

The amphibians of São Paulo State, Brazil amphibians of São Paulo

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Abstract: The State of São Paulo is one of the most studied regions of Brazil in regard to amphibian species richness and distribution. However, we still do not have a list of species for the State. Therefore, we present here a list including 231 species of amphibians (225 anurans and six caecilians), of which 27 are endemic. We present data about previous and current taxonomists and speculate about future prospects in the study and conservation of amphibian biodiversity in São Paulo State.

Keywords: *Amphibia, Anura, Gymnophiona, São Paulo State, Brazil, inventory, Atlantic Forest, Cerrado, biodiversity, conservation.*

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Resumo: O Estado de São Paulo é uma das regiões mais estudadas do Brasil no que diz respeito à riqueza de espécies e distribuição dos anfíbios. No entanto, ainda não temos uma lista de espécies para o Estado. Portanto, apresentamos aqui uma lista, incluindo 231 espécies de anfíbios (225 anuros e seis cecílias), das quais 27 são endêmicas. Apresentamos dados sobre os antigos e atuais taxonomistas e especulações sobre o futuro dos estudos e conservação da biodiversidade dos anfíbios no Estado.

Palavras-chave: *Amphibia, Anura, Gymnophiona, Estado de São Paulo, Brasil, inventário, Floresta Atlântica, Cerrado, biodiversidade, conservação.*

Introduction

Brazil is the country with the richest amphibian fauna, housing 849 species (SBH 2009), which represents 13.2% of the 6,433 species presently known for the world (Frost 2009). A large part of this richness is accounted due to Brazil's continental proportions, as well as by the great number of tropical and subtropical ecosystems in the country, including the Amazon Forest, the Cerrado, the Pantanal, the Caatinga, the Atlantic Forest, and the Pampa. The State of São Paulo is located in southeastern Brazil where two biomes occur: the Cerrado and the Atlantic Forest (Oliveira-Filho & Fontes 2000). Both the Atlantic Forest and the Cerrado were included among the 34 biodiversity hotspots of the world (Mittermeier et al. 2005).

São Paulo State (SP) is part of the Brazilian region where anurans have been most studied, since it concentrates several research centers. For the last 80 years, important scientific collections were created in São Paulo State, such as the amphibian collection at the Museu de Zoologia "Prof. Adão José Cardoso", housed in the Universidade Estadual de Campinas, Campinas, SP (ZUEC: with around 17,000 amphibian specimens), the Célio F. B. Haddad amphibian collection, housed in the Universidade Estadual Paulista, Rio Claro, SP (CFBH: with around 25,000 amphibian specimens), the amphibian collection of the Museu de Zoologia da Universidade de São Paulo, housed in the Universidade de São Paulo, São Paulo, SP (MZUSP: with around 130,000 amphibian specimens), the Jorge Jim collection, now housed at Museu Nacional, RJ (JJ: with around 17,000 specimens), and the amphibian collection at the Departamento de Zoologia e Botânica, housed in the Universidade Estadual Paulista, São José do Rio Preto, SP (DZSJRP: with around 13,000 specimens).

However, in general, there are still major gaps of information on the amphibian species of São Paulo State including the fields of taxonomy, morphology, cytogenetics, natural history, ecology, and conservation. Not even a list of species occurrence in São Paulo State is available. In 1998 an attempt to estimate diversity of the state was performed which listed 180 described species of anuran amphibians and predicted that there were more than 60 additional species to be described for the state (Haddad 1998). In 2006, during a workshop,

a total of 248 amphibian species have been estimated for the state (Rosa-Feres et al. 2008). The present study gathers a first compilation of species known to occur in São Paulo State and discusses the richness of species found in each biome, as well as the species showing restricted endemism, which could be used as an indication of priority in the conservation of such species. We also discuss the contributions of researchers with descriptions of species from São Paulo State, as well as the tendencies in expansion of knowledge about the anuran fauna of this region in Brazil.

Methods

Our sampling was performed in the main amphibian collections of São Paulo State: CFBH (Célio F. B. Haddad amphibian collection, Universidade Estadual Paulista, Rio Claro), MZUSP (Museu de Zoologia da Universidade de São Paulo, São Paulo), and ZUEC (Museu de Zoologia "Prof. Adão José Cardoso", Universidade Estadual de Campinas, Campinas). We also based our data on our professional experiences, interviews with other herpetologists who worked in São Paulo State, and the literature, such as regional species lists, species descriptions, and distribution notes. Scientific names follow Frost (2009).

Concerning the taxonomists who described species that occur in São Paulo State, we performed an analysis over the decades since 1750, recording each author separately when a species has been described by more than one author.

We considered as endemic only those species showing distribution restricted to a small limited-range site, such as islands or segments of a mountain range of 500 km² or less. The species accumulation curve considered all species that occur in the state, even if the type locality of the species is not located in São Paulo State.

Results

We listed 236 amphibian species in São Paulo State (Table 1). Of these, 230 are anuran species (e.g., figures 1 and 2) belonging to 13 families and 47 genera, and six species are Gymnophiona (e.g., Figure 3) belonging to only one family and three genera (Table 1).

Table 1. Amphibians of São Paulo State, its occurrence in biomes, and endemism (see methods).

Species	Atlantic Forest	Cerrado	Endemic species
GYMNOPHIONA			
Caeciliidae			
<i>Luetkenotyphlus brasiliensis</i> (Lütken, 1851)	x	-	-
<i>Microcaecilia supernumeraria</i> Taylor, 1969	x	-	-
<i>Siphonops annulatus</i> (Mikan, 1820)	x	-	-
<i>Siphonops hardyi</i> Boulenger, 1888	x	-	-
<i>Siphonops insulanus</i> Ihering, 1911	x	-	-
<i>Siphonops paulensis</i> Boettger, 1892	x	-	-
ANURA			
Amphignathodontidae			
<i>Flectonotus fissilis</i> (Miranda-Ribeiro, 1920)	x	-	-
<i>Flectonotus goeldii</i> (Boulenger, 1895 "1894")	x	-	-
<i>Flectonotus ohausi</i> (Wandolleck, 1907)	x	-	-
<i>Gastrotheca albolineata</i> (A. Lutz & B. Lutz, 1939)	x	-	-
<i>Gastrotheca fissipes</i> (Boulenger, 1888)	x	-	-
<i>Gastrotheca microdiscus</i> (Andersson in Lönnberg & Andersson, 1910)	x	-	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
Brachycephalidae			
<i>Brachycephalus ephippium</i> (Spix, 1824)	x	-	-
<i>Brachycephalus hermogenesi</i> (Giaretta & Sawaya, 1998)	x	-	-
<i>Brachycephalus nodoterga</i> Miranda-Ribeiro, 1920	x	-	x
<i>Brachycephalus pitanga</i> Alves, Sawaya, Reis & Haddad, 2009	x	-	x
<i>Brachycephalus vertebralis</i> Pombal, 2001	x	-	x
<i>Ischnocnema bolbodactyla</i> (A. Lutz, 1925)	x	-	-
<i>Ischnocnema gehrti</i> (Miranda-Ribeiro, 1926)	x	-	-
<i>Ischnocnema guentheri</i> (Steindachner, 1864)	x	-	-
<i>Ischnocnema hoehnei</i> B. Lutz, 1959 "1958"	x	-	-
<i>Ischnocnema holti</i> Cochran, 1948	x	-	x
<i>Ischnocnema juipoca</i> Sazima & Cardoso, 1978	x	x	-
<i>Ischnocnema lactea</i> (Miranda-Ribeiro, 1923)	x	-	x
<i>Ischnocnema nigriventris</i> (A. Lutz, 1925)	x	-	-
<i>Ischnocnema parva</i> (Girard, 1853)	x	-	-
<i>Ischnocnema pusilla</i> (Bokermann, 1967)	x	-	x
<i>Ischnocnema randorum</i> Heyer, 1985	x	-	-
<i>Ischnocnema spanios</i> Heyer, 1985	x	-	x
Bufo			
<i>Dendrophryniscus brevipollicatus</i> Jiménez de la Espada, 1871 "1870"	x	-	-
<i>Dendrophryniscus leucomystax</i> Izecksohn, 1968	x	-	-
<i>Melanophryniscus moreirae</i> (Miranda-Ribeiro, 1920)	x	-	x
<i>Rhinella icterica</i> (Spix, 1824)	x	-	-
<i>Rhinella hoogmoedi</i> Caramaschi & Pombal, 2006	x	-	-
<i>Rhinella ornata</i> (Spix, 1824)	x	-	-
<i>Rhinella rubescens</i> (A. Lutz, 1925)	-	x	-
<i>Rhinella schneideri</i> (Werner, 1894)	x	x	-
Centrolenidae			
<i>Vitreorana eurygnatha</i> (A. Lutz, 1925)	x	-	-
<i>Vitreorana uranoscopa</i> (Müller, 1924)	x	-	-
Ceratophryidae			
<i>Ceratophrys aurita</i> (Raddi, 1823)	x	-	-
Craugastoridae			
<i>Haddadus binotatus</i> (Spix, 1824)	x	-	-
Cycloramphidae			
<i>Cycloramphus acangatan</i> Verdade & Rodrigues, 2003	x	-	-
<i>Cycloramphus boraceiensis</i> Heyer, 1983	x	-	-
<i>Cycloramphus carvalhoi</i> Heyer, 1983	x	-	x
<i>Cycloramphus dubius</i> (Miranda-Ribeiro, 1920)	x	-	-
<i>Cycloramphus eleutherodactylus</i> (Miranda-Ribeiro, 1920)	x	-	-
<i>Cycloramphus faustoi</i> Brasileiro, Haddad, Sawaya, Sazima 2007	x	-	x
<i>Cycloramphus granulatus</i> A. Lutz, 1929	x	-	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
<i>Cycloramphus izecksohni</i> Heyer, 1983	X	-	-
<i>Cycloramphus jordanensis</i> Heyer, 1983	X	-	X
<i>Cycloramphus juimirim</i> Haddad & Sazima, 1989	X	-	X
<i>Cycloramphus lutzorum</i> Heyer, 1983	X	-	-
<i>Cycloramphus semipalmatus</i> (Miranda-Ribeiro, 1920)	X	-	-
<i>Cycloramphus stejnegeri</i> (Noble, 1924)	X	-	X
<i>Macrogenioglottus alipioi</i> Carvalho, 1946	X	-	-
<i>Odontophrynus americanus</i> (Duméril & Bibron, 1841)	X	X	-
<i>Odontophrynus cultripes</i> Reinhardt & Lütken, 1861”1862”	-	X	-
<i>Proceratophrys appendiculata</i> (Günther, 1873)	X	-	-
<i>Proceratophrys boiei</i> (Wied-Neuwied, 1825)	X	-	-
<i>Proceratophrys melanopogon</i> (Miranda-Ribeiro, 1926)	X	-	-
<i>Proceratophrys moratoi</i> Jim & Caramaschi, 1980	-	X	X
<i>Thoropa miliaris</i> (Spix, 1824)	X	-	-
<i>Thoropa petropolitana</i> (Wandolleck, 1907)	X	-	-
<i>Thoropa taophora</i> (Miranda-Ribeiro, 1923)	X	-	-
<i>Zachaenus parvulus</i> (Girard, 1853)	X	-	-
Hylidae			
<i>Aparasphenodon bokermanni</i> Pombal, 1993	X	-	-
<i>Aparasphenodon brunoi</i> Miranda-Ribeiro, 1920	X	-	-
<i>Aplastodiscus albosignatus</i> (A.Lutz & B.Lutz, 1938)	X	-	-
<i>Aplastodiscus arildae</i> (Cruz & Peixoto, 1987 “1985”)	X	-	-
<i>Aplastodiscus callipygius</i> (Cruz & Peixoto, 1985 “1984”)	X	-	-
<i>Aplastodiscus ehrhardti</i> (Müller, 1924)	X	-	-
<i>Aplastodiscus eugenioi</i> (Carvalho-e-Silva & Carvalho-e-Silva, 2005)	X	-	-
<i>Aplastodiscus leucopygius</i> (Cruz & Peixoto, 1985 “1984”)	X	-	-
<i>Aplastodiscus perviridis</i> A. Lutz in B. Lutz, 1950	X	X	-
<i>Bokermannohyla ahenea</i> (Napoli & Caramaschi, 2004)	X	-	-
<i>Bokermannohyla astartea</i> (Bokermann, 1977)	X	-	-
<i>Bokermannohyla circumdata</i> (Cope, 1871)	X	-	-
<i>Bokermannohyla claresignata</i> (Lutz & Lutz, 1939)	X	-	-
<i>Bokermannohyla clepsydra</i> (A. Lutz, 1925)	X	-	-
<i>Bokermannohyla gouveai</i> (Peixoto & Cruz, 1992)	-	-	X
<i>Bokermannohyla hylax</i> (Heyer, 1985)	X	-	-
<i>Bokermannohyla izeckshoni</i> (Jim & Caramaschi, 1979)	X	-	-
<i>Bokermannohyla luctuosa</i> (Pombal & Haddad, 1993)	X	-	-
<i>Bokermannohyla sazimai</i> (Cardoso & Andrade, 1983”1982”)	-	X	-
<i>Dendropsophus anceps</i> (A. Lutz, 1929)	X	-	-
<i>Dendropsophus berthallutzae</i> (Bokermann, 1962)	X	-	-
<i>Dendropsophus decipiens</i> (A. Lutz, 1925)	X	-	-
<i>Dendropsophus elegans</i> (Wied-Neuwied, 1824)	X	-	-
<i>Dendropsophus elianeae</i> (Napoli & Caramaschi, 2000)	X	X	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
<i>Dendropsophus giesleri</i> (Mertens, 1950)	x	-	-
<i>Dendropsophus jimi</i> (Napoli & Caramaschi, 1999)	-	x	-
<i>Dendropsophus limai</i> (Bokermann, 1962)	x	-	-
<i>Dendropsophus microps</i> (Peter, 1872)	x	-	-
<i>Dendropsophus minutus</i> (Peters, 1872)	x	x	-
<i>Dendropsophus nanus</i> (Boulenger, 1889)	x	x	-
<i>Dendropsophus rhea</i> (Napoli & Caramaschi, 1999)	-	x	-
<i>Dendropsophus sanborni</i> (Schmidt, 1944)	x	x	-
<i>Dendropsophus seniculus</i> (Cope, 1868)	x	-	-
<i>Dendropsophus wernerii</i> (Cochran, 1952)	x	-	-
<i>Hypsiboas albomarginatus</i> (Spix, 1824)	x	-	-
<i>Hypsiboas albopunctatus</i> (Spix, 1824)	x	x	-
<i>Hypsiboas bischoffi</i> (Boulenger, 1887)	x	-	-
<i>Hypsiboas caingua</i> (Carrizo, 1991 "1990")	x	-	-
<i>Hypsiboas caipora</i> Antunes, Faivovich & Haddad, 2007	x	-	-
<i>Hypsiboas crepitans</i> (Wied-Neuwied, 1824)	x	-	-
<i>Hypsiboas cymbalum</i> (Bokermann, 1963)	x	-	x
<i>Hypsiboas faber</i> (Wied-Neuwied, 1821)	x	x	-
<i>Hypsiboas latistriatus</i> (Caramaschi & Cruz, 2004)	x	-	-
<i>Hypsiboas lundii</i> (Burmeister, 1856)	x	x	-
<i>Hypsiboas pardalis</i> (Spix, 1824)	x	-	-
<i>Hypsiboas polytaenius</i> (Cope, 1870)	x	-	-
<i>Hypsiboas prasinus</i> (Burmeister, 1856)	x	x	-
<i>Hypsiboas punctatus</i> (Schneider, 1799)	-	x	-
<i>Hypsiboas raniceps</i> Cope, 1862	x	x	-
<i>Hypsiboas semilineatus</i> (Spix, 1824)	x	-	-
<i>Itapotihyla langsdorffii</i> (Duméril & Bibron, 1841)	x	x	-
<i>Phasmahyla cochranii</i> (Bokermann, 1966)	x	-	-
<i>Phasmahyla guttata</i> (A. Lutz, 1924)	x	-	-
<i>Phrynomedusa bokermanni</i> Cruz, 1991	x	-	x
<i>Phrynomedusa fimbriata</i> Miranda-Ribeiro, 1923	x	-	-
<i>Phrynomedusa marginata</i> (Izecksohn & Cruz, 1976)	x	-	-
<i>Phrynomedusa vanzolinii</i> Cruz, 1991	x	-	-
<i>Phyllomedusa azurea</i> Cope, 1862	-	x	-
<i>Phyllomedusa ayeaye</i> (B. Lutz, 1966)	x	x	-
<i>Phyllomedusa burmeisteri</i> Boulenger, 1882	x	-	-
<i>Phyllomedusa distincta</i> A. Lutz in B. Lutz, 1950	x	-	-
<i>Phyllomedusa rohdei</i> Mertens, 1926	x	-	-
<i>Phyllomedusa tetraploidea</i> Pombal & Haddad, 1992	x	x	-
<i>Pseudis platensis</i> Gallardo, 1961	-	x	-
<i>Scinax alcatraz</i> (B. Lutz, 1973)	x	-	x
<i>Scinax alter</i> (B. Lutz, 1973)	x	-	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
<i>Scinax angrensis</i> (B. Lutz, 1973)	X	-	-
<i>Scinax argyreornatus</i> (Miranda-Ribeiro, 1926)	X	-	-
<i>Scinax ariadne</i> (B. Lutz, 1973)	X	-	-
<i>Scinax atratus</i> (Peixoto, 1989)	X	-	-
<i>Scinax berthae</i> (Barrio, 1962)	X	X	-
<i>Scinax brienii</i> (Witte, 1930)	X	-	-
<i>Scinax caldarum</i> (B. Lutz, 1968)	X	-	-
<i>Scinax canastrensis</i> (Cardoso & Haddad, 1982)	-	X	-
<i>Scinax crospedospilus</i> (A. Lutz, 1925)	X	-	-
<i>Scinax duartei</i> (B. Lutz, 1951)	X	-	-
<i>Scinax eurydice</i> (Bokermann, 1968)	X	-	-
<i>Scinax faivovichii</i> Brasileiro, Oyamauchi & Haddad, 2007	X	-	-
<i>Scinax flavoguttatus</i> (A. Lutz & B. Lutz, 1939)	X	-	-
<i>Scinax fuscomarginatus</i> (A. Lutz, 1925)	X	X	-
<i>Scinax fuscovarius</i> (A. Lutz, 1925)	X	X	-
<i>Scinax hayii</i> (Barbour, 1909)	X	-	-
<i>Scinax hiemalis</i> (Haddad & Pombal, 1987)	X	-	-
<i>Scinax jureia</i> (Pombal & Gordo, 1991)	X	-	-
<i>Scinax littoralis</i> (Pombal & Gordo, 1991)	X	-	-
<i>Scinax nasicus</i> (Cope, 1862)	-	X	-
<i>Scinax obtriangulatus</i> (B. Lutz, 1973)	X	-	-
<i>Scinax peixotoi</i> Brasileiro, Haddad, Sawaya & Martins, 2007	X	-	-
<i>Scinax perereca</i> Pombal, Haddad & Kasahara, 1995	X	-	-
<i>Scinax perpusillus</i> (A. Lutz & B. Lutz, 1939)	X	-	-
<i>Scinax rizibilis</i> (Bokermann, 1964)	X	-	-
<i>Scinax similis</i> (Cochran, 1952)	X	X	-
<i>Scinax squalirostris</i> (A. Lutz, 1925)	-	X	-
<i>Scinax trapicheiroi</i> (B. Lutz, 1954)	X	-	-
<i>Scinax x-signatus</i> (Spix, 1924)	X	X	-
<i>Sphaenorhynchus caramaschii</i> Toledo, Lingnau, Garcia & Haddad, 2007	X	-	-
<i>Sphaenorhynchus orophilus</i> (A. Lutz & B. Lutz, 1938)	X	-	-
<i>Sphaenorhynchus surdus</i> (Cochran, 1953)	X	-	-
<i>Trachycephalus imitatrix</i> (Miranda-Ribeiro, 1926)	X	-	-
<i>Trachycephalus lepidus</i> (Pombal, Haddad & Cruz, 2003)	X	-	-
<i>Trachycephalus mesophaeus</i> (Hensel, 1867)	X	-	-
<i>Trachycephalus nigromaculatus</i> Tschudi, 1838	-	X	-
<i>Trachycephalus venulosus</i> (Laurenti, 1768)	X	X	-
Hylodidae			
<i>Crossodactylus caramaschii</i> Bastos & Pombal, 1995	X	-	-
<i>Crossodactylus dispar</i> A. Lutz, 1925	X	-	-
<i>Crossodactylus gaudichaudii</i> Duméril & Bibron, 1841	X	-	-
<i>Crossodactylus grandis</i> B. Lutz, 1951	X	-	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
<i>Hylodes asper</i> (Müller, 1924)	x	-	-
<i>Hylodes cardosoi</i> Lingnau, Canedo & Pombal Jr, 2008	x	-	-
<i>Hylodes dactylocinus</i> Pavan, Narvaes & Rodrigues, 2001	x	-	x
<i>Hylodes heyeri</i> Haddad, Pombal & Bastos, 1996	x	-	-
<i>Hylodes magalhaesi</i> (Bokermann, 1964)	x	-	x
<i>Hylodes mertensi</i> (Bokermann, 1956)	x	-	-
<i>Hylodes nasus</i> (Lichtenstein, 1823)	x	-	-
<i>Hylodes ornatus</i> (Bokermann, 1967)	x	-	-
<i>Hylodes phyllodes</i> Heyer & Cocroft, 1986	x	-	-
<i>Hylodes sazimai</i> Haddad & Pombal, 1995	x	-	-
<i>Megaelosia bocainensis</i> Giaretta, Bokermann & Haddad, 1993	x	-	x
<i>Megaelosia boticariana</i> Giaretta & Aguiar, 1998	x	-	x
<i>Megaelosia goeldii</i> (Baumann, 1912)	x	-	-
<i>Megaelosia massarti</i> (Witte, 1930)	x	-	x
Leiuperidae			
<i>Eupemphix nattereri</i> Steindachner, 1863	-	x	-
<i>Physalaemus atlanticus</i> Haddad & Sazima, 2004	x	-	-
<i>Physalaemus barrioi</i> Bokermann, 1967	x	-	-
<i>Physalaemus bokermanni</i> Cardoso & Haddad, 1985	x	-	x
<i>Physalaemus centralis</i> Bokermann, 1962	x	x	-
<i>Physalaemus cuvieri</i> Fitzinger, 1826	x	x	-
<i>Physalaemus jordanensis</i> Bokermann, 1967	x	-	-
<i>Physalaemus maculiventris</i> (A. Lutz, 1925)	x	-	-
<i>Physalaemus marmoratus</i> (Reinhardt & Lütken, 1862 “1861”)	-	x	-
<i>Physalaemus moreirae</i> (Miranda-Ribeiro, 1937)	x	-	-
<i>Physalaemus olfersii</i> (Lichtenstein & Martens, 1856)	x	-	-
<i>Physalaemus signifer</i> (Girard, 1853)	x	-	-
<i>Physalaemus spiniger</i> (Miranda-Ribeiro, 1926)	x	-	-
<i>Pseudopaludicola falcipes</i> (Hensel, 1867)	-	x	-
<i>Pseudopaludicola mystacalis</i> (Cope, 1887)	-	x	-
<i>Pseudopaludicola riopiedadensis</i> Mercadal de Barrio & Barrio, 1994	-	x	x
<i>Pseudopaludicola saltica</i> (Cope, 1887)	-	x	-
Leptodactylidae			
<i>Leptodactylus ajurauna</i> Berneck, Costa & Garcia, 2008	x	-	-
<i>Leptodactylus bokermanni</i> Heyer, 1973	x	-	-
<i>Leptodactylus chaquensis</i> Cei, 1950	x	x	-
<i>Leptodactylus flavopictus</i> A. Lutz, 1926	x	-	-
<i>Leptodactylus furnarius</i> Sazima & Bokermann, 1978	x	x	-
<i>Leptodactylus fuscus</i> (Schneider, 1799)	x	x	-
<i>Leptodactylus jolyi</i> Sazima & Bokermann, 1978	x	x	-
<i>Leptodactylus labyrinthicus</i> (Spix, 1824)	x	x	-
<i>Leptodactylus marmoratus</i> (Steindachner, 1867)	x	-	-

Table 1. Continued...

Species	Atlantic Forest	Cerrado	Endemic species
<i>Leptodactylus mystaceus</i> (Spix, 1824)	X	-	-
<i>Leptodactylus mystacinus</i> (Burmeister, 1861)	X	X	-
<i>Leptodactylus notoaktites</i> Heyer, 1978	X	-	-
<i>Leptodactylus ocellatus</i> (Linnaeus, 1758)	X	X	-
<i>Leptodactylus podicipinus</i> (Cope, 1862)	-	X	-
<i>Leptodactylus sertanejo</i> Giaretta & Costa, 2007	-	X	-
<i>Leptodactylus syphax</i> Bokermann, 1969	-	X	-
<i>Paratelmatobius cardosoi</i> Pombal & Haddad, 1999	X	-	-
<i>Paratelmatobius gaigeae</i> (Cochran, 1938)	X	-	X
<i>Paratelmatobius mantiqueira</i> Pombal & Haddad, 1999	X	-	X
<i>Paratelmatobius poecilogaster</i> Giaretta & Castanho, 1990	X	-	-
Microhylidae			
<i>Arcovomer passarellii</i> Carvalho, 1954	X	-	-
<i>Chiasmocleis albopunctata</i> (Boettger, 1885)	-	X	-
<i>Chiasmocleis atlantica</i> Cruz, Caramaschi & Izecksohn, 1997	X	-	-
<i>Chiasmocleis carvalhoi</i> Cruz, Caramaschi & Izecksohn, 1997	X	-	-
<i>Chiasmocleis leucosticta</i> (Boulenger, 1888)	X	-	-
<i>Chiasmocleis mantiqueira</i> Cruz, Feio & Cassini, 2007	X	-	-
<i>Dermatonotus muelleri</i> (Boettger, 1885)	-	X	-
<i>Elachistocleis ovalis</i> (Schneider, 1799)	X	X	-
<i>Elachistocleis bicolor</i> (Guérin-Méneville, 1838)	X	X	-
<i>Myersiella microps</i> (Duméril & Bibron, 1841)	X	-	-
<i>Stereocyclops parkeri</i> (Wettstein, 1934)	X	-	-
Strabomantidae			
<i>Barycholos ternetzi</i> (Miranda-Ribeiro, 1937)	-	X	-
<i>Holoaden luederwaldti</i> Miranda-Ribeiro, 1920	X	-	X
Total 236	211	58	28

Among these amphibian species, 211 are found in the Atlantic Forest, and 58 in the Cerrado (Table 1). Of these 236 species, 28 are endemic to small areas (e.g., Figures 4, 5, 6, and 7), corresponding to around 12 % of the species occurring in the state. Six species are considered threatened and one species is considered extinct according to the Brazilian list of threatened amphibians (Fundação Biodiversitas 2003).

To date, 90 researchers have already contributed with the description of species that occur in São Paulo State. Until the 1920s, only foreign researchers had described species from the state. Two major periods in species description could be recognized (Figure 8). The first in the 1820s, mostly related to Spix, and the second about 100 years later, in the 1920s, mostly related to the papers of Miranda-Ribeiro and Adolpho Lutz. From 1950 to the present, the species descriptions in the state maintained a constant pace, with an average of 20 species described per decade. The species accumulation curve based on species registered in São Paulo State shows a tendency to continue growing (Figure 8).



Figure 1. Adult female *Scinax ariadne*, Serra da Bocaina, municipality of São José do Barreiro, São Paulo State, southeastern Brazil.

Figura 1. Fêmea adulta de *Scinax ariadne*, Serra da Bocaina, município de São José do Barreiro, Estado de São Paulo, sudeste do Brasil.

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Figure 2. Adult male *Paratelmatobius poecilogaster*, Santa Virgínia, municipality of São Luis do Paraitinga, São Paulo State, southeastern Brazil.

Figura 2. Macho adulto de *Paratelmatobius poecilogaster*, Santa Virgínia, município de São Luis do Paraitinga, Estado de São Paulo, sudeste do Brasil.



Figure 5. Adult male *Scinax alcatraz*, Ilha dos Alcatrazes, municipality of São Sebastião, São Paulo State, southeastern Brazil.

Figura 5. Macho adulto de *Scinax alcatraz*, Ilha dos Alcatrazes, município de São Sebastião, Estado de São Paulo, sudeste do Brasil.



Figure 3. Adult *Siphonops paulensis*, Barão Geraldo, municipality of Campinas, São Paulo State, southeastern Brazil. Photo By J. P. Pombal Jr.

Figura 3. Adulto de *Siphonops paulensis*, Barão Geraldo, município de Campinas, Estado de São Paulo, sudeste do Brasil. Fotografia de J. P. Pombal Jr.



Figure 6. Adult male *Megaelasia massarti*, Paranapiacaba, municipality of Santo André, São Paulo State, southeastern Brazil.

Figura 6. Macho adulto de *Megaelasia massarti*, Paranapiacaba, município de Santo André, Estado de São Paulo, sudeste do Brasil.



Figure 4. Adult female *Cycloramphus* cf. *juimirim*, municipality of Mongaguá, São Paulo State, southeastern Brazil.

Figura 4. Fêmea adulta de *Cycloramphus* cf. *juimirim*, municipality of Mongaguá, Estado de São Paulo, sudeste do Brasil.



Figure 7. Adult male *Proceratophrys moratoi*, municipality of Botucatu, São Paulo State, southeastern Brazil.

Figura 7. Macho adulto de *Proceratophrys moratoi*, município de Botucatu, Estado de São Paulo, sudeste do Brasil.

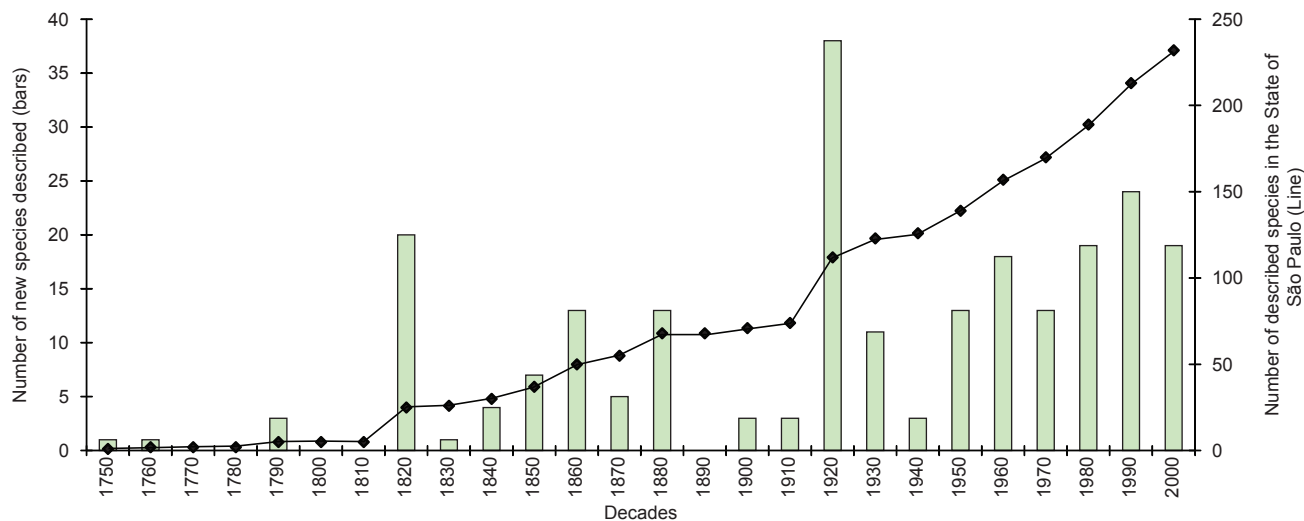


Figure 8. Cumulative species richness (line) and number of species described per decade (bars) in São Paulo State.

Figura 8. Curva acumulativa da riqueza de espécies (linha) e número de espécies descritas por décadas (barras) no Estado de São Paulo.



Figure 9. Adult male *Phyllomedusa* sp., municipality of Biritiba Mirim, São Paulo State, southeastern Brazil.

Figura 9. Macho adulto de *Phyllomedusa* sp., município de Biritiba Mirim, Estado de São Paulo, sudeste do Brasil.



Figure 11. Adult male *Phyllomedusa ayeaye*, municipality of Poços de Caldas, Minas Gerais State, southeastern Brazil.

Figura 11. Macho adulto de *Phyllomedusa ayeaye*, município de Poços de Caldas, Estado de Minas Gerais, sudeste do Brasil.



Figure 10. Adult female *Brachycephalus pitanga*, Santa Virgínia, municipality of São Luis do Paraitinga, São Paulo State, southeastern Brazil.

Figura 10. Fêmea adulta de *Brachycephalus* sp., Santa Virgínia, município de São Luis do Paraitinga, Estado de São Paulo, sudeste do Brasil.



Figure 12. Adult male *Bokermannohyla izecksohni*, municipality of Botucatu, São Paulo State, southeastern Brazil. Photo by I. Sazima.

Figura 12. Macho adulto de *Bokermannohyla izecksohni*, município de Botucatu, Estado de São Paulo, sudeste do Brasil. Fotografia de I. Sazima.



Figure 13. Adult male *Melanophryniscus moreirae*, Itamonte, municipality of Itatiaia, Minas Gerais State, southeastern Brazil.

Figura 13. Macho adulto de *Melanophryniscus moreirae*, Itamonte, município de Itatiaia, Estado de Minas Gerais, sudeste do Brasil.



Figure 14. Adult male *Scinax canastrensis*, municipality of Alpinópolis, Minas Gerais State, southeastern Brazil.

Figura 14. Macho adulto de *Scinax canastrensis*, município de Alpinópolis, Estado de Minas Gerais, sudeste do Brasil.



Figure 15. Adult male *Rhinella rubescens*, Serra do Cipó, Minas Gerais State, southeastern Brazil.

Figura 15. Macho adulto de *Rhinella rubescens*, Serra do Cipó, Estado de Minas Gerais, sudeste do Brasil.

The taxonomists who participated in the description of more than 10 species were Adolpho Lutz (24 species between the 1920s and 1950s), Célio F. B. Haddad (20 species from the 1980s to present), Alípio de Miranda Ribeiro (18 species between the 1920s and 1940s), Werner C. A. Bokermann (18 species between the 1950s and 1990s), Bertha Lutz (17 species between the 1930s and 1970s), José P. Pombal Jr. (16 species from the 1980s to present), Carlos A. G. da Cruz (12 species from the 1980s to present), Johann B. von Spix (12 species in the 1920s), Ronald W. Heyer (11 species from the 1980s to present), and Ulisses Caramaschii (10 species from the 1970s to present). These researchers participated in the description of 137 species, which is equivalent to around 60% of the species in the state (see Table 1).

Discussion

Several taxa considered as occurring in São Paulo State need taxonomic review. For instance, the genus *Elachistocleis* is represented in São Paulo by *E. bicolor* and *E. ovalis*, two doubtful names to apply to the populations occurring in this region (see Lavilla et al. 2003). An examination of specimens and literature suggests the existence of more than two species of *Elachistocleis* in São Paulo State. Another example is *Leptodactylus gracilis*, a species cited for São Paulo State by Heyer (1978) based on specimens from “alto da Serra de Paranapicaba, Município de Santo André”. In this same year Sazima and Bokermann described *Leptodactylus jolyi*, based on specimens from the same place. Since *L. gracilis* are known to occur in southern Brazil, in elevations about 500 m above sea level, we believe the specimens from higher elevations occurring in São Paulo must be named *L. jolyi*.

The total number of species recognized for São Paulo State agrees with previous predictions of about 250 species for the region (Haddad 1998; Rossa-Feres et al. 2008). However, our knowledge is still incipient, and the total number of species should increase in the upcoming years (e.g., Figure 9 an unnamed new species and Figure 10 a newly described species), as indicated by the species accumulation curve (Figure 8). Fundamentally, this occurs for two reasons: a larger number of researchers working on the subject and the use of new methodologies (e.g., bioacoustics, cytogenetics, and molecular biology) that allow the recognition of cryptic species (e.g., Faivovich et al. 2004, Lourenço et al. 2007, Toledo et al. 2007, Berneck et al. 2008).

The amphibian richness in São Paulo State corresponds to about 28% of the Brazilian richness (SBH 2009), and about 4% of the world diversity (Frost 2009). São Paulo is one of the most studied states in Brazil, therefore the percentage of species recorded in the state may be more realistic, as compared to the rest of the country.

The first peak in amphibian species descriptions in São Paulo State took place as a consequence of the expedition carried out by the German researcher, Johann Baptist von Spix (1781-1826), on behalf of the Bavarian Academy of Science, which started in 1817 and lasted until 1820. In 1821, Spix published the book *Brasilien in seiner Entwicklung seit der Entdeckung bis auf unsere Zeit* (The development of Brazil from discovery to our time), which was followed by many other books that cover the Brazilian biodiversity explored during that expedition. His most important work, in collaboration with Von Martius (completed after Spix's death), was *Reise in Brasilien* (Voyage through Brazil; 1823-1831). Spix listed 3,381 animal species in his expedition and about 130 Brazilian amphibians.

In the second peak of the São Paulo State amphibian species descriptions, one may highlight the Brazilian researcher, Alípio de Miranda Ribeiro (1874-1939), who had been working at the Museu

Nacional, Rio de Janeiro, since 1894. He participated in the *Rondon Commission*, going along on their first expedition (1908-1910), wherein he made valuable observations and specimen collections. Later, he published many articles describing 66 species and one amphibian genus.

The increase in number of taxonomists working in São Paulo State in the past five decades, influencing the rise in species descriptions throughout those decades, can be largely explained by the scientific development of this region fomented by funding institutions such as CNPq (created in the 1950s) and FAPESP (created in the 1960s). Another important factor in the intensification of taxonomic studies on amphibians was the organization of herpetological collections and universities during that period.

The Brazilian list of threatened amphibians (Fundação Biodiversitas 2003) includes six species which occur in São Paulo State: *Thoropa petropolitana* ("Endangered"), *Hypsiboas cymbalum*, *Bokermannohyla izeckshoni*, *Phyllomedusa ayeaye*, *Scinax alcatraz*, and *Proceratophrys moratoii* ("Critically Endangered"). *Phrynomedusa fimbriata* is considered "Extinct". However, the rising number of studies performed in São Paulo State suggests that this list of threatened species may be already outdated. We may cite cases such as that of *Phyllomedusa ayeaye* (Figure 11), which had its distribution extended to approximately 200 km beyond its type locality (Araújo et al. 2007a), and *Bokermannohyla izeckshoni* (Figure 12) which was recently discovered at two localities aside from its type locality (Toledo et al. 2008), which may alter their conservation status. Endemic island species that have been currently described, such as *Scinax peixotoi* (Brasileiro et al. 2007a) and *Scinax faivovichii* (Brasileiro et al. 2007b), will probably fit into a threatened category.

The recent rise in the number of studies on amphibians in São Paulo State resulted not only from the descriptions of new species, but also from the recordings of species that were previously unknown for the state, like *Melanophryniscus moreirae* (Marques et al. 2006) (Figure 13), *Phyllomedusa ayeaye* (Araújo et al. 2007a) (Figure 11), *Barycholos ternetzi*, *Scinax canastrensis* (Figure 14), and *Rhinella rubescens* (Figure 15) (Araújo et al. 2007b).

Most of the species of the State of São Paulo are found in the Atlantic Rainforest, probably due to its higher rainfall and humidity (when compared to the Cerrado), since these conditions favor a broad range of micro-habitats that can be used by amphibians (Haddad 1998). The steep topography and geographical barriers present in the Atlantic Forest, such as on the Serra do Mar and the Serra da Mantiqueira mountain ranges, also generates a high biodiversity, by isolating populations and consequently favoring speciation and endemism. The plant stratification and larger number of micro-habitats available in the Atlantic Forest, such as bromeliads, favor the evolution of specialized reproductive modes (Haddad & Sawaya 2000; Haddad & Prado 2005) and the occupation of different habitats, thus increasing the occupation by several different species with different requirements.

Fire is a part of the Cerrado's natural cycle, therefore restricting the number of species that are able to adapt to such a condition, and favoring the establishment of more tolerant species. The Cerrado remnants occupy about 2% of São Paulo State (Kronka et al. 1998) which may also influence the relative low species richness.

Although São Paulo State is one of the best-studied regions in Brazil (concerning the amphibian taxonomy), the real number of species that may inhabit the state is difficult to predict, but (based on the species accumulation curve) we can predict there are many amphibian species yet to be described.

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References

- ARAÚJO, C.O., CONDEZ, T.H. & HADDAD, C.F.B. 2007a. Amphibia, Anura, *Phyllomedusa ayeaye* (B. Lutz, 1966): distribution extension, new state record, and geographic distribution map. Check List. 3(2):156-158.
- ARAÚJO, C.O., CONDEZ, T.H. & HADDAD, C.F.B. 2007b. Amphibia, Anura, *Barycholos ternetzi*, *Chaunus rubescens*, and *Scinax canastrensis*: distribution extension, new state record. Check List. 3(2):153-155.
- BERNECK, B.V.M., COSTA, C.O.R. & GARCIA, P.C.A. 2008. A new species of *Leptodactylus* (Anura: Leptodactylidae) from the Atlantic Forest of São Paulo State, Brazil. Zootaxa. 1795:46-56.
- BRASILEIRO, C.A., HADDAD, C.F.B., SAWAYA, R.J. & MARTINS, M. 2007a. A new and threatened species of *Scinax* (Anura: Hylidae) from Queimada Grande Island, southeastern Brazil. Zootaxa. 1391:47-55.
- BRASILEIRO, C.A., OYAMAGUCHI, H.M. & HADDAD, C.F.B. 2007b. A new island species of *Scinax* (Anura: Hylidae) from Southeastern Brazil. Jour. of Herp. 41(2):271-275.
- FROST, D.R. 2009. Amphibian species of the world: an online reference. Version 5.2 American Museum of Natural History, New York. <http://research.amnh.org/herpetology/amphibia/index.php> (último acesso em 07/10/2009)
- FAIVOVICH, J., GARCIA, P.C.A., ANANIAS, F., LANARI, L., BASSO, N.G. & WHEELER, W.C. 2004. A molecular perspective on the phylogeny of the *Hyla pulchella* species group (Anura: Hylidae). Mol. Phylog. and Evol. 32:938-950.
- FUNDAÇÃO BIODIVERSITAS. 2003. Lista da fauna brasileira ameaçada de extinção. Fundação Biodiversitas, Brasília e Belo Horizonte. http://www.biodiversitas.org.br/f_ameaca/ibama2.htm (último acesso em 07/10/2009)
- HADDAD, C.F.B. 1998. Biodiversidade dos anfíbios do Estado de São Paulo. In Biodiversidade do Estado de São Paulo, Brasil: síntese do conhecimento ao final do século XX. (R.M.C. Castro, ed.). FAPESP, São Paulo, p. 17-26. (v. 6)
- HADDAD, C.F.B. & PRADO, C.P.A. 2005. Reproductive modes in frogs and their unexpected diversity in the Atlantic forest of Brazil. BioScience 55(3):207-217.
- HADDAD, C.F.B. & SAWAYA, R.J. 2000. Reproductive modes of Atlantic Forest Hylid frogs: a general overview and the description of a new mode. Biotropica. 32(4b):862-871.
- HEYER, W.R. 1978. Systematics of the *fuscus* group of the frog genus *Leptodactylus* (Amphibia, Leptodactylidae). Sci. Bull. of Nat. Hist. Mus. Los Angeles. 29:1-85.
- KRONKA, F.J.N., NALON, M.A., MATSUKUMA, C.K., PAVÃO, M., GUILLAUMON, J.R., CAVALLI, A.C., GIANNOTTI, E., IWANE, M.S.S., LIMA, L.M.P.R., MONTES, J., DEL-CALI, I.H. & HAACK, P.G. 1998. Áreas de domínio de cerrado no Estado de São Paulo. Secretaria de Estado do Meio Ambiente, São Paulo.
- LAVILLA, E.O., VAIRA, M. & FERRARI, L. 2003. A new species of *Elachistocleis* (Anura: Microhylidae) from the Andean Yungas of Argentina, with comments on the *Elachistocleis ovalis* - *E. bicolor* controversy. Amphibia-Reptilia. 24:269-284.
- LOURENÇO, L.B., BACCI Jr., M., MARTINS, V.G., RECCO-PIMENTEL, S.M. & HADDAD, C.F.B. 2007. Molecular phylogeny and karyotype

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- differentiation in *Paratelmatobius* and *Scythrophrys* (Anura, Leptodactylidae). *Genetica*. 132(3):255-266.
- MARQUES, R.M., COLAS-ROSAS, P.F., TOLEDO, L.F. & HADDAD, C.F.B. 2006. Amphibia, Anura, Bufonidae, *Melanophryniscus moreirae*: distribution extension. *Check List*. 2(1):68-69.
- MITTERMEIER, R.A., GIL, P.R., HOFFMAN, M., PILGRIM, J., BROOKS, T., MITTERMEIER, C.G., LAMOUREUX, J. & FONSECA, G.A.B. 2005. Hotspots revisited: earth's biologically richest and most endangered terrestrial ecoregions. Conservation International, Washington.
- OLIVEIRA-FILHO, A.T. & FONTES, M.A.L. 2000. Patterns of floristic differentiation among Atlantic Forests in Southeastern Brazil, and the influence of climate. *Biotropica*. 32(4b):793-810.
- ROSSA-FERES, D.C., MARTINS, M., MARQUES, O.A.V., MARTINS, I. A., SAWAYA, J.R. & HADDAD, C.F.B. 2008. Herpetofauna. In *Diretrizes para a conservação da biodiversidade no Estado de São Paulo* (R.R. Rodrigues, C.A. Joly, M.C.W. Brito, A. Paese, J.P. Metzger, L. Casatti, M.A. Nalon, M. Menezes, N.M. Ivanauskas, V. Bolzani & V.L.R. Bononi, coords.). FAPESP, São Paulo, p. 83-94.
- SAZIMA, I. & BOKERMANN, W.C.A. 1978. Cinco novas espécies de *Leptodactylus* do centro e sudeste brasileiro (Amphibia, Anura, Leptodactylidae). *Rev. Bras. de Bio.* 38(4):899-912.
- SOCIEDADE BRASILEIRA DE HERPETOLOGIA - SBH. 2009. Lista de espécies de anfíbios e répteis do Brasil. Sociedade Brasileira de Herpetologia, São Paulo. <http://www.sbherpetologia.org.br/> (ultimo acesso em 07/10/2009)
- TOLEDO, L.F., GARCIA, P.C.A., LINGNAU, R. & HADDAD, C.F.B. 2007. Description of a new species of *Sphaenorhynchus* (Anura: Hylidae) from Brazil. *Zootaxa*. 1658:57-68.
- TOLEDO, L.F., BRASILEIRO, C.A., ARAÚJO, O.G.S. & HADDAD, C.F.B. 2008. Amphibia, Anura, Hylidae, *Bokermannohyla izecksohni*: distribution extension. *Check List*. 4(4):422-444.

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