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Anuran species of the Salto Morato Nature Reserve in Paraná, southern Brazil: review of the species list

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Abstract: We provide an updated checklist of the anurans of the Salto Morato Nature Reserve (SMNR), Paraná, southern Brazil, including information on species endemism, conservation status, habitat use, and reproductive modes. We sampled the study area between February 2013 and July 2015, using Visual Encounter Surveys, totaling 700 hours of sampling effort. We supplement our primary data with secondary data (published papers and voucher specimens), and through these, we found a total of 54 anuran species representing 23 genera and 10 families. All the frogs recorded are endemic to the Atlantic Forest. Although no species has been listed as Endangered on the Red Lists of Paraná state, Brazil, and the IUCN, five are classified as Data Deficient. Most of the species recorded were arboreal (55.5%), a third were terrestrial (33.3%), and the remainders were rheophilic (11.1%). We identified 18 different reproductive modes, with types 1 (lay eggs in lentic water where the tadpoles develop) and 23 (direct development of terrestrial eggs) being the most common. Our findings indicate that the SMNR currently has the greatest diversity of anuran species and reproductive modes of any area in southern Brazil.

Key words: Amphibia; Atlantic Forest; reproductive mode; species inventory

INTRODUCTION

Amphibian assemblages have been studied widely in Brazil (Conte and Rossa-Feres 2007; Garey and Hartmann 2012; Zina et al. 2012; Oliveira et al. 2013), where they provide important data for the understanding of the ecological relationships among species in time (Santos-Pereira et al. 2011) and space (Juncá 2006; Ferreira et al. 2012). Species lists (Wachlevski and Rocha 2010; Telles et al. 2012; Affonso et al. 2014; Almeida-Gomes et al. 2014; Crivellari et al. 2014) typically constitute an essential first step for the monitoring of the fauna of specific habitats and the assessment of the status of species and their populations, which can be used to guide conservation decision-making (Pimenta et al. 2005), especially considering that most strategies are based on local species richness (Rocha et al. 2003) and on the extinction risk of different species (Miller et al. 2006).

Overall, 988 of the 6,600 currently recognized anuran species (Frost 2016) are known to occur in Brazil (Segalla et al. 2014). The Brazilian Atlantic Forest is home to more than 500 anuran species, of which approximately 85% are endemic to this biome (Haddad et al. 2013). The considerable biodiversity and endemism of the Atlantic Forest, and the ongoing degradation of its habitats, have led to the inclusion of this biome among the world's conservation hotspots (Myers et al. 2000).

A total of 147 anuran species are known to occur in the Brazilian state of Paraná (Toledo and Batista 2012). A large part of the coastal areas of this state was covered originally by the different Atlantic Forest rainforest formations and associated ecosystems. The northern coast of Paraná, together with the southern extreme of the coast of the neighboring state of São Paulo, encompasses the largest continuous remnant of the Atlantic Forest (Câmara 2005), which maintains more than half of its original forest cover (Hassler 2005). The Lagamar Complex, a set that provides the integrated management of more than 40 protected areas, is located in this largest remnant. The Salto Morato Nature

Reserve (SMNR), which was recognized as a UNESCO Natural Heritage Site in 1999 (FGBPN 2011), in turn, is located in this complex.

The first survey of the frog fauna of the SMNR was conducted as part of the original reserve management plan, during which 19 species of frog were recorded (Bittencourt et al. 1994). About 17 years later, Santos-Pereira et al. (2011) surveyed the reserve's leaf-litter frog community, identifying seven species. Shortly after, Garey and Hartmann (2012) updated the SMNR anuran checklist to 42 species, belonging to 17 genera and nine families, including the new species *Brachycephalus tridactylus* Garey, Lima, Hartmann & Haddad, 2012. A number of other studies have provided additional data on some frog species of the SMNR (e.g., Costa et al. 2010; Costa and Toledo 2013; Santos-Pereira et al. 2010, 2013, 2015).

Here, we provide an updated anuran checklist for the Salto Morato Nature Reserve, based on intensive sampling throughout the altitudinal gradient at SMNR (in places never before sampled) over a two-year period. Based on the data collected, we provide information on endemism, conservation status, habitat use and the reproductive modes of the anuran species found in the reserve.

MATERIALS AND METHODS

Study area

The Reserva Natural Salto Morato, or Salto Morato Nature Reserve (SMNR, 25°09′ S; 048°16′ W) is a private natural heritage reserve (Reserva Particular do Patrimônio Natural – RPPN), with a total area of 2,252 ha of dense Atlantic Forest, located in the Guaraqueçaba Environmental Protection Area (APA de Guaraqueçaba) on the north coast of Paraná, in southern Brazil (Figure 1). The APA de Guaraqueçaba, in turn, is part of the Lagamar Complex (Figure 1). According to the Koeppen classification, the climate of the area is CFA, that is, subtropical humid, with mean annual temperatures of around 21°C, rising to 25°C in the warmest months, and reaching almost 17°C in the coldest months. The region has hot summers, infrequent frosts, and a tendency for rainfall to peak during the summer months, but without a well-defined dry season. Rainfall rates are relatively high, with annual precipitation of over 2,000 mm, and mean relative humidity of the air of 85%. The local climate is influenced mainly by the Tropical and Polar Atlantic air masses (FBPN 2011).

Data collection

To document the frog fauna of the SMNR, we conducted eight field excursions of 8 to 10 days between February 2013 and July 2015. Samples were taken throughout the altitudinal range of the reserve, from 25 to 930 m. We used Visual Encounter Surveys (VES, Crump and Scott 1994) for our sampling method, totaling 1,400 transects and 700 hours of sampling effort. We searched carefully for frogs in streams, puddles, bromeliads, leaf litter, trunks, rocks, and other environments found in the forest. Each transect lasted 30 minutes, and was separated by at least 100 m from the subsequent transect, in order to reduce the potential for spatial pseudo-replication and guarantee the independence of the data. To estimate total frog species richness in the reserve, we considered the species observed during the transects and the specimens encountered during non-systematic observations. The scientific nomenclature adopted here was that of Frost (2016). Representative specimens were collected (ICMBio license no. 30739) and deposited as vouchers in the Capão da Imbuia Natural History Museum (MHNCI) in Curitiba, Paraná, and the National Museum (MNRJ) in Rio de Janeiro (Appendix).

To update the anuran inventory for the SMNR, we supplemented our primary data with secondary data from published papers and voucher specimens representing the locality deposited in scientific collections. Published papers were identified based on the location of the study area, while SpeciesLink (2015) was consulted for the identification of vouchers at institutions such as the Museum of Zoology at Campinas State University (ZUEC-AMP) in Campinas, São Paulo, the Célio F.B. Haddad collection (CFBH) in Rio Claro, São Paulo, the herpetological collection at the Capão da Imbuia Museum (MHNCI - Herpeto) in Curitiba, Paraná, and the amphibian collection (DZSJRP) in São José do Rio Preto, São Paulo, Brazil.

Data analysis

In order to evaluate the reliability of the data with regard to the estimate of frog species richness, we plotted a rarefaction curve of species based on the species records and sampling effort. The data were analyzed in EstimateS 9.1 (with 1,000 randomizations and the without replacement of samples), using the Bootstrap richness estimator (Colwell 2013).

We classified frog habitat in the reserve through field observations supported by published data. The reproductive mode of each species was defined using the classification of Haddad et al. (2013). Atlantic Forest endemism was defined based on Haddad et al. (2013) and Frost (2016). Conservation status and the potential threat level of each species were determined from the data available in the red lists of Paraná (Segalla and Langone 2004), Brazil (MMA 2014), and the IUCN (IUCN 2015).

RESULTS

We recorded a total of 40 frog species belonging to 21 genera and nine families in the SMNR (primary

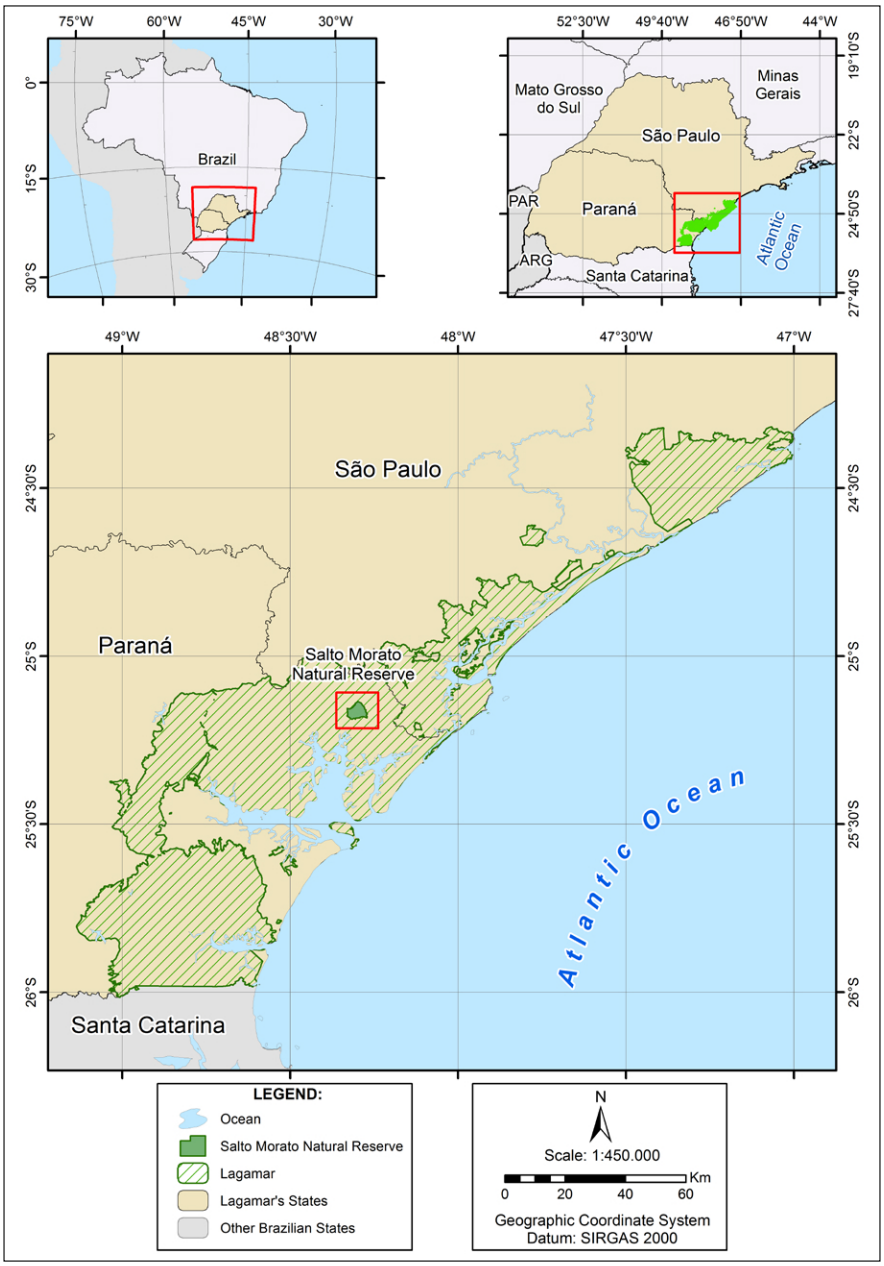

Figure 1. Location of the Salto Morato Nature Reserve, Paraná state, southern Brazil.

data). The results of our study added 12 frog species to the existing inventory (Garey and Hartmann 2012), indicating the occurrence of a total of 54 anuran species at Salto Morato (Table 1) belonging to 23 genera distributed in 10 families (Brachycephalidae, Bufonidae, Centrolenidae, Craugastoridae, Cycloramphidae, Hemiphractidae, Hylidae, Hylodidae, Leptodactylidae and Odontophrynidae). We did not record any additional species from museum collections that had not been recorded in previous studies (Santos-Pereira et al. 2011; Garey and Hartmann 2012). The frog species richness estimated for the area by Bootstrap, considering only the data from the present study (active search method), was 45 species, and the rarefaction curve tended towards the asymptote (Figure 2). The Hylidae was the most species-rich family (23 species), followed by the

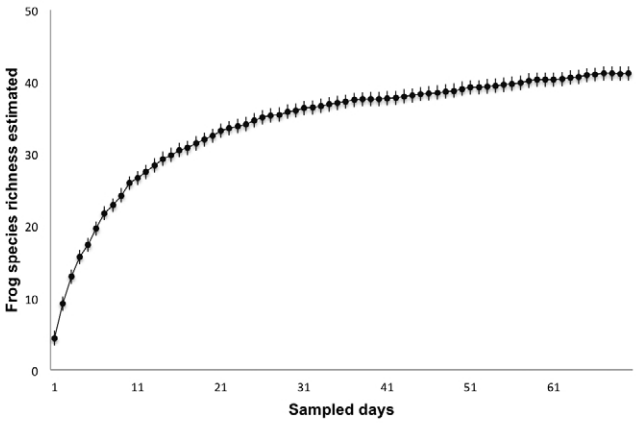

Figure 2. Rarefaction curve of anuran species based on the species records and sampling effort (sampled days) in the Salto Morato Nature Reserve, Paraná state, southern Brazil and its average standard deviation (bars). Richness estimator used: Bootstrap.

Table 1. Frog species recorded in the Salto Morato Nature Reserve, Paraná state, southern Brazil. The species were classified according to habitat occupied as arboreal (A), terrestrial (T) and rheophilic (R). Reproductive modes (RM) of each species are represented by the numbers *sensu* Haddad et al. 2013 (see Table 2). The source refers to the source information of the occurrence record of frog species, as follows: Present study (1) and Garey and Hartmann 2012 (2). * Endemic frog species of the Paraná. ** Micro-endemic frog specie of the RNSM.

Taxon	Habitat	RM	Source
Brachycephalidae			
Brachycephalus hermogenesi (Giaretta & Sawaya, 1998)	T	23	1
Brachycephalus tridactylus Garey, Lima, Hartmann & Haddad, 2012**	T	23	1; 2
Ischnocnema henselii Heinicke, Duellman & Hedges, 2007	T	23	1; 2
Ischnocnema sambaqui (Castanho & Haddad, 2000)*	T	23	1
Ischnocnema sp. (gr. *henselii*)	T	23	2
Ischnocnema cf. *spanios*	A	23	1
Ischnocnema sp. (gr. *lactea*)	A	23	1
Ischnocnema sp.	T	23	1; 2
Bufonidae			
Dendrophryniscus berthalutzae Izecksohn, 1994 "1993"	A	8	1; 2
Dendrophryniscus leucomystax Izecksohn, 1968	A	8	1; 2
Rhinella abei (Baldissera-Jr, Caramaschi & Haddad, 2004)	T	1	1; 2
Rhinella hoogmoedi Caramaschi & Pombal, 2006	T	1	1; 2
Rhinella icterica (Spix, 1824)	T	1	1; 2
Centrolenidae			
Hyalinobatrachium uranoscopum (Müller, 1924)	A	25	2
Craugastoridae			
Haddadus binotatus (Spix, 1824)	T	23	1; 2
Cycloramphidae			
Cycloramphus cf. *asper*	R	19	1
Cycloramphus mirandaribeiroi Heyer, 1983*	R	-	1
Hemiphractidae			
Fritziana sp. (gr. *fissilis*)	A	36	2
Gastrotheca microdiscus Cochran, 1955 "1954"	A	37	1
Hylidae			
Aplastodiscus albosignatus (A. Lutz & B. Lutz, 1938)	A	5	1
Bokermannohyla hylax (Heyer, 1985)	A	4	1; 2
Dendropsophus berthalutzae (Bokermann, 1962)	A	24	1; 2
Dendropsophus elegans (Wied-Neuwied, 1824)	A	1	2
Dendropsophus microps (Peters, 1872)	A	1	2
Dendropsophus minutus (Peters, 1872)	A	1	2
Dendropsophus seniculus (Cope, 1868)	A	1	2
Dendropsophus werneri (Cochran, 1952)	A	1	2
Hypsiboas albomarginatus (Spix, 1824)	A	1	1; 2
Hypsiboas faber (Wied-Neuwied, 1821)	A	1 or 4	1; 2
Hypsiboas semilineatus (Spix, 1824)	A	1 or 2	1; 2
Itapotihyla langsdorffii (Duméril & Bibron, 1841)	A	1	1
Phyllomedusa distincta Lutz, 1950	A	24	1; 2
Scinax fuscovarius (Lutz, 1925)	A	1	1; 2
Scinax littoralis (Pombal & Gordo, 1991)	A	1	1; 2
Scinax perereca Pombal, Haddad & Kasahara, 1995	A	1	1; 2
Scinax cf. *argyreornatus*	A	1	1; 2
Scinax cf. *tymbamirim*	A	1	1
Scinax gr. *perpusillus*	A	6	1; 2
Scinax sp1. (gr. *alter*)	A	1	2
Scinax sp2. (gr. *alter*)	A	1	2
Scinax sp. (aff. *berthae*)	A	-	2
Trachycephalus mesophaeus (Hensel, 1867)	A	1	1; 2
Hylodidae			
Crossodactylus caramaschii Bastos & Pombal, 1995	R	3	1
Hylodes cardosoi Lingnau, Canedo & Pombal, 2008	R	3	1
Hylodes cf. *heyeri*	R	3	1; 2
Hylodes sp. (aff. *asper*)	R	3	2
Leptodactylidae (Leptodactylinae)			
Adenomera marmorata (Steindachner, 1867)	T	32	1; 2
Adenomera sp. (aff. *marmorata*)	T	32	2
Adenomera cf. *bokermanni*	T	32	1; 2
Leptodactylus latrans (Steffen, 1815)	T	11	1; 2
Leptodactylus notoaktites Heyer, 1978	T	30	1; 2
Leptodactylidae (Leiuperinae)			
Physalaemus spiniger (Miranda-Ribeiro, 1926)	T	11; 14 or 28	1; 2
Physalaemus sp. (aff. *olfersii*)	T	11	2
Odontophrynidae			
Proceratophrys boiei (Wied-Neuwied, 1825)	T	1	1; 2

Paraná or anywhere in southern Brazil. Species richness was high in comparison with other sites in Paraná (e.g., São José dos Pinhais, 34 species, Conte and Rossa-Feres 2006; Morretes, 32 species, Armstrong and Conte 2010; Guaratuba, 32 species, Cunha et al. 2010) and in the neighboring state of São Paulo (e.g., Intervales State Park, 47 species, Bertoluci and Rodrigues 2002; Juréia-Itatins Ecological Station, 26 species, Pombal and Gordo 2004; Carlos Botelho State Park, 19 species, Moraes et al. 2007). High species richness, similar to that observed at Salto Morato, has been recorded at other Atlantic Forest sites (PETAR, state of São Paulo, 60 species, Araujo et al. 2010; Taquara Municipal Natural Park, state of Rio de Janeiro, 50 species, Sales et al. 2009; Peti Environmental Station, state of Minas Gerais, 48 species, Bertoluci et al. 2009; Michelin Ecological Reserve, state of Bahia, 48

Figure 3. Some anuran species from the Salto Morato Nature Reserve, Paraná state, southern Brazil. **A)** *Brachycephalus hermogenesi*; **B)** *Brachycephalus tridactylus*; **C)** *Ischnocnema henselii*; **D)** *Ischnocnema sambaqui*; **E)** *Ischnocnema* sp. gr. *lactea*; **F)** *Dendrophryniscus berthalutzae*; **G)** *Dendrophryniscus leucomystax*; **H)** *Rhinella abei*; **I)** *Rhinella hoogmoedi*; **J)** *Rhinella icterica*; **L)** *Haddadus binotatus* and **M)** *Cycloramphus mirandaribeiroi*. Photos by Manuela Santos-Pereira.

Figure 4. Some anuran species from the Salto Morato Nature Reserve, Paraná state, southern Brazil. **A)** *Gastrotheca microdiscus*; **B)** *Aplastodiscus albosignatus*; **C)** *Bokermannohyla hylax*; **D)** *Dendropsophus berthalutzae*; **E)** *Hypsiboas albomarginatus*; **F)** *Hypsiboas faber*; **G)** *Hypsiboas semilineatus*; **H)** *Itapotihyla langsdorffii*; **I)** *Phyllomedusa distincta*; **J)** *Sinax fuscovarius*; **L)** *Scinax littoralis*; **M)** *Scinax perereca*; **N)** *Sinax* cf. *argyreornatus*; **O)** *Scinax* cf. *tymbamirim* and **P)** *Trachycephalus mesophaeus*. Photos by Manuela Santos-Pereira, except "F", taken by Luiz Felipe Barata Bittencourt.

Figure 5. Some anuran species from the Salto Morato Nature Reserve, Paraná state, southern Brazil. **A)** *Crossodactylus caramaschii*; **B)** *Hylodes cardosoi*; **C)** *Hylodes* cf. *heyeri*; **D)** *Adenomera marmorata*; **E)** *Adenomera* cf. *bokermanni*; **F)** *Leptodactylus latrans*; **G)** *Leptodactylus notoaktites*; **H)** *Physalaemus spiniger*; and **I)** *Proceratophrys boiei*. Photos by Manuela Santos-Pereira.

Brachycephalidae (eight species) and Leptodactylidae, with seven species (Table 1; Figures 3–5).

Most frog species recorded at Salto Morato are Atlantic Forest endemics (Table 1), except for *Dendropsophus elegans* (Wied-Neuwied, 1824), *Dendropsophus minutus* (Peters, 1872), *Leptodactylus latrans* (Steffen, 1815), *Rhinella icterica* (Spix, 1824) and *Scinax* sp. (aff. *berthae*). *Ischnocnema sambaqui* (Castanho & Haddad, 2000), *Cycloramphus mirandaribeiroi* Heyer, 1983, and *Brachycephalus tridactylus* Garey, Lima, Hartmann, & Haddad, 2012 are endemic to Paraná state, and the latter is a micro-endemic of the SMNR, being found only at the reserve's highest altitudes (i.e., from 800 to 930 m) (Frost 2016).

None of the frog species recorded at the SMNR are classified as threatened in the red lists of Paraná (Segalla and Langone 2004), Brazil (MMA 2014) or the IUCN (2015). However, four species (*Ischnocnema sambaqui, Cycloramphus mirandaribeiroi, Cycloramphus* cf. *asper* and *Hylodes* cf. *heyeri*) are listed as Data Deficient (DD) by the IUCN. *Ischnocnema sambaqui* and *C. mirandaribeiroi*, together with *Gastrotheca microdiscus* (Andersson 1910) are also listed as DD in Paraná.

Most (55.5%) of the species found in the reserve were arboreal, one-third (33.3%) were terrestrial, while a small group (11.1% of the total) were rheophilic (Table 1). A total of 18 reproductive modes were recorded, including three (modes 5, 19 and 37) not recorded previously in the reserve (Garey and Hartmann 2012) (Table 1). The largest group of species (38.8% of the total) lay eggs in lentic water (Table 1), where the tadpoles develop (mode 1) and in 16.7%, there is direct development of terrestrial eggs (mode 23). All others were much less common.

DISCUSSION

Our data indicated that Salto Morato contains a considerable portion of the frog species richness of Paraná state (more than one-third; Toledo and Batista 2012) and is the site with the greatest anuran diversity in

Table 2. Characteristics of the reproductive modes recorded in frogs in the Salto Morato Nature Reserve, Paraná state, southern Brazil (adapted from Haddad et al. 2013).

Reproductive modes characteristics		Type
Aquatic eggs		
Eggs placed directly in water	Eggs and exotrophic tadpoles in still water	1
	Eggs and exotrophic tadpoles in running water	2
	Eggs and early larval stages in subaquatic chambers; exotrophic tadpoles in streams	3
	Eggs and early larval stages in natural or constructed basins; after flooding, exotrophic tadpoles in ponds or streams	4
	Eggs and early larval stages in underground "nests"; after flooding, exotrophic tadpoles in still water or streams	5
	Eggs and exotrophic tadpoles in water accumulated in tree holes or in aerial plants	6
	Eggs and endotrophic tadpoles in water accumulated in tree holes or in aerial plants	8
Eggs in foam nest	Foam nest floating on still water, exotrophic tadpoles in still water	11
	Foam nest floating on water accumulated on the axils of terrestrial bromeliads; exotrophic tadpoles in still water	14
Terrestrial or arboreal eggs		
Eggs on ground, on rocks, or in burrows	Eggs on wet rocks, rock crevices, or tree roots above water, exotrophic semi-terrestrial tadpoles on rocks or rock crevices in a water film or on the water/land interface	19
	Direct development of terrestrial eggs	23
Arboreal eggs	After hatching, exotrophic tadpoles that drop in still water	24
	After hatching, exotrophic tadpoles that drop in running water	25
Eggs in foam nest	Foam nest on the humid forest floor; after flooding, exotrophic tadpoles in still water	28
	Foam nest with eggs and early larval stages in underground constructed chamber; after flooding exotrophic tadpoles in still water	30
	Foam nest in underground constructed chamber; endotrophic tadpoles complete development in nest	32
Eggs carried by adult	Eggs carried on the back or in dorsal pouch of female; endotrophic tadpoles in water accumulated in bromeliads or bamboos	36
	Eggs carried on the back or in dorsal pouch of female; direct development into froglets	37

species, Camurugi et al. 2010). Given the estimate of species richness and the fact that the species rarefaction curve approximated the asymptote, it seems reasonable to assume that the sampling approach and total sampling effort were appropriate for the inventory of the local anuran assemblage.

The SMNR also has a high proportion of endemic Atlantic Rainforest frog species (90.7%). This may be favored by the relatively humid conditions of the dense rainforest that dominates the reserve, given the dependence of amphibians on moisture, the considerable altitudinal variation, which may favor the speciation process, and the marked heterogeneity of habitats and microhabitats (Haddad et al. 2013). Two of the three frogs endemic to the SMNR are brachycephalids, which is consistent with the overall pattern in Paraná, where most of the 17 endemic species are brachycephalids of the genus *Brachycephalus* (Haddad et al. 2013). The populations of the *Brachycephalus* species are typically restricted to islands of montane forest (Pombal Jr. et al 1998; Ribeiro et al. 2005; Alves et al. 2006) surrounded by valleys, which promote intense isolation and facilitate allopatric speciation (Pie et al. 2013), as probably occurred in the case of *Brachycephalus tridactylus* in the SMNR and some other members of this genus in southern Brazil (Ribeiro et al. 2015).

Although none of the frog species recorded in the SMNR is currently classified as Endangered, *Ischnocnema sambaqui, Cycloramphus mirandaribeiroi, Cycloramphus* cf. *asper* and *Hylodes* cf. *heyeri* are listed as Data Deficient (DD) by the IUCN (2015), while *I. sambaqui* and *C. mirandaribeiroi*, together with *Gastrotheca microdiscus* are also listed as DD in Paraná (Segalla and Langone 2004), emphasizing the overall lack of information available on the conservation status of these species. At least some of these species may be under threat, and more data are required, although their inclusion in the red lists does potentially stimulate further research (Segalla and Langone 2004).

As in many other areas of the Atlantic Forest (e.g., Conte and Rossa-Feres 2006; Bertoluci et al. 2007; Carvalho-e-Silva et al. 2008; Almeida-Gomes et al. 2010), the Hylidae was the most species diverse frog family in the SMNR. Most of the species were arboreal, and reproduce by mode 1 (eggs and tadpoles deposited in standing water). A considerable proportion of the frog species belong to the Terrarana group (*sensu* Hedges et al. 2008), represented in this study by the Brachycephalidae and Craugastoridae, which have direct development of terrestrial eggs (reproductive mode 23), and tend to dominate the leaf-litter communities in tropical forests (e.g., Scott 1976; Lieberman 1986; Fauth et al. 1989; Giaretta et al. 1997; 1999; Rocha et al. 2001; 2007; 2011; Siqueira et al. 2009; Santos-Pereira et al. 2011). As they do not depend on bodies of water for reproduction (e.g. Scott 1976; Hedges et al. 2008), these species are widely distributed in forest habitats. In comparison with earlier inventories of the SMNR (Garey and Hartmann 2012), the proportion of species of the Terrarana was relatively high in the present study, possibly due to procedural differences, in particular, the increased sampling effort throughout the forest and the whole of the reserve's altitudinal gradient. This increased sampling effort included stream habitats,

which enabled the observation of rheophillic species which, in contrast with those of the Terrarana group, lay their eggs in water. In the SMNR, the rheophillic frogs included members of the Hylodidae, which lay their eggs in underwater chambers (reproductive mode 3), and the Cycloramphidae, which lay their eggs on wet rocks, in rock crevices, or on tree roots above water (reproductive mode 19; Haddad et al. 2013). The life history of these species, which depend on streams to carry out their full life cycle, has been associated with the decline of amphibian species in forested habitats (Stuart et al. 2004; Whiles et al. 2006). It is interesting to note that the two cycloramphids (*C. mirandaribeiroi* and *C.* cf. *asper*) and the hylodid (*H.* cf. *heyeri*) recorded in the present study are classified as DD, which emphasizes the importance of monitoring their populations. By contrast, the previous study of Garey and Hartmann (2012) recorded some species of hylids, unrecorded by us. The answers for this difference in species occurrence may result from: i) most of those species were recorded by Garey and Hartmann (2012) in lowland open areas. However after eight years these areas does not remain as open areas, but by now in advanced successional stage (locally called "capoeirão"). So, considering the observed change in structural habitats it is possible that a successional of frog species here also follow the change in habitat. ii) one should suggest possible local extinction. However although we can not discard/ such possibility we believe that to infer on local extinction it is needed some monitoring for longer years that our study (two years).

The high species richness and the diversity of reproductive modes recorded in the Salto Morato Nature Reserve, combined with the high rates of endemism and the presence of populations of Data Deficient species, all reinforce the importance of the SMNR for the conservation of frog species and the safeguarding of anuran communities in the Atlantic Forest biome.

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APPENDIX

Voucher list

MHNCI: *Ischnocnema* sp. (9895); *Rhinella abei* (9907); *Gastrotheca microdiscus* (9879); *Aplastodiscus albosignatus* (9865); *Bokermannohyla hylax* (9866); *Hypsiboas albomarginatus* (9890); *Hypsiboas semilineatus* (9893); *Itapotihyla langsdorffii* (9900); *Scinax fuscovarius* (9914); *Scinax littoralis* (9916); *Scinax perereca* (9919); *Scinax* cf. *argyreornatus* (9911); *Scinax* cf. *tymbamirim* (9920) *Trachycephalus mesophaeus* (9921); *Leptodactylus notoaktites* (9903).

MNRJ: *Brachycephalus hermogenesi* (87914); *Brachycephalus tridactylus* (87908); *Ischnocnema henselii* (87924); *Ischnocnema sambaqui* (87930); *Ischnocnema* cf. *spanios* (87931); *Ischnocnema* sp. (gr. *lactea*) (85800); *Dendrophryniscus berthalutzae* (85785); *Dendrophryniscus leucomystax* (87922); *Rhinella hoogmoedi* (85813); *Haddadus binotatus* (87921); *Cycloramphus* cf. *asper* (87917); *Cycloramphus mirandaribeiroi* (85784); *Dendropsophus berthalutzae* (85786); *Scinax* gr. *perpusillus* (85814); *Crossodactylus caramaschii* (85782); *Hylodes cardosoi* (85792); *Hylodes* cf. *heyeri* (85799); *Adenomera marmorata* (85820); *Adenomera* cf. *bokermanni* (MNRJ 87923); *Leptodactylus latrans* (87911); *Physalaemus spiniger* (85807); *Proceratophrys boiei* (85810).