Acta Herpetologica 12(2): 157-165, 2017
DOI: 10.13128/Acta_Herpetol-18179

Species composition and richness of anurans in Cerrado urban forests from central Brazil

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Submitted on: 2016, 21st April; revised on: 2017, 15th April; accepted on: 2017, 25th May
Editor: Gentile Francesco Ficetola

Abstract. Brazil harbors the greatest diversity of amphibians on the planet although there are few studies dealing with urban fauna. The objective of this study is to describe the species composition and richness of anurans in urban Cerrado fragments from Campo Grande municipality, Mato Grosso do Sul state, central Brazil. The specimens were sampled in three stages through pitfall traps and visual/acoustic surveys. Seventeen species were recorded (17.7% of anuran species registered in Mato Grosso do Sul), with Leptodactylidae and Hylidae being the most represented families. The existence of a high number of green areas and water bodies in the urban area likely favors anuran species in the region. The anuran communities in urban areas of Campo Grande were dominated by species which use a broad range of habitats. In this study there was the record of a new species of anuran, *Proceratophrys dibernardoi*, for the state of Mato Grosso do Sul. The forest fragments that had the highest similarity for species composition were those with similar environmental conditions. The knowledge of the fauna that occurs in urban areas is important because natural habitats suffer severe fragmentation and degradation and species present in these areas may disappear in a shorter period of time.

Keywords. Anuran, city, urbanization, Cerrado, habitat fragmentation.

INTRODUCTION

There are approximately 7,600 amphibian species in the world (Frost, 2017), most of them occurring in tropical regions where natural landscapes have been altered by human activities (Ellis and Ramankutty, 2008). Brazil has 1,080 amphibian species (Segalla et al., 2016) and at least 209 are recorded for the Cerrado and adjoining biomes (Valdujo et al., 2012). The Cerrado is a biodiversity hotspot being currently affected by landscape changes (Soares-Filho et al., 2014) and so conservation strategies must be viewed as a priority (Overbeck et al., 2015). Threats to the Cerrado domain and associated biodiversity include land conversion for agriculture and pasture as well as urban expansion (Klink and Machado, 2005), which in turn can result in the isolation and reduction of the population size of several species and cause local extinctions.

Amphibians are amongst the most endangered vertebrate groups in the world (Stuart et al., 2004; Hamer and McDonnell, 2008; Verdade et al., 2010). Some factors that affect amphibian populations are habitat destruction, introduced species, climate change, UV-B radiation, pollution and disease (Young et al., 2001; Verdade et al., 2010).

ISSN 1827-9635 (print)
ISSN 1827-9643 (online)

Urbanization causes habitat fragmentation, loss, isolation and degradation (Hamer and McDonnell, 2008) and associated biotic and abiotic habitat changes (Aronson et al., 2014), being a process that promotes profound changes in the environment. Many amphibian species are threatened by the expansion of urban areas (Hamer and McDonnell, 2008). In urban habitats the major factors impacting amphibians are changes in natural vegetation and hydrological courses (Hamer and McDonnell, 2008), aquatic and terrestrial pollution (Paul and Meyer, 2001; Croteau et al., 2008), predation by domestic animals (Woods et al., 2003), roadkills (Andrews et al., 2008), and diseases (Croteau et al., 2008).

Urban development may change the species composition and decrease the richness and diversity of amphibians (Rubbo and Kiesecker, 2005; Hamer and McDonnell, 2008; McKinney, 2008; Hamer and McDonnell, 2010). Many species recorded in the urban environment use multiple types of habitat, being habitat generalists (Hamer and McDonnell, 2008). However several species with specific habitat requirements, still poorly known to science or endangered are also recorded in this type of environment (Grandinetti and Jacobi, 2005; Knispel and Barros, 2009; Ferreira et al., 2010; Silva et al., 2011; Pereira et al., 2013).

At least 84% of the population within Brazil resides within urban areas (IBGE, 2015) and the state of Mato Grosso do Sul (central Brazil) has one of the highest urbanization rates in the country (Almeida, 2009). In Mato Grosso do Sul the predominant Cerrado vegetation with its distinct physiognomies such as palm swamps (*veredas*), gallery forests, wet campos, and closed woodlands harbors 97 amphibian species (Souza et al., in press). Despite this considerable richness, there are few studies on urban species in this region (Ávila and Ferreira, 2004). The objectives of this study were to describe

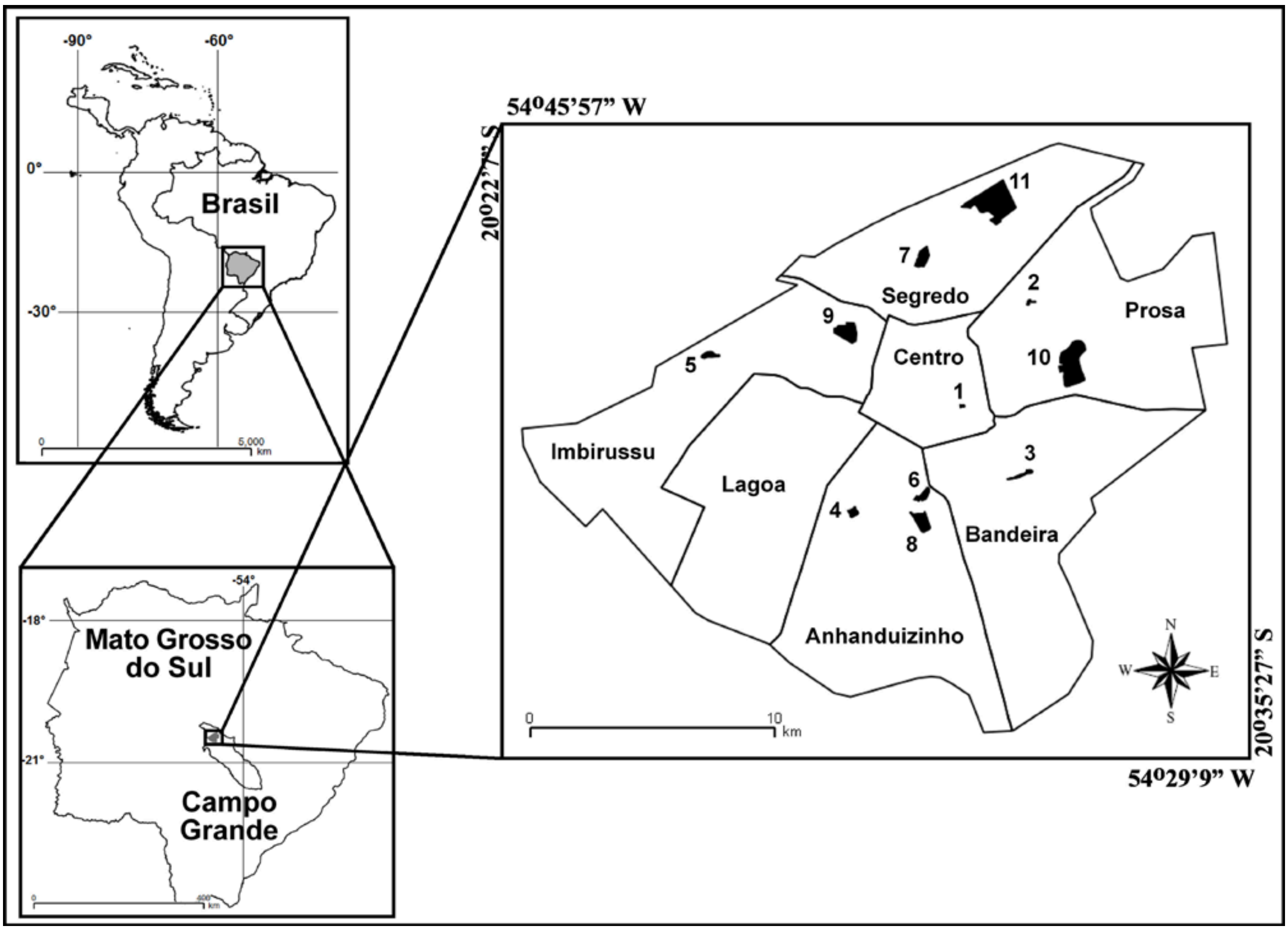

Fig. 1. Localization of the 11 urban Cerrado fragments in Campo Grande municipality, Mato Grosso do Sul state, central Brazil. 1. Itanhangá Square (IS); 2. Sóter Ecological Park (SEP); 3. Coqueiral Farm (CF); 4. Anhanduí Ecological Park (AEP); 5. Imbirussu Environmental Education Center (IEEC); 6. Mato Grosso do Sul Federal University Fish Center (UFMSF); 7. Dom Bosco University (DBU); 8. Mato Grosso do Sul Federal University Cerrado (UFMSC); 9. Military College (MC); 10. Prosa State Park (PSP); 11. Matas do Segredo State Park (MSSP).

the species composition and richness of anurans in urban Cerrado fragments from Campo Grande municipality, Mato Grosso do Sul state, central Brazil.

MATERIAL AND METHODS

Study site

Campo Grande municipality has 840,000 habitants living in an area of 8,100 km^2. The altitude is 532 m a.s.l. and climate is characterized by a dry (April to September) and wet period (October to March). Mean annual rainfall is 1,530 mm and mean annual temperature ranges between 18 and 28.8 ºC. Around 21% of the area exhibits native Cerrado vegetation while the remainder is covered by pastures, agricultural fields and developed areas (PLANURB, 2015). The urban perimeter of Campo Grande has an area of 154.4 km^2 and a population density of 104 inhabitants/km^2. The city has 28 headsprings and 18 green areas (parks and protected areas) covering about 864 hectares (PLANURB, 2015).

Eleven urban forest fragments with size ranging from 1.8 to 170.2 ha were selected for this study (Fig. 1): Itanhangá Square (IS; 1.8 ha), Sóter Ecological Park (SEP; 3.4 ha), Coqueiral Farm (CF; 10 ha), Anhanduí Ecological Park (AEP; 10.8 ha), Imbirussu Environmental Education Center (IEEC; 13.2 ha), Mato Grosso do Sul Federal University Fish Center (UFMSF; 15.4 ha), Dom Bosco University (DBU; 28.8 ha), Mato Grosso do Sul Federal University Cerrado (UFMSC; 35.2 ha), Military College (MC; 48.6 ha), Prosa State Park (PSP; 128 ha), and Matas do Segredo State Park (MSSP; 170.2 ha). There are bodies of water in all forest fragments, except: DBU, UFMSC and MC.

Data collection

Anurans were sampled in three stages - from November 2012 to March 2013, November 2013 to April 2014, and November 2014. Sampling methodology included pitfall traps and visual/acoustic surveys (Heyer et al., 1994). Active sampling was made independent of the pitfall trap sampling. The pitfall traps were used in all periods of the study, while visual/ acoustic surveys were used during the second and third stage. Each pitfall trap line consisted of four 30 l plastic buckets connected by 50 cm height drift-fences. The number of lines varied from one to two according to fragment size (areas larger than 20 ha had two lines). Pitfall traps were kept opened during four consecutive days by month in the first stage of the study and seven consecutive days by month from the second and third stage (to increase the sampling effort), and checked every 48 hours.

Visual/acoustic surveys were realized at night in one 30 x 30 m quadrat in each fragment. In forest fragments with water bodies, the active sampling was conducted in the wet areas or in their vicinity. In each forest fragment five nights of sampling were conducted, once a month (totaling five months of sampling), except in UFMSC and DBU where we made three and four nights of sampling, once a month, respectively. Visual/ acoustic surveys had an average duration of two hours, starting at dusk (18:30 h).

Voucher specimens were deposited at the Coleção Zoológica de Referência of the Universidade Federal de Mato Grosso do Sul (ZUFMS, Campo Grande, Mato Grosso do Sul state). Nomenclature followed Frost (2017).

Data analysis

To evaluate the sampling effort, we used a species accumulation curve based on the samples, often known as Mao Tau estimate (Chiarucci et al., 2008; Colwell et al., 2012). These data were analysed with a presence-absence matrix, with taxa in rows and samples in columns; Mao Tau estimate is suitable when a number of samples are available (Hammer et al., 2001). Each forest fragment was considered a sampling unit and the sufficiency in sampling was considered when the slope of the curve approached zero.

To estimate the similarity in anuran species composition among forest fragments sampled we used a cluster analysis (UPGMA) based on a similarity matrix constructed with the Sørensen index for the community. For this analysis, only presence and absence data of species on each site were used to be able to concatenate presence of species from the different methods used. It was also used the k-means algorithm to create several partitions forming a cascade from 2 to 6 groups. Calinski criteria (Calinski-Harabasz, 1974) was used to determine the optimum number of groups for the k-means. The groups assigned to each local were then used to determine the indicator value (Dufrene and Legendre, 1997) of each species to evaluate its importance in determining the local group.

All analyses were performed with R (R Core Team, 2016), using vegan (Oksanen et al., 2016) and indicspecies (De Caceres and Legendre, 2009) packages.

RESULTS

Seventeen anuran species from four families were recorded (Table 1). Leptodactylidae was the richest family (11 species), followed by Hylidae (four species) and Bufonidae and Odontophrynidae (one species each). *Dendropsophus nanus*, *Hypsiboas punctatus*, *Hypsiboas raniceps* and *Leptodactylus syphax* were sampled exclusively by visual/acoustic search while *Leptodactylus* cf. *elenae* and *Physalaemus nattereri* were sampled only by pitfall traps. Richness among sites ranged from one to 10 (Table 1).

Cumulative species curve reached the asymptote with eleven samples (Fig. 2), with an expected total richness of 17. Based on the Calinski criteria two major groups for the sampled locals (Fig. 3) were observed, with the group IS and SEP more similar (75%), followed by PSP and MSSP (67%) and AEP, CF, UFMSF, palm swamps areas, with 57% or more of similarity (Table 2). *Hypsiboas punctatus* and *Leptodactylus podicipinus* had the higher indi-

Table 1. Anuran species recorded at 11 Cerrado urban fragments in Campo Grande municipality, Mato Grosso do Sul state, central Brazil. See text for site abbreviation.

Species/Family	Sites										
	IS	SEP	CF	AEP	IEEC	UFMSF	DBU	UFMSC	MC	PSP	MSSP
Bufonidae											
Rhinella schneideri (Werner, 1894)	x	x	x	x	x	x				x	x
Hylidae											
Dendropsophus nanus (Bounlenger, 1889)				x	x	x				x	
Hypsiboas punctatus (Schneider, 1799)			x	x	x	x					x
Hypsiboas raniceps Cope, 1862					x	x					
Scinax fuscovarius (Lutz, 1925)						x				x	x
Leptodactylidae											
Adenomera diptyx (Boettger, 1885)	x		x	x	x	x		x		x	x
Leptodactylus cf. *elenae* Heyer, 1978							x				
Leptodactylus fuscus (Schneider, 1799)				x							x
Leptodactylus labyrinthicus (Spix, 1824)	x	x		x							
Leptodactylus mystacinus (Burmeister, 1861)							x		x	x	x
Leptodactylus podicipinus (Cope, 1862)				x		x				x	x
Leptodactylus syphax Bokermann, 1969	x	x		x							
Physalaemus albonotatus (Steindachner, 1864)			x	x		x				x	
Physalaemus centralis Bokermann, 1962							x			x	
Physalaemus cuvieri Fitzinger, 1826		x		x	x						
Physalaemus nattereri (Steindachner, 1863)					x				x	x	
Odontophrynidae											
Proceratophrys dibernardoi Brandão, Caramaschi, Vaz-Silva and Campos, 2013									x	x	x
Richness	4	4	4	10	7	8	3	1	3	10	8

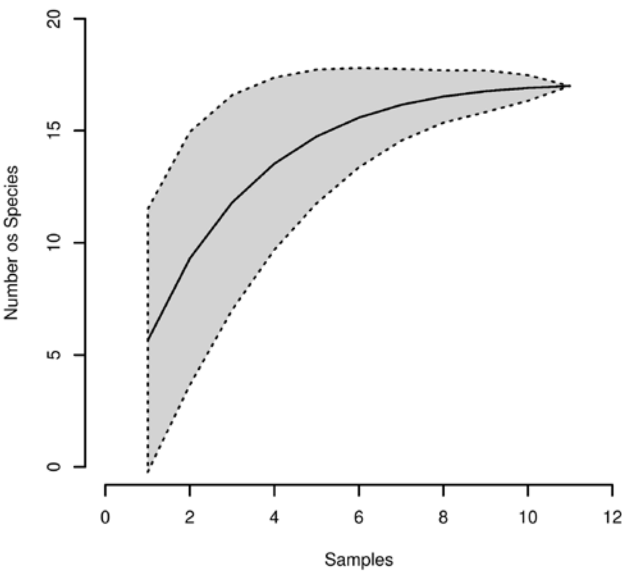

Fig. 2. Cumulative species curve (solid line) for 11 Cerrado urban fragments in Campo Grande municipality, Mato Grosso do Sul state, central Brazil. Gray space represents 95% confidence intervals.

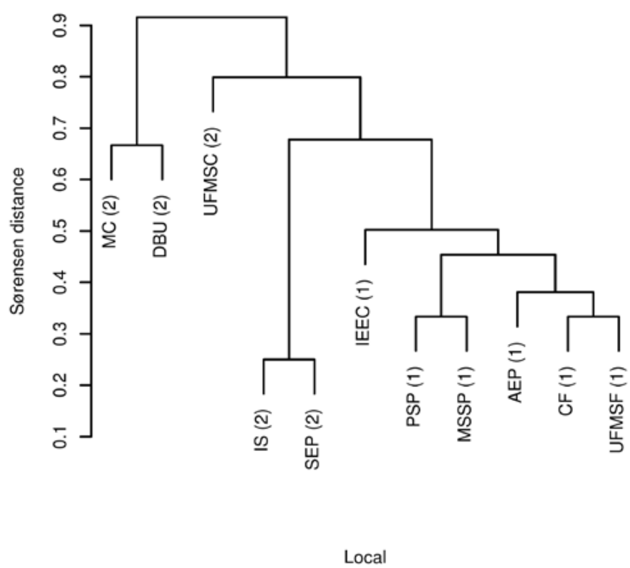

Fig. 3. Similarity cluster analysis (UPGMA) with the Sørensen index for 11 Cerrado urban fragments in Campo Grande municipality, Mato Grosso do Sul state, central Brazil. See text for abbreviations.

Table 2. Similarity values of Sørensen index between 11 Cerrado urban fragments in Campo Grande municipality, Mato Grosso do Sul state, central Brazil.

	UFMSC	CF	MC	IEEC	IS	AEP	UFMSF	PSP	MSSP	SEP
CF	0.40									
MC	0.00	0.00								
IEEC	0.00	0.36	0.20							
IS	0.40	0.50	0.00	0.18						
AEP	0.18	0.57	0.00	0.59	0.57					
UFMSF	0.22	0.67	0.00	0.67	0.33	0.67				
PSP	0.18	0.43	0.46	0.47	0.29	0.50	0.67			
MSSP	0.22	0.50	0.36	0.40	0.33	0.56	0.62	0.67		
SEP	0.00	0.25	0.00	0.36	0.75	0.57	0.17	0.14	0.17	
DBU	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.31	0.18	0.00

Table 3. Group to which each species was classified, followed by the indicator value for the group 1 (CF, IEEC, AEP, UFMSF, PSP and MSSP) and group 2 (UFMSC, MC, IS, SEP and DBU) and the respective significance for use as an indicator species.

	Group	IV for group 1	IV for group 2	P
Adenomera diptyx	1	0.563	0.130	0.224
Dendropsophus nanus	1	0.667	0.000	0.055
Eupemphix nattereri	1	0.208	0.075	1.000
Hypsiboas punctatus	1	0.833	0.000	0.016
Hypsiboas raniceps	1	0.333	0.000	0.452
Leptodactylus cf. *elenae*	2	0.000	0.200	0.467
Leptodactylus fuscus	1	0.333	0.000	0.460
Leptodactylus labyrinthicus	2	0.049	0.282	0.562
Leptodactylus mystacinus	2	0.152	0.218	1.000
Leptodactylus podicipinus	1	0.833	0.000	0.015
Leptodactylus syphax	2	0.049	0.282	0.529
Physalaemus albonotatus	1	0.667	0.000	0.054
Physalaemus centralis	2	0.076	0.109	1.000
Physalaemus cuvieri	1	0.208	0.075	1.000
Proceratophrys dibernardoi	1	0.208	0.075	1.000
Rhinella schneideri	1	0.714	0.114	0.047
Scinax fuscovarius	1	0.500	0.000	0.175

cator values for group 1, while no species were distinctiveness for group 2 (Table 3).

DISCUSSION

Seventeen species of anurans were recorded in the urban area of Campo Grande, representing 17.7% of the species reported for Mato Grosso do Sul state. The existence of a high number of green areas and water bodies in the urban environment can favor anuran species in the region. Most species detected in Campo Grande are able to tolerate environments altered by anthropogenic factors. Some of the species observed are endemic to the Cerrado and a new species (*P. dibernardoi*) was recorded in the state. Forest fragments with similar environmental conditions have similar anuran composition.

The predominance of Leptodactylidae and Hylidae species is an expected result because of the large number of species of these families in the Neotropics (Duellman, 1988), also configuring the most specious families in Brazil (Segalla et al., 2016). On the other hand, the few species recorded for Bufonidae and Odontophrynidae in the present study can reflect the low diversity of these taxa in Cerrado areas (Valdujo et al., 2012).

Although none of the species recorded in this study was assigned to any threat status category (ICMbio, 2014), some points must be considered. The recently described *Proceratophrys dibernardoi* (Brandão et al., 2013) represents a new species record for Mato Grosso do Sul state and was found at least in three sampled urban areas. Furthermore, *Physalaemus centralis*, *P. nattereri* e *P. dibernardoi* are typical Cerrado species (Valdujo et al., 2012; Brandão et al., 2013). As a biodiversity hotspot (Myers et al., 2000), the Cerrado is suffering from intensive landscape changes resulting from land use (Ratter et al., 1997) which requires ongoing research on management, conservation and urban planning (Soares-Filho et al., 2014; Overbeck et al., 2015).

Most (70.6%) of the anuran urban species found in Campo Grande municipality utilize a broad range of habitats and are found in anthropogenic environments, such as *Dendropsophus nanus* (Reichle et al., 2004). Anurans from urban areas are mainly represented by habitat generalist species (Hamer and McDonnell, 2008; Ferreira et al., 2010; Zocca et al., 2014) such as *Scinax fuscovarius* (Aquino et al., 2010), common species in the urban environment (Ávila and Ferreira, 2004; Grandinetti and Jacobi, 2005; Rodrigues et al., 2008; Torres, 2012; Pereira et al., 2013). Species that live in urban areas also have high fertility (Hamer and McDonnell, 2010), and reproduce in degraded aquatic environments (Lane and Burgin, 2008). *Rhinella schneideri*, for example, a species present in urban areas of Brazil (Ávila and Ferreira, 2004; Shibatta et al., 2009; Corrêa et al., 2014), uses a broad variety of habitats (Aquino et al., 2004), females produce more than 5.000 eggs (Uetanabaro et al., 2008) and individuals of this species were found in forest fragments in Campo Grande whose water bodies are contaminated by sewage and garbage.

Despite the predominance of habitat generalists in urban systems, species habitat specialists are also recorded (Ferreira et al., 2010) and species still little known to science (Santana et al., 2008). New anuran species are being discovered in the urban environment (Santana et al., 2012; Feinberg et al., 2014). This means that cities can harbor a considerable biological community that provides interesting appeal for management and environmental education programs (Feinberg et al., 2014). The species *Physalaemus centralis* and *P. nattereri* are more sensitive to anthropogenic habitat disturbances (Aquino et al., 2004; Colli et al., 2004) than others species recorded in this study; maybe for this reason there were low numbers recorded in the urban area (Melo et al., 2007; present study). *Proceratophrys dibernardoi* is a species with few biological data available because it was recently discovered (Brandão et al., 2013).

The forest fragments with high similarity among species were those that presented similar environmental conditions, such as types of vegetation and levels of anthropogenic impact. Itanhangá Square and SEP have the highest similarity between species. They are smaller fragments and are much modified by human activities. The two green areas are surrounded by built-up areas and suffer great pressure of the surroundings. Matas do Segredo State Park and PSP are the largest fragments present in the urban area of Campo Grande and also the best preserved ones. The MSSP and PSP harbor headsprings and have similar Cerrado physiognomies (Imasul, 2009, 2011). The PSP is surrounded by roads and other human constructions, whereas the MSSP has part of its area facing rural area. The palm swamps of AEP, CF and UFMSF have a small area and suffer great anthropogenic surrounding pressures. Anhanduí Ecological Park is a palm swamp in regeneration and the entire fragment is surrounded by roadways and is affected by sporadic fires. Coqueiral Farm is a small privately owned area and harbor Bandeira's headspring. The site is completely surrounded by roads and is impacted with urban development in its vicinity. Mato Grosso do Sul Federal University Fish Center has a lot of garbage and the Cabaça stream is polluted by sewage (SEMADUR, 2015). The fragment is completely surrounded by human constructions.

The knowledge of urban biodiversity is important since forest fragments in cities suffer high ecological impacts mainly associated to border effect with direct consequence for forest and litter dwelling species. Long-term and multidisciplinary studies are required to understand the dynamic connections between environmental and socioeconomic processes in the cities (Tanner et al., 2014), resulting in important tools for conservation and management programs for urban ecosystems.

Preserving green areas inside an urban matrix is important for biodiversity protection (Cornelis and Hermy, 2004). For anurans, urban forest fragments are extremely important sites since they represent areas for shelter, feeding, dispersion and reproduction (Becker et al., 2008; Hamer and MacDonnell, 2008; Sabbag and Zina, 2011). In this way, some actions for conserving anurans in urban areas should include green areas restoration and management, including connecting corridors to facilitate the possibility of species dispersal.

ACKNOWLEDGMENTS

We thank Instituto de Meio Ambiente de Mato Grosso do Sul for authorization to carry out this study in state conservation units; Secretaria Municipal de Meio Ambiente e Desenvolvimento Urbano for authorizing this study in parks and other green areas of the city. We thank commanders of the Military College (colonels Gil de Melo Rolim and Ricardo Guilherme Ribeiro de Almeida), Hemerson Pistori and the owner of the Coqueiral Farm by authorizations for the collection respectively at the MC, the DBU and CF. We thank the Diego Santana, Jose Luiz Massao, Liliane Piatti and Vanda Lucia Ferreira for helping us with species identification; Jeffrey Himmelstein for reviewing the English. We thank CNPq for project financing, CAPES for the scholarship granted to author Cláudia Márcia Marily Ferreira and ICMBio/ SISBIO by the authorization (Nº. 10379) to collect and transport the animals. Franco Leandro de Souza receives grant from CNPq (303006/2014-5).

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