

## **Nonvolant mammals of the Grota do Angico Natural Monument, northeast of Brazil: a complementary approach to the small species**

Mamíferos não-voadores do Monumento Natural Grota do Angico, nordeste do Brasil: uma abordagem complementar para pequenas espécies

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**Resumo** A Caatinga brasileira é a região semiárida mais densamente povoada do planeta. Apesar disso, a biota e os processos ecológicos locais são pouco conhecidos. A biota do estado de Sergipe também é pouco conhecida, embora metade do mesmo seja recoberto por Caatinga, atualmente com cerca de 10% de remanescentes florestais. Em busca de melhor compreender a comunidade de mamíferos da Caatinga de Sergipe, no presente estudo, inventariou-se a fauna de mamíferos não-voadores (principalmente pequenas espécies) da área protegida semiárida Monumento Natural Grota do Angico (GANM; 2.138 ha), entre janeiro e dezembro de 2010. Os dados foram coletados através de observações diretas, registros de vestígios (fezes e pegadas), relatos de informantes locais, e armadilhagem (amadilhas de queda, tipo Sherman e Tomahawk), em cinco dias a cada mês, avaliando a eficiência de amostragem e estimando a riqueza de espécies utilizando a curva de acumulação de espécies e o estimador Jackknife 1, respectivamente. Foram registradas 16 espécies que representam 11 famílias e cinco ordens. Rodentia

(n = 6) foi a ordem mais representativa, seguida por Carnivora (n = 5), e Didelphimorphia (n = 3), com uma única espécie registrada apenas por informantes locais (*Hydrochoerus hydrochaeris*). As ordens Cingulata e Primates contabilizaram apenas uma espécie cada. Com sete espécies capturadas, o estimador (Jack 1,  $8.8 \pm 1.8$ ) não indicou diferença entre as capturas e o potencial de riqueza. Os relatos da ocorrência de mamíferos de médio/grande porte no passado recente (e.g., *Pecari*, *Dasybus*, *Sylvilagus*, *Galictis*, and *Dasyprocta*) indicam a extinção local em decorrência da pressão de caça e/ou redução/fragmentação de habitat. Em uma abordagem geral, a GANM atualmente tem 20 espécies de mamíferos, enquanto a Caatinga de Sergipe conta com um total de 31 espécies de mamíferos. Apesar da ausência das espécies de maior porte e de alguns predadores, os resultados ressaltam a importância do GANM na conservação da fauna local e dos ecossistemas da região, contribuindo para a compreensão da diversidade de mamíferos na Caatinga de Sergipe.

**Palavras-chave:** Semiárido, diversidade de mamíferos, Área Protegida; Sergipe

**Abstract** The Brazilian Caatinga are the most densely populated semiarid zone of the planet. Despite this, the local biota and ecological processes are still poorly known. The biota of the Brazilian state of Sergipe is also poorly known, although half of which is part of the Caatinga, currently with about 10% of forest remnants. In order to better understand the mammal community of the Caatinga of Sergipe, in the present study, we inventoried the nonvolant mammalian fauna (mainly small species) of the semiarid protected area Grota do Angico Natural Monument (GANM; 2,138 ha), between January and December, 2010. We collected data through direct observation, records of vestiges (feces, tracks), reports from local residents, and trapping (pitfall, Sherman, and Tomahawk traps) on five days each month, evaluating sampling efficiency and estimating species richness by using the cumulative species curve and the estimator Jackknife 1, respectively. We recorded 16 species, representing 11 families and 5 orders. Rodentia ( $n=6$ ) was the most representative order, followed by Carnivora ( $n=5$ ), and Didelphimorphia ( $n=3$ ), with only one species reported exclusively by local residents (*Hydrochoerus hydrochaeris*). The orders Cingulata and Primates had one species each. With seven captured species, the estimated species richness (Jack 1,  $8.8\pm1.8$ ) indicated no differences between capturing and potential richness. The reports of the occurrence of medium/large-bodied mammals in the recent past (e.g., *Pecari*, *Dasybus*, *Sylvilagus*, *Galictis*, and *Dasyprocta*) indicates local extinction due to hunting pressure and/or habitat reduction/fragmentation. As a complementary approach, the GANM currently has 20 mammal species, while the Caatinga of Sergipe counts a total of 31 mammal species. Despite the absence of large-bodied species and some predators, the present results highlight the importance of the GANM in the conservation of the local fauna and the ecosystems of the region, contributing to the understanding of the diversity of mammals in the Caatinga of Sergipe.

**Keywords:** Semi-arid, Mammal diversity, Protected Area, Sergipe.

The Brazilian Caatingas are seasonal, dry and semi-arid, has a deciduous forest and high temperatures (Prado 2003; Leal et al. 2005). The Biome is considered the most densely populated semi-arid region of the world, which has led to the anthropogenic degradation of more than 40% of its original area (Castelletti et al. 2003). While it covers approximately half of the territory of the state of Sergipe, less than 10% of the original vegetation remains, and much of this habitat is degraded (Santos et al. 2013).

The ongoing degradation of the Caatinga has accelerated the loss of endemic species and essential ecological functions, as well as creating nuclei of desertification in many areas (Leal et al. 2003; Leal et al. 2005). These conditions are intensified by the general paucity of information on the biological diversity of these ecosystems and their ecological processes (Alcoforado-Filho et al. 2003; Leal et al. 2003), as well as the lack of protected areas, with less than 11% of the total area in strictly protected areas (Leal et al. 2005).

In the specific case of the mammal, the species play a crucial role in the maintenance of tropical forests (Terborgh 1988, 1992, Dirzo and Miranda 1990, Janson and Emmons 1990), even in the dry forests of the Brazilian Caatinga. Until recently, the few available data were restricted to a small number of sites (e.g. Oliveira and Langguth 2004), which reflects on the small percentage (6%) of known threatened species in the Caatinga (Costa et al. 2005). This scenario may be still current, despite the increase in the knowledge of the Caatinga mammal species composition (Paglia et al. 2012).

Virtually few was known about the mammalian fauna of the Caatinga of Sergipe, northeast of Brazil, as noted in Oliveira et al. (2003). Just recently, specific studies expanded the knowledge about the mammal community in specific sites of the Caatinga of the state (e.g., Freitas et al. 2011, Bezerra et al. 2014, Dias et al. 2014, Rocha et al. 2015, Dias and Bocchiglieri 2016). Given this situation, the present study focused on the small mammalian fauna of a protected area (Grota do Angico Natural Monument), in northern Sergipe, as a complimentary approach to the recent survey of medium/large mammal community of the protected area (see Dias and Bocchiglieri 2016). Currently, the Grota do Angico Natural Monument represents one of the primary remnants of Caatinga vegetation of the state, whereas the complimentary approach indicates a mammalian fauna

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## Introduction

relatively diverse, to the study site.

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## Materials and Methods

### *Study area*

The Grotta do Angico Natural Monument (GANM; 2,138 ha; 09°39'S, 37°40'W), is a protected area located in the municipalities of Poço Redondo and Canindé do São Francisco, in the Brazilian state of Sergipe, at an altitude of approximately 200 m a.s.l. (Figure 1). This protected area is located within the Southern Backlands Depression (Velloso *et al.* 2002), part of the Caatinga morphoclimatic domain of Ab'Saber (1974). The local climate is tropical hot and semi-arid, BSh according to Köppen's classification (Alvarez *et al.* 2013), with mean annual rainfall of approximately 500 mm, distributed irregularly over the course of the year, but generally with a dry season of at least eight months (Nimer 1972, Velloso *et al.* 2002).

The GANM is located in the valley of the São Francisco River, which has a relatively shallow soil (Andrade-Lima 1981). The vegetation within the study area is shrubby-arboreal, and its structure and composition are consistent with habitats at an advanced stage of regeneration (see Silva *et al.* 2013).

### *Sampling*

We sampled the mammalian fauna using a combination of methods, over five consecutive days each month between January and December 2010. To the capturing of specimens, we used a combination of pitfall-type traps (N=96 buckets), Sherman-type traps (N = 30) and Tomahawk-type traps (N=4). All traps, except the Tomahawk, were equally distributed in three distinct transects. Each pitfall trap consisted of four 30 L buckets buried in the ground in a Y configuration linked by drift fences of nylon mesh (5 m x 0.7 m). We set the Sherman traps in pairs near each pitfall trap, placing one on the ground, and other on tree branches, in order to sample both terrestrial and arboreal species. We set the Tomahawk traps on the ground; these traps were set alternately each month at different sites with evidences (tracks and feces) of presence of medium-bodied mammals, just in order to confirm their occurrence. We used several baits, such as bacon, sardines, corn, peanuts, banana, pineapple and cucumber, increasing the possibility of attracting carnivorous, frugivorous and omnivorous species. We

do not set the Sherman and Tomahawk traps in the last two months of the sampling period (November and December).

We moved trapped animals to the laboratory, at field station, to the identification and record morphometric parameters, as total body length (mm), caudal length (mm), anterior/posterior foot length (mm) and weight (g). We use coded incisions on the ear to mark the released specimens. While the collected specimens were handled in accordance with Sikes *et al.* (2011).

Additionally, we collected data on the occurrence of mammal species within the study area opportunistically during fieldwork. We surveyed existing trails and riverbanks on foot for the identification of vestiges, such as tracks, feces and burrows, or direct observation, whenever possible. We also obtained information on the occurrence of some cryptic species through local informants, residents of the area or surrounding areas.

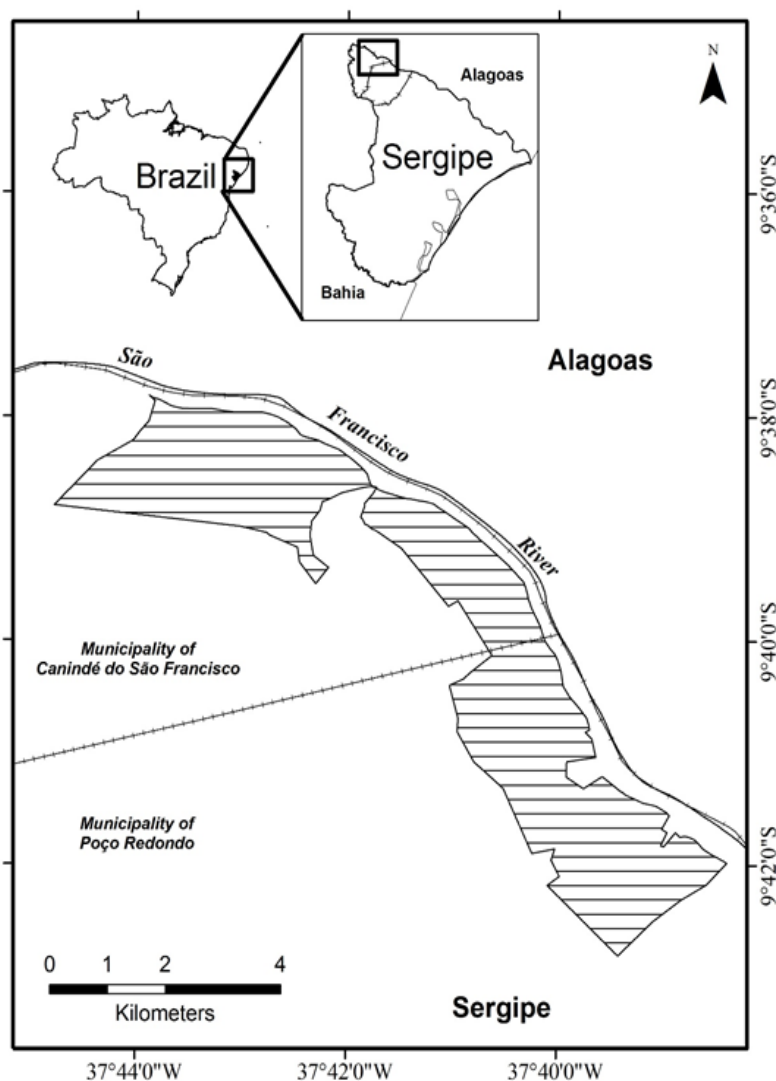
### *Data analysis*

We calculated the sampling effort by multiplying the number of each type trap by the number of sampling days. We ran the Jackknife 1 species richness estimator and species accumulation curve (observed and estimated) based on 1,000 replications, in the software EstimateS 9.0 (Colwell 2012). Records derived from direct observations, observation of vestiges, and indicative from local informers were not included in these analyses. The taxonomy followed Wilson and Reeder (2005), while we identified the specimens following Gardner (2008), Patton *et al.* (2015), Feijó and Langguth (2013), Gurgel-Filho *et al.* (2015).

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## Results and Discussion

The effort resulted in a total of 5,750 trap-nights for the pitfalls, 1,500 trap-nights for the Sherman traps, and 200 trap-nights for the Tomahawk traps. During this, we recorded the presence of 16 mammal species, representing 11 families and 5 orders in the GANM (Table 1, Figure 2). We captured seven species, observed eight, while a single species was recorded exclusively by the report of local informants. In the present study, we recorded eight species of small and eight species of medium/large mammals. Rodentia was the most diverse order, with



**Figure 1** Location of the Grota do Angico Natural Monument in Sergipe, northeastern Brazil.

six species (37.5% of the total), followed by Carnivora ( $n = 5$ ; 31.3%), Didelphimorphia ( $n = 3$ ; 18.8%), Cingulata ( $n = 1$ ; 6.3%) and Primates ( $n = 1$ ; 6.3%).

The estimated species richness, based only in captured species, derived from the Jackknife 1 ( $8.8 \pm 1.8$ ) was not significantly different of observed richness (Figure 3). However, further samplings may record a higher number of small mammal species, mainly the marsupials and rodents recorded in near or similar forest remnants, as some species of opossum (*Cryptonanus agricolai* and *Marmosops incanus*) and rats (*Necromys lasiurus*, *Oecomys catherinae*, *Oligoryzomys stramineus* and *Trinomys albispinus*), recorded in Caatinga remnants from neighboring municipalities (Bezerra et al., 2014, Rocha et al. 2015).

Concerning the medium/large mammal species, we highlight the absence of the *Sylvilagus brasiliensis* and the *Galictis cuja*, also present in neighboring or similar areas (Bezerra et al. 2014, Dias et al. 2014). Nonetheless, there is evidence that some

larger-bodied mammals, including peccaries (*Pecari tajacu*) and agoutis (*Dasyprocta* sp.) may have occurred within the study area in the recent past, given historical records from surrounding areas (Oliveira et al. 2003).

The potential presence of a common armadillo species (*Dasypus* sp.) (i.e., Dias and Bocchiglieri 2016) may refer to the nine-banded armadillo (*Dasypus novemcinctus*), the only common armadillo present in surrounding areas (see Rocha et al. 2015), which is reported to no longer exist in the study area, according to local informers. Although Dias and Bocchiglieri (2016) considered the occurrence through the presence of burrows, here we do not consider this armadillo in the total species account to the area.

Except for the small rodent and didelphid species, all the other species cited above are preferred targets by subsistence poachers throughout the Neotropics (Redford and Robinson 1987, Alves et al. 2016). Therefore, it seems likely that their extinction

**Table 1** List of mammalian species present in the Grota do Angico Natural Monument, Sergipe, Brazil, according to records of the present study and from Dias and Bocchiglieri (2016).

Taxon	Common name	Present Study (type of record <sup>1</sup> )	Dias and Bocchiglieri 2016
ORDER Didelphimorphia			
FAMILY Didelphidae			
<i>Didelphis marsupialis</i> Linnaeus, 1758*	White-eared Opossum	C,S	
<i>Gracilinanus agilis</i> (Burnmeister, 1854)	Agile Gracile Opossum	C	
<i>Monodelphis domestica</i> (Wagner, 1842)	Gray Short-tailed Opossum	C	
ORDER Cingulata			
FAMILY Dasypodidae			
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	Six-banded Armadillo	S,V	x
ORDER Pilosa			
FAMILY Mymecophagidae			
<i>Tamandua tetradactyla</i> Linnaeus, 1758	Collared anteater		x
ORDER Primates			
FAMILY Callitrichidae			
<i>Callithrix jacchus</i> (Linnaeus, 1758)	Common Marmoset	S,V	
ORDER Carnivora			
FAMILY Felidae			
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot		x
<i>Leopardus tigrinus</i> (Schreber, 1775)	Little Spotted Cat		x
<i>Puma yagouaroundi</i> (É. Geoffroy, 1803)	Jaguarundi	S	x
FAMILY Canidae			
<i>Cerdocyon thous</i> (Linnaeus, 1766)	Crab-eating Fox	C,S	x
FAMILY Mustelidae			
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical Otter	S	x
FAMILY Mephitidae			
<i>Conepatus amazonicus</i> (Lichtenstein, 1838)**	Striped Hog-nosed Skunk	S	x
FAMILY Procyonidae			
<i>Procyon cancrivorus</i> (Cuvier, 1798)	Crab-eating Raccoon	S,V	x
ORDER Cetartiodactyla			
FAMILY Cervidae			
<i>Mazama gouazoubira</i> G. Fisher, 1814	Gray Brocket		x
ORDER Rodentia			
FAMILY Cricetidae			
SUBFAMILY Sigmodontinae			
<i>Calomys matthevi</i> Gurgel-Filho, Feijó and Langguth, 2015***	Mattevi's short-tailed mouse	C	
<i>Wiedomys pyrrhorhinus</i> (Wied, 1821)	Red-nosed Mouse	C	
FAMILY Caviidae			
SUBFAMILY Caviinae			
<i>Galea spixii</i> (Wagler, 1831)	Spix's Yellow-toothed Cavy	S	
SUBFAMILY Hydrochoerinae			
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	Capybara	I	x
<i>Kerodon rupestris</i> (Wied, 1820)	Rock Cavy	S	x
FAMILY Echimyidae			
SUBFAMILY Eumysopinae			
<i>Thrichomys laurentius</i> (Thomas, 1904)	São Lourenço Punaré	C	

1 - C = capturing; S = sighting; V = vestiges; I = Local informant; \* Previously *Didelphis albiventris*, see Gurgel-Filho et al. (2015); \*\* Previously *Conepatus semistriatus*, see Feijó and Langguth (2013); \*\*\* Previously *Calomys expulsus*, see Gurgel-Filho et al. (2015).

enhanced by habitat fragmentation.

With our complementary approach, the Grota do Angico Natural Monument reaches the amount of 20 mammal species, from which 8 are small and 12 are medium/large species. According to the available data of mammal species to the Caatinga of Sergipe, the GANM has the higher species richness in the State (Table 2). The following sites with higher richness are the Serra da Guia (S = 19; Rocha et al. 2015), Serra dos Macacos (S = 12; Dias et al. 2014, pers. obs.) and a sampled area in the municipality of Canindé do São Francisco (S = 11; Bezerra et al. 2014) (Table 2). Nonetheless, this result may be an artifact of the methods of data sampling. Most of other sites were shortly sampled with a bias to small or medium/large mammal species, which resulted in a non-balanced inventory of species. We advocate, therefore, that the increase in data sampling in the known sites may also increase the number of species known to those areas.

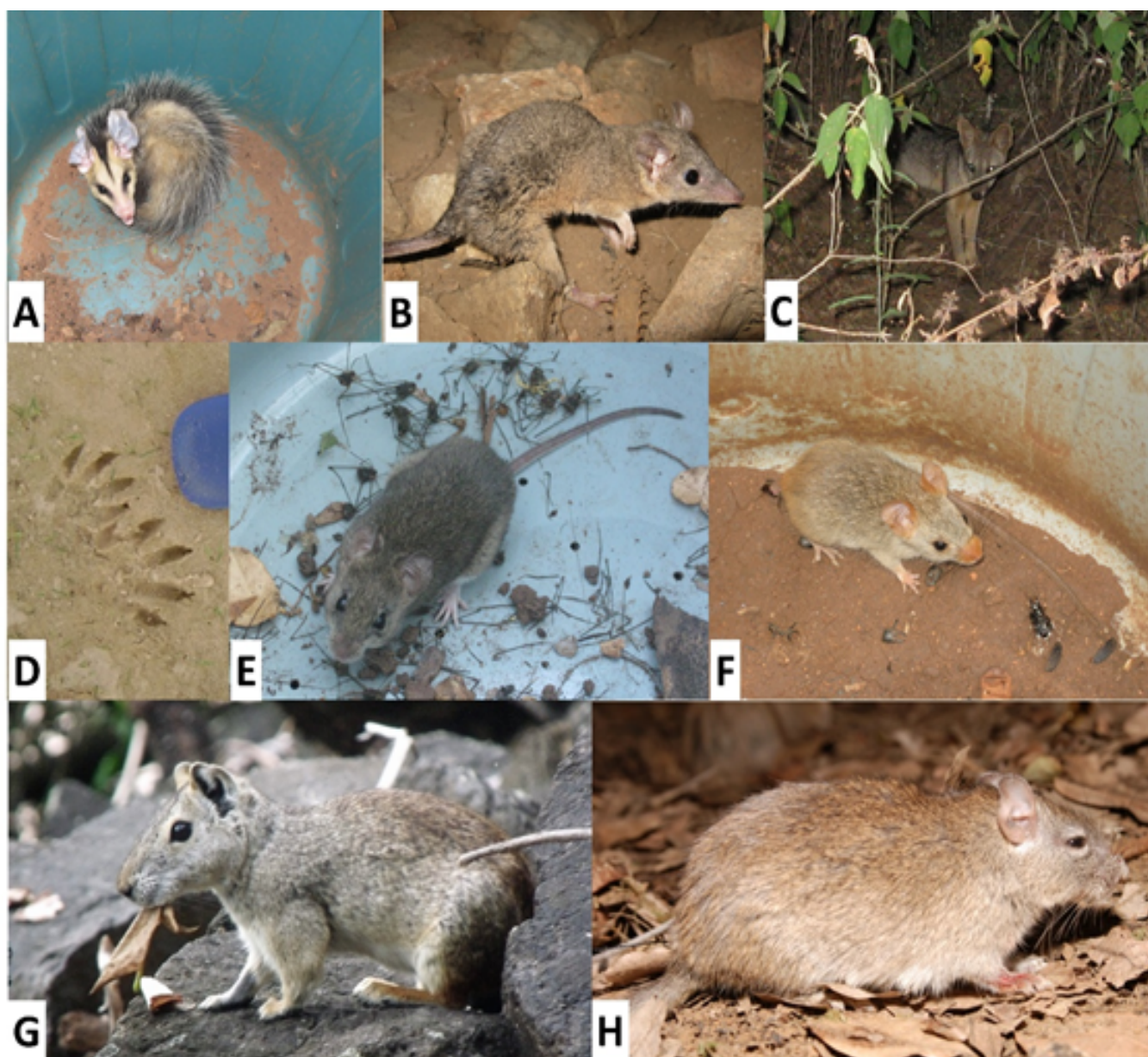
The available data also indicate a lack of mammal inventories in a large portion of the Caatinga of Sergipe, currently concentrated in the north portion of the State. Thus, the increase of samplings in new areas may increase the known species for the Caatinga of Sergipe, currently with 31 species (Table 2).

The results of the present study contribute to the understanding of the diversity of the mammal species to the poorly known fauna both to the whole Caatinga as for Sergipe. The results indicate that occasionally only few additional species may still be recorded within the study area, which corroborate the evidence that most large-bodied game species have already been systematically hunted from the area, and perhaps from the region. Therefore, the Grota do Angico Natural Monument plays a fundamentally and important role in the conservation of the mammalian fauna and of the ecosystems of Caatinga of the region, given its relatively high number of species and already be a protected area.

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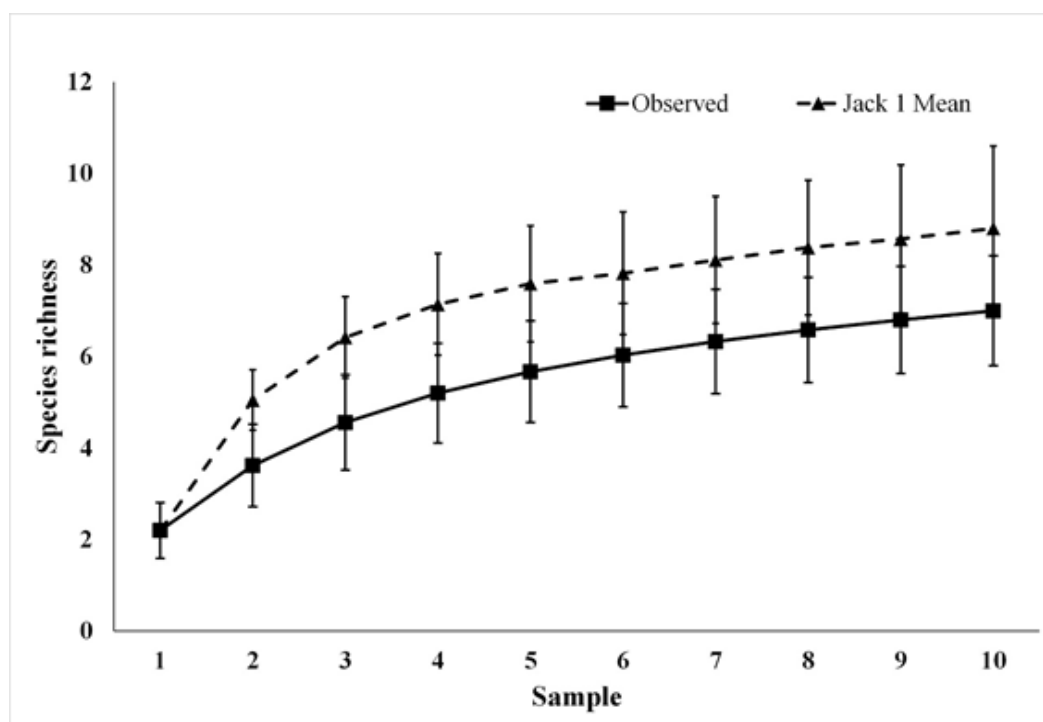
**Figure 2** Nonvolant mammals captured in the present study, at the Grota do Angico Natural Monument in Sergipe, northeastern Brazil. A = *Didelphis marsupialis*; B = *Monodelphis domestica*; C = *Cercocyon thous*; D = track of *Procyon cancrivorus*; E = *Calomys matthevii*; F = *Wiedomys pyrrhorhinus*; G = *Kerodon roosei*; H = *Thrichomys laurentius*.

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**Figure 3** Species accumulation curve (line) and rarefaction curve (dashed) of the Jackknife 1 estimator for captured mammals in the Grota do Angico Natural Monument, Sergipe, Brazil. Vertical bars correspond to standard deviations.

**Table 2** Mammal species richness in Caatinga habitat in Sergipe – Brazil, according to currently studies, and its respective total mammal species richness, small species richness and medium/large species richness.

Study Site	Total richness	Small species	Medium/Large species	References
Municipality of Nossa Senhora da Glória	8	5	3	Bezerra et al., 2014
Municipality of Monte Alegre de Sergipe	7	4	3	Bezerra et al., 2014
Municipality of Porto da Folha	4	2	2	Bezerra et al., 2014
Municipality of Poço Redondo	6	4	2	Bezerra et al., 2014
Municipality of Canindé do São Francisco	11	7	4	Bezerra et al., 2014
Fazenda São Pedro	9	4	5	Freitas et al., 2011
Serra dos Macacos	12	2	10	Dias et al 2014; Pers. obs.
Serra da Guia	19	11	8	Rocha et al., 2015
Grota do Angico Natural Monumento	20	8	12	Dias & Bocchiglieri, 2016; <b>Present Study</b>
<b>Mammals of the Caatinga of Sergipe</b>	<b>31</b>	<b>15</b>	<b>16</b>	-

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