Jardim Botânico de Brasília

ISSN 1983-6996
Versão impressa

ISSN 2359-165X
Versão *on line*

Heringeriana

8(2): 202-221. 2014

CONSERVATION UNITS IN THE CORE AREA OF THE CERRADO DOMAIN: AN OVERVIEW ON THE SMALL NONVOLANT MAMMALS (RODENTIA AND DIDELPHIMORPHIA)

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ABSTRACT - A review of small non-volant mammal species of the APA Gama e Cabeça de Veado was carried out, including new surveys in the "Estação Ecológica do Jardim Botânico" (EEJBB) and "Reserva Ecológica do Instituto Brasileiro de Geografia e Estatística" (REIBGE). Thirty-one small mammal's species are registered for the APA Gama and Cabeça de Veado, including one exotic species. *Didelphis albiventris, Hylaeamys megacephalus,* and *Oxymycterus delator* were collected for the first time in EEJBB. The APA Gama e Cabeça de Veado has a central position in the Cerrado domain sharing six species with the Amazon domain, five with Atlantic Forest, and 13 with Caatinga. The APA Gama e Cabeça de Veado encompasses the home range of at least six non-volant small mammal species endemic of Cerrado domain, and it has an important role in the protection of these endemic species and species that occurs in those four South America morphoclimatic domains.

Keywords: APA Gama e Cabeça de Veado, habitat use, karyotype, marsupials, rodents.

RESUMO (Unidades de conservação na área central do domínio Cerrado: um resumo dos pequenos mamíferos não-voadores (Rodentia e Didelphimorphia) **-** Uma revisão das espécies de pequenos mamíferos não voadores da Área de Proteção Ambiental (APA) Gama-Cabeça de Veado foi realizada, incluindo novas coletas na Estação Ecológica do Jardim Botânico (EEJBB) e na Reserva Ecológica do Instituto Brasileiro de Geografia e Estatística (REIBGE). São registrados para a APA Gama e Cabeça de Veado 31 espécies de pequenos mamíferos não voadores, incluindo uma espécie exótica. O número de espécies de mamíferos registradas na EEJBB aumentou para 12, devido aos novos registros de *Didelphis albiventris*, *Hylaeamys megacephalu*s e *Oxymycterus delator*. A APA possui uma posição central no Cerrado, e compartilha seis espécies com o domínio da Amazônia, cinco com o domínio da Mata Atlântica, e 13 com o domínio da Caatinga. A APA abriga parte da distribuição de pelo menos seis espécies de pequenos mamíferos não voadores endêmicos do domínio do Cerrado, e tem um papel especial por fornecer proteção ambiental para estas espécies endêmicas, e para as espécies que ocorrem nesses quatro domínios morfoclimáticos sul-americano.

Palavras-chaves: APA Gama e Cabeça de Veado, cariótipo, marsupiais, roedores, uso do habitat.

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INTRODUCTION

The Cerrado domain is an important center of South American endemism (Cracraft, 1985; Haffer, 1985; Müller, 1973; Rizzini, 1979). Located almost exclusively in central Brazil (IBGE, 2004), the Cerrado domain has around 251 mammal species (Paglia *et al.*, 2012), 25 being endemic species (Carmignotto *et al.*, 2012). The Distrito Federal (DF) of Brazil has a core position in the Cerrado, and encompasses the home range of several endemic species (Bonvicino *et al.*, 2012). The DF region is also interesting because it houses the headwaters of rivers contributing to three major river basins of South America, the São Francisco, Amazon and Paraná-Prata systems.

Small nonvolant mammals of the orders Rodentia and Didelphimorphia compose the majority of endemic species of the Cerrado (Carmignotto *et al.*, 2012; Marinho-Filho *et al.*, 2002). Small mammals present the highest specificity of habitat among the mammals of this domain, as well as limited dispersion capacity (*e.g.*, Lacher *et al.*, 1989; Lacher & Alho, 2001; Mares & Ernest, 1995). The richness of these taxonomic groups in the region shows the importance of a region as key to the biodiversity conservation, in both local and regional scales.

The "Área de Proteção Ambiental das Bacias do Gama e Cabeça de Veado" (APAGCV), located in the central area of the Cerrado domain (IBGE, 2004) is important due to its strategic localization as a buffer area between urban areas and the natural environments in DF, and by harboring hydric resources from both Gama and Cabeça de Veado Basins (Felfili & Santos, 2004).

Based on recent inventory work, herein were report an account of species of small rodents and marsupials of APA Gama e Cabeça de Veado. The aim of this study was to update the list of the small nonvolant mammal fauna with the purpose of increasing the knowledge of the Cerrado small nonvolant mammals of the region and its relationship with neighboring domains. So that, new and published data were used, including the karyotype and geographic distribution of the species in relation to bordering domains.

MATERIAL AND METHODS

Study Area - The APA Gama e Cabeça de Veado (APAGCV) has 25,000 ha, and was created in 1986 between the coordinates 15º52' – 15º59'S and 47º50' – 47º58'W, to include protect and urbanized areas and rural lands. The APAGCV includes three continuous administrative areas, with a number of uses focusing in both environmental education and preservation, such as conservation, research, and enjoyment (Felfili & Santos, 2004). The "Estação Ecológica do Jardim Botânico" (EEJBB) with 5,000 ha is the major area, followed by "Estação Ecológica da Universidade de Brasília", including the Fazenda Água Limpa, with 4,040 ha, and the Reserva Ecológica do Instituto Brasileiro de Geografia e Estatística (REIBGE), previously known (until 1975) as "Reserva do Roncador", with 1,360 ha (figure 1). There is also the "Centro de Instrução e Adestramento de Brasília" (CIAB), a military reserve, and the "Alfa Area", another

military reserve, bordering the APA with 6,000 ha (Carmignotto, 2005). Together, all areas comprise a large protected area in the core part of the Cerrado domain. The soil is predominantly latosol in Paranoá plain, cambisol in hilly ground, litosol in headwaters to southwestern APA, and flooded soil in the valleys (Felfili & Santos, 2004). A mosaic of Cerrado vegetation, including forest and open vegetation formations occur in the area (Ratter, 1991).

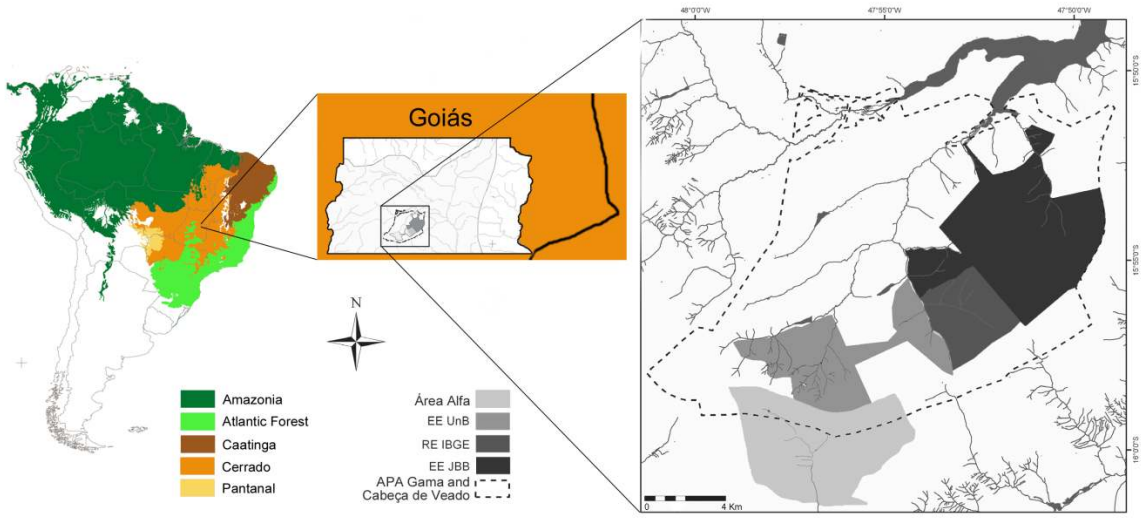

Figure 1. Map showing the APA Gama e Cabeça de Veado, modified from Couto & Aquino (2011).

Sampling procedures - Surveys of small mammals were performed in EEJBB during dry (July 21 to 26, 2013) and rainy (April 10 to 27, 2014) seasons. A survey was also performed in REIBGE in rainy season. Live traps (Sherman® and Tomahawk) were placed in EEJBB in linear ground transects, with a few traps set around one-two meters high in trees. Different vegetation types found in the area were sampled and classified based on previous studies of Cerrado vegetation (Eiten, 1994). A bibliographic review of small mammals previously collected in APA Gama e Cabeça de Veado was also carried out (Table 1).

Two expeditions were carried out with 1,820 traps-nights. A total effort of 880 traps-night was performed during the dry season. Four different vegetation types were sampled with different efforts as follow: (a) "campo sujo" (195 traps-night), (b) "campo de murundum" (251 traps-night), (c) "cerrado *sensu stricto*" (with 88 traps-night), (d) "cerrado rupestre" (200 traps-night), and (e) "campo úmido" (=humid field, 146 traps-night). In the rainy season 940 traps-night were placed as follow: (a) "campo sujo" (160 traps-night), (b) "campo de murundum" (125 traps-night), (c) "cerrado *sensu stricto*" (120 traps-night), (d) "cerrado rupestre" (200 traps-night), (e) “vereda” with humid field (215 traps-night), and (f) gallery forest (120 traps-night). Discrepancies in trap effort were mainly due to vegetation type availability.

Table 1. Species captured in APA Gama e Cabeça de Veado specifying locality, number of specimens followed by the habitat (when available) and font (superscripts). Conservation units acronyms: EEJBB = Estação Ecológica do Jardim Botânico de Brasília, REIBGE = Reserva Ecológica do Roncador IBGE, FAL = Fazenda Água Limpa, CIAB = Centro de Instrução e Adestramento de Brasília, AA = Área Alfa. CT = cerrado *sensu stricto*, CD = cerradão, CL = campo limpo, CR = cerrado rupestre, CS = campo sujo, CU = campo úmido, GF = gallery forest, MU = campo de murundum. [a] = Santos & Henriques (2010), [b] = Amaral (2005), [c] = Silva (2013), [d] = Briani *et al*. (2004), [e] = Carmignotto (2005), [f] = Locks (1981), [tsD] = this study in dry season, [tsR] = this study in rainy season.

Taxon	APA	JBB	FAL	IBGE	CIAB	AA
DIDELPHIMORPHIA						
Caluromys lanatus	4 CD[c], 4 GF[c]		e			
Cryptonanus agricolai				1 CT [tsR], e	1GF, 3CT, 3 Campo cerrado, 1CL[e]	
Didelphis albiventris	4 CT[c], 14 CD[c], 4 GF[c], CT[d]	1 VE-1 GF[tsR]		e		
Gracilinanus agilis	22 CT[c] 14 CD[c], 42 GF[c], CT[d]	83 CD[b], 1 CT[tsD], 5 GF[tsR]		29 CD[b], e		
Monodelphis americana	1 CD[c]		e	2 CD[b], e	e	
Monodelphis kunsi			e	e		
Philander opossum				e		
Thylamys velutinus	CT[d]			e		
RODENTIA						
Cavidae						
Cavia aperea			e	e	CU[e]	
Echimyidae						
Phyllomys sp.	1 GF[c]					
Proechimys roberti	3 GF[c]		e	e	GF[e]	
Thrichomys sp.*						
Sigmodontinae						
Akodon gr. *cursor*.			e	e		

Calomys expulsus	1 CT[c], 1 CD[c], CT[d]		1 CR[a]	e	e	
Calomys tener	CT[d]	4 CR[a], 1 GF[tsR]	46 CR[a], e	e, 2 CT[tsR]		e
Cerradomys scotti	15 CT[c], 3 CD[c]	3 CR[tsD], 1 MU[tsD], 2 CR[tsR], 2 CR[a], 3 CD[b]	12 CR[a], e	1 CD[b], e	CT, campo cerrado, CS[e]	
Hylaeamys megacephalus	7 CD[c], 15 GF[c]	1 GF[tsR], 3 CD[b],	e	2 CD[b], e	GF, CU[e]	
Microakodontomys transitorius					CL, CU[e]	
Necromys lasiurus	5 CT[c], CT[d]	7 CR[a], 5CS-7CU-16MU[tsD], 3MU-3VE-5CS-2 [tsR]	3 CR[a], e	e, 3 CT[tsR]	CT, campo cerrado, CS, CL, CU[e]	e
Nectomys rattus	1 MG[c]			e	GF[e]	
Oecomys bicolor **	5 CD[c], 27 GF[c]		e	e	GF[e]	e
Oecomys cleberi		1 VE[tsR]	1[f]			
Oecomys catherinae	5 GF[c]					
Oligoryzomys mattogrossae		1 CR[tsD], 2 CR[a]	7 CR[a], e	e , 5 CT[tsR]	GF, CL, CU[e]	
Oligoryzomys nigripes			e	e , 1 CT[tsR]	e	
Oxymycterus delator		4 CU[tsD], 1 MU[tsR]	e	e	12 GF-CU-CL[e]	
Rhipidomys macrurus	13 CD[c], 25 GF[c]	11 CD[b]	e	12 CD[b], e		e
Thalpomys cerradensis	CT[d]		e			
Thalpomys lasiotis		4 CR[a], 1 GF[tsE]	2 CR[a], e	e		
Wiedomys cerradensis	CT[d]					
Muridae						
Mus musculus	CT[d]					

* Registered in the APA, but without specific locality (Fonseca & Redford, 1984). ** Rocha *et al*. (2012) postulated that this species did not occur in Distrito Federal, and species identified as *Oecomys bicolor* probably belong to *O. cleberi*.

Simultaneously, in the second expedition, system interception and fall traps, herein called pitfall traps, were arranged in transects placed on "cerrado *sensu stricto*" with different post-fire succession areas in the REIBGE (see Costa *et al*., 2013). In five areas, named A (15°57'18.6" S and 47°52'18.9"W), B (15°56'6.8"S and 47°52'11.0" W), C (15°56'12.2"S and 47°52'6.5"W), D (15°56'16.8"S and 47°52'3.1"W) and E (15°56'1.5"S and 47°52'14.7"W), 40 plastic buckets of 20 L were arranged in 10 sites, each containing four buckets connected by 6 m x 0.5 m of galvanized plate fences and arranged on a Y-shaped setting with 120° angles, being one central and three peripheral. A total effort of 1,200 pitfalls-night was employed with this method. In EEJBB (15°53'09.4" S and 47°50'30.6" W) and REIBGE (15°56'47.64"S and 47°52'8.26"W), 80 Polyvinyl Chloride (PVC) pipes with 20 L and 30 cm of diameter were arranged on a Y-shaped setting with 120° angles, being one central and three peripheral, in two gallery forests (40 pvc pipes in each), respectively.

Voucher specimens will be deposited in the mammal collection (LBCE) of the Laboratório de Biologia e Parasitologia de Mamíferos Silvestres Reservatórios, IOC, Fiocruz, Rio de Janeiro, RJ. The acronym CRB refers to Cibele R. Bonvicino's field number (SISBIO license number 11375-1).

Comparative success of capture with live traps are expressed as percentage (%) calculated by dividing the total number of individuals of each species caught in each habitat by the effort applied in this habitat (number of Sherman® was traps used). The relative abundance of species estimate dividing the number of specimens of each species by the number of captured specimens (Magurran, 2004).

To confirm the species identification some specimens were karyotyped in the field. Chromosome preparations were obtained from short-term bone marrow cultures following Andrade *et al*. (2004). FNa refers to autosome fundamental number. Taxonomic nomenclature and species distribution follows Patton *et al.* (2015) for rodents and Gardner (2008) for marsupials. When additional data is included, it is cited in the respective species section.

Sampling efficiency was evaluated by accumulation and rarefaction species curves (Gotelli & Colwell, 2001). Species accumulation curves and Jackknife were estimated with EstimateS 8.2.0 (Colwell, 2004). The second-order Jackknife estimator (Jackknife 2) was used due to its efficiency in conditions of low equability (Brose *et al.,* 2003).

RESULTS

Eight marsupial and 23 rodent species were collected in the APA Gama e Cabeça de Veado (Table 1), including one exotic species, *Mus musculus*. In our survey 12 species were collected, some of them only in pitfall traps (Table 2). Species accumulation curves by sampling day showed a tendency to increase (Figure 2), with one species added by day of sampling. The estimated richness for EEJBB and REIBGE was 19.79 species, representing 68% of the richness of the APA.

Table 2. Taxa and number of specimens collected in EEJBB and REIBGE with life traps (first and second expeditions – represented between brackets with first/second numbers, respectively), and pitfalls (second expedition only).

Taxa	Life trap	Pitfall
Didelphimorphia		
Cryptonanus agricolai	0/0	1
Didelphis albiventris	0/2	0
Gracilinanus agilis	1/5	0
Rodentia		
Calomys tener	0/0	4
Cerradomys scotti	4/2	0
Hylaeamys megacephalus	0/1	0
Necromys lasiurus	28/13	3
Oecomys cleberi	0/1	0
Oligoryzomys mattogrossae	1/0	5
Oligoryzomys nigripes	0/0	1
Oxymycterus delator	4/1	0
Thalpomys lasiotis	0/0	1

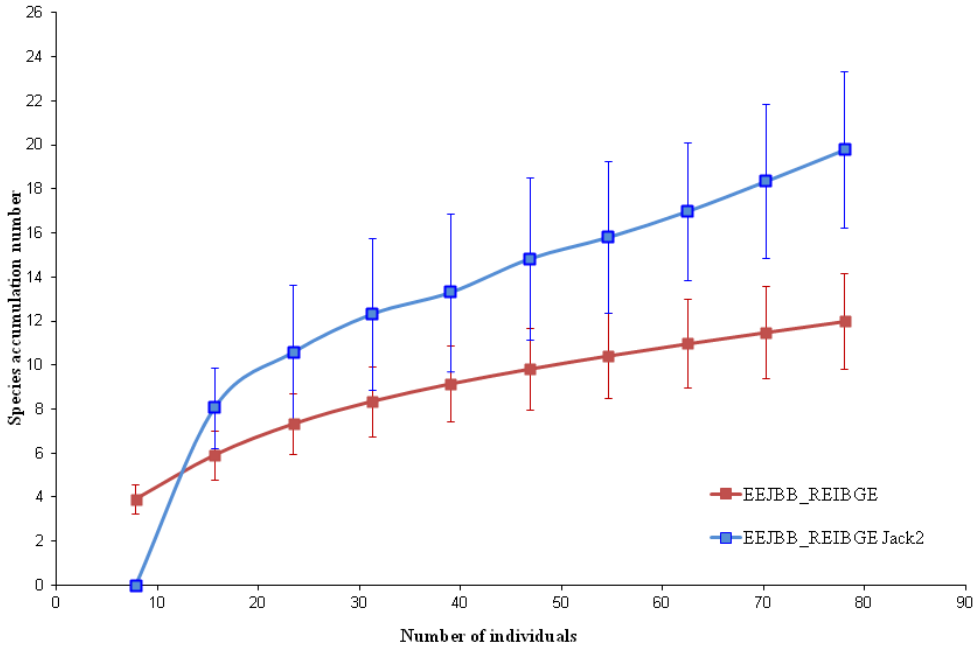

Figure 2. Species accumulation curve. Mean and mean rarefaction curves of the increased number of species registered with the increase in sampling effort and in the number of individuals surveyed in the EEJBB and REIBGE. Bars are the standard deviation from each mean value.

During the rainy season, "cerrado *sensu stricto*" presented 5% of success, followed by "campo sujo" with 3.7%, "campo de murundum" with 3.1%, "vereda and campo úmido" with 2.3%, "cerrado rupestre" with 1.0% and gallery forest with 0.8%. The marsupials represented 30% of the community and the rodents accounted for 70%, being *N. lasiurus* the most abundant species (50%) followed by *G. agilis* with 20.8%, and *Cerradomys scotti* and *Didelphis albiventris* with 8.2%. The species richness was similar in the "cerrado rupestre", "campo sujo" and gallery forest, with only one species captured, while two species were captured in "campo de murundum" (*Necromys lasiurus* and *Oxymycterus delator*), and "cerrado *sensu stricto*" (*Gracilinanus agilis* and *Didelphis albiventris*).

Oligoryzomys mattogrossae showed 2n = 62 and FNa = 65, a large sized submetacentric X chromosome, and a small sized acrocentric Y chromosome (Figure 3A). *Oligoryzomys nigripes* showed 2n = 62 and FNa = 82 (Figure 3B), a large sized metacentric X chromosome and a small sized Y chromosome. *Oxymycterus delator* showed 2n = 54 and FNa = 64, a large sized X chromosome and a small sized submetacentric Y chromosome (Figure 3C). *Cerradomys scotti* showed 2n = 58 and FNa = 70, with a large sized submetacentric X chromosome and a medium sized submetacentric Y chromosome (Figure 3D). *Necromys lasiurus* showed 2n = 34 and FNa = 34, a medium sized acrocentric X chromosome, and a small sized Y chromosome (Figure 3E).

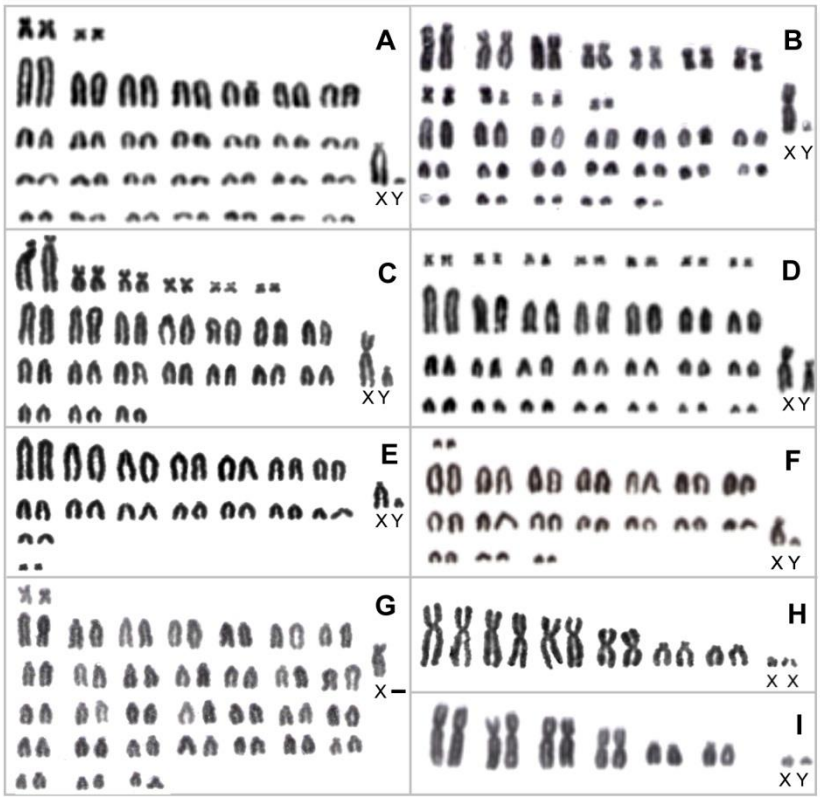

Figure 3. Karyotypes in Giemsa stain coloration of selected specimens captured in EEJBB and REIBGE. **A.** *Oligoryzomys mattogrossae* male CRB3141. **B**. *Oligoryzomys nigripes* male CRB3291. **C.** *Oxymycterus delator* male CRB3146. **D.** *Cerradomys scotti* male CRB3130. **E.** *Necromys lasiurus* male, **F.** *Thalpomys lasiotis* male CRB3292. **G.** *Calomys tener* male CRB 3278. **H.** *Gracilinanus agilis* female CRB3161. **I.** *Cryptonanus agricolai* male CRB3279. **X and Y** = female and male sexual chromosomes.

Thalpomys lasiotis showed 2n = 38 and FNa = 38, with a large submetacentric X chromosome and a small Y chromosome (Figure 3F). *Calomys tener* showed 2n = 66 and FNa = 66, with a large submetacentric X chromosome (Figure 3G). *Gracilinanus agilis* showed 2n = 14, with a small X chromosome (Figure 3H). *Cryptonanus agricolai* showed 2n = 14, with a small X chromosome (Figure 3I). *Hylaeamys megacephalus* showed 2n = 54 and FNa = 62, and a median sized acrocentric X chromosome (not showed).Some species were captured only in the pitfall traps in EEJBB and REIBGE, *Cryptonanus agricolai, Oligoryzomys mattogrossae,* and *Necromys lasiurus* were captured in "cerrado *sensu stricto*", and *Thalpomys cerradensis* and *Calomys tener* in gallery forest (Table 2). Data about use of habitat and small mammal richness for previous and presently recorded species in the APA Gama and Cabeça de Veado are discussed below.

DISCUSSION

Richness and Habitat use – Based on our surveys and literature review, we found 30 native species of non-volant small mammals in the APA Gama e Cabeça de Veado area, which comprises 68% of the expected species of these mammals (orders Rodentia and Didelphimorphia). The high species' richness for the Cerrado domain can be partially attributed to habitat specificity of the small mammals, leading to a different faunal composition among the different phytophysiognomies (Alho *et al*., 1986; Mares *et al*., 1986; Henriques *et al*., 1997; Carmignotto *et al*., 2014). Furthermore, some species present specific microhabitat use (Lacher & Alho, 2001). Still around 30% of this community was not sampled, indicating that a higher capture effort, including other diversified capture methods, such as traps on tree canopy, and/or surveying along more intermediary seasons could sample more species.

The didelphid *Cryptonanus agricolai* was captured only with pitfall trap in the "cerrado *sensu stricto*" of REIBGE (Table 1). This species also was captured in "vereda" (Bonvicino *et al*., 2012). However, it is possible that *C. agricolai* is restricted to the Caatinga, and that the Cerrado specimens belong to another taxon (A.P. Carmignotto unpub. data in Bezerra *et al*., 2014). *Gracilinanus agilis* is inhabitant of forested formations, being more frequently collected in "cerradão" and gallery forest (Amaral, 2005; Henriques *et al*., 1997). It was collected in "cerrado *sensu stricto*", and in the APA it was also registered in "cerradão" and gallery forest (Table 1). In the Cerrado domain *Gracilinanus agilis* populations can show a decrease in the dry season (Amaral 2005), which would can explain the smaller number of individuals (1) caught in this study during the dry season. *Didelphis albiventris* is a generalist and widespread species able to use both altered and conserved, forested and open vegetation formations, as well as urban ambient (Bonvicino *et al*., 2002, 2012). It was captured in "vereda" and gallery forest in the rainy season, but in the APA it was also registered in "cerradão" (Table 1).

Among the rodent species, *Calomys tener* use a wide range of habitat in open vegetation formation as "campo sujo" to forested formations as "cerradão", being more frequent in "cerrado *sensu stricto*" (Alho *et al*., 1986; Mares *et al*., 1986; Henriques *et al.*, 1997). It was collected in gallery forest and "cerrado *sensu stricto*", and in the APA it was also registered in "cerrado rupestre" (Table 1), suggesting that this species is generalist in the habitat use. *Cerradomys scotti* can be considered a generalist species. It occurs in a variety of vegetation types from "campo limpo" to "cerradão" (Amaral, 2005; Briani *et al*., 2004; Henriques *et al*., 1997; Lacher & Alho, 2001; Santos & Henriques, 2010; Silva, 2013). It was collected in "cerrado rupestre" and "campo de murundum", and in the APA it was also registered in "cerradão", and "cerrado *sensu stricto*" (Table 1). This is the first time that *C. scotti* was registered in "campo de murundum" in the EEJB. *Hylaeamys megacephalus* was captured in gallery forest, but in the APA it was also registered in "cerradão" (Table 1). This is a generalist, abundant and common species in both natural and altered vegetation in Cerrado occurring in forested formation like "cerradão", gallery forest and semideciduous forest and in open vegetation formation like "cerrado *sensu stricto*" and "campo cerrado" (Bonvicino *et al*., 2011).

Necromys lasiurus is a generalist species usually found in high densities in open areas of the Cerrado domain (Magnusson *et al*., 1995). It was captured in "campo sujo", "campo de murundum", "vereda" and "campo úmido", and in the APA it was also registered in "cerrado rupestre" and "cerrado *sensu stricto*" (Table 1). This was the most captured species in both expeditions, a similar result found by Alho and Souza (1982) and Becker *et al.* (2007) in Cerrado of central Brazil. Carmignotto *et al*. (2014) and Vieira *et al.* (2005), nevertheless, found high variation of population size throughout the year, which could be explained by differential availability of food resources. *Oligoryzomys mattogrossae* can be considered a generalist species, occurring in several habitats, from open grasslands to forested environments such gallery forest and "vereda" (Carmignotto, 2005). It was captured in the "cerrado rupestre" and "cerrado *sensu stricto*" (Table 1). *Oxymycterus delator* can be considered a habitat specialist species. This species is mainly found in moist and opened habitats, and in the edge of forest gallery (Bonvicino & Bezerra, 2003; Carmignotto, 2005; Marinho-Filho *et al*., 1998). It was captured in "campo úmido" and "campo de murundum", and in the APA it was also registered in "campo limpo" and gallery forest (Table 1). *Thalpomys lasiotis*, a habitat specialist species, locally abundant, is common in regurgitated of barn owl and was found in "campo de murundum" and "campo úmido" in the Cerrado of Bahia state (Bonvicino *et al*., 2012). It was collected in gallery forest, and in the APA it was also captured in "cerrado rupestre" (Table 1).

Oecomys cleberi inhabits forest formations as all species of the genus. It was captured in "vereda" during the rainy season; it was already registered in the APA, however without specify habitat (Table 1). *Oecomys cleberi* is only confidently known from a small

number of localities (four from Rocha *et al.,* 2012, plus the specimen herein collected). However, several records of small-sized *Oecomys* from the Cerrado of central Brazil are currently assigned to *O. bicolor* (*e.g*., Mares & Ernest, 1995; Marinho-Filho *et al*., 2002; Alho, 2005) and may represent *O. cleberi* (see discussion in Carmignotto *et al.*, 2014), and should be reanalyzed since the two species are morphologically similar (Rocha *et al.*, 2012).

Different phytophysiognomies were inventoried in other studies in the APA Gama e Cabeça de Veado (Table 1), and some species appear have restricted habitat use, such as *Oecomys catherinae, Oecomys* '*bicolor*'*, Nectomys rattus, Phyllomys* sp.*, Proechimys roberti, Thalpomys lasiotis, Thylamys velutinus, Rhipidomys macrurus, Monodelphis americana,* and *Caluromys lanatus*, that occur only in forest formations (*e.g.,* gallery forest and "cerradão", Table 1). The segregation pattern between open vegetation and forested habitats is characteristic in Cerrado small nonvolant mammals (Bonvicino *et al*., 1996; Bonvicino *et al*., 2002; Carmignotto, 2005; Carmignotto *et al.*, 2014; Lacher & Alho, 2001; Talamoni & Dias, 1999).

Karyotypic considerations - Small nonvolant mammals of subfamily Sigmodontinae are characterized by morphological similarity between related species, and karyotype data are very useful in supporting the identification of cryptical and undescribed species.

Oligoryzomys mattogrossae is characterized by 2n = 62 and FNa = 64 in specimens identified as *O. fornesi* from Brazilian localities, such as in the Cerrado of Goiás state (Trott *et al*., 2007, Bonvicino *et al*., 2011), Bahia (Pereira & Geise, 2007, Bonvicino *et al*., 2012), and Distrito Federal (Svartman, 1989), and in localities from Caatinga of Pernambuco state (Furtado, 1981). *Oligoryzomys mattogrossae* karyotype, 2n = 62 and FNa = 65, herein found, differs from those already described due to one pericentric inversion affecting one chromosome of one medium sized pair of acrocentric chromosome (pair 7, Figure 3A). *Oligoryzomys nigripes* karyotype (Figure 3B) was similar to the previously described specimens (Paresque *et al*., 2007) from almost all its distribution in Brazil, including areas in Cerrado, Caatinga, and Atlantic Forest. *Cerradomys scotti* showed karyotype (Figure 3D) similar to others described from several localities of Cerrado of Goiás and Bahia states, and in the Distrito Federal (Bonvicino *et al*., 1999). *Necromys lasiurus* showed karyotype (Figure 3E) similar to the described for this species in localities in the Caatinga of Bahia (Pereira & Geise, 2007) and Pernambuco states (Geise *et al.*, 2010), Cerrado of Minas Gerais (Moreira *et al.,* 2009) and Goiás states (Bonvicino *et al.,* 2005, 2007a), and Atlantic Forest of São Paulo state (Bonvicino *et al*., 2007b). *Oxymycterus delator* showed 2n = 54 and FNa = 62 (Figure 3C), similar to karyotypes described for this species in localities in the Cerrado of Goiás (Bonvicino *et al.,* 2005). *Thalpomys lasiotis* showed 2n = 38 and FNa = 38 (Figure 3F), similar to the karyotype reported for other specimens from Brasília (Armada *et al*., 1983; Yonenaga-Yassuda *et al.,* 1987; Andrade *et al*., 2004). *Hylaeamys megacephalus* showed

karyotype similar to those described for specimens from Goiás state (Bonvicino *et al.* 2011).

Gracilinanus agilis specimens showed 2n= 14 and FNa= 24 (Figure 3H), similar to karyotypes described to specimens from Cerrado localities in the states of Goiás (Bonvicino *et al*., 2011), Bahia (Bonvicino *et al*., 2012), Minas Gerais (Geise & Astúa, 2009), and Mato Grosso (Garcia *et al*., 2010). *Cryptonanus agricolai* specimen showed 2n = 14 and FNa = 24 (Figure 3I), similar to the karyotype reported for this genus (Voss *et al*., 2005).

Small mammal's fauna affinities with other domains - Several studies were carried out with small mammals in APA Gama e Cabeça de Veado (*e.g*., Amaral, 2005; Briani *et al.,* 2004; Santos & Henriques, 2010; Silva, 2013) with 29 species inventoried, seven marsupials and 22 rodents, including an exotic species, *Mus musculus* (Table 1).

The affinities of Cerrado species inhabitants of forested formations with the Amazon fauna, and the Cerrado species inhabitants of open vegetation formation with the Caatinga were already detected in previous studies in the northeastern of Cerrado domain (Carmignotto & Aires, 2011). The APA Gama e Cabeça de Veado shared four species with the Amazon domain: *Philander opossum*, *Hylaeamys megacephalus*, *Oecomys 'bicolor'*, and *Proechimys roberti* (Bonvicino *et al*., 2008; Figure 4), and the two widespread species *Necromys lasiurus* and *Nectomys rattus*, that also occur in Amazon. The local fauna of APA Gama e Cabeça de Veado also shared several elements with Atlantic Forest, like *Calomys tener*, *Oecomys catherinae*, *Phyllomys* sp., *Oligoryzomys nigripes*, and *Monodelphis americana* (Figure 4). Data herein presented are in agreement with the postulation that the Amazon and the Atlantic Forest are not exclusive in terms of their small mammal faunas; both overlap broadly with taxa occurring in gallery forests and dry forests in the Cerrado of central Brazil (Costa, 2003). The APA is located in the Brazilian Distrito Federal that houses the headwaters of two major river basins of South America, the Amazon basin in the Amazon domain, and the Platinum basin in the Atlantic Forest domain (IBGE, 1977). The connection of these two basins with the studied area plays a fundamental role for the presence of the shared fauna with Atlantic Forest and Amazon.

The small nonvolant mammal community of APA Gama e Cabeça de Veado has, at least, five of the nine endemic species of Cerrado domain (Carmignotto *et al.*, 2012) - *Microakodontomys transitorius, Oecomys cleberi*, *Thalpomys cerradensis*, *Thalpomys lasiotis*, and *Thylamys velutinus* (Table 1 and Figure 4) - showing the importance of this protect area. This APA shared 13 elements with the small nonvolant mammals found in Caatinga, *Cryptonanus agricolai, Didelphis albiventris*, *Gracilinanus agilis*, *Monodelphis americana*, *Calomys expulsus*, *Necromys lasiurus*, *Nectomys rattus*, *Oligoryzomys mattogrossae*, *O. nigripes*, *Oxymycterus delator, Rhipidomys macrurus*, *Wiedomys cerradensis*, and *Cavia aperea* (Carmignotto *et al*., 2012). About 20% of the

mammalian fauna of Cerrado and Caatinga domains are endemic of both domains, with the majority of these 48 endemic species strongly associated with open habitats, and most of them represent lineages that diversified in open-country formations (Carmignotto *et al*., 2012). This picture shows the importance of this protected area for species that occurs in these four important South America morphoclimatic domains.

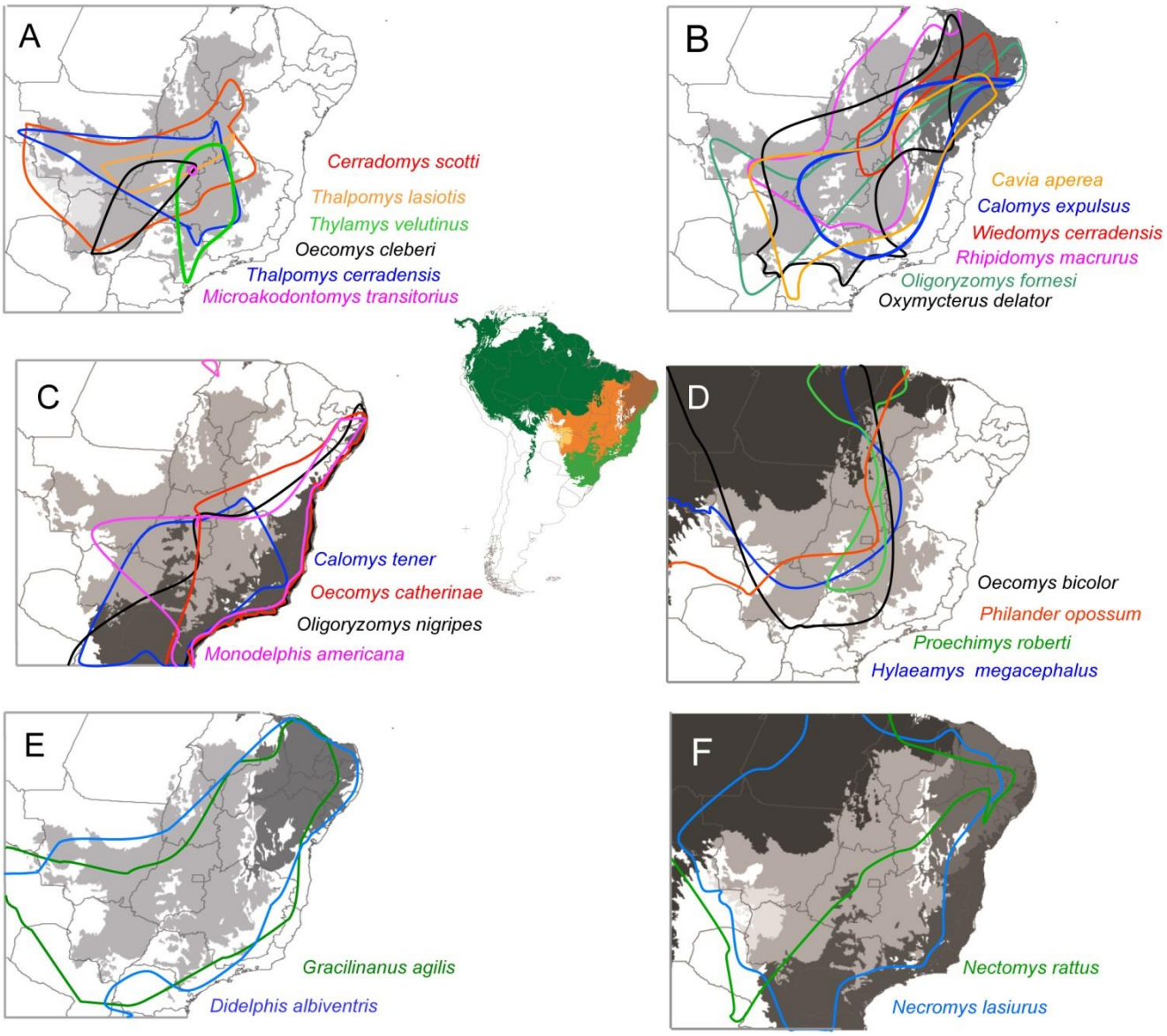

Figure 4. South America map showing the major Brazilian domains, Cerrado in orange, Pantanal in yellow, Caatinga in brown, Amazonia in dark green, and Atlantic Forest in light green, and maps showing the geographic distribution of APA Gama e Cabeça-de-veado species with species of **A.** endemic of Cerrado domain, **B.** Cerrado and Caatinga domains, **C.** Cerrado and Atlantic Forest domains, **D.** Cerrado and Amazonia domains, **E-F.** widespread distributions. The geographic distributions of *Oecomys bicolor* and *O. cleberi* need further review.

ACKNOWLEDGEMENTS

We are grateful for help in fieldwork to Scott M. Lindbergh, Carlos J.S. Morais, Gabriel O. Caetano, Heitor C. Sousa, Moisés L.G. Siqueira, Rogério C. Santana, Sara Fagundes. To Guarino R. Colli by permitting the use of the pitfall traps. We are also grateful to Jardim Botânico de Brasília, especially to Vânia de A. Soares for laboratories facilities, and to REIBGE, especially to Betânia Goes for the study authorization and access in the RECOR. To Héctor N. Seuánez for corrected a draft of this manuscript. Work supported by CNPq grant 307669/2013-0 and FAPERJ grant E26/102.956/2011 to CRB, CAPES/FAPERJ grant E26/102.804/2011 to AL, and CNPQ grant 372459/2013-7 to ARB. License for collection was given by SISBIO.

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