

RESEARCH ARTICLE

Updated list of mammals of the Island of Santa Catarina, southern Brazil

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ABSTRACT. The Island of Santa Catarina is the largest island on the Brazilian coast. Within the Atlantic Forest domain, it serves as a model for investigating the decline in biodiversity within this ecosystem. This decline is associated with the loss of a large part of forest cover and mammalian species. Although the forest environment in the island has recovered more in comparison to the rest of the Atlantic Rainforest (66% versus 28%, respectively), the isolation typical of islands has hindered the recolonization of sensitive species, particularly those that are threatened. Two decades after the first publication of the mammal list of the Island of Santa Catarina, we revised past data to identify which species became extinct and which native and exotic species remain, focusing on the inclusion of Chiroptera. Through bibliographical reviews, scientific collections and field surveys, a total of 59 species of native mammals, non-volant and volants, were confirmed. Among these, eight species were determined to be extirpated, all threatened with extinction, including large ungulates and top cats, in addition to the occurrence of nine domestic and exotic invasive species. Studies employing specific methodologies and sampling techniques in inadequately assessed environments have the potential to augment species richness, particularly among rodents, marsupials, and bats.

KEY WORDS. Atlantic Forest, defaunation, extinct species, inventory, isolation, invasive species.

INTRODUCTION

The survey of the species composition within a specific geographical region, along with the regular and continuous updating of this data, are essential factors to underpin conservation and management efforts aimed at preserving mammalian assemblages (Holland et al. 2012, Teta et al. 2018). Species surveying can be conducted using a range of methods, including track identification, animal trapping, reports from local residents, and camera traps (Flaquer et al. 2007, Kindberg et al. 2009, Lyra-Jorge et al. 2008, McCleery et

al. 2014, Valente et al. 2018, Cerbo and Biancardi 2013). One popular method for capturing medium and large-sized mammals is through the use of camera traps, while wire traps and mist nets are commonly used to catch small non-volant animals and bats, respectively. However, of sampling can be conducted using multiple methods, which, in turn, allows for a larger number of species to be registered (Lyra-Jorge et al. 2008, Espartosa et al. 2011).

The diversity of indigenous species present in a specific region can indicate how well the ecosystem is functioning (Fleishman et al. 2006, Maestre et al. 2011). Therefore, con-

ducting species surveys is essential as the first step in comprehending ecosystem structure and species assemblages (Hilty and Merenlender 2000, Jones 2011). As a result, it is feasible to investigate current and absent functional roles, and suggest species management strategies to restore the mammal community. Because insular environments are vulnerable, this type of information is especially important, since many species are unlikely to recolonize (Gillespie and Clague 2009). In defaunated regions, such information is equally crucial to facilitate actions aimed at reconstituting assemblages (Regan et al. 2008, Galetti et al. 2009, Bogoni et al. 2016, Robinson et al. 2018).

Both isolation and loss of fauna are issues that are specific to the Island of Santa Catarina, the largest island on the Brazilian coast, which harbors approximately 66% of native vegetation (Neves et al. 2017). This island underwent a profound process of land use and occupancy from colonization until 1970, with a substantial reduction in native vegetation cover (76.1%) due to agricultural expansion (Caruso 1983). This, coupled with hunting pressure dating back to its colonization and the introduction of invasive exotic species (Graipel et al. 2001), has impacted the composition of the mammal assemblage and led to the significant loss of species crucial for maintaining assemblages, such as apex predators, like jaguars and pumas (Haro 1996).

Two decades after the first list of terrestrial mammal species on the Island of Santa Catarina (Graipel et al. 2001), this study provides an updated assessment and discussion of the presence of current, extinct, and exotic species, along with the inclusion of Chiroptera.

MATERIAL AND METHODS

Study site

The Island of Santa Catarina (ISC) covers an area of 421.98 km² and is situated between the coordinates 27°22'S and 27°50'S; 48°25'W and 48°33'W (Neves et al. 2017). It stretches for 54 km from north to south, and has a maximum width of 18 km (Florianópolis 2004). It is separated from the mainland by a narrow channel of approximately 500 m (GAPLAN 1986). The Island is covered by a variety of vegetation formations, such as mangroves, sandbanks, forests of quaternary plains and hillside forests (Klein 1978). Neves et al. (2017) classified the ISC into 17 distinct land use and land cover categories, including tree vegetation (186.70 km²), shrub vegetation (38.18 km²), herbaceous vegetation (37.20 km²), wetlands (24.84 km²), mangroves (17.23 km²), reforestation (8.80 km²), agriculture (1.33 km²), and urban-

ization (52.99 km²) (Fig. 1). Additionally, it is noteworthy that there are 21 conservation units covering approximately 39% of the total territory. According to the Köppen classification, the climate in the area falls under the Cfa category (humid subtropical), with an average temperature of 20 °C and an annual precipitation of approximately 1500 mm distributed throughout the year (CECCA 1997).

The list of Graipel et al. (2001) was updated using five main methods. First, we compiled bibliography and studies about mammals on the ISC from 1995 to 2023. Secondly, we compiled and identified materials deposited in the Scientific Collection of Mammals at the Federal University of Santa Catarina (UFSC) and in the Zoological Collection of the Regional University of Blumenau (CZFURB). Additionally, we conducted survey studies under the Fauna Floripa Project between October 2019 and May 2022 and survey studies for sampling bats from 2017 to 2018. During these studies, records were obtained through the use of camera traps for medium- and large-sized mammals, live traps for rodents and marsupials, and mist nets for bats (see details below). The coordinates of the sampling points are available in Supplementary File 1. The nomenclature and taxonomic ordering follow Abreu et al. (2023), while the common names are based on the works of Graipel et al. (2001, 2017).

Sampling of medium and large mammals

Medium and large mammals were sampled in nine areas, included conservation units (number of authorization for scientific activities: # 055/2019 – Department of Conservation Units/Fundação Municipal do Meio Ambiente de Florianópolis, and # 019/2019 – Santa Catarina Environmental Institute). A total of 24 sampling plots were set up (modified Rapeld method, Magnusson et al. 2005) with a camera trap (Bushnell Essential E3) at the center point (Fig. 1). Areas of vegetation with different successional stages on ISC were sampled at least 1 km apart, with a conservative estimate of 30 days per season for an approximate sampling effort of 6,596 trap-days.

Sampling of small non-volant mammals

The sampling of non-volant small mammals (<1 kg; Chiarello 2000) was conducted between 2020 and 2022, in five areas on the Island of Santa Catarina (numbers of authorization for scientific activities and collect: # 27/2020 – Department of Conservation Units/Fundação Municipal do Meio Ambiente de Florianópolis, and # 76798 – Authorization and Information System in Biodiversity/Instituto Chico Mendes de Conservação da Biodiversidade). Within

each sampling area, two permanent plots were established, separated by a minimum of 1 km (Fig. 1). Each plot represented a 250 m transect with 25 points spaced 10 m apart (Modified Rapeld Method, Magnusson et al. 2005). Live-capture traps, such as the Tomahawk (260 x 140 x 90 mm) and Sherman (250 x 80 x 90 mm) traps, were utilized in each plot, positioned alternately on the ground and the understory. Semi-annual campaigns were conducted over three consecutive nights each during the summer and winter seasons, resulting in a cumulative sampling effort of 1,500

trap nights. Peanut butter, bananas, and bacon were used as baits. Following the capture, the individuals were identified according to their species and released at the site of capture, because all the species captured had previously been collected and deposited in Scientific Mammal Collection of the Universidade Federal de Santa Catarina.

Sampling of bats

Bats (numbers of collect's authorizations by Authorization and Information System in Biodiversity/Instituto Chico

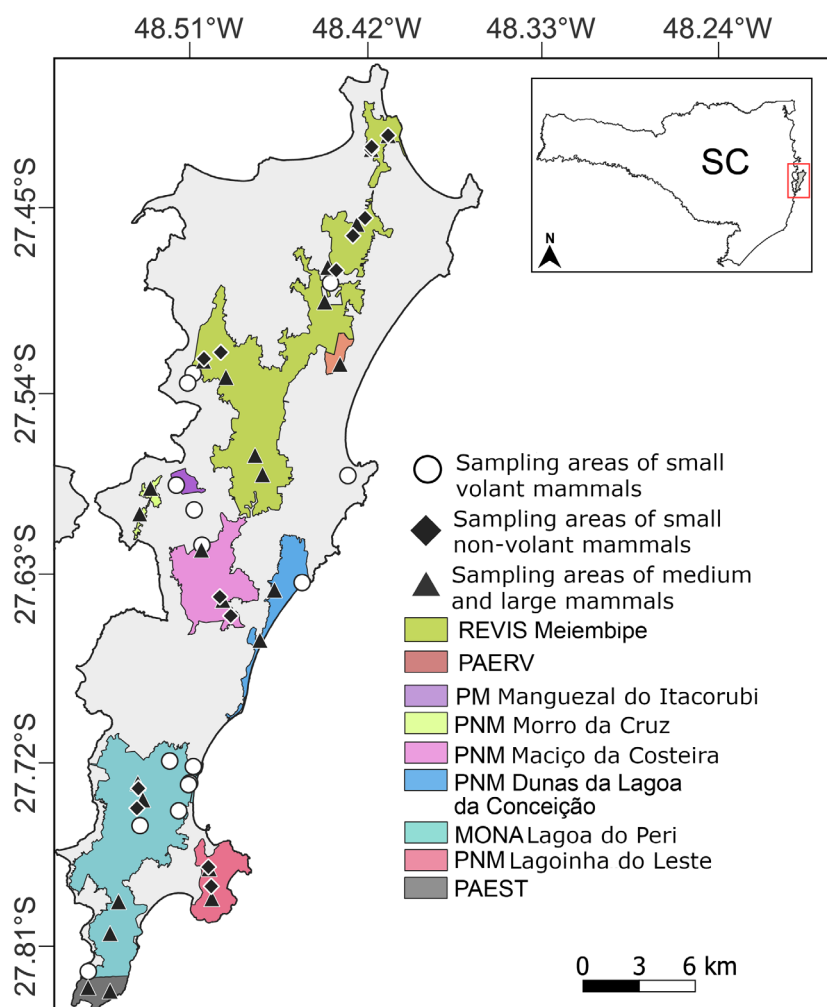


Figure 1. Mammal species survey areas on Island of Santa Catarina, with emphasis on the ten sampled Conservation Units. The abbreviations mean: REVIS Meiembipe- Meiembipe Municipal Wildlife Refuge; PAERV- Rio Vermelho State Park; PM Manguezal do Itacorubi- Itacorubi Mangrove Municipal Natural Park; PNM Morro da Cruz- Morro da Cruz Municipal Natural Park; PNM Maciço da Costeira- Maciço da Costeira Municipal Natural Park; PNM Dunas da Lagoa da Conceição- Dunas da Lagoa da Conceição Municipal Natural Park; MONA Lagoa do Peri- Lagoa do Peri Municipal Natural Monument; PNM Lagoinha do Leste- Lagoinha do Leste Municipal Natural Park; PAEST- Serra do Tabuleiro State Park.

Mendes de Conservação da Biodiversidade and Department of Conservation Units/Fundação do Meio Ambiente de Florianópolis: 9087-1, 72233 and 4489/2017) were captured in 2017 and 2018 across 10 forest remnants on ISC (Fig. 1). Mist nets were employed at ground level (Kunz 1990), strategically positioned in areas of natural clearings, near or intersecting rivers, along forest edges, within natural shelters, and at locations with plants known to attract bat species by the presence of fruits and flowers (Dias and Peracchi 2008).

A total of 10 sampling nights were conducted, with one at each of the ten sampled points. On each night, six mist nets were set up: two measuring 3 m x 3 m, two measuring 7 m x 3 m, and two measuring 12 m x 3 m. The nets remained operational for a period of 6 hours, from 6:00 p.m. to midnight, resulting in a cumulative sampling effort of 8,604 m²-h, calculated as proposed by Straube and Bianconi (2002). The captured bats were identified to species using external characteristics, aided by the dichotomous keys provided by Vizotto and Taddei (1973), Díaz et al. (2016) and Reis et al. (2017). A selection of individuals was gathered and preserved as biological material, following all the procedures approved by the Animal Use Ethics Committee, in the zoological collection of the Universidade Regional de Blumenau (CZFURB) (see Table 1), while the remaining individuals were released back into their original capture location.

Records organization and estimative of species richness

The recorded species were categorized as native, exotic (CONSEMA 2012), and extirpated. For the latter category, we considered past occurrences on the Island of Santa Catarina, when species identification was feasible through detailed descriptions provided by travelers during the 18th and 19th centuries (Haro 1996), as well as species-level records in sambaquis deposits made by humans contain bones of animals and shells (Olimpio 1995). Threat categories are presented in accordance with state-level (CONSEMA 2011), national (MMA 2022), and global (IUCN 2023) lists. The list of species, which encompasses accession numbers in scientific collections, records in protected areas, and publication years, can be found in Supplementary File 2.

To estimate the species richness of the Island of Santa Catarina through the rarefaction curve, we combined all the data from the three categories of mammals sampled in this study, and all sampling points due to differences between methodologies. We constructed the curve using 1,000 bootstrap replications and calculated the species richness estimator Chao2 with the “iNEXT” package. These analyses were performed using the R software (R Core Team 2023).

RESULTS

A total of 59 native mammal species have been documented on the ISC, belonging to seven orders and 17 families (Table 1). Four non-volant species have been added to the previous list by Graipel et al. (2001) based on a bibliographic survey, sampling records and material deposited in scientific collections: *Cavia cf. magna*, *Galictis cuja*, *Hydrochoerus hydrochaeris*, and *Kannabateomys amblyonyx* (UFSC 6415). Additionally, two species previously reported on ISC, solely through interviews, had their occurrence confirmed by camera traps: *Eira barbara* (mentioned by Campos et al. 2012) and *Coendou spinosus* (this study). Regarding the *Phyllomys*, Loss and Leite (2011) reported three species for ISC: *P. medius*, *P. nigrispinus*, and *P. sulinus*.

Among the bats, Cherem et al. (2004) listed 22 species for Florianópolis, which were recorded on the insular part, the ISC (S. Althoff pers. obs.). The specimen CZFURB-SLA 445, identified as *Eumops hansae*, and CZFURB-SLA 118 and 592, identified as *Artibeus jamaicensis*, actually belongs to the species *M. molossus* and *A. planirostris*, respectively. Here we record five other additional species for ISC: *Chiroderma doriae*, *Artibeus obscurus*, *Tonatia bidens*, *Pygoderma bilabiatum*, and *Vampyressa pusilla*.

In this study, 32 mammals were recorded through live-capture and camera traps. Nonetheless, the estimation of species richness curve, generated with 95% confidence interval, is around 39 species (36 to 43 species) and will be approaching stability with the number of species recorded for the ISC, potentially increasing and stabilizing beyond 75 sampling points (Fig. 2).

Currently, no species present on the ISC is threatened with extinction at a global (IUCN 2023) or national level (MMA 2022). At the state level (CONSEMA 2011), *Chironectes minimus*, *Lutreolina crassicaudata* and *Cuniculus paca* are the three species that are categorized as vulnerable (Table 1).

Eight species that were threatened globally, nationally, or statewide were considered extirpated (Table 2). The extirpated species on the ISC, based on both records of sambaquis (Olimpio 1995) and accounts of early travelers (Haro 1996), are: *Tapirus terrestris*, *Leopardus pardalis*, *Panthera onca*, *Puma concolor*, *Blastocerus dichotomus*, *Ozotoceros bezoarticus*, *Tayassu pecari* and *Alouatta guariba clamitans*. Other species may have also been extirpated from the ISC, considering the records of small wild cats (*Leopardus* sp.), deer (*Subulo gouazoubira* or *Mazama* spp.), and peccaries (Tayassuidae) in sambaquis (Olimpio 1995). However, due the low reliability of individual records of sambaquis as they can be brought

Table 1. List of terrestrial mammals and their conservation status for the Island of Santa Catarina. The conservation status is defined at the state level (CONSEMA 2011) and the global level (IUCN 2023). The collection's number are from bat captured in this study and deposited in zoological collection of the Regional University of Blumenau (CZFURB).

Taxon	Common name	Status	Record type	Collection's number
Didelphimorphia: Didelphidae				
<i>Chironectes minimus</i> (Zimmermann, 1780)	Water-opossum	IUCN(LC), SC(VU)	B, C	
<i>Didelphis aurita</i> Wied-Neuwied, 1826	Big-eared-opossum	IUCN(LC)	A, B, C	
<i>Marmosa paraguayana</i> Tate, 1931	Tate's-woolly-mouse-opossum	IUCN(LC)	A, B, C, Cap	
<i>Lutreolina crassicaudata</i> (Desmarest, 1804)	Big-lutrine-opossum	IUCN(LC), SC(VU)	A, B, C, Cap	
Pilosa: Myrmecophagidae				
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	Southern-tamandua	IUCN(LC)	A, B, C	
Cingulata: Chlamyphoridae				
<i>Cabassous tatouay</i> (Desmarest, 1804)	Greater naked-tailed armadillo	IUCN(LC)	B, C	
Cingulata: Dasypodidae				
<i>Dasypus novemcinctus</i> Linnaeus, 1758	Nine-banded armadillo	IUCN(LC)	A, B, C	
<i>Dasypus septemcinctus</i> Linnaeus, 1758	Seven-banded armadillo	IUCN(LC)	B	
Primates: Cebidae				
<i>Sapajus nigritus</i> (Goldfuss, 1809)	Black-capuchin	IUCN(NT)	A, B	
Carnivora: Canidae				
<i>Cerdocyon thous</i> (Linnaeus, 1766)	Crab-eating fox	IUCN(LC)	A, B, C	
Carnivora: Mustelidae				
<i>Eira barbara</i> (Linnaeus, 1758)	Tayra	IUCN(LC)	A, B	
<i>Galictis cuja</i> (Molina, 1782)	Lesser grison	IUCN(LC)	A	
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical otter	IUCN(NT)	A, B, C	
Carnivora: Procyonidae				
<i>Nasua nasua</i> (Linnaeus, 1766)	Ring tailed coati	IUCN(LC)	A, B, C	
<i>Procyon cancrivorus</i> (G. Cuvier, 1798)	Crab-eating raccoon	IUCN(LC)	B	
Chiroptera: Molossidae				
<i>Molossus molossus</i> (Pallas, 1766)	Bat	IUCN(LC)	B, C, Cap	
<i>Tadarida brasiliensis</i> (L. Geoffroy St.-Hilaire, 1824)	Bat	IUCN(LC)	B, C	
Chiroptera: Noctilionidae				
<i>Noctilio leporinus</i> (Linnaeus, 1758)	Greater-bulldog bat	IUCN(LC)	B, C	
Chiroptera: Phyllostomidae				
<i>Anoura caudifer</i> (E. Geoffroy St.-Hilaire, 1818)	Tailed tailless bat	IUCN(LC)	B, C	
<i>Anoura geoffroyi</i> Gray, 1838	Geoffroy's tailless bat	IUCN(LC)	B, C	
<i>Artibeus fimbriatus</i> Gray, 1838	Bat	IUCN(LC)	B, C	CZFURB-SLA 7016, 7017
<i>Artibeus planirostris</i> (Spix, 1823)	Bat	IUCN(LC)	B, C, Cap	
<i>Artibeus lituratus</i> (Olfers, 1818)	Bat	IUCN(LC)	B, C, Cap	
<i>Artibeus obscurus</i> (Schinz, 1821)	Bat	IUCN(LC)	Cap	CZFURB-SLA 7018
<i>Carollia perspicillata</i> (Linnaeus, 1758)	Bat	IUCN(LC)	B, C, Cap	CZFURB-SLA 6935
<i>Chiroderma doriae</i> Thomas, 1891	Bat	IUCN(LC)	C, Cap	CZFURB-SLA 6027, 7015
<i>Vampyressa pusilla</i> (Wagner, 1843)	Bat	IUCN(DD)	Cap	CZFURB-SLA 7019
<i>Desmodus rotundus</i> (É. Geoffroy St.-Hilaire, 1810)	Common-vampire-bat	IUCN(LC)	B, C, Cap	CZFURB-SLA 6929
<i>Glossophaga soricina</i> (Pallas, 1766)	Bat	IUCN(LC)	B, C, Cap	
<i>Mimon bennettii</i> (Gray, 1838)	Bat	IUCN(LC)	B, C, Cap	CZFURB-SLA 6028
<i>Pygoderma bilabiatum</i> (Wagner, 1843)	Bat	IUCN(LC)	Cap	CZFURB-SLA 6926
<i>Sturnira lilium</i> (É. Geoffroy St.-Hilaire, 1810)	Bat	IUCN(LC)	B, C, Cap	CZFURB-SLA 6933, 6934
<i>Tonatia bidens</i> (Spix, 1823)	Bat	IUCN(DD)	C, Cap	CZFURB-SLA 6029
Chiroptera: Vespertilionidae				
<i>Eptesicus brasiliensis</i> (Desmarest, 1819)	Bat	IUCN(LC)	B, C	

Continues

Taxon	Common name	Status	Record type	Collection's number
<i>Eptesicus diminutus</i> Osgood, 1915	Bat	IUCN(LC)	B, C, Cap	
<i>Eptesicus furinalis</i> (d'Orbigny & Gervais, 1847)	Bat	IUCN(LC)	B, C	
<i>Lasiurus blossevillei</i> (Lesson, 1826)	Bat	IUCN(LC)	B, C	
<i>Lasiurus ega</i> (Gervais, 1856)	Bat	IUCN(LC)	B, C	
<i>Myotis levis</i> (I. Geoffroy St.-Hilaire, 1824)	Bat	IUCN(LC)	B, C	CZFURB-SLA 6034, 6035
<i>Myotis nigricans</i> (Schinz, 1821)	Bat	IUCN(LC)	B, C	CZFURB-SLA 6930, 6931, 6932
<i>Myotis riparius</i> Handley, 1960	Bat	IUCN(LC)	B, C	
Rodentia: Caviidae				
<i>Cavia</i> cf. <i>magna</i>	Greater-guinea-pig		B, C	
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	Capybara	IUCN(LC)	A, B, C	
Rodentia: Cricetidae				
<i>Akodon montensis</i> Thomas, 1913	Rat	IUCN(LC)	B, C, Cap	
<i>Euryoryzomys russatus</i> (Wagner, 1848)	Rat	IUCN(LC)	B, C, Cap	
<i>Juliomys pictipes</i> (Osgood, 1933)	Rat	IUCN(LC)	B, C	
<i>Nectomys squamipes</i> (Brants, 1827)	Rat	IUCN(LC)	B, C	
<i>Oligoryzomys flavescens</i> (Waterhouse, 1837)	Rat	IUCN(LC)	B, C	
<i>Oligoryzomys nigripes</i> (Olfers, 1818)	Rat	IUCN(LC)	B, C	
<i>Oxymycterus quaestor</i> Thomas, 1903	Quaestor hociendo	IUCN(LC)	B, C	
<i>Sooretamys angouya</i> (G. Fisher, 1814)	Rat	IUCN(LC)	B, C, Cap	
Rodentia: Cuniculidae				
<i>Cuniculus paca</i> (Linnaeus, 1766)	Paca	IUCN(LC), SC(VU)	A, B	
Rodentia: Dasyproctidae				
<i>Dasyprocta azarae</i> Lichtenstein, 1823	Agouti	IUCN(DD)	A, B, C	
Rodentia: Echimyidae				
<i>Kannabateomys amblyonyx</i> (Wagner, 1845)	Atlantic bamboo rat	IUCN(LC)	C	
<i>Myocastor coypus</i> (Molina, 1782)	Nutria	IUCN(LC)	B, C	
<i>Phyllomys nigrispinus</i> (Wagner, 1842)	Black-spined atlantic tree-rat	IUCN(LC)	B, C	
<i>Phyllomys medius</i> (Thomas, 1909)	Long-furred atlantic tree-rat	IUCN(LC)	B, C	
<i>Phyllomys sulinus</i> Leite, Christoff & Fagundes, 2008	Southern atlantic tree-rat	IUCN(DD)	B, C	
Rodentia: Erethizontidae				
<i>Coendou spinosus</i> (Cuvier, 1823)	Paraguayan hairy dwarf porcupine	IUCN(LC)	A, B	

Record types: (A) camera trap, (B) bibliographic survey, (C) scientific collection, (Cap) capture.

Table 2. Terrestrial mammals considered extirpated from the Island of Santa Catarina and their conservation status. The conservation status is defined by state level (CONSEMA 2011), national level (MMA 2022) and global level (IUCN 2023).

Taxon	Common name	Status	Record type
Perissodactyla: Tapiridae			
<i>Tapirus terrestris</i> (Linnaeus, 1758)	South American tapir	IUCN (VU), BR (VU), SC (EN)	A, B
Cetartiodactyla: Cervidae			
<i>Blastocerus dichotomus</i> (Illiger, 1815)	Marsh deer	IUCN (VU), BR (VU)	A, B
<i>Ozotoceros bezoarticus</i> (Linnaeus, 1758)	Pampas deer	IUCN (NT), BR (VU), SC (VU)	A, B
Cetartiodactyla: Tayassuidae			
<i>Tayassu pecari</i> (Link, 1795)	White-lipped peccary	IUCN (VU), BR (VU), SC (CR)	A, B
Primates: Atelidae			
<i>Alouatta guariba clamitans</i> Cabrera, 1940	Southern brown howler	IUCN (VU), BR (VU), SC (VU)	A, B, C
Carnivora: Felidae			
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot	IUCN (LC), SC (EN)	A
<i>Panthera onca</i> (Linnaeus, 1758)	Jaguar	IUCN (NT), BR (VU), SC (CR)	A, B
<i>Puma concolor</i> (Linnaeus, 1771)	Puma	IUCN (LC), SC (VU)	A, B

Record types: (A) Sambaquis, (B) Bibliographic survey, (C) Reintroduction in progress since January, 2024.

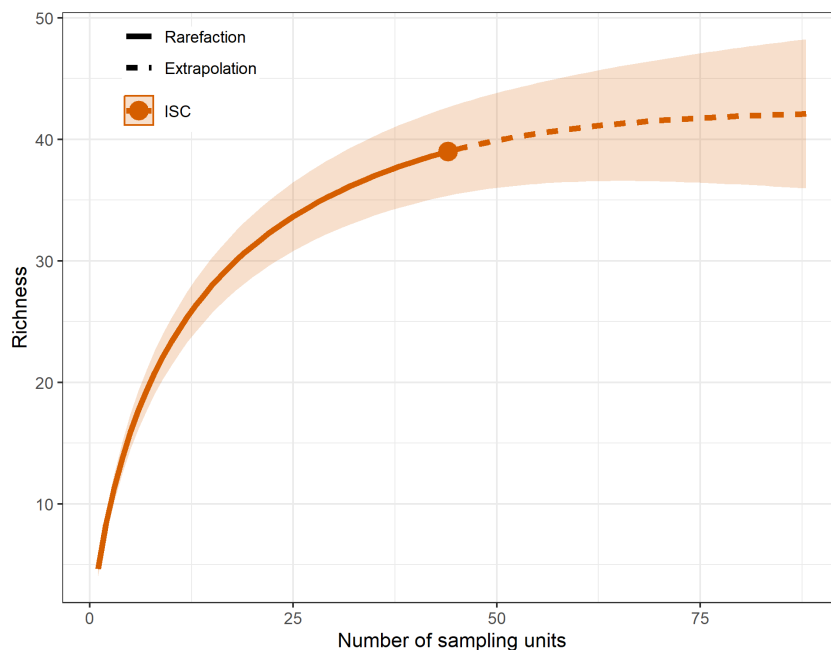


Figure 2. Estimates of species richness curve for terrestrial mammals, registered on Island of Santa Catarina in this study conducted from 2017 to 2022.

from nearby continent, were not included as extirpated. We should highlight that *Alouatta guariba clamitans* is part of an ongoing reintroduction program, led by Silvestres SC program, that released families in protected areas since January of 2024 (V. Kannan pers. comm.). We also add that in January 2018, a *Leopardus* sp. specimen was recorded as roadkill and deposited in the Mammal Collection of the Universidade Federal de Santa Catarina (UFSC), under the number UFSC 6236. However, this record was made near the Center for Wildlife Triage, and it may correspond to a captive individual of undetermined origin.

Among the domestic and invasive exotic mammals, documented in natural environments, nine species were recorded (Table 3). Individuals of *Callithrix penicillata* were frequently recorded on the trails of all 19 sampling points with camera traps that are located in forest ambient, including the more preserved areas. We did not record individuals of *C. jacchus*, but there are observations in coastal vegetation (restingas and mangroves; I. Ghizoni-Jr pers. comm.). Vocalization of *Callithrix* also was recorded on the trails, but we were not able to identify the individuals to species based on sound only. Therefore, hybrid individuals and *C. geoffroyi* were not confirmed in this study. On the other hand, wild boars were only recorded within the boundaries of the conservation unit of the Lagoa do Peri Municipal Natural Monument.

Table 3. Domestic and invasive exotic terrestrial mammals, recorded in the areas of the Island of Santa Catarina.

Taxon	Common Name	Record Type
Primates: Callithrichidae		
<i>Callithrix geoffroyi</i> (É. Geoffroy, 1812)	Marmoset	B
<i>Callithrix jacchus</i> (Linnaeus, 1758)	Marmoset	B
<i>Callithrix penicillata</i> (É. Geoffroy, 1812)	Marmoset	A, B, C
Cetartiodactyla: Suidae		
<i>Sus scrofa</i> Linnaeus, 1758	Wild boar	A
Carnivora: Canidae		
<i>Canis familiaris</i> Linnaeus, 1758	Dog	A
Carnivora: Felidae		
<i>Felis catus</i> Linnaeus, 1758	Cat	A
Rodentia: Muridae		
<i>Mus musculus</i> Linnaeus, 1758	Mouse	C
<i>Rattus norvegicus</i> (Berkenhout, 1769)	Brown rat	C
<i>Rattus rattus</i> (Linnaeus, 1758)	Rat	C

Record types: (A) Camera trap, (B) Bibliographic survey, (C) Scientific collection.

DISCUSSION

More than two decades after the Graipel et al. (2001) survey, the number of recorded mammal species listed for the ISC has increased by 136%, from 25 to 59 species, with the potential to increase to 67 according to the species richness estimation curve (Fig. 2). The addition and confirmation of

records for medium and large mammals, taxonomic revisions for non-volant small mammals, and the inclusion of 22 bat species listed by Cherem et al. (2004) for Florianópolis and confirmed for ISC and five species that did not have records for ISC, have increased the number of mammal species in the island fauna by 34.

The Santa Catarina archipelago has islands of varying size and mammal richness. For example, the ISC, covering 421.98 km², harbors 59 species of mammals; Arvoredo Island, located 10.6 km north of the ISC and 12.7 km east of the mainland, covers an area of 2.7 km² and boasts 11 species (S. Althoff pers. obs., Salvador et al. 2009); Ratonés Island, also located between the continent and Island of Santa Catarina, spans 1.94 km² (Salvador et al. 2009) and hosts three species (Graipel et al. 1997); and the Moleques do Sul Islands, located near the southern tip of the ISC, encompass 0.1 km² (Furnari 2011) and accommodate only one mammal species, *Cavia intermedia*, an endemic species (Cherem et al. 1999). The number of species on ISC is similar to that observed on the nearby mainland; the State Park of Serra do Tabuleiro, which covers 850 km², is home to 74 native species (Cherem et al. 2011). This highlights the high mammal richness of the ISC, which is related to its size and proximity to the mainland, as predicted by the Island Biogeography Theory (MacArthur and Wilson 1967). It also highlights the significance of this area, as a reference for research on island environments with Atlantic Forest vegetation, and the effects of poorly permeable matrices on isolated remnants of continental regions, where natural recolonization is hindered or even unviable (MacArthur and Wilson 1967).

Heterogeneous environments with extensive, connected, uniform and legally protected vegetation patches can sustain species diversity (Brancalion et al. 2016, Fahrig 2017, Metzger et al. 2019). This seems to be the case for the Island of Santa Catarina, considering the current documentation of mammal richness. Despite undergoing intensive land use and land cover changes, which have led to the formation of highly fragmented areas (Ferretti 2013), ISC still displays significant environmental heterogeneity with regenerating secondary forests (Neves et al. 2017), as well as primary vegetation cores and a substantial proportion of protected areas (Góes and Ferretti 2023). These factors foster species that are resilient to changes in land use and land cover, particularly in the absence of strict predators (Terborgh et al. 2001, Estes et al. 2011, Magioli et al. 2021, Moore et al. 2023). This may be the case for *Dasyprocta azarae*, which was previously recorded in the south of the ISC (Graipel et al. 2001), and is currently reported in most protected areas evaluated during the present

study (see Supplementary Files 1 and 2). These same factors may have also influenced the recolonization of *Hydrochoerus hydrochaeris*. This species was considered extinct on the ISC by Graipel et al. (2001), but the swimming abilities (Ferraz et al. 2007) and resilience of individuals (Magioli et al. 2021) enables them to cross the sea between the mainland and ISC, a phenomenon frequently reported by local residents (B. Lima-Silva pers. obs.). However, it cannot be definitively stated that natural recolonization occurred. Two females and one male, from the municipality of Laguna-SC, escaped from a breeding facility located in the Campeche neighborhood, in the south of ISC, following heavy rains in 2001, and one of the escaped females was confirmed dead. Nonetheless, an increase in the number of individuals was noted from the remaining pair (P.R.M. Miller pers. comm.).

In addition to increased legal protection, environmental regeneration, and the absence of specialist wild predators (Chape et al. 2005, Magioli et al. 2021, Pires and Galetti 2023), the rise in the number of species recorded on the ISC may be linked to the recent use of camera traps. Camera traps represent a passive sampling method that can operate over extended periods and across various locations without the influence of human presence (Caravaggi et al. 2017), thus increasing sampling effort and, consequently, the likelihood of species recording (Srbek-Araujo and Chiarello 2013, Mason et al. 2022). This may have influenced the recording of elusive species in this study, such as *Galictis cuja* and *Eira barbara* (Tobler et al. 2008, Srbek-Araujo and Chiarello 2013, Dechner et al. 2018). It should be noted that in November 2019, a carcass of *Galictis cuja* was found in the vicinity of the Maciço da Costeira Municipal Natural Park (F. Farias pers. comm.), which predates the record made in this study. Regarding the confirmation of the presence of *Coendou spinosus*, it may be attributed to a random event, considering that this species is arboreal and, as a result, rarely descends to the ground (Paglia et al. 2012, Menezes et al. 2020). In such cases, installing tree-mounted camera traps can complement sampling efforts for this species and other arboreal animals (Moore et al. 2021).

The number of marsupial species at the ISC has not increased since Graipel et al. (2001), which may be, at least in part, explained by the use of wire and aluminum sheet traps exclusively in the samplings. Some marsupials, such as *Cryptonanus* sp. and *Monodelphis* sp., have been captured more frequently in pitfall traps (Umetsu et al. 2006) or recorded in owl pellets (Cherem et al. 2018). Sampling of small arboreal mammals was conducted in a few areas in the ISC approximately 20 years ago, between 1998 and

2006 (Antunes et al. 2009, Goulart et al. 2006, Graipel et al. 2003). The use of appropriate methods for capturing in the canopy (Graipel 2003, Graipel and Moraes 2004) after two decades of forest regeneration in the sampled areas, as well as in new areas, can contribute to the recording of arboreal rodents and marsupials that were previously restricted to the most preserved forest core. On the other hand, the low richness of non-volant small mammals on ISC, compared to the nearby mainland (Cherem et al. 2011), may be attributed to local extinction. In this regard, employing complementary methodologies for sampling small mammals, and conducting studies at archaeological sites, may yield more appropriate data on the reduction of diversity within this group on the Island of Santa Catarina.

Bats are a well-represented group on the ISC, with approximately 74.3% of the species recorded in municipalities along the coast of Santa Catarina (Cherem et al. 2004), including *T. bidens* (cited by Gardner 2008). However, as new studies are carried out, such as those utilizing alternative sampling methods, such as song-meter recording for insectivorous bats (Parker and Bernard 2018, Gómez-Corea et al. 2021), bat richness is anticipated to rise, particularly in light of the improved quality of habitat as a result of extended natural area protection. This may allow populations with low densities to increase (Lacki et al. 2007), thus enabling new records. Furthermore, the recolonization of bats from the nearby mainland is facilitated by the permeability of the matrix for a winged group (Frick et al. 2008, Breed et al. 2010), especially considering the narrow channel that separates ISC from the mainland.

Regarding the invasive exotic species recorded at the ISC, marmosets have proven to be successful invaders due to their common occurrence in all sampled areas, while wild boars were rarely captured by camera traps. The exact dates of introduction of these species to ISC are not precise; there are reports of their occurrence in the late 1980s (Graipel et al. 2001) and the early 2010s (M.A. Tortato pers. comm.), respectively. In addition to the difference in the timing of introduction of these species, studies have demonstrated that marmosets prefer secondary forests and open areas (Ferrari et al. 2013, Hue et al. 2016, Secco et al. 2018). This suggests that the history of environmental disturbance (Caruso 1983), may have facilitated the establishment of these species at the ISC. In the case of wild boar, their presence was uncommon on ISC even though they are one of the most common mammal species worldwide and can grow their populations quickly in the right conditions (Heise-Pavlov et al. 2009, West et al. 2009). This could be related to the low amount

of cropland in the areas adjacent to the forested environments on the island (0.3% crops; Neves et al. 2017), making the environment less favorable for the population growth of the species (Martins et al. 2019, Moore et al. 2023). There are reports of the pursuit and killing of wild boar when they are linked to damage to crops. Hunting, however, has only been documented for *Dasyus novemcinctus*, *Cuniculus paca*, *Dasyprocta azarae*, *Nasua nasua*, and *Tamandua tetradactyla* (B. Lima-Silva pers. comm.).

The increase in the number of species, recorded at the ISC, has primarily been attributed to the inclusion of bats and the use of other sampling methodologies, such as camera traps. However, we emphasize the importance of environmental public policies in the preservation and apparent population increase of rodents, such as *Dasyprocta azarae*, *Hydrochoerus hydrochaeris*, and *Coendou spinosus*, as the expansion of municipal conservation units, may have contributed to vegetation regeneration over the past 50 years (Góes and Ferretti 2023). Nevertheless, short-term recolonization of extirpated species is unlikely, especially for species that are threatened at the state, national, or global level, have low population densities due to habitat loss (Ripple et al. 2017), and are sensitive to environmental changes (Magioli et al. 2021). The reintroduction program of *Alouatta guariba clamitans*, a vulnerable species at all levels (MMA 2022, IUCN 2023, CONSEMA 2011), in protected areas conducted by Silvestres SC program, is an example of management action for an extirpated species with a low chance of short-term recolonization (Gonzalez-Socoloske and Snarr 2010). Thus, even with well-preserved areas on the nearby mainland, and the feasibility of swimming crossings for some species (Galetti et al. 2017, Stratton et al. 2022), becomes evident that environmental policies focused on management actions are important measures that can help reverse the loss of biodiversity in the Island of Santa Catarina.

We anticipate that if further studies employing different sampling methods are conducted, it is possible that additional mammal species, particularly bats, rodents and marsupials, will be found on the Island of Santa Catarina. Additionally, the impact of invasive exotic species on native fauna warrants attention. This type of research is important to complement the list of species of existing assemblages on Island of Santa Catarina, thus stabilizing the estimation curve of species richness. As such, it can serve as the foundation for environmental policy formulation and decision-making by managers of environmental agencies, with the ultimate objective of preserving the Island of Santa Catarina's native mammal population.

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Competing Interests

The authors have declared that no competing interests exist.

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Supplementary material 1

Supplementary File 1. Sampling points in protected areas for each of the terrestrial mammal groups (small <1 kg: rodents, marsupials, and bats; medium and large >1 kg) on Island of Santa Catarina. *Desterro Environmental Conservation Unit is a conservation area managed by the Universidade Federal de Santa Catarina and is encompassed by the Meimbiupe Municipal Wildlife Refuge.

Authors: B. Lima-Silva et al.

Data type: Georeferenced data.

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Link: <https://doi.org/10.3897/zoologia.41.e23102>

Supplementary material 2

Supplementary File 2. List of terrestrial mammals recorded for Island of Santa Catarina with citations in subsequent studies, specimens deposited in the Mammal Collection of the Universidade Federal de Santa Catarina (abbreviated as UFSC and SANTUR) and in the Zoological

Collection of the Fundação Universidade Regional de Blumenau (CZFURB-SLA), and records in this study in protected areas.

Authors: B. Lima-Silva et al.

Data type: Species data.

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