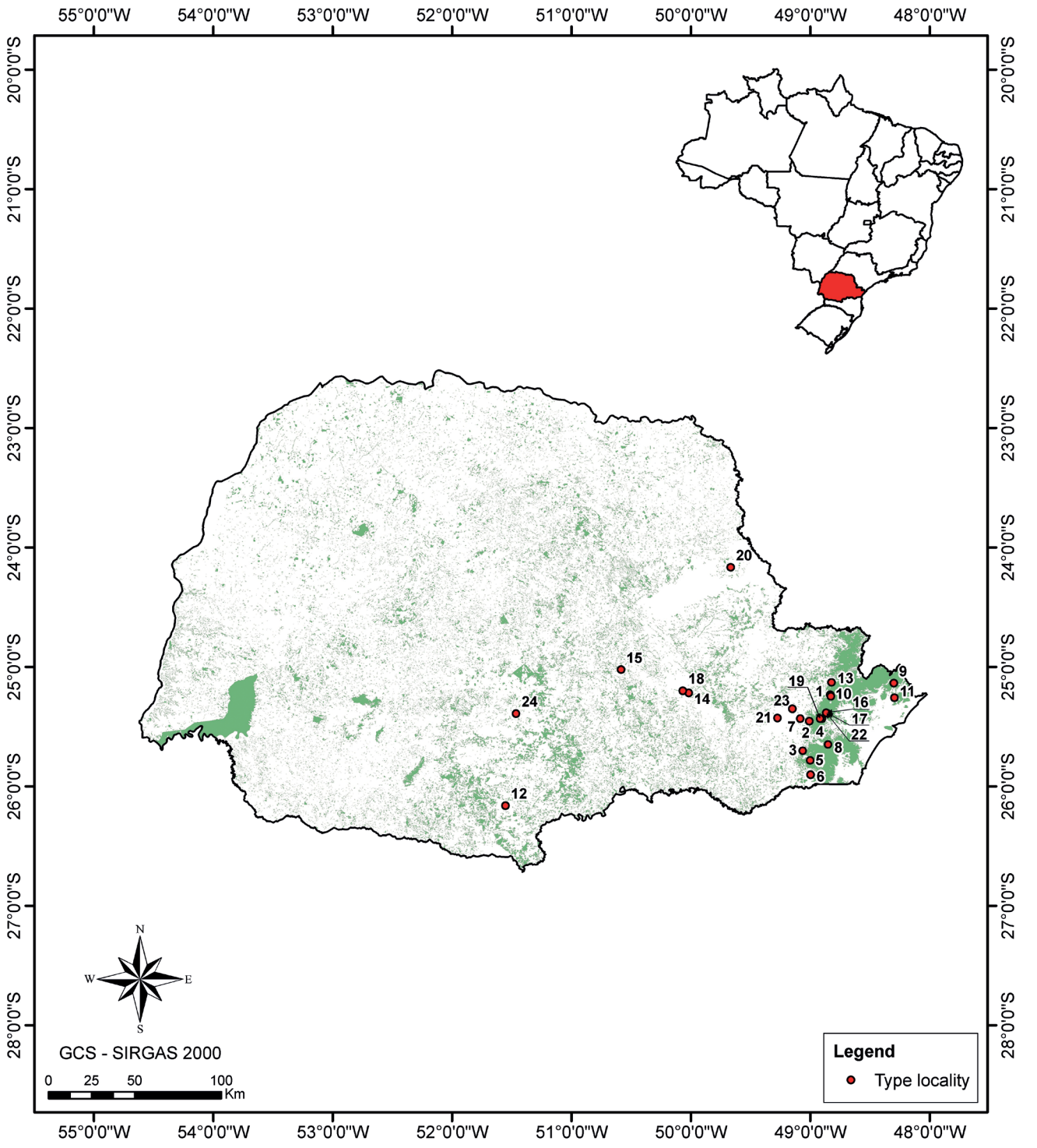

Figure 1. Type localities of the anuran species in the state of Paraná, southern Brazil. Abbreviations: mun., municipality; P.E., Parque Estadual (State Park). *Brachycephalus brunneus* (1 = Pico Caratuva, mun. Campina Grande do Sul), *B. ferruginus* (2 = Pico Marumbi, mun. Morretes), *B. izecksohni* (3 = Pico Torre da Prata, from mun. Guaratuba to mun. Paranaguá), *B. leopardus* (4 = Serra do Araçatuba, mun. Tijucas do Sul), *B. pernix* (5 = Morro Anhangava, in Serra da Baitaca, Conjunto Marumbi, mun. Quatro Barras), *B. pombali* (6 = Morro dos Padres, Pico da Igreja, mun. Guaratuba), *B. tridactylus* (7 = Pico do Morato, mun. Guaraqueçaba), *Ischnocnema paranaensis* (8 = Pico Paraná, mun. Antonina), *I. sambaqui* (9 = mun. Guaraqueçaba), *Dendrophryniscus stawiarskyi* (10 = mun. Bituruna), *Melanophryniscus alipioi* (11 = Serra do Capivarí, mun. Campina Grande do Sul), *M. vilavelhensis* (12 = P. E. de Vila Velha, mun. Ponta Grossa), *Cycloramphus duseni* (13 = mun. Ipiranga), *C. mirandaribeiroi* (14 = São João da Graciosa, mun. Morretes), *C. rhyakonastes* (15 = São João da Graciosa, mun. Morretes), *Gastrotheca microdiscus* (16 = mun. Ponta Grossa), *Bokermannohyla langei* (17 = Pico do Marumbi, mun. Morretes), *Boana jaguariaivensis* (18 = P. E. do Cerrado, mun. Jaguariaíva), *Sphaenorhynchus surdus* (19 = mun. Curitiba), *Hylodes cardosoi* (20 = Porto de Cima, mun. Morretes), *Physalaemus insperatus* (21 = Área de Proteção Ambiental Guaratuba, Serra da Pedra Branca do Araraquara, mun. Guaratuba) and *Scythrophrys sawayae* (22 = Banhado, mun. Guarapuava).

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Table 2. Putative determinations of the anuran amphibians of the state of Paraná, southern Brazil, that have been deposited in scientific collections (search in the website SpeciesLink 2017). Scientific collections: DZSJRP = Departamento de Zoologia São José do Rio Preto, NMNH = National Museum of Natural History, MZUEL = Museu de Zoologia da Universidade Estadual de Londrina, ZUEC = Museu de Zoologia da Universidade Estadual de Campinas, FNJV = Fonoteca Neotropical Jacques Vielliard, CFBH = Coleção Célio F. B. Haddad. Source: [1] = Berneck et al. (2016), [2] = Garcia et al. (2007), [3] = Lingnau & Bastos (2007) and [4] = Sá et al. (2014).

Taxon	Tentatively updated taxon	Voucher number
Colostethus brunneus (Cope, 1887)	*Allobates brunneus* (Cope, 1887)	NMNH-Animalia_BR 148487
Dendrophryniscus brevipollicatus (Jiménez de la Espada, 1870)	*Dendrophryniscus stawiarskyi* Izecksohn, 1994	NMNH-Animalia_BR 217659
Bufo crucifer Wied-Neuwied, 1821	*Rhinella abei* (Baldissera, Caramaschi & Haddad, 2004)	MZUEL-Herpeto 1134
Vitreorana eurygnatha (Lutz, 1925)	*Vitreorana eurygnatha* (Lutz, 1925)	NMNH-Animalia_BR 284502
Vitreorana parvula (Boulenger, 1895)	*Vitreorana uranoscopa* (Müller, 1924)	ZUEC-AMP 284502
Aplastodiscus albofrenatus (Lutz, 1924)	*Aplastodiscus ehrhardti* (Müller, 1924) [1]	DZSJRP 5252
Aplastodiscus cochranae (Mertens, 1952)	*Aplastodiscus cochranae* (Mertens, 1952)	FNJV 0033953
Aplastodiscus leucopygius (Cruz & Peixoto, 1985)	*Aplastodiscus leucopygius* (Cruz & Peixoto, 1985)	FNJV 0033943
Boana joaquini (Lutz, 1968)	*Boana semiguttata* (A. Lutz, 1925) [2]	FNJV 0033075
Boana polytaenia (Cope, 1870)	*Boana polytaenia* (Cope, 1870)	ZUEC-AMP 10502
Bokermannohyla astartea (Bokermann, 1967)	*Bokermannohyla hylax* (Heyer, 1985)	NMNH 125516
Ololygon angrensis (Lutz, 1973)	*Ololygon littoralis* (Pombal & Gordo, 1991)	ZUEC-AMP 4724
Phrynohyas venulosa (Fitzinger, 1843)	*Trachycephalus typhonius* (Linnaeus, 1758)	MZUEL-Herpeto 362
Scinax brieni Faivovich, Haddad, Garcia, Frost & Wheeler, 2005	*Ololygon brieni* (De Witte, 1930)	NMNH-Animalia_BR 125515
Crossodactylus bresslaui Müller, 1924	*Crossodactylus caramaschii* Bastos & Pombal, 1995	MZUEL-Herpeto 748
Crossodactylus gaudichaudii Duméril & Bibron, 1841	*Crossodactylus gaudichaudii* Duméril & Bibron, 1841	DZSJRP-Amphibia-adults 6296
Hylodes asper (Müller, 1924)	*Hylodes cardosoi* Lingnau, Canedo & Pombal, 2008 or *Hylodes heyeri* Haddad, Pombal & Bastos, 1996 [3]	NMNH-Animalia_BR 149648
Hylodes perplicatus (Miranda-Ribeiroi, 1926)	*Hylodes cardosoi* Lingnau, Canedo & Pombal, 2008 or *Hylodes heyeri* Haddad, Pombal & Bastos, 1996 [3]	NMNH-Animalia_BR 125509
Leptodactylus bolivianus Boulenger, 1898	*Leptodactylus chaquensis* Cei, 1950 [4]	DZSJRP-Amphibia-adults 8625
Leptodactylus ocellatus Girard, 1853	*Leptodactylus latrans* (Steffen, 1815)	CFBH 21025
Physalaemus biligonigerus (Cope, 1861)	*Physalaemus biligonigerus* (Cope, 1861)	ZUEC-AMP 10371
Physalaemus marmoratus (Reinhardt & Lütken, 1862)	*Physalaemus marmoratus* (Reinhardt & Lütken, 1862)	DZSJRP-Amphibia-tadpoles 0832.03
Pseudopaludicola falcipes (Hensel, 1867)	*Pseudopaludicola falcipes* (Hensel, 1867)	NMNH-Animalia_BR 149646
Elachistocleis ovalis (Schneider, 1799)	*Elachistoclei bicolor* (Guérin-Méneville, 1838)	MZUEL-Herpeto 671

We identified 29 localities at which anurans have been inventoried in the state of Paraná, of which, just under half (48.3%) are located with the metropolitan region of Curitiba city, while a further 34.5% are found within the central-northern region of the state (Figure 2), creating a highly disproportionate distribution of sampling sites within the state.

Discussion

The 137 anuran species recorded in the present study for the Brazilian state of Paraná is close to the 147 species predicted for the state by Toledo & Batista (2012), and thus appears to be a relatively reliable estimate. In that study, the authors constructed a Brazilian list of species based on range distribution shapes (shadow maps analysis), including species occurrences by Brazilian states, and therefore, we assume that species recorded by them to Paraná but not registered in our study do not occur in the state; these anuran species are: *Ischnocnema manezinho* (Garcia, 1996), *Melanophryniscus spectabilis* Caramaschi & Cruz, 2002, *Rhinella granulosa* (Spix, 1824), *Cycloramphus diringshofeni* Bokermann, 1957, *Proceratophrys appendiculata* (Günther, 1873), *Fritziana goeldii* (Boulenger, 1895), *Dendropsophus elianeae* (Napoli & Caramaschi, 2000), *D. rubicundulus* (Reinhardt & Lütken, 1862), *Boana geographica* (Spix, 1824), *B. guentheri* (Boulenger, 1886), *Phyllomedusa burmeisteri* Boulenger, 1882, and *Pithecopus hypochondrialis* (Daudin, 1800). However, some of the taxa

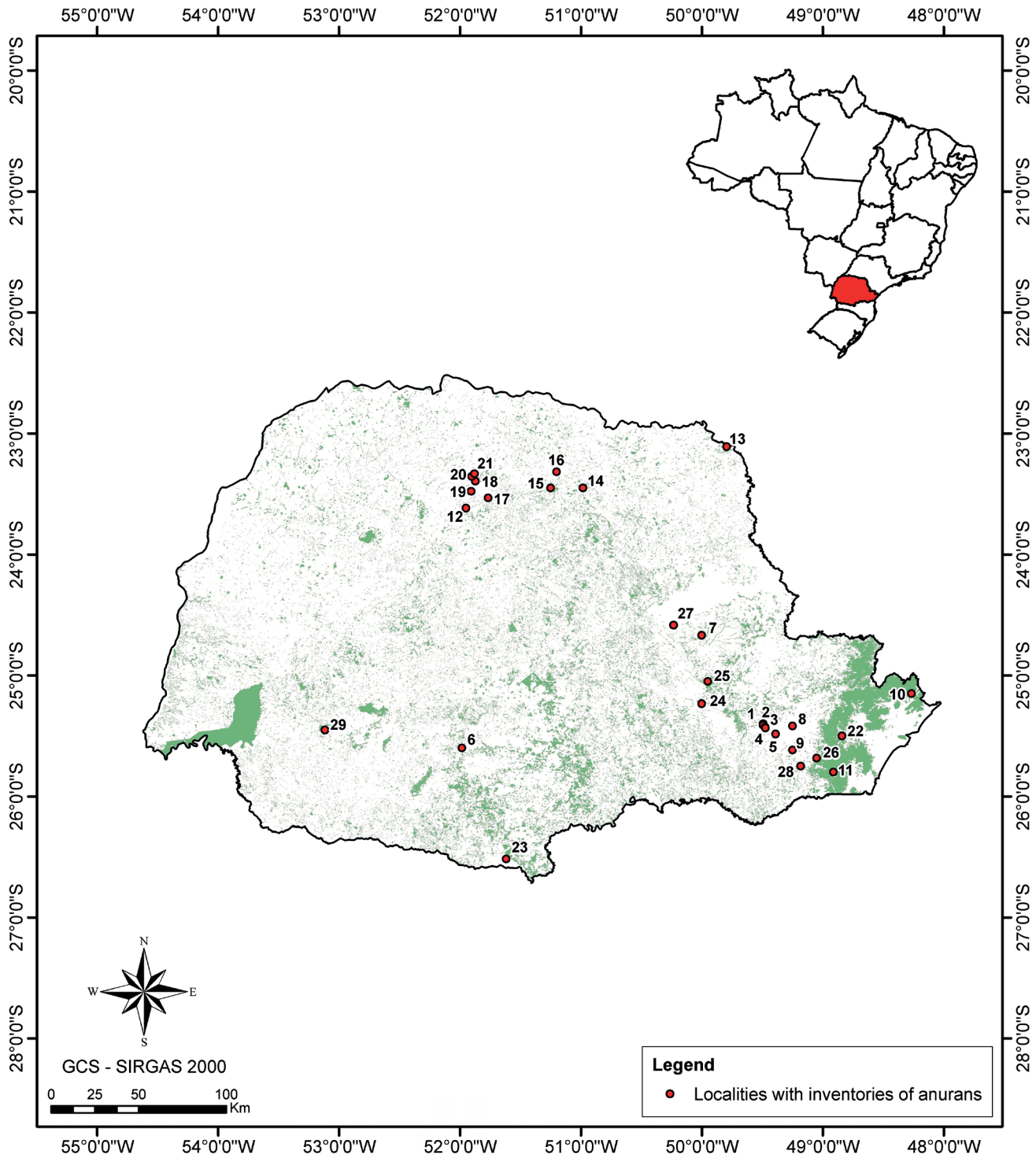

Figure 2. Municipalities with inventories of anurans in the state of Paraná, southern Brazil. 1-5 = Campo Largo (Leivas & Hiert 2016); 6 = Candói, Pinhão and Foz do Jordão (Crivellari et al. 2014); 7 = Castro (Crivellari et al. 2014); 8 = Curitiba (Crivellari et al. 2014); 9 = Fazenda Rio Grande (Conte & Rossa-Feres 2007); 10 = Guaraqueçaba (Garey & Hartmann 2012, Santos-Pereira et al. 2011, 2016); 11 = Guaratuba (Cunha et al. 2010); 12 = Itambé (Affonso & Delariva 2012); 13 = Jacarezinho (Nazaretti & Conte 2015); 14-16 = Londrina (Affonso & Delariva 2012, Benarde & Anjos 1999, Machado et al. 1999); 17 = Marialva (Affonso & Delariva 2012); 18-21 = Maringá (Affonso et al. 2014); 22 = Morretes (Armstrong & Conte 2010); 23 = Palmas (Crivellari et al. 2014); 24 = Ponta Grossa (Crivellari et al. 2014); 25 = Ponta Grossa, Castro and Carambeí (Crivellari et al. 2014); 26 = São José dos Pinhais (Conte & Rossa-Feres 2006); 27 = Tibagi (Crivellari et al. 2014); 28 = Tijucas do Sul (Conte & Machado 2005); and 29 = Três Barras do Paraná (Bernarde & Machado 2001).

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recorded in Paraná require revision. For example, eight species were identified "aff.", "cf." or "gr." in the articles consulted. One of them is *Adenomera* cf. *bokermanni*, cited by Santos-Pereira et al. (2016), and *A.* aff. *bokermanni* by Armstrong & Conte (2010) and Garey & Hartmann (2012). This species was originally described as *Adenomera bokermanni* by Heyer (1973), type locality in the municipality of Paranaguá, state of Paraná, and it seems very likely that the taxon cited in more recent studies corresponds to this species, given that these records refer to localities extremely close to the type locality of *A. bokermanni*, that is, municipalities of Morretes (Armstrong & Conte 2010) and Guaraqueçaba (Garey & Hartmann 2012, Santos-Pereira et al. 2016). *Ischnocnema spanios* (cited as "cf." in Santos-Pereira et al. 2016) is known to occur only from the minicipalyti of Boracéia (type locality of this species, Heyer, 1985) to the municipality of São Paulo (L. Malagoli, pers. comm.). Santos-Pereira et al. (2016) collected an anuran of the genus *Cycloramphus*, which they identified as *C.* cf. *asper*, although vouchers were juveniles (MNRJ 87917-87918), which hampered the identification of the species. The occurrence of *Hylodes* aff. *asper* by the first time by Garey & Hartmann (2012) in the municipality of Guaraqueçaba may have been a mistake. Some years previously, Lingnau et al. (2008) described this species from a nearby municipality in the state of Paraná, Morretes, which is less than 90 km from Guaraqueçaba, and discussed the geographic distribution of *Hylodes asper* (Müller, 1924). For many years, herpetologists believed that the geographic range of *H. asper* extends from the state of Santa Catarina to the state of Rio de Janeiro, although this species has often been confused with *H. perplicatus* (Miranda-Ribeiro, 1926) or *H. cardosoi* Lingnau, Canedo & Pombal, 2008. The geographic range of *H. asper* is now restricted to an area from the state of Rio de Janeiro to Paranapiacaba, municipality of Santo André in the state of São Paulo, while *H. cardosoi*, but not *H. asper*, is found in the south of state of *São Paulo* (Lingnau et al. 2008). Therefore, we believe that the record of *Hylodes* aff. *asper* from Salto Morato, municipality of Guaraqueçaba, does in fact refers to *H. cardosoi*, but unfortunately, there are no voucher specimens or vocal records that might help confirm this hypothesis. *Boana stellae* (Kwet, 2008) is known only from the southern slope of the Araucaria Plateau in the center of the state of Rio Grande do Sul (Kwet 2008). *Ololygon perpusillus* is apparently restricted to the municipality of Rio de Janeiro (Peixoto 1987). *Elachistocleis cesarii* is known from northeastern Brazil, in the states of Ceará, Sergipe, and Bahia, central Brazil, in the states of Mato Grosso, Goiás, and Federal District, and southeastern Brazil, in the states of Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo (Caramaschi 2010). It is important to note that *Fritziana* gr. *fissilis* was recorded in two separate studies at the same locality, municipality of Guaraqueçaba, on the northern coast of the state of Paraná (Garey & Hartmann 2012, Santos-Pereira et al. 2016). In this case, further fieldwork will be required to confirm the occurrence of the species in the state of Paranábecause the genus *Fritziana* requires a taxonomic review and the specimens cannot be assigned reliably to a specific species at the present time.

In addition to these taxonomically problematic anurans, several other species assigned to Paraná by Frost (2017) were not included in our list. As we found no other reliable evidence or records of the occurrence of these species in Paraná, we did not include them in our inventory. These species are *Boana curupi* (Garcia, Faivovich & Haddad, 2007), *Bokermannohyla claresignata* (Lutz & Lutz, 1939), *Trachycephalus imitatrix* (Miranda-Ribeiro, 1926), *Cycloramphus izecksohni* Heyer, 1983 and *Boana crepitans* (Wied-Neuwied, 1824). In the case of *B. claresignata*, the only evidence is the record of Lutz (1973), who found tadpoles similar to those described for the species, but don't recorded any adult individual. Garcia et al. (2007) assumed that *B. curupi* occurs in Paraná, due to its association with the Paraná and Uruguay rivers, but we don't find any record of this anuran in the state of Paraná. Lutz (1973) found that the *T. imitatrix* specimens from southern Brazil (the "southern" form) were relatively large in size, and had a distinct type of iris, which is consistent with the description of *T. dibernardoi* Kwet & Solé, 2008. The analysis of the specimens from the municipality of Telêmaco Borba revealed the larger body size and dorsal markings typical of *T. dibernardoi* (Conte et al. 2010). In addition, the description of *T. dibernardoi* for the region near Curitiba (Kwet & Solé 2008) refers to a voucher specimen from a survey of the Fazenda Rio Grande (DZSJRP 8810; Conte & Rossa-Feres 2007), where this anuran was confused with *T. imitatrix* (Conte et al. 2010). Given this evidence, we concluded that *T. dibernardoi*, rather than *T. imitatrix*, occurs in Paraná, as recorded by Lutz (1973), and that the occurrence of *T. imitatrix* recorded *by* Conte & Rossa-Feres (2006, 2007) at São José dos Pinhais and Fazenda Rio Grande does in fact refer to *T. dibernardoi*. In the case of *C. izecksohni*, Frost (2017) only mentioned that the species occurs in the Serra do Mar coastal range, in the states of São Paulo, Paraná and Santa Catarina. Frost (2017) considered *B. crepitans* to occur in northern Brazil, with an allopatric population in the northeast, ranging as far south as Paraná and Santa Catarina. On these last two localities, we found available information about this anuran species only from the referred website.

Boana faber, *Scinax fuscovarius*, *Dendropsophus minutus* and *Ischnocnema henselii* were the anurans recorded most frequently in the studies analyzed. This reflects, in part, the wide geographic distribution of these species in Brazil (Frost 2017), as well as their life history strategies. In the case of the hylids, for example, populations are often associated with open areas or even disturbed habitats (Lucas & Fortes 2008; Almeida-Gomes et al. 2010, 2014), resulting in a greater tolerance of these species to anthropogenic impacts in the environment. In particular, *I. henseli*, which is found in the leaf litter, was considered to be one of the dominant species of the anuran community at Guaraqueçaba (Santos-Pereira et al. 2011), given the considerable variety of microhabitats found in the leaf litter of the forest floor. This suggests that *I. henseli* besides frequent, is also an abundant leaf-litter frog found in the forest floor, and this possibly also indicates a greater environmental tolerance by this frog.

By contrast, 32 (23.3%) of the 137 anuran species identified in the literature search were recorded in only one study, and most of these species are endemic to Paraná or occurs only also in the region that includes the neighboring states of Santa Catarina and São Paulo. While these records may reflect a relatively restricted distribution for these species, they may also be the result of subsampling in Paraná, given that research on anurans in this state is still incipient (Santos-Pereira 2016) with inventories of anuran species concentrated basically in two regions of state (see discussion below). The restricted occurrence of many species may also be related to the devastation of the state's forests, which has often impacted their structure, resulting in direct effects on their anuran species richness, including the possible eradication of the most sensitive forms. Only 11.7% of the original Atlantic Forest cover of

Paraná now remains, and it has the highest historic rate of deforestation of any state of the Brazil (Fundação SOS Mata Atlântica & Instituto Nacional de Pesquisas Espaciais 2015).

Eleven (57.9%) of the 19 endemic species recorded in the present study are brachycephalids, and nine of these are *Brachycephalus* species, which is 26.5% of the 34 species currently recognized for this genus (Frost 2017). The species of this genus are found on the eastern coast of Brazil between the states of Bahia, in the northeast, and Santa Catarina, in the south (Frost 2017), with most occurring at altitudes of over 600 m in the Serra do Mar (Ribeiro et al. 2005, Alves et al. 2006). Many of these species have been described recently (Garey et al. 2012b, Ribeiro et al. 2015, 2017, Bornschein et al. 2016a), which emphasizes the importance of surveys in the least well-known remnants of Atlantic Forest, which are often found in relatively inaccessible areas of high altitude. The biodiversity corridors of the Atlantic Forest – the Central Atlantic Forest corridor, the Serra do Mar corridor, and the Northeast corridor (Rocha et al. 2003) – contain a considerable number of endemic vertebrates, including anuran amphibians, and the coast of Paraná is located within the largest continuous remnant of Atlantic Forest, which is part of the Serra do Mar corridor (Câmara 2005), which implies that the state may have more endemic anurans than currently known. This is consistent with the position of Pimm et al. (2010), who predicted that many endemic species of amphibians, birds, and mammals are yet to be discovered in the Brazil.

The type localities of the anuran species described from specimens collected in Paraná are concentrated in the east of the state. This probably reflects the greater research efforts in this region, where we recorded the highest number of localities with anuran inventories, and also to the principal remnants of native forest (Câmara 2005). Additionally, this can be reflected the flora inventories and the proximity of large urban centers or the presence of specialists in the taxonomic groups in these urban areas. Another factor is the presence (and density) of roads, which implies accessibility to natural areas (Pautasso 2007, Ficetola et al. 2013).

In the state of Paraná, the exotic invader anuran *Lithobates catesbeianus* has been recorded in 15 municipalities up until now (Santos-Pereira & Rocha 2015). In general, these municipalities are located within a 60 km radius of commercial frog farms, indicating that, in most cases, the invasion of natural areas by *L. catesbeianus* has resulted from the escape of captive individuals into the natural environment (Santos-Pereira & Rocha 2015). As the records show that *L. catesbeianus* is widely distributed in different regions of the state, it is possible that the actual area occupied by the bullfrog in the state of Paraná is much larger than currently thought. Further surveys in the state may provide new evidence on the extent of the area invaded by *L. catesbeianus*.

The red lists consulted during the present study revealed several inconsistencies in the conservation status of the anuran species identified in the state of Paraná. Some of these discrepancies may be the result of a certain asynchrony between the regional, national and global assessments (Rodríguez et al. 2000). The conservation status of non-endemic species will also vary according to the scale of analysis, even though it should be consistent among the state, national and global red lists (Brito et al. 2010). This indicates the existence of discrepancies between the national and global lists, given that two species endemic to the state of Paraná (*B. pernix* and *I. paranaensis*) are listed as DD by the IUCN, although *I. paranaensis* is not even listed by the Brazilian government. Similarly, *Pseudis cardosoi* is listed by the IUCN, but does not appear on the lists for Paraná or Brazil. In the specific case of the State list, the publication is more than 10 years old (Segalla & Langone 2004), and requires revision, whereas on a broader scale, species not endangered in Paraná may be under threat in other states. As the regional lists are not updated regularly, they tend to provide outdated assessments of conservation status. This situation may reduce the effectiveness of these lists as guidelines for conservation practices, given that most measures are currently based on the evaluation of the extinction risk of the species (Miller et al. 2006). It is important to note that the regional lists are important conservation tools, given that most measures are implemented on a local scale (Possingham et al. 2002). Half of the anuran species recorded by us in this study that were categorized as data deficient in Paraná list or by the IUCN are endemic of this state. This reinforces the need for further research into the viability of their populations and the habitats they occupy, and their potential risk of extinction.

Based on the assessment of the IUCN (2017), most of the anuran species recorded in the present study – predominantly hylids – have stable populations. This is probably at least partly due to the fact that these are among the most abundant species in anuran communities, in particular in the Atlantic Forest (e.g., Conte & Rossa-Feres 2006, Almeida-Gomes et al. 2010, Santos-Pereira et al. 2016). For example, the three species recorded most frequently in the publications analyzed in the present study (*Boana faber*, *Dendropsophus anceps* and *Scinax fuscovarius*) are known to be very common species (IUCN 2017), and *S. fuscovarius* is common even in deforested areas. The majority of leptodactylids have stable populations, and many of them [e.g., *Adenomera marmorata* Steindachner, 1867, *Physalaemus cuvieri* Fitzinger, 1826 and *Leptodactylus mystaceus* (Spix, 1824)], are common throughout their geographic ranges (IUCN 2017). Populations are declining in 26 species, which may reflect impacts on the ecosystems in which these anurans are found, in particular the high deforestation rates recorded throughout the state of Paraná. For example, *Aplastodiscus ehrhardti* (Müller, 1924), *Proceratophrys brauni* Kwet & Faivovich, 2001 and *Scythrophrys sawayae* (Cochran, 1953) are relatively common species and their populations, while classified as declining by the IUCN, are stable in suitable habitats. Other example is *Pleurodema bibroni*, a rare species that occurs in widely scattered populations, being probably extinct in Montevideo Department, Uruguay, because of habitat destruction (IUCN 2017). The populations of only two anuran species listed here (*Rhinella schneideri* and *Lithobates catesbeianus*) are thought to be increasing (IUCN 2017). *Lithobates catesbeianus* is widespread in Paraná (Santos-Pereira & Rocha 2015). This species is known worldwide from thousands of localities and is usually very abundant with increasing populations (IUCN 2017). In 28 cases, mostly brachycephalids and bufonids, population trends are unclear, although some brachycephalids, such as *Brachycephalus brunneus*, *B. ferruginus*, *B. izecksohni*, *Ischnocnema henselii* and *I. sambaqui*, are locally abundant (IUCN 2017). No data are available on the population trends of other brachycephalids, i.e., *B. pombali* and *I. spanios* (IUCN 2017). The populations of the *Brachycephalus* species are typically restricted to fragments of hill forests (Pombal et al. 1998, Ribeiro et al. 2005, Alves et al. 2006), separated by valleys, which isolates the populations (Pie et al. 2013) and makes them difficult to survey effectively. In the case

of the bufonids, *Dendrophryniscus stawiarskyi*, for example, is known only from three specimens collected in the early 1980s, and there is currently no information on its population status, while the species of the genus *Melanophryniscus*, *M. alipioi* and *M. tumifrons* (Boulenger, 1905), are extremely difficult to survey, although the former species is commonly encountered during the breeding season (IUCN 2017). This possibly is due to the fact that the anuran species of this genus show explosive breeding, reproducing in small and ephemeral water bodies (e.g. Cairo et al. 2008, Laufer et al. 2015). Given this scenario, we identified three main variables that are important for the evaluation of the population viability of anurans – the abundance of the species, the difficulty of capturing specimens and the quality of the environment inhabited by the population.

While we identified an additional 10 anuran species during the survey of the scientific collections available in the SpeciesLink database, we did not include these species in our inventory of the anurans of the state of Paraná. The record of *Allobates brunneus*, for example, is almost certainly erroneous, given that the genus *Allobates* is not found in Paraná (Verdade & Rodrigues 2007). While it may be possible that *Vitreorana eurygnatha* occurs in Paraná, we found only a single specimen in the Brazilian National Museum of Natural History (NMNH), so at this time, we prefer to exercise caution, and not confirm that the species occurs in Paraná. Similarly, we have classified *Aplastodiscus cochranae*, *A. leucopygius*, *Crossodactylus gaudichaudii*, *Leptodactylus chaquensis* and *Physalaemus biligonigerus* as tentative occurrences, pending the confirmation of the taxonomic identification of the specimens. In the specific case of *Boana polytaenia*, we consider the identification doubtful, given that Cruz & Caramaschi (1998) did not refer to the occurrence of the species in Paraná in their review [the only species of this complex known unequivocally to occur in the state of Paraná, at the present time, and that was included in our list, is *Boana jaguariavensis* (Caramaschi, Cruz & Segalla, 2010)]. It seems likely the record of *Ololygon brieni* does in fact refers to *O. littoralis* (Pombal & Gordo 1991). Finally, it does seem likely that *Pseudopaludicola falcipes* occurs in Paraná, given that this species is cited by Frost (2017).

The inventories of anurans in the state of Paraná have been concentrated primarily in the metropolitan region of the Curitiba city, in the eastern extreme, and the central-northern region of the state, while there are severalgeographic distribution gaps in most of the state. This concentration of research in the north and east of the state reflects the proximity of its principal universities, including the Federal University of Paraná, in the Curitiba city, and the State universities of Londrina and Maringá, both located in the central-northern region. The metropolitan region of Curitiba, which extends as far as the Atlantic coast, also encompasses several other institutions, including universities and museums, and a major portion of the largest continuous remnant of Atlantic Rainforest found in Brazil. This region also contains a number of protected areas, which may stimulate the interest of researchers seeking well-preserved environments and faunal communities. It is interesting to note that there has been no inventory of anurans in the Foz do Iguaçu micro-region, in western Paraná, which includes the Iguaçu National Park, one of Brazil's first national parks, created in 1939.

This study was the first attempt to compile a comprehensive inventory of the anuran fauna of the Brazilian state of Paraná. We consider our list of species to be a relatively reliable estimate of the anuran diversity of the state, although we do expect new species to be added to the list, in particular because many areas have yet to be sampled adequately. In addition to the need for more extensive surveys, especially in areas that have yet to be sampled adequately, a number of forms require taxonomic review. We also emphasize the need for the conservation of the state's remaining natural habitats, as well as further research on the invasion of the region by the exotic frog, *Lithobates catesbeianus,* especially in relation to the escape and dispersal of animals from local frog farms.

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Author Contributions

Manuela Santos-Pereira: Substantial contribution to the conception and design of the work; Contribution in the acquisition of the data; Contribution in the analysis and interpretation of the data; Contribution in the writing of the work; Contribution in the critical review appending intellectual content.

José P. Pombal Jr.: Substantial contribution in the acquisition of the data; contribution in the analysis and interpretation of the data; contribution in the writing of the work; contribution in the critical review appending intellectual content.

Carlos Frederico Duarte Rocha: Substantial contribution to the conception and design of the work; contribution in the acquisition of the data; contribution in the analysis and interpretation of the data; contribution in the writing of the work; contribution in the critical review appending intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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