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Herpetofauna of the Serra do Tombador Nature Reserve, State of Goiás, Central Brazil

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Abstract. Data on species occurrence and richness are important to support conservation actions for strategic areas. To increase knowledge about the herpetofauna of the Cerrado biome, we present a list of amphibians and reptiles' species from the Private Reserve of Natural Heritage Serra do Tombador (RNST). The fieldwork was performed in November 2016 and the samplings were carried out through pitfall traps, active search, occasional encounters, and third-party records. We also consider the species recorded in the RNST Management Plan. We recorded 34 amphibians and 55 reptiles, and expanded the known distribution of some species. The observed and estimated amphibian species curves showed a tendency to stabilize, with the observed richness representing 89% of the number of species expected. On the other hand, observed and estimated reptile species curves did not show a stabilization trend. Even considering the smallest sample period in this study, the richness of amphibian and reptile species was similar or greater to those found in protected areas in the Cerrado, close to the RNST. The presence of species with restricted endemism, recently described, and data deficient highlights the importance of the RNST for the conservation of the Cerrado herpetofauna.

Keywords. Amphibians; Biodiversity; Cerrado; Conservation; Reptiles.

INTRODUCTION

The Cerrado is the second largest Brazilian biome and has the greatest biodiversity of all savannas in the world, albeit considered the third conservation hotspot concerning its extension area (Myers *et al.,* 2000; Klink & Machado, 2005). The Cerrado holds a high diversity and expressive endemism of plants and animals (Diniz *et al.,* 2010), which is associated with great environmental heterogeneity, combining grassland, savanna, and forest formations in the landscape (Ribeiro & Walter, 2008). The high rate of fragmentation and loss of natural habitats due to agriculture (especially for soy production, Rausch *et al.,* 2019) and urban expansion has increased over the past two decades (Strassburg *et al.,* 2017), resulting in habitat losses of about 25% of the original Cerrado cover land and a significant decrease in connectivity across the biome (Grande *et al.,* 2020). The conservation status of the Cerrado is even more worrying due to the low representativeness of its original vegetation in protected areas (only 6.5%, Françoso *et al.,* 2015), high rates of annual deforestation, and the political obstacles in creating new protected areas (Strassburg *et al.,* 2017). Thus, private conservationist initiatives, such as the creation of Private Natural Heritage Reserves (RPPN) have become particularly important for the protection of the biome biodiversity (Silva *et al.,* 2015).

Protected areas are indispensable tools for biodiversity conservation, especially for species more sensitive to changes in natural vegetation cover, such as amphibians and reptiles (Ramalho *et al.,* 2019; Oliveira *et al.,* 2019). In the Cerrado, about 52% of the 209 species of amphibians and 39% of the 267 species of reptiles are endemic (Nogueira *et al.,* 2011; Valdujo *et al.,* 2012). Recent studies have shown that the central region of the

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biome is one of the most diverse in terms of herpetofauna (Ramalho *et al.,* 2019; Vaz-Silva *et al.,* 2020), especially in the Chapada dos Veadeiros and nearby areas (França & Braz, 2013; Santoro & Brandão, 2014). Although there are some protected areas in the region, such as the Parque Nacional da Chapada dos Veadeiros, large areas are still subsampled or not properly protected. Therefore, both reptile and amphibian populations remain susceptible to threats in the region, such as burning, agriculture, habitat modification for grazing, coal production, hydroelectric projects, mining, and urban expansion (Colli *et al.,* 2002; Oda *et al.,* 2017). In this sense, data on species occurrence and richness are extremely important to support realistic conservation strategies (Santoro & Brandão, 2014; Ramalho *et al.,* 2019), especially by facing the Linnean and Wallacean shortfalls on biodiversity knowledge (Hortal *et al.,* 2015).

Furthermore, data on the natural history of species, such as their regional distribution and the habitat they occupy, are very important not only to identify areas of occurrence and patterns of community composition, but also to indicate the conservation needs of different regions when choosing protected areas, and improving further analysis in finer geographical scale on biota regionalization (de Mello *et al.,* 2015; Azevedo *et al.,* 2016; Françoso *et al.,* 2020). For example, some species of herpetofauna can be used as environmental indicators of certain environments due to their habitat preferences (Nogueira *et al.,* 2005, 2009; Gambale *et al.,* 2014; Santoro & Brandão, 2014), or their diversity patterns can be used to support conservation policies (Azevedo *et al.,* 2016).

Based on the strategic location of the Private Reserve of Natural Heritage (RPPN) Serra do Tombador Nature Reserve (RNST), and its potential to replicate models for biodiversity conservation and management of natural resources in an iconic region in the Cerrado biome, we present the richness and species composition of herpetofauna found in the RNST, aiming to increase knowledge about the Cerrado biodiversity. Moreover, the region where RNST is located is often recovered as a priority area for Cerrado conservation in different assessments (Pinto *et al.,* 2008; WWF, 2015; Azevedo *et al.,* 2016), and herpetofaunal checklists can highlight the occurrence of conservation targets at local scales.

MATERIAL AND METHODS

Study area

The Reserva Natural Serra do Tombador (RNST; Serra do Tombador Nature Reserve) is located in the Northern portion of the state of Goiás (Fig. 1), in a region classified as the "Tocantins Highlands" in the land system of

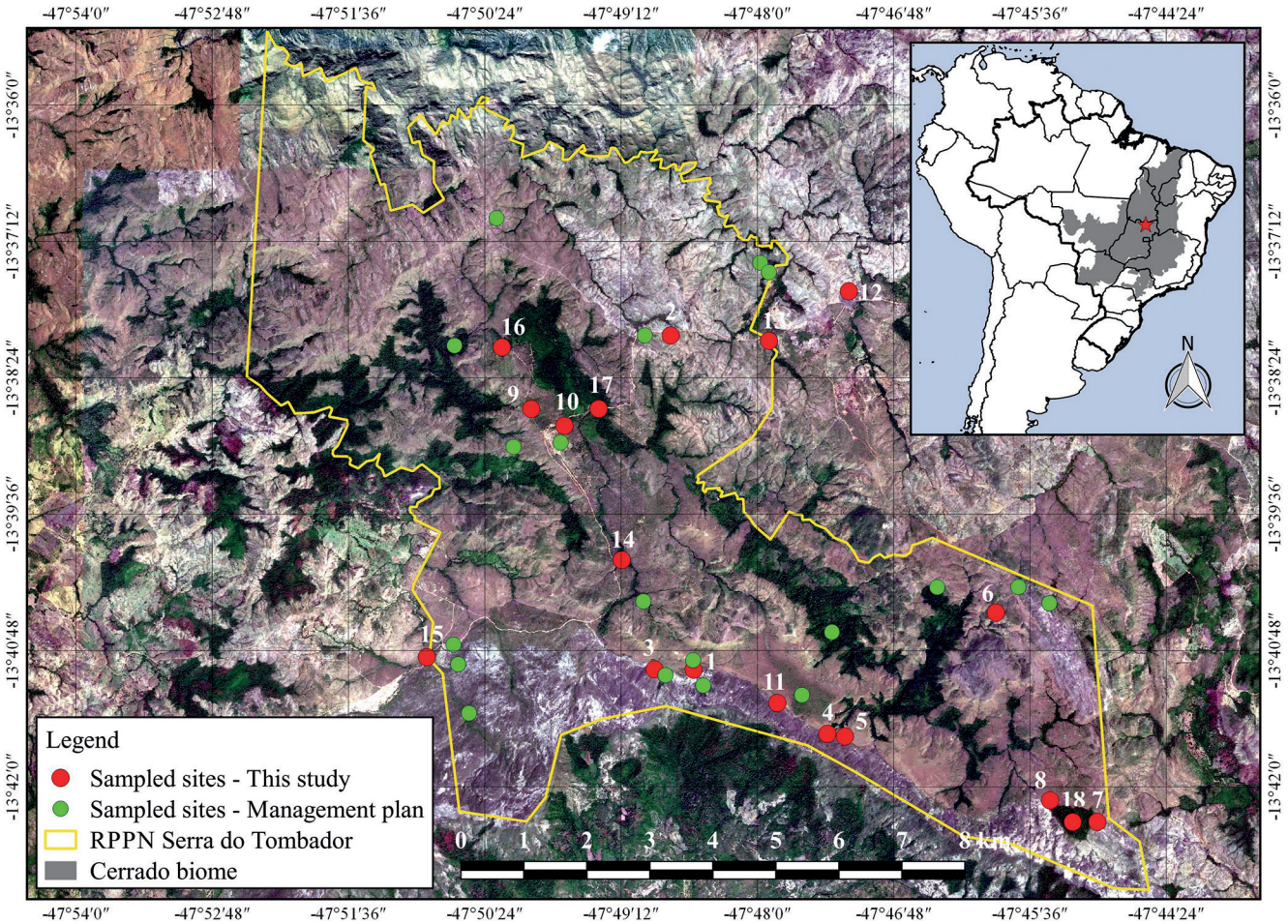

Figure 1. The geographic location of the Serra do Tombador Nature Reserve, state of Goiás, Brazil. In red are the sampling sites of this study and green are the sampling sites of the Management Plan. The type of habitat for each sampled site is shown in Table 1.

Cochrane *et al.* (1985), which encompasses the biogeographical unit "Veadeiros Plateau" (Azevedo *et al.,* 2016), characterized by the presence of several endemic amphibians and reptiles (Santoro & Brandão, 2014; Azevedo *et al.,* 2016). This region presents high annual temperatures, with low seasonal variation, along with high radiation during the dry season (Françoso *et al.,* 2020). The landscape in the region is largely heterogeneous, compassing the highest plateaus in the biome, mostly covered by open fields, along with dense forests at the deep valleys on the Tocantins River course. The landscape heterogeneity reflects the high biodiversity of the region, which is barely conserved by the few protected areas, such as the Chapada dos Veadeiros National Park (240,000 ha), Chapada de Nova Roma Ecological Station (6,811 ha), and several Natural Heritage Private Reserves (summing about 21,500 ha, Silva *et al.,* 2015).

The Reserva Particular do Patrimônio Natural (RPPN; Natural Heritage Privates Reserves) corresponds to a conservation unit category in the Brazilian protected areas system, that is created by private landowners' request (Brasil, 2000). RPPNs are created by an administrative act of the government on behalf of the landowner interest, aiming to conserve biodiversity in perpetuity, being research, conservation, education, and ecotourism, the only activities allowed in these areas (Brasil, 2000; Pegas & Castley, 2014, 2016). Therefore, RPPNs boundaries cannot be altered even when the landowners decide to trade their lands (Pegas & Castley, 2016). The RPPNs have a very positive impact on biodiversity conservation in Brazil, especially by protecting key habitats for threatened species (Mittermeier *et al.,* 2005), by allowing the participation of landowners in the biodiversity conservation challenge, by improving the habitat connectivity, by promoting regional strategies of conservation, and by representing an opportunity for economic benefits to landowners, mainly by touristic activities (Pegas & Castley, 2014). Furthermore, the RPPN category allowed the creation of a dynamic system of private conservation unities, composed of more than 1,700 reserves, that protects around 810,000 ha distributed in Brazil, especially in the country's hotspots (Cerrado and Atlantic Rain Forest biomes) (Pegas & Castley, 2016; CNRPPN, 2021).

The RNST has 8,730.45 hectares and is one of the largest private reserves in the Cerrado biome, having a prominent role in the conservation of biodiversity in the Chapada dos Veadeiros region (Silva *et al.,* 2015). In the RNST there are environments of forests (*e.g.,* gallery forest and seasonal forest), grasslands (*e.g., campo limpo, campo sujo,* and *cerrado rupestre*) and savannas (cerrado *stricto sensu, cerradão,* and *veredas*), with 93.3% of the area corresponding to natural areas (Françoso & Brandão, 2013).

Sampling methods

The field surveys were carried out over 15 consecutive days, from November 11 to 26, 2016. The samplings were performed through pitfall traps, active search controlled by time (visual and auditory), occasional encounters, and third-party records. We also included species registered in the Management Plan of the RNST (Plano de Manejo da Reserva Natural Serra do Tombador, 2011). After obtaining the species list of the Management Plan, we disregard the species: (1) already registered by us, (2) with uncertain taxonomic classifications (*e.g., Tropidurus* cf. *montanus*), and (3) with erroneous identification (*e.g., Varzea bistriata* (Spix, 1825) and *Xenodon severus* (Linnaeus, 1758) – records outside the known range). We selected three representative environments of the RNST for the installation of pitfall traps (Table 1). Each pitfall station consisted of 20 60-liter buckets buried in the ground, arranged linearly, and connected by a 60 cm height plastic canvas, totaling 60 buckets. Each station was reviewed daily and the sampling effort with this method was 21,600 hours (24 hours per bucket * 60 buckets * 15 days of sampling). The active visual and auditory surveys controlled by time consisted of sampling each site (Table 1), where random transects were performed by two or three researchers for two hours in the morning (08:00-10:00 h) and four hours at night (19:00-23:00 h), totaling 90 hours/researcher of sampling effort (6 hours a day * 15 days of sampling). Photographic records of species that were made by the RNST staff, as well as species recorded while traveling between sampling sites (occasional records) were considered as third-party records in the final species list but were not used in the statistical analyzes.

Table 1. Coordinates and sampling method carried out at each site during the survey of the Herpetofauna in the Serra do Tombador Nature Reserve, municipality of Cavalcante, state of Goiás, Brazil. Abbreviations: AS = Active search; PT = Pitfall trap.

Sites	Coordinates		Method	Cerrado environment
S1	13°40′59.69″S	47°48′35.19″W	AS	Cerrado grassland (*campo limpo*)/ outcropping watercourse
S2	13°38′03.25″S	47°48′47.33″W	AS	Cerrado grassland (*campo sujo*)
S3	13°40′59.53″S	47°48′55.86″W	AS, PT	Cerrado grassland (*campo limpo*)/ outcropping watercourse
S4	13°41′33.57″S	47°47′24.61″W	AS	Cerrado grassland (*campo limpo*)/ outcropping watercourse
S5	13°41′34.90″S	47°47′15.26″W	AS	Cerrado grassland (*campo limpo*)/ outcropping watercourse
S6	13°40′29.60″S	47°45′55.50″W	AS	Cerrado grassland (*campo sujo*)/ outcropping watercourse
S7	13°42′20.10″S	47°45′01.93″W	AS	Cerrado grassland (*campo sujo*)/ outcropping watercourse
S8	13°42′08.65″S	47°45′26.89″W	AS	Cerrado grassland (*campo limpo*)/ outcropping watercourse
S9	13°38′42.06″S	47°50′01.04″W	AS, PT	Cerrado grassland (*campo sujo*)
S10	13°38′50.96″S	47°49′43.47″W	AS	Cerrado grassland (*campo sujo*)
S11	13°41′17.29″S	47°47′50.99″W	AS	Cerrado grassland (*campo sujo*)/ outcropping watercourse
S12	13°37′39.92″S	47°47′13.21″W	AS	Cerrado grassland (*campo limpo*)/dam
S13	13°38′06.13″S	47°47′55.42″W	AS	Gallery forest
S14	13°40′01.80″S	47°49′13.17″W	AS	Gallery forest
S15	13°40′53.10″S	47°50′56.15″W	AS	Gallery forest
S16	13°38′09.50″S	47°50′16.50″W	AS, PT	Seasonal semi-deciduous forest
S17	13°38′48.24″S	47°49′38.33″W	AS	Seasonal semi-deciduous forest
S18	13°42′20.18″S	47°45′14.92″W	AS	Seasonal semi-deciduous forest

Some individuals sampled were placed in plastic bags containing identification tags, and later identified at the RNST headquarters, where they were destined for release at the same sampled site or to be housed in scientific collections. Collected specimens were anesthetized and euthanized with external application of 5% lidocaine (in the case of amphibians) or with by injection of 10% lidocaine into the coelomic cavity (in the case of reptiles), fixed in 10% formalin for 24 hours, and subsequently conserved in 70% alcohol. All collected specimens were deposited at the Laboratório de Fauna e Unidades de Conservação (LAFUC) at the University of Brasília (UNB), but not yet allocated to museum numbers[1]. Data on the species' threat status were obtained from IUCN (International Union for the Conservation of Nature, 2016) and the Brazilian Red List (MMA, 2014; ICMBio, 2018), and the distribution in the biomes was obtained mainly by Valdujo *et al.* (2012) for amphibians and Nogueira *et al.* (2011) for reptiles.

Statistical analysis

The richness and abundance data from active searches and pitfall traps served as the basis for the statistical analysis. To assess the efficiency of the sampling effort, we performed individual-based accumulation curves of abundance matrices separately for amphibians, lizards and snakes, where rows corresponded to species and the total abundance of each species is represented in a column. Additionally, the observed rarefaction curve was extrapolated using the Jackknife1 estimator, which estimates the richness based on the rarity of the species. The efficiency of the sampling effort was assessed by the percentage of observed richness in comparison to the estimated richness, as well as by the graphical interpretation of the accumulation curves and their respective standard deviations. The rarefied curves and richness estimates were generated from 999 randomizations utilizing the software EstimateS 9.1.0 (Colwell & Elsensohn, 2014).

RESULTS

Amphibians

We recorded 755 individuals of 34 species of amphibians distributed in two orders (Anura and Gymnophiona) and 10 families (Table 2). Figs. 2 to 5 show photos of amphibian species registered in the RNST. Among the anurans, the most specious family was Hylidae (12 species), followed by Leptodactylidae (10), Bufonidae (4), and Odontophrynidae (2). The other families (Aromobatidae, Craugastoridae, Dendrobatidae, Microhylidae, and Phyllomedusidae) were represented by one species each. Gymnophiona was represented only by the species *Siphonops paulensis* Boettger, 1892, belonging to the family Siphonopidae (Table 2).

The most abundant amphibian species were *Physalaemus cuvieri* Fitzinger, 1826 (105 records), *Leptodactylus syphax* Bokermann, 1969 (93), *Barycholos ternetzi* (Miranda-Ribeiro, 1937) (77), *Adenomera* cf. *hylaedactyla* (77), and *Pithecopus oreades* (Brandão, 2002) (67). On the other hand, ten species were considered rare, with one or two individuals (Table 2). Fifteen anuran species are endemic to the Cerrado biome (Table 2).

The observed and estimated amphibian species curves showed a tendency to stabilize (Fig. 6A). The observed richness (31 species) represented approximately 89% of the number of species expected by the estimator based on abundance (Jack1 = 35 ± 2). The greatest richness was found in gallery forest environments (21 species), followed by *campo limpo* (18), *campo sujo* (12), and lastly the seasonal semi-deciduous forest (9) (Table 2). Three amphibian species were recorded only by occasional encounters and third-party records outside the previously established sites.

Some of the recorded species are poorly known. *Allobates goianus* is classified as Endangered (EN) according to the Brazilian Red List and Data Deficient (DD) according to the IUCN. *Leptodactylus tapiti* Sazima and Bokermann, 1978 and *Pithecopus oreades* are DD, and *Scinax rupestris* Araújo-Vieira, Brandão, and Faria, 2015 and *Proceratophrys branti* Brandão, Caramaschi, Vaz-Silva, and Campos, 2013 have no evaluation as they were recently described (Table 2). The records of *L. tapiti* and *Scinax rupestris* at RNST represent the first record of these species beyond their type-locality (Chapada dos Veadeiros).

Reptiles

We recorded 54 individuals of 40 reptile species during our field searches. We also added 15 species registered in the Management Plan (not recorded by us) and the current list indicated the occurrence of 55 species in the RNST (Table 3). Figs. 7 to 10 show photos of reptile species registered in the RNST. The species are distributed in three orders (Testudines, Crocodylia, and Squamata) and 19 families. The orders Testudines and Crocodylia were represented by one species each (Table 3). Squamata was represented by suborders Amphisbaenia, Sauria, and Serpentes. Amphisbaenians were represented by three species of Amphisbaenidae. The most specious lizard families were Teiidae (4 species), Gymnophthalmidae, and Tropiduridae (3 spp., each), and among the snakes, the most specious families were Dipsadidae (20 spp.), Boidae, and Viperidae (3 spp., each).

Overall, the reptiles showed low abundance in the RNST, including 36 rare species, with one (31 species) or two records (5) (Table 3). The most abundant species were *Bothrops moojeni* Hoge, 1966 (4 records), *Ameiva ameiva* (Linnaeus, 1758) (3), *Ameivula ocellifera* (Spix, 1825) (3), and *Copeoglossum nigropunctatum* (Spix, 1825) (3) (Table 3). Among the recorded species, 15 are endemic to the Cerrado biome (Table 3).

None of the reptile species accumulation curves reached stability, although trends were different between lizards and snakes. The observed and estimat-

1 Due to the COVID-19 pandemic, LAFUC-UNB is closed and the voucher numbers for the specimens collected are not available at the moment. After allocating these specimens to museum numbers, they can be requested from the author R.A.B. (reuberbrandao@gmail.com).

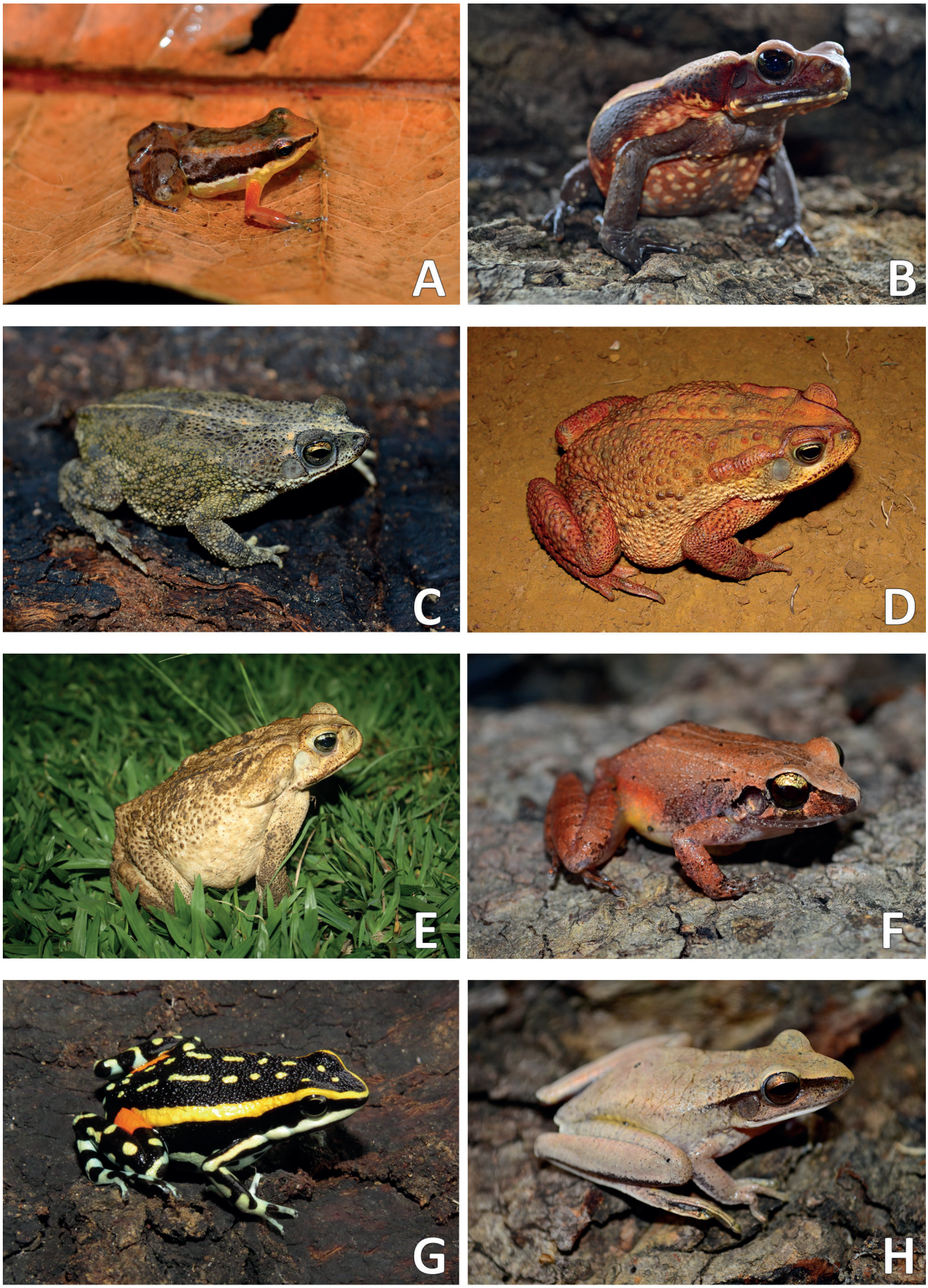

Figure 2. Anuran species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Allobates goianus,* (B) *Rhaebo guttatus,* (C) *Rhinella mirandaribeiroi,* (D) *R. rubescens,* (E) *R. diptycha,* (F) *Barycholos ternetzi,* (G) *Ameerega flavopicta,* (H) *Boana albopunctata.*

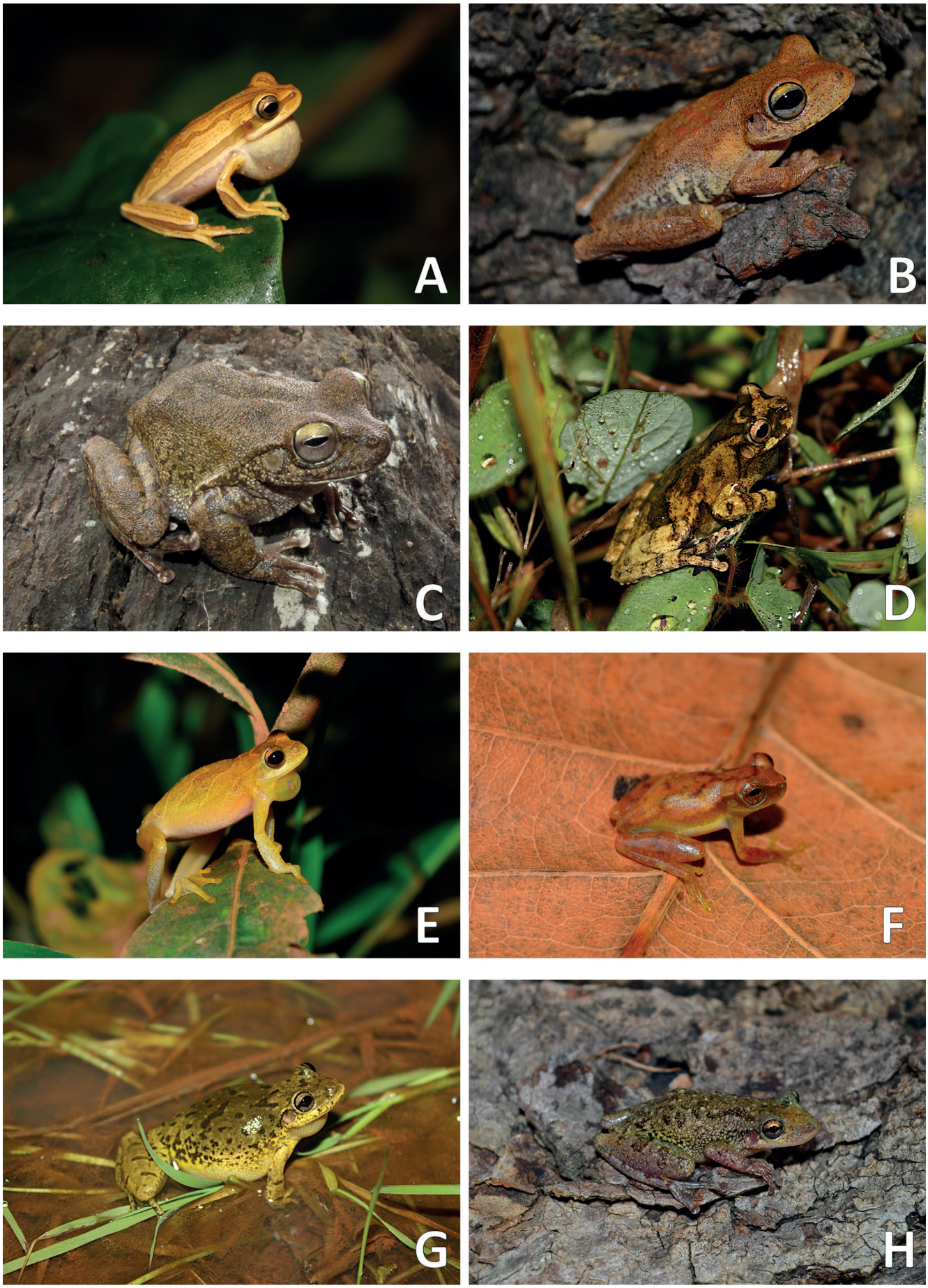

Figure 3. Anuran species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Boana goiana,* (B) *B. lundii,* (C) *Bokermannohyla pseudopseudis,* (D) *Dendropsophus melanargyreus,* (E) *D. minutus,* (F) *D.* gr. *microcephalus,* (G) *Scinax fuscovarius,* (H) *Scinax* gr. *ruber.*

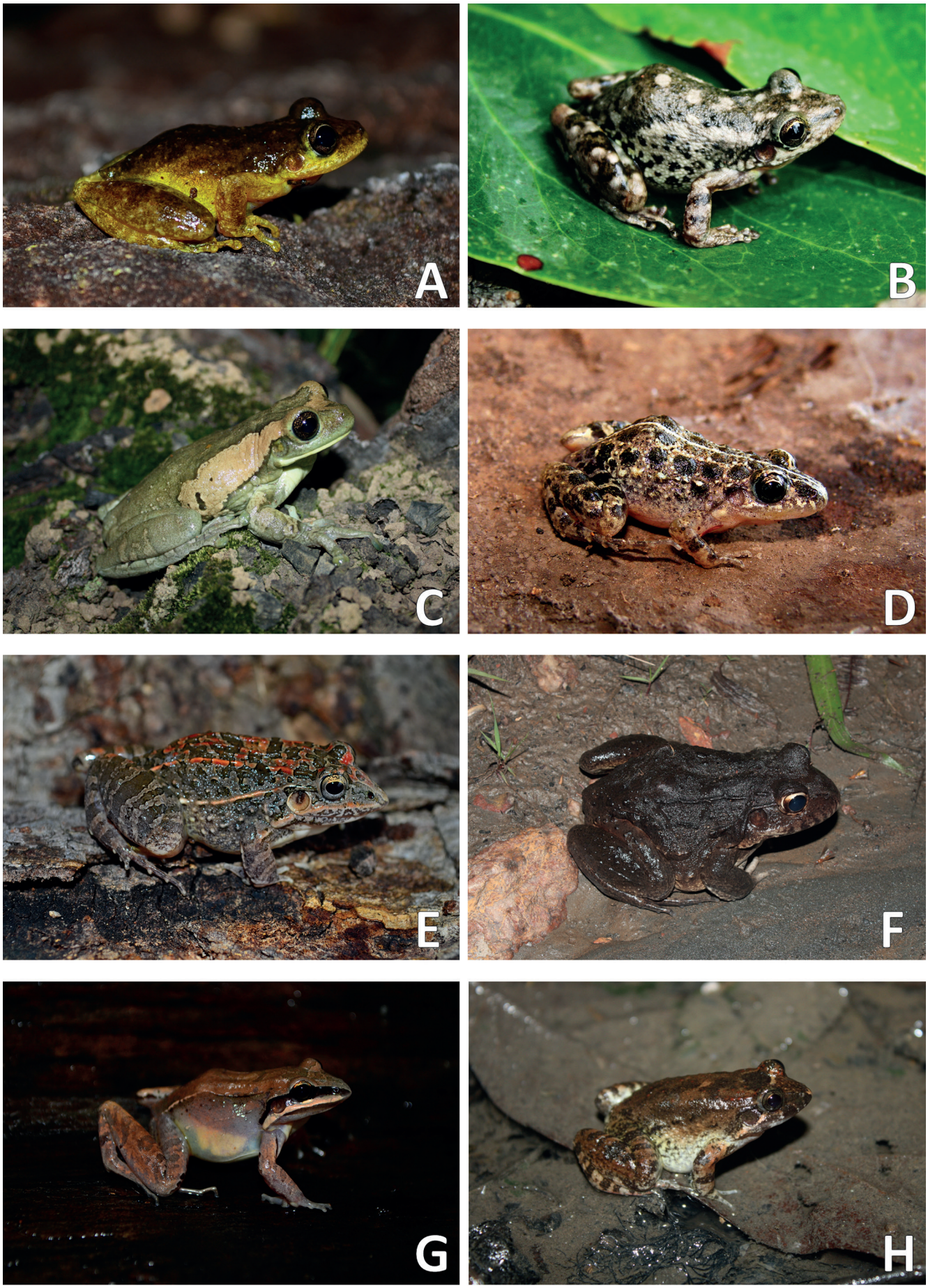

Figure 4. Anuran species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Scinax rupestris,* (B) *Scinax* sp., (C) *Trachycephalus typhonius,* (D) *Adenomera saci,* (E) *Leptodactylus fuscus,* (F) *L. labyrinthicus,* (G) *L. mystaceus,* (H) *L. natalensis.*

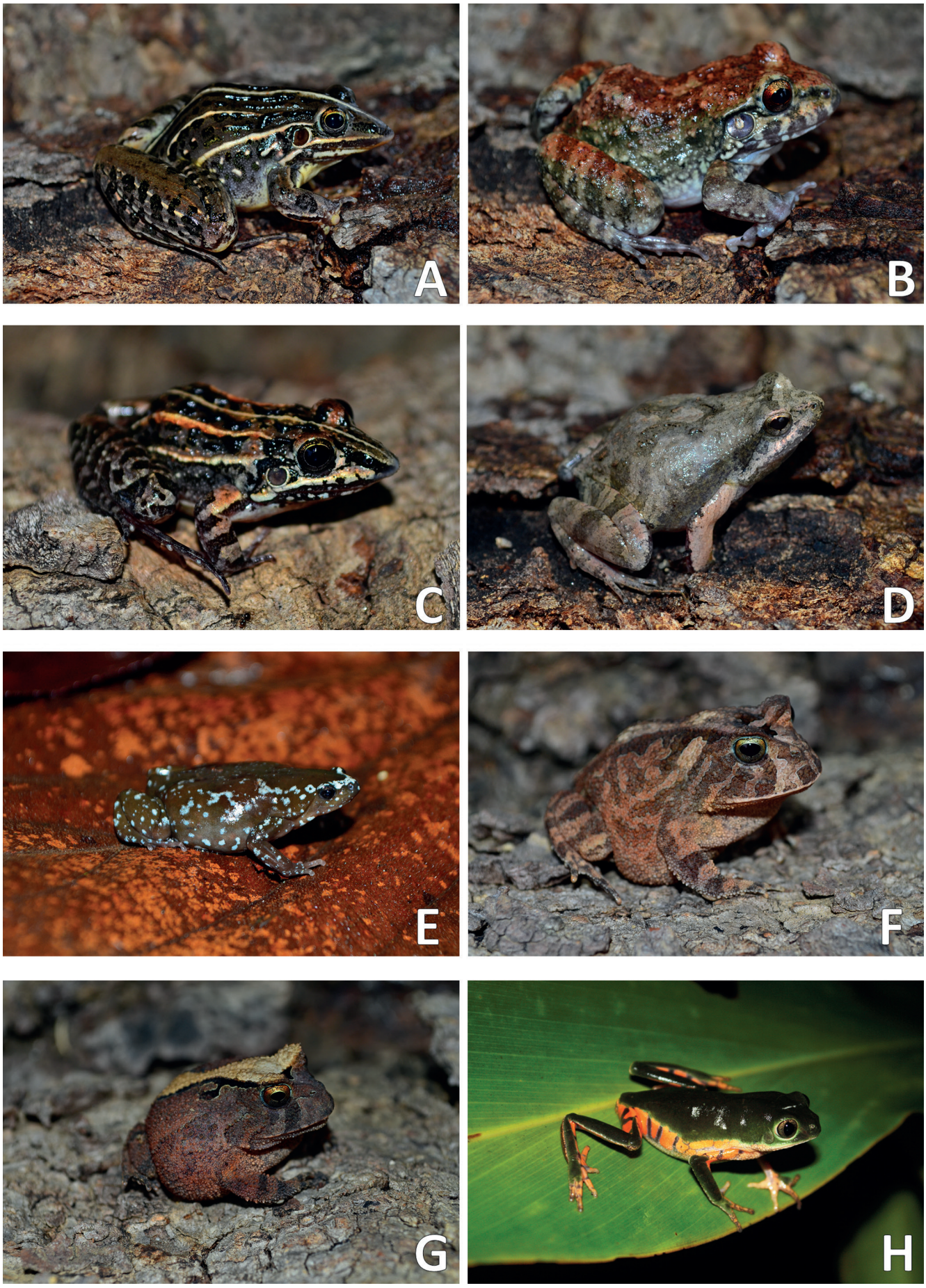

Figure 5. Anuran species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Leptodactylus sertanejo,* (B) *L. syphax,* (C) *L. tapiti,* (D) *Physalaemus cuvieri,* (E) *Chiasmocleis albopunctata,* (F) *Proceratophrys branti,* (G) *Proceratophrys goyana,* (H) *Pithecopus oreades.*

Table 2. Abundance of amphibian species recorded in different environments during the herpetofauna survey carried out in November 2016 at the Serra do Tombador Nature Reserve, municipality of Cavalcante, Goiás, Brazil. Abbreviations: OF = Open field (*campo limpo*), CE = Cerrado grassland (*campo sujo*), GF = Gallery forest, SF = Seasonal Semideciduous Forest; AE= Accidental encounter; AB = abundance; DIS = Distribution (END = endemic, CE = Cerrado, AF = Atlantic Forest, AM = Amazon, or WID = widely distributed – occurrence in three or more biomes); IUCN = Global threat category; MMA = National threat category (Ordinance No. 444); NE = Not evaluated, DD = Data deficient, EN = Endangered, LC = Least concern. * Asterisks represent species also collected in the Management Plan.

TAXA	Environments					AB	DIS	IUCN/MMA
	OF	CE	GF	SF	AE			
Anura								
Aromobatidae								
Allobates goianus (Bokermann, 1975)				25		25	END	DD/EN
Bufonidae								
Rhaebo guttatus (Schneider, 1799)				2		2	AM, CE	LC
Rhinella mirandaribeiroi (Gallardo, 1965)*	1					1	WID	LC
Rhinella rubescens (Lutz, 1925)		1	1			2	END	LC
Rhinella diptycha (Cope, 1862)	1	1	1		1	4	WID	LC
Craugastoridae								
Barycholos ternetzi (Miranda-Ribeiro, 1937)*		10	35	32		77	END	LC
Dendrobatidae								
Ameerega flavopicta (Lutz, 1925)*	24	5			1	30	END	LC
Hylidae								
Boana albopunctata (Spix, 1824)*	8		8			16	WID	LC
Boana goiana (Lutz, 1968)*			7			7	END	LC
Boana lundii (Burmeister, 1856)*			2			2	END	LC
Bokermannohyla pseudopseudis (Miranda-Ribeiro, 1937)	5			1		6	END	LC
Dendropsophus melanargyreus (Cope, 1887)		20	5			25	WID	LC
Dendropsophus minutus (Peters, 1872)*	10	20	9			39	WID	LC
Dendropsophus gr. *microcephalus*			26			26	—	—
Scinax fuscovarius (Lutz, 1925)*	6	10	5			21	WID	LC
Scinax gr. *ruber*	4					4	—	—
Scinax rupestris Araújo-Vieira, Brandão & Faria, 2015	41					41	END	NE
Scinax sp.			2	3		5	—	—
Trachycephalus typhonius (Linnaeus, 1758)					1	1	WID	LC
Leptodactylidae								
Adenomera cf. *hylaedactyla*	56	10	7	4		77	—	—
Adenomera saci Carvalho & Giaretta, 2013					1	1	END	LC
Leptodactylus fuscus (Schneider, 1799)*	1					1	WID	LC
Leptodactylus labyrinthicus (Spix, 1824)	11	3	1			15	WID	LC
Leptodactylus mystaceus (Spix, 1824)*			3			3	—	—
Leptodactylus natalensis Lutz, 1930			1			1	WID	LC
Leptodactylus sertanejo Giaretta & Costa, 2007	16					16	END	LC
Leptodactylus syphax Bokermann, 1969*	73	4	8	8		93	END	LC
Leptodactylus tapiti Sazima & Bokermann, 1978	3					3	END	DD
Physalaemus cuvieri Fitzinger, 1826*	60	12	23	10		105	WID	LC
Microhylidae								
Chiasmocleis albopunctata (Boettger, 1885)			5			5	WID	LC
Odontophrynidae								
Proceratophrys branti Brandão, Caramaschi, Vaz-Silva & Campos, 2013			1			1	END	NE/LC
Proceratophrys goyana (Miranda-Ribeiro, 1937)*	1	4	1	26		32	END	LC
Phyllomedusidae								
Pithecopus oreades (Brandão, 2002)	38		28		1	67	END	DD/LC
Gymnophiona								
Siphonopidae								
Siphonops paulensis Boettger, 1892*					1	1	WID	LC
Total	359	100	179	111	5	755	34 species	

ed lizard species curves show a slight stabilization trend, and the observed richness (10 species) represented approximately 72% of the estimated richness (Jack1 = 13.78 ± 1.71) (Fig. 6B). On the other hand, observed and estimated snake species curves did not show a stabilization trend, and the observed richness (10 species) represented only 55% of the estimated richness (Jack1 = 18.25 ± 1.44) (Fig. 6C). The greatest richness of reptiles was found in the *campo limpo* and *campo sujo* environments (8 species, each), followed by seasonal semi-deciduous forest (5 spp.) and gallery forest (3 spp.). Twenty reptile species were recorded only by occasional

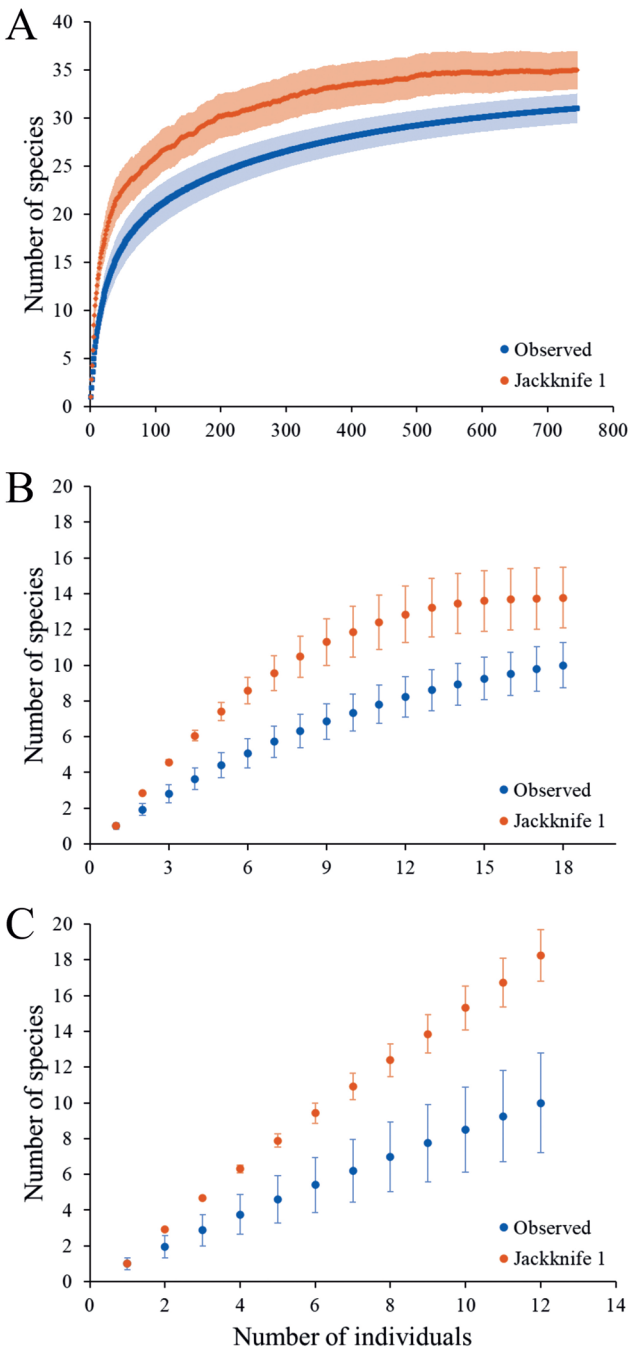

Figure 6. Observed and estimated species accumulation curves for amphibians (A), lizards (B), and snakes (C) recorded in the Serra do Tombador Nature Reserve, state of Goiás, Brazil. The analysis was performed only with records obtained from active surveys and pitfall traps.

encounters and third-party records outside the previously established sites, whereas the other 15 species were obtained through the Management Plan list (Table 3). None of the recorded species are considered threatened.

DISCUSSION

Amphibians

The amphibian richness recorded in the RNST represents 16% of the species known for the Cerrado biome (Valdujo *et al.,* 2012) and 30% of the species found in the state of Goiás, Brazil (Vaz-Silva *et al.,* 2020). Even considering the smallest sample period in this study, the richness of amphibian species was greater or similar to that found in nearby protected areas, such as Estação Ecológica Águas Emendadas (21 species; Brandão & Araújo, 1998), Parque Nacional das Emas (25; Kopp *et al.,* 2010), Área de Proteção Ambiental da Cafuringa (29 species; Brandão *et al.,* 2006), Floresta Nacional de Silvânia (33; Morais *et al.,* 2012) and the Parque Estadual Altamiro de Moura Pacheco (35; Ramalho *et al.,* 2018). Greater species richness was found for the Parque Nacional da Chapada dos Veadeiros (54; Santoro & Brandão, 2014) and Parque Estadual Serra de Caldas Novas (41; Ramalho *et al.,* 2019). Due to the proximity to the Parque Nacional da Chapada dos Veadeiros, it is possible that many species that are found there can also be registered in the RNST in future long-term monitoring studies.

The species *Proceratophrys branti* recorded in this study is not found in any other protected areas of the Cerrado. We must highlight the occurrence of *Allobates goianus* (Bokermann, 1975), which is considered endangered (Ramalho *et al.,* 2020), *Bokermannohyla pseudopseudis* (Miranda-Ribeiro, 1937), which has an uncertain potential distribution, and species with undefined taxonomic status, such as *Dendropsophus* gr. *microcephala* and *Scinax* sp., which may represent new taxa. These species were not identified at a specific level because their morphology was not compatible with other species of the genus. Overall, the most abundant species were those from open environments and that have prolonged reproduction, while most of the rare species registered show explosive reproduction (Vaz-Silva *et al.,* 2020).

Considering the species distribution pattern, we found 16 anurans endemic to the Cerrado biome (Valdujo *et al.,* 2012; Santoro & Brandão, 2014; Azevedo *et al.,* 2016). *Adenomera saci* Carvalho and Giaretta, 2013, *Allobates goianus, L. tapiti, P. oreades,* and *S. rupestris* are species with type locality in the Chapada dos Veadeiros and Serra da Mesa (*P. oreades*), being considered typical of the North region of the state of Goiás. *Leptodactylus tapiti* and *Scinax rupestris,* species highly dependent on rocky environments close to streams, were until then found only in the type-locality at Chapada dos Veadeiros highlands (Brandão & Álvares, 2013; Araújo-Vieira *et al.,* 2015). Thus, the RNST plays an important role in preserving species dependent on specific conditions or the integrity of the environments that make up the Cerrado biome, especially in the northern region of the State of Goiás.

The sampling effort employed was efficient to characterize the local amphibian communities, as can be evidenced by the tendency to stabilize the observed and estimated species accumulation curves. The field activities of this study were carried out during the peak of the breeding season of the Cerrado amphibian species (Guerra *et al.,* 2020), allowing us to obtain a good representation of the species that occur in the RNST. The distribution of species in the richest environments (gallery forests and natural grassland formations) can be

Table 3. Abundance of reptile species recorded in different environments during the herpetofauna survey carried out in November 2016 at the Serra do Tombador Nature Reserve, municipality of Cavalcante, Goiás, Brazil. Abbreviations: OF = Open field (*campo limpo*), CE = Cerrado grassland (*campo sujo*), GF = Gallery forest, SF = Seasonal Semideciduous Forest; AE= Accidental encounter; DIS = Distribution (END = endemic, CE = Cerrado, AF = Atlantic Forest, AM = Amazon, or WID = widely distributed – occurrence in three or more biomes); IUCN = Global threat category; NT = National threat category (Ordinance No. 444); NE = Not evaluated, DD = Data deficient, EN = Endangered, LC = Least concern, NT = Near Threatened. *Asterisks represent species collected in the Management Plan.

TAXA	Vegetation types					AB	DIS	IUCN/NT
	OF	CE	GF	SF	AE			
Testudines								
Chelidae								
Mesoclemmys vanderhaegei (Bour, 1973)*						—	WID	NT/LC
Crocodylia								
Alligatoridae								
Paleosuchus palpebrosus (Cuvier, 1807)					1	1	WID	LC
Squamata								
Amphisbaenidae								
Amphisbaena alba Linnaeus, 1758*					1	1	WID	LC
Amphisbaena fuliginosa Linnaeus, 1758*					1	1	WID	LC
Amphisbaena talisiae Vanzolini, 1995*						—	END	NE/DD
Sauria								
Dactyloidae								
Norops meridionalis Boettger, 1885	1	1				2	WID	LC
Norops brasiliensis Vanzolini & Williams, 1970*						—	WID	LC
Gekkonidae								
Hemidactylus mabouia (Moreau de Jonns, 1818)	1					1	WID	LC
Gymnophthalmidae								
Cercosaura olivacea (Gray, 1845)						—	WID	LC
Colobosaura modesta (Reinhardt & Lütken, 1862)*				2		2	AM, CE	LC
Micrablepharus maximiliani (Reinhardt & Lütken, 1862)*						—	WID	LC
Hoplocercidae								
Hoplocercus spinosus Fitzinger, 1843					1	1	END	LC
Mabuyidae								
Copeoglossum nigropunctatum (Spix, 1825)*	2				1	3	WID	LC
Notomabuya frenata (Cope, 1862)*		1				1	WID	LC
Phyllodactydae								
Gymnodactylus amarali Barbour, 1925*						—	WID	LC
Phyllopezus pollicaris (Spix, 1825)	1					1	WID	LC
Polychrotidae								
Polychrus acutirostris Spix, 1825					1	1	WID	LC
Sphaerodactylidae								
Coleodactylus brachystoma (Amaral, 1935)*						—	END	LC
Teiidae								
Ameiva ameiva (Linnaeus, 1758)*		3				3	WID	LC
Ameivula ocellifera (Spix, 1825)*	1	2				3	WID	LC
Salvator merianae Duméril & Bibron, 1839*					1	1	WID	LC
Tupinambis quadrilineatus Manzani & Abe, 1997*		1				1	END	LC
Tropiduridae								
Tropidurus itambere Rodrigues, 1987*						—	END	LC
Tropidurus oreadicus (Rodrigues, 1987)*	1	1				2	AM, CE	LC
Tropidurus torquatus (Wied, 1820)*						—	AF, CE	LC
Serpentes								
Boidae								
Boa constrictor (Stull, 1932)*					1	1	WID	LC
Eunectes murinus (Linnaeus, 1758)					1	1	WID	LC
Epicrates crassus Cope, 1862					1	1	END	LC
Colubridae								
Spilotes pullatus (Linnaeus, 1758)					1	1	WID	LC
Dipsadidae								
Apostolepis sanctaeritae Werner, 1924*					1	1	END	LC
Atractus albuquerquei Da Cunha & Do Nascimento, 1983					1	1	END	LC
Atractus pantostictus Fernandes & Puorto, 1993		1				1	END	LC

TAXA	Vegetation types					AB	DIS	IUCN/NT
	OF	CE	GF	SF	AE			
Chironius flavolineatus Jan, 1863*						—	END	LC
Drymarchon corais (Boie, 1827)*						—	WID	LC
Erythrolamprus poecilogyrus (Wied-Neuwied, 1824)					1	1	—	—
Erythrolamprus macrosomus (Amaral, 1936)*					1	1	WID	LC
Imantodes cenchoa (Linnaeus, 1758)				1		1	WID	LC
Leptodeira annulata (Linnaeus, 1758)*				1	1	2	WID	LC
Oxybelis aeneus (Wagler, 1824)*						—	WID	LC
Oxyrhopus petolarius (Linnaeus, 1758)	1					1	WID	LC
Oxyrhopus trigeminus Duméril, Bibron & Duméril, 1854					1	1	WID	LC
Philodryas nattereri Steindachner, 1870*					1	1	WID	LC
Philodryas olfersii (Liechtenstein, 1823)		1			1	2	WID	LC
Phimophis guerini (Duméril, Bibron & Duméril, 1854)*			1			1	WID	LC
Dipsas mikanii (Schlegel, 1837)			1			1	WID	LC
Tantilla melanocephala (Linnaeus, 1758)*						—	AM, CE	LC
Thamnodynastes cf. *hypoconia*					1	1	—	—
Xenodon merremii (Wagler, 1824)					1	1	WID	LC
Xenopholis undulatus (Jensen, 1900)					1	1	END	LC
Leptotyphlopidae								
Trilepida fuliginosa (Passos, Caramaschi & Pinto, 2006)*						—	END	LC
Trilepida koppesi (Amaral, 1955)	1					1	END	LC
Typhopidae								
Amerotyphlops brongersmianus (Vanzolini, 1976)				1		1	WID	LC
Viperidae								
Bothrops marmoratus Da Silva & Rodrigues, 2008*						—	END	LC
Bothrops moojeni Hoge, 1966			1	2	1	4	END	LC
Crotalus durissus Amaral, 1926					1	1	WID	LC
Total	9	11	3	7	24	54	55 species	

explained by the availability of aquatic environments for reproduction, such as streams and ponds in gallery forests, *veredas,* and other marshy environments of natural grasslands at the Cerrado biome. It is important to highlight that in addition to the 14 species previously recorded in the Management Plan, our study added another twenty species to the studied area.

Reptiles

The recorded reptile richness represents 20% of the species present in the Cerrado (Nogueira *et al.,* 2011). The richness is greater than that known for other nearby protected areas, such as the Estação Ecológica de Águas Emendadas (51; Brandão & Araújo, 1998; Colli & Brandão, 2008), Área de Proteção Ambiental Cafuringa (47; Brandão *et al.,* 2006), and the Parque Estadual da Serra de Caldas Novas (30 species; Ramalho *et al.,* 2019). Only the nearby protected area Reserva Ecológica do IBGE (63 species; Colli *et al.,* 2011) presented a great number of species in relation to the RNST. Even considering only the 40 species sampled during our field activities, nearby areas that have been monitored for longer periods have fewer species richness, such as the Floresta Nacional de Silvânia (30; Morais *et al.,* 2012). It is important to consider that the Floresta Nacional de Silvânia has a smaller area and less habitat heterogeneous in relation to RNST, therefore, it is expected to present a smaller number of species.

Concerning the other Cerrado protected areas, the species *Amphisbaena fuliginosa* Linnaeus, 1758, *Bothrops marmoratus* Da Silva & Rodrigues, 2008, *Coleodactylus brachystoma* (Amaral, 1935) and *Xenopholis undulatus* (Jensen, 1900) were only registered in the RNST. Other species such as *Apostolepis sanctaeritae* Werner, 1924, *Atractus albuquerquei* Da Cunha & Do Nascimento, 1983, *Gymnodactylus amarali* Barbour, 1925, and *Tupinambis quadrilineatus* Manzani & Abe, 1997 were recorded in the RNST and another location in the Cerrado (Recoder & Nogueira, 2007; Santos *et al.,* 2008; Valdujo *et al.,* 2009). Although most species are classified as non-threatened (Least Concern in IUCN assessment), many reptiles still lack information on ecology and natural history, preventing researchers from indicating well-founded threat categories. In addition, five reptile species are listed in Appendix II of the CITES list (CITES, 2014): *Boa constrictor* (Stull, 1932), *Eunectes murinus* (Linnaeus, 1758), *Epicrates crassus* Cope, 1862, *Salvator merianae* Duméril & Bibron, 1839, and *Tupinambis quadrilineatus* Manzani & Abe, 1997. These species represent neotropical reptiles that are targets of the trade and illegal trafficking of their products or by-products.

The most abundant species were the most generalists, including *Bothrops moojeni, Ameiva ameiva, Ameivula ocellifera,* and *Copeoglossum nigropunctatum. Bothrops moojeni,* commonly known as *jararaca, jararacuçu,* or *caiçaca,* is a common snake in riparian environments of the Cerrado, being easily found even in altered environments (Nogueira *et al.,* 2003). The other most abundant species are more resilient lizards, numerous locally, less cryptic, and that actively foraging during the day (Ramalho *et al.,* 2014). Fifteen endemic reptile

Figure 7. Reptile species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Paleosuchus palpebrosus,* (B) *Amphisbaena fuliginosa,* (C) *Boa constrictor,* (D) *Epicrates crassus,* (E) *Apostolepis sanctaeritae,* (F) *Atractus albuquerquei,* (G) *A. pantostictus,* (H) *Erythrolamprus poecilogyrus.*

Figure 8. Reptile species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Imantodes cenchoa,* (B) *Leptodeira annulata,* (C) *Oxyrhopus petolarius,* (D) *O. trigeminus,* (E) *Philodryas olfersii,* (F) *Phimophis guerini,* (G) *Dipsas mikanii,* (H) *Xenodon merremii.*

Figure 9. Reptile species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Xenopholis undulatus,* (B) *Trilepida koppesi,* (C) *Crotalus durissus,* (D) *Norops meridionalis,* (E) *Hemidactylus mabouia,* (F) *Colobosaura modesta,* (G) *Hoplocercus spinosus,* (H) *Copeoglossum nigropunctatum.*

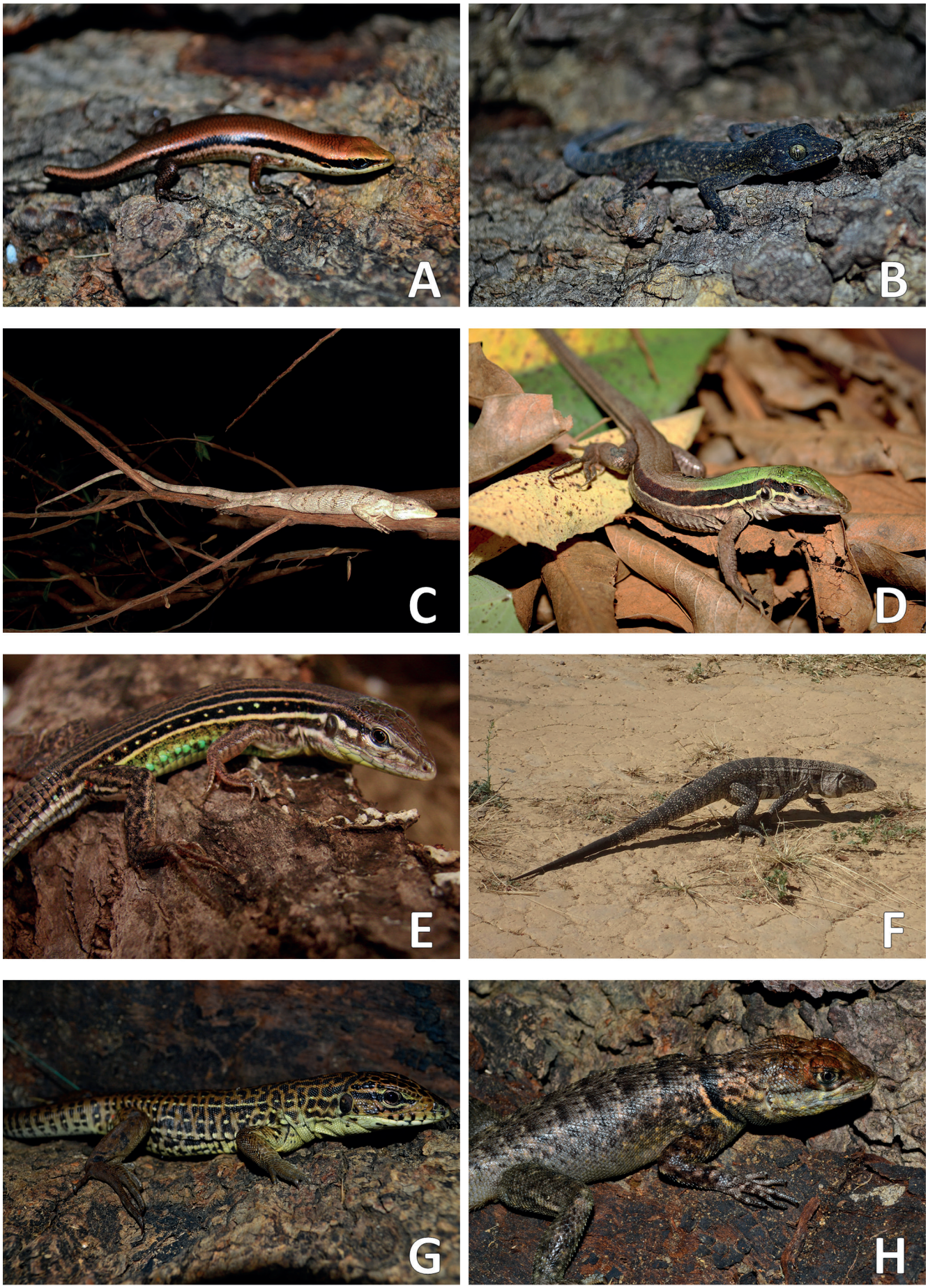

Figure 10. Reptile species recorded in Serra do Tombador Nature Reserve, state of Goiás, Brazil: (A) *Notomabuya frenata,* (B) *Phyllopezus pollicaris,* (C) *Polychrus acutirostris,* (D) *Ameiva ameiva,* (E) *Ameivula ocellifera,* (F) *Salvator merianae,* (G) *Tupinambis quadrilineatus,* (H) *Tropidurus oreadicus.*

species were recorded, highlighting again the ecological relevance of RNST for the protection of the Cerrado biodiversity.

The sampling effort employed was not sufficient to record all reptile species of the RNST, as evidenced by the ascendancy of the observed and estimated species accumulation curves. This indicates that new species of reptiles may still be registered in future studies in the area. This pattern is commonly found in studies of reptile checklists (Ramalho *et al.,* 2014; Santos *et al.,* 2014), even those using longer monitoring periods (Morais *et al.,* 2012). Many reptiles such as snakes and some lizards have fossorial habits, discrete behaviors, and cryptic coloring patterns, which often hinder visual encounters, affecting their detectability (Ramalho *et al.,* 2019). We must highlight that the sum of the species sampled during the field activities of this study with those recorded in the Management Plan allowed a great increase in the total richness of the RNST. Long-term studies, adding greater sample intensity, as well as the use of third-party data (for example, photos and record videos eventually taken by local people) are good methods for improving knowledge about the reptile species. Based on this, we suggest that RNST staff implement a Citizen Science program aiming to contribute to the knowledge of local biodiversity (see Price & Dorcas, 2011), especially for the record of hard-to-find species, such as snakes and amphisbaenians. These data, eventually gathered by local staff, researchers, tourists, and visitors can improve the information of local animals by providing data, images, and location of record for posterior id validation. These records should be stored by local managers.

As found in other studies, open environments in the Cerrado have greater species diversity than forest areas (Brandão & Araújo, 2002; Brasileiro *et al.,* 2005; Nogueira *et al.,* 2005; Ramalho *et al.,* 2019). The horizontal stratification of the open habitats of the Cerrado allows the coexistence of species that explore different microhabitats, favoring a high reptile richness (Colli *et al.,* 2002; Nogueira *et al.,* 2009). Nevertheless, differences in richness can also be attributed to intrinsic factors of each area, such as the availability of resources, the occurrence of local disturbs, and environmental heterogeneity (Nogueira *et al.,* 2009).

Information about species composition is recognized as one of the main factors for choosing strategic areas for conservation. The presence of species with restricted endemism, recently described and data deficient in RNST, highlights the importance of inventorying areas of ecological relevance to remedy the lack of knowledge about the taxonomy and distribution (Linnean and Wallacean shortfalls) of amphibians and reptiles in the Cerrado. Furthermore, the irreplaceability of narrowly endemic species as highlighted in our updated checklist supports and reinforces the importance of RNST as one of the main protected areas for herpetofauna conservation in the Cerrado biome.

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