

Medium and large sized mammals of the Boqueirão da Onça, North of Bahia State, Brazil

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Abstract. The mosaic of protected areas of Boqueirão da Onça (8.636 km²), created in the north of Bahia state, is located in the Caatinga, an exclusively Brazilian biome, but exposed to a range of anthropic impacts that threaten its species and natural resources. Few data are available for various zoological groups in Caatinga, including mammals. In order to characterize the community of mammals of this region, considering species richness, we installed 80 camera-trap stations. With a sampling effort of 10,370 camera-days we recorded 28 species (22 wild and six domestic). Opportunistically, we recorded four mammals, resulting in a total richness of 32 species, five of which are included in the global list of endangered species, and seven in the national list. The results are significant, since the richness of wild mammals of the Boqueirão da Onça ($S = 26$) presented a high value when compared to other Caatinga localities. During the study we found evidence of human activities threatening the conservation of the region, such as poaching and deforestation. Therefore, there is an urgent need in the publication of the Management Plan of the recently created Boqueirão da Onça National Park, to minimize negative impacts on biodiversity and ensure the maintenance of ecological processes.

Key-Words. Caatinga; Camera-trap; Northeast Brazil; Threatened species; Tropical Dry Forest.

INTRODUCTION

The Caatinga is one of the largest and most distinguished Brazilian biomes representing almost 70% of the northeastern region and 11% of the national territory (Castelletti *et al.*, 2003). The climate is semi-arid with scarce and irregular rains and the region consists of seasonally dry tropical forest composed of a mosaic xerophilic, deciduous, woody and thorny physiognomies (Costa *et al.*, 2007; Albuquerque *et al.*, 2012; Queiroz *et al.*, 2017). Although it is considered one of the most important semi-arid regions in South America in terms of biodiversity, knowledge about its fauna and ecological processes is scarce when compared to other Brazilian biomes (Santos *et al.*, 2011; Sunderland *et al.*, 2015).

The biodiversity of the Caatinga has been affected by agriculture and livestock farming for centuries, especially with the consolidation of colonial process and the expansion of population to the northeastern backland ("sertão") in the 19th century (Evangelista, 2011). Extensive livestock (overgrazing), poaching, mining, unus-

tainable wood extraction and low-tech agriculture are practiced by a densely and low-income population, largely dependent on natural resources (Gariglio *et al.*, 2010, Ribeiro-Neto *et al.*, 2016). These impacts on vegetation caused by anthropogenic factors have culminated in desertification nuclei in some regions of the Caatinga (Coimbra-Filho & Câmara, 1996; Ribeiro-Neto *et al.*, 2016), threatening the persistence of wildlife species (Oliveira & Diniz-Filho, 2010; Oliveira *et al.*, 2012). And the prospects are not very encouraging, considering the progress of the establishment of wind energy companies in the most preserved areas of the biome (Bernard *et al.*, 2014; Dias *et al.*, 2019).

The loss and modification of natural habitats have been considered the greatest threats to the conservation of the diversity and the main disturbing agent of the mammal communities (Cuarón, 2000; Porras *et al.*, 2016). Medium and large sized mammals are key elements to the ecosystem, as they play an important role in forest maintenance and regeneration, as well as providing ecological services that are essential for the environment in

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structuring the biological communities (Cuarón, 2000; Jones & Safi, 2011).

The intervention region of this study, the Boqueirão da Onça, is the largest continuum of preserved caatinga vegetation and one of the most representative regions of the biome (Dias *et al.*, 2019). This continuity of habitats is important, particularly for the maintenance of large mammals, mainly carnivores, due to the need for extensive home ranges and specific resources to survive (Astete *et al.*, 2008). During data collection, the study area was not officially a protected area, and the process of land use and occupation followed some current environmental laws. However, although there are already laws for the use of the area, many details still need to be written in the document that will guide the Management Plan in order to establish the norms, restrictions for the use and actions to be developed in the protected area and its surroundings. Meanwhile, we run up against time to delay the negative effects of human activities in the region, since its biodiversity is alien to human pressures such as poaching and conflicts between humans and large predators (Paula *et al.*, 2013; Dias *et al.*, 2019).

Therefore, we consider that the conservation of mammals and decision making regarding the management of natural areas begins with updated information on the composition of communities by including primary data in inventories and environmental impact assessment (Pardini *et al.*, 2003, Silveira *et al.*, 2010). The occurrence of iconic or flag species may be a preliminary indicator of the conservation status of the area and provides the direction of management and conservation strategies. In this study we aimed to characterize the mammal community in Boqueirão da Onça in terms of species richness (S) and to assess conservation status at the regional, national and global levels.

MATERIALS AND METHODS

Study site

The region of Boqueirão da Onça is located in the northern of Bahia State (Fig. 1), comprising the municipalities of Sento Sé, Umburanas, Campo Formoso, Juazeiro and Sobradinho. It is a continuum of approximately 9,000 km² of preserved caatinga, recently declared a mosaic of Protected Areas (decree-laws 9,336/18 and 9,337/18), and considered a hotspot for biodiversity conservation within the biome (MMA, 2016). The mosaic is formed by the National Park (NP) Boqueirão da Onça (3,469 km²), with full protection by Federal Law Nº 9,985/2000 (permission only for indirect use of its natural resources), and the Environmental Protection Area (EPA) Boqueirão da Onça (5.057 km²), with sustainable use also by Federal Law Nº 9,985/2000 (part of the area with a degree of human occupation and permission for direct use). The climate of Boqueirão da Onça is predominantly semi-arid (Bsh type in the Köppen classification system), with mean temperature of 30°C and mean annual precipitation of 693 mm (Álvares *et al.*, 2013a, b).

The caatinga vegetation in Boqueirão da Onça is a mosaic of deciduous woody vegetation, prickly shrubs and seasonally dry tropical forests (IBGE, 2012; Banda *et al.*, 2016). Despite the predominance of Caatinga flora, there are regions with species belonging to Cerrado, Amazon and Atlantic Forest ecoregions (Siqueira Filho *et al.*, 2012). The landscape is heterogeneous with “veredas” (physiognomy composed of palm trees and shrub-herbaceous vegetation and humid soil), extensive plateaus, saws and “boqueirões” (regional name for a deep valley dug by a river, with water or not during the wet season). The region is also rich in grottoes, or creeks and springs, and very few of them have accumulated water during the driest periods of the year, crucial for the wildlife.

Sampling methodology

Data collected for this investigation is part of two different studies, one from medium and large sized mammal species monitoring program to meet the condition for installation license of a wind farm (Enel Green Power and “Programa Amigos da Onça”) (Study 1), and the second was part of a research about analysis of occupancy of the mammals of the Boqueirão da Onça (Study 2). For the Study 1 inspections along trails and camera trapping surveys (Tigrinus) were carried out from April 2016 until May 2017. The Study 2 counted only on the installation of camera traps (Ltl Acorn 5210A and Bushnell) carried out from January to July 2017.

Camera traps in both studies (N = 80) were installed along dirt roads (poacher trails, human and animal paths), previously recognized as potential use of medium and large sized mammals and programmed to operate continuously (24 h/day) taking pictures or shooting video (minimum interval of 30 s). Recorded observations were considered independent each photo or video obtained at each camera trap station every 1 hour. In the Study 2, we randomly selected 60 points to establish the sampling sites. The cameras were then distributed to ensure that two adjacent sites were at least 1.5 km apart.

Also, for the Study 1 all direct (live or dead mammals) and indirect evidences (*e.g.*, scats, tracks, scent marks, vocalization) obtained through inspections along trails were considered a record (Wemmer *et al.*, 1996). Tracks of medium and large sized mammals were identified in loco, whenever possible, and when necessary, photographed with a standard measuring instrument for identification in comparison with the specialized literature (*e.g.*, Borges & Tomás, 2008; Becker & Dalponte, 2013). In addition, due to the non-existence of small mammal species surveys in the study area, we considered the opportunity to cite some species recorded during our studies. The taxonomic classification was based on Wozencraft (2005) and Schiaffini *et al.* (2013) for Mephitidae; Kitchener *et al.* (2017) for Felidae; and Wilson & Reeder (2005) for all other groups. The conservation status of each species was obtained from the red lists of the International Union for Conservation of Nature (IUCN), of the Brazilian Environment Ministry (MMA, 2018), and in Cassano *et al.* (2017).

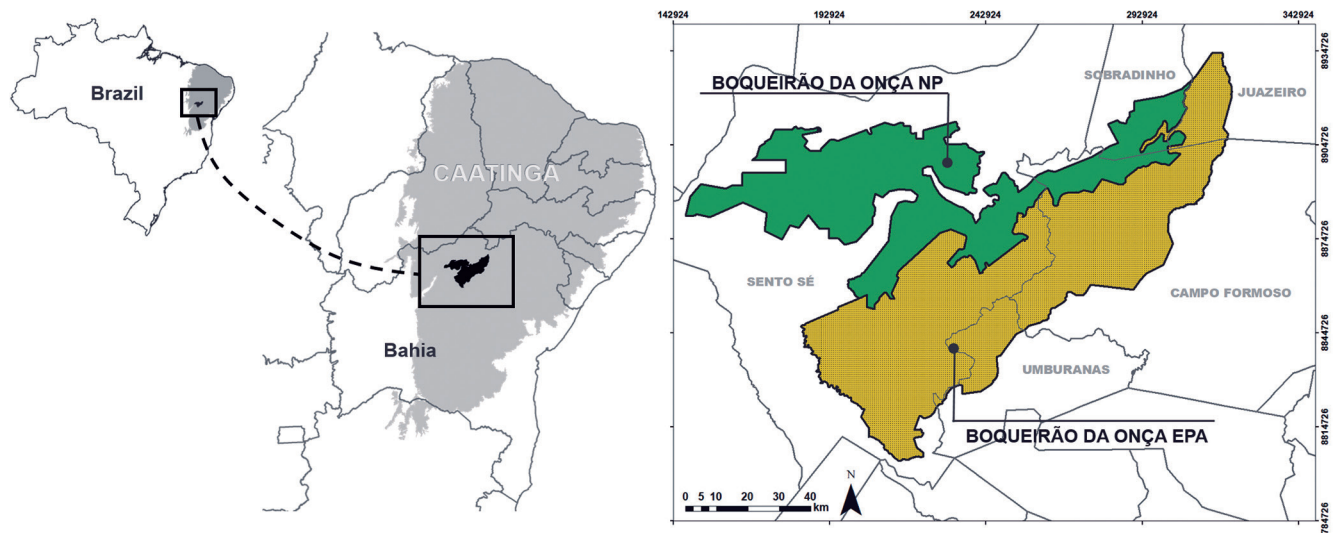


Figure 1. Mosaic formed by the National Park (NP) Boqueirão da Onça and the Environmental Protection Area (EPA) Boqueirão da Onça. Insertions on the left indicate the distribution of the Caatinga biome in northeastern Brazil and the location of the study area in the north of Bahia State, Brazil.

RESULTS

With a total of 80 sampling sites, the sample efforts spent by both studies were (8,570 + 1,800) 10,370 traps*^{day} for camera-trap and 120 km for trail. We recorded 32 species of mammals in Boqueirão da Onça, 26 wild and six domestics (3,654 independent records), being nine species threatened at the regional level, seven at the national level and five of them globally threatened of extinction (Fig. 2; Table 1). We recorded opportunistically two primates, *Alouatta caraya* (Humboldt, 1812) and *Callithrix jacchus* (Linnaeus, 1758), one carnivore *Galictis cuja* (Molina, 1782) and one frugivore *Tayassu pecari* (Link, 1795).

DISCUSSION

The richness of medium and large terrestrial mammals of the Boqueirão da Onça ($S = 26$) presented a high value when compared to other localities, since recent inventories carried out in the Caatinga indicated the occurrence between seven and 29 species (Guedes *et al.*, 2000; Freitas *et al.*, 2011; Rocha *et al.*, 2014; Dias & Bocchiglieri, 2016; Deiciellos, 2016; Dias *et al.*, 2017; Freitas *et al.*, 2017; Pereira & Peixoto, 2017; Marinho *et al.*, 2018).

The number of species recorded in Boqueirão da Onça (this study) corresponds to 74% of medium and large size mammals found in the same region based on Paula *et al.* (2011), adding one more species to their list (*D. albiventris*). Moreover, according to the most recent compilation of the Caatinga mastofauna (Carmignotto & Astúa, 2017), the number of species recorded in the present study represents 27% of the non-volant mammals that occur in the biome. A diverse set of habitats along with a low human density enables the maintenance of a rich mastofauna in this part of the Caatinga. This makes the Boqueirão da Onça a priority area for conservation (MMA, 2016).

However, its biodiversity is under imminent threat due to a number of anthropogenic impacts, and in recent years, this condition was aggravated because of intense changes in land use (Dias *et al.*, 2019). Among the endangered species of Boqueirão da Onça, carnivores make up the majority, which is not surprising given that this group is particularly vulnerable due to intrinsic biological characteristics, such as large body sizes, requirements for large home ranges, low densities and slow population growth rates (Crooks *et al.*, 2011). In many parts of the world, large predators are threatened by loss and fragmentation of habitats, conflicts with livestock breeders and poachers (Chapron *et al.*, 2014; Di Minin *et al.*, 2016), by directly removing wild predators or by indirectly depleting a wide variety of their preys (Karanth & Chellam, 2009). In Boqueirão da Onça, the carnivores are exposed to all these impacts and, in addition, the establishment of wind farms also pose a potential threat (Dias *et al.*, 2019).

A wind farm not only involves turbines accidents with animals but also a series of cumulative and indirect impacts associated with these infrastructures, such as sound and visual disturbances, vibration, microclimatic changes, vehicles traffic, barrier and corridor effect, electromagnetic field generation, as well as the fragmentation of habitats, which, together with the opening of roads, facilitates the access of poachers in areas formerly remote (Helldin *et al.*, 2012; Costa *et al.*, 2017).

The high number of records of domestic species in the natural habitats of our study area is also of concern. Particularly dogs can cause serious damage to native mammals, since they are related to predation (Campos *et al.*, 2007; Lacerda *et al.*, 2009), restriction on distribution (Lacerda *et al.*, 2009; Massara *et al.*, 2018) and disseminating diseases (Curi *et al.*, 2016). Considering the ecological importance and the degree of threat to which mammals are subjected (Di Marco *et al.*, 2014), it is crucial to ensure their protection. In this sense, the creation of protected areas has been the most efficient strategy,

since its objective is the long-term conservation of nature, ecosystem services and the associated cultural values (Dudley, 2008). Thus, the focus of protected areas for

the conservation of threatened species has been a powerful argument to justify their establishment, especially in developing countries (Athreya et al., 2013).

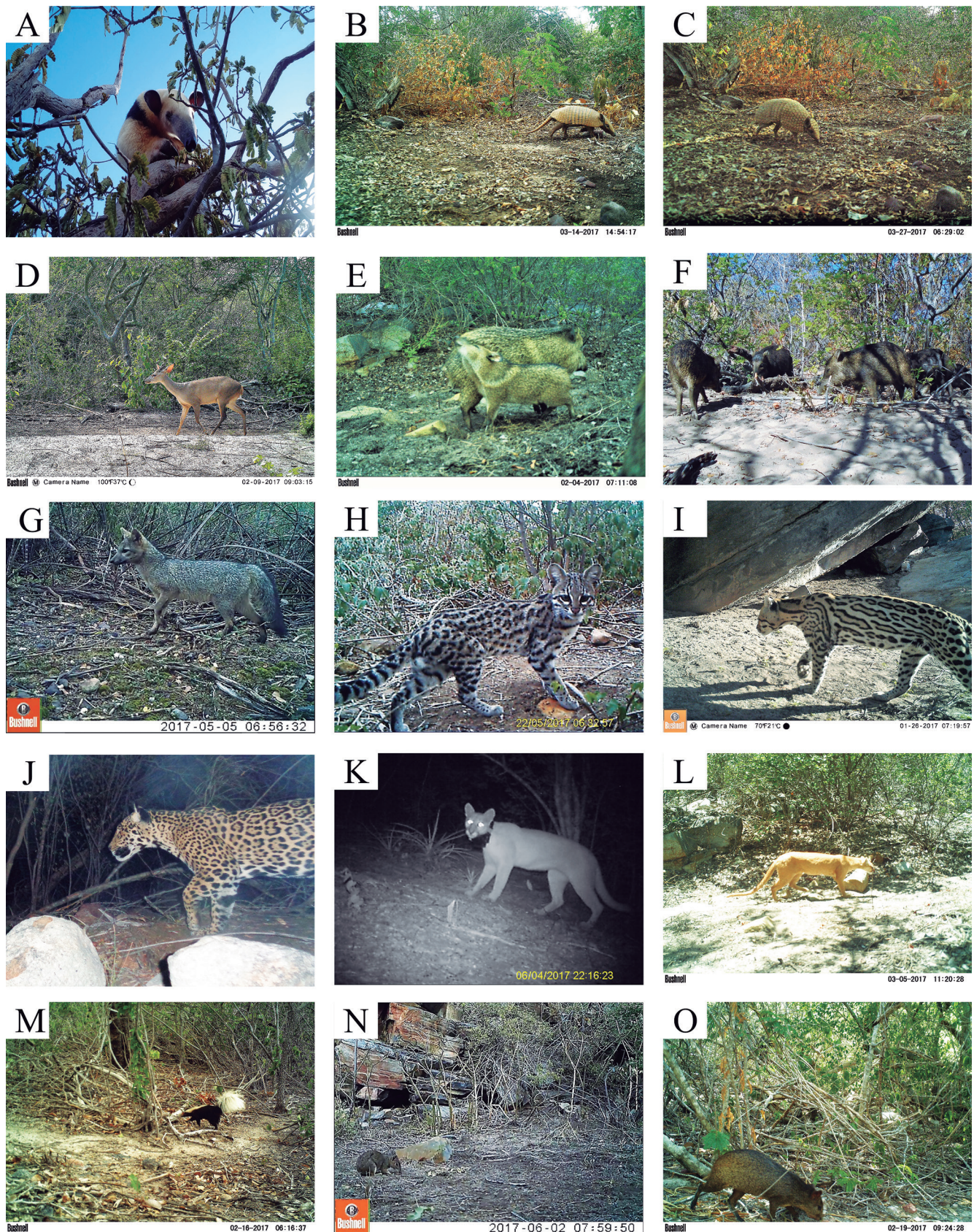


Figure 2. Mammals registered in Boqueirão da Onça, Bahia State, northeastern Brazil. (A) *Tamandua tetradactyla*; (B) *Euphractus sexinctus*; (C) *Tolypeutes tricinctus*; (D) *Mazama gouazoubira*; (E) *Pecari tajacu*; (F) *Tayassu pecari*; (G) *Cerdocyon thous*; (H) *Leopardus tigrinus*; (I) *Leopardus pardalis*; (J) *Panthera onca*; (K) *Puma concolor*; (L) *Herpailurus yagouaroundi*; (M) *Conepatus semistriatus*; (N) *Kerodon rupestris*; (O) *Dasyprocta nigriclunis*.

Table 1. Relation of mammal species recorded in the Boqueirão da Onça, Bahia, Brazil. Records from camera trap (Ct), visual (Vi), tracks (Tr), burrows (Bu), scat (Sc), and threat categories: Least concern = LC; Near threatened = NT; vulnerable = VU; Endangered = EN; Critically endangered = CR.

| Species | Popular name | Camera trap Records | Record type | Bahia | Brazil | IUCN |
|--|-------------------------|---------------------|----------------|-------|--------|------|
| DIDELPHIMORPHIA | | | | | | |
| <i>Didelphis albiventris</i> ^{1,2} | Opossum | 47 | Ct, Vi | — | — | LC |
| PILOSA | | | | | | |
| <i>Myrmecophaga tridactyla</i> ² | Giant Anteater | 1 | Ct | VU | VU | VU |
| <i>Tamandua tetradactyla</i> ² | Southern Tamandua | 21 | Ct, Vi | — | — | LC |
| CINGULATA | | | | | | |
| <i>Dasyops novemcinctus</i> ^{1,2} | Nine-banded Armadillo | 78 | Ct, Tr, Bu | — | — | LC |
| <i>Euphractus sexcinctus</i> ^{1,2} | Six-banded Armadillo | 35 | Ct, Tr, Vi | — | — | LC |
| <i>Tolypeutes tricinctus</i> ^{1,2} | Three-banded Armadillo | 52 | Ct, Tr, Vi | EN | EN | VU |
| PERISSODACTYLA | | | | | | |
| <i>Equus asinus</i> ^{1,2} | Donkey | 43 | Ct, Tr, Vi | — | — | — |
| <i>Equus caballus</i> ^{1,2} | Horse | 6 | Ct, Tr, Vi | — | — | — |
| ARTIODACTYLA | | | | | | |
| <i>Mazama gouazoubira</i> ^{1,2} | Gray Brocket Deer | 348 | Ct, Tr, Vi, Sc | — | — | LC |
| <i>Pecari tajacu</i> ^{1,2} | Collared Peccary | 226 | Ct, Tr, Vi, Sc | NT | — | LC |
| <i>Tayassu pecari</i> ² | White-lipped Peccary | 0 | Ct | EN | VU | VU |
| <i>Bos taurus</i> ^{1,2} | Cattle | 454 | Ct, Tr, Vi | — | — | — |
| <i>Capra aegagrus hircus</i> ² | Goat | 47 | Ct, Tr, Vi | — | — | — |
| <i>Ovis aries</i> ^{1,2} | Sheep | 9 | Ct, Tr, Vi | — | — | — |
| PRIMATES | | | | | | |
| <i>Alouatta caraya</i> ² | Black Howler Monkey | 0 | Vi | — | — | LC |
| <i>Callithrix jacchus</i> ² | Common Marmoset | 0 | Vi | — | — | LC |
| CARNIVORA | | | | | | |
| <i>Canis familiaris</i> ^{1,2} | Dog | 85 | Ct, Tr, Vi | — | — | — |
| <i>Cerdocyon thous</i> ^{1,2} | Crab-eating Fox | 256 | Ct, Tr, Vi | — | — | LC |
| <i>Leopardus pardalis</i> ^{1,2} | Ocelot | 217 | Ct, Tr, Sc | VU | — | LC |
| <i>Leopardus tigrinus</i> ^{1,2} | Oncilla | 65 | Ct, Tr | VU | EN | VU |
| <i>Panthera onca</i> ^{1,2} | Jaguar | 15 | Ct, Tr, Sc | CR | VU | NT |
| <i>Puma concolor</i> ^{1,2} | Puma | 35 | Ct, Tr | VU | VU | LC |
| <i>Herpailurus yagouaroundi</i> ^{1,2} | Jaguarundi | 36 | Ct, Tr | VU | VU | LC |
| <i>Conepatus semistriatus</i> ^{1,2} | Striped Hog-nosed Skunk | 21 | Ct, Tr | — | — | LC |
| <i>Eira barbara</i> ^{1,2} | Tayra | 1 | Ct, Vi | — | — | LC |
| <i>Galictis cuja</i> ^{1,2} | Lesser Grison | 0 | Tr | — | — | LC |
| <i>Nasua nasua</i> ^{1,2} | Coati | 2 | Ct, Vi | — | — | LC |
| <i>Procyon cancrivorus</i> ^{1,2} | Crab-eating Raccoon | 2 | Ct, Tr | — | — | LC |
| RODENTIA | | | | | | |
| <i>Galea spixii</i> ^{1,2} | Spix's Cavy | 835 | Ct, Vi | — | — | LC |
| <i>Kerodon rupestris</i> ^{1,2} | Rock Cavy | 352 | Ct, Tr, Vi, Sc | — | — | LC |
| <i>Dasyprocta nigriclunis</i> ^{1,2} | Black-rumped Agouti | 302 | Ct, Tr | — | — | — |
| <i>Thrichomys sp.</i> ² | Common Punaré | 63 | Ct, Vi | — | — | — |

^{1,2}Species records from studies 1 and 2.

For sixteen years the region has been proposed for the creation of Boqueirão da Onça National Park, process under responsibility of the Chico Mendes Institute for Biodiversity Conservation – ICMBio, under cooperation of the Ministry of Environment – MMA. However, the process faced successive changes due to different interests of land use and occupation of the region which culminated in the creation of a mosaic of different kinds of protected areas with a decrease of over 50% on the integral protected area, originally proposed.

In 2018, the creation of a mosaic of Protected Areas on the study area, Boqueirão da Onça National Park (3,470 km²), Boqueirão da Onça Environmental Protected Area (5,050 km²) and Toca da Boa Vista Wildlife Zone (116 km²) is crucial to guarantee the preservation of

some unique conditions present in the region, including different types of soils (texture, formation and morphology), geological aspects (*e.g.*, granites and micaxists). In addition, the largest caves of Latin America, Toca da Boa Vista and Toca da Barriguda (Cruz *et al.*, 2018), water resources, different rock arts (painted or drawn pictographs, engraved or carved petroglyphs) (Whitley, 2005) of prehistoric times (most of them still unknown by researchers) and endemic species of fauna and flora of the Caatinga (Ramos *et al.*, 2010).

Long-term studies are recommended to monitor mammals and other groups of fauna in the region, as well as to assess and evaluate the abundance of species of major interest for conservation. In addition, the information presented may be important to support National

Action Plan for the Conservation of Species, and the elaboration of the Management Plan for Boqueirão da Onça National Park, to mitigate human wildlife conflicts, to promote the integration of the protected area into the economic and social life of neighboring communities and to guarantee the persistence of wildlife species.

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