

Non-volant mammals from Domingos Martins municipality, state of Espírito Santo, southeastern Brazil

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ABSTRACT: The goal of this study was to contribute to the knowledge of the mammals in the state of Espírito Santo, presenting a list to the Domingos Martins municipality. Regarding the mammals inventory, data obtained from field work and through digital search by species deposited in scientific collections and available on the SpeciesLink database were used. We recorded 47 non-volant mammal species, including 12 endemic in the Atlantic Forest and nine listed as threatened. Domingos Martins, despite being undersampled when compared to other mammals inventories in the state of Espírito Santo, represents 57% of the terrestrial mammals listed in the state. This shows the potential of the municipality in relation to mammal conservation, not only in the state, but also for Atlantic Forest biome.

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INTRODUCTION

The Atlantic Forest has been subject to anthropogenic pressure since early European colonization, mainly because this vegetation occupies the east coastal area from most of the South American continent (Dean, 1996). The process of colonization, occupation and, finally, industrialization of the Brazilian territory has resulted in a highly fragmented landscape, where most of forest remnants are smaller than 50 ha and isolated (Dean 1996; Ribeiro *et al.* 2009).

The list of Brazilian mammals currently includes 701 species, of which 298 occur in the Atlantic Forest (Paglia *et al.* 2012). Of those, 90 species are endemic (Paglia *et al.* 2012) and 69 are considered endangered according to the International Union for the Conservation of Nature (IUCN) classification (Machado *et al.* 2008).

The state of Espírito Santo, located in southeastern Brazil, was originally covered by approximately 90% of Atlantic Forest (Thomaz 2010). Currently this state has only 8% left of its original Atlantic Forest cover (Pereira 2007; Fundação SOS Mata Atlântica 2010) that is represented mainly by small isolated forest patches, and located on private properties (Passamani *et al.* 2000). Nevertheless, this state lies in a highly diverse area for mammals, harboring about 50% of the mammal species that occur in the Atlantic Forest (Moreira *et al.* 2008). Moreover, this number probably will increase, since many localities in this state have never been sampled or were undersampled (Moreira *et al.* 2008).

Considering the relevance of the state of Espírito Santo of mammal diversity and the high level of fragmentation of their remnants (Passamani *et al.* 2000; Thomaz 2010), the goal of our study was to fill gaps in the current knowledge of mammal occurrence and distribution in this state, presenting a terrestrial mammal inventory for

Domingos Martins municipality. This primary information is necessary and very important once they contribute to the knowledge about the distribution of mammals and are the first step to the establishment of species conservation strategies (Costa *et al.* 2005; Passamani 2007).

MATERIALS AND METHODS

Study Site

This study was carried out in Domingos Martins municipality (20°19'30" S, 40°38'05" W), located in the central region of the state of Espírito Santo, Brazil (Figure 1). This region is characterized by a mountainous area with altitudes ranging from 500 to 1000 m and a subtropical climate (Koppen 1948). Mean annual temperature is about 22°C, with minimum and maximum mean temperatures of 9.4°C and 30.7°C, respectively (Incapar 2011). Mean annual precipitation is about 1,366 mm, with most of the rainfall occurring between October and April (Incapar 2011).

The forest in the region is classified as Dense Ombrophilous Forest (IBGE 1987) and most specifically as Montane Dense Ombrophilous Forest (Magnago *et al.* 2008). This forest is characterized by non-deciduous trees, a high plant species diversity and 10–20 m trees, with some emergent species can reach up 30 m high (Magnago *et al.* 2008).

Data Collection

In order to assess the non-volant mammal species previously listed for Domingos Martins, we conducted a search on the major internet journal databases for all literature published until March 2013, using “mammals” and “Domingos Martins” as keywords. Additionally, previously unpublished records were taken from

specimens deposited in scientific collections (see Appendix 1) through information available at the SpeciesLink digital database with the same keywords (Centro de Referência em Informação Ambiental—CRIA). Also, we consider the non-published data from the Pedra Azul State Park management plan.

Field sample

We conducted field work in the forest fragments at Morro do Chapéu (20°16' S, 40°38' W). The data were obtained in two samples – from November 2010 to February 2011 and from March 2013 to June 2013 – using four camera traps (Bushnell trophy cam 8mp). We installed the camera traps on tree trunks at approximately 45cm from the ground, in four different fragments approximately two kilometers apart from one another (20°16'46" S, 40°38' 25" W AF 1; 20°19'45" S, 40°40'53" W AF 2; 20°22'44" S, 40°40'29" W AF 3; 20°16'53" S, 40°51'15" W AF 4, Figure 1). The cameras were installed 200m from the unofficial roads inside forest fragments where we previously found mammal tracks. The camera traps obtained data during 80 days, operating 24 hours/day, for approximately 10 days of monthly effort. We used baits to attract mammal species. These baits were made of bacon, pineapple and catnip and placed separately near each camera. We also performed diurnal and nocturnal censuses for species by performing active searches along unofficial roads, and including records considering visual sights, vocalization, tracks and feces. The tracks and feces were identified using field guides (Becker and Dalponte 1991; Carvalho-Junior and Luz 2008). The total sampling effort for the camera traps was 320 trap*days, each fragment having a total sampling effort of 80 trap*days and we covered a total of 165km in the surveys.

Data Analysis

For the taxonomic arrangement and to identify Atlantic Forest endemics, we followed the Annotated Checklist of Brazilian Mammals (Paglia *et al.* 2012). The threat status of each species was defined using the IUCN red list for classification for the global status (IUCN 2012), the Brazilian Red List of Endangered Species (Machado *et al.* 2008) for the national status and the Threatened Species List of the state of Espírito Santo (Chiarello *et al.* 2007) for the local status.

RESULTS

We registered 47 native species of mammals distributed in eight orders. The most diverse order was Rodentia, with 14 species, Carnivora (12 species), Didelphimorphia (7) and Primates (5) (Table 1). We also registered two exotic species, both from the order Carnivora (*Canis lupus familiaris* and *Felis catus*).

We highlight the presence of nine species included in the red list (Table 1, Figure 2). Among them, five are threatened at a global scale, and nine species at national level. Yet, the sampled areas harbor eight species included in the red list from Espírito Santo state (Figure 2) such as *Chaetomys subspinosus* and *Bradypus torquatus*, four cats: *Puma concolor*, *Leopardus guttulus*, *Leopardus pardalis* and *Leopardus wiedii* and also the primates *Callicebus personatus* and *Callithrix flaviceps*. Furthermore, 12 of the recorded species are endemic to the Atlantic Forest. This represents 15% of the Atlantic Forest endemic mammals, including: *Didelphis aurita*, *Gracilinanus microtarsus*, *Callithrix geoffroyi*, *Callithrix flaviceps*, *Callicebus personatus*, *Sapajus nigritus*, *Alouatta guariba*, *Bradypus torquatus*, *Chaetomys subspinosus*, *Thaptomys nigrita*, *Guerlinguetus ingrami* and *Trinomys panema*.

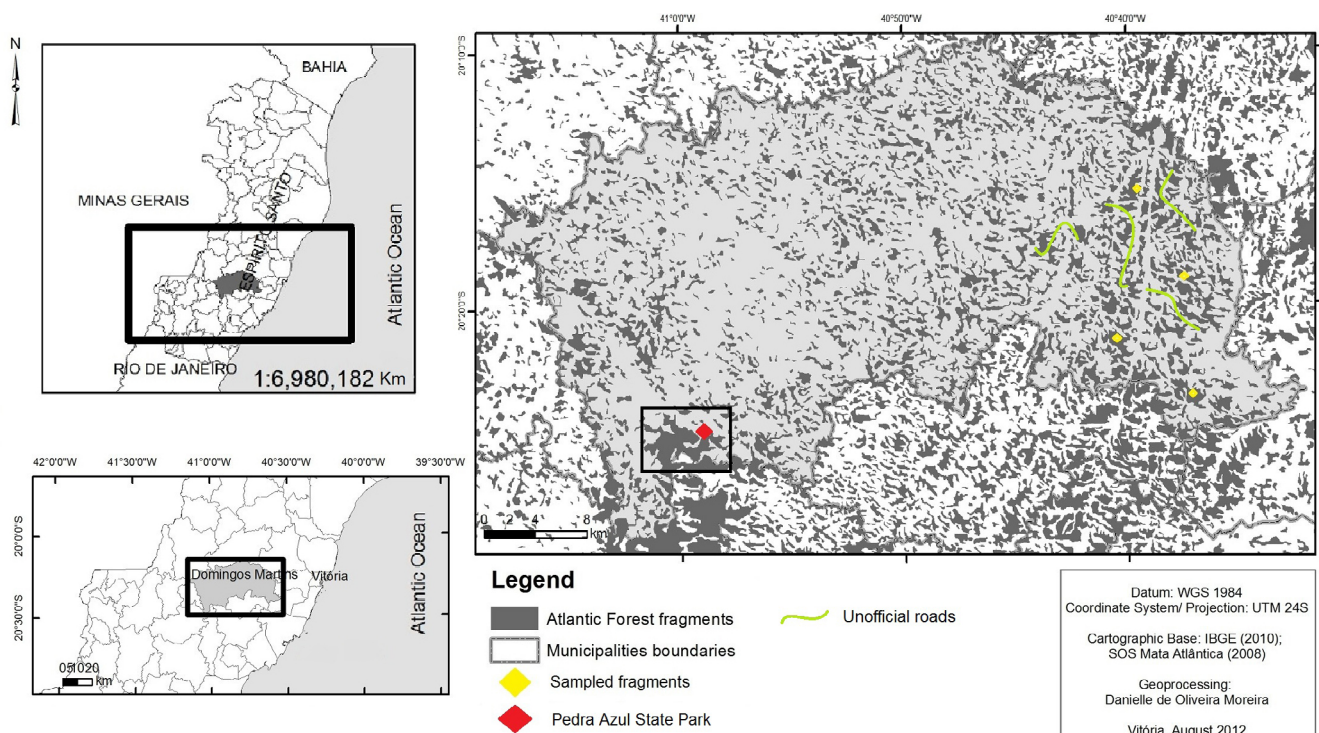


FIGURE 1. Location of Domingos Martins municipality in the Espírito Santo state, Brazil. Small scale maps highlights the sampled points to mammals record.

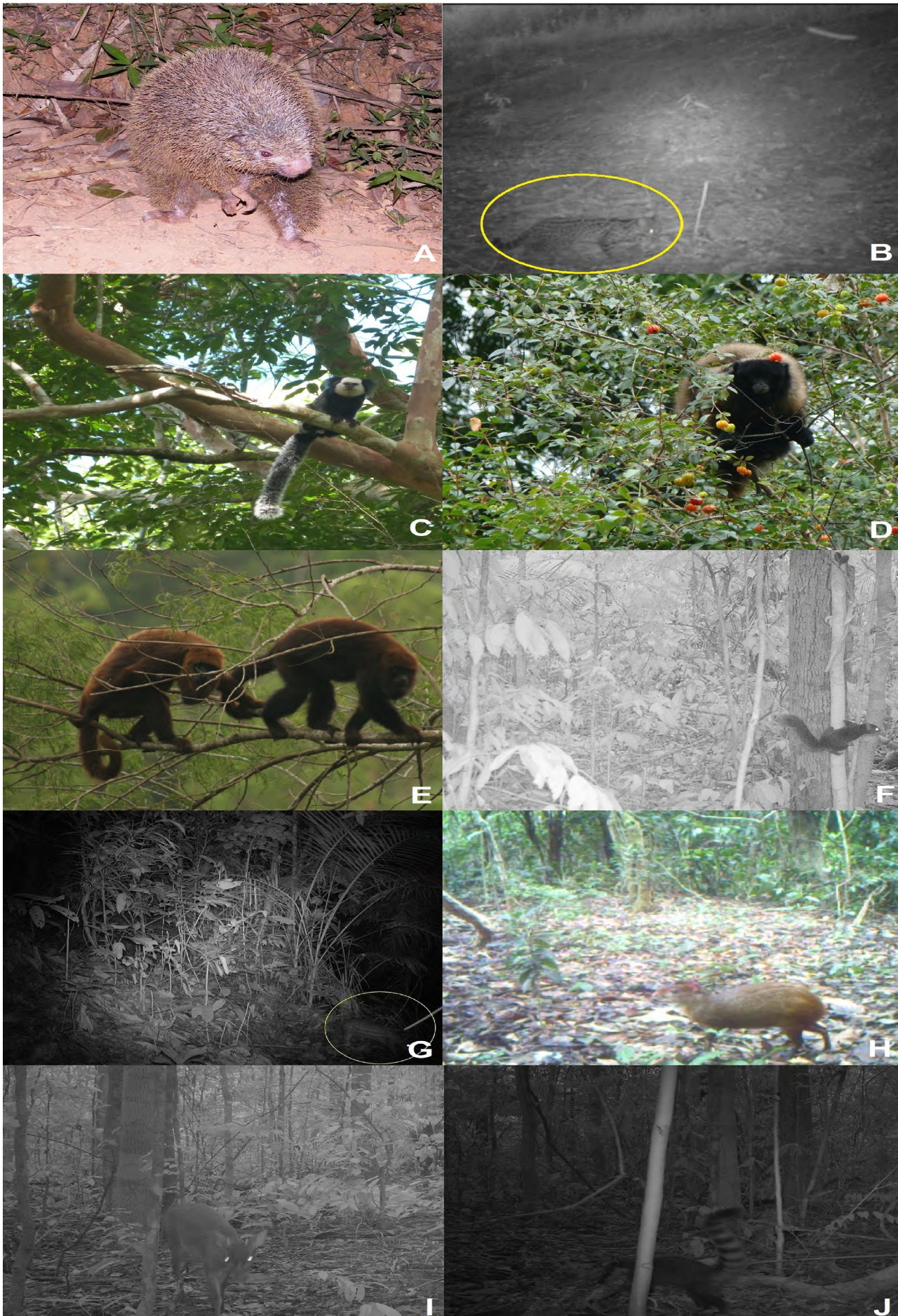


FIGURE 2. Mammal species recorded at Domingos Martins municipality, Espírito Santo state, Brazil. (A, *Chaetomys subspinosus*; B, *Leopardus guttulus*; C, *Callithrix geoffroyi*; D, *Callicebus personatus*; E, *Alouatta guariba*; F, *Guerlinguetus ingrami*; G, *Cuniculus paca*; H, *Dasyprocta leporina*; I, *Mazama gouazoubira*; J, *Nasua nasua*).

TABLE 1. List of non-volant mammals species Domingos Martins municipality with their respective category of threat and types of records. Categories of threat of extinction: Endangered - EN, vulnerable - Vu and critically endangered – CR according to the global list of IUCN 2012; the national list (BR) Machado et al. 2008 and the List of Threatened Species of the Espírito Santo state (ES) Chiarello et al. 2007. Sampling methods: footprints (FP), camera traps by location 1, 2, 3 and 4 (CT), feces (Fe), sighting (Si), vocalization (Vo), scientific collection (SC) and data obtained from Pedra Azul State Park management plan (MP). *Exotic species not included in the total percentage of native species calculated for the municipality of Domingos Martins (ES).

TAXON	CATEGORY OF THREAT	RECORD
DIDELPHIMORPHIA		
Family Didelphidae		
<i>Didelphis aurita</i> (Wied-Neuwied, 1826)		SC; Si; CT2
<i>Gracilinanus microtarsus</i> (Wagner, 1842)		SC; SD
<i>Marmosa murina</i> (Linnaeus, 1758)		SC
<i>Micoureus paraguayanus</i> (Tate, 1931)		SD
<i>Marmosops incanus</i> (Lund, 1840)		SC
<i>Metachirus nudicaudatus</i> (Desmarset, 1817)		SC; CT1,2
<i>Philander frenatus</i> (Olfers, 1818)		SC
RODENTIA		
Family Caviidae		
<i>Hydrochaeris hydrochaeris</i> (Linnaeus, 1766)		Si; FP; Fe
<i>Cavia fulgida</i> Wagler, 1831		SD; Si
Family Cuniculidae		
<i>Cuniculus paca</i> (Linnaeus, 1766)		Si; FP; CT1,2,3,4
Family Erethizontidae		
<i>Chaetomys subspinosus</i> (Olfers, 1818)	VU ^{IUCN} ; BR; ES	Si
<i>Coendou spinosus</i> (F. Cuvier, 1823)		Si
Family Sciuridae		
<i>Guerlinguetus ingrami</i> (Thomas, 1901)		Si
Family Cricetidae		
<i>Oligoryzomys nigripes</i> (Olfers, 1818)		SC
<i>Akodon cursor</i> (Winge, 1887)		SC; SD
<i>Thaptomys nigrita</i> (Lichtenstein, 1829)		SD
<i>Oxymycterus dasytrichus</i> (Schinz, 1821)		SD
<i>Delomys sublineatus</i> (Thomas, 1903)		SD
<i>Rhipidomys mastacalis</i> (Lund, 1840)		SC
Family Echimyidae		
<i>Trinomys panema</i> (Moojen, 1948)		SC; SD
Family Dasypodidae		
<i>Dasyprocta leporina</i> (Linnaeus, 1758)		Si; CT2,3
LAGOMORPHA		
Family Leporidae		
<i>Sylvilagus brasiliensis</i> (Linnaeus, 1758)		Si
CINGULATA		
Family Dasypodidae		
<i>Cabassous unicinctus</i> (Linnaeus, 1758)		Si
<i>Dasypus novemcinctus</i> Linnaeus, 1758		Si; FP; CT1,3,4
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)		Si
PILOSA		
Family Myrmecophagidae		
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)		Si; CT2,3
Family Bradypodidae		
<i>Bradypus torquatus</i> Illiger, 1811	EN ^{IUCN} ; BR; ES	Si; SC
<i>Bradypus variegatus</i> Schinz, 1825		SD
PRIMATES		
Family Atelidae		
<i>Alouatta guariba</i> (Humboldt, 1812)	CR ^{IUCN} ; BR	Si; Vo; SD
Family Cebidae		
<i>Sapajus nigritus</i> (Goldfuss, 1809)		FP; SD
Family Callitrichidae		
<i>Callithrix geoffroyi</i> (Humboldt, 1812)		Si; Vo
<i>Callithrix flaviceps</i> (Thomas, 1903)	EN ^{IUCN} ; BR; ES	Si; SD
Family Pitheciidae		
<i>Callicebus personatus</i> (É. Geoffroy, 1812)	VU ^{IUCN} ; BR; ES	Si; Vo
ARTIODACTYLA		
Family Cervidae		
<i>Mazama americana</i> (Erxleben, 1777)		SC, Si
<i>Mazama gouazoubira</i> (Fischer, 1814)		CT2,4
CARNIVORA		
Family Canidae		
<i>Cerdocyon thous</i> (Linnaeus, 1766)		Si; CT1,3
<i>Canis lupus familiaris</i> Linnaeus, 1758*		Si; FP; CT1,2
Family Felidae		
<i>Leopardus guttulus</i> (Hensel, 1872)	VU ^{BR} ; ES	FP; CT2; Fe
<i>Leopardus pardalis</i> (Linnaeus, 1758)	VU ^{BR} ; ES	FP; SD
<i>Leopardus wiedii</i> (Schinz, 1821)	VU ^{BR} ; ES	FP; CT4
<i>Puma concolor</i> (Linnaeus, 1771)	VU ^{BR} ; EN ^{ES}	Fe; SD
<i>Puma yagouaroundi</i> (É. Geoffroy, 1803)		SD
<i>Felis catus</i> Linnaeus, 1758*		Si; CT1
Family Mustelidae		
<i>Eira barbara</i> (Linnaeus, 1782)		Si
<i>Galictis cuja</i> (Molina, 1776)		FP
<i>Lontra longicaudis</i> (Olfers, 1818)		FP
Family Procyonidae		
<i>Nasua nasua</i> (Linnaeus, 1766)		Si, CT1,3,4
<i>Procyon cancrivorus</i> (G. Cuvier, 1798)		FP; CT2,3
<i>Potos flavus</i> (Scheber, 1774)		SC

DISCUSSION

Considering that the state of Espírito Santo has 84 species of non-volant mammals (Moreira *et al.* 2008), approximately 56% of species listed for the state occur at Domingos Martins municipality. Also, this municipality harbors almost 80% of the mammals recorded in the Santa Teresa municipality, which has the highest mammal richness registered in the state with 62 species (Passamani *et al.* 2000). Considering that Santa Teresa was intensively sampled for long-term studies (see Passamani 2000; Passamani *et al.* 2000; Srbek-Araújo and Chiarello 2005), this result demonstrates that the Domingos Martins municipality could play an important role at conservation strategies and is also a potential area where a high mammal richness can be found. Also, the number of mammal species recorded in Domingos Martins will surely increase expressively, since our inventory did not sample the order Chiroptera, which represents one of the richest group in the state of Espírito Santo (Moreira *et al.* 2008) and in the whole Atlantic Forest as well (Paglia *et al.* 2012).

Most of the threatened species listed in the present study are included in the lowest threat category considering the local scale. Besides, these species were recorded, in Espírito Santo and in other Atlantic Forest sites, in most of the forested landscapes and large fragments (Chiarello *et al.*, 2008). Also, these species are dependent on native forest and large forest fragments to hold viable populations, like the wild cats (Oliveira 1998; Michalski *et al.* 2006; Chiarello, 1999) and primates (Michalski and Peres 2005). More importantly, these data shows that the conservation status of these species can be replaced to a better one if actions to restore and connect isolated forest remnants be implemented as soon as possible in the state. The record of several endemic species demonstrates the importance of the municipality - which has 24% of its territory covered by Atlantic Forest remnants (Fundação SOS Mata Atlântica 2010)—for mammal conservation, since endemism have been commonly used as an important criteria when choosing areas for the purpose of species conservation (Prevedello and Carvalho 2006).

Our findings showed that Domingos Martins municipality has a high richness of non-volant mammals, despite being undersampled in relation to mammals. This demonstrates the potential of the municipality to harbor a high diversity of mammals in the state of Espírito Santo and consequently its importance to conservation strategies regarding mammals not only in the local scale, but for the whole Atlantic Forest.

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APPENDIX 1. List of the specimens deposited in museum that were collected in Domingos Martins municipality and their voucher number. NPM - Núcleo em Ecologia e Desenvolvimento Socio-Ambiental de Macaé (NUPEM – UFRJ Campus Macaé), Rio de Janeiro, Brazil; UFES-MAM - Coleção de Mamíferos da Universidade Federal do Espírito Santo, Espírito Santo, Brazil; MBML - Museu de Biologia Prof. Mello Leitão, Espírito Santo, Brazil.

SCIENTIFIC NAME	VOUCHER NUMBER
Didelphimorphia	
<i>Didelphis aurita</i> (Wied-Neuwied, 1826)	NPM 230
<i>Gracilinanus microtarsus</i> (Wagner, 1842)	MBML 2562; NPM 224, 225, 226, 234, 235; UFES-MAM 937
<i>Marmosops incanus</i> (Lund, 1840)	UFES-MAM 938, 939, 940, 941, 942; MBML 2504, 2506; NPM 221
<i>Micoureus paraguayanus</i> (Tate, 1931)	MBML 2563; NPM 232
<i>Marmosa murina</i> (Linnaeus, 1758)	MBML 2499; NPM 228, 233
<i>Metachirus nudicaudatus</i> (Desmarest, 1817)	MBML 2463; NPM 223;
<i>Philander frenatus</i> (Olfers, 1818)	UFES-MAM 947
Rodentia	
Family Muridae	
Subfamily Sigmodontinae	
<i>Oligoryzomys nigripes</i> (Olfers, 1818)	NPM 236
<i>Akodon cursor</i> (Winge, 1887)	UFES-MAM 943, 944, 946
<i>Rhipidomys mastacalis</i> (Lund, 1840)	MBML 2571
Family Echimyidae	
<i>Trinomys panema</i> (Moojen, 1948)	NPM 227, 229; UFES-MAM 945
Pilosa	
Family Bradypodidae	
<i>Bradypus torquatus</i> Illiger, 1811	UFES-MAM 1918
Carnivora	
Family Procyonidae	
<i>Potos flavus</i> (Scheber, 1774)	NPM 231
Artiodactyla	
Family Cervidae	
<i>Mazama americana</i> (Erxleben, 1777)	MBML 1820