

Mammals of the Tandilia Mountain system, current species inhabiting Pampean highland grasslands

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Abstract

Neotropical temperate grasslands comprise the Pampas ecoregion in Argentina. This region is also the center of agricultural development in Argentina, which has led to a significant simplification and homogenization of the landscape. The Tandilia Mountains, located in the Southeast of the ecoregion, house one of the last remnants of the highland grassland that acts as a refuge for several native species, including both endemic and threatened species. This work aims to present an updated inventory of mammal species that inhabit the highland grassland remnants of the Tandilia Mountains. We used several sources of information to compile the list, including museum collections, citizen science projects (i.e., iNaturalist, EcoRegistros, and Argentinian Network for Monitoring Run Over Fauna), literature, and personal observations. We recorded 40 species of mammals, which include 32 native species and eight exotic species. The richest orders were Rodentia (42.5%), Chiroptera (17.5%), and Carnivora (12.2%). The native mammals found in the Tandilia Mountains represent 44% of the mammal diversity of the Pampas ecoregion, among which there are endemic species of the ecoregion, species whose populations are declining globally, and threatened species. Unfortunately, the presence of protected areas in the system is limited to a few small ones, which highlights the urgency of increasing the number and variety of protected areas. The information presented in this work contributes to the knowledge of biodiversity and the planning of conservation actions for the last remnants of highland grasslands.

Keywords

Argentina, biodiversity, checklist, conservation, Tandil

Introduction

With a surface larger than 700,000 km², the Río de la Plata grasslands form the largest temperate grassland in the Neotropics (Soriano et al. 1992). These grasslands comprise the Pampas ecoregion in Argentina, the Savannas of Uruguay, and a portion of northeastern Argentina and Rio Grande do Sul in Brazil (Soriano et al. 1992). In Argentina, the Pampas ecoregion extends over most of the province of Buenos Aires (except the southern portion), the south portion of Entre Ríos, southeastern Córdoba, southern Santa Fe, and the northeastern portion of La Pampa province (Burkart et al. 1999). As Argentina's most important grassland ecosystem, its complete extension consists of approximately 398,966 km² (Matteucci 2012). This region is also the center of agricultural development in Argentina, which has led to significant simplification and homogenization of the landscape (Bilenca and Miñarro 2004). In the province of Buenos Aires, these vast plains are interrupted in their southernmost portion by the Tandilia and Ventania Mountains (Bilenca and Miñarro 2004; Matteucci 2012).

The Tandilia Mountains, located in the southeastern portion of the Buenos Aires province, consist of foothills and moderate-sloping plains that reach the Atlantic Ocean (Cingolani 2011). In this system, the native vegetation, which consists of highland grassland, is restricted to hills (cerrilladas) where rocky outcrops and shallow soils prevent cultivation (Herrera and Laterra 2008), thus limiting agricultural extension over native habitats. In these areas, the natural grasslands act as a refuge for native, endemic, and endangered species (Cantero et al. 2014; Kristensen et al. 2014; Herrera et al. 2019, 2022; Vera et al. 2021). Due to their importance, Bilenca and Miñarro (2004) proposed them as Valuable Pasture Areas.

Historically, mammals were represented in the Pampas ecoregion by large carnivores such as *Puma concolor*, *Panthera onca* and *Chrysocyon brachyurus*, as well as by large herbivores such as *Ozotoceros bezoarticus*, *Blastocerus dichotomus* and *Lama guanicoe*, in addition to rodents, armadillos, and bats (Medan et al. 2011). Changes brought about by agriculture, introduced livestock, and invasive species generated important modifications in mammal assemblages, which resulted in the local extinction of mainly large mammals and the decimation of populations of some species, while hardly affecting other mammal species (Baldi and Paruelo 2008; Bilenca et al. 2008, 2012; Medan et al. 2011). Currently, studies on the richness and distribution of mammals in the Pampas grasslands are asymmetric, and certain areas, such as the southeastern portion of the Province of Buenos Aires, contain little information (Galliari et al. 1991; Pardiñas et al. 2004). The oldest records on the diversity of mammals in the Tandilia Mountains correspond to those cited by Holmberg (1884), while the updated specific bibliography is limited to isolated studies (e.g., Velasco et al. 2013; O'Connor et al. 2019, 2020).

Wild species play an essential role in maintaining the ecosystem. From an anthropic point of view, mammals of the Pampas Ecoregion offer a wide variety of ecosystem services, mainly those related to ecosystem regulation processes, such as

the biological control of species that are harmful to humans (Gorosábel et al. 2020). Studying species richness and generating inventories is of vital importance to be able to establish patterns within different groups of species and understand what has caused them (Yahnke et al. 1998; Krebs 2008). This work aims to present an updated list of mammal species present in the highland grassland remnants of the Tandilia Mountains. This work establishes a baseline for developing management and conservation strategies for the mammal species inhabiting these Neotropical grasslands.

Methods

Study area

The Tandilia Mountains are located in the southeastern Pampas ecoregion (Fig. 1), covering a distance of 350 km in length and a maximum of 50–60 km in width, oriented along a northwest-southeast axis. This system is characterized by small hills and mountains that stand 50 and 500 m above the Pampas plains, with a maximum height of approximately 524 m (Cingolani 2011). These mountains are surrounded by a peri-mountain plain containing more or less pronounced hills and streams and fresh and brackish-water lagoons (Martínez 2001; Dalla Salda et al. 2006; De Rito et al. 2020).

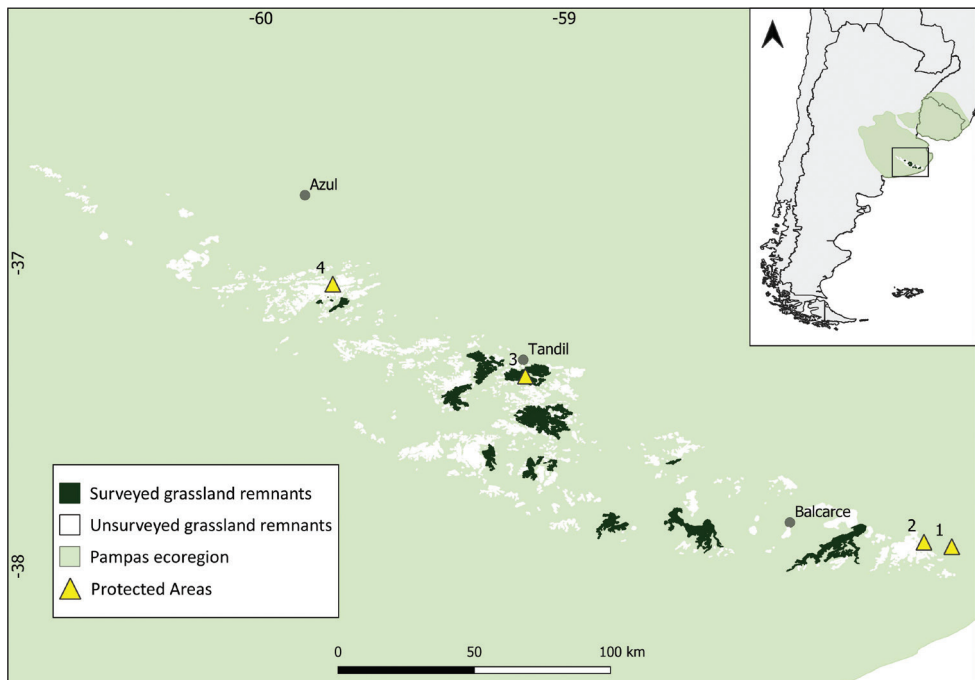


Figure 1. Surveyed (camera trapping) and unsurveyed highland grassland remnants of the Tandilia Mountains in the Pampas ecoregion. The protected areas are: 1) Laguna de Los Padres Nature Reserve, 2) Paititi Private Natural Reserve; 3) Sierra del Tigre Natural Reserve; 4) Boca de la Sierra Natural Reserve.

The climate of the region is temperate sub-humid to humid with a marked seasonality in temperature (Falasca et al. 2000; Echeverría et al. 2017). The average annual precipitation is 800–850 mm (Burgos and Vidal 1951; Valicenti et al. 2010). The vegetation of the Tandilia Mountains consists of highland grassland; however, due to the presence of agricultural processes, these grasslands are restricted to non-arable environments (Soriano et al. 1992; Herrera et al. 2022). This grassland is composed of a great diversity of grasses and dicotyledons, predominantly species of the genera *Piptochaetium*, *Nassella*, *Briza*, *Poa*, *Aristida*, *Setaria*, *Oxalis*, *Paspalum*, and *Baccharis* (Frangi 1975; Cabrera 1976; Valicenti et al. 2010; Echeverría et al. 2017; De Rito et al. 2020). Grasslands that develop around watercourse edges are mainly dominated by *Cortaderia selloana* (Frangi 1975; Sabatino et al. 2017; De Rito et al. 2020).

Data source

We used several sources of information to compile a list of the mammal species present in the Tandilia Mountains, including museum collections, citizen science projects, literature, and personal observations. We reviewed the database of the Museo de La Plata collection and we visited said collection to examine those specimens (N = 44) whose information was not uploaded or available in the database. We also included specimens collected within the Tandilia mountain region which were deposited in other museum collections (i.e., the Argentinean Bernardino Rivadavia Natural Sciences Museum (MACN); the Michigan State University Museum, MSU; the Paleobiology Database, PBDB; the Museum of Texas Tech University, TTU; and the Museum of Vertebrate Zoology, MVZ) and those reported on the Global Biodiversity Information Facility (www.gbif.org/). We applied a geographical polygon filter (i.e., the Tandilia Mountain range) and compiled a list containing all records of mammal species (<https://doi.org/10.15468/dl.48ffnu>) deposited in museums, excluding those records that corresponded to fossil records.

We searched records in three citizen science projects where users upload photographic records: 1) the iNaturalist (www.inaturalist.org) online database, where we applied a geographical polygon filter to search this database and selected only those records of mammal species that were research grade; 2) the EcoRegistros database (www.ecoregistros.org), where we applied a filter for the province of Buenos Aires to search for records in this database using the map tool, and selected all mammal records that were recorded for the Tandilia Mountains area; and 3) the Argentinian Network for Monitoring Run-Over Fauna (Red Argentina de Monitoreo de Fauna Atropellada, fauna-atropellada.org.ar), where we selected all the mammal records for the Tandilia Mountains.

For the compilation of data accessed through literature, we revised the following bibliography on mammals reported within the Tandilia Mountains: Galliari and Pardiñas (2000), Leveau et al. (2004), Pardiñas et al. (2004), Barquez et al. (2006), Abba and Vizcaíno (2011), Fernández et al. (2012), Velasco et al. (2013), Chimento

and De Lucca (2014), Giacomini (2015), Stelatelli and Baladrón (2015), Isacch et al. (2016), O'Connor et al. (2019, 2020), Barquez and Díaz (2020), De Lucca and Chimento (2020), Olmedo et al. (2021) and González Noschese et al. (2022).

We also included data recorded between September 2016 and June 2021 from personal fieldwork observations and camera trap records obtained within the framework of a vertebrate monitoring project associated with highland grassland remnants. We surveyed 27 highland grassland remnants throughout the Tandilia Mountain System (Fig. 1), with 192 camera stations and a sampling effort of 3719 camera trap days, totaling 3069 observations of mammals. We also included verified records (e.g., photos and videos) from the local community (e.g., rural inhabitants, rescue centers, etc.).

We calculated the percentage of the mammals associated with the grasslands of the Pampas ecoregion that is represented in the Tandilia System, as well as how many native and invasive species are represented in the composition of the system. For this, we reference the species reported for the Pampean ecoregion by Secretaría de Ambiente y Desarrollo Sustentable de la Nación y Sociedad Argentina para el Estudio de los Mamíferos (2019).

We included the conservation status of the listed species following the global categorization of Red List of Threatened Species (www.iucnredlist.org) and the Argentinean Red List (Secretaría de Ambiente y Desarrollo Sustentable de la Nación y Sociedad Argentina para el Estudio de los Mamíferos 2019).

Results

We obtained a list of 40 mammal species inhabiting the highland grassland of the Tandilia Mountains, belonging to 7 orders, 18 families, and 35 genera. Of these species, 32 are considered native species and 8 are exotic (Table 1; Figs 2, 3; See Suppl. material 1). The orders with the largest number of species were rodents (17 species) and bats (7 species), which represented 42.5% and 17.5% of the species present, respectively (Fig. 4). The conservation statuses of two native species are currently categorized with some degree of threat.

From the different sources consulted to prepare the list of mammals, we obtained 33 species listed in museum collections, nine of which were found in the Museo de La Plata collection (67 records), and 33 in the GBIF database (2728 records). From the citizen science projects, 22 species were found, 19 in EcoRegistros (58 records), 18 in iNaturalist (107 records), and two in the Red Argentina de Monitoreo de Fauna Atropellada (2 records). On the other hand, 16 species were detected by camera traps and 20 species could be listed from occasional observations (our own observations and those generated by local people).

Of the 85 species of mammals that are reported for the Pampean ecoregion, 75 correspond to native species, 42.7% of which are represented in the Serrano de Tandilia System, while 80% of the 10 invasive species found in the ecoregion are present in the grassland remnants.

Table 1. The mammal species inhabiting the Tandilia Mountains. Common names and conservation status are provided at the global (IUCN) and country (Argentina) levels. Source of records: V: Vouchers in Museums collections; CS: records of citizen science projects; O: Occasional Observations; CT: Camera Trap Record; B: Bibliography; *Indicates exotic species. LC: Least Concern; NT: Near Threatened.

Taxon	Common name	Conservation Status (IUCN Argentina)	Source				
			V	CS	O	CT	B
Order Didelphimorphia							
Family Didelphidae							
<i>Didelphis albiventris</i>	White-eared Opossum	LC LC	♦	♦	♦	♦	♦
<i>Lutreolina crassicaudata</i>	Little Water Opossum	LC LC	♦	♦			
<i>Monodelphis dimidiata</i>	Southern Short-tailed Opossum	LC LC	♦	♦	♦		♦
<i>Thylamys pallidior</i>	Pallid Fat-tailed Opossum	LC LC		♦			♦
Order Cingulata							
Family Clamyphoridae							
<i>Chaetophractus villosus</i>	Large Hairy Armadillo	LC LC	♦	♦	♦	♦	♦
Family Dasypodidae							
<i>Dasypus hybridus</i>	Southern Long-Nosed Armadillo	NT NT	♦	♦	♦	♦	♦
Order Chiroptera							
Family Molossidae							
<i>Tadarida brasiliensis</i>	Brazilian Free-tailed Bat	LC LC	♦	♦			♦
Family Vespertilionidae							
<i>Eptesicus furlinalis</i>	Argentine Brown Bat	LC LC	♦				♦
<i>Histiotus montanus</i>	Small Big-eared Brown Bat	LC LC	♦		♦		♦
<i>Lasiurus blossevillii</i>	Southern Red Bat	LC LC	♦	♦			♦
<i>Lasiurus (cinereus) villosissimus</i>	Hoary Bat	LC LC	♦				♦
<i>Myotis dinellii</i>	Dinelli's Myotis	LC LC					♦
<i>Myotis levis</i>	Yellowish Myotis	LC LC	♦				♦
Order Carnivora							
Family Canidae							
<i>Lycalopex gymnocercus</i>	Pampas Fox	LC LC	♦	♦	♦	♦	♦
Family Felidae							
<i>Leopardus geoffroyi</i>	Geoffroy's Cat	LC LC	♦	♦	♦	♦	♦
<i>Puma concolor</i>	Puma	LC LC	♦	♦	♦	♦	♦
Family Mephitidae							
<i>Conepatus chinga</i>	Molina's Hog-nosed Skunk	LC LC	♦	♦	♦	♦	♦
Family Mustelidae							
<i>Galictis cuja</i>	Lesser Grison	LC LC	♦	♦	♦	♦	♦
Order Cetartiodactyla							
Family Cervidae							
<i>Axis axis</i> *	Chital	LC Not evaluated		♦	♦	♦	♦
<i>Cervus elaphus</i> *	Red Deer	LC Not evaluated					♦
<i>Dama dama</i> *	Fallow Deer	LC Not evaluated		♦	♦	♦	♦
Family Suidae							
<i>Sus scrofa</i> *	Wild Boar	LC Not evaluated	♦	♦		♦	♦
Order Rodentia							
Family Caviidae							
<i>Cavia aperea</i>	Brazilian Guinea Pig	LC LC	♦	♦	♦	♦	♦
<i>Galea leucoblephara</i>	Lowland Yellow-toothed Cavy	LC LC	♦	♦	♦		♦
Family Chinchillidae							
<i>Lagostomus maximus</i>	Plains Viscacha	LC LC	♦	♦	♦	♦	♦

Taxon	Common name	Conservation Status (IUCN Argentina)	Source				
			V	CS	O	CT	B
Family Cricetidae							
<i>Akodon azarae</i>	Azara's Grassland mouse	LC LC	♦	♦		♦	
<i>Calomys laucha</i>	Small Vesper Mouse	LC LC	♦			♦	
<i>Calomys musculus</i>	Drylands Vesper Mouse	LC LC	♦			♦	
<i>Holochilus vulpinus</i>	Crafty Marsh Rat	LC LC	♦			♦	
<i>Necomys lasiurus</i>	Hairy-tailed Bolo mouse	LC LC				♦	
<i>Necomys obscurus</i>	Dark Bolo Mouse	LC NT	♦			♦	
<i>Oligoryzomys flavescens</i>	Yellow Pygmy Rice Rat	LC LC	♦			♦	
<i>Oxymycterus rufus</i>	Rat Roux	LC LC	♦		♦	♦	
<i>Reithrodon auritus</i>	Bunny Rat	LC LC	♦			♦	
Family Hydrochaeridae							
<i>Hydrochoerus hydrochaeris</i>	Capybara	LC LC	♦	♦	♦	♦	
Family Muridae							
<i>Mus musculus</i> *	House Mouse	LC Not evaluated	♦		♦	♦	
<i>Rattus norvegicus</i> *	Brown Rat	LC Not evaluated	♦		♦	♦	
<i>Rattus rattus</i> *	House Rat	LC Not evaluated	♦	♦			
Family Myocastoridae							
<i>Myocastor coypus</i>	Coypu	LC LC	♦	♦	♦	♦	
Order Lagomorpha							
Family Leporidae							
<i>Lepus europaeus</i> *	European Hare	LC Not evaluated	♦	♦	♦	♦	

Discussion

In this work, we present an updated inventory of the mammal species inhabiting the Tandilia Mountains. Approximately half (42.7%) of the mammal species of the Pampas ecoregion currently inhabit the Tandilia Mountains. In the recent past, the highland grassland of these mountains supported a high mammal diversity (Quintana and Mazzanti 2014). Archaeological sites within the Tandilia Mountains have reported *Lama guanicoe*, *Ctenomys talarum* and *Ozotocerus bezoarticus* as frequent mammal species (Quintana and Mazzanti 2014). By the end of the 19th century, *O. bezoarticus* seemed to still be common, and other mammal species, such as *Leopardus colocolo* and *Chrysocyon brachyurus*, which were reported in the Tandilia Mountains (Holmberg 1884), had both become currently absent in the region.

Some species, such as *Puma concolor* and *Hydrochoerus hydrochaeris*, seem to be recolonizing the Pampas grassland (Doumecq Milieu et al. 2012; De Lucca and Chimento 2020). In the case of *P. concolor*, it had been experiencing population decline in the region and was considered extinct in most parts of the Pampas during the 20th century (Cabrera and Yepes 1940). However, over the last decades, the records of *P. concolor* have been increasing, showing a recovery process across the Pampas ecoregion (Chimento and De Lucca 2014; De Lucca and Chimento 2020). In the Tandilia Mountains, records have become more frequent since 2011, and our recent camera trap studies have confirmed its presence in several highland grassland remnants (Chimento and De Lucca 2014). In the case of *H. hydrochaeris*, breeding



Figure 2. Native mammals recorded by camera traps located within highland grassland remnants of the Tandilia Mountains: **A)** Capybara (*Hydrochoerus hydrochaeris*), **B)** Geoffroy's Cat (*Leopardus geoffroyi*), **C)** Pampas Fox (*Lycalopex gymnocercus*), **D)** Melanic Geoffroy's Cat (*Leopardus geoffroyi*), and **E)** Puma (*Puma concolor*).

populations were recently reported in the southern Tandilia Mountains (Doumecq Milieu et al. 2012). These grassland remnants in the Tandilia Mountains could function as corridors and refuges, facilitating the recolonization process of these species in the Pampas ecoregion.

The invasion of alien species is an increasing threat to biodiversity worldwide (Early et al. 2016). The Tandilia Mountains host 80% of the invasive mammal species reported for the Pampas region and most of these are categorized as generating high environmental risk (*Sus scrofa*, *Cervus elaphus*, *Lepus europaeus*, *Rattus norvegicus*, *Rattus rattus*, and *Mus musculus*) (Lizarralde 2016). Some of these species could be threatening native species by intertrophic or intratrophic interactions (Davis 2003). Future studies must evaluate the population size and trend, and the impact on the native biodiversity, of these invasive mammal species.

We did not find specific records in the Tandilia Mountains for three species of bats (*Dasypterus ega*, *Molossus molossus*, and *Eumops patagonicus*), even though the



Figure 3. Exotic mammal species recorded by camera traps in highland grassland remnants of the Tandilia Mountains: **A)** European Hare (*Lepus europaeus*), **B)** Wild Boar (*Sus scrofa*), and **C)** Fallow Deer (*Dama dama*).

Tandilia Mountains are included in these species' distribution maps (Barquez and Díaz 2019, 2020; Díaz and Bárquez 2019; Montani et al. 2019). Thus, we decided to exclude these three bat species from our list. However, we found records for them in nearby localities and thus consider their presence in the region highly probable.

In the case of *Thylamys pallidior*, the last reported ranges did not include the Tandilia Mountains (Parera 2018; Albanese and Martin 2019). However, we found several records for this species in the Tandilia Mountains, including three individuals found in Barn owl pellets (Fernández et al. 2012), one individual collected in 2015, and one photographed in 2015, both in Sierra de Los Padres (Stellatelli and Baladrón 2015; iNaturalist ID 55355680).

We excluded three collected species from our list of mammal species of the Tandilia mountains. Two of these species are far from their native ranges, so we considered them accidental records or records related to the illegal pet trade (Murray et al. 1997; Bisceglia et al. 2019). The specimen of *Herpailurus yagouaroundi*, collected in Tandil in 1924 (MACN-Ma 32.199) could be an accidental or extralimital

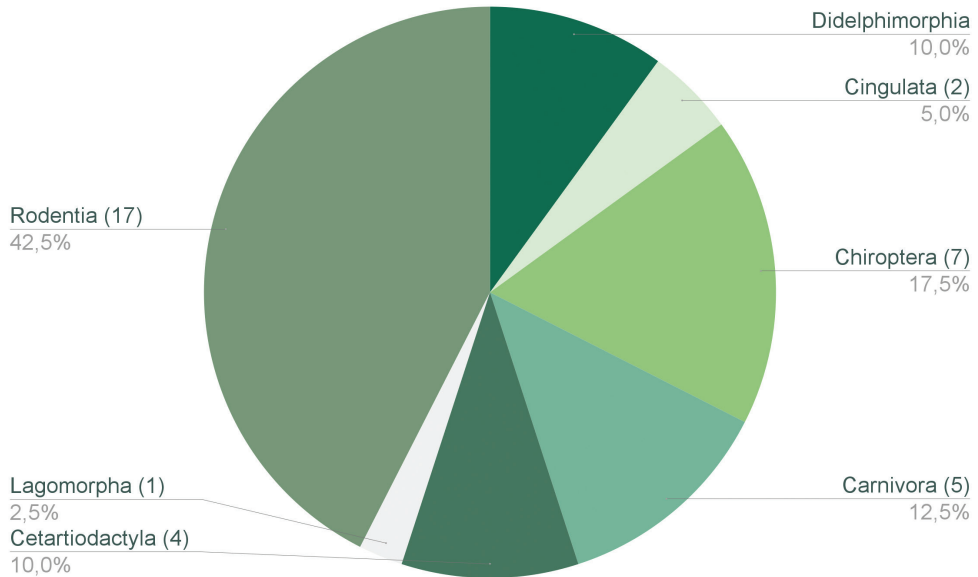


Figure 4. Percentage of mammal species by order reported in the Tandilia Mountains.

record. The origin of one *Leopardus pardalis* collected in Balcarce (MACN-Ma 158-24) could be related to the illegal pet trade. In the case of the third excluded species (i.e., *Myotis chilensis*), we excluded it because the specimen (MACN-Ma 15344) was identified as *Myotis levis* (Velasco et al. 2013).

Regarding the conservation status of mammal species present in the Tandilia Mountains, at least six species are reported to be experiencing population declines. The populations of the Near Threatened *Dasypus hybridus* are declining globally, and its population status is concerning (Abba and Gozalez 2014; Abba et al. 2019). In Argentina, populations of these species have decreased by 25–30% over the last 12 years (Abba et al. 2019). The populations of *Necomys obscurus*, one of the four endemic mammal species of the Pampas ecoregion, are also declining, and the Argentinean Red List included the species as Near Threatened (Libardi and Gómez Villafaña 2019; Roach and Naylor 2019). In addition, four other species are also declining: *Conepatus chinga*, *Oxymycterus rufus*, *Myocastor coypus*, and *Puma concolor* (Nielsen et al. 2015; Emmons et al. 2016; Ojeda et al. 2016; Pardiñas et al. 2016). Unfortunately, only 0.15% of the Tandilia Mountains range is protected (Herrera et al. 2022). Therefore, there is an urgent need to increase the number and range of protected areas and other conservation actions (e.g., habitat restoration) aimed at preserving the last remnants of the highland grassland and its biodiversity.

Of the different methods used to enumerate species records, camera traps recorded the smallest number of species (16 species) compared to the other methods. Camera traps are a useful tool for the detection of medium and large mammals (O'Connell et al. 2011), which limits their use for the detection of species such as

rodents or bats. It should also be considered that camera trap sampling is designed according to the target species, which influences the cameras' detection capacity (O'Connell et al. 2011). In contrast, other methods, such as citizen projects, where the community participates in data collection, can make important and reliable contributions, making them a powerful tool for collecting biodiversity data at large geographic and temporal scales (Allen and Cooper 2006). On the other hand, the data provided by museum collections, of which we list 33 species, are a reliable source of records arising from numerous and diverse studies.

The information gathered contributes to the knowledge of the mammal biodiversity currently inhabiting the highland grasslands of the Tandilia Mountains. The presence of threatened and endemic species and the inclusion of newly reported species for the region highlight the importance of this grassland for conserving Pampean biodiversity.

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Supplementary material 1

List of specimens reported for the Tandilia Mountains

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Data type: List of specimens' occurrences (excel file)

Explanation note: We used several sources of information to compile the list of specimens, including museum collections, citizen science projects (i.e., iNaturalist, EcoRegistros, and Argentinian Network for Monitoring Run Over Fauna), literature, and personal observations.

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