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REPTILE SPECIES COMPOSITION IN THE MIDDLE GURGUÉIA AND COMPARISON WITH INVENTORIES IN THE EASTERN PARNAÍBA RIVER BASIN, STATE OF PIAUÍ, BRAZIL

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ABSTRACT

*The reptile diversity of the Middle Gurguéia River Basin in southern Piauí, Brazil, is little known. The rapid expansion of agriculture in the region is converting the Cerrado and Caatinga into large farming areas, which threatens biodiversity and hastens its loss. In this study, 68 specimens of reptiles from a university collection were examined, comprising 29 species: ten lizards, one amphisbaenian, 15 snakes, two turtles and one crocodylian. They were collected from five locations in the Middle Gurguéia Basin, a region not previously evaluated for reptiles. The most abundant species is a member of Tropidurus. Comparison with eight other areas in the eastern Parnaíba Basin indicated that the diversity of reptiles in the Middle Gurguéia is similar to that in other Caatinga-Cerrado ecotone areas. The reptile assemblage in the eastern Parnaíba Basin comprises 100 species of reptiles: 39 lizards, five amphisbaenians, 50 snakes, four chelonians and two crocodylians. This study expanded the known distributions of some reptiles and recorded the first occurrence of *Helicops leopardinus* (Schlegel, 1837) for Piauí. A cluster analysis showed that the reptile composition concords with the habitat where species were found, i.e. Cerrado, Caatinga or ecotone. Studies that associate habitat structure with each species are essential to propose efficient strategies for reptile management and conservation for the entire Parnaíba River Basin, mostly in areas that are not yet protected.*

KEY-WORDS: Reptilia; *Helicops*; Ecotone; Cerrado; Caatinga.

INTRODUCTION

Although knowledge of the biodiversity of the Cerrado, Caatinga and ecotone areas has increased, the fauna of these vegetation complexes is still little

known and many areas have never been inventoried (Rodrigues, 2005a). Reptilia is a well-understood group, but in the five largest Brazilian collections, reptiles from many key areas and ecosystems are not represented (Rodrigues, 2005b). Except for the well-

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known Crocodylia, the number of Brazilian reptile species is still underestimated, due to insufficient inventories and the small number of taxonomists (Rodrigues, 2005b).

According to Costa & Bérnils (2015), 773 reptile species can be found in Brazil: six crocodylians, 36 chelonians, 73 amphisbaenians, 266 lizards and 392 snakes. The 185 species known from the Cerrado include five crocodylians, ten turtles, 33 amphisbaenians (20 endemic), 76 lizards (32 endemic) and 158 snakes (51 endemic) (Colli *et al.*, 2002). Records from the Caatinga show 47 lizards, ten amphisbaenians, 112 snakes (Guedes *et al.*, 2014), four chelonians and three crocodylians, totaling 176 species (Rodrigues, 2005b).

In the eastern Parnaíba Basin, State of Piauí, some areas have been inventoried: Parque Nacional Serra da Capivara (Cavalcante *et al.*, 2014), Estação Ecológica Uruçuí-Una (Dal Vechio *et al.*, 2013), Parque Nacional Serra das Confusões (Dal Vechio *et al.*, 2016), Parque Nacional Sete Cidades (Rocha & Prudente, 2010), and sites in the municipalities of Valença (Vanzolini, 1976), Castelo do Piauí (Rodrigues & Prudente, 2011), Picos (Benício *et al.*, 2015a), Barras (Benício *et al.*, 2015b) and Batalha (Silva *et al.*, 2015).

Southern Piauí State is among the Brazilian regions most covered by agribusiness (Reydon & Monteiro, 2006) Here we provide a list of reptiles for the Middle Gurguéia region (MG) and a cluster analysis of the reptile species composition within the MG, comparing with eight previous inventories in the eastern Parnaíba River Basin in the state.

MATERIAL AND METHODS

Study site

The collection studied includes reptiles from five municipalities in the Middle Gurguéia region (MG), southwestern Piauí: Alvorada do Gurguéia (AG) 08°27'03.6"S, 43°52'05.05"W; Cristino Castro (CC) 08°47'36.0"S, 44°12'26.2"W; Palmeira do Piauí (PP) 08°43'32.7"S, 44°14'04.5"W; Redenção do Gurguéia (RG) 09°28'24.8"S, 44°36'2.30"W, and Bom Jesus (BJ) 09°05'18.6"S, 44°19'41.4"W. Figure 1 shows these areas in the Gurguéia River Basin and eight other areas previously inventoried in the Parnaíba River Basin, used here for comparison: the municipalities of Batalha (BT; Silva *et al.*, 2015), Barras (BR; Benício *et al.*, 2015b), Castelo do Piauí (CP; Rodrigues & Prudente, 2011), Picos (PC; Benício

et al., 2015a), and the conservation units Parque Nacional Sete Cidades (7C; Rocha & Prudente, 2010), Parque Nacional Serra da Capivara (CA; Cavalcante *et al.*, 2014), Estação Ecológica de Uruçuí-Una (UU; Dal Vechio *et al.*, 2013), and Parque Nacional Serra das Confusões (CO; Dal Vechio *et al.*, 2016). Notes on the geographic distribution of reptiles of the Parnaíba River Basin are provided in the discussion. Authors of species are listed only in the tables.

Data collection

The data from the Gurguéia River Basin are based on a reptile collection formerly housed in the Laboratório de Zoologia, Universidade Federal do Piauí (UFPI), Campus Professora Cinobelina Elvas (CPCE), Bom Jesus, Piauí. Labels found with the specimens indicate that they were fixed in 10% formalin, preserved in 70% ethanol, and collected by active searching from 2010 to 2012. No collecting effort was available. The nomenclature follows recent taxonomic literature (Zaher *et al.*, 2009; Wüster & Bérnils, 2011; Harvey *et al.*, 2012; Dal Vechio *et al.*, 2016). Following this study, all specimens were deposited in the Laboratório Especial de Coleções Zoológicas (LE CZ), Instituto Butantan, São Paulo, Brazil (Appendix 1). The conservation status of the species was obtained from the report of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2016).

Data analysis

We first analyzed the similarity among the five sites in the Middle Gurguéia. In a second analysis, we considered all these five sites as one, termed MG. We compared the species composition in MG with eight other areas previously inventoried in the eastern Parnaíba River Basin, termed PRB (Fig. 1): 7C, BT, BR, CP, PC, CA, UU and CO. Inventories in areas CP and 7C, which included only snakes, were not included in the analysis for all taxa, as this would have biased the results. For both analyses, similarity dendrograms were constructed using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) algorithm, using the Jaccard coefficient in the software R version 3.0.3 (R Development Core Team, 2014), Vegan package (Oksanen *et al.*, 2016). The Jaccard distance measures dissimilarities among sites, based on species incidences (presences-absences) (Magurran, 2013).

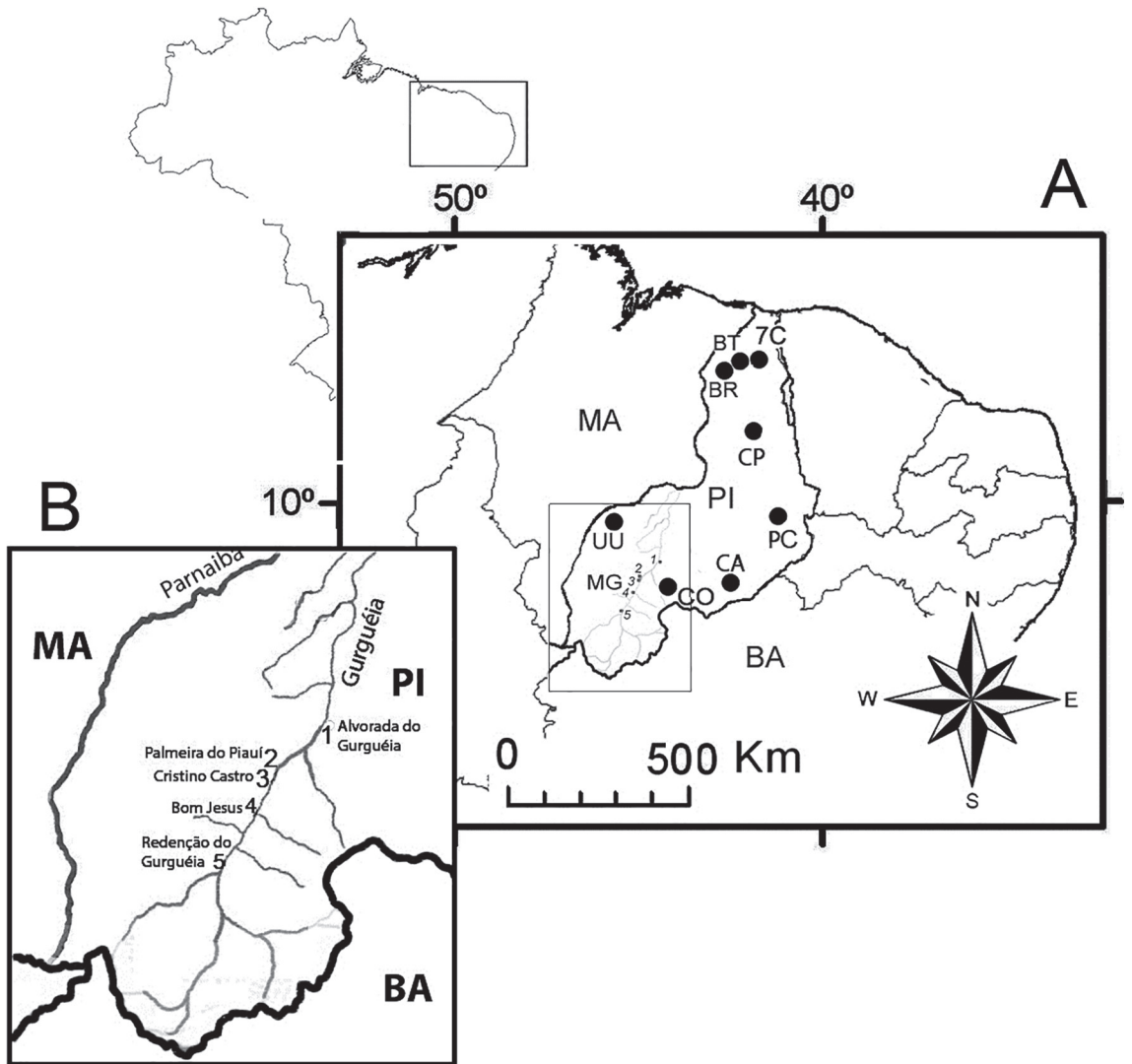


FIGURE 1: Study areas in the Middle Gurguéia and previously studied areas. **(A):** northeastern Brazil: Piauí (PI), Bahia (BA) and Maranhão (MA). Black dots show the locations where other studies were conducted: Barras (BR), Batalha (BT), Parque Nacional Sete Cidades (7C), Castelo do Piauí (CP), Picos (PC), Parque Nacional Serra da Capivara (CA), Parque Nacional Serra das Confusões (CO) and Estação Ecológica do Uruçuí-Una (UU); **(B):** The five municipalities in this study in the Middle Gurguéia (MG), Gurguéia River Basin, southeastern Piauí: 1: Alvorada do Gurguéia (AG), 2: Palmeira do Piauí (PP), 3: Cristino Castro (CC), 4: Bom Jesus (BJ) and 5: Redenção do Gurguéia (RG).

RESULTS

Reptiles in the Middle Gurguéia

We analyzed a total of 69 specimens: 33 lizards; five amphisbaenians; 28 snakes; two chelonians, *Mesoclemmys tuberculata* and *Phrynops geoffroanus*; and one crocodylian, *Paleosuchus palpebrosus*. The lizards belong to eight families (nine genera, ten species) and the snakes to four families (15 genera, 15 species). A species of Amphisbaenidae was also represented. Tables 1 and 2 list the reptile species, their families, and the number of specimens recorded from each location. Four species are listed as vulnerable in Ap-

pendix 2 of CITES (2016): *Iguana iguana*, *Salvator merianae*, *Boa constrictor* and *P. palpebrosus*.

Among the lizards collected in MG, the most abundant was *Tropidurus hispidus* (11 specimens), recorded in BJ, CC and PP, followed by *Tropidurus semitaeniatus* (seven specimens), recorded in MG, CO, CA and UU. These two species likely also occur in the other areas, because both are widespread in northeastern Brazil (Passos *et al.*, 2016).

The municipalities of Bom Jesus (BJ) and Cristino Castro (CC) had three species in common, *Amphisbaena vermicularis*, *Hemidactylus mabouia* and *T. hispidus*; only *T. hispidus* occurred in both Cristino Castro (CC) and Palmeira do Piauí (PP).

TABLE 1: Species of reptiles and number of individuals recorded in each study area of the Middle Gurguéia River Basin. Municipalities: AG: Alvorada do Gurguéia, BJ: Bom Jesus, CC: Cristino Castro, PP: Palmeira do Piauí, RG: Redenção do Gurguéia. MG* refers to samples with no specific point of collection, but certainly within the MG region. T = Total number of specimens.

	AG	BJ	CC	PP	RG	MG*	T
REPTILIA							
AMPHISBAENIDAE							
<i>Amphisbaena vermicularis</i> Wagler, 1824		3	2				5
GEKKONIDAE							
<i>Hemidactylus mabouia</i> (Moreau de Jonnés, 1818)		1	1				2
IGUANIDAE							
<i>Iguana iguana</i> (Linnaeus, 1758)		1					1
POLYCHROTIDAE							
<i>Polychrus acutirostris</i> Spix, 1825				1			1
TEIIDAE							
<i>Ameiva ameiva</i> (Linnaeus, 1758)				3			3
<i>Salvator merianae</i> (Duméril & Bibron, 1839)						1	1
TROPIDURIDAE							
<i>Tropidurus hispidus</i> (Spix, 1825)		1	1	9			11
<i>Tropidurus semitaeniatus</i> (Spix, 1825)				7			7
SCINCIDAE							
<i>Mabuya heathi</i> (Schmidt & Inger, 1951)				2			2
PHYLLODACTYLIDAE							
<i>Gymnodactylus geckoides</i> Spix, 1825		1					1
GYMNOPHTHALMIDAE							
<i>Micrablepharus maximiliani</i> (Reinhardt & Lütken, 1862)			4				4
BOIIDAE							
<i>Boa constrictor</i> Linnaeus, 1758		1					1
<i>Epicrates assisi</i> Machado, 1945		1		1			2
COLUBRIDAE							
<i>Chironius flavolineatus</i> (Boettger, 1885)				1			1
<i>Helicops leopardinus</i> (Schlegel, 1837)		1					1
<i>Oxybelis aeneus</i> (Wagler, 1824)				1			1
<i>Spilotes pullatus</i> (Linnaeus, 1758)		1					1
DIPSADIDAE							
<i>Apostolepis cearensis</i> Gomes, 1915					1		1
<i>Erythrolampus poecilogyrus</i> (Wied, 1825)		2					2
<i>Leptodeira annulata</i> (Linnaeus, 1758)					1		1
<i>Oxyrhopus trigeminus</i> Duméril, Bibron & Duméril, 1854		4		2			6
<i>Philodryas nattereri</i> Steindachner, 1870	1	3		2			6
<i>Phimophis iglesiasii</i> (Gomes, 1915)		1					1
<i>Psomophis joberti</i> (Sauvage, 1884)		1					1
<i>Xenodon merremii</i> (Wagler, 1824)		2					2
VIPERIDAE							
<i>Crotalus durissus</i> Linnaeus, 1758						1	1
CHELIDAE							
<i>Mesoclemmys tuberculata</i> (Luederwaldt, 1926)		1					1
<i>Phrynops geoffroanus</i> (Schweigger, 1812)		1					1
ALLIGATORIDAE							
<i>Paleosuchus palpebrosus</i> (Cuvier, 1807)						1	1
TOTAL	1	26	8	29	2	3	69

TABLE 2: Diversity of nine areas in the Parnaíba River Basin: MG: Middle Gurguéia (this study); CP: Castelo do Piauí; PC: Picos; CO: Parque Nacional Serra das Confusões; CA: Parque Nacional Serra da Capivara; UU: Estação Ecológica do Uruçuí-Una; 7C: Parque Nacional Sete Cidades; BR: Barras and BT: Batalha municipalities. Asterisks indicate number of animals collected not provided. CP and 7C did not inventory lizards. Symbols refer to individuals found only in: Δ: Cerrado, □: Caatinga and ◇: Cerrado-Caatinga ecotone.

	MG	CP	PC	CO	CA	UU	7C	BR	BT
REPTILIA									
DACTYLOIDAE									
<i>Norops brasiliensis</i> Vanzolini & Williams, 1970 Δ						2			
<i>Norops meridionalis</i> (Boettger, 1885) Δ						15			
GEKKONIDAE									
<i>Hemidactylus agrius</i> Vanzolini, 1978 ◇									*
<i>Hemidactylus brasiliensis</i> (Amaral, 1935)				16	28	15			
<i>Hemidactylus mabuia</i> (Moreau de Jonnés, 1818)	2		*			3		*	*
<i>Lygodactylus klugei</i> (Smith, Martin & Swain, 1977)			*		14				
GYMNOPHTALMIDAE									
<i>Calyptommatus confusionibus</i> Rodrigues, Zaher & Curcio, 2001 □				14					
<i>Colobosauroides cearensis</i> Cunha, Lima-Verde & Lima 1991 ◇									*
<i>Colobosaura modesta</i> (Reinhardt & Lütken, 1862)				45	7	44			
<i>Micrablepharus maximiliani</i> (Reinhardt & Lütken, 1862)	4			32	100	85			*
<i>Procellosaurinus erythrocerus</i> Rodrigues, 1991 □				16	92				
<i>Vanzosaura rubricauda</i> (Boulenger, 1902) ◇			*						
HOPLOCERCIDAE									
<i>Hoplocercus spinosus</i> Fitzinger, 1843				18		13			
IGUANIDAE									
<i>Iguana iguana</i> (Linnaeus, 1758)	1		*	2	1	7		*	*
LEIOSAURIDAE									
<i>Enyalius bibronii</i> Boulenger, 1885 □				18	6				
SCINCIDAE									
<i>Copeoglossum nigropunctatum</i> (Spix, 1825)					6	10			
<i>Mabuya frenata</i> (Cope, 1862) □				10					
<i>Mabuya beathi</i> (Schmidt & Inger, 1951)	2		*	11				*	*
<i>Mabuya nigropunctata</i> (Spix, 1825) □				17					
PHYLLODACTYLIDAE									
<i>Gymnodactylus geckoides</i> Spix, 1825 ◇	1		*						
<i>Phyllopezus pollicaris</i> (Spix, 1825)			*	12	33	25			*
POLYCHROTIDAE									
<i>Polychrus acutirostris</i> Spix, 1825	1		*			4			*
SPHAERODACTYLIDAE									
<i>Coleodactylus brachystoma</i> (Amaral, 1935)				1		19			
<i>Gonatodes humeralis</i> (Guichenot, 1855) ◇								*	*
TEIIDAE									
<i>Ameiva ameiva</i> (Linnaeus, 1758)	3		*	29	16	109		*	*
<i>Ameivula ocellifera</i> (Spix, 1825)								*	*
<i>Ameivula confusioniba</i> (Arias, De Carvalho, Rodrigues & Zaher, 2011) □				*					
<i>Ameivula</i> cf. <i>mumbuca</i> Colli <i>et al.</i> , 2003 Δ						162			
<i>Ameivula</i> sp. □				*					
<i>Glaucomastix venetacauda</i> (Arias, De Carvalho, Rodrigues & Zaher, 2011)			*	23	56				
<i>Kentropyx calcarata</i> Spix, 1825 Δ						5			
<i>Salvator merianae</i> (Duméril & Bibron, 1839)	1		*	2	1	1		*	*
<i>Tupinambis quadrilineatus</i> Manzani & Abe, 1997 Δ						12			
<i>Tupinambis teguixin</i> (Linnaeus, 1758) ◇								*	
TROPIDURIDAE									
<i>Stenocercus squarrosus</i> Nogueira & Rodrigues, 2006 □				13	5				
<i>Tropidurus helena</i> (Manzani & Abe, 1990) □					61				
<i>Tropidurus hispidus</i> (Spix, 1825)	11		*	84	100			*	*

	MG	CP	PC	CO	CA	UU	7C	BR	BT
<i>Tropidurus oreadicus</i> Rodrigues, 1987 Δ						301			
<i>Tropidurus semitaeniatus</i> (Spix, 1825)	7			32	52	45			*
AMPHISBAENIDAE									
<i>Amphisbaena alba</i> Linnaeus, 1758 Δ						8			
<i>Amphisbaena frontalis</i> Vanzolini, 1991 □				5					
<i>Amphisbaena miringoera</i> Vanzolini, 1971				1		5			
<i>Amphisbaena polystega</i> (Duméril, 1851)				1		14			
<i>Amphisbaena vermicularis</i> Wagler, 1824	5		*	2		17		*	
TYPHLOPIDAE									
<i>Trilepida</i> cf. <i>fuliginosa</i> □				5					
<i>Typhlopsbron gersmianus</i> Vanzolini, 1972 Δ						5			
LEPTOTYPHLOPIDAE									
<i>Tricheilostoma brasiliensis</i> (Laurent, 1949) Δ						4			
BOIDAE									
<i>Boa constrictor</i> Linnaeus, 1758	1	1	*			6	3		
<i>Corallus hortulanus</i> (Linnaeus, 1758)				3	2	6			
<i>Epicrates assisi</i> Machado, 1945	2	2		1		3	1	*	
<i>Eunectes murinus</i> (Linnaeus, 1758)						4	1	*	
COLUBRIDAE									
<i>Chironius exoletus</i> (Linnaeus, 1758) Δ						1			
<i>Chironius flavolineatus</i> (Boettger, 1885)	1					14			
<i>Drymarcon corais</i> (Boie, 1827)				3			3		
<i>Drymoluber brazili</i> (Gomes, 1918) □				2					
<i>Helicops leopardinus</i> (Schlegel, 1837) ◇	1								
<i>Leptophis ahaetulla</i> (Linnaeus, 1758)				1		2	3		
<i>Mastigodryas bifossatus</i> (Raddi, 1820)		1				6			
<i>Mastigodryas boddaerti</i> (Sentzen, 1796)						2	1		
<i>Oxybelis aeneus</i> (Wagler, 1824)	1		*	1	2		2		
<i>Spilotes pullatus</i> (Linnaeus, 1758)	1	1		3	1	6	4	*	
<i>Tantilla melanocephala</i> (Linnaeus, 1758)				2		5	2		
DIPSADIDAE									
<i>Apostolepis cearensis</i> Gomes, 1915	1	4		10		11	1		
<i>Apostolepis polylepis</i> Amaral, 1921 Δ						1			
<i>Boiruna</i> sp. Δ						2			
<i>Erythrolampus poecilogyrus</i> (Wied-Neuwied, 1825)	2	9	*			62	2		
<i>Erythrolamprus miliaris</i> (Linnaeus, 1758) □				1					
<i>Erythrolamprus reginae</i> (Linnaeus, 1758) Δ						17			
<i>Erythrolamprus taeniogaster</i> (Jan, 1863) Δ						3			
<i>Erythrolampus viridis</i> (Günther, 1862)		8	*	1			4	*	
<i>Helicops angulatus</i> (Linnaeus, 1758) Δ						7			
<i>Hydrops triangularis</i> (Wagler, 1824) Δ						8			
<i>Leptodeira annulata</i> (Linnaeus, 1758) ◇	1	3					3	*	
<i>Lygophis paucidens</i> Hoge, 1953		2				2			
<i>Oxyrhopus trigeminus</i> A.M.C. Duméril, Bibron & A.H.A. Duméril, 1854	6	7	*	3	2	20	9	*	
<i>Oxyrhopus rhombifer</i> A.M.C. Duméril, Bibron & A.H.A. Duméril, 1854 Δ						14			
<i>Philodryas nattereri</i> Steindachner, 1870	6	10	*	1	4	30	1	*	
<i>Philodryas</i> cf. <i>aestiva</i> Duméril, Bibron & A.H.A. Duméril, 1854 ◇			*						
<i>Philodryas olfersii</i> (Lichtenstein, 1823)				1	1	17	1	*	*
<i>Philodryas joberti</i> (Sauvage, 1884) ◇								*	*
<i>Phimophis iglesiasi</i> (Gomes, 1915)	1	5			1	4			
<i>Pseudoboa nigra</i> (Duméril, Bibron & A.H.A. Duméril, 1854)		2	*	5	1	2	6	*	
<i>Psomophis joberti</i> (Sauvage, 1884)	1	1				15	2	*	
<i>Rodriguesophis iglesiasi</i> (Gomes, 1915)				1		4			
<i>Sibynomorphus mikanii</i> (Schlegel, 1837) Δ						1			

	MG	CP	PC	CO	CA	UU	7C	BR	BT
<i>Taeniophallus occipitalis</i> (Jan, 1863)						3	1		
<i>Thamnodynastes</i> sp.		8			6	17			
<i>Xenodon merremii</i> (Wagler, 1824)	2			1	1	110	6		
<i>Xenodon nattereri</i> (Steindachner, 1867)		5		1		1			
ELAPIDAE									
<i>Micrurus ibiboboca</i> (Merrem, 1820)		1	*			7	9		
VIPERIDAE									
<i>Bothrops lutzi</i> (Miranda-Ribeiro, 1915)		3			2	2			
<i>Bothrops moojeni</i> Hoge, 1966 Δ						104			*?
<i>Bothropoides erythromelas</i> Amaral, 1923				*					
<i>Crotalus durissus</i> (Linnaeus, 1758)	1	1		1		15	5		
CHELIDAE									
<i>Mesoclemmys perplexa</i> Bour & Zaher, 2005 □				3					
<i>Mesoclemmys tuberculata</i> (Luederwaldt, 1926)	1			6	1			*	
<i>Phrynops</i> cf. <i>tuberosus</i> (Peters, 1870) Δ						4			
<i>Phrynops geoffroanus</i> (Schweigger, 1812) ◇	1		*					*	*
ALLIGATORIDAE									
<i>Caiman crocodilus</i> (Linnaeus, 1758) Δ						3			
<i>Paleosuchus palpebrosus</i> (Cuvier, 1807) ◇	1		*					*	
Total Specimens	69	74	*	460	602	1,471	70	*	*
Total Species	29	19	25	47	28	64	22	24	18

For snakes, *Philodryas nattereri* was present in AG, BJ and PP, and *Oxyrhopus trigeminus* in BJ and PP. All other snakes each appeared at only one site. The most abundant family was Dipsadidae, with eight species.

The dendrogram for all reptile species of the MG region showed BJ and PP as the most similar, while RG differed most from the other localities (Fig. 2).

Similarity between reptiles in MG and other areas in the eastern Parnaíba River Basin

We compared the results for MG with eight previously studied areas in the eastern Parnaíba River Basin (CP, PC, CO, CA, UU, 7C, BR and BT). The richness of reptiles from all studies comprised 100 species: 39 lizards, five amphisbaenians, 50 snakes, four turtles and two crocodylians (Table 2).

Of the nine inventories carried out in the eastern Parnaíba River Basin (PRB), the most specimens and highest richness were found in the Estação Ecológica de Uruçuí-Una (Dal Vechio *et al.*, 2013) and the Parque Nacional Serra das Confusões (Dal Vechio *et al.*, 2016), respectively (Table 2).

Helicops leopardinus (Schlegel, 1837) was found only in MG. From the label, this specimen was found in a small stream near the municipality of Bom Jesus, Piauí (see Appendix 1).

The species found in more than seven localities were *Iguana iguana*, *Ameiva ameiva*, *Salvator merianae*, *Epicrates assisi*, *Spilotes pullatus*, *Oxyrhopus trigeminus*, *Philodryas nattereri*, and *Pseudoboa nigra* (Table 2).

The largest number of reptile species shared by two sites was between CO and UU with 27 species, followed by CO and CA with 23 species. The smallest number of shared species was between 7C and BT, with one species only. The dendrogram for lizards indicated two groups: (1) MG, PC, BT, BR and (2) CA, CO and UU (Fig. 3).

The most common snakes recorded were *B. constrictor* (except in CO, CA, BR, and BT), *Epicrates assisi* (except in PC, CA and BT), *Spilotes pullatus* (except in PC and BT), *Apostolepsis cearensis* (except in PC, CA, BR and BT), *Xenodon merremii* (except in CP, PC, BR and BT), *Oxyrhopus trigeminus*, *Philodryas nattereri* (except in BT), *P. olfersi* (except in MG, CP and PC), *Pseudoboa nigra* (except in MG and BT), and *Crotalus durissus* (except in PC, CA, BR and BT).

The dendrogram for snakes showed similar compositions between (1) MG, CP, 7C and UU; (2) BT and CO; and (3) CA and BR; while PC was less similar, forming a separate cluster (Fig. 4).

The dendrogram resulting from a comparison of all sites and all species showed two groups: (1) MG, BT, BR and PC, and (2) CA, CO and UU (Fig. 5). Areas CP and 7C (only snakes) were not included in

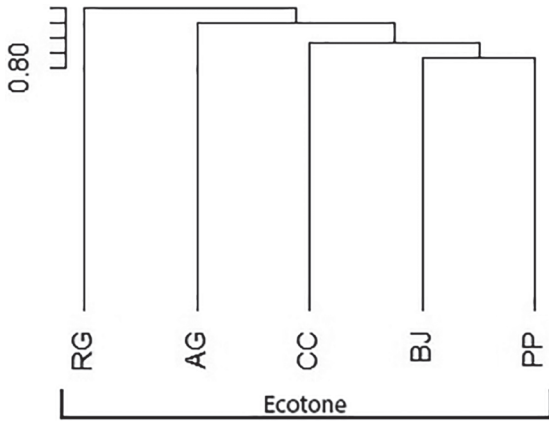


FIGURE 2: Dendrogram for similarity of reptile species compositions in five areas in the Middle Gurguéia (MG), southern Piauí. The rule bar shows the Jaccard coefficient. RG: Redenção do Gurguéia, AG: Alvorada do Gurguéia, CC: Cristino Castro, BJ: Bom Jesus, PP: Palmeira do Piauí.

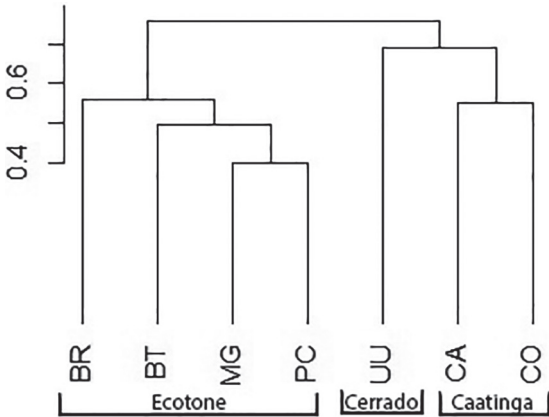


FIGURE 3: Dendrogram for similarity of lizard species composition in the Middle Gurguéia (MG) with previously studied areas in Piauí. The rule bar shows the Jaccard coefficient. BR: Barras, BT: Batalha, MG: Middle Gurguéia, PC: Picos, UU: Estação Ecológica do Uruçuí-Una, CA: Parque Nacional Serra da Capivara, CO: Parque Nacional Serra das Confusões. Castelo do Piauí (CP) and Parque Nacional Sete cidades (7C) were not included in this analysis.

this analysis. However, even if these areas were included, the result would show no bias, resulting in the same topology as Fig. 5, only CP and 7C grouping with UU.

Surprisingly, all dendrograms for the Parnaíba River Basin (Figs. 3-5), including MG, demonstrated a close relationship of the reptile fauna with the environments where they were found: Cerrado (UU), Caatinga (CA and CO) and Cerrado-Caatinga ecotone (PC, BR, MG, BT, 7C, CP). This result was also confirmed by the species that were found exclusively in areas of Cerrado (19 species), Caatinga (14) and Cerrado-Caatinga ecotone (12), as apparent from the symbols in Table 2.

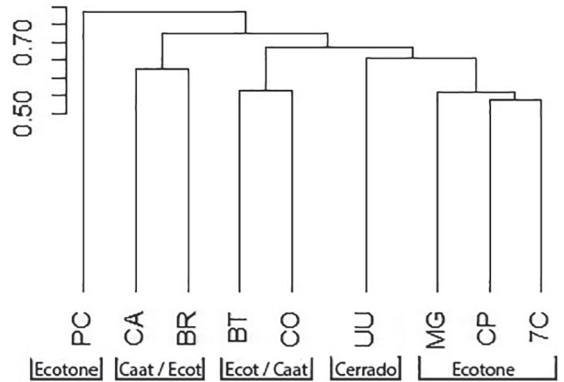


FIGURE 4: Dendrogram for similarity of snake species compositions in the Middle Gurguéia (MG) with other previously studied areas in Piauí. The rule bar shows the Jaccard coefficient. PC: Picos, CA: Parque Nacional Serra da Capivara, BR: Barras, BT: Batalha, CO: Parque Nacional Serra das Confusões, UU: Estação Ecológica do Uruçuí-Una, CP: Castelo do Piauí, 7C: Parque Nacional Sete Cidades.

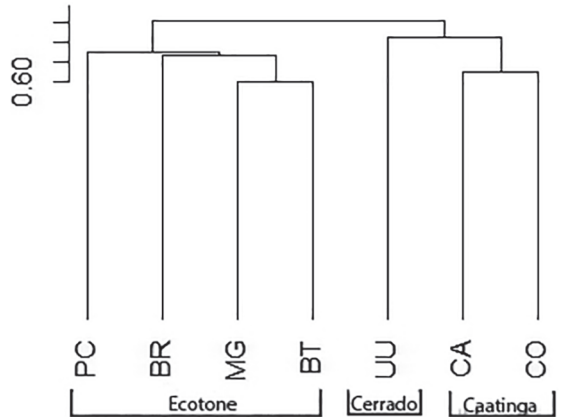


FIGURE 5: Dendrogram for similarity of all reptile species compositions in the Middle Gurguéia (MG) and other previously studied areas in Piauí. The rule bar shows the Jaccard coefficient. PC: Picos, BR: Barras, BT: Batalha, UU: Estação Ecológica do Uruçuí-Una, CA: Parque Nacional Serra da Capivara, CO: Parque Nacional Serra das Confusões. Castelo do Piauí (CP) and Sete Cidades (7C) were not included in this analysis.

DISCUSSION

The reptile assemblage in the Middle Gurguéia

Although this study was based on a collection of reptiles that lacks information about the collection effort, we consider that no data should be discarded or neglected. This assertion is supported by the finding of a specimen of *Helicops leopardinus*, the first record of this species for Piauí. *Helicops* is a genus of semi-aquatic and very specialized snakes (Cisneros-Heredia, 2006), so we suggest that more-thorough collections should be carried out in the Parnaíba River Basin, especially near water bodies.

The list of reptile species found in MG indicates an affinity with the Cerrado-Caatinga ecotone (e.g., *Gymnodactylus geckooides*; *Hemidactylus agrius*; *Vanzosaura rubricauda*) in concordance with results from other studies (Colli *et al.*, 2002; Rodrigues, 2003; Sawaya *et al.*, 2008), although some species (e.g., *Boa constrictor*; *Spilotes pullatus*, *Philodryas nattereri*, *Iguana iguana*, *Ameiva ameiva* and *Salvator merianae*) were found in areas outside these habitats (Henderson *et al.*, 1995; Bérnils *et al.*, 2001; Cicchi *et al.*, 2007; Vaz-Silva *et al.*, 2007). In addition, the fauna of MG was similar only to the inventories carried out in Picos (Benício *et al.*, 2015a), Barras (Benício *et al.*, 2015b) and Batalha (Silva *et al.*, 2015), all areas of Cerrado-Caatinga ecotone (Figs. 3-5), reinforcing the evidence that the composition of the fauna in MG is not associated with the Cerrado or Caatinga biomes separately.

Comparison between species composition in Middle Gurguéia with inventoried areas of eastern Parnaíba River Basin (PRB)

The finding of the largest number of individuals and the highest reptile richness in the inventories conducted in the Parque Nacional Serra da Capivara (CA) and Parque Nacional Serra das Confusões (CO) may result from a higher collection effort in these studies compared to surveys in other localities in the PRB (Rocha & Prudente, 2010; Rodrigues & Prudente, 2011; Cavalcante *et al.*, 2014; Benício *et al.*, 2015a, b; Silva *et al.*, 2015). The CO inventory discovered and described five new species (see Table 2), which was attributed to the collection effort (Dal Vecchio *et al.*, 2016).

The dendrograms of similarity among the nine study areas of the PRB, including MG (Figs. 3-5), showed that the species composition is correlated with the Cerrado, Caatinga or ecotone areas (transitions between these biomes). Species found predominantly in one of these environments may have a narrower niche compared to species found at virtually all sites in the PRB. This argument is supported by studies that demonstrate the association of reptile species with the structure of the environment (Garden *et al.*, 2007; Stumpel & Werf, 2012). Pelegrin *et al.* (2017) described differences in microhabitat preferences in the Caatinga among *Tropidurus hispidus*, *T. helena* and *T. semitaeniatus*, three sympatric species found in the Parque Nacional Serra da Capivara. *Drymoluber brazili*, *Micrablepharus maximiliani* and *Tupinambis quadrilineatus*, which were also found in other areas of Piauí, were recorded in areas with a predominance

of Caatinga, Cerrado-Caatinga ecotone and Cerrado vegetation, respectively (Moura *et al.*, 2010; Freitas *et al.*, 2012; Silva *et al.*, 2013).

Further studies of the degree of interaction of reptile species within the vegetation composition and physical structure in the Cerrado, Caatinga and/or ecotone areas should be conducted to confirm the species-environment association, in order to explain the reptile diversity and composition in the PRB. Understanding the distribution, composition and determining factors for the presence of each reptile species in each environment is fundamentally important for species conservation and management, especially for species that are considered vulnerable, as observed in this study.

CONCLUSIONS

Our examination of this collection revealed a new record for the state of Piauí, the snake *Helicops leopardinus* (Schlegel, 1837). The cluster analysis showed that the reptile fauna in the eastern Parnaíba River Basin is closely identified with Cerrado, Caatinga or ecotonal areas individually.

Because of the rapid landscape transformation in northeastern Brazil, changing Cerrado and Caatinga vegetation complexes (including ecotonal areas) into agricultural areas, it is imperative to understand the diversity of species and their environmental relationships in order to inform the development of conservation strategies, especially in unprotected areas such as the Middle Gurguéia.

RESUMO

Pouco se sabe sobre a diversidade de répteis na bacia do Médio rio Gurguéia, sul do Piauí, Brasil. A rápida expansão da agricultura na região que converte o Cerrado e a Caatinga em grandes áreas de plantio, ameaça a biodiversidade e acelera sua perda. Neste estudo foram examinados 68 espécimes de répteis de uma coleção universitária que compreende 29 espécies: dez lagartos, uma anfisbena, 15 serpentes, duas tartarugas e um crocodiliano, de cinco localidades do Médio Gurguéia, uma região até então não avaliada para esse grupo zoológico. As espécies mais abundantes pertencem ao gênero Tropidurus. Uma análise comparativa com outras oito áreas do leste da bacia do Parnaíba indicou que a diversidade de répteis no Médio Gurguéia é consistente com trabalhos realizados em áreas ecotonais Caatinga-Cerrado. A diversidade de répteis no leste da bacia do Parnaíba

compreende 100 espécies de répteis: 39 lagartos, cinco anfisbenas, 50 serpentes, quatro tartarugas e dois crocodilianos. Além disso, este estudo expande a distribuição para os répteis e registra pela primeira vez a ocorrência da serpente *Helicops leopardinus* (Schlegel, 1837) para o Piauí. A análise de agrupamento mostrou que os répteis possuem identidade com o ambiente em que foram encontrados: Cerrado, Caatinga ou área de ecótono. Desta forma, estudos que associem a estrutura de hábitat com cada espécie são necessários para propor estratégias eficientes de manejo e conservação de répteis para toda a bacia do rio Parnaíba, principalmente em áreas ainda não protegidas.

PALAVRAS-CHAVE: Reptilia; *Helicops*; Ecótono; Cerrado; Caatinga.

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APPENDIX 1

List of the specimens used in this study, followed by the collection site and collection number, housed at the Instituto Butantan, IBSP: Instituto Butantan São Paulo; CRIB: Collection of Reptiles of Instituto Butantan.

Ameiva ameiva (Linnaeus, 1758), Palmeira do Piauí, PI, IBSP.CRIB.0380;

Amphisbaena vermicularis Wagler, 1824, Bom Jesus, PI, IBSP.CRIB.0403; IBSP.CRIB.0404; IBSP.CRIB.0405; IBSP.CRIB.0406; Cristino Castro, PI, IBSP.CRIB.0402;

Apostolepis cearensis Gomes, 1915, Redenção do Gurguéia, PI, IBSP-80.942;

Boa constrictor Linnaeus, 1758, Bom Jesus (Colégio Agrícola UFPI), PI, IBSP-81.301;

Chironius flavolineatus (Boettger, 1885), Palmeira do Piauí, PI, IBSP-80.935;

Crotalus durissus Linnaeus, 1758, PI, IBSP-81.316;

Epicrates assisi Machado, 1945, Bom Jesus, PI, IBSP-81.304; Canto do Buriti (6 km ao sul da cidade, BR135, km 170), PI, IBSP-81.317; Palmeira do Piauí, PI, IBSP-80.933;

Erythrolamprus poecilogyrus (Wied, 1825), Bom Jesus, PI, IBSP-81.302; IBSP-81.303;

Gymnodactylus geckoides Spix, 1825, Bom Jesus, PI, IBSP.CRIB.0394;

Helicops leopardinus (Schlegel, 1837), Bom Jesus, PI, IBSP-80.937;

Hemidactylus smabuia (Moreau de Jonnés, 1818), Bom Jesus, PI, IBSP.CRIB.0395; IBSP.CRIB.0396; Cristino Castro, PI;

Iguana iguana (Linnaeus, 1758), Bom Jesus, PI, IBSP.CRIB.0391;

Leptodeira annulata (Linnaeus, 1758), Redenção do Gurguéia, PI, IBSP-80.943;

Mabuya heathi (Schmidt & Inger, 1951), Palmeira do Piauí, PI, IBSP.CRIB.0393; IBSP.CRIB.0397;

Mesoclemmys tuberculata (Luederwaldt, 1926), Bom Jesus, PI, IBSP.CRIB.0334;

Micrablepharus maximiliani (Reinhardt & Lütken, 1862), Cristino Castro, PI, IBSP.CRIB.0398; IBSP.CRIB.0399; IBSP.CRIB.0400; IBSP.CRIB.0401;

Oxybelis aeneus (Wagler, 1824), Palmeira do Piauí, PI, IBSP-80.936;

Oxyrhopus trigeminus Duméril, Bibron & Duméril, 1854, Bom Jesus, PI, IBSP-80.938; IBSP-80.939; IBSP-80.840; Palmeira do Piauí, PI, IBSP-81.310; IBSP-81.311;

Philodryas nattereri Steindachner, 1870, Alvorada do Gurguéia, PI, IBSP-81.313; Bom Jesus (UFPI), PI, IBSP-81.307; IBSP-81.308; IBSP-81.309; Palmeira do Piauí, PI, IBSP-81.312; IBSP-80.934;

Phrynops geoffroanus (Schweigger, 1812), Bom Jesus, PI, IBSP.CRIB.0335;

Psomophis joberti (Sauvage, 1884), Bom Jesus, PI, IBSP-80.941;

Spilotes pullatus (Linnaeus, 1758), BR135, Km 367, PI, Monte Alegre do Piauí, IBSP-81.314;

Tropidurus hispidus (Spix, 1825), Bom Jesus, PI, IBSP.CRIB.0392; Cristino Castro, PI, IBSP.CRIB.0390; Palmeira do Piauí, PI, IBSP.CRIB.0381; IBSP.CRIB.0382; IBSP.CRIB.0383; IBSP.CRIB.0384; IBSP.CRIB.0385; IBSP.CRIB.0386; IBSP.CRIB.0387; IBSP.CRIB.0388; IBSP.CRIB.0389;

Tropidurus semitaeniatus (Spix, 1825), Palmeira do Piauí, PI, IBSP.CRIB.0373; IBSP.CRIB.0374; IBSP.CRIB.0375; IBSP.CRIB.0376; IBSP.CRIB.0377; IBSP.CRIB.0378; IBSP.CRIB.0379;

Xenodon merremii (Wagler, 1824), Bom Jesus, PI, IBSP-81.305; IBSP-81.306.