

# The mammalian faunas endemic to the Cerrado and the Caatinga

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## Abstract

We undertook a comprehensive, critical review of literature concerning the distribution, conservation status, and taxonomy of species of mammals endemic to the Cerrado and the Caatinga, the two largest biomes of the South American Dry-Diagonal. We present species accounts and lists of species, which we built with criteria that, in our opinion, yielded results with increased scientific rigor relative to previously published lists – e.g., excluding nominal taxa whose statuses as species have been claimed only on the basis of unpublished data, incomplete taxonomic work, or weak evidence. For various taxa, we provided arguments regarding species distributions, conservation and taxonomic statuses previously lacking in the literature. Two major findings are worth highlighting. First, we unveil the existence of a group of species endemic to both the Cerrado and the Caatinga (i.e., present in both biomes and absent in all other biomes). From the biogeographic point of view, this group, herein referred to as Caatinga-Cerrado endemics, deserves attention as a unit – just as in case of the Caatinga-only and the Cerrado-only endemics. We present preliminary hypotheses on the origin of these three endemic faunas (Cerrado-only, Caatinga-only, and Caatinga-Cerrado endemics). Secondly, we discovered that a substantial portion of the endemic mammalian faunas of the Caatinga and the Cerrado faces risks of extinction that are unrecognized in the highly influential Red List of Threatened Species published by the International Union for Conservation of Nature (IUCN). “Data deficient” is a category that misrepresents the real risks of extinction of these species considering that (a) some of these species are known only from a handful of specimens collected in a single or a few localities long ago; (b) the Cerrado and the Caatinga have been sufficiently sampled to guarantee collection of additional specimens of these species if they were abundant; (c) natural habitats

of the Cerrado and the Caatinga have been substantially altered or lost in recent decades. Failures either in the design of the IUCN criteria or in their application to assign categories of extinction risks represent an additional important threat to these endemic faunas because their real risks of extinctions become hidden. It is imperative to correct this situation, particularly considering that these species are associated to habitats that are experiencing fast transformation into areas for agriculture, at an unbearable cost for biodiversity.

### Keywords

Brazil, Bolivia, biogeography, checklist, conservation, Dry Diagonal, evolution, habitat, mammals, nomenclature, savannas, taxonomy

## Introduction

The Caatinga and the Cerrado are the two largest biomes of the so-called Dry Diagonal of South America – a massive belt of land characterized by low precipitation and high seasonality – and together they occupy more than 30% of the Brazilian territory. The latter constitutes a vast (2 million km<sup>2</sup>) mosaic of xeromorphic vegetation types, from either dry (*campo limpo*) or humid (*campo úmido*) grasslands to woodlands (*cerradão*), and also harboring gallery forests, and patches of deciduous and semideciduous forests (Silva and Bates 2002, Voss et al. 2009, Carmignotto et al. 2012). The Cerrado encompasses areas from northeastern to southwestern Brazil, eastern Bolivia, and northern Paraguay. With deep soils rich in Aluminum, the Cerrado is irrigated by perennial watercourses (Coutinho 2006); its dry season lasts four months per year, with the rainfall concentrated in the wet season, and averaging annual values of 800–2000 mm (Ab'Sáber 1974, Nimer 1989). Neighboring the Cerrado is the Caatinga, a biome that occupies an extensive area (800,000 km<sup>2</sup>) of northeastern Brazil (Prado 2008). Its predominant habitat types are dry forests and xeric scrubs, although it also harbors patches of savannas (Andrade-Lima 1981). The climate of the Caatinga is markedly hot and dry, with highly erratic rainfall ranging from 240 to 1500 mm (Sampaio 1995, Prado 2008), and a severe period of drought lasting at least 5 months with high temperatures (Nimer 1989).

The Caatinga and the Cerrado harbor unique mammalian faunas whose evolutionary origin, biogeography, and conservation status remain poorly understood. Contrary to the mammalian fauna from open vegetation formations of northern South America (see Gutiérrez et al. 2014 and references therein), the mammals of the Caatinga and Cerrado biomes in northeastern, central, and southwestern South America have received some attention. New species either endemic to or predominantly distributed in these two biomes have been described (e.g., Sazima et al. 1978, Moojen et al. 1997, Bonvicino 2003, Bonvicino et al. 2003); data on the distribution of members of these faunas have been published (e.g., Marinho-Filho and Veríssimo 1997, Bezerra et al. 2007, 2010, Sá-Neto and Marinho-Filho 2013); patterns of phylogeographic variation have been detected (e.g., Carvalho et al. 2011,

Nascimento et al. 2013); and assessments of their extinction risks have been conducted (e.g. Zimbres et al. 2012). In addition, a few studies have synthesized various kinds of ecological and biogeographic information of the mammalian faunas from the Caatinga and the Cerrado (Marinho-Filho et al. 2002, Oliveira et al. 2008, Carmignotto et al. 2012). Despite these valuable contributions, the study of these unique faunas remains in its infancy.

In order to facilitate further research, herein we provide lists and species accounts of the mammal species endemic to the Caatinga and the Cerrado. These species accounts focus on geographic distributions and conservation statuses according to published assessments. Due to the importance of clarifying taxonomic issues for biodiversity conservation (Gutiérrez and Helgen 2013), we provide discussions for taxa with unclear taxonomic statuses integrating all sources of relevant information currently available in the literature. We also conducted a critical discussion of the conservation status of our focal faunas. This aspect is particularly important taking into account that, due to expansion of land used for agriculture, only 47% of the original vegetation of the Cerrado remains (Beuchle et al. 2015), and its protected areas cover about 2% of this biome (Klink and Machado 2005), and that whereas the Caatinga preserves a larger portion of its original vegetation (63%; Beuchle et al. 2015), only ca. 1% of it is under strict federal protection, and it is being affected by accelerated desertification (Albuquerque et al. 2012).

## **Methods**

We conducted a critical review of literature concerning the distribution and conservation of mammalian species endemic to the Cerrado and the Caatinga. We used four main sources for constructing a preliminary list of focal species. These sources are the modern syntheses of the mammals of the Cerrado (Marinho-Filho et al. 2002) and the Caatinga (Oliveira et al. 2008), and their most recent update (Carmignotto et al. 2012); the most recent list of the mammals of Brazil (Paglia et al. 2012); and the two currently available volumes of the book series *Mammals of South America* (Gardner 2008, Patton et al. 2015). The preliminary list was then refined to obtain a final list by: (1) considering information from a plethora of studies published in peer-reviewed journals and books; (2) removing species for which no enough evidence of their nature as either endemic or valid species have been published – this applied also to cases in which authors mentioned the existence of unpublished data or manuscripts in support of their views, but such information remain unavailable for scientific scrutiny.

Two considerations regarding the scope of the present study need to be made. First, the geographic scope of our study differs from some of those used in previous studies. For example, contrary to Carmignotto et al. (2012), we did not regard the Pantanal as part of the Cerrado, as we consider it to be a biome itself, with particular influences from other humid biomes (see Werneck 2011 and references therein).

Second, although differentiated, isolated populations that are often recognized as subspecies can be of importance from the conservation point of view, given the limited knowledge currently available about these faunas, we herein focused only on taxa recognizable at the species level.

We constructed species accounts composed primarily of two sections, distribution and conservation, but when necessary we also included an additional section devoted to taxonomic and nomenclatural considerations. For the distribution section, we indicated whether the species is endemic to the Cerrado, the Caatinga, or both, and presented a list of the administrative entities for which records supported by voucher specimens exist – with the only exceptions of *Cebus libidinosus* and *Lycalopex vetulus*, species for which some of the literature cited included ecological studies and direct observations made by mammalogists on free ranging individuals. We refer to publications that reported such records. We considered species as “endemic” in a strict way. That is, we excluded from our list of endemic species those that despite being predominantly distributed in the Cerrado, the Caatinga, or both, also occur in other biomes in areas that do not match patches of Caatinga or Cerrado vegetation. To do so, we followed the limits of the Brazilian biomes as defined by the *Instituto Brasileiro de Geografia e Estatística* (IBGE 2004a) and information reported in the literature regarding habitat types at collection localities. We did include in our list of endemics those species for which marginal records exist in the ecotones between our focal biomes (the Cerrado and the Caatinga) and other biomes, or in patches of Cerrado or Caatinga vegetation nearby the current contact zones between these and their neighbor biomes. Similarly, in cases in which a species was predominantly distributed in one of our focal biomes (e.g., the Caatinga) and transitional areas/ecotones with our other focal biome (i.e., the Cerrado, in this example), we considered that species endemic to the focal biome in which it is predominantly distributed (i.e. the Caatinga, in this example). In addition, we flag cases in which species have been regarded in the literature as endemics to our focal biomes, but that either more recent or revisited information demonstrate that they are not. We also flag the existence of species only known from transitional areas between our focal biomes and other biomes, as well as known undescribed species that might be endemic to our focal biomes, but for which further research is necessary to understand their distribution. In addition to the geographic distribution, for each species we indicate whether it has been recorded in open vegetation formations, forest, or both types of habitat.

For the conservation section, we used two sources: (1) the IUCN Red List of Threatened Species (available at <http://www.iucnredlist.org>), consulted in October–December 2016 (see citations relevant to each species under *Species accounts*); and (2) the official national list of threatened species published by the Brazilian government (ICMBIO-MMA 2016). The latter list only mentions species to which a category of threat has been assigned (i.e., it does not include species that are not threatened). We compared the conservation status (risk of extinction) that these two sources assigned to each species, and provided recommendations to improve their accuracy with regard to the focal species of this study.

## Results

### Species accounts

#### **Didelphimorphia, Didelphidae, Didelphinae, Thylamyini**

##### ***Cryptonanus agricolai* (Moojen, 1943)**

**Distribution.** *Cryptonanus agricolai* is endemic to the Cerrado and the Caatinga, and has also been collected in contact zones between these biomes and the Amazon in northern Mato Grosso and southwestern Piauí states (Bezerra et al. 2009). Records of *C. agricolai* in the Atlantic forest were obtained from pellets of *Tyto alba* and might actually correspond to individuals captured in the Cerrado, the Caatinga, or both (Souza et al. 2010), as these owls can potentially forage through long distances (up to ~31 km; Hegdal and Blaskiewicz 1984). According to Bezerra et al. (2014), unpublished molecular data suggest that *C. agricolai* is absent from the Cerrado; however, we will refrain from adopting this view until these data become publicly available (contra Carmignotto et al. 2012). The current, known distribution of *C. agricolai* includes the Brazilian states of Ceará, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Pernambuco, Piauí, Sergipe, and Tocantins (Voss et al. 2005, Bezerra et al. 2009, 2014, Carmignotto and Aires 2011, Bonvicino et al. 2012, Gómes et al. 2015, Gurgel-Filho et al. 2015, Hannibal and Neves-Godoi 2015, de la Sancha and D'Elía 2015). Alleged records from a locality in São Paulo state have been mentioned in the literature (see Martin et al. 2012), but they were made based on animals that were released (i.e., no voucher specimens are available) and identified using unreported criteria.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Cryptonanus agricolai* (see Carmignotto et al. 2016a). The species was not included in the official list of threatened species of Brazil (ICMBio-MMA 2016).

##### ***Thylamys (Xerodelphis) karimii* (Petter, 1968)**

**Distribution.** *Thylamys karimii* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Bahia, Goiás, Mato Grosso, Minas Gerais, Pernambuco, Piauí, Rondônia, Sergipe, and Tocantins, and in the Distrito Federal (Carmignotto and Monfort 2006, Carvalho et al. 2009, Bruna et al. 2010, Carmignotto and Aires 2011, Bonvicino et al. 2012, Bezerra et al. 2014). The species has not been reported for Bolivia, but its presence on the Serranía de Huanchaca in the Santa Cruz department of that country might be expected (Giarla et al. 2010).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Vulnerable” to *Thylamys karimii* (see Carmignotto et al. 2016b). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Thylamys (Xerodelphis) velutinus* (Wagner, 1842)**

**Distribution.** *Thylamys velutinus* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Minas Gerais, São Paulo, and in the Distrito Federal (Vieira and Palma 1996, Bonvicino and Bezerra 2003, Giarla et al. 2010, Bonvicino et al. 2014). Marginal records are known from transitional areas that harbor isolated patches of Cerrado vegetation embedded within the Atlantic Forest biome (see Caceres 2012 and references therein).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Near Threatened” to *Thylamys velutinus* (see Carmignotto and Astúa 2016). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

**Cingulata, Dasypodidae, Tolypeutinae, Tolypeutini*****Tolypeutes tricinctus* (Linnaeus, 1758)**

**Distribution.** *Tolypeutes tricinctus* is endemic to the Cerrado and the Caatinga (contra Wetzel et al. 2007), and has been recorded in the Brazilian states of Alagoas, Bahia, Ceará, Goiás, Maranhão, Paraíba, Pernambuco, Piauí, Sergipe, and Tocantins (Sanborn 1930, Moojen 1943; Silva and Oren 1993, Santos et al. 1994, Oliveira 1995, Marinho-Filho et al. 1997, Zimbres et al. 2012, 2013, Feijó et al. 2015a). The species had been traditionally considered an endemic of the Caatinga biome, however records of the species well within the Cerrado biome and in native Cerrado habitat type have been reported (Marinho-Filho et al. 1997; see also figure 2 in Feijó et al. 2015a).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Vulnerable” to *Tolypeutes tricinctus* (see Miranda et al. 2014). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

**Chiroptera, Phyllostomidae, Lonchophyllinae*****Lonchophylla bokermanni* Sazima, Vizotto & Taddei, 1978**

**Distribution.** *Lonchophylla bokermanni* is endemic to the Cerrado, where it has been collected in the Brazilian state of Minas Gerais (Dias et al. 2013, Teixeira et al. 2014, Almeida et al. 2016). Specimens collected in the Atlantic Forest of Brazil and previously identified as *L. bokermanni* (by Nascimento et al. 2013) actually correspond to the recently described *Lonchophylla peracchii* (Dias et al. 2013).

**Conservation.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Lonchophylla bokermanni* (see Aguiar et al. 2016; see also Teixeira et al. 2014). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### *Lonchophylla dekeyseri* Taddei, Vizotto & Sazima, 1983

**Distribution.** *Lonchophylla dekeyseri* is endemic to the Cerrado (contra Leal et al. 2013), and has been collected in the Brazilian states of Goiás, Mato Grosso do Sul, Minas Gerais, and in the Distrito Federal (Taddei et al. 1983, Coelho and Marinho-Filho 2002, Aguiar et al. 2014, Moratelli and Dias 2015, Almeida et al. 2016). Additional specimens assigned to *L. dekeyseri* exist for the Bolivian state of Santa Cruz (in the Cerrado), and for the Brazilian states of Piauí (in the Cerrado-Caatinga ecotone) and Paraíba (in the Caatinga) (Woodman and Timm 2006, Leal et al. 2013). However, the taxonomic identifications of these specimens need to be reevaluated based on the morphological criteria recently proposed by Moratelli and Dias (2015), who noted the following: “We are not convinced that *L. dekeyseri* occurs in the Bolivian savannah and in the Cerrado–Caatinga ecotone in NE Brazil. One of the specimens supporting these records was examined a long time ago (DZSJRP 11459), and the other two (USNM 584472, 584473) are distinct from other samples of *L. dekeyseri* as determined in a previous discriminant function analysis. These specimens are not included in this analysis because we were not able to compare them with samples from other localities.” We provisionally regard *L. dekeyseri* as endemic to the Brazilian Cerrado until further studies determine the taxonomic identity of specimens collected in Bolivia, the Cerrado-Caatinga ecotone, and the Caatinga.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Lonchophylla dekeyseri* (see Aguiar and Bernard 2016). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

### *Lonchophylla inexpectata* Moratelli & Dias, 2015

**Distribution.** *Lonchophylla inexpectata* is endemic to the Caatinga, and has been recorded in the Brazilian states of Pernambuco and Bahia (Moratelli and Dias 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 has not yet evaluated the extinction risk of *Lonchophylla inexpectata*. The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016). Confirmed specimens of *L. inexpectata* are currently known from only three localities. Although an exhaustive revision of specimens housed in zoological collections might reveal a higher number of localities for the species, a provisional conservation status denoting some risk of extinction seems a sensible action considering the extremely low number of confirmed localities, particularly considering trends of habitat loss in the Caatinga (Albuquerque et al. 2012).

### *Xeronycteris vieirai* Gregorin & Ditchfield, 2005

**Distribution.** *Xeronycteris vieirai* is endemic to the Caatinga, and has been recorded in the Brazilian states of Bahia, Minas Gerais, Paraíba, and Pernambuco (Gregorin and Ditchfield 2005, Nogueira et al. 2007, 2014a, 2015, Astúa and Guerra 2008).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Xeronycteris vieirai* (see Solari 2015). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016). Eleven years after its description (Gregorin and Ditchfield 2005), *X. vieirai* is known from only eight specimens and seven localities from the Caatinga (Gregorin and Ditchfield 2005, Nogueira et al. 2007, 2014a, 2015, Astúa and Guerra 2008), a biome with large disturbed areas as well as areas undergoing desertification (Albuquerque et al. 2012). Considering habitat loss, the specialized diet and the endemic nature of *X. vieirai*, Gregorin and Ditchfield (2005) noted that the species might be one of most threatened species of mammals in Brazil. We agree with this view, and strongly encourage NGOs and governmental agencies in charge of producing influential “red lists of threatened species” to reevaluate the conservation status they have assigned to *Xeronycteris vieirai*; a realistic category for the species should reflect at the very least a moderate risk of extinction, particularly considering trends of habitat loss in the Caatinga (Albuquerque et al. 2012).

### Chiroptera, Phyllostomidae, Micronycterinae

#### *Micronycteris sanborni* Simmons, 1996

**Distribution.** *Micronycteris sanborni* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Ceará, Minas Gerais, Paraíba, Piauí, Pernambuco, and Tocantins (Simmons 1996, Gregorin et al. 2008, Cunha et al. 2009, Feijó et al. 2010, 2015b, Nogueira et al. 2015, Silva et al. 2015). An alleged record of the species for the Amazon biome has been recently published (López-Baucells et al. 2013), but no voucher specimen supports this claim and the individual that forms the basis of this record lacked the pure white ventral pelage coloration that seems to be characteristic of *M. sanborni* (see Simmons 1996, Feijó et al. 2015b). Applying Hitchens’ razor, we dismiss the alleged record for the Amazon biome (contra López-Baucells et al. 2013), a view we share with other authors (see Nogueira et al. 2014b, Feijó et al. 2015b). In addition, as noted by Feijó et al. (2015b), alleged records from the state of Mato Grosso do Sul need to be confirmed. One of the two specimens that formed the basis of these records (see Santos et al. 2010) lacks the pure white ventral pelage coloration typical of confirmed vouchers of *M. sanborni* (see above) – and according to Siles et al. (2013) it might actually correspond to *M. yatesi*. No information about the morphology of the other specimen has been published (see Cunha et al. 2009).



**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Micronycteris sanborni* (see Tavares and Aguirre 2008). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

## Chiroptera, Phyllostomidae, Stenodermatinae

### *Chiroderma vizottoi* Taddei & Lim, 2010

**Distribution.** *Chiroderma vizottoi* is endemic to the Caatinga, and has been recorded in the Brazilian states of Ceará and Piauí (Gregorin et al. 2008, Taddei and Lim 2010, Silva et al. 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 has not yet evaluated the status of *Chiroderma vizottoi*. The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

## Primates, Cebidae, Callitrichinae

### *Callithrix penicillata* (É. Geoffroy in Humboldt, 1812)

**Distribution.** *Callithrix penicillata* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Goiás, Maranhão, Minas Gerais, Piauí, São Paulo, and in the Distrito Federal (de Vivo 1991, Miranda and Faria 2001, Rylands et al. 2009, Coimbra-Filho et al. 2006, Bruna et al. 2010, Vilela and Del-Claro 2011, Garbino 2015b). However, according to Rylands et al. (2009 p. 36) the records from Maranhão, which were reported by de Vivo (1991) based on skins deposited at the Museu Nacional (Rio de Janeiro), likely correspond to introductions of the species in areas far away from the native range of the species. Similarly, translocations of individuals out of their native range have been considered as a possible causal explanation for the existence of a hybrid zone between *C. penicillata* and *C. geoffroyi* in the Atlantic Forest (Fuzessy et al. 2014). Rylands et al. (2009) also commented that habitat transformation (with loss of forest) and introductions (resulting from misguided release of confiscated animals) have led *C. penicillata* to occupy, and perhaps replace other species of *Callithrix*, at localities south and east of its native range.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Callithrix penicillata* (see Rylands and Mendes 2008). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

## Primates, Cebidae, Cebinae

### *Cebus (Sapajus) libidinosus* Spix, 1823

**Distribution.** *Cebus libidinosus* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Bahia, Ceará, Goiás, Maranhão, Minas Gerais, Paraíba, Piauí, Pernambuco, Rio Grande do Norte, São Paulo, Tocantins, and Distrito Federal (Pontes et al. 2006, Vilela 2007, Canale et al. 2009, Bruna et al. 2010, Lynch-Alfaro et al. 2012a, 2014, Feijó and Langguth 2013, Fragaszy et al. 2013, Gomes et al. 2015, Mendes et al. 2015, Nova et al. 2015).

**Nomenclature.** We regard *libidinosus* as a member of the genus *Cebus*, subgenus *Sapajus*, and advocate for the use of the name *Sapajus* at the subgenus-level (contra Lynch-Alfaro et al. 2012a, 2012b, 2014). The division between the gracile (untufted) and robust (tufted) groups of capuchin monkeys has been known for over a century (see Elliot 1913, Hershkovitz 1949, 1955), and the names *Cebus* and *Sapajus* have been applied to them at the subgenus-level, respectively (e.g., Silva-Junior 2001, Ferreira et al. 2009, Casado et al. 2010). Lynch-Alfaro et al. (2012a) recommended elevating *Sapajus* to the genus-level based on their estimated age for the split between the gracile and robust lineages of *Cebus* (95% highest posterior density = 4.21–7.86 Ma). This estimate resulted from the analysis of sequence data from two mitochondrial genes. Subsequently, Lynch-Alfaro et al. (2012b) summarized known morphological and behavioral differences between gracile and robust lineages, restated the gene-tree argument of Lynch-Alfaro et al. (2012a), and advocated for elevating *Sapajus* at the genus level; ‘expert opinions’ have been invoked to promote this view (Lynch-Alfaro et al. 2014). Although several NGOs, ecologists, and ethologists started to adopt this proposal, dissent exists (e.g., Rosenberger 2012, Feijó and Langguth 2013, this study). Clearly, the differences and phylogenetic split between the two lineages of capuchin monkeys should be recognized with Linnean nomenclature; however, the most suitable action to do so, at least provisionally, is to use *Sapajus* and *Cebus* as subgenera of *Cebus*. At least three reasons support this view, as follows (see also Voss et al. 2014, Garbino 2015a):

(1) Elevating *Sapajus* to the genus level is unnecessary, as it does not accomplish anything than using the name at the subgenus level could not.

(2) At least for now, using the age since the split between *Sapajus* and *Cebus* as an argument to elevate *Sapajus* at the genus level is flawed for two reasons. First, because the age of that split, as estimated by Lynch-Alfaro et al. (2012a), was inferred based on data from a single locus, it should be considered a preliminary one (i.e., a working hypothesis). Secondly, the artifactual current taxonomy of platyrrhine monkeys (see Rosenberger and Matthews 2008, Rosenberger 2012, Garbino 2015a and references therein) prevents sensible comparisons of age of splits among pairs of platyrrhine sister genera. This is a consequence of the wide, dogmatic acceptance of genera that have been proposed on the basis of criteria that are typically used to recognize species (at best) in most other groups of mammals. A recent example of this

phenomenon is provided by the recent proposal to validate the name *Leontocebus* as a genus, to contain the *nigricollis* group of *Saguinus*, using as an argument the fact that it is sympatric with other tamarin lineage (Rylands et al. 2016) – note that this same unacceptable criterion (i.e., sympatry) and divergence-time have been used by Byrne et al. (2016) to propose the recognition of *Cheracebus* as a “genus” and without even considering the more sensible option of regarding *Cheracebus* as a subgenus of *Callicebus*; we herein propose to use *Cheracebus* at the subgenus level only. Clearly, the currently inflated taxonomy of New World primates should be fixed, and several proposed genera should be lumped into fewer ones. This process has already begun (e.g., Garbino 2015a, this study), but it is far from completion.

(3) Continuing to recognize the long established, monophyletic genus *Cebus*, and subgenera *Sapajus* and *Cebus* within it, allows for more efficient communication among scientists. First, the use of the genus-(subgenus)-species format (i.e. using the subgenus name, when pertinent) readily confers phylogenetic information. In this case, the genus name *Cebus* informs about the sister-taxon relationship between the subgenera *Sapajus* and *Cebus* – supported by a number of synapomorphies (see Lynch-Alfaro et al. 2012b) – whereas the subgenera names, *Sapajus* and *Cebus*, recognize the differences between the two lineages that underwent different evolutionary histories. Furthermore, association of the genus name *Cebus* with the species epithets of both lineages of capuchin monkeys have existed for decades, and unnecessarily disrupting this association (by elevating *Sapajus* to the genus level) might pose difficulties in scientific communication, for example for literature searches or for merging data from public repositories (e.g., GenBank, Global Biodiversity Information Facility).

We take the opportunity to emphasize the importance of using the subgenus rank to preserve nomenclatural stability, similar to what have been recently done for other groups of mammals (Giarla et al. 2010, Voss et al. 2014, Díaz-Nieto et al. 2016, Teta et al. 2016). This aspect is especially important for New World primates, whose generic and alpha-level taxonomy should be rectified in the upcoming decades.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Cebus (Sapajus) libidinosus* (see Rylands and Kierulff 2015). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

## Primates, Pitheciidae, Callicebinae, Callicebini

### *Callicebus (Callicebus) barbarabrownae* Hershkovitz, 1990

**Distribution.** *Callicebus barbarabrownae* is endemic to the Caatinga, and has been recorded in the Brazilian states of Bahia and Sergipe (Hershkovitz 1990b, Marinho-Filho and Veríssimo 1997, Printes et al. 2011 and 2013, Marques et al. 2013, Corsini and Moura 2014).

**Nomenclature.** We regard *barbarabrownae* as a member of the genus *Callicebus*, subgenus *Callicebus*. The arguments presented by Byrne et al. (2016) to propose splitting *Callicebus* (as traditionally understood) into different genera are flawed for the same reasons we have already discussed under the account of *Cebus libidinosus* (see above).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Critically Endangered” to *Callicebus barbarabrownae* (see Veiga et al. 2008). The species appears in the official list of threatened species of Brazil with the category “Critically Endangered” (ICMBIO-MMA 2016).

## **Carnivora, Canidae, Caninae, Canini**

### ***Lycalopex vetulus* (Lund, 1842)**

**Distribution.** *Lycalopex vetulus* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Bahia, Ceará, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Piauí, São Paulo, and in the Distrito Federal (Costa and Courtenay 2003, Courtenay et al. 2006, Dalponte 2009, Bocchiglieri et al. 2010, Ribeiro et al. 2010, Olifiers and Delciellos 2013; see also Supplementary Material of Bubadué et al 2016). The species has also been observed in the Brazilian state of Tocantins (Carmignotto and Aires 2011).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Lycalopex vetulus* (see Dalponte and Courtenay 2008). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

## **Rodentia, Caviidae, Caviinae**

### ***Galea spixii* (Wagler, 1831)**

**Distribution.** *Galea spixii* is endemic to the Caatinga, and has been recorded in the Brazilian states of Alagoas, Bahia, Ceará, Minas Gerais, Pará, Pernambuco, São Paulo (Bezerra 2008, Norgueira et al. 2015, Dunnun 2015 and references therein).

**Taxonomy.** Some authors have regarded *Galea spixii* and *G. flavidens* as different species (Ellerman 1941, Bonvicino et al. 2005, Weksler and Bonvicino 2008a, Dunnun 2015); however the latter species has never been incorporated into a phylogenetic study based on molecular data (e.g., Dunnun and Salazar-Bravo 2010), and a modern morphological study that included all extant species in the genus did not find differences to distinguish *G. flavidens* from *G. spixii* (Bezerra 2008; but see Bonvicino et al. 2008). We follow Bezerra (2008) in treating *Galea flavidens* as a junior synonym of *Galea spixii*. The same author also found that populations

currently referred to as *Galea spixii* actually might be composed by multiple valid species (Bezerra 2008).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Galea spixii* (see Catzeffis et al. 2016a). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

## Rodentia, Caviidae, Hydrochoerinae

### *Kerodon acrobata* Moojen, Locks & Langguth, 1997

**Distribution.** *Kerodon acrobata* is endemic to the Cerrado, and has been recorded only in the Brazilian states of Goiás and Tocantins (Moojen et al. 1997, Bezerra et al. 2010, Zappes et al. 2014).

**Conservation status.** The red list of the IUCN ver 3.1 assigned the category “Data Deficient” to *Kerodon acrobata* (see Roach 2016). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

### *Kerodon rupestris* (Wied-Neuwied, 1820)

**Distribution.** *Kerodon rupestris* is endemic to the Caatinga, and has been recorded in the Brazilian states of Alagoas, Bahia, Ceará, Minas Gerais, Paraíba, and Pernambuco (Moojen et al. 1997, Lessa et al. 2005, Dunnun 2015 and references therein). Indications of the species presence in the Cerrado (e.g., Marinho-Filho et al. 2002, Carmignotto et al. 2012) do not seem to be supported by voucher specimens.

**Conservation status.** The red list of the IUCN ver 3.1 assigned the category “Least Concern” to *Kerodon rupestris* (see Catzeffis et al. 2016b). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

## Rodentia, Cricetidae, Sigmodontinae, Akodontini

### *Gyldenstolpia planaltensis* (Avila-Pires, 1972)

**Distribution.** *Gyldenstolpia planaltensis* is endemic to the Cerrado, and has been recorded in the Brazilian state of Mato Grosso, and in the Distrito Federal (Bezerra et al. 2011, Pardiñas and Bezerra 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 has not yet attempted to evaluate the extinction risk of *Gyldenstolpia planaltensis*. The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

### ***Juscelinomys candango* Moojen, 1965**

**Distribution.** *Juscelinomys candango* is endemic to the Cerrado, and is only known from its type locality in the Brazilian Distrito Federal (Moojen 1965, Emmons 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Extinct” to *Juscelinomys candango* (see Leite and Patterson 2008). The species appears in the official list of threatened species of Brazil with the category “Critically Endangered (Likely Extinct)” (ICMBIO-MMA 2016).

### ***Juscelinomys huanchacae* Emmons, 1999**

**Distribution.** *Juscelinomys huanchacae* is endemic to the Cerrado, and is only known from the Bolivian department of Santa Cruz (Emmons 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Juscelinomys huanchacae* (see Dunnun et al. 2008). Since the known records are restricted to Bolivian cerrado, the species was not considered to be included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### ***Oxymycterus delator* Thomas, 1903**

**Distribution.** *Oxymycterus delator* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Bahia, Ceará, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Piauí, São Paulo, and Tocantins, and in the Distrito Federal; and in the Paraguayan departments of Canindeyú and Paraguari (Emmons 1999, Hoffmann et al. 2002, Andrade et al. 2004, Bonvicino et al. 2005, 2008, 2012, 2014, Bruna et al. 2010, Ribeiro et al. 2010, Carmignotto and Aires 2011, Owen 2013, Gurgel-Filho et al. 2015, Oliveira and Gonçalves 2015, Stumpp et al. 2016). It has been indicated that the species occurs also in the Chaco biome (Carmignotto et al. 2012), but we are not aware of reported specimens that support this notion. D’Elía et al. (2008) noted that in Paraguay the species is restricted to the Oriental Region (east of the Paraguay River), where areas with Chaco’s physiognomy are absent and, instead, isolated patches of Cerrado can be found (Owen 2013).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Oxymycterus delator* (see Patterson et al. 2008). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### ***Thalpomys cerradensis* Hershkovitz, 1990**

**Distribution.** *Thalpomys cerradensis* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Goiás, Mato Grosso, Tocantins, and in the

Distrito Federal (HersHKovitz 1990a, Andrade et al. 2004, Gonçalves et al. 2006, Ribeiro et al. 2010, Carmignotto and Aires 2011, Bonvicino et al. 2012, Pardiñas and Teta 2015).

**Conservation status.** The red list of the IUCN ver 3.1 assigned the category “Least Concern” to *Thalpomys cerradensis* (see Marinho-Filho et al. 2016a). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

### *Thalpomys lasiotis* Thomas, 1916

**Distribution.** *Thalpomys lasiotis* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Minas Gerais, Rondônia, and São Paulo, and in the Distrito Federal (HersHKovitz 1990a, Ribeiro et al. 2010, 2011, Rocha et al. 2011a, Pardiñas and Teta 2015).

**Conservation status.** The red list of the IUCN ver 3.1 assigned the category “Least Concern” to *Thalpomys lasiotis* (see Marinho-Filho et al. 2016b). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

## Rodentia, Cricetidae, Sigmodontinae, Oryzomyini

### *Cerradomys marinhus* (Bonvicino, 2003)

**Distribution.** *Cerradomys marinhus* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia and Minas Gerais (Carmignotto and Aires 2011, Percequillo 2015, Tavares et al. 2016).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Cerradomys marinhus* (see Bonvicino and Percequillo 2008). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### *Euryoryzomys lamia* (Thomas, 1901)

**Distribution.** *Euryoryzomys lamia* is endemic to the Cerrado, and has been recorded in the Brazilian states of Minas Gerais and Goiás (Prado and Percequillo 2013).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Euryoryzomys lamia* (see Percequillo and Weksler 2008). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

***Microakodontomys transitorius* Hershkovitz, 1993**

**Distribution.** *Microakodontomys transitorius* is endemic to the Cerrado, and has been recorded in the Brazilian Distrito Federal (Hershkovitz 1993, Bonvicino et al. 2014, Paresque and Hanson 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Microakodontomys transitorius* (see Marinho-Filho and Vieira 2010). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

***Oecomys cleberi* Locks, 1981**

**Distribution.** *Oecomys cleberi* is endemic to the Cerrado, and has been recorded in the Brazilian Distrito Federal (Locks 1981, Rocha et al. 2012, Carleton and Musser 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Oecomys cleberi* (see Costa et al. 2008). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Oligoryzomys moojeni* Weksler & Bonvicino, 2005**

**Distribution.** *Oligoryzomys moojeni* is endemic to the Cerrado, and has been recorded in the Brazilian states of Goiás and Tocantins (Miranda et al. 2009, Weksler and Bonvicino 2005, Carmignotto and Aires 2011, Di-Nizo et al. 2015, Gomes et al. 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Oligoryzomys moojeni* (see Weksler and Bonvicino 2008b). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Oligoryzomys rupestris* Weksler & Bonvicino, 2005**

**Distribution.** *Oligoryzomys rupestris* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Goiás, and Minas Gerais (Weksler and Bonvicino 2005, Pereira and Geise 2009, Di-Nizo et al. 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Oligoryzomys rupestris* (see Weksler and Bonvicino 2008c). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).



***Oligoryzomys stramineus* Bonvicino & Weksler, 1998**

**Distribution.** *Oligoryzomys stramineus* is endemic to the Cerrado and the Caatinga, and has been recorded in the Brazilian states of Bahia, Ceará, Goiás, Minas Gerais, Paraíba, Pernambuco and Piauí (Bonvicino and Weksler 1998, Weksler and Bonvicino 2005, 2015, Geise et al. 2010, Fernandes et al. 2012).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Oligoryzomys stramineus* (see Weksler and Bonvicino 2008d). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

**Rodentia, Cricetidae, Sigmodontinae, Phyllotini*****Calassomys apicalis* Pardiñas, Lessa, Salazar-Bravo & Câmara, 2014**

**Distribution.** *Calassomys apicalis* is endemic to the Cerrado, and has been recorded only in the Brazilian state of Minas Gerais (Pardiñas et al. 2014).

**Conservation status.** The red list of the IUCN ver. 3.1 has not yet attempted to evaluate the extinction risk of *Calassomys apicalis*. The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Calomys expulsus* (Lund, 1840)**

**Distribution.** *Calomys expulsus* is endemic to the Cerrado and the Caatinga (contra Gurgel-Filho et al. 2015). All but one known records attributable to this species are located within these biomes; the exceptional record comes from a site likely harboring transitional conditions, in terms of physiognomy and climate, between those of the Caatinga and Atlantic Forest, in the Brazilian state of Pernambuco (see Gurgel-Filho et al. 2015, who referred to this species as *C. mattevii*, which we consider a junior synonym of *C. expulsus*; see “Taxonomy”, below). Specimens attributed to *C. expulsus* have been recorded in the Brazilian states of Bahia, Goiás, Minas Gerais, Pernambuco, Piauí, Sergipe, and in the Distrito Federal (Bonvicino and Almeida 2000, Bonvicino et al. 2003, Almeida et al. 2007, Haag et al. 2007, Bonvicino et al. 2012, Bezerra et al. 2014, Gurgel-Filho et al. 2015 and references therein, Nogueira et al. 2015). According to Gurgel-Filho et al. (2015), unpublished results of a phylogenetic study recovered samples of “*C. mattevii*” (= *C. expulsus*) in a clade in which samples from the states of Ceará and Tocantins – for which we presume no karyotype were available – were also included.

**Taxonomy.** We provisionally consider the recently described *Calomys mattevii* as a junior synonym of *Calomys expulsus*. Gurgel-Filho et al. (2015) asserted that two specimens karyotyped by Geise et al. (1996), collected in Lagoa Santa (the type local-

ity of *Calomys expulsus*), Minas Gerais, with  $2n=36/FN=66$ , correspond to *C. expulsus*; however, Gurgel-Filho et al. (2015) did not examine these specimens. These authors alleged that the karyotype  $2n=66/FN=68$ , widely attributed by authors to *C. expulsus* (e.g., Bonvicino and Almeida 2000, Mattevi et al. 2005, Haag et al. 2007, Bezerra et al. 2014, Salazar-Bravo 2015), would have to correspond to a different species (other than *C. expulsus*), which they described as *C. mattevii*. Although it is plausible that the specimens reported by Geise et al. (1996) were indeed *C. expulsus*, this cannot be assumed as certain because multiple species of *Calomys* might occur in Lagoa Santa (not only *C. expulsus*). In fact, Lagoa Santa is also the type locality of *C. tener* (see Winge 1887, Salazar-Bravo 2015), and the identity of the specimens from Lagoa Santa that were the basis of Geise et al.'s (1996) report has also been attributed to *C. cerqueirai* (Bonvicino et al. 2010; see also Colombi and Fagundes 2015, Salazar-Bravo 2015 and citations therein). Examination of the specimens from which Geise et al. (1996) obtained the reported karyotypes, and comparisons of their morphologies with respect to type material of *C. expulsus*, would be necessary to evaluate whether Gurgel-Filho et al.'s (2015) conjecture is correct. Unfortunately, it is unclear whether the specimens karyotyped by Geise et al. (1996) were ever deposited in a zoological collection, and whether their morphology matches that of *C. expulsus* – see similar concern expressed by Bonvicino and Almeida (2000, p. 347). Moreover, the karyotype reported by Geise et al. (1996) was not ever part of a formal peer-reviewed publication; it was rather reported as an abstract from a presentation at a scientific meeting – the 42th National Congress of Genetics of the *Sociedade Brasileira de Genética* – that have permeated into the literature. In addition, to support their conjecture and decision to describe *C. mattevii*, Gurgel-Filho et al. (2015) disregarded the use of morphological data as relevant to assess the taxonomic status of *C. mattevii*. However, we argue that it is possible to use morphometrics to discriminate among some species of *Calomys*; albeit not an easy task, and might not always lead to evidence that allow unambiguous discrimination among the studied species, several authors have accomplished it in the past (e.g., Bonvicino and Almeida 2000, Bonvicino et al. 2003, Cordeiro-Estrela et al. 2006).

In summary, given the aforementioned uncertainties in the description of *Calomys mattevii*, we provisionally consider it a junior synonym of *C. expulsus*. Collecting, karyotyping, and sequencing *Calomys* from the type locality of *C. expulsus* (see above), and using this material in comparative analyses that should include typical, or at least topotypical, material of other members of the large-size group of the genus (i.e., *C. callidus*, *C. callosus*, *C. cerqueirai*, and *C. tocantinsi*) is a necessary step to evaluate the taxonomic status of *C. mattevii*. On the meantime, we consider that karyotype  $2n=66/FN=68$  corresponds to *C. expulsus*, following Bonvicino and Almeida (2000), who asserted that the morphology of their karyotyped specimens is congruent with morphological characters and measurements of the holotype of *C. expulsus* as reported by Winge (1887) and Hershkovitz (1962), respectively.

**Conservation status.** The red list of the IUCN ver 3.1 assigned the category “Least Concern” to *Calomys expulsus* (see Bonvicino and Geise 2008a). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Calomys tocantinsi* Bonvicino, Lima & Almeida, 2003**

**Distribution.** *Calomys tocantinsi* is endemic to the Cerrado, and has been recorded in the Brazilian states of Mato Grosso and Tocantins (Bonvicino et al. 2003, 2010, Cordeiro-Estrela et al. 2006, Rocha et al. 2011a).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Calomys tocantinsi* (see Bonvicino and Marinho-Filho 2008a). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

**Rodentia, Cricetidae, Sigmodontinae, Thomasomyini*****Rhipidomys cariri* Tribe, 2005**

**Distribution.** *Rhipidomys cariri* is endemic to the Caatinga, and has been recorded in the Brazilian states of Bahia, Ceará, and Pernambuco (Tribe 2005, 2015, Geise et al. 2010, Fernandes-Ferreira et al. 2015, Gurgel-Filho et al. 2015).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Rhipidomys cariri* (see Patton et al. 2008a). The species appears in the official list of threatened species of Brazil with the category “Vulnerable” (ICMBIO-MMA 2016).

**Rodentia, Cricetidae, Sigmodontinae, Wiedomyini*****Wiedomys cerradensis* Gonçalves, Almeida & Bonvicino, 2005**

**Distribution.** *Wiedomys cerradensis* is endemic to the Cerrado, and has been recorded in the Brazilian states of Bahia, Ceará, Goiás, and Tocantins (Gonçalves et al. 2005, Bezerra et al. 2013, Bonvicino 2015, Gurgel-Filho et al. 2015). Gurgel-Filho et al. (2015) indicated that the species also occurs in the Brazilian states of Piauí, Maranhão, Paraíba, and Pernambuco, but did not provide evidence supporting this assertion.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Wiedomys cerradensis* (see Bonvicino and Marinho-Filho 2008b). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Wiedomys pyrrhorhinos* (Wied-Neuwied, 1821)**

**Distribution.** *Wiedomys pyrrhorhinos* is endemic to the Caatinga, and has been recorded in the Brazilian states of Alagoas, Bahia, Minas Gerais, Paraíba, and Pernambuco

(Maia and Langguth 1987, Pereira and Geise 2009, Souza et al. 2011a, Bonvicino 2015, Nogueira et al. 2015). Bonvicino (2015) indicated that the species is also present in the state of Sergipe, but this assertion is based on an abstract presented at the XXIV Jornadas Argentinas de Mastozoología. Citation of this abstract is as follows:

Souza ALG, Pessôa LM, Menezes AN, Bezerra AMR, Bonvicino CR (2011) O rio São Francisco como provável barreira geográfica para as duas espécies do gênero *Wiedomys* (Rodentia). Revista del Museo de La Plata, Zoología 18(172): 163R. [abstract presented in the XXIV Jornadas Argentinas de Mastozoología, La Plata, Argentina, November 8–11, 2011].

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Wiedomys pyrrhorhinos* (see Marinho-Filho and Langguth 2016). The species was not included in the official list of threatened species of Brazil (ICM-BIO-MMA 2016).

## Rodentia, Echimyidae, Eumysopinae

### *Carterodon sulcidens* (Lund, 1838)

**Distribution.** *Carterodon sulcidens* is endemic to the Cerrado, and has been recorded in the Brazilian states of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, and in the Distrito Federal (Ribeiro et al. 2010, Bezerra et al. 2011, Bezerra and Bonvicino 2015a and references therein).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Data Deficient” to *Carterodon sulcidens* (see Lacher 2016). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### *Phyllomys brasiliensis* Lund, 1840

**Distribution.** *Phyllomys brasiliensis* is endemic to the Cerrado, and has been recorded in the Brazilian state of Minas Gerais (Emmons et al. 2002, Leite 2003, Leite and Loss 2015).

**Conservation.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Phyllomys brasiliensis* (see Loss and Leite 2016). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

### *Thrichomys apereoides* (Lund, 1839)

**Distribution.** *Thrichomys apereoides* is endemic to the Cerrado (contra Oliveira and Langguth 2004, Paglia et al. 2012), and has been recorded in the Brazilian state of Minas Gerais (Nogueira et al. 2015, Pessôa et al. 2015, Stumpp et al. 2016; but see “Taxonomy”, below).

**Taxonomy.** Based on karyological data, Bonvicino et al. (2002) changed the traditional notion that the genus *Thrichomys* was monotypic (*T. apereoides*). Subsequently, two other studies gave support to the polytypic nature of *Thrichomys*, one based on karyological data and morphometric analyses (Pessôa et al. 2004), and the other on karyological data and phylogenetic (maximum parsimony, maximum likelihood) and phenetic (neighbor joining) analyses of cytochrome-*b* sequences (Braggio and Bonvicino 2004). A synthetic view of progress made since then has been recently published (by Pessôa et al. 2015a), and restricted species names to populations from type localities and nearby areas. In absence of a comprehensive systematic review for the genus *Thrichomys*, we provisionally adhere to that synthesis, according to which *T. apereoides* is restricted to a few localities in the state of Minas Gerais. Nevertheless, records potentially attributable to this species exist for localities corresponding to the Cerrado biome in the Brazilian states of Goiás and Tocantins (Bezerra et al. 2013, Gomes et al. 2015). Clearly, a systematic review including karyotyped and sequenced samples from throughout the distribution of all currently recognized species and their type localities is needed to establish species boundaries and distributions.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Thrichomys apereoides* (see Roach and Naylor 2016b). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

### *Thrichomys inermis* (Pictet, 1843)

**Distribution.** *Thrichomys inermis* is endemic to the Caatinga (contra Carmignotto et al. 2012, Paglia et al. 2012), and has been recorded in the Brazilian state of Bahia (Pereira and Geise 2009, Pessôa et al. 2015a). Alleged records of the species for the Brazilian state of Tocantins, from what seems to correspond to the Cerrado biome, reported in abstracts of meeting presentations have permeated through the literature – e.g., cited by Oliveira and Bonvicino (2006), Bonvicino et al. (2008), Pessôa et al. (2015a) – but, to the best of our knowledge, tangible evidence of the species being present in states and biomes other than Bahia and the Caatinga, respectively, is still lacking. The aforementioned abstracts are as follows:

Carvalho AH, Fagundes V (2005) Área de ocorrência de três táxons do gênero *Thrichomys* (Echimyidae, Rodentia) baseados em identificação cariotípica. In: Fagundes V, Costa LP, Leite YLR, Mendes SL (Eds), Livros de resumos, III Congresso Brasileiro de Mastozoologia. Espírito Santo, Aracruz, p. 102.

Carvalho AH, Lopes MOG, Svartman M (2008) Cariótipo de *Thrichomys inermis* (Rodentia, Echimyidae) do Tocantins. XXVII Congresso Brasileiro de Zoologia, Curitiba.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Thrichomys inermis* (see Bonvicino and Geise 2008b). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Trinomys albispinus* (I. Geoffroy, 1838)**

**Distribution.** *Trinomys albispinus* is endemic to the Cerrado and the Caatinga (contra Carmignotto et al. 2012, Paglia et al. 2012), and has been recorded in the Brazilian states of Bahia, Minas Gerais, and Sergipe (Souza et al. 2006, Pessôa et al. 2015b).

**Taxonomy.** The recently published synopsis of the genus *Trinomys* by Pessôa et al. (2015b) followed the views of Reis and Pessôa (1995) and Souza et al. (2006) in treating *Trinomys minor* as a subspecies of *T. albispinus* (i.e., *T. a. minor*). Reis and Pessôa (1995) did not discuss the biogeographic context they presumably considered to designate *minor* as a subspecies of *T. albispinus* (then allocated in the genus *Proechimys*) instead of a valid species. Souza et al. (2006) considered *minor* as a subspecies of *T. albispinus* due to the fact that karyotypes that they and Leal-Mesquita et al. (1992) attributed to *albispinus* and *minor*, respectively, shared the same diploid and autosomal fundamental numbers ( $2n=60$ ,  $FN_a=116$ ), morphology of the sex chromosomes, and size of the first and second pairs of autosomes. Pessôa et al. (2015b) textually described a topology presumably resulting from phylogenetic analyses based on cytochrome-*b* sequences by Souza (2011 [an unpublished Ph.D. dissertation]) in which samples attributed to *minor* were nested within a haplogroup formed by samples attributed to *T. albispinus sertoniensis* (= *T. a. albispinus* [sensu Pessôa et al. 2015b and references therein]). We currently lack access to both the sequence data and the analyses that formed the basis of Pessôa et al.'s (2015b) views. Regardless, we argue that *T. minor* and *T. albispinus* represent different, valid species, for the following reasons: (1) the two species occur in a geographic context in which no clear barrier to dispersal separate them (see map in Pessôa et al. 2015b: 1004), and records of both species exists at only 30 km away from each other (see Souza et al. 2006); (2) the two species present well marked morphological differences (Reis and Pessôa 1995, Pessôa and Strauss 1999, Souza et al. 2006), and specimens with intermedium morphological characteristics have not been reported. These aspects strongly suggest that *minor* and *albispinus* do not constitute different subspecies of a single species, but rather that they are valid biological species, able to maintain their morphological differences in close geographic proximity and in absence of barriers to dispersal (i.e., virtually in sympatry) – even if they share the same karyotype and shallow genetic divergences. According to Pessôa et al. (2015b), Lack-Ximenes (2005 [an unpublished Ph.D. dissertation]) also recommends treating *T. minor* as a species rather than as a subspecies of *T. albispinus*. A number of potential causes could explain the yet-to-be-confirmed topology described in the species account by Pessôa et al. (2015b), including incomplete lineage sorting and other more technical aspects of the analyses and/or data (e.g., saturation of sequences, biases in nucleotide composition). Addressing these possibilities is pending from future publication of the sequence data used in those analyses and from future efforts to obtain nuclear sequence data from populations of *T. minor* and *T. albispinus*.

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Least Concern” to *Trinomys albispinus* (see Bonvicino et al. 2016). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Trinomys minor* (Reis & Pessôa, 1995)**

**Distribution.** *Trinomys minor* is endemic to the Cerrado and the Caatinga (not Carmignotto et al. 2012, Paglia et al. 2012), and has been recorded in the Brazilian state of Bahia (Pessôa et al. 2015b).

**Taxonomy.** See the Taxonomy section of *Trinomys albispinus* (above).

**Conservation status.** The red list of the IUCN ver. 3.1 has not yet attempted to evaluate the extinction risk of *Trinomys minor*, and although the IUCN acknowledged that the Lack-Ximenes's (2005) unpublished Ph.D. dissertation concluded that *minor* merited species-level recognition, it treated *minor* as a subspecies of *T. albispinus* (see Bonvicino et al. 2016). The species was not included in the official list of threatened species of Brazil (ICMBIO-MMA 2016).

***Trinomys yonenagae* (Rocha, 1996)**

**Distribution.** *Trinomys yonenagae* is endemic to the Caatinga, and has been recorded in the Brazilian state of Bahia (Rocha 1995, Pessôa et al. 2015b, Tavares et al. 2016).

**Conservation status.** The red list of the IUCN ver. 3.1 assigned the category “Endangered” to *Trinomys yonenagae* (see Roach and Naylor 2016a). The species appears in the official list of threatened species of Brazil with the category “Endangered” (ICMBIO-MMA 2016).

**Discussion**

*Endemic faunas and taxonomic richness.* Three endemic mammalian faunas can be recognized in our results: one endemic to the Caatinga (ten species that are currently allocated in ten genera; hereafter “Caatinga-only endemics”), other endemic to the Cerrado (22 species that are currently allocated in 18 genera; hereafter “Cerrado-only endemics”), and another endemic to the Caatinga and the Cerrado in combination (i.e., formed by taxa with presence in both biomes; eleven species that are currently allocated in ten genera; hereafter “Caatinga-Cerrado endemics”). Altogether, these faunas encompass 43 species (allocated in 31 genera) that are only found in either the Caatinga, or the Cerrado, or both (Tables 1 and 2). Discrepancies between these figures – as well as the taxonomic identity of the taxa that form their basis – with respect to those from previous syntheses (e.g., Marinho-Filho et al. 2002, Ribeiro et al. 2010, Carmignotto et al. 2012) can be explained by the following factors: (1) some of the currently available data on the taxonomy and distribution of these faunas were not available when previous syntheses were conducted (see under Species Accounts); (2) the geographic scope considered in the present study differ from some of those used in previous studies – e.g., contrary to Carmignotto et al. 2012, we did not regard the Pantanal as part of the Cerrado, as we consider it to be a biome itself, with particular in-

**Table 1.** List of mammal species endemic to the Caatinga, the Cerrado, or both, and their habitat and conservation statuses. Biome: Caatinga (Ca), Cerrado (Ce). Habitat: forest (F), open (O; e.g., campo limpo, cerrado *sensu stricto*; Oliveira and Marquis 2002), Locs: approximate number of localities for which voucher specimens exist according to the literature (see Species Accounts). IUCN: conservation status according to the International Union for the Conservation of Nature (Red List of Threatened Species version 3.1). ICMBio-MMA: conservation status according to the *Instituto Chico Mendes de Conservação da Biodiversidade-Ministério do Meio Ambiente* of Brazil (ICMBio-MMA 2016). Categories for conservation statuses: Data Deficient (DD), Low Concern (LC), Vulnerable (VU), Near Threatened (NT), Endangered (EN), Critically Endangered (CR), Extinct (EX); species that have not been evaluated by the IUCN or the ICMBio-MMA are indicated with m-dashes. Differences with respect to previous lists (from the literature) are discussed in the Results section.

Order, Family	Species	Biome	Habitat	Locs.	IUCN	ICMBio-MMA	
Chiroptera, Phyllostomidae	<i>Chiroderma vizottoi</i>	Ca	F	4	–	–	
	<i>Lonchophylla inexpectata</i>	Ca	F, O <sup>1</sup>	3	–	–	
	<i>Xeronycteris vieirai</i>	Ca	O <sup>2</sup>	6	DD	VU	
Primates, Pitheciidae	<i>Callicebus barbarabrownae</i>	Ca	F	>15	CR	CR	
Rodentia, Caviidae	<i>Galea spixii</i>	Ca	O	>15	LC	–	
	<i>Kerodon rupestris</i>	Ca	O	>15	LC	VU	
Rodentia, Cricetidae	<i>Rhipidomys cariri</i>	Ca	F	10	DD	VU	
	<i>Wiedomys pyrrhorhinos</i>	Ca	F, O	14	LC	–	
Rodentia, Echimyidae	<i>Thrichomys inermis</i>	Ca	F, O	12	LC	–	
	<i>Trinomys yonenagae</i>	Ca	O	2	EN	EN	
Didelphimorphia, Didelphidae	<i>Thylamys (Xerodelphis) velutinus</i>	Ce	O	7	NT	VU	
Chiroptera, Phyllostomidae	<i>Lonchophylla bokermanni</i>	Ce	F, O <sup>1</sup>	4	EN	–	
	<i>Lonchophylla dekeyseri</i>	Ce	F, O	6	EN	EN	
Primates, Cebidae	<i>Callithrix penicillata</i>	Ce	F, O	>15	LC	–	
Rodentia, Caviidae	<i>Kerodon acrobata</i>	Ce	F, O	5	DD	VU	
Rodentia, Cricetidae	<i>Calassomys apicalis</i>	Ce	O	2	–	–	
	<i>Calomys tocantinsi</i>	Ce	F, O	10	LC	–	
	<i>Cerradomys marinhos</i>	Ce	F, O	2	DD	–	
	<i>Euryoryzomys lamia</i>	Ce	F <sup>3</sup>	3	EN	EN	
	<i>Gyldenstolpia planaltensis</i>	Ce	O	3	–	–	
	<i>Juscelinomys candango</i>	Ce	O	1	EX	CR/EX	
	<i>Juscelinomys huanchacae</i>	Ce	O	4	DD	–	
	<i>Microakodontomys transitorius</i>	Ce	F, O	2	EN	EN	
	<i>Oecomys cleberi</i>	Ce	F	4	DD	–	
	<i>Oligoryzomys moojeni</i>	Ce	F, O	7	DD	–	
	<i>Oligoryzomys rupestris</i>	Ce	O	3	DD	EN	
	<i>Thalpomys cerradensis</i>	Ce	O	>15	LC	VU	
	<i>Thalpomys lasiotis</i>	Ce	O	10	LC	EN	
	<i>Wiedomys cerradensis</i>	Ce	F, O	3	DD	–	
	Rodentia, Echimyidae	<i>Carterodon sulcidens</i>	Ce	O	12	DD	–
		<i>Phyllomys brasiliensis</i>	Ce	F, O	2	EN	EN
<i>Thrichomys apereoides</i>		Ce	O	15	LC	–	
Didelphimorphia, Didelphidae	<i>Cryptonomys agricolai</i>	Ca, Ce	F, O <sup>4</sup>	10	DD	–	
	<i>Thylamys (Xerodelphis) karimii</i>	Ca, Ce	F, O	>15	VU	–	



Order, Family	Species	Biome	Habitat	Locs.	IUCN	ICMBio-MMA
Cingulata, Dasypodidae	<i>Tolypeutes tricinctus</i>	Ca, Ce	F, O	>15	VU	EN
Chiroptera, Phyllostomidae	<i>Micronycteris sanborni</i>	Ca, Ce	F, O	13	DD	–
Primates, Cebidae	<i>Cebus (Sapajus) libidinosus</i>	Ca, Ce	F, O	>15	LC	–
Carnivora, Canidae	<i>Lycalopex vetulus</i>	Ca, Ce	O	>15	LC	VU
Rodentia, Cricetidae	<i>Calomys expulsus</i>	Ca, Ce	F, O	>15	LC	–
	<i>Oligoryzomys stramineus</i>	Ca, Ce	F, O	>15	LC	–
	<i>Oxymycterus delator</i>	Ca, Ce	O	>15	LC	–
Rodentia, Echimyidae	<i>Trinomys albispinus</i>	Ca, Ce	F	12	LC	–
	<i>Trinomys minor</i>	Ca, Ce	O	3	–	–

<sup>1</sup> Unpublished observations suggest that *Lonchophylla inexpectata*, *L. bokermanni*, and *L. dekeyseri* occur in open and forest habitat types (R. Moratelli *in litt.* for *L. inexpectata* and *L. bokermanni*; personal observations for *L. dekeyseri*).

<sup>2</sup> *Xeronycteris vieirai* is associated to outcroppings in open habitats; however, some of this outcroppings are located near forests, and it is likely that the species forages in them (M. Nogueira *in litt.*).

<sup>3</sup> Two of the three known localities known for *Euryoryzomys lamia* correspond to transitional areas between gallery forest and open habitats (see Bonvicino et al. 1998).

<sup>4</sup> Currently available records for *Cryptonanus agricolai* suggest that it occurs in open habitats as well as in enclaves of moist forests within the Caatinga locally known as *brejos de altitude*.

**Table 2.** Number of genera and species endemic to the Caatinga, the Cerrado, or both, per mammalian order. The column “Caatinga-Cerrado” corresponds to endemic taxa with presence in both biomes, whereas the column “all endemics” corresponds to taxa either endemic to the Caatinga, or to the Cerrado, or endemic to both in combination.

	Caatinga-only		Cerrado-only		Caatinga-Cerrado		All endemics	
	Genera	Species	Genera	Species	Genera	Species	Genera	Species
Didelphimorphia	0	0	0	1	0	2	0	3
Cingulata	0	0	0	0	0	1	0	1
Chiroptera	1	3	0	2	0	1	1	6
Primates	0	1	0	1	0	1	0	3
Carnivora	0	0	0	0	1	1	1	1
Rodentia	0	6	5	18	2	5	7	29
Total	1	10	5	22	3	11	9	43

fluences from other humid biomes (see Werneck 2011 and references therein); (3) we disregarded information that has not ever been published, but that had permeated into the literature in the form of cited abstracts that merely correspond to presentations in scientific meetings, personal observations, or unpublished data (with the only exception of habitat information for three species of *Lonchophylla* and *Xeronycteris vieirai*; see Table 1). Current and future fieldwork and taxonomic research will undoubtedly alter our current list of endemic species (Table 1). For instance, future research might reveal that the distributions of species currently known only from transitional zones between our focal and neighboring biomes are larger than currently understood, which

might render some of these species as endemic to our focal biomes (see section “Species currently only known from transitional areas”, below).

Species richness was the highest in the Cerrado-only endemics, followed by the Caatinga-Cerrado endemics, and then by the Caatinga-only endemics. The order with highest species richness in all three faunas aforementioned was rodents; all other orders were represented by only one to three species (Tables 1 and 2). Pooling together the three faunas, bats were the second most important order, with six species. These results are congruent with patterns found in earlier studies (e.g., Marinho-Filho et al. 2002, Carmignotto et al. 2012 and references therein). The fact that the Caatinga-Cerrado endemics present an intermedium level of species richness between that of the Caatinga-only and the Cerrado-only endemics suggests the possibility that the Cerrado might have functioned as a source of ancestral populations for the Caatinga. This process might be explained by (1) the chronological order in which the Caatinga and the Cerrado established in the region, with the Cerrado being established substantially earlier than the Caatinga, and (2) by the larger size and higher habitat heterogeneity of the Cerrado (see Werneck 2011 and references therein; Carmignotto et al. 2012). Nevertheless, this process and its potential causal explanations remain as hypotheses to be tested employing other sources of information and considering additional factors, as the possible effect of species extinction masking past patterns of species richness in the focal biomes.

As demonstrated, from the biogeographic point of view, the Caatinga-Cerrado endemics deserve attention as a unit, as is the case for the Caatinga-only and the Cerrado-only endemics (e.g. Carmignotto et al. 2012). The Caatinga-Cerrado endemic fauna is composed of two marsupials (*Cryptonanus agricolai*, *Thylamys karimii*), one xenarthran (*Tolypeutes tricinctus*), one bat (*Micronycteris sanborni*), one primate (*Cebus libidinosus*), one carnivore (*Lycalopex vetulus*), and five rodents (*Calomys expulsus*, *Oligoryzomys stramineus*, *Oxymycterus delator*, *Trinomys albispinus*, *Trinomys minor*). Two genera are currently known to be endemic to the Caatinga-Cerrado unit (the marsupial genus *Cryptonanus* and the rodent genus *Kerodon*). Among Caatinga-Cerrado endemics, only *Trinomys albispinus* seems to be strictly associated to forest habitat, whereas *Lycalopex vetulus*, *Oxymycterus delator*, and *Trinomys minor* seem strictly associated to open habitat. The remaining seven species are likely associated to both open and forest habitats (Table 2; see also Species Accounts). This heterogeneity in habitat association suggests a complex biogeographic history. To dig into this history, it is necessary to revise the phylogenetic information existing for each of these species, and integrate it with that for Caatinga-only and Cerrado-only endemics. Such a task is out of the scope of the present study, which aims to set a baseline, regarding the distribution, taxonomy, and conservation statuses of the focal species, upon which further studies could be built. However, we stress that delimiting these three faunas (Caatinga-only, Cerrado-only, and Caatinga-Cerrado endemics) as discrete study subjects – rather than focusing only on two of them, those of the Caatinga and the Cerrado – and then integrating information about their corresponding biogeographic patterns, might provide novel information regarding the evolutionary origin of the biota of open dry habitats of central and northeastern South America.

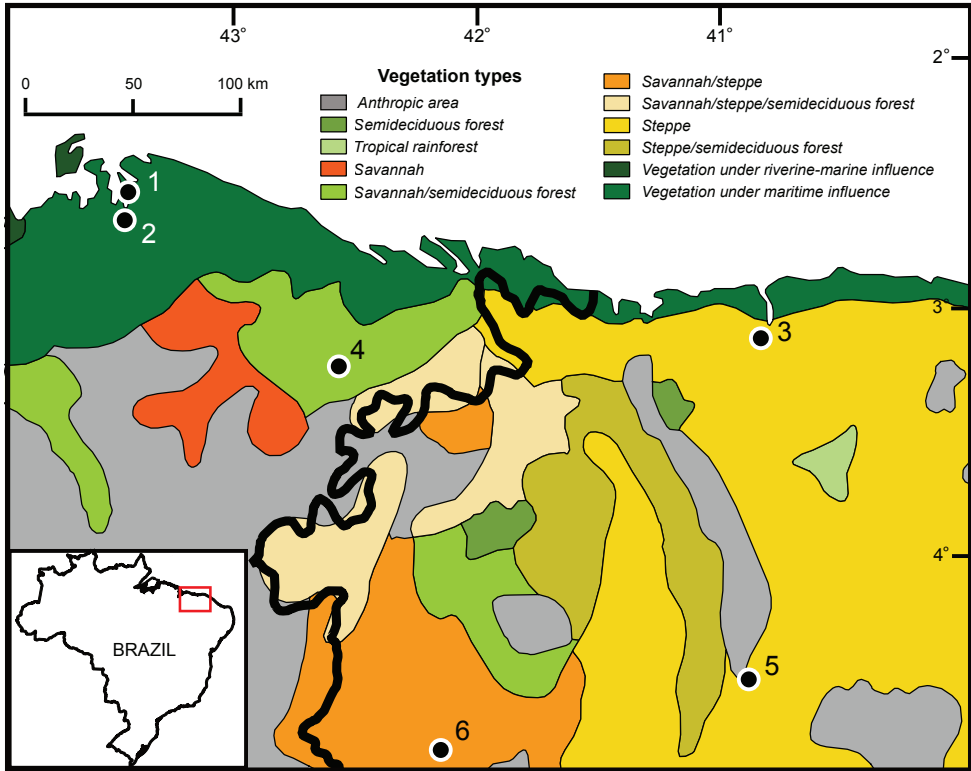
*Species currently only known from transitional areas.* A group of species are currently known only from transitional areas between our focal biomes and other adjacent biomes. These species include *Oligoryzomys utiaritensis*, *Rhipidomys ipukensis*, and an undescribed species of *Akodon*, all of which occur in transitional areas between the Brazilian Cerrado and the Amazon (Rocha 2011b, Pardiñas et al. 2015, Weksler and Bonvicino 2015); it is unclear whether they are restricted to those transitional areas, or if they are rather Cerrado, or Amazon, endemics with presence in the contact zones between these two biomes. Similarly, *Calomys cerqueirai* and *Phyllomys brasiliensis* are known from transitional areas between the Cerrado and the Atlantic Forest (Bonvicino et al. 2010, Leite and Loss 2015, Salazar-Bravo 2015); it remains to be investigated whether these species are restricted to those transitional areas, or if they are rather Cerrado, or Atlantic Forest, endemics with presence in the contact zones between these biomes.

*A howler monkey endemic to the Cerrado and the Caatinga?* A case that deserves special discussion is that of a group of populations of howler monkeys from the northern part of the Brazilian states of Ceará, Maranhão, and Piauí. These populations have been regarded as a valid species, *Alouatta ululata* (e.g., Elliot 1912, 1913, Gregorin 2006), or as either a subspecies (Bonvicino et al. 1989) or a junior synonym (Groves 2001, 2005) of *Alouatta belzebul*. The primary argument based on which recognizing “*ululata*” as a valid taxon (either a species or a subspecies of *A. belzebul*) has been advocated is the existence of sexual dimorphism on pelage coloration in this form; however, there is a wide variation in color pelage within *A. belzebul*, and some variation exists even among samples of “*ululata*” (see Gregorin 2006). In fact, in his review of Brazilian species of *Alouatta*, Gregorin (2006) acknowledged to have defined “*Alouatta ululata*” based on its “... sexual dicromism [sic] on pelage, but this character can be an artefate [sic] due the small sample”, and that this taxon needs to be further studied to confirm its validity. One such study was recently published based on analyses of sequence data from the mitochondrial cytochrome-*b* gene (CYTB) and karyotypes (Viana et al. 2015). This study found no karyological differences between *A. belzebul* and “*ululata*”, and its phylogenetic analyses recovered “*ululata*” nested within a haplogroup formed by all analyzed samples of *A. belzebul*. Given that karyological and CYTB data have proven to be taxonomically informative in *Alouatta* (e.g., Bonvicino et al. 1995, Cortés-Ortiz et al. 2003), the results just described suggest that “*ululata*” might just be a junior synonym of *A. belzebul*. The Principal Component Analysis conducted by Gregorin (2006) on the basis of linear measurements taken on skulls and mandibles support this view, as no morphometric discontinuities between “*ululata*” and samples of *A. belzebul* were detected. Nevertheless, considering that only one sample of “*ululata*” was analyzed in the study by Viana et al. (2015), and that future efforts based on more samples and the use of faster evolving parts of the genome – e.g., the mitochondrial control region, nuclear introns, or some flanking regions of ultra conserved elements – could potentially reveal that “*ululata*” represent a lineage worth nomenclatural recognition, we conservatively treat “*ululata*” as a subspecies of *A. belzebul* (i.e., *A. b. ululata*), a status also considered by Bonvicino et al. (1989). Future efforts to clarify the taxonomic status of populations that have been referred to as “*ululata*” should test for an addition-

al possibility, which is that population that have been referred to as corresponding to “*ululata*” could represent hybrids between *A. belzebul* and *A. caraya* (Garbino *in litt.*). With respect to the distribution of *A. b. ululata*, some authors regarded it as endemic to the Cerrado and the Caatinga (Carmignotto et al. 2012), whereas others regarded it as restricted to the Amazonia and the Caatinga (Paglia et al. 2012). Using Geographic Information Systems, we determined that occurrence localities of *A. b. ululata* (from Gregorin 2006, Viana et al. 2015) are within the borders of Cerrado and the Caatinga biomes as defined by the *Instituto Brasileiro de Geografia e Estatística* (IBGE 2004b) (Figure 1). Within these biomes, *A. b. ululata* inhabits predominantly transitional areas between dry, open vegetation and Amazon rain forest (*floresta pluvial amazônica*; Gregorin 2006). Whereas assessing the real taxonomic status of populations currently attributed to *A. b. ululata* remains to be accomplished, conservation efforts should be invested in protecting its endangered populations (see de Oliveira and Kierulff 2008).

*A porcupine endemic to the Caatinga?* Feijó and Langguth (2013) described an alleged new species of porcupine, *Coendou baturitensis*, on the basis of four specimens from the Baturité Range in the Brazilian state of Ceará, in the Caatinga biome. These authors mentioned that the [alleged] new species differs from *C. prehensilis* in the color pattern of quills and in having a darker general appearance. In absence of a larger sample and quantitative analyses that take into account the geographic and non-geographic variation within *C. prehensilis* and other species of *Coendou*, we are not convinced that *C. baturitensis* represents a valid species. Therefore, herein we provisionally treat *C. baturitensis* as a junior synonym of *C. prehensilis* (see also Voss 2015b).

*Species previously regarded as endemic.* A number of species that were previously considered as endemic to the Caatinga, the Cerrado, or both, are not considered endemic to those geographic units in this study because: (1) our criterion to deem a species as endemic is stricter than that used by other authors (see Methods); or (2) recently published information demonstrate that these species are present in biomes other than the Caatinga and the Cerrado; or because (3) we do not consider them valid species. Due to either of the former two criteria, we excluded the following species from our list of endemics: *Calomys tener*, *Cerradomys langguthi*, *Cerradomys vivoi*, *Cerradomys maracajuensis*, *Cerradomys subflavus*, *Ctenomys brasiliensis*, *Ctenomys nattereri*, *Clyomys laticeps*, *Dasyprocta azarae*, *Guerlinguetus poaiae*, *Kunsia tomentosus*, *Phyllomys blainvillii*, *Pseudoryzomys simplex*, *Rhipidomys macrurus*, *Thrichomys laurentius* (see Cordeiro-Estrela et al. 2006, de la Sancha et al. 2011, Bezerra 2015, Bezerra and Bonvicino 2015b, Bidau 2015, Patton and Emmons 2015, Percequillo 2015, Pessôa et al. 2015a, Salazar-Bravo 2015, de Vivo and Carmignotto 2015, Voss 2015a, Caccavo and Oliveira 2016). Besides the cases of *Alouatta ululata* and *Coendou baturitensis*, which we do not consider valid species (see discussion of cases above), we adhere to recent synopses of mammal genera provided by various authors, and do not recognize the following names as corresponding to valid species: *Guerlinguetus poaiae*, *Urosciurus urucumus*, *Dasyprocta nigriclunis*, and *Rhipidomys cearanus* (see Patton and Emmons 2015, Tribe 2015, de Vivo and Carmignotto 2015).



**Figure 1.** Localities of *Alouatta belzebul ululata* reported in the literature (Viana et al. 2015). Borders of biomes and habitat types as regarded by the *Instituto Brasileiro de Geografia e Estatística* (IBGE 2004a, b). Thick line represents the borders of the Cerrado (left) and the Caatinga (right) according to the IBGE (2004a). Localities: **1** Maranhão, Primeira Cruz (Igarapé das Palmeiras) (2.50°S, 43.33°W; Gregorin 2006) **2** Maranhão, Humberto de Campos (antiga Miritiba) (2.62°S, 43.45°W; Gregorin 2006) **3** Ceará, Granjá (Goiabeira) (3.10°S, 40.83°W; Gregorin 2006) **4** Maranhão, Boa Vista (3.22°S, 42.57°W; Gregorin 2006) **5** Ceará, São Benedito (Bom Jardim) (4.50°S, 40.88°W; Gregorin 2006); Piauí, Campo Maior [4.50°S, 40.88°W; description of locality from Viana et al. (2015); coordinates assigned by us and assessed via Google Earth version 7.1.7.2602]. Geographic coordinates in decimal degrees rounded to the nearest tenth. The original names in Portuguese for the vegetation types as reported by the IBGE (2004b) and their corresponding translation into English are as follows: *área antropizada* (anthropogenic area); *floresta estacional semidecidual* (semideciduous forest or dry forest); *floresta ombrófila aberta* (tropical rainforest); *savana* (savannah); *savana/floresta estacional* (savannah/semideciduous forest); *savana/savana estépica* (savannah/steppe); *savana/savana estépica/floresta estacional* (savannah/steppe/semideciduous forest); *savana estépica* (steppe); *savana estépica/floresta estacional* (steppe/semideciduous forest); *vegetação com influência fluviomarinha* (vegetation under riverine-marine influence); *vegetação com influência marinha* (vegetation under maritime influence).

**Conservation.** A substantial portion of the endemic mammalian faunas of the Caatinga and the Cerrado faces high risk of extinction; however, this fact has been dangerously overlooked. Considering the information published by the International Union for Conservation of Nature (IUCN; see Methods and Species Accounts), the great

majority of members of the endemic faunas of the Caatinga and the Cerrado are either of low concern, lack data for assessing their extinction risk, or have not been considered yet by the IUCN (Table 3). According to IUCN data, these three categories (Low Concern, Data Deficient, not evaluated) conform 80% of the Caatinga-only endemics (8 out of 10 species), 68% of the Cerrado-only endemics (15 out of 22 species), 82% of the Caatinga–Cerrado endemics (9 out of 11 species), and 74% of all endemics (32 out of 43 species). We argue that this situation does not reflect the reality of these faunas. Our reasons are as follows:

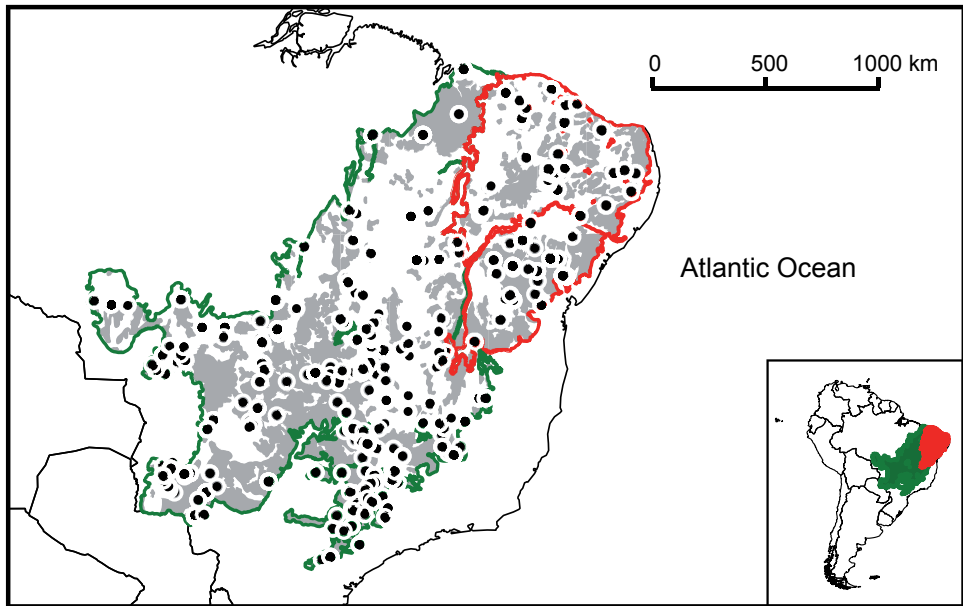
For mammals, the Caatinga and the Cerrado have been relatively well sampled; yet several of their endemic species are known only from a handful of localities. Since the second half of the 20<sup>th</sup> century, surveys of mammals in both the Caatinga and the Cerrado covered numerous sites (Mares et al. 1989, Marinho-Filho and Veríssimo 1997, Marinho-Filho et al. 1997, Bonvicino and Bezerra 2003, Bonvicino et al. 2005, 2012, Bezerra et al. 2007, 2009, 2010, 2014, Astúa and Guerra 2008, Oliveira et al. 2008, Bocchiglieri et al. 2010, Bruna et al. 2010, Silva et al. 2015; see also Marinho-Filho et al. 2002, Carmignotto et al. 2012 and references therein; see also citations under Species Accounts). Although biodiversity inventories in the Caatinga and the Cerrado are far from being complete, both biomes are relatively well sampled when compared to other biomes (e.g., the Amazon). A map (Figure 2) showing localities where sampling of mammals have taken place in the Caatinga and the Cerrado, based on data from both the Global Biodiversity Information Facility (GBIF) and the contribution by Ribeiro et al. (2010), documents that our focal biomes have been relatively well sampled. The sampling shown on this map is a quite conservative proxy of the degree of sampling conducted in these biomes, as it lacks data from Brazilian and several North American collections that are not yet available through GBIF or that were not included in the publication by Ribeiro et al. (2010) – this latter study used data from some of the Brazilian collections and focused on endemic and threatened species of the Cerrado, lacking data for species that did not meet either of these conditions. Given the sampling effort achieved in the last decades, we argue that most, if not all, of the endemic species of the Caatinga and the Cerrado to which the IUCN assigned the category “Data Deficient” are rather species with recognizable risks of extinction. The category “Data Deficient” implies the possibility that future efforts (i.e., museum work, fieldwork, or both) might demonstrate that these species are sufficiently common to be of Low Concern; however, the sampling already conducted should have yielded enough distributional records if the species did not have very low population sizes, extremely restricted distributions, or both. The application of the IUCN criteria for assigning conservation statuses globally are clearly inadequate when applied to species that are known from few records and are endemic to regions that have been well sampled.

Natural habitat loss has been pervasive in the Caatinga and the Cerrado. Due to agriculture or transformation of rural areas into urban areas, both of these biomes have lost enormous amounts of their natural habitats (Klink and Machado 2005, Leal et al. 2005, Beuchle et al. 2015). In addition to agriculture, the Caatinga suffer of high degrees of habitat transformation due to human occupation, with replacement of gallery and dry

**Table 3.** Representation of species endemic to the Caatinga, the Cerrado, or both, in each category of conservation status. The column “Caatinga-Cerrado” corresponds to taxa with presence in both biomes, whereas the column “all endemics” corresponds to taxa either endemic to the Caatinga, or to the Cerrado, or endemic to both in combination. s: number of species; IUCN: conservation status according to the International Union for the Conservation of Nature (Red List of Threatened Species version 3.1); ICMBio-MMA: conservation status according to the *Instituto Chico Mendes de Conservação da Biodiversidade-Ministério do Meio Ambiente* of Brazil (ICMBio-MMA 2016). Categories for conservation statuses: Data Deficient, Low Concern, Vulnerable, Near Threatened, Endangered, Critically Endangered, and Extinct. See Methods for descriptions of each of these categories.

Category	Caatinga-only			Cerrado-only			Caatinga-Cerrado			All endemics						
	IUCN		ICMBio-MMA	IUCN		ICMBio-MMA	IUCN		ICMBio-MMA	IUCN		ICMBio-MMA				
	s	%	s	%	s	%	s	%	s	%	s	%				
Not evaluated	2	20	5	50	2	9	12	55	1	9	9	82	5	12	26	60
Data Deficient	2	20	0	0	8	36	0	0	2	18	0	0	12	28	0	0
Low Concern	4	40	0	0	5	23	0	0	6	55	0	0	15	35	0	0
Near Threatened	0	0	0	0	1	5	0	0	0	0	0	0	1	2	0	0
Vulnerable	0	0	3	30	0	0	3	14	2	18	1	9	2	5	7	16
Endangered	1	10	1	10	5	23	6	27	0	0	1	9	6	14	8	19
Critically Endangered <sup>1</sup>	1	10	1	10	0	0	1	5	0	0	0	0	1	2	2	4
Extinct	0	0	0	0	1	5	0	0	0	0	0	0	1	2	0	0
Total number of species	10		10		22		22		11		11		43		43	

<sup>1</sup> ICMBio-MMA regards some species as Critically Endangered or Extinct; for simplicity, in this table one species (*Juscelinomyx candango*; see Table 1) with that combination of two categories was treated as Critically Endangered.



**Figure 2.** Sampling conducted for mammals and habitat lost due to human activities in the Caatinga and the Cerrado. Dots represent sites where sampling has been conducted according to data from the Global Information Biodiversity Facility (GBIF) and Ribeiro et al. (2010). These data represent a highly conservative proxy of the sampling conducted in these biomes (see Discussion). Areas in grey represent areas where habitat loss has occurred due to human activities. Borders of the Caatinga (red) and the Cerrado (green) are restricted to Brazil (i.e., does not include the small portions of the Cerrado in Bolivia and Paraguay). The plotted data for habitat loss and biome borders were obtained from the *Instituto Brasileiro de Geografia e Estatística*.

forests by open vegetation via charcoal production, timber and cattle ranching (Sampaio 1995, Leal et al. 2005, Miles et al. 2006, Pennington et al. 2006, Werneck 2011); and in the Cerrado invasive African grasses and uncontrolled fire also contribute to the elimination of natural habitats (Klink and Machado 2005). Using data from the *Instituto Brasileiro de Geografia e Estatística* (<http://www.ibge.gov.br>), we generated a map that shows extensive areas of the Cerrado and the Caatinga that have suffered of habitat transformation due to human activities (Figure 2). The extent and accelerated trend of habitat loss in both biomes make it even more likely that species for which only a handful of localities are known are facing high risks of extinction, therefore deserving conservation categories that indicate such a situation (rather than the category “Data Deficient”).

The Red List published by the IUCN is highly influential in conservation planning initiatives; hence, a review and improvement of the IUCN criteria, and of how are they applied, based on the issues we just described, represents an imperative task for the conservation of these and other endemic faunas. Sensible assessments of their conservation statuses should reflect realities of species, which is not currently the case of several of our focal species, including eleven rodents (*Calassomys apicalis*, *Cerra-*



*domys marinhus*, *Gyldenstolpia planaltensis*, *Juscelinomys huanchacae*, *Kerodon acrobata*, *Oligoryzomys moojeni*, *Oligoryzomys rupestris*, *Thalpomys cerradensis*, *Trinomys minor*, *Trinomys yonenagae*, *Wiedomys cerradensis*) and two bats (*Xeronycteris vieirai* and *Lonchophylla inexpectata*). Both bat species have been recently described; hence, because future reexamination of museum specimens might reveal that these species are more common than currently thought, the category “Data Deficient”, which has been assigned to them, might be justifiable. All other cases are undoubtedly facing certain recognizable risk of extinction.

When compared with the IUCN assessment, the Brazilian national assessment of the conservation statuses yielded categories that seem more congruent with the high risks of extinction these species face. Nevertheless, many of the species evaluated by the IUCN have not been considered in this national assessment, indicating the need for a larger and more expedite effort by Brazil’s *Ministério do Meio Ambiente* (ICMBIO-MMA 2016) to assure the conservation of the unique fauna Brazil harbors in the Caatinga and the Cerrado. This is an urgent task because many of these endemic species are associated to habitats that are experiencing fast transformation into areas for agriculture, at an unbearable cost for biodiversity.

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