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Small Non-Volant Mammals of an Ecotone Region between the Cerrado Hotspot and the Amazonian Rainforest, with Comments on Their Taxonomy and Distribution

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Alexandra M. R. Bezerra, Ana Paula Carmignotto, and Flávio H. G. Rodrigues (2009) Small non-volant mammals of an ecotone region between the Cerrado hotspot and the Amazonian rainforest, with comments on their taxonomy and distribution. *Zoological Studies* **48**(6): 861-874. Araguaia National Park is located on Bananal I., Tocantins state, Brazil. This conservation unit exists in the transitional area between Cerrado, a tropical savanna hotspot, and Amazonian biomes. Transitional zones are thought to be characterized by high species richness due to the overlap of species distributional ranges, and by a high level of endemism provided by the uniqueness of these regions. The aim of this study was to survey small non-volant mammals and analyze the species composition, richness, and endemism in order to test the above hypotheses, and to contribute to the increasing knowledge of the mammalian fauna of the Cerrado, since the northern portion of this biome is one of the most poorly known. We surveyed marsupials and small rodents using both live and pitfall traps with total trapping efforts of 2259 live trap-nights and 3200 pitfall trap-nights. We found that typical inhabitants of the Cerrado biome occurred side by side with species commonly distributed in the Amazonian rainforest, in addition to the presence of 2 regionally endemic rodents. Nevertheless, the low species richness (13 species) and percentage of endemics surveyed demonstrate that Bananal I. presents some special characteristics, such as climate seasonality and periodic inundation, which may have influenced the small non-volant mammal community richness and composition, which need to be further studied.
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Transitional or tension zones are generally found in areas of contact between different ecosystems (RADAMBRASIL 1981, IBGE 1993). These areas are extremely complex and usually composed of a mosaic of physiognomies, or of special ones restricted to these contact zones (Ab'Sáber 1977, Oliveira-Filho and Ratter 2002). Biogeographically, transitional regions are thought to be characterized by high species richness due to the overlap of species distributional ranges, being composed of inhabitants of adjacent biomes, and also by a high level of endemism provided by the uniqueness of the regions (Vitt 1991, Silva 1995, New 2002, Ratter et al. 2003, Cáceres et al. 2007).

Araguaia National Park (ANP) is located on Bananal I., Tocantins state, Brazil, in a transitional area between the Amazon, an evergreen Neotropical rainforest that covers approximately 7 × 10^6 km^2 throughout Brazil, and the Cerrado of central Brazil, which covers approximately 2 ×

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10^6 km^2 and is the largest and richest Neotropical savanna (IBGE 2004). The Amazon-Cerrado contact zone is very broad (7950 km) ranging from the state of Maranhão to Mato Grosso along a northeast-southwest axis (Dinerstein et al. 1995, Silva 1996). This transitional area is characterized by the presence of permanently moist to semideciduous forests and gallery forests that penetrate the Cerrado along major South American rivers, such as the Tocantins and Araguaia (Eiten 1972, Ackerly et al. 1989).

Additionally, ANP harbors a great variety of habitat types characteristic of the Cerrado, ranging from open grasslands to semideciduous and gallery forests (RADAMBRASIL 1981, Eiten 1994). The coexistence of physiognomies from these distinct ecosystems makes this area biogeographically important. The Araguaia River region was pointed out as being a priority area for conservation because of its high biological importance and level of endemism (Ramsar Wetlands Convention 1998, MMA 2006). The fauna and flora of this region are poorly known, and large areas have yet to be surveyed, which makes biogeographical analyses and the elaboration of conservation proposals difficult (Silva and Bates 2002).

Small non-volant mammals (small rodents and marsupials) comprise the majority of endemic species of the Cerrado (Fonseca et al. 1999, Marinho-Filho et al. 2002, Carmignotto 2005), and are also the ones which present greater habitat selectivity and smaller dispersion capacities among Neotropical mammals (e.g., Emmons 1984, Mares et al. 1986, Lacher et al. 1989, Mares and Ernest 1995, Lacher and Alho 2001). These characteristics also make small mammals more vulnerable to habitat changes, especially to rapid and vast anthropogenic ones (Carmignotto 1999), highlighting the importance of this group in understanding both the diversity and biogeography of the Cerrado fauna (Marinho-Filho et al. 2002, Carmignotto 2005).

In the last decade, several taxonomic publications revealed a high number of endemic species in the Cerrado (e.g., Bonvicino and Weksler 1998, Langguth and Bonvicino 2002, Bonvicino 2003, Bonvicino et al. 2003). However, there is only 1 study on the small-mammal community in the Araguaia River region, which was located about 500 km to the south of Bananal I., localized in a core area of the Cerrado biome (Bonvicino et al. 1996).

The objective of this study was to survey small non-volant mammals of ANP since it is located in a transitional area between the Cerrado and Amazon rainforest in order to test whether this community is characterized by Amazon and Cerrado inhabitants, by high species richness, and by a high number of endemic species. Additionally, we hoped to contribute to increasing knowledge about the marsupials and rodents of the Cerrado, providing comments about the taxonomy and the geographic distributions of the species surveyed.

MATERIAL AND METHODS

Study area

ANP is located on the northern portion of Bananal I. Bananal I. is one of the larger fluvial island in the world and was formed in the Araguaia River, a very important river of the Araguaia-Tocantins basin with headwaters ca. 800 km into the Cerrado biome, and its mouth at the Tocantins River, a tributary of the Amazon River (Fig. 1). ANP has an area of 557,714 ha (IBAMA 2004) situated in the municipalities of Pium and Lagoa da Confusão, in southwestern Tocantins state, adjacent to Mato Grosso state (10°27'S, 50°29'W) (Fig.1). The landscape of ANP is characterized by the presence of open and forested physiognomies typical of the Cerrado biome, such as campo limpo, an open dry grassland with no shrubs or arboreal cover; campo de murundum, an open grassland formation with islands of dense vegetation; campo úmido, an open humid grassland formation; and cerrado *sensu stricto*, a savanna dominated by shrubs and trees, often 3-8 m high, comprising up to 40% of the arboreal cover (see Eiten 1994); in addition to flooded and unflooded gallery forests and semideciduous forests patches (Floresta Estacional Decidual Submontana) (RADAMBRASIL 1981, IBGE 1993).

The climate is classified as Köppen's Aw: Tropical chuvoso (RADAMBRASIL 1981), with a moist summer and dry winter. The average annual precipitation is between 1750 and 2000 mm, with a rainy season between Oct. and Mar./Apr.; and a dry season restricted to May-Sept., with < 50 mm of monthly precipitation in June-Aug. (RADAMBRASIL 1981, IBAMA 2004). The temperature ranges 8-42°C throughout the year, with a mean annual temperature of 24-26°C (RADAMBRASIL 1981, IBAMA 2004). This region is characterized by extensive plains, at around 200-220 m in elevation. The relief together with the presence of hydromorphic soils and a shallow water table causes periodic inundations, especially in months of higher rainfall (Jan.-Mar.), when the island is partially submerged (RADAMBRASIL 1981).

Sampling procedures

A survey of small non-volant mammals was carried out from 30 Mar. to 14 Apr. 1999 during the late rainy season, using 2 different methods of live and pitfall traps. These methods were used because they were shown to be complementary by capturing different species and individuals of the community (Voss and Emmons 1996, Hice and Schmidly 2002). Each capture station was composed of 1 live-capture trap (Sherman® 7.6 × 8.9 × 22.9 cm; H.B. Sherman® Folding Traps, Tallahassee, FL.) placed in the soil or in the understory. The capture stations were established at 13 m intervals along linear transects that varied in length according to the size of the vegetation patch (with 30-50 capture stations). The bait was a mixture of peanut butter, sardines, banana, and maize flour. The total effort for this method was of 2259 trap-nights (Table 1). We also placed 25 capture stations with pitfall traps in 2 points surveyed: an open dry grassland formation and a semideciduous forest patch. The capture stations were composed by 4 buckets of 35 L each, which were spaced 8 m apart and dispersed in the form of the letter T, with no drift fences between the buckets. The total effort with this method was

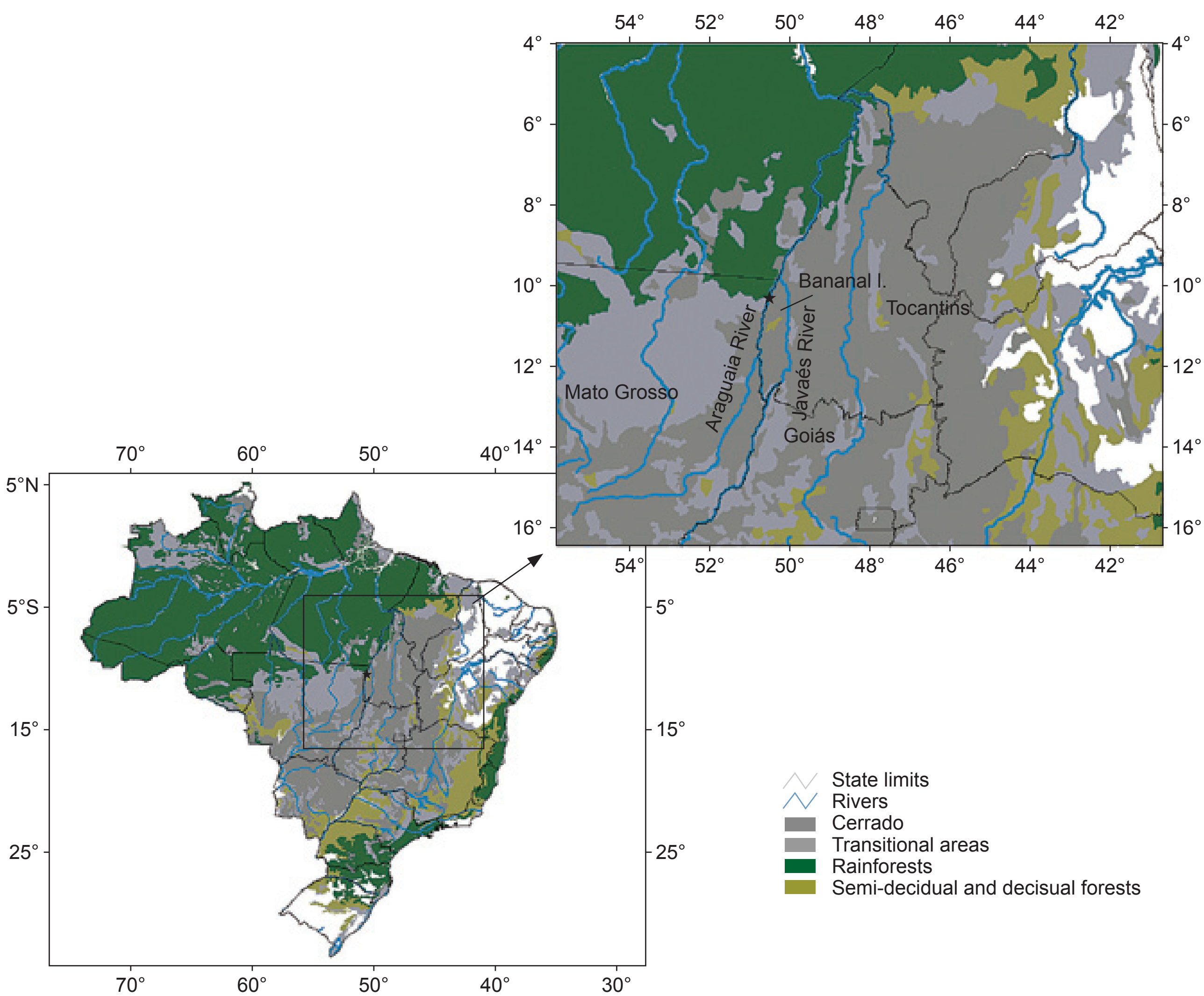

Fig. 1. Map of Brazil showing the location of Araguaia National Park (ANP; star). The vegetation biomes followed IBGE (1993). Bananal I. and the main rivers that form this region are shown in detail, together with the surveyed locality on the northern portion of the island (ANP; star).

3200 trap-nights (Table 1).

Twelve different points were sampled at ANP, which represent the various physiognomies found at the study site. These habitats were grouped into 3 main categories: dense savannas (cerrado *sensu stricto*); open grasslands (campo de murundum, campo limpo, and campo úmido); and forests (flooded and unflooded gallery forests and semideciduous forest patches).

Identification and preservation of specimens

In order to identity the species of small mammals, we used external and craniodental morphological characters, together with karyotype information and comparisons to scientific materials housed in the Museu Nacional, Universidade Federal do Rio de Janeiro (MN) and in the Museu de Zoologia da Universidade de São Paulo (MZUSP). For each specimen collected, we extracted basic measurements of mass (g) and head and body, tail, ear, and foot lengths (mm) (see Moojen 1943); and identified the sex and age classes (juvenile, subadult, and adult using pelage and craniodental characters; see Voss et al. 2001) to help in the correct taxonomic identification. Chromosome preparations were obtained in the field from bone marrow cells after *in vivo* colchicine treatment and were taken from a majority of species surveyed (Table 2). Voucher specimens collected during this study were prepared as either skin with skull and a partial skeleton or as fluid (preserved in 10% formalin and maintained in 70% ethanol) and are deposited in the MN (see Appendix).

Ecology

The capture success was calculated by dividing the total number of captures by the total trap effort, and the relative abundance by dividing the total number of individuals per species by the sum of all individuals surveyed, both of which were multiplied by 100 and expressed as a percentage

Table 1. Different sampling sites (SS) studied at Araguaia National Park (ANP) showing the habitat type, the capture effort using Sherman (S; trap-nights) and pitfall traps (P; trap-nights), capture success (CS; %), and the number of captures (N) and number of species (R). The pitfall trap data are given in parentheses. These sites were grouped into 3 main habitat categories (HCs): grasslands including campo de murundum, campo úmido, and campo limpo (I); dense savannas including cerrado *sensu stricto* (II); and forests including flooded and unflooded gallery forests and semideciduous forest patches (III)

SS	Habitat	S (trap-nights)	P (trap-nights)	CS (%)	N	R	HC
1	Campo de murundum	210	1600	27.62 (0.81)	58 (13)	5 (2)	I
2	Campo úmido/Gallery forest	180	-	2.78	05	4	I
3	Campo úmido	206	-	31.02	64	5	I
4	Campo limpo	119	-	1.68	2	2	I
	Subtotal	715	1600	18.04 (0.81)	129 (13)	6 (2)	
5	Cerrado *sensu stricto*	174	-	0.57	1	1	II
6	Cerrado *sensu stricto*	210	-	4.29	09	2	II
7	Cerrado *sensu stricto*	210	-	0.95	02	2	II
	Subtotal	594	-	2.02	12	3	
8	Semideciduous forest	210	-	3.81	08	2	III
9	Semideciduous forest	210	-	1.90	04	2	III
10	Flooded gallery forest	117	-	1.71	02	2	III
11	Gallery forest	203	-	0.99	2	2	III
12	Gallery forest	210	1600	7.14 (0)	15 (0)	4 (0)	III
	Subtotal	950	1600	3.26 (0)	31 (0)	5 (0)	
	Total	2259	3200	7.61 (0.41)	172 (13)	10 (2)	

(%). The rarefaction method was used to verify the sampling completeness, using both observed and extrapolated species richness values (Gotelli and Colwell 2001). Species richness was estimated using the 2nd order Jackknife estimator (Brose et al. 2003). We also calculated the Shannon-Wienner diversity (H') and the evenness ($e^{H'}/S$, where S is the total number of species surveyed) indices (Magurran 2003) to aid in the community analysis. All analyses used the software EstimateS vers. 8.0 (Colwell 2004). Maps were drawn using the IBGE database (IBGE, 1993) and ArcView GIS 3.1(1998) software.

Taxonomy and zoogeography

To discuss the zoogeography, we considered the occurrence of species surveyed in other biomes, such as the Amazon, Atlantic rainforest, Caatinga, and Pantanal. These data as well as the nomenclature used were based on several authors: Lemos and Cerqueira (2002), Carmignotto (2005), and Gardner (2005 2008) for marsupials; and Emmons and Feer (1997), Bonvicino and Weksler (1998), Musser et al. (1998), Bonvicino and Almeida (2000), Bonvicino et al. (2003), Carmignotto (2005), Musser and Carleton (2005), Woods and Kilpatrick (2005), Weksler et al. (2006), and Bezerra (2008) for rodents. Specimens occurring in enclaves of the Cerrado biome along both the Amazon and Atlantic rainforest biomes were cited as occurring in the Cerrado. For information on habitats and habits, we followed Emmons and Feer (1997) and Eisenberg and Redford (1999), otherwise, we cite specific authors.

Table 2. Small non-volant mammals surveyed at Araguaia National Park (ANP) by trap type (S, Sherman and P, pitfall) or other methods (V, visualization and F, fecal samples), and the karyotype (2*n*/FNa), number of individuals (N), and relative abundance (RA; %, which only used trapping data) for each species

Taxon	S	P	V/F	2*n*/FNa	N	RA (%)
Order Didelphimorphia						
Family Didelphidae Gray 1821						
Cryptonanus agricolai (Moojen 1943)	-	01	-	14/20	01	0.5
Didelphis albiventris Lund 1840	-	-	01[1]	-	01	-
Didelphis marsupialis Linnaeus 1758	-	-	01[2]	-	01	-
Gracilinanus agilis (Burmeister 1854)	06	-	-	14/24	06	3.3
Marmosa murina (Linnaeus 1758)	02	-	-	14/20	02	1.1
Order Rodentia						
Family Cricetidae Fischer 1817						
Calomys tocantinsi Bonvicino et al. 2003	16	-	-	46/66	16	8.7
Holochilus sciureus Wagner 1842	01	-	02[2]	-	03	0.5
Hylaeamys megacephalus (Fischer 1814)	37[3]	-	-	54/62	37	20.0
Necromys lasiurus (Lund 1841)	101[3]	12	-	34/34	113	61.1
Oecomys bicolor (Tomes 1860)	01	-	-	-	01	0.5
Oligoryzomys cf. *microtis* (Allen 1916)	01	-	-	-	01	0.5
Pseudoryzomys simplex (Winge 1887)	04	-	-	2*n* = 56	04	2.2
Family Echimyidae Gray 1825						
Thrichomys sp.	03	-	-	30/56	03	1.6
Total	172	13	04	-	189	100

[1]One individual of *D. albiventris* was seen in a forest area along the Araguaia River at night and ca. 5 m from our car. [2]One hemimandible of *D. marsupialis* and 2 cranial fragments of *Hol. sciureus* were recovered from fecal samples of the manned-wolf *Chrysocyon brachiurus* in an area of cerrado *sensu stricto* near a semideciduous forest and inside a semideciduous forest, respectively. [3]This number indicates captures not individual numbers, since some individuals of *Hyl. megacephalus* (23 collected and 14 released) and *N. lasiurus* (28 collected and 85 released) were released without marking.

RESULTS AND DISCUSSION

Sampling and ecology

During the study period we obtained 185 captures (86 individuals collected and 99 captured and released) belonging to 8 rodent and 3 marsupial species. Two additional species of opossum were registered: *Didelphis albiventris* through visualization and *D. marsupialis* recorded in a fecal sample of a manned-wolf, *Chrysocyon brachiurus* (Table 2).

The pitfall trap method collected only 2 species: 1 rodent, *Necromys lasiurus*, and 1 marsupial, *Cryptonanus agricolai*. The capture rate was also low at 0.4% (*n* = 13). These results may have been influenced by the absence of drift fences between the buckets, which were shown to be very important in capturing small vertebrates when using this method (Corn 1994, Umetsu et al. 2006). The live-trap method proved to be more efficient for surveying both species (10) and individuals (172 captures), and presented a high capture rate during the study (7.6%). This result, however, is due to the great number of captures of 2 rodent species on 3 transect lines: of *N. lasiurus* (*n* = 113) in campo de murundum (27.1%) and campo úmido areas (31%), and of *Hylaeamys megacephalus* (*n* = 37) in a gallery forest area (7.1%) (Table 2). The other 9 sampled sites showed a mean capture rate of 2.1%, similar to ones obtained in other localities of the Cerrado (2%-5% by Marinho-Filho et al. 1994, Bonvicino et al. 1996, Lacher and Alho 2001). In fact, these 2 species were most abundant in ANP, respectively comprising 61% and 20% of the community sampled. The 3rd most common species (*n* = 16) was the rodent *Calomys tocantinsi* (8%), with other species been represented by 1-6 individuals (Table 2). Differences among relative abundances of species surveyed are clearly expressed in the result of the evenness index (E = 0.30). Hence, the diversity index (H' = 1.35) had a low value, not just due to the heterogeneity of the distribution of species abundances but also to the number of species surveyed. The small non-volant mammal species richness found in ANP, 13 species, is low compared to other studies in the Cerrado biome (Bonvicino et al. 1996 2002a 2005). The species accumulation curve (Fig. 2) exhibits an expected higher number of species for the region, estimated to be 22 species, demonstrating that our survey represented only 59% of the ANP species richness.

In terms of the 3 main habitat categories, the grasslands showed a high number of captures (*n* = 142), and also a high number of species (7), followed by the forests (*n* = 31; 5 species), and finally by the cerrado *sensu stricto* (*n* = 12; 3 species) (Table 3). The majority of species were preferentially found in one of the habitat categories, except for *Gracilinanus agilis*, which showed similar numbers of individuals in both the cerrado *sensu stricto* and gallery forest. The other

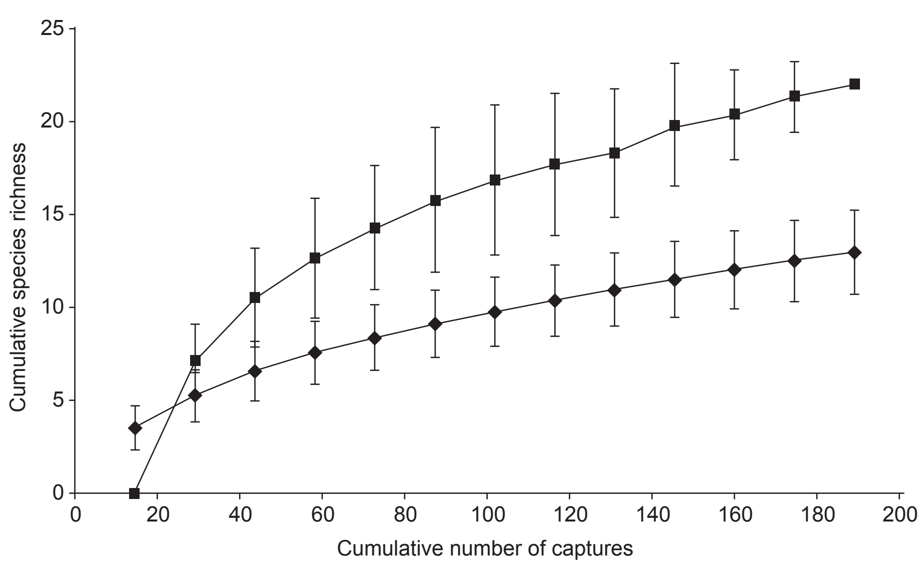

Fig. 2. Observed species (solid triangles) and extrapolated species (solid squares) accumulation curves for small non-volant mammals surveyed at Araguaia National Park (ANP).

species could be divided into open (*Cry. agricolai*, *Cal. tocantinsi*, *N. lasiurus*, *Holochilus sciureus*, *Oligoryzomys* cf. *microtis*, *Pseudoryzomys simplex*, and *Thrichomys* sp.) and forested (*Marmosa murina*, *Hyl. megacephalus*, and *Oecomys bicolor*) inhabitants, a structure typical of small non-volant mammals of the Cerrado (Carmignotto 2005). Habitat selectivity shown by the majority of species in ANP (Table 3) is in accordance with habitat data of other studies in the Cerrado biome (Marinho-Filho et al. 2002). The habitat type where *Cry. agricolai* was recorded (campo de murundum), however, deserves attention, since there is little habitat information for this species (cited as *Gracilinanus* sp. in Carmignotto 2005, Voss et al. 2005). The same is true for the recently described species *Cal. tocantinsi*, which was found in a secondary semideciduous forest, campo de murundum, and campo úmido. The species was previously collected in the cerradão, cerrado *sensu stricto*, and campo sujo, and building near cerrado areas (Bonvicino et al. 2003). A species not commonly found in the Cerrado is *Oligoryzomys* cf. *microtis* that inhabits evergreen lowland forests, gallery forests, and disturbed open areas inside lowland forests (Patton et al. 2000). At ANP, we captured an individual inside a forest along a natural lagoon.

Taxonomic identity and nomenclature

The marsupial species surveyed in ANP (*Cry. agricolai*, *D. albiventris*, *D. marsupialis*, *Gracilinanus agilis*, and *M. murina*) were easily assigned to species level. Species of the genus *Didelphis* are recognizable by their large body size and can be distinguished from each other by the color of the ears, being black in *D. marsupialis* and white in *D. albiventris* (Cerqueira and Lemos 2000). Diagnostic characters of the cranium include the total length, which is larger in *D. marsupialis*, and also the size and morphology of the 2nd inferior premolar, which is smaller and triangular in *D. albiventris* and larger and oval in *D. marsupialis* (Lemos and Cerqueira 2002). Small marsupials from the genera *Cryptonanus*, *Gracilinanus*, and *Marmosa* can be misidentified in the field, but using both qualitative (pelage and craniodental characters) and quantitative characters, they are readily distinguished (see Voss et al. 2005). *Marmosa murina* is the largest representative followed by *G. agilis*, with specimens of *Cry. agricolai* the smallest. The tail morphology of naked, dark, caudal scales which

Table 3. Occurrence of small mammal species by habitat type and biome. Habitats were grouped into 3 main categories: I - grasslands including campo de murundum, campo úmido, and campo limpo; II - dense savannas including cerrado *sensu stricto*; and III - forests including flooded and unflooded gallery forests and semideciduous forest patches. The biomes analyzed were Amazon (AM), Atlantic rainforest (AR), Caatinga (CA), Cerrado (CE), and Pantanal (PA). Specimens registered by visual records and recovered from fecal samples are in parentheses

Species	I	II	III	AM	AR	CA	CE	PA
Cryptonanus agricolai	01					X	X	
Didelphis albiventris			(1)			X	X	X
Didelphis marsupialis		(1)		X			X	
Gracilinanus agilis		3	3			X	X	X
Marmosa murina			2	X	X		X	X
Calomys tocantinsi	15		1				X	
Holochilus sciureus		1	(2)	X			X	
Hylaeamys megacephalus	5	8	24	X	X		X	X
Necromys lasiurus	113			X	X	X	X	X
Oecomys bicolor			1	X			X	
Oligoryzomys cf. *microtis*	1			X				
Pseudoryzomys simplex	4					X	X	
Thrichomys sp.	3						X	
Total	142	12 (1)	31 (3)	7	3	5	12	5

are larger than the caudal hairs in *M. murina*, and the hairy, yellowish-brown, and smaller caudal scales in the other 2 species comprises good diagnosable characters, as is the presence of the secondary foramen ovale in *G. agilis* and its absence in *Cry. agricolai* (see Voss et al. 2005). In terms of nomenclature, the only new name is *C. agricolai*, since it was considered a subspecies of *G. emiliae* until recently (see Voss et al. 2005).

Rodent species are more problematic, being readily identified at the genus level, but not as easily at the species level. The genus *Calomys*, for example, can be distinguished from other genera by the tail length which is less than the body length, by the grayish coloration of the dorsal and ventral pelage, and by the small white feet. However, *Cal. tocantinsi*, *Cal. callosus*, and *Cal. expulsus* belong to the group of large-sized *Calomys* species that occur in Brazil, known also as the *callosus* group, and are morphologically very similar. Bonvicino et al. (2003) found significant differences in only three of 28 cranial measures, being diagnosable especially by its karyological data 2*n* = 46 and FNa = 66 (Fagundes et al. 2000, Bonvicino et al. 2003). The genus *Holochilus* has similar problems. It is distinguished by the presence of inter-digital foot webs of the hind feet, large body and feet sizes, an orangish-brown dorsal pelage, a whitish venter, smooth fur, and a tail never longer than the body size. The extant species boundaries, however, are undefined, pending a generic-level revision (see Patton et al. 2000, Musser and Carleton 2005). The genus *Necromys*, with 1 species occurring in Brazil (*N. lasiurus*; see Macêdo and Mares 1987), is externally similar to *Calomys*, also with the tail length less than the body length, but is distinguished by larger and darker feet, the brownish dorsal coloration, and clearer circumocular fur. *Oecomys bicolor* is an arboreal species, characterized by the tail length being longer than the body length, with a hair tuft at its end, short large feet, a whitish venter, brownish dorsal pelage, very long vibrissae, and a small body size (see Patton et al. 2000). This species can be distinguished from others of the genus by these combinations of characters. Specimens of *Oligoryzomys* are also easily recognizable: the tail length is also longer than the body length, but they are smaller than *Oec. bicolor*, and their feet are longer and narrower, with a yellowish venter, and dark brownish dorsal coloration. The species, however, are very difficult to identify, because the small body-sized group of *Oligoryzomys* (*Oli. flavescens*, *Oli. fornesi*, *Oli. microtis*, and *Oli. rupestris*) are very similar taxa, being best distinguished by karyotypic data (*Oli. microtis* with 2*n* = 64, FNa = 66 and *Oli. fornesi* with 2*n* = 62, FNa = 64 (Bonvicino and Weskler 1998). The identification of the ANP specimen as *Oli.* cf. *microtis* is based on the set of characters cited above and also on the geographic distribution. *Pseudoryzomys simplex* is a monotypic genus, being distinguished from the others by the tail length being less than the body length, large hind feet with foot webs, a medium body size, and grayish dorsal and ventral coloration. In terms of *Galea spixii* (reported from Bananal I. based on a specimen housed in the MN; Carmignotto 2005), the genus is easily recognizable by the absence of a tail, the presence of only 3 toes on the hind feet, and by clearer circumocular fur. Recently Bezerra (2008) revised the genus, found that specimens from Tocantins state did not group with the typical *G.* aff. *spixii* from northeastern Brazil, and suggested studying more specimens from central Brazil to provide a better framework of the taxonomic status of these populations. One case of a newly renamed rodent is *Hylaeamys megacephalus*, which was previously under the genus, *Oryzomys*. This genus was recently divided into 10 new genera, and the former name was restricted to the *palustris*-group, represented by *Ory. palustris* and *Ory. couesi*. Species of the *megacephalus* group received the name *Hylaeamys* (Weksler et al. 2006). *Hylaemys megacephalus* can be diagnosable by the tail length being less than or equal to the body length, a medium body size, large, narrow and whitish hind feet, large ears without hairs, the orange dorsal coloration, and a grayish venter (see Percequillo 1998). The genus *Thrichomys* was traditionally considered monospecific (Woods 1993), but this genus was recently revised by several authors and shown be polytypic (karyotype by Bonvicino et al. 2002b; morphology by Basile 2003; molecular data by Braggio and Bonvicino 2004). Four species are currently recognized, based mainly on karyotypic data: *Thr. inermis* (populations with 2*n* = 26 and FNa = 48) from east Bahia and Tocantins, *Thr. pachyurus* (2*n* = 34 and FNa = 64) from Mato Grosso and Mato Grosso do Sul states, and Paraguay; *Thr. apereoides* (2*n* = 28 and FNa = 50, 52), from Minas Gerais, Goiás, and Bahia states; *Thr. laurentius* (2*n* = 30 and FNa = 54), from northeastern Brazil, occurring from Ceará to Bahia states; and *Thrichomys* sp. (2*n* = 30 and FNa = 56) from Distrito Federal, Goiás and Tocantins states (Bonvicino et al. 2002b, Basile 2003, Braggio and

Bonvicino 2004). It is characterized by a large body size, the tail length equal to or longer than the body length, being densely covered by hairs, a long, soft, grayish-brown dorsal pelage, and a whitish venter.

Zoogeography

The composition of the small non-volant mammal community surveyed at ANP is characterized by the presence of typical inhabitants of the Cerrado, such as *Cal. tocantinsi*, which is known from the type locality, Rancho Beira Rio, Formoso do Araguaia, and ANP, Tocantins state, and Vila Rica and Cocalinho, Mato Grosso state (Fagundes et al. 2000, Bonvicino et al. 2003), and *Thrichomys* sp., distributed in cerrado *sensu stricto* areas of the states of Tocantins, Goiás, and Minas Gerais (Bonvicino et al. 2002b); and by Amazonian representative species such as *D. marsupialis*, which is known from the Amazon and transitional areas with the Cerrado biome (Eisenberg and Redford 1999, Cerqueira and Lemos 2000), *Hol. sciureus*, which occurs in the Amazon and Cerrado biomes (Fonseca et al. 1996), and *Oli.* cf. *microtis*, that occurs in Amazon and areas adjacent to the Cerrado biome (Weksler and Bonvicino 2005), corroborating the ecotone character of the region, and the dissimilar composition of small-mammal communities found throughout the Cerrado biome.

Carmignotto (2005) divided the Cerrado into 4 different regions based on the small-mammal community composition. The northern one, including northeastern Mato Grosso, north of Goiás, Tocantins, Maranhão, and west of Piauí state (fig. 3.50 in Carmignotto 2005) is characterized by species with a geographic range restricted to this region, such as *Cal. tocantinsi* and *Thrichomys* sp., and by Amazonian inhabitants, as was found at ANP. That is why the majority of species surveyed present greater overlap with the Amazon biome, especially forest inhabitants, which penetrate into the Cerrado in the northern portion of the biome (Table 3). The community present at ANP is composed of species that have a great distributional range in the Cerrado and other biomes. *Cryptonanus agricolai* is commonly found in xeric habitats from Caatinga and open formations of the Cerrado in east-central Brazil (Gardner 2008), and also occurs in contact zones with the Amazon in northern Mato Grosso state, and with the Caatinga in southwestern Piauí state (cited as *Gracilinanus* sp. by Carmignotto 2005). *Didelphis albiventris* is associated with open formation habitats and deciduous forests, and occurs through the Caatinga, Cerrado, Pantanal, and Campos do Sul biomes, also being found in transitional and disturbed areas of forested biomes (Fonseca et al. 1996, Eisenberg and Redford 1999, Gardner 2008). *Gracilinanus agilis* occurs throughout the Caatinga, Pantanal, and Cerrado biomes and in transitional areas with the Atlantic rainforest in the southwestern portion of the Cerrado (Fonseca et al. 1996, Eisenberg and Redford 1999, Costa et al. 2003). *Necromys lasiurus* occurs in the Atlantic rainforest, Caatinga, Cerrado, Pantanal, and Amazon biomes (Eisenberg and Redford 1999), being restricted to both open and anthropic areas such as pastures, plantations, and secondary growth vegetation, but never in primary forests (see Umetsu and Pardini 2007). *Pseudoryzomys simplex* was considered endemic of the Cerrado biome (Fonseca et al. 1996), but also occurs in marshes of northeastern Brazil and in the Chaco region of Bolivia, Paraguay, and Argentina (Pine and Wetzel 1975, Voss and Myers 1991, Anderson 1997). *Hylaeamys megacephalus* occurs in the Atlantic rainforest, Cerrado, Amazon, and Pantanal biomes (Percequillo 1998). *Marmosa murina* occurs in almost all Brazilian biomes: the Amazon, Atlantic rainforest, Pantanal, and Cerrado (Fonseca et al. 1996). *Oecomys bicolor* occurs in areas of the Amazon, Pantanal, and Cerrado biomes (Fonseca et al. 1996, Eisenberg and Redford 1999).

Silva and Bates (2002) recognized the Araguaia River valley as a subarea of endemism for bird species within the Cerrado biome. Despite the very poor scientific knowledge of this region, Silva and Bates (2002) were able to suggest the Araguaia River valley together with Paranã River valley (Tocantins-Paranã interfluve) as possible regions of occurrence of endemics for other taxonomic groups as well (the rodent *Kerodon acrobata* was cited as an example of an endemic mammal that occurs in dry forests of the northeastern Goiás state in the Paranã River valley). We found only 2 regional endemics in the northern portion of the Cerrado (*Cal. tocantinsi* and *Thrichomys* sp.), that do not exactly match the areas proposed by Silva and Bates (2002), being much wider and encompassing not only forests of these valleys, but other habitat types as well.

Information from molecular data also reinforces this distinct composition pattern along the Cerrado biome. Costa et al. (2003) found 3 distinctive clusters for *G. agilis*, suggesting a high correlation with the traditional subspecies *sensu* Cabrera (1958): *agilis beatrix* for the clade composed of populations of Crato of Ceará state and Uruçui-Una of Piauí state (see Costa et al. 2003 fig. 3, p. 279); and *agilis agilis* for the clade composed by populations of Nova Ponte of Minas Gerais state, Passo do Lontra of Mato Grosso do Sul state, Poconé and Barra do Garças of Mato Grosso state, and Caldas Novas and Serra da Mesa of Goiás state. For *M. murina*, just 1 clade was recognizable in the Cerrado, which showed a closer relationship with the Atlantic rainforest clade (Costa 2003). In contrast, small genetic divergence was exhibited among Cerrado populations of *Hyl. megacephalus*, but they were closer to Amazonian than to Atlantic rainforest populations (Costa 2003). These data can increase the number of species known from the Cerrado biome and also of regional endemics, since the delimited clades show a restricted distributional range in the Cerrado. The relationship of Cerrado species or populations with the adjacent biomes was also clarified, boosting our understanding of the evolutionary history of small mammals in the Cerrado.

The richness found at ANP was low. Considering the information on specimens housed in scientific collections (Carmignotto 2005), only 1 additional species was registered for this region: *Galea* aff. *spixii*. Yet, this number is far from the estimated richness (22 species) for the ANP. This may be the result of a lack of studies in this region that is in need of further surveys employing greater trap efforts, especially of pitfall traps with drift fences, and including sampling in both the rainy and wet seasons. However, since museum data did not substantially increase the number of species, the low species richness and endemics could be a real characteristic of this region. This could be related to the seasonal flooding of the island that decreases the area available for species survivorship, thus limiting the number of species that are supported in these harsh conditions (e.g., August 1983, Grelle 2003, Diniz-Filho et al. 2008). This phenomenon may also explain the low evenness in the distribution of species abundances, with some species very adapted to these environmental variables, and others not as well (Williams et al. 2001, Chamberlain and Leopold 2003).

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APPENDIX. Specimens examined from Araguaia National Park and areas adjacent to Bananal I., Tocantins state, Brazil

Order Didelphimorphia
Family Didelphidae Gray 1821
Cryptonanus Voss et al. 2005
Cryptonanus agricolai (Moojen 1943)
(*n* = 2): MN 66318 (male, skull and skin) – ANP (this study); MZUSP 6822 (skull and fluid skin) – Bananal I., Tocantins state (11°30'S, 50°15'W).
Didelphis Linnaeus 1758
Didelphis marsupialis Linnaeus 1758
(*n* = 1): MN 66320 (hemimandible only) – ANP (this study).
Gracilinanus Gardner and Creighton 1989
Gracilinanus agilis (Burmeister 1854)
(*n* = 6, all skin and skull): MN 60488 and MN 66268 (females); MN 60473, MN 60494, MN 60499, and MN 60506 (males) – ANP (this study).
Marmosa Gray 1821
Marmosa murina (Linnaeus 1758)
(*n* = 2, all skin and skull): MN 66279 (female); MN 60461 (male) – ANP (this study).

Order Rodentia
Family Cricetidae Fischer 1817
Subfamily Sigmodontinae Wagner 1843
Calomys Waterhouse 1837
Calomys tocantinsi Bonvicino et al. 2003
(*n* = 16, all skin and skull): MN 60470, MN 60477, MN 60485, MN 60495, MN 60513, MN 60527, MN 66280, and MN 66282 (females); MN 60474, MN 60509, MN 60525, MN 60526, MN 66267, MN 66270, MN 66290, and MN 66291 (males) – ANP (this study).
Holochilus Brandt 1835
Holochilus sciureus Wagner 1842
(*n* = 3): MN 66316 (male, skin and skull); MN 66321 (fragments of 2 skulls) – ANP (this study).
Hylaeamys Weksler et al. 2006
Hylaeamys megacephalus Fischer 1814
(*n* = 28, all skin and skull): MN 60460, MN 60507, MN 60508, MN 60510, MN 60514, MN 66283, MN 66286, MN 66292, MN 66295, and MN 66296 (females); MN 60459, MN 60472, MN 60475, MN 60479, MN 60497, MN 60498, MN 60501, MN 60503, MN 60511, MN 60512, MN 60515, MN 66287, and MN 66288 (males) – ANP (this study).
Necromys Ameghino 1889
Necromys lasiurus (Lund 1841)
(*n* = 28, 21 skin and skull and 7 fluid): MN 60462, MN 60464, MN 60466, MN 60467, MN 60471, MN 60476, MN 60500, MN 60502, MN 60504, MN 60505, MN 66297 (fluid), and MN 66311 (fluid) (females); MN 60463, MN 60465, MN 60468, MN 60469, MN 60478, MN 60481, MN 60482, MN 60483, MN 60484, MN 60486, MN 60487, MN 66278 (fluid), MN 66298 (fluid), MN 66302 (fluid), MN 66303 (fluid), and MN 66304 (fluid) (males) – ANP (this study).
Oecomys Thomas 1906
Oecomys bicolor (Tomes 1860)
(*n* = 1): MN 66315 (skin and skull, young female) – ANP (this study).
Oligoryzomys Bangs 1900
Oligoryzomys cf. *microtis* (Allen 1916)
(*n* = 1): MN 66317 (skin and skull, male) – ANP (this study).
Pseudoryzomys Hershkovitz 1962
Pseudoryzomys simplex (Winge 1887)

(*n* = 4, all skin and skull): MN 60496, MN 66269 and MN 66281 (females); MN 60480 (male) – ANP (this study).

Family Caviidae
Subfamily Caviinae
Galea Meyen 1832
Galea spixii (Wagler 1831)
(*n* = 1): MN 2615 – Furo das Pedras, Ilha do Bananal (10°28'S, 50°23'W).

Family Echimyidae Gray 1825
Subfamily Eumysopinae Rusconi 1845
Thrichomys Trouessart 1880
Thrichomys sp.
(*n* = 3): MN 66293 (female, fluid); MN 66289 and MN 66294 (males, skin and skull) – ANP (this study).