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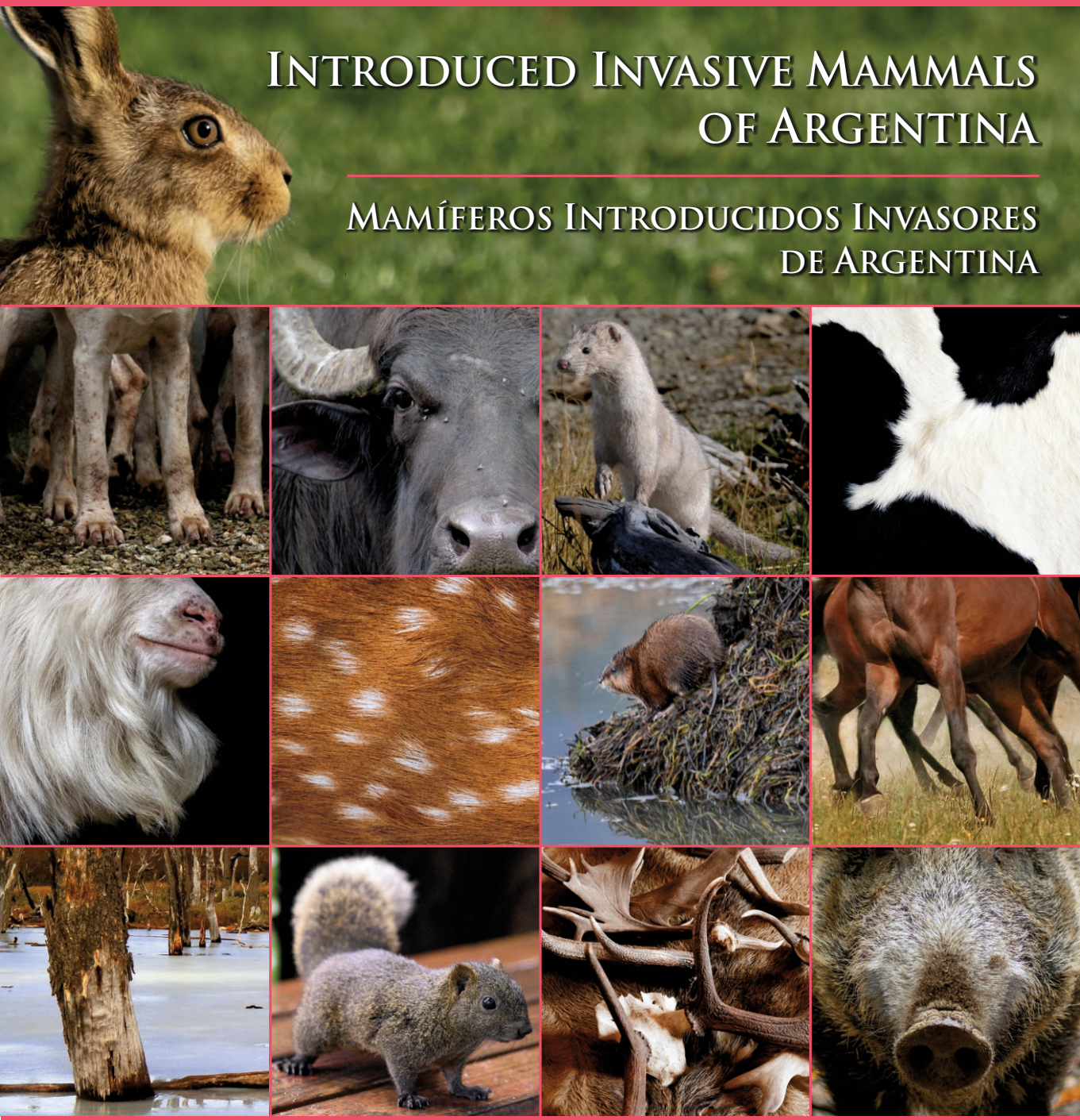
Volume 3

Introduced Invasive Mammals of Argentina

Mamíferos Introducidos Invasores de Argentina



Alejandro E. J. Valenzuela, Christopher B. Anderson, Sebastián A. Ballari and **Ricardo A. Ojeda**, Editors

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Introduced Invasive Mammals of Argentina

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Introduced invasive species are a major driver of local to global environmental change, including important negative impacts on biodiversity, ecosystem processes, economies, health and other social values. At the same time, however, different social actors can hold diverse representations of these species, particularly of introduced invasive mammals (IIMs). Such divergent values and perceptions can lead to conflicts regarding the management of IIMs, but also invite researchers and managers to be reflexive regarding their own work at a more fundamental level. Therefore, it is key that we advance towards a holistic understanding of IIMs and develop strategies to manage them based on solid technical information and plural perspectives regarding their multiple values. Despite a rich history of initiatives in Argentina to study and manage IIMs, until now there has not been an opportunity to assess the state-of-the-art knowledge in our country. This book seeks to provide rigorous, relevant and legitimate information to support research, policymaking and management decisions regarding IIMs in Argentina. With this objective in mind, the book presents a series of chapters selected to highlight priority topics concerning the conceptualization and implementation of IIM research and management. Then, fact sheets are provided for the different IIMs found in Argentina. Finally, beyond the realm of academic inquiry, the timing of this publication is ideal to re-enforce policy and decision-making, such as the recently approved National Invasive Exotic Species Strategy, which seeks to implement actions and enhance institutional capacities related to invasive species management in Argentina, and the Convention on Biological Diversity's new Global Biodiversity Framework, which also addresses biological invasions as part of broader efforts to attain the 2050 Vision for Living in Harmony with Nature.

Dr. Alejandro E.J. Valenzuela
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Editors, Vol. III SAREM Series A

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Foreword

Biological invasions by introduced species are one of the great changes rapidly transforming the globe today, with innumerable impacts on economics, human health, ecosystem services, and biodiversity. Mammals are among the most impactful of invasive species, transmitting diseases to humans, livestock, and native animals, trampling native grasslands, voraciously devouring vegetation from groundcover to saplings of forest trees, fouling water, causing erosion, and preying on and outcompeting native animals. They were among the first species humans introduced worldwide and in Argentina, both deliberately (*e.g.*, livestock) and inadvertently (*e.g.*, rats and mice). They have been introduced for sport (*e.g.*, deer, boar) and companionship (*e.g.*, cats, dogs), or simply as attractive ornamentals (*e.g.*, squirrels). Some that are meant to be kept in captivity, such as cats, dogs, and squirrels, escape and establish feral populations.

Argentina looms large in the history of biological invasions by introduced mammals. The earliest permanent European settlers of Buenos Aires in 1580 discovered huge herds of feral horses already on the pampas, and soon after, Vázquez de Espinoza described feral horses in Tucumán that were "in such numbers that they cover the face of the earth…". Many sheep were in Tucumán as well at that time, and of course later sheep were enormously numerous in Patagonia, effecting huge changes in the vegetation and driving land degradation and desertification to this day. When Charles Darwin visited the La Plata region in 1832 during the voyage of the Beagle, he reported that "…countless herds of horses, cattle, and sheep, not only have altered the whole aspect of the vegetation, but they have almost banished the guanaco, deer and ostrich. Numberless other changes must likewise have taken place; the wild pig in some parts probably replaces the peccari; packs of wild dogs may be heard howling on the wooded banks of the less-frequented streams; and the common cat, altered into a large and fierce animal, inhabits rocky hills."

Approximately 40 mammals have been introduced to South America, of which 25–30 have established populations; most of these are in the Southern Cone. In Argentina, I count 23 successfully introduced mammal species, including feral cats, dogs, and cows. Many, such as rats, rabbits, boar, and goats, are widely distributed around the world. By contrast, the hairy armadillo has been introduced nowhere else but from the mainland of Patagonia to Tierra del Fuego Island. Strikingly, except for the rats and house mouse, all these mammals were brought to Argentina deliberately; this is very different from, say, introduced insects. A few of these invasive mammals, like the squirrel, were not intended to be released, but I hesitate to term such invaders truly "accidental," because the people who brought them should have realized that escapes or later releases were almost inevitable. Of course, almost all of these mammals were introduced before the late twentieth century, which was when most scientists and the public began to recognize the extent and importance of impacts of introduced species. However, the squirrel and armadillo introductions were recent enough that potential impacts should have been foreseen. Things could be worse, of course—mammals deliberately brought to Argentina that either were released, but did not establish persistent populations or have not yet escaped from hunting preserves include reindeer, silver fox, mule deer, African buffalo, white-tailed deer, Père David's deer, thar, barbary sheep, wisent, mouflon, chamois, and ibex.

The technology of eradicating introduced invasive mammals has made enormous strides in the last thirty years—at least 31 mammal species have been eradicated from islands worldwide, including relatively large islands like South Georgia. Both Norway and ship rats have been eradicated hundreds of times, and house mice about 100 times. Most large mammals, such as deer and horses, are technologically easier eradication targets—many can simply be tracked and shot, for instance. However, mammals more than any other introduced species pose the complication that many people—especially hunters—simply do not want to eradicate them, and many animal welfare advocates, even those recognizing the damage some invaders cause, object to eradicating them by the only currently feasible means—killing them, humanely if possible. Even rat eradication has been impeded on animal rights/animal welfare grounds, and free-ranging dog and cat populations frequently are seen more as animal welfare issues than as conservation problems to broad sectors of some societies. In Argentina, the problem of implementing feasible eradication programs for invasive mammals is epitomized by the rather schizophrenic attitude taken by the National Parks Administration (Administración de Parques Nacionales – APN) towards red deer. The APN's conservation imperative is supported by the section of Law #22,351 that forbids propagating introduced animals, yet red deer, known to damage native species and ecosystems, are managed in Lanín National Park to foster ongoing hunting, and even to improve the size and quality of the deer for better hunting trophies. Additionally, there is often inconsistent and inadequate funding for managing and eradicating invasive mammals in protected areas, almost always constituting a supervening impediment even when a rational and effective goal is stated.

Argentine scientists have participated heavily in the rapid growth of modern invasion science since its inception in the 1980s, and they and overseas colleagues have conducted substantial research on the biology and impacts of many of the introduced invasive mammals in Argentina, as well as other invasive species. Some of the threats posed by these mammals have even become widely known to the general public in Argentina and beyond—the spread of the beaver from Tierra del Fuego to the mainland has been an international news story. *Introduced Invasive Mammals of Argentina* is therefore an exciting and timely addition to the literature on invasions in southern South America for both the Argentine public (and its political representatives and environmental managers) and scientists worldwide. The many authors assembled for this book explore how these biological invasions happened in the first place, how they spread, what they do to biodiversity, ecosystems, and human enterprises, what has been done about them so far, what can be done about them now, and what might be done with them in the future. The editors and authors are to be congratulated for an excellent exposition of the Argentine part of a growing global phenomenon.

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Callosciurus erythraeus
Pallas's squirrel, ardilla de vientre rojo

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Resumen. La ardilla de vientre rojo, *Callosciurus erythraeus* (Pallas, 1778), es una ardilla arborícola y diurna originaria del sudeste Asiático que fue introducida en varios países de Europa, en Japón y en Argentina, logrando establecerse exitosamente. En Argentina fue introducida en la localidad de Jáuregui, partido de Luján, provincia de Buenos Aires en 1970 y hasta el momento se han registrado 28 eventos independientes de escapes o liberaciones de individuos, dando lugar a la presencia de ardillas en al menos 20 partidos o departamentos en las provincias de Buenos Aires, Santa Fe, Córdoba, Mendoza y en la Ciudad Autónoma de Buenos Aires (CABA). El traslado mediado por el ser humano debido a su atractivo ornamental y como mascota es la principal causa del origen de nuevos focos. Habita ambientes arbolados continuos o fragmentados, en zonas rurales, semiurbanas, residenciales y urbanas. Consume principalmente frutos, semillas y hojas de árboles y arbustos y construye nidos en los árboles usando hojas, ramas y corteza. El mayor daño registrado en Argentina es el descortezamiento de árboles, ya sea en plantaciones comerciales, ornamentales, en parques urbanos o en propiedades privadas, junto con los daños ocasionados en distinto tipo de infraestructuras, en el tendido eléctrico, en el cableado telefónico y en sistemas de riego. En relación a la salud pública y animal, esta especie es portadora renal de la bacteria *Leptospira interrogans* y posee parásitos adquiridos en el nuevo ambiente. Hasta el momento no existen planes sistemáticos orientados al control de las poblaciones, si bien se ha realizado un piloto de control en la población del foco de Cañada de Gómez, provincia de Santa Fe, que permitió disminuir su abundancia, y recientemente, se ha llevado a cabo un plan de control en una estancia privada en el foco de Tupungato, Mendoza. Existe un avance en lo que se refiere a las normativas orientadas a regular la captura, tenencia, traslado, comercialización y control de esta especie a nivel Nacional, Provincial y Municipal, pero es necesario seguir trabajando para generar nuevas normativas y asegurarse que las normativas ya existentes sean cumplidas.

General description of the species

General characters

Callosciurus erythraeus is a medium-sized diurnal tree squirrel (Fig. 1). It is native to southeast Asia, and it has been introduced in Argentina, as well as in France, Belgium, Japan, Hong Kong, Italy and the Netherlands (Lurz *et al.*, 2013). It inhabits different types of both continuous and fragmented arboreal habitats in natural and human-made forested patches. In Argentina, it occurs mainly in rural, urban, suburban and residential areas, including within or near protected areas, urban parks and commercial plantations for wood and fruit production (Guichón and Doncaster, 2008; Benitez *et al.*, 2013; Hertzriken, 2021).

Figure 1. Adult of *Callosciurus erythraeus* in Buenos Aires province, Argentina. (Photo: Marina Hertzriken).

Body measurements obtained in Argentina are smaller than those reported in other countries. The range of adult weight of individuals measured in the main invasion focus (Luján, Buenos Aires province) is 262–270 g (Cassini and Guichón, 2009; Benitez, 2017), while in Taiwan and Japan adults reach 309–467 g (Yo *et al.*, 1992; Chakraborty, 1985; Tamura and Tereauchi, 1994). The mean total length of 32 specimens captured in Luján was 388.5 ± 24.8 mm (Cassini and Guichón, 2009).

This species has an agouti dorsal pelage (described as olive brown to grayish olive) and a black dorsal strip that can be present or absent (Cassini and Guichón, 2009). Ventral pelage varies from an intense red—which is the typical coloration—to a yellowish/orange color, giving different color patterns: from red bellies with yellowish/orange areas in some ventral parts (armpits, groin and chest) or yellowish/orange bellies with other ventral areas more reddish (Cassini and Guichón, 2009). The face from the nose up to the base of the ears is golden orange.

Diet

C. erythraeus in Argentina eats mainly fruits, seeds and leaves. Fruits and seeds represented the bulk of the diet in all seasons (feces analysis: >44%; behavioral observations: >38%) in two invasion foci studied in Argentina (Zarco *et al.*, 2018). Squirrels also consume epiphytic and climbing plants, flowers, bark, ferns, invertebrates, fungi, lichens, mosses and bird eggs in lesser proportions (Lurz *et al.*, 2013; Zarco *et al.*, 2018). Although squirrels feed on several tree and shrub species, only six species dominated their diet: *Cupressus* sp., *Cotoneaster* sp., *Pyracantha* sp., *Ligustrum lucidum*, and *Melia azederach* (Zarco *et al.*, 2018). Bark consumption was recorded from feces analyses throughout the year and included the genus *Cedrus*, *Cupressus*, *Eucalyptus*, *Fraxinus*, *Ligustrum*, *Melia*, *Morus*, *Pinus*, *Platanus*, *Polylepis*, *Prunus*, and *Robinia* (Zarco *et al.*, 2018). The consumption of flowers, seeds and fruits recorded in Argentina is similar to the diet composition described in its native range and in other countries where it has been introduced, such as Japan (Setoguchi, 1990; Lurz *et al.*, 2013). Diet composition varies throughout the year and among sites according to food availability (Lurz *et al.*, 2013; Zarco *et al.*, 2018).

Reproduction and population characteristics

Squirrels reproduce throughout the year in Luján, where reproductively active females, immature individuals and a high proportion of mature males can be found in every season (Benitez, 2017). Squirrels build nests in trees using bark and leaves to raise their offspring (Fig. 2). Preliminary results indicated an annual survival rate of 0.37–0.58 (Benitez, 2017), and a seasonal survival rate similar to those described in other introduced ranges, but higher than in their native range (Benitez, 2017). The lowest survival rates were found in winter, and there were no differences between males and females (Benitez, 2017).

Males have larger home ranges than females (Tamura *et al.*, 1987; Dozières *et al.*, 2015). Mean home range in Luján was 0.38 ha for females (n=12), almost an order of magnitude smaller than that of males (3.29 ha, n=3) (Benitez, 2017). These home ranges are smaller than those reported in other countries, where this species has been introduced, such as Japan (females: 0.48–0.72 ha) and France (females: 2.4–4.3 ha) (Tamura *et al.* 1987, 1988; Dozières *et al.*, 2015; Benitez, 2017).

Diseases and parasites

In Argentina, *C. erythraeus* has not been found to host novel parasites, but has acquired parasites from the recipient community (Gozzi *et al.*, 2013a, 2014). Ectoparasites

Figure 2. Nest of *Callosciurus erythraeus* covered by leaves. (Photo: Borja Baguette Pereiro).

include the flea *Polygenis* (*Polygenis*) *rimatus*, the mites *Androlaelaps fahrenholzi* and *Ornithonyssus* cf. *bacoti*, and the botfly *Cuterebra* sp. Mites of the genus *Cheyletus* that are not considered parasites were also found (Gozzi *et al.*, 2013a). Endoparasites were represented by nematodes of the genus *Stylestrongylus* and *Pterygodermatites* (Gozzi *et al.*, 2014). Regarding zoonotic diseases, *C. erythraeus* was found to be a renal carrier of *Leptospira interrogans* (samples obtained in Cañada de Gómez, Santa Fe province) and could be involved in the epidemiology of leptospirosis (Gozzi *et al.*, 2013b). In addition, feces and serum of squirrels from the main invasion foci were studied for detection of *Salmonella* spp. and *Toxoplasma gondii* respectively, finding negative results (Gozzi, 2015).

In its native range *C. erythraeus* is host of different ectoparasite and endoparasite species. In France, Belgium and Italy, where it has been introduced, this species harbors parasites acquired locally, but also species that have been introduced into the new environment with the founder squirrels (Asakawa, 2005; Sato *et al.*, 2007; Shinozaki *et al.*, 2004; Dozières *et al.*, 2010; Lurz *et al.*, 2013; Mazzamuto *et al.*, 2016; Eguchi *et al.*, 2022).

Genetics

A genetic study conducted in Argentina supported the hypothesis of a single introduction event, followed by subsequent translocations within the country (Gabrielli *et al.*, 2014; Guichón *et al.*, 2015). The genetic characterization of sequences from squirrels captured in Argentina was related to *Callosciurus finlaysonii* according to D-loop and Cytochrome b mitochondrial markers (Gabrielli *et al.*, 2014). Anyway, due to the intraspecific variation among sequences of *Callosciurus* belonging to different subspecies or collected from different regions, further research taking into account diagnostic morphological

characters and genetic markers are needed to elucidate the complex taxonomy of the genus *Callosciurus* and the phylogeny of *C. erythraeus* and *C. finlaynsonii* (Gabrielli *et al.*, 2014).

History of the invasion

C. erythraeus was intentionally introduced into Argentina in 1970 in the locality of Jáuregui, Luján district, Buenos Aires province (Aprile and Chicco, 1999). The introduced squirrels were obtained from a pet shop in the Netherlands and taken to a ranch near the town of Jáuregui for ornamental purposes by an European family longing for squirrels. Then, by 1973 about five out of the 10 individuals introduced had been released or escaped from the cage and originated the first wild population of this species in Argentina (Aprile and Chicco, 1999; Guichón *et al.*, 2005). Since then, this original wild population has expanded (Guichón and Doncaster, 2008) and intentional human transport and release have given rise to several other invasion foci (Benitez *et al.*, 2013; Borgnia *et al.*, 2013, 2019; Guichón *et al.*, 2015, 2020).

Patterns of expansion and current distribution

C. erythraeus inhabits natural, urban and rural environments in association with the presence of trees; both the establishment and the natural spread of this species are favored by the presence of arboreal patches. Squirrels can use fragmented woodland patches, such as tree lines along roads and railways, as well as arboreal patches in parks in urban and residential areas both for its establishment and its expansion (Guichón *et al.*, 2005; Benitez *et al.*, 2013). For example, the presence of riparian vegetation along the Luján River favored its dispersal and resulted in a concentric expansion from the original release site (Guichón and Doncaster, 2008; Benitez *et al.*, 2013). This species uses suitable arboreal habitats that offer food and nesting resources for their establishment and avoid open habitat. In highly fragmented urban-rural landscapes, they also use cables, roofs and wire fences, among other human-made pathways, to reach suitable habitat. To date, 28 independent escape or release events of *C. erythraeus* (including the original introduction of the species) have been recorded in Argentina (see Guichón *et al.*, this volume). At present, this species is found in more than 20 districts or departments in the autonomous city of Buenos Aires (CABA) and four provinces: Buenos Aires, Córdoba, Santa Fe and Mendoza (Coniglione and Zalba, 2018; Guichón *et al.*, 2020) (Fig. 3, Tab. 1). Buenos Aires province has the largest area occupied by squirrels (> 180,000 ha), with the main invasion focus (Luján) encompassing several districts (Table 1). The number of released or escaped squirrels in each recorded event varies from two to 30 individuals (Table 1). Squirrel density in the main invasion focus is higher than recorded in its native range and in other sites where it has been introduced, although low and intermediate densities were recorded in other foci initiated more recently (Benitez *et al.*, 2013) (Table 1). The main reason that led to the introduction of this species is related to its charisma and attractive appeal to humans, who release individuals in parks and ranches to enrich wildlife and for ornamental purposes, and in some cases to keep (temporarily) as a pet (Benitez *et al.*, 2013; Borgnia *et al.*, 2013; Guichón *et al.*, 2015).

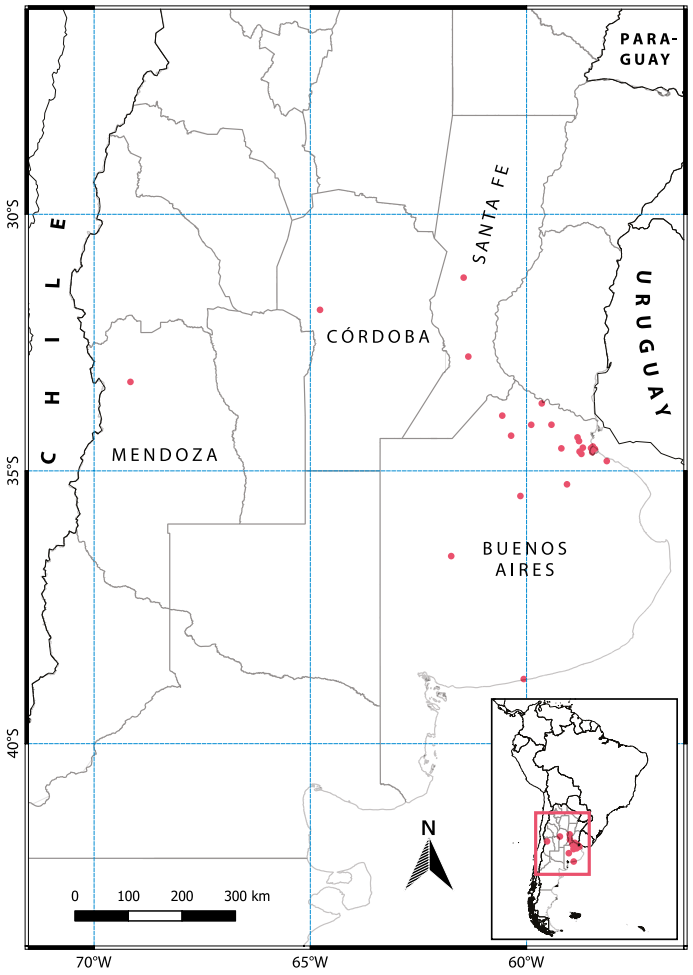

Figure 3. Distribution of *Callosciurus erythraeus* in Argentina showing the sites that represent independent releases/escapes in Argentina. Modified from Guichón *et al*. (2019). (Mapping: Alfredo Claverie and Ian Barbe).

Impacts

C. erythraeus causes different changes and damage to natural and productive systems (Fig. 4). Debarking of commercial plantations and ornamental trees is among the most widespread impacts reported (Bertolino and Lurz, 2013; Lurz *et al.*, 2013). In Argentina, this squirrel species damages a large number of tree species by debarking, many of which are of economic importance, such as *Eucalyptus dunni* and *Pinus elliotti* (Pedreira *et al.*, 2017; 2020). The damage to urban services, such as gnawing cables used for lighting, telephone and television (see Fig. 4), was also reported, and the consumption of grains in storage silos and damage to irrigation systems have been recorded in suburban and rural environments (Guichón *et al.*, 2005). Damage to natural systems involves potential modification of plant reproduction due to the consumption of flowers, fruits and seeds, and the dispersal

Table 1. List of sites where independent release or escape events of *Callosciurus erythraeus* have been recorded in Argentina. We indicate the year of introduction or date of the first observation of squirrels in the area, the invaded area (year of estimation), spread rate since liberation, relative abundance [95% confidence interval] (year of estimation), and estimated relative density [95% confidence interval]. Arrecifes and Capitán Sarmiento are considered a single invasion focus resultant from two independent releases (Source: Benitez *et al.*, 2013; Guichón *et al.*, 2015; Coniglione and Zalba, 2018; Guichón *et al.*, 2020; Borgnia *et al.*, 2019).

Release/escape site	Year	Number of squirrels released/ escaped	Invaded area (km²)	Districts/ Departments per province included in the invaded area	Spread rate (km/year)	Relative abundance (squirrel/point)	Relative density (squirrel/ha)
Luján[1]	1973	25	1336 (2009)	Luján, Mercedes, San Andrés de Giles, Exaltación de la Cruz, Pilar, Gral. Rodríguez	0.61	1.89 [1.58–2.24] (2007)	15.3 [12.0–19.5]
Escobar[1]	1995	Unknown	34 (2008)	Escobar	0.39	0.41 [0.22–0.69] (2008)	3.23 [1.72–5.53]
Arrecifes[1]	1995	30	317 (2014)	Arrecifes	0.53	1.90 [0.6–3.0] (2014)	14.8 [4.5–23.8]
25 de Mayo[1]	1997	Unknown	122 (2012)	25 de Mayo	0.66	0.90 [0.5–1.2] (2012)	6.7 [3.9–9.4]
Cañada de Gómez[2]	1999	8	33 (2009)	Iriondo	0.44	0.61 [0.31–1.09] (2009)	4.86 [2.43–8.70]
La Cumbrecita[3]	2000	30	0.42 (2010)	Calamuchita	0.05	0.42 [0.18–0.83] (2010)	3.35 [1.45–6.60]
Capitán Sarmiento[1]	2001	2	*See Arrecifes*	Capitán Sarmiento	*See Arrecifes*	0.90 [0.5–1.5] (2014)	7.3 [3.9–12.2]
Lobos[1]	2002	2	6 (2017)	Lobos	0.18	–	–
Plaza San Martín[4]	2004[a]	Unknown	Not established	*	–	–	–
Fac. Agronomía UBA[4]	2005[a]	Unknown	Not established	*	–	–	–
Salto[1]	2005[a]	4	16 (2014)	Salto	0.41	0.30 [0.1–0.8] (2014)	2.3 [0.5–6.3]
San Miguel[1]	2007[a]	Unknown	7 (2012)	San Miguel	0.53	0.60 [0.2–1.3] (2012)	4.9 [1.9–10.2]
Parque Gral. Paz[4]	2007	Unknown	–	*	–	–	–
Rafaela[2]	2008	20	3 (2014)	Castellanos	0.33	0.80 [0.5–1.5] (2014)	6.2 [3.6–11.6]
Parque Avellaneda[4]	2010[a]	Unknown	–	*	–	–	–
Del Viso[1]	2011[a]	Unknown	–	Pilar	–	–	–
Claromecó[1]	2011[a]	–	–	Tres Arroyos	–	–	–
Tupungato[5]	2011	10	–	Tupungato	–	–	–
Daireaux[1]	2012	Unknown	0.2 (2014)	Daireaux	0.12	–	–
Moreno[1]	2013[a]	–	–	Moreno	–	–	–
San Pedro[1]	2013[a]	Unknown	–	San Pedro	–	–	–
San Cristóbal[4]	2014[a]	Unknown	Not established	*	–	–	–
Merlo[1]	2015[a]	Unknown	0.12 (2018)	Merlo	–	–	–
Villa Lía[1]	2015[a]	–	–	San Antonio de Areco	–	–	–
Botánico Thays[4]	2015[a]	–	–	*	–	–	–
Berazategui[1]	2016[a]	–	–	Berazategui	–	–	–
EMyDDHH[4,A]	2017[a]	–	–	*	–	–	–
Pergamino[1]	2018[a]	–	–	Pergamino	–	–	–

[a] Provisional data corresponding to the first observation of squirrels in the area; * sites belonging to Ciudad Autónoma de Buenos Aires (CABA); – insufficient data/under study. [A] Espacio de la memoria y de los Derechos Humanos (ex ESMA), [1] Buenos Aires province, [2] Santa Fe province, [3] Córdoba province, [4] CABA, [5] Mendoza province.

Figure 4. a. Damage caused by *Callosciurus erythraeus* on a tree by debarking; **b.** a squirrel with a ball of bark in its mouth; **c-d.** fruits (orange and nuts) damaged by squirrels; **e-f.** gnawed cables and irrigation hoses. (Photos: Adrián Gorrindo, Mariela Borgnia).

of introduced species (Bobadilla *et al.*, 2016; Zarco *et al.*, 2018). These squirrels also could decrease native bird abundance and richness although more studies are needed (Pereira *et al.*, 2003; Messetta *et al.*, 2005). The species close proximity to protected areas, such as the Parque Nacional Ciervo de los Pantanos which offers suitable habitat conditions for this squirrel, must raise an alert of conservation concern because its spread may threaten sensitive native species protected in this reserve.

As mentioned above, we found that *C. erythraeus* is a renal carrier of *Leptospira interrogans*. So, it might be involved in the epidemiology of the transmission of leptospirosis. Studies about the zoonotic potential of this species in its native range and in other introduced areas is still scarce; therefore, more studies would provide new insight into the role of this species as a reservoir of zoonotic pathogens.

Finally, a cultural impact of squirrels should also be considered since *C. erythraeus* is a charismatic species, which can lead to local communities undervaluing native fauna and even changing their cultural identity (Borgnia *et al.*, 2103). For example, in the original introduction site (Jáuregui, Luján, Buenos Aires province) this introduced and invasive squirrel species has become a local icon.

Management

In Argentina, systematic control programs for this species are mainly isolated and driven by independent actions of local producers to temporarily reduce squirrel numbers on their properties to mitigate squirrel damage. As an example, control actions using live-trapping and euthanasia were conducted in a private ranch located in Cañada de Gómez, Santa Fe province in 2010 (Benitez, 2017). Both the capture success and time-area counts, the two estimators of population density employed, showed that the number of individuals decreased due to control actions conducted in a six-month period (Fig. 5).

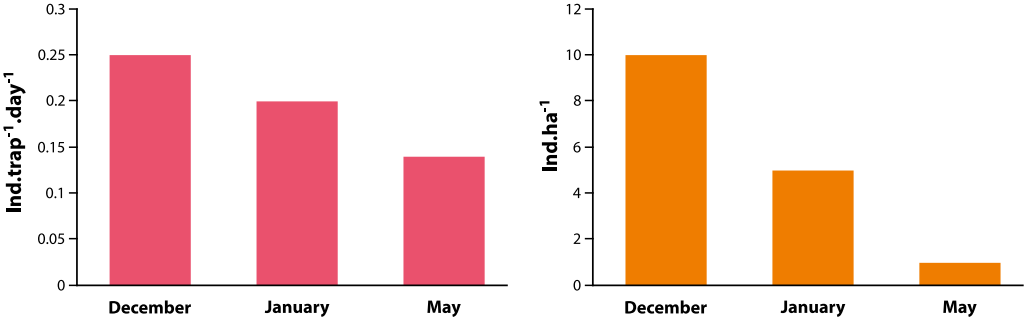

Figure 5. Reduction of squirrel population density based on capture success (**left**) and time-area counts (**right**) during a pilot control plan conducted in December 2009, January 2010 and May 2010 in Cañada de Gómez, Santa Fe province. Trapping effort: 22.5 traps/day (16 days). Squirrels captured: 72.

Recently, control actions organized by the Mendoza provincial government in coordination with national and local authorities were implemented in a private farm in the locality of Tupungato (DRNR, 2021; Benitez, V., unpublished data; Guichón *et al.*, this volume).

Regarding the legal framework, the GEF project entitled "Strengthening Governance for the Protection of Biodiversity through the Formulation and Implementation of the National Invasive Exotic Species Strategy" (GCP/ARG/023/GFF), coordinated by the national ministry of environment (Ministerio de Ambiente y Desarrollo Sostenible) in association with the UN's Food and Agriculture Organization, has recently come into force. This program intends to integrate various actions related to the problem associated with the invasion of this squirrel and other introduced species in the country. At a national level, the red bellied squirrel was recently categorized as a restricted and required control species (Resolution #109/2021, Ministerio de Ambiente y Desarrollo Sostenible). In the province of Buenos Aires, the Rural Code includes *C. erythraeus* in the category of "harmful" or "injurious" species that can be hunted with poison (Decree #2018-279 GDEBA GPBA). To date, there are three Municipality Ordinances in Buenos Aires province that include the prevention of the expansion of this species: Luján (#5996/11), Capitán Sarmiento (#2125/13), and Daireaux (#2262/18).

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