Oecologia Australis
23(4):1027-1052, 2019
https://doi.org/10.4257/oeco.2019.2304.25

ANURAN SPECIES COMPOSITION FROM CHACO AND CERRADO AREAS IN CENTRAL BRAZIL

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Abstract: Herein, we present an updated inventory and the variations of frog communities' composition from five areas of humid Chaco and Cerrado in municipality of Porto Murtinho, Mato Grosso do Sul state, Brazil. This municipality is located in an area with three ecoregions: Chaco, Cerrado and Pantanal. Through acoustic and visual nocturnal/diurnal and pitfall evaluations from a period of over five years, we recorded 31 species in the Cerrado and 29 species in the humid Chaco. About 90% of the species were previously registered in the municipality of Porto Murtinho. A non-metric multidimensional analysis based on a presence/absence matrix revealed a separation in our sampling sites and communities with Cerrado and humid Chaco characteristics. This peculiarity in the species composition must be related to the transition zone, with the presence of mixed species characteristics of Cerrado and humid Chaco in both areas in the municipality of Porto Murtinho experiences a high degree of deforestation pressure, which threatens both the Cerrado and humid Chaco vegetation. This highlights the importance of knowledge actions about the richness and composition of species, corroborating ecological tools to support conservation in this region.

Keywords: Amphibia; Porto Murtinho; species inventory; transition zone.

INTRODUCTION

Species inventories are an important starting point for biology as these records help us understand patterns and processes of biodiversity dynamics (Hortal *et al.* 2015). These catalogues of species diversity can also indicate knowledge gaps and provide relevant data for conservation plans, as well as identify priorities (Stohlgren *et al.* 1995). Despite the request for global efforts to obtain information about biodiversity (CBD Secretariat 1992), the heterogeneous distribution of sampling efforts for many taxonomic groups emphasizes the need to conduct and update local inventories, especially for threatened taxa (Uetanabaro *et al.* 2007, Jenkins *et al.* 2015, Gutiérrez & Marinho-Filnho 2017). Even so, studies have been discussed the problem that many areas of the world have been poorly sampled regarding most taxa, generating inadequate information about species distributions at global, regional, and local levels (Wallacean shortfall), and they highlight that this diversity still needs to

be adequately described and cataloged (Linnean shortfall) (Whittaker *et al.* 2005, Hortal *et al.* 2015).

In Brazil, the Cerrado, Chaco and Caatinga are part of the so-called dry diagonal of vegetal formations (Prado & Gibbs 1993, Neves *et al.* 2015). These formations present seasonally dry periods, adapted vegetation and complex distribution, yet few studies have been done related to their biodiversity and conservation (Oliveira-Filho *et al.* 2006). At a regional level, information and conservation actions are needed in areas of Cerrado and Chaco, which has repeatedly been stressed (Banda-R *et al.* 2016, Roque *et al.* 2016) The Chaco presents high conservation priority due to its peculiar fauna and flora (Dinerstein *et al.* 1995), while the Cerrado is one of the 35 worldwide biodiversity hotspots (Mittermeier *et al.* 2011). The high level of land-to-agriculture conversion and the poor status of land protection are the main problems that these domains face (Silva *et al.* 2006).

Research about the ecology of anuran communities in these formations has increased knowledge about species distribution in different localities (*e.g.*, Maffei *et al.* 2011, Santos *et al.* 2011, Gambale *et al.* 2014, Pereira *et al.* 2016). The order Anura is a threatened vertebrate group in the worldwide (Storfer 2003, Stuart 2004, Whiles *et al.* 2006), mainly due to habitat loss (Becker *et al.* 2007, Becker & Zamudio 2011). Brazil has about 1,039 anuran species (Segalla *et al.* 2016) with knowledge gaps for the southwestern Mato Grosso do Sul state (Souza *et al.* 2017).

In this study, we present a survey about the anuran composition in Chaco and Cerrado formations in the southeast region of Porto Murtinho, a municipality located in a Chaco, Cerrado and Pantanal transition zone of Mato Grosso do Sul, Brazil (*e.g.*, Souza *et al.* 2010, Benites *et al.* 2017, Dinerstein *et al.* 2017). We updated the species list from this municipality and compared the species composition of our sampling sites to studies carried out in nearby areas, aiming to understand how the anuran communities vary in transitions zones of these ecoregions. In addition, keeping in mind the high anthropic pressure in the vegetation environments in the municipality, we demonstrate the conservation status of the anuran species inventoried in this study.

MATERIAL AND METHODS

Study area

This study was conducted at five sites located in the municipality of Porto Murtinho, State of Mato Grosso do Sul, Brazil. Three locations presented Cerrado ecoregion vegetation characteristics and two locations presented humid Chaco ecoregion vegetation characteristics, following (Dinerstein *et al.* 2017) (Table 1; Figure 1). The municipality of Porto Murtinho presents large territorial extension (17744.4 km²; IBGE 2017), high environmental heterogeneity (Pott *et al.* 2011) and it is considered a transition area of the Chaco, Cerrado and Pantanal ecoregions (Benites *et al.* 2017). The climate of the region is Aw, according to Köoppen, with a hot and wet summer, and a dry and cool winter (Climate-date 2017). At the same time, the region is conducive to the development of agricultural activities, which have been carried out for a long time in the region and its surrounding areas, as shown by Souza *et al.* (2017).

Species data

Species samplings from selected sites (Table 1) were performed during six months and a total of eight field surveys completed in five areas, with four in the dry season (August 2013, September 2014, August 2015 and August 2016) and four in the rainy season (March 2014, January 2015, December 2015 and January 2017). The sampling effort was calculated as the listening hours done by each researcher (total hours/campaign x 2 researchers x total number of campaigns), totaling 128 h. For the capture effort of pitfall traps, effort calculation was made using the amount of days per campaign times the number of buckets (pitfalls), totaling 704 h.

Capture methods were adopted using pitfall traps and active search (visual and acoustic encounters) (Heyer *et al.* 1994). To install pitfalls, ~20 m long trails were made within the native vegetation, where Y- lines were then installed with five or six 60 l buckets set with 5-m intervals. We considered a minimum distance of 5 m from the edge of the forest to the beginning of each pitfall line. The acoustic method was carried out for two days during each campaign (17:00 to 21:00 h) in two existing water bodies near the Cerrado site 3 and Chaco site 2. This temporal patterning was

Table 1. Sampling sites of anurans from the Cerro Porã and Cangalha farms, municipality of Porto Murtinho, Mato Grosso do Sul, Brazil, and geographic coordinates (*datum* WGS 84).

Site	Latitude	Longitude	Location
Cerrado 1 (Cr1)	22°1'47.86" S	57°29'21.30" W	Savannah area in ecological corridor between hills characterized by open trees and dense tree vegetation
Cerrado 2 (Cr2)	22°2'28.94" S	57°32'2.58" W	Steppic Savannah with *Attalea phalerata* (Mart. Ex Spreng.), in a Protect Area inside a suppression area
Cerrado 3 (Cr3)	22°0'59,38" S	57°27'9.40" W	Portion of the study area with remnants of vegetation characteristic of Cerradão. Also performed acoustic technique in a permanent water pound
Chaco 1 (Ch1)	22°6'43.87" S	57°27'55.96" W	Near a *Mata Ciliar* of the Rio Perdido
Chaco 2 (Ch2)	22°8'7.44" S	57°33'57.00" W	Next to a mountain chain characterized by Steppic Savannah. Also performed acoustic technique in a permanent water pound

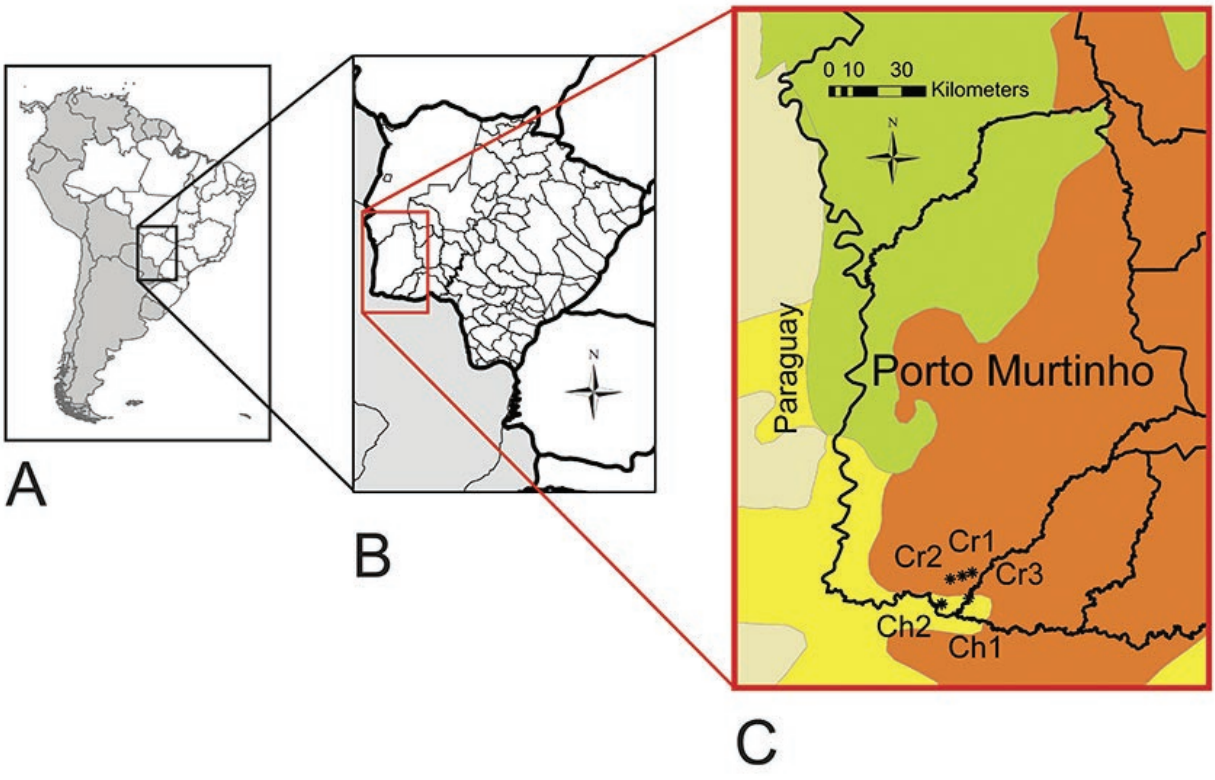

Figure 1. Localization of sampling points for anurans of the municipality of Porto Murtinho, Mato Grosso do Sul State, Brazil. A) Map of South America highlighting the geopolitical division of Brazil; B) Municipality division of the Mato Grosso do Sul State, Brazil, with distribution of different ecoregions in the municipality of Porto Murtinho, as delineated by Dinerstein *et al.* (2017): yellow = humid Chaco; brow = dry Chaco; green = Pantanal; orange = Cerrado. Abbreviations correspond to sampling points and are described at Material and Methods section.

established due to the behavioral variations of the species regarding vocalization habits (Wells 1977, Rodrigues *et al.* 2003, Prado *et al.* 2005, Moreira *et al.* 2007, Toledo *et al.* 2007, Uetanabaro *et al.* 2008).

During the samplings each group of pitfall traps was visited once a day. The captured specimens (Environmental Authorization for Wildlife Management in situ IMASUL n° 23/104460/2013 e n° 61/402873/2015) were photographed and released in capture locations after species identification by comparing their morphological characteristics observed in the field and revising their original or revalidated descriptions to support the taxonomic identifications (Ribeiro *et al.* 2005, Toledo *et al.* 2007, Uetanabaro *et al.* 2008). We followed Frost (2018) for the nomenclature of amphibians.

Aiming to improve our list of species, we used online databases to find registers of anuran species from the municipality of Porto Murtinho in published articles. Specifically, we used Web of Science (which includes the main academic journals of world), Scielo (which includes the main journals of South America) and Google Scholar. We searched for general keywords such as "anuran", "frog", "sapo" ("frog" in Portuguese) in combination with "Mato Grosso do Sul" and "Porto Murtinho". Uetanabaro *et al.* (2007), Rosset *et al.* (2009), Souza *et al.* (2010, 2017), Amaral *et al.* (2012), Sugai *et al.* (2012), Sugai *et al.* (2014a) and Pansonato *et al.* (2011) provided additional information about registers of anuran species. Considering the opinion of experts (see Acknowledgements), we removed four species from the species list of Souza *et al.* (2017): *Boana crepitans* (Wied-Neuwied 1924), *Scinax similis* (Cochran, 1952), *Adenomera martinezi* (Bokermann 1956) and *Leptodactylus gracilis* (Duméril & Bibron 1840). According to this view, the presence of these species in the state is questionable, thus we decided to remove them in order to avoid overestimation of the number of species for Mato Grosso do Sul state.

The conservation status of the species was classified according to the International Union for Conservation of Nature and Natural Resources Red List of Threatened Species (IUCN 2018). This study also classified species using the CITES list (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (CITES 2017) and the Brazil's official list of endangered species (Brasil 2014).

Data analysis

In order to determine if the composition of the anurans species varied among our studied areas (which we consider as a "transition area" of humid Chaco and Cerrado) and other similar studies in ecoregions of humid Chaco, Cerrado and Pantanal (Uetanabaro *et al.* 2007, Souza *et al.* 2010, Pansonato *et al.* 2011, Sugai *et al.* 2014b, Pesci *et al.* 2018), we performed a Non-Metric Multidimensional Scaling (NMDS) analysis followed by a pairwise comparison of Analysis of Similarity (ANOSIM) using Paleontological Statistics software (v. 3.18). For this analysis, our data were both evaluated as a "transition zone" of humid Chaco and Cerrado and also as belonging to one of these ecoregions. The previous studies were chosen because they were carried out in landscapes with similar configurations as the Paraguay River basin (ZEE 2009) and the Apa River basin, such as vegetation fragments inserted into regions with predominance of cattle ranching. Also, authors of these studies used similar methods for sample and to identify anuran species (*i.e.*, acoustic and pitfall traps). We did not consider the temporal scale, since temporal variations in each study are often planned according to logistical conditions and technical and financial resources.

The NMDS was based on the presence and absence matrix of anuran species and used the Jaccard index of similarity. The order distortion in relation to the original data matrix was determined by stress. According to Clarke (1993), stress values around 0.2 correspond to a regular fit, while level around 0.1 indicate a good fit and a value close to 0 is an excellent fit. Finally, for the effort analysis, we constructed an accumulation curve of species richness (presence/absence data) based on our survey data and estimated species richness through Chao 2 and Jackknife 1 with one thousand randomizations using the EstimateS 9.1.0 program (Colwell 2013).

RESULTS

Anuran composition in the municipality of Porto Murtinho

During the five years of collection we found 31 species in the study sites in the Cerrado and 29 species in environments with Chaco characteristics. In total, 32 species of anurans, distributed in five families and 16 genera, were found in both

vegetation formations (Table 2; Figure 2). The Cerrado sites showed higher species richness and Leptodactylidae (N = 13) and Hylidae (N = 10) were the most representative families. About 90% of the species (N = 29) we recorded had previously been registered in the municipality, with first records of *Leptodactylus mystacinus*, *Leptodactylus syphax*, and *Boana albopunctata*. Considering previous studies about species occurrence in Chaco and Cerrado regions in the municipality of Porto Murtinho, 43 species had previously been listed.

Through the NMDS analysis (stress = 0.1329), we were able to distinguish a pattern of species composition among the ecoregions (Figure 3). The species compositions of our sampling sites were visually much more similar to each other than to the other areas. Despite this hypothesis, through ANOSIM, we were unable to find significant differences considering our areas as "transition region" (R = 0.5556, p = 0.0663) or belonging to ecoregion classifications as Cerrado and humid Chaco (R = 0.3519, p = 0.1061).

The estimators of species richness showed that the observed richness for our sampling sites corresponded to 95.6% and 85.9% of the medium estimated richness by Chao 2 (S est = 33.46, SD = 1.84) and Jackknife 1 (S est = 37.25, SD = 4.34), respectively (Figure 3).

Considering this and previous studies, we registered 46 species of anurans in the municipality of Porto Murtinho. None species are listed on the Brazilian Ministry of the Environment's List of Threatened Species and CITES. Following the IUCN Red List (IUCN 2018), *Lepidobatrachus asper* is considered as "Near Threatened", six species are categorized as "Data Deficient" and 39 species are categorized as "Least concern" (Table 2).

DISCUSSION

The amphibian species composition found in this study represents approximately 20% of the total number of species estimated in the Cerrado and Brazilian Chaco (Souza *et al.* 2010, Valdujo *et al.* 2012) and about 40% of the species estimated in the State of Mato Grosso do Sul. To date, the number of species recorded in the municipality of Porto Murtinho (i.e., N = 46 species) is higher than the number of species from other municipalities in south-central Brazil, such as Primavera do Leste (N = 25) and Nobres (N = 39) in Mato Grosso State (Santos *et al.* 2011, Silva *et al.* 2015), Barro Alto (N = 39) in the Goiás State (Gambale *et al.* 2014), and Borebi (N = 27), São Paulo State (Maffei *et al.* 2011).

All species from our study area have previously been recorded in Mato Grosso do Sul State (Souza *et al.* 2017) (Figure 4), but their occurrence was not uniform. *Boana albopunctata,* which we recorded in locations in the Chaquenha region, has only previously been recorded in the Cerrado of Mato Grosso do Sul State. This species were previously found in several environments, including flat lands and flooded areas, like the collection areas (Toledo *et al.* 2003, Araújo *et al.* 2007). On the other hand, *Rhinella azarai, L. syphax, Rhinella scitula, Elachistocleis motogrosso* and *L. mystacinus* prefer alluvial forest environments, with open fields close to temporary or permanent ponds, characteristics that may be associating such species to the areas of Chaco that present great diversity of environments and climatic changes throughout the year (Zavattini 2009, Pott *et al.* 2014).

Considering our sampling, *Boana punctata, Pseudopaludicola motorzinho* and *Rhinella diptycha* were only found in Cerrado sites, while *B. albopunctata* was only found in the humid Chaco. Of the 31 species registered in the Cerrado sites, *Leptodactylus bufonius* had no previous registers in this ecoregion in Mato Grosso do Sul State according to Souza *et al.* (2017). However, in that year, Faggioni *et al.* (2017) described the reproductive biology of an *L. bufonius* population of this species from a location in the municipality of Porto Murtinho. In the case of the humid Chaco, *R. azarai* and *R. scitula* have previously been registered by Narvaes & Rodrigues (2009) and Sugai *et al.* (2014a), respectively, but *L. syphax, E. matogrosso* and *L. mystacinus* also had not been registered prior to this region of Mato Grosso do Sul State, according to Souza *et al.* (2017). In addition, two other species, *Proceratophrys dibernardoi* (Ferreira *et al.* 2016) and *Ameerega berohoka* (Sant'anna *et al.* 2017), were recently recorded in two sites of Mato Grosso do Sul State. Thus, such as in other animal groups (*e.g.*, Koroiva *et al.* 2017, Rodrigues *et al.* 2018), new inventories should still increase the number of species recorded for both Cerrado and humid Chaco in the state.

In summary, the differences found between the species composition from the humid Chaco and

Table 2. Checklist of anurans species of Chaco and Cerrado from the municipality of Porto Murtinho and Mato Grosso do Sul State (MS), Brazil. Conservation status (NT = near threatened; LC = least concern; DD = data deficient, NC = non-classified) from IUCN Red List (2018). PNSB = Parque Nacional da Serra da Bodoquena. *Species recorded only in the municipality of Porto Murtinho, Mato Grosso do Sul, Brazil.

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Family Bufonidae										
*Melanophryniscus fulvoguttatus** (Mertens, 1937)	LC	x	x			x	x		x	x
*Melanophryniscus klappenbachi** Prigioni & Langone, 2000	LC						x			
Rhinella azarai (Gallardo, 1965)	LC	x				x			x	x
Rhinella bergi (Céspedez, 2000)	LC		x			x	x	x		
Rhinella diptycha (Cope, 1862)	LC	x	x	x	x	x	x	x	x	
Rhinella fernandezae (Gallardo, 1957)	LC							x		

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Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Rhinella major (Muller & Helmich, 1936)	DD		x	x		x	x	x	x	x
Rhinella mirandaribeiroi (Gallardo, 1965)	DD					x				
Rhinella ocellata (Günther, 1858)	LC					x				
Rhinella paraguayensis Ávila, Pansonato & Strüssmann, 2010	DD					x				
Rhinella rubescens (A. Lutz, 1925)	LC					x				
Rhinella scitula (Caramaschi & Niemeyer, 2003)	DD	x			x	x			x	x

Table 2. Continued on next page...

Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Family Ceratophryidae										
Ceratophrys cranwelli Barrio, 1980	LC		x				x	x		
*Lepidobatrachus asper** Budgett, 1899	NT						x			
Family Craugastoridae										
Haddadus binotatus (Spix, 1824)	LC		x							
Family Odontophrynidae										
Odontophrynus americanus (Duméril & Bibron, 1841)	LC	x				x		x		
*Odontophrynus lavillai** Cei, 1985	LC		x					x		

Table 2. Continued on next page...

Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Proceratophrys goyana (Miranda-Ribeiro, 1937)	LC					x				
Family Dendrobatidae										
Ameerega picta (Tschudi, 1838)	LC	x				x				
Ameerega braccata	LC					x				
Family Hylidae										
Boana punctata (Schneider, 1799)	LC	x	x		x	x	x		x	
Boana raniceps (Cope, 1862)	LC	x	x	x	x	x	x	x	x	x
Dendropsophus araguaya (Napoli & Caramaschi, 1998)	DD					x				
Dendropsophus cerradensis (Napoli & Caramaschi, 1998)	DD					x				

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Dendropsophus elianeae (Napoli & Caramaschi, 2000)	LC	x		x	x	x				
Dendropsophus jimi (Napoli & Caramaschi, 1999)	LC				x	x				
Dendropsophus melanargyreus (Cope, 1887)	LC		x	x			x			
Dendropsophus microcephalus (Cope, 1886)	LC	x								
Dendropsophus minutus (Peters, 1872)	LC	x		x	x	x	x		x	x
Dendropsophus nanus (Boulenger, 1889)	LC	x	x	x	x	x	x	x	x	x
Dendropsophus rubicundulus (Reinhardt and Lütken, 1862)	LC	x								

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Dendropsophus sanborni (Schmidt, 1944)	LC					x		x		
Boana albopunctata (Spix, 1824)	LC					x				x
Boana aff. geographica (Spix, 1824)	DD				x					
Boana caingua (Carrizo, 1991)	LC					x				
Boana crepitans (Wied-Neuwied, 1924)	LC					x				
Boana lundii (Burmeister, 1856)	LC					x				
Lysapsus limellum Cope, 1862	LC		x	x		x	x		x	x
Osteocephalus taurinus Steindachner, 1862	LC					x				

Table 2. Continued on next page...

Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Pseudis paradoxa (Linnaeus, 1758)	LC	x		x		x	x			
Pseudis platensis Gallardo, 1961	DD		x		x	x	x	x	x	x
Scinax acuminatus (Cope, 1862)	LC		x	x		x	x	x		
Scinax constrictus Lima, Bastos & Giaretta, 2005	LC					x				
Scinax fuscomarginatus (Lutz, 1925)	LC	x	x	x	x	x	x		x	x
Scinax fuscovarius (Lutz, 1925)	LC		x	x	x	x	x	x	x	x
Scinax nasicus (Cope, 1862)	LC		x	x		x	x	x	x	x
Scinax ruber (Laurenti, 1768)	LC	x				x				
Scinax squalirostris (Lutz, 1925)	LC	x					x			

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Trachycephalus typhonius (Linnaeus, 1758)	LC	x	x	x	x	x	x	x		
Family Phyllomedusidae										
Phyllomedusa sauvagii Boulenger, 1882	LC	x	x			x	x		x	x
Pithecopus azureus (Cope, 1862)	DD	x	x	x	x	x	x	x	x	x
Family Leptodactylidae										
Adenomera diptyx (Boettger, 1885)	LC		x	x	x	x	x		x	x
Adenomera hylaedactyla (Cope, 1868)	LC					x				
*Leptodactylus bufonius** Boulenger, 1894	LC		x	x			x	x	x	x

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Leptodactylus chaquensis Cei, 1950	LC	x	x	x		x	x	x	x	x
Leptodactylus elenae Heyer, 1978	LC	x	x	x		x	x	x	x	x
Leptodactylus furnarius Sazima & Bokermann, 1978	LC				x					
Leptodactylus fuscus (Schneider, 1799)	LC	x	x	x	x	x	x	x	x	x
Leptodactylus jolyi Sazima & Bokermann, 1978	DD	x								
Leptodactylus labyrinthicus (Spix, 1824)	LC	x	x	x		x	x			
Leptodactylus latinasus Jiménez de la Espada, 1875	LC							x		
Leptodactylus latrans (Steffen, 1815)	LC				x	x		x		

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Leptodactylus mystaceus (Spix, 1824)	LC					x				
Leptodactylus mystacinus (Burmeister, 1861)	LC	x		x	x	x		x	x	x
Leptodactylus podicipinus (Cope, 1862)	LC	x	x	x	x	x	x	x	x	x
Leptodactylus syphax Bokermann, 1969	LC	x				x			x	x
Physalaemus albonotatus (Steindachner, 1864)	LC	x	x	x	x	x	x	x	x	x
Physalaemus biligonigerus (Cope, 1861 "1860")	LC		x	x		x		x	x	x
Physalaemus centralis Bokermann, 1962	LC			x		x				

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Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Physalaemus cuvieri Fitzinger, 1826	LC	x			x	x	x		x	x
Physalaemus marmoratus (Reinhardt & Lütken, 1862)	LC					x				
Physalaemus nattereri (Steindachner, 1863)	LC	x	x	x	x	x	x		x	x
Pseudopaludicola motorzinho Pansonato, Veiga-Menoncello, Mudrek, Jansen, Recco-Pimentel, Martins & Strüssmann, 2016	LC	x	x	x	x	x			x	
Pseudopaludicola ternetzi Miranda-Ribeiro, 1937	LC				x					

Table 2. Continued on next page...

Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Family Microhylidae										
Chiasmocleis albopunctata (Boettger, 1885)	LC	x	x	x		x	x	x	x	x
Chiasmocleis mehelyi Caramaschi and Cruz, 1997	DD					x				
Dermatonotus muelleri (Boettger, 1885)	LC		x	x		x	x			
Elachistocleis bicolor (Guérin-Menéville, 1838)	LC	x	x			x	x	x		
Elachistocleis cesarii (Miranda Ribeiro (1920))	DD					x				
Elachistocleis haroi Pereyra, Akmentins, Laufer & Vaira, 2013	NC							x		

Table 2. Continued on next page...

Table 2. ...Continued

Species	IUCN status	Locality / Biome								
		PNSB	Porto Murtinho	Cáceres	Camapuã	MS	MS	Formosa	Porto Murtinho	Porto Murtinho
		Cerrado	Chaco	Pantanal	Cerrado	Cerrado	Chaco	Chaco	Cerrado	Chaco
Elachistocleis magnus Toledo, 2010	NC			x						
Elachistocleis matogrosso Caramaschi, 2010	DD		x	x	x	x			x	x
Family Strabomantidae										
Oreobates crepitans (Bokermann, 1965)	DD					x				
Species richness		34	35	32	26	64	36	29	31	29
Reference		Uetanabaro *et al.* (2007)	Souza *et al.* (2010)	Pansonato *et al.* (2011)	Sugai *et al.* (2014b)	Souza *et al.* (2017)	Souza *et al.* (2017)	Pesci *et al.* (2018)	This study	This study

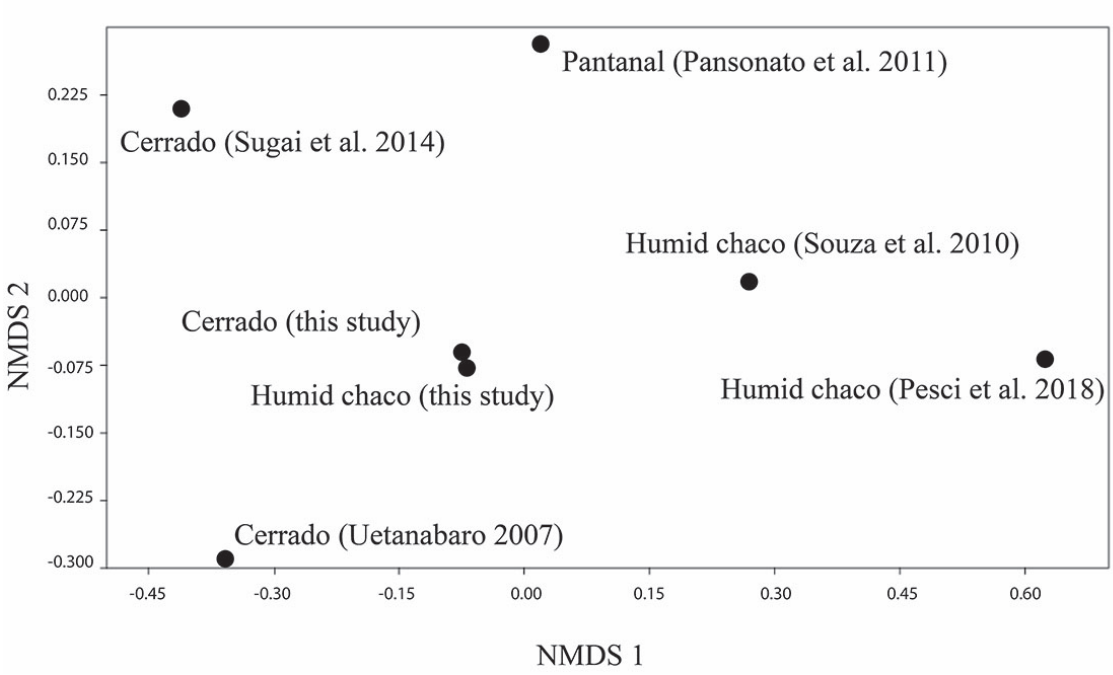

Figure 2. Species accumulation curve comparing the number of observed species (Sobs, squares) and the estimated richness of anuran species for our sampling sites in the municipality of Porto Murtinho, Mato Grosso do Sul, Brazil. The estimates were calculated with the estimator Chao 2 and Jackknife 1. Black diamonds = number of species observed (est); Black square= Chao 2 richness estimator; Light grey circles = Jackknife 1 richness estimator.

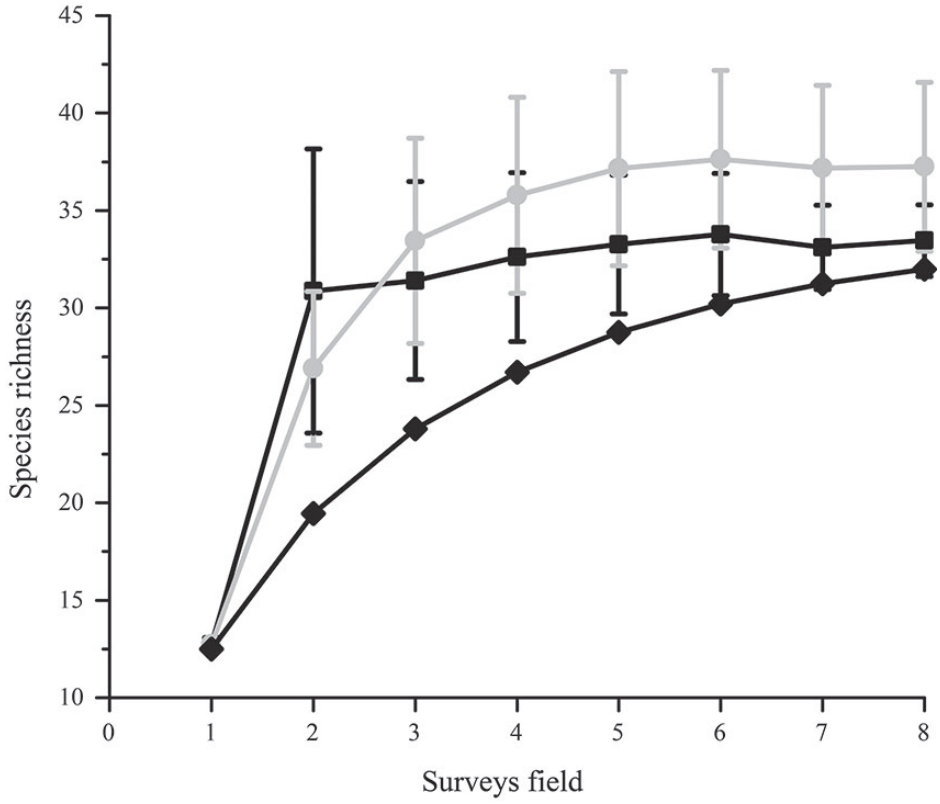

Figure 3. Nonmetric multidimensional scaling of the selected studies for species composition of anurans of the municipality of Porto Murtinho, Mato Grosso do Sul State, Brazil and comparison with different areas of the diagonal of dry vegetal formations.

Figure 4. Species registered in the study area in the municipality of Porto Murtinho, Mato Grosso do Sul, Brazil. a) *Boana raniceps*, b) *Dendropsophus nanus,* c) *Chiasmocleis albopunctata,* d) *Melanophryniscus fulvoguttatus,* e) *Leptodactylus bufonius,* f) *Leptodactylus mystacinus,* g) *Leptodactylus chaquensis,* h) *Physalaemus nattereri,* i) *Adenomera diptix*, j) *Rhinella scitula*, k) *Phyllomedusa sauvagii,* l) *Pithecopus azureus*. Photos by Cyntia C. Santos and Berinaldo Bueno

Cerrado and other areas with the same formations (Uetanabaro *et al.* 2007, Souza *et al.* 2010, Sugai *et al.* 2014a) must be related to the preferences between the type of environment where the species were found. Considering that this study area is in the Chaco and Cerrado transition zone, the presence of different phytophysiognomies that are connected to each other, such as flat lands and natural springs between limestone, natural and temporary water bodies and swamps or permanent dams, in addition to alluvial forests and the riparian forests of the Perdido River, present a complex and permissible environment for a wide variety of species. As stated by Zanella

(2011), the evolutionary history of the Caatinga, Cerrado and Chaco could be independent, since the endemic patterns for each of these regions have specific characteristics (Morrone 2014). However, in transition zones, multiple factors can cause the differentiation of community composition (Kark *et al.* 2007, Vasconcelos *et al.* 2010, Sabbag & Zina 2011) we hypothesized that anuran species richness and the number of reproductive modes from different Brazilian localities vary according to climatic and altitudinal variables. Published data were compiled from 36 Brazilian localities and climatic and altitudinal data were extracted from an available database. In addition to ecological and historical processes (Moritz *et al.* 2000), today we discuss how the scale influences these aspects and changes the species responses (Willis & Whittaker 2002, Kark & van Rensburg 2006). Obviously, water availability is still considered a key factor for maintaining frogs since these taxa are totally dependent on this resource for their survival (Duellman & Trueb 1994, Pough *et al.* 2015), but, intrinsic characteristics of each species might outweigh the delimitation in previously established ecoregions.

As highlighted by Morais *et al.* (2013), there are still few studies about the natural history and distribution range of many anuran species. About 15% of the species found in the municipality of Porto Murtinho has not previously been classified on the endangered species lists, especially classed as "Data Deficient". Species inventories could fill such knowledge gaps and improve insight on the actual risk situation of species in Mato Grosso do Sul State, particularly regarding knowledge about geographic distribution. In addition, recently, the high level of environmental diversity, ecological peculiarities, and the presence of endemic species have raised the interest of researchers in the municipality of Porto Murtinho, which have improved the knowledge of taxonomically undersampled groups and attracting new researchers and opportunities to this municipality (*e.g.* Gomes & Araujo 2015, Gomes *et al.* 2016, Benites *et al.* 2017).

Newly named one of the top priority conservation areas by the Brazilian Ministry of the Environment, the municipality of Porto Murtinho is greatly important for biodiversity conservation (Brasil 2016). The municipality's severe vegetation loss (Harris *et al.* 2006) in recent years deserves greater concern and action because of the wide diversity of anuran species (Rosset *et al.* 2009, Souza *et al.* 2010, 2017, Sugai *et al.* 2013). The municipality of Porto Murtinho is the only place in Brazil where *Odontophrynus lavillai* (Rosset *et al.* 2009) and *L. asper* (Sugai *et al.* 2013) occur, the latter being recorded as "near threatened" by the IUCN (2018) in Mato Grosso do Sul State. Thus, the anuran composition and the great landscape complexity of the Chaco and Cerrado environments evidence the importance of increasing studies about the ecology of communities and natural history of species, such as those that make up the municipality of Porto Murtinho, since they are necessary and important for conservation of organisms and for sensitive regions with high levels of anthropogenic threats.

ACKNOWLEDGMENTS

We thank Mahil Agropecuária and Città Planejamento Urbano e Ambiental for supporting this work. We thank also three anonymous referees and the herpetology expert, Diego José Santana, for their very useful suggestions and comments. We thank Berinaldo Bueno for his photos of *Leptodactylus bufonius*, *Phyllomedusa sauvagii* and *Pithecopus azureus*. CCS, CVJ, RK and ERS were financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) – Finance Code 001. CCS received financed in part also a FUNDECT-MS and Capes/Cofecub (Project n°875/2017 Process n°88887.143361/2017-00). R.K. was supported by PNPD/CAPES Program Fellowship and FIXAM-I/FAPEAM (Ed. n°005/2018 Process n° 062.01503/2018) postdoctoral scholarship.

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Submitted: 15 May 2018
Accepted: 25 February 2019
Published online: 16 December 2019
Associate Editors: Camila Aoki, Gudryan J. Barônio & Arnildo Pott