Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The ecological role of the European rabbit in the Magellanic/Fuegian ecosystem of southernmost Chile

Francisca Mann-Vollrath
Pontificia Universidad Católica de Chile
Jennifer Paola Correa-Cuadros (jpcorrea4@uc.cl)
Pontificia Universidad Católica de Chile
María Isidora Ávila-Thieme
Instituto Milenio en Socio-Ecología Costera (SECOS)
Melanie Duclos
Center of Applied Ecology and Sustainability (CAPES)
Fabian M. Jaksic
Pontificia Universidad Católica de Chile

Research Article

Keywords: Community effect, food web, Magallanes, Oryctolagus cuniculus, Patagonia, prey shift.

Posted Date: July 17th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3159014/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

The ecological role of the European rabbit in the Magellanic/Fuegian ecosystem of southernmost Chile

Francisca Mann-Vollrath[1, 2], Jennifer Paola Correa-Cuadros[1, 2]; María Isidora Ávila-Thieme[1, 3, 4], Melanie Duclos[2, 5], Fabian M. Jaksic[1, 2]

[1]Pontificia Universidad Católica de Chile, Facultad de Ciencias Biológicas, Departamento de Ecología, Chile; [2]Center of Applied Ecology and Sustainability (CAPES), Chile; [3]Instituto Milenio en Socio-Ecología Costera (SECOS), Chile; [4]Advanced Conservation Strategies (ACS), United States of America; [5]Centro de Investigación para la Sustentabilidad (CIS-UNAB), Chile

Corresponding author: Jennifer Paola Correa-Cuadros

Email: jpcorrea4@uc.cl

Abstract

The European rabbit has invaded numerous ecosystems around the world, but rarely steppes. We studied the food web in the Magallanes region of southernmost Chile, where the rabbit is now a key player, interacting with species at different trophic levels. Because the rabbit is currently well embedded in the Magellanic/Fuegian ecosystem, especially in the steppe, any changes in its local abundance can spread out through trophic interactions and generate unwanted impacts in the regional food web. We used a multi-species trophic network approach and built the food web of the Magellanic/Fuegian steppe based on the rabbit interspecific relationships through a bibliographic review. We evaluated its topological properties and performed a species extinction analysis to assess the relative importance of the rabbit. The network has 222 nodes (64% native, 12% exotic, and 23% mixed), 576 links, and a connectance of 0.011. The rabbit was the most connected node of the network, had the second largest dietary breadth, and was the sixth with the highest number of predatory species. Our results suggest that rabbit control could trigger several ecological impacts on other regional species, such as releasing herbivory pressure on plants of various genera. In addition, by reducing or removing a staple prey resource for predators, they may decrease their abundance or change their diet to alternative prey, generating unexpected effects. The multi-species network approach could be a complementary tool to apply a more holistic management of the rabbit, which would allow the identification of non-target species that should be monitored when control is being applied, and thereby generate early warnings against unwanted impacts.

Keywords

Community effect, food web, Magallanes, *Oryctolagus cuniculus*, Patagonia, prey shift.

Introduction

The European rabbit (*Oryctolagus cuniculus*) is a native of the Iberian Peninsula (and perhaps also northern Africa), which has been translocated almost everywhere in the world since the times of the Roman Empire (Lever 1985, Long 2003). The first record of rabbit introduction to America –specifically to Isabela Island, now Santo Domingo-- dates back to November 1493 (Rabadá 2008). Although currently it is classified as an endangered species in its native lands (Smith and Boyer 2007, Lees and Bell 2008), it has become one of the most damaging invasive species in the world (Lowe et al. 2000). The first reference to rabbits in central Chile was by Ignacio Molina in 1788 (Camus et al. 2008), but Delibes and Delibes-Mateos (2015) provided an earlier date: 1765 in Tierra del Fuego Island, in the extreme south of the country, now shared by Argentina and Chile. The fate of these latter rabbits seems to have been extinction. Considering only Chile, currently the rabbit occupies ca. 8.9 million hectares (PNUD 2017) and has a discontinuous distribution from the Antofagasta to the Araucanía Regions, and then from Aysén to Magallanes Regions (Jaksic et al. 2002; Camus et al. 2008; Correa-Cuadros et al. 2022, 2023).

In the Magallanes Region, which extends from the Pacific Ocean east across the Strait of Magellan and halfway to Tierra del Fuego Island (Molina 2011, ODEPA 2021), the introduction of rabbits was attempted several times from 1873-74 to 1913, but none of these introductions bore fruit, and it was that of 1936 which generated the rabbit outbreak of 1950-52 (Arentsen 1954; Correa-Cuadros et al. 2022, 2023). Once well established, its population grew rapidly due to the rabbits' high reproductive capacity, and because their potential predators did not feed on them while simultaneously being hunted for their skins (Arentsen 1954; Pisano 1985; Correa-Cuadros et al. 2022, 2023). Subsequently, the high rabbit population in Magallanes Region generated an economic income for their meat and skins (Iriarte and Jaksic 1986, Iriarte et al. 1997, Camus et al. 2008), but also had serious consequences for ranchers, by competing for food with sheep and transforming grasslands into wastelands (Pisano 1985; Camus et al. 2008; Correa-Cuadros et al. 2022, 2023). This led various control efforts, the most effective being that of 1953, when the myxoma virus was introduced to Tierra del Fuego Island (Arentsen 1954; Berríos 2005; Correa-Cuadros et al. 2022, 2023) which --although reducing the rabbit population by 99% (Jaksic and Yáñez 1983; Correa-Cuadros et al. 2022, 2023)-- it failed to eradicate it. The individuals that survived possibly developed viral resistance (Berríos 2005) and today rabbits are still found in both continental and insular areas of the Magallanes Region (Correa-Cuadros et al. 2022, 2023).

The rabbit in Chile is considered an invasive species that causes significant damage: Economically speaking, it generates a loss of 3.25 million US dollars per year (PNUD 2017, MMA 2017). Ecologically speaking, it causes numerous effects at the population, community, and ecosystem levels, summarized by Correa-Cuadros et al. (2022, 2023). The long history of rabbit invasion means that it has become an integral part of the Magellanic/Fuegian ecosystem, interacting with species at different trophic levels, simultaneously being prey, competitor, and herbivore (Correa-Cuadros et al. 2022, 2023). Rabbits in continental Magallanes and neighboring Tierra del Fuego Island consume plant biomass and generate important negative impacts on its abundance (Amaya and Bonino 1981, Bonino and Soriguer 2009, Huertas-Herrera et al. 2022). They feed on seedlings of various native shrubs and trees (e.g., *Berberis* and *Nothofagus*) and non-native herbs (e.g., *Poa* and *Vicia*), thus affecting their regeneration (Amaya and Bonino 1981, Bonino and Soriguer 2009, Huertas-Herrera et al. 2022). Plants that are not consumed by rabbits spread and generate changes in the botanical composition of the ecosystem (Bonino 2006, Bonino and Soriguer 2009). In addition, rabbit burrows increase soil erosion (Silva and Saavedra 2008; Correa-Cuadros et al. 2022, 2023). Rabbits also have negative impacts on sheep production by consuming the forage available for livestock, thus reducing the output of meat and wool for export (Bonino 2006; Bonino and Soriguer 2009; Correa-Cuadros et al. 2022, 2023). They also compete with native mammals for food and habitat, but favor the population increase of predators and scavengers by being a subsidy of abundant prey (Lambertucci et al. 2009, Barbar et al. 2016, Barbar and Lambertucci 2018). Among several other Magellanic/Fuegian predators, the puma (*Puma concolor*), *Lycalopex* foxes, *Leopardus* cats, and the Buzzard eagle (*Geranoaetus melanoleucus*) incorporate rabbits as staple prey to their diet (Jaksic et al. 1983, Zurita et al. 2023). Also, facultative and carrion eaters such as the caracaras *Caracara plancus* and *Milvago chimango*, and the Andean condor (*Vultur gryphus*) benefit from their presence (Duclos et al. 2020). Thus, the rabbit has become a novel and staple prey resource of the regional food web.

Because the rabbit is now embedded in the Magellanic/Fuegian steppe ecosystem and interacts with multiple species, a change in its abundance can spread out through trophic interactions and generate unexpected effects or unwanted impacts in the regional food web. This may be of concern because the Magallanes Region hosts several endangered native species (Molina 2011, Salinas 2016, ODEPA 2021). Therefore, it seems necessary to gain a better understanding of the role that the rabbit plays in the regional ecosystem, especially in the face of attempts at controling it. One way to study this is through a multi-species food web approach (De Ruiter et al. 2005). Food webs describe predator-prey relationships within a community (Pimm et al. 1991, Dunne 2009) and these networks help capture the complexity of an ecosystem and allow to understand how a given disturbance (e.g., rabbit introduction, outbreak, or eradication) spreads and affects the presence and abundance of other members of the local community or food web (Abrams et al. 1996, Yodzis 1988, Dunne et al. 2002a, Dunne 2009, Smith-Ramesh et al. 2016, Ávila-Thieme et al. 2023). In addition, a multi-species approach is a complementary tool to develop a more holistic management of the rabbit, identifying the non-target species that should be monitored when and if control is applied, and thereby generate early warnings against potential unwanted impacts. To carry out this approach, a rabbit-centered food web was built for the Magellanic/Fuegian steppe ecosystem to assess its relative importance and ecological role.

Materials and methods

Study site

The Magallanes Region is centered at ca. 53°S and 71°W (ranges 48°40'-56°00'S and 66°30'-75°40'W) and comprises 132,297 km^2 excluding the Antarctic territory (ODEPA 2021). The corresponding adjective is Magellanic (see also Molina 2011). Geographically speaking, there is a continental portion, separated from an extensive archipelago by the Strait of Magellan. The largest island of that archipelago is Tierra del Fuego Island (Isla Grande de Tierra del Fuego, in Spanish), situated within a polygon ca. 52-55°S and 65-72°W. This large island (ca. 48,000 km^2) is split east-west between Argentina and Chile (40:60), respectively, at meridian 68°34'W. The corresponding adjective is Fuegian. The surrounding archipelago contains seven medium-sized islands (Hoste, Santa Inés, Navarino, Dawson, Aracena, Clarence, and Staten; ranging from 4,100 to 500 km^2 in the same decreasing sequence), and ca. 3,000 smaller islands and islets, most of them located to the southwest of Tierra del Fuego Island (Argentina's Staten Island excepted) and thus are in Chilean territory.

The Magallanes Region (Fig. 1) has three major climates (Xercavins 1984): temperate cold rainy (mean annual temperature 6°C and mean annual rainfall 3,000 mm), cold steppe (short and cool summers and slightly cold winters, mean annual rainfall of 500 mm), and high ice (mean monthly temperature not higher than 0°C and annual snowfall 1,000 to 3,000 mm). It is divided into three major biomes (Salinas 2016, CONAF 2019, Sanchez and Morales 2022): the Andean-Patagonian forest biome, the Evergreen forest and peat bog biome, and the Patagonian steppe biome. The Andean-Patagonian forest biome consists of deciduous forests, with woody physiognomy and a slight herbaceous layer. The lenga (*Nothofagus pumilio*) is the characteristic tree of this biome, together with the canelo (*Drimys winteri*), and the coihue (*Nothofagus betuloides*). The Evergreen forest and peat bog biome, also has a woody aspect with *Nothofagus* trees and peat bogs of *Sphagnum magellanicum* as representative species. The Patagonian steppe biome is characterized by low-shrub vegetation, herbs and grasses. The rabbit is present chiefly in the Patagonian steppe and scrub biomes (Venegas and Sielfeld 1998).

The Magallanes Region has ca. 58% of its surface protected within the State's System of Protected Wilderness Areas (SNASPE, in Spanish), because it harbors a high number of unique species (Molina 2011, Salinas 2016, ODEPA 2021). Among the economic activities, sheep farming stands out, followed by artisanal and industrial fishing, aquaculture, tourism, and forestry (Vera 2008). According to the national inventory of species of the Ministry of the Environment, the Region harbors 176 species of animals and 242 species of plants (Salinas 2016, MMA 2020).

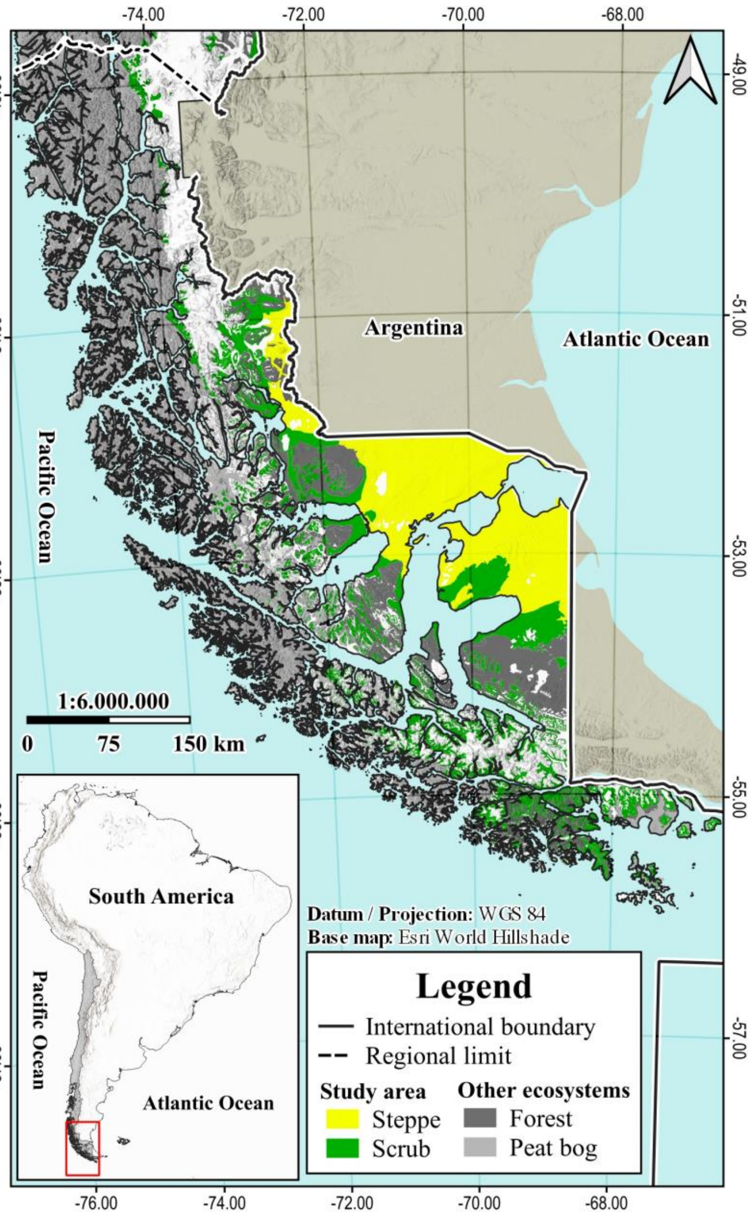


Figure 1. Magellanic ecosystems in the southern part of Chile. The steppe and scrub were the main study area to build the Magellanic food web.

Food web construction

For the construction of the network, the list of species present in the Magallanes Region was compiled using the national inventory of species (MMA 2020). This list was supplemented with diet information from those species in the Region, with focus on the relationship with rabbits. A bibliographic review was carried out through Google Scholar, Web of Science, Scopus, and other search engines for scientific publications or technical reports (but not abstracts), including theses, journal articles, books, and book chapters. Keywords such as south, southern, southernmost, Magallanes, Patagonia, Tierra del Fuego, Chile, Diet, Lagomorph, Rabbit, *Oryctolagus cuniculus*, were searched in English and Spanish languages, solely or in combination.

At first, only documentation related to rabbits specifically in the Magallanes Region was selected. Works on the trophic role of rabbits in the Region (either as herbivore, competitor, or prey) were especially sought after, as well as those on the diet of their potential predators. However, due to the scarce information on the diet of predators present in the Magallanes Region, information from neighboring Argentine Patagonia and Tierra del Fuego Island was added, because of shared biogeography, ecology, and evolution. Thirdly, when no diet information was available from those austral regions, diet analyses of predators were sought from neighboring regions of Chile and Argentina that shared the most similar ecosystems and species. Finally, when no other published sources were found, wildlife experts from CONAF-Magallanes (National Forestry Corporation) and SAG-Magallanes (Agricultural and Livestock Service) were consulted on predator-rabbit relationships in that region.

During the bibliographic search, it was observed that diet analyses did not have the same taxonomic resolution of prey, generating shortcomings in the construction of the trophic network. An example of this were publications reporting predators that consumed "passerines" versus those identifying passerine species (e.g., *Zonotrichia capensis*). Not being advisable to consider these prey as two different nodes (because that given species also belongs to the passerine node), it was decided that if >50% of predator diets reported only the clustered node (e.g., passerines), only such bundled node would be used, removing species-specific nodes. This way, any predator that consumed a given passerine species would be connected to the bundled node and not to separate specific nodes. In the contrary case, that the majority of species present in the region consumed a given species of a grouped node (for example, some species specifically consumed one or more species of *Nothofagus: N. antarctica, N. dombeyi, N. obliqua, N. pumilio, N. betuloides,* or *N. nitida*) while others were reported to consume the cluster node (*Nothofagus* spp.), it was assumed that the latter could eat either of those species.

Finally, those species with predators but without prey were designated as basal species, and they included species without dietary data as well as insectivorous birds and insects, because they were not expected to compete for food with rabbits. It should be emphasized that because the trophic network built is centered on the rabbit and its role in the food web of the Magallanes Region, it incorporated the predators and scavengers that consume rabbits, its herbivorous competitors, and the food plants it consumes.

Food web analysis

Through a list of interactions between species, a binary adjacency matrix was constructed, where 0 means that there is no trophic interaction and 1 that there is. The structural attributes of the network were analyzed, such as species richness (S), number of links (L), connectance ($C=L/S^2$), generality SD (standard deviation of generality; generality of a node is the number of species it consumes normalized by L/S), and vulnerability SD (standard deviation of vulnerability; vulnerability of a node is the number of species it is consumed by normalized by L/S) (Dunne et al. 2002b, Montoya et al. 2006, Dunne 2009). In turn, the nodes were classified as either native or exotic, but some orders, families or genera had both types of species, for which reason they were called "mixed nodes". An example is the *Agrostis* spp. node, which contains native (e.g., *Agrostis glabra*) and introduced (e.g., *Agrostis capillaris*) species. The network was built using the Network 3D program (Yoon et al. 2004, Williams 2010). To identify the relative importance of rabbits into the food web, we calculated the connectivity, number of predators and number of prey of each node and ranked the rabbit position.

Species extinction analysis

To evaluate the ecological mechanisms involved (e.g., release from predation, reduction of trophic niche) that could trigger short-term responses in the ecosystem --and may aid in the eventual control of the rabbit--, an analysis of species extinction was carried out. For this, the node belonging to the rabbit was removed from the network and the percentage of prey lost to predators (reduction of trophic niche) and the percentage of predators that lost prey (release from predation/herbivory) were subsequently quantified. The extinction analysis was performed using the NetworkExtinction package (Ávila-Thieme et al. 2023) and igraph (Csardi and Nepusz 2006) in R.

Results

The food web of the rabbit in the Magallanes Region resulted in a network with 222 nodes and 576 trophic interactions (Links, L) and a connectance of 0.011 (Fig. 2). 8% of the nodes corresponded to top predators, 10% to intermediate species (consumers), and 82% to basal species. The latter were made up of plants, insectivorous rodents and passerines, insects themselves, and of those consumers for which it was not possible to find dietary information. In turn, the network was made up of 143 native nodes (64%), 27 exotic (12%), and 52 mixed (23%) (Table 1S, Fig. 2). The link density (L/S) was equal to three, representing the number of interactions per node. The network had a vulnerability SD = 1.4 and a generality SD = 2.9, which implies that the network was more homogeneous in terms of vulnerability than in generality, having nodes with very wide dietary breadth (e.g., guanaco *Lama guanicoe* with 47 prey items, or sheep *Ovis aries* with 40 prey) versus others with much narrower dietary breadth (e.g., Colocolo cat, *Leopardus colocolo* with two prey items). In the network, the rabbit was the most connected species, with connectance = 11.4. This means that of all the nodes identified, the rabbit node had the most trophic interactions, associated with a total of 59 links. At the same time, it was the second most in generality (17,374), after the lama *Lama guanicoe* (18,146).

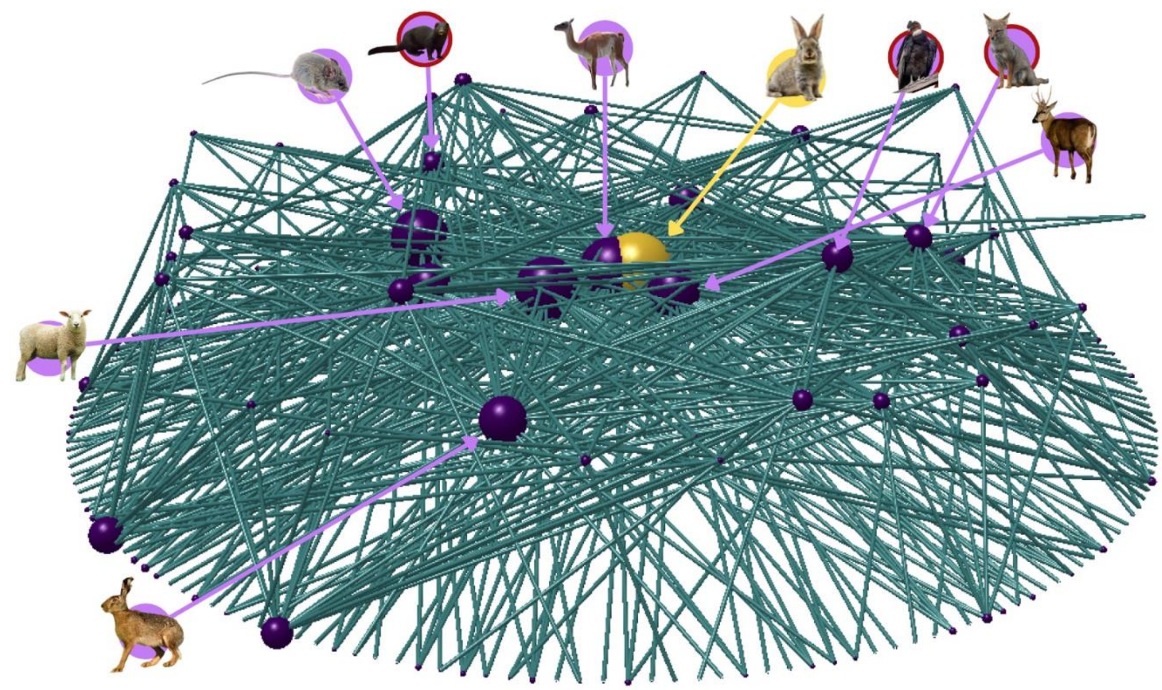
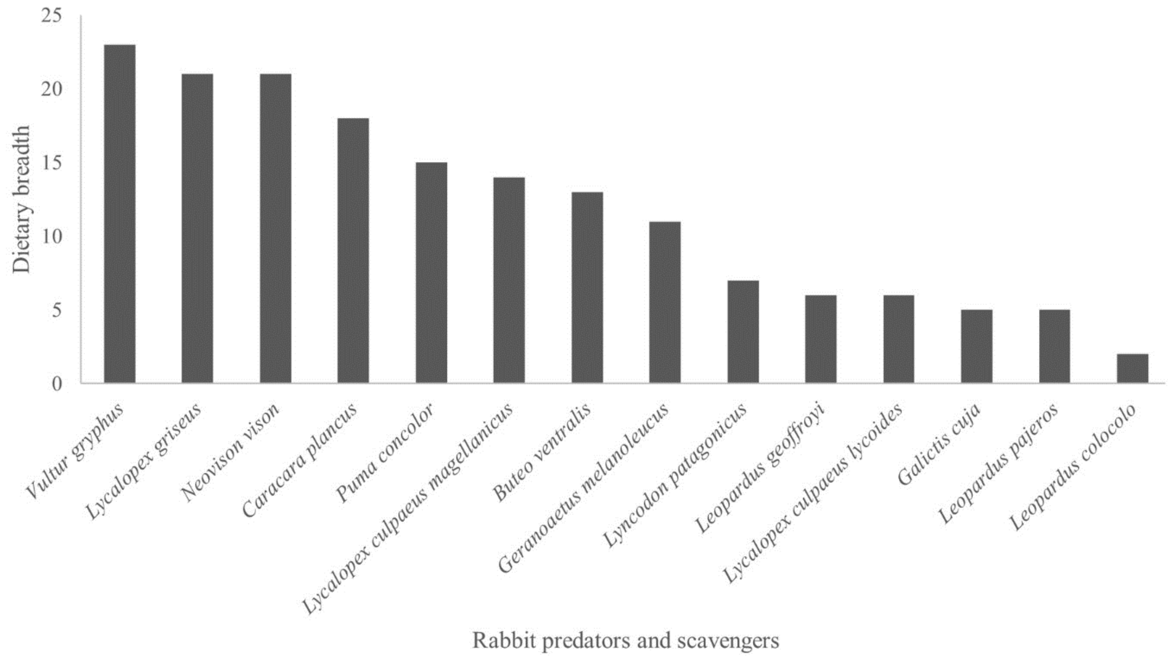


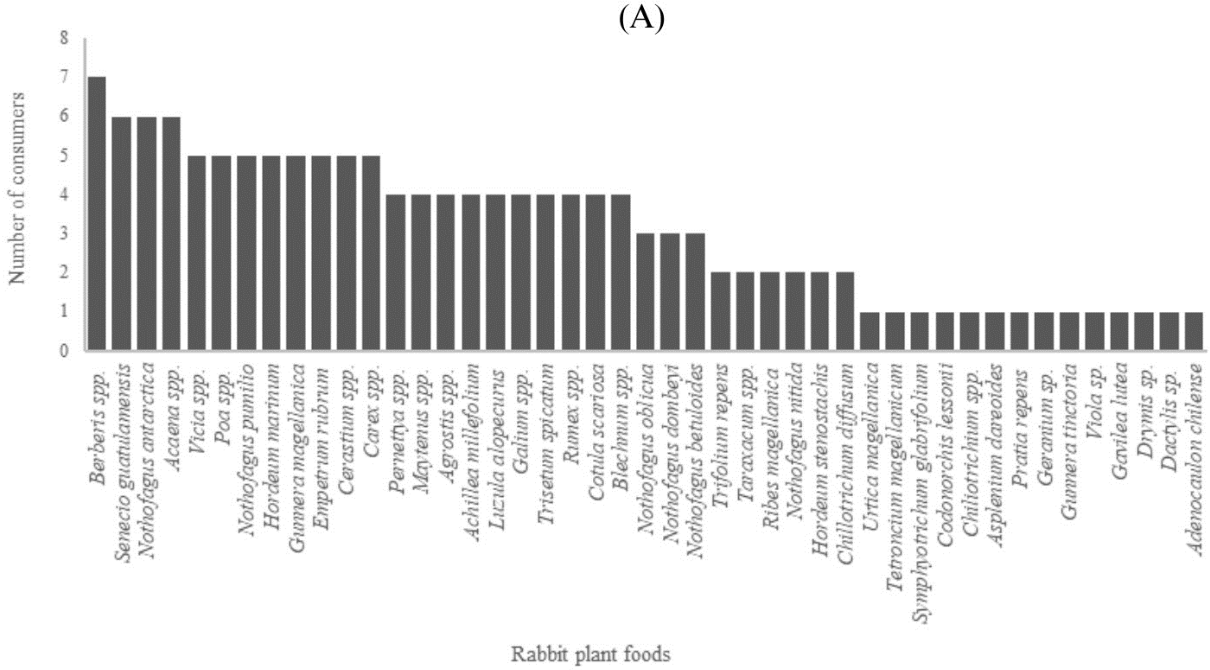
Figure 2: Food web of the rabbit *Oryctolagus cuniculus* in the Magellanic/Fuegian steppe of southernmost Chile. Each circle represents a node (usually a species), and each line a link (trophic interaction). The rabbit node is shown in yellow and the remaining nodes in purple. The size of each node represents the number of trophic interactions associated with it: the larger the size, the more trophic interactions. Large nodes clockwise from rabbit are *Vultur*

gryphus (native scavenger), *Lycalopex griseus* (native predator), *Hippocamelus bisulcus* (native herbivore), *Lepus europaeus* (exotic herbivore), *Ovis aries* (domesticated herbivore), *Oligoryzomys longicaudatus* (native herbivore), *Neovison vison* (exotic predator), and *Lama guanicoe* (native herbivore). Predators/scavengers are circled in red.

The rabbit was preyed on by 14 species, of which 13 were native (the continental fox *Lycalopex culpaeus magellanicus* was treated separately from the Fuegian fox *Lycalopex culpaeus lycoides;* see Iriarte and Jaksic 2022) and one was an exotic invasive (*Neovison vison*) (Fig. 3A). Among predators/scavengers with the broadest dietary breadth were *Vultur gryphus*, *Lycalopex griseus*, and *Neovison vison*. Rabbit predators with the narrowest dietary breadth were *Leopardus colocolo, L. pajeros,* and *L. geoffroyi*. The latter could be those that depend more strongly on rabbit abundance. On the other hand, the rabbit preys (as a herbivore) on 45 species (Fig. 3B), of which 69% of the species or genera had two or more herbivores, the remaining 31% being consumed only by rabbits. The percentages of exotic, native, and mixed nodes of the species consumed by rabbits were 58%, 13%, and 29%, respectively.



(A)



(B)

Figure 3: Relative importance of the rabbit *Oryctolagus cuniculus* in the Magellanic/Fuegian steppe of southernmost Chile. (A) Dietary breadth of rabbit predators in decreasing order. (B) Resources used by rabbits in decreasing order.

When removing the rabbit from the network (Fig. 4A), 12 nodes lost from 10 to 20% of their consumers, ten lost from 20-30%, three lost 30-40%, six lost 40-50%; finally, 14 nodes lost 100% of their consumers. Among the predators that consumed the rabbit, most of them were not greatly affected by its removal, because they did not lose more than 20% of their prey (Fig. 4B). Only one species, *Leopardus colocolo*, lost 50% of its prey. Thus, the main ecological mechanism triggered by the removal of the rabbit node was the release of pressure on plants from its herbivory.

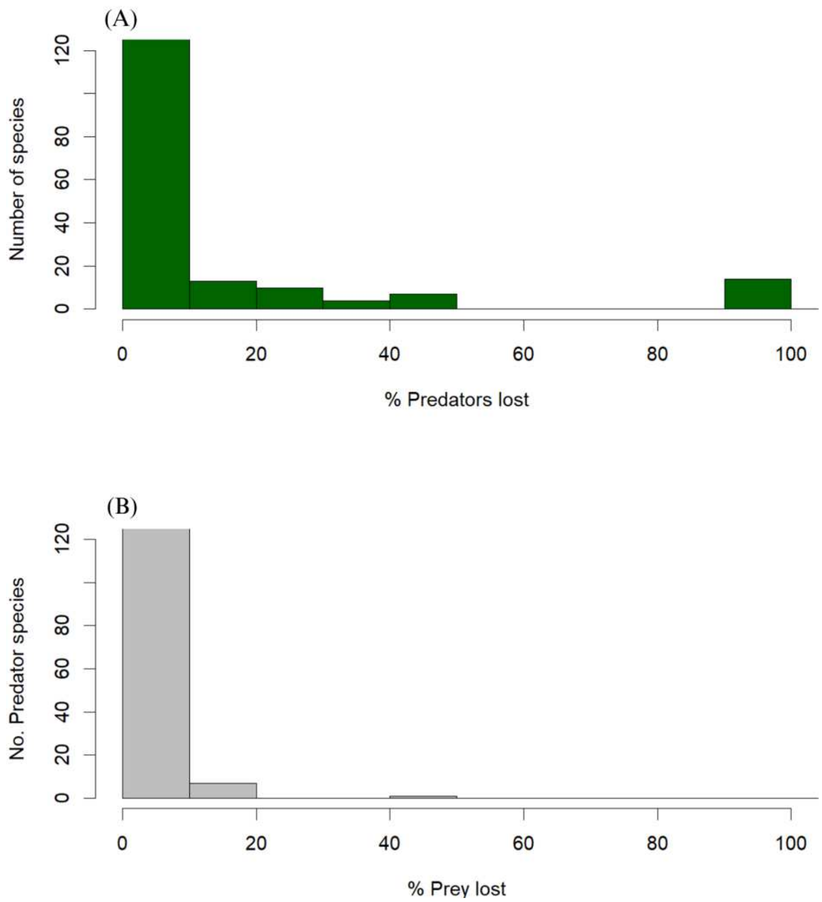


Figure 4: Species extinction analysis of the rabbit *Oryctolagus cuniculus* in the Magellanic/Fuegian steppe of southernmost Chile. (A) Number of prey species that lose a certain percentage of predators by removing the rabbit from the network. (B) Number of predator species that, when eliminating the rabbit, lose a certain percentage of their prey.

Discussion

Together with the increase in connectivity within ecosystems because of human influence, there is usually an increase in biological invasions into new environments (Everett 2000, Jaksic and Castro 2021). Although the often negative effects of introduced species have been extensively studied, an invasive exotic species does not carry an intrinsic negative or positive value, and for this reason the effects that it could have on an ecosystem should be studied (Camus et al. 2021). Our study highlights the role of the European rabbit in the food web of the Magellanic/Fuegian steppe ecosystem, as a consumer of plants, as a potential competitor of other herbivores, and as new prey for various predators, native and exotic to the Magallanes Region.

The analysis of the network generated shows the European rabbit as the most connected species, highlighting how immersed it is in the regional ecosystem, even though numerous interventions have been carried out for its control or eradication. The rabbit is prey of 14 species (one is an exotic predator) and a consumer of 45 plant species or genera (native or exotic). Thus, it has different effects on the food web depending on the trophic relationship it has with other species, being simultaneously an herbivore, a competitor, and a prey.

A simulated control of the rabbit, which translates into a decrease in its abundance, would be especially detrimental to Magellanic predators with low dietary breadth. For example, the cat *Leopardus colocolo* would lose an important fraction of its diet, but also because it has low mobility, limiting its possibilities to move to farther places for finding other or the same food sources. In addition, rabbits play less role on the diet of Fuegian fox *Lycalopex culpaeus lycoides*, and the grison *Galictis cuja*, in comparison with *L. coloco*. However, rabbits' control could have important indirect impacts its prey species, intensifying the predation pressure. Moreover, their relatively low mobility (small home ranges) contrasts with that of other predators with higher dietary breadth and mobility (e.g., Andean condor and puma), who may move to farther places for finding other or the same food sources. Similar results was obtained in a semi-arid scrub in northern Chile (Gübelin et al. 2023), where the rabbit was also the most connected species, in addition to fulfilling similar ecological roles as consumer, competitor, and prey. Interestingly, the two food webs had *Leopardus colocolo* and *Galictis cuja* as the species with the lowest dietary breadth. On the other hand, in the scrub food web, the Andean condor *Vultur gryphus* and the puma *Puma concolor* had very narrow dietary breadth, in marked contrast with the Magellanic/Fuegian trophic network. This could be explained by the latter network covering an entire Region as compared to the scrub network, which had a much smaller geographical extent. Among the

Magellanic/Fuegian rabbit predators, the raptors *Buteo ventralis* and *Geranoaetus melanoleucus* --because their low dietary breadths between the avian predators-- would be the ones most likely affected by rabbit control or eradication, changing and intensifying their feed by another prey such birds, other mammals, reptiles, or insects for *B. ventralis*, and hares or guanaco for *G. melanoleucus* (pers. comm. M. Duclos). Of special concern is *Buteo ventralis*, a species of vulnerable conservation status (Iriarte et al. 2019).

Among the native plants eaten by rabbits in the Magellanic/Fuegian ecosystem are *Nothofagus* spp. and *Acaena* spp., which sustain a large number of consumers; while *Gavilea lutea, Adenocaulon chilense*, and *Asplenium dareoides* are only eaten by rabbits. The latter species could then be relieved of herbivory pressure, which could lead to an increase in their biomass. But in addition to eating plants, rabbits are also known to be legitimate disperser of some species (e.g., Fernández and Sáiz 2007, Castro et al. 2008, Bobadilla et al. 2023). In the Magallanes Region, perhaps *Empetrum rubrum* could be dispersed by rabbits. Still, the effect of rabbits' intense consumption of plants may negatively impact some species of conservation or forestry concern (Correa-Cuadros et al. 2022, 2023; Valenzuela 2023) as well as livestock production, especially of sheep (Camus et al. 2008, 2021; Valenzuela 2023).

Overall, the positive effect that the rabbit has on the Magellanic/Fuegian food web cannot be ignored: It has become a staple prey for different regional predators, generating a food subsidy which allows them to maintain higher population abundances, while shifting away predation on native prey, as documented in Argentinian Patagonia (Palacios et al. 2012; Barbar et al. 2016, 2018; Barbar and Lambertucci 2018, 2019, 2023) and in central Chile (Correa-Cuadros et al. 2022, 2023; Gübelin et al. 2023). If controlled or eradicated, perhaps predators would direct higher predation pressure on another invader, the European hare (*Lepus europaeus*), which would not be unwelcome news (Jaksic 2023).

Author Contributions

F Mann-Vollrath, JP Correa-Cuadros, and MI Ávila-Thieme designed the study and analyzed the data. F Mann-Vollrath, JP Correa-Cuadros, MI Ávila-Thieme, M Duclos, and FM. Jaksic cowrote the text. JP Correa-Cuadros and FM Jaksic drafted the unified version of the manuscript.

Funding

We are grateful to ANID PIA/BASAL FB0002 for funding this research. JPC acknowledges the support of FONDECYT 3220027 and MIAT FONDECYT 3220110.

Acknowledgments

We are grateful to the Center of Applied Ecology and Sustainability (CAPES) for the opportunity to carry out this research and to ANID PIA/BASAL FB0002 for funding it. JP Correa-Cuadros is grateful to FONDECYT 3220027 and MI Ávila-Thieme FONDECYT 3220110. Also, to the Corporación Nacional Forestal (CONAF; more specifically CONAF-Magallanes and their park rangers), to the Servicio Agrícola y Ganadero (SAG; more specifically SAG-Magallanes), and especially to Nicolás Soto, for support in the food web data input. We thank Megan McFarland for kindly checking the English version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abrams PA, Menge BA, Mittelbach GG, Spiller DA, Yodzis P (1996). The Role of Indirect Effects in Food Webs. Food Webs, 371–395. doi:10.1007/978-1-4615-7007-3_36

Amaya J (1981) Estado actual de las investigaciones de especies de la fauna consideradas perjudiciales en la patagonia. Actas Simposia 6tas. Jornadas Argentinas de Zoología. pp 159-171

Amaya J, Bonino N (1981) El conejo silvestre europeo (*Oryctolagus cuniculus*) en Tierra del Fuego. IDIA (Buenos Aires) 387-388:14-33.

Angulo E (2003) Factores que afectan a la distribución y abundancia del conejo en Andalucía.

Arentsen P (1954) Control biológico del conejo: difusión del virus mixomatosis cuniculus, por contagio directo, en la Isla Grande de Tierra del Fuego. Boletín Ganadero (Punta Arenas) 43:1-26.

Arriagada A, Arriagada J, Luisa B, Suazo C (2011) Dieta estival del águila (*Geranoaetus melanoleucus*) en la Región de Aysén, Patagonia Chilena [Summer diet of Black-chested Buzzard-eagle (*Geranoaetus melanoleucus*) in Aysén District, Chilean Patagonia]. Ecotrópicos. 24(2):164-171.

Atalah A, Sieldfeld W, Venegas Canelo C (1980) Antecedentes sobre el nicho trófico de *Canis g. griseus* Gray 1836 en Tierra del Fuego. In Anales del Instituto de la Patagonia.

Ávila-Thieme MI, Corcoran D, Kusch E, Castillo SP, Valdovinos FS, Navarrete SA, Marquet PA (2023) NetworkExtinction: NetworkExtinction: An R package to simulate extinction propagation and rewiring potential in ecological networks. Methods in Ecology and Evolution, 00, 1–1 5. https://doi.org/10.1111/2041-210X.14126

Baldwin, H. (2018) *Nothofagus antarctica*. The IUCN Red List of Threatened Species 2018: e.T96477198A96479935. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T96477198A96479935.en.

Baldwin, H. (2018) *Nothofagus betuloides*. The IUCN Red List of Threatened Species 2018 e.T96477198A96479935. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T96477198A96479935.en.

Baldwin, H. (2018) *Nothofagus nitida*. The IUCN Red List of Threatened Species 2018: e.T96478547A96480010. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T96478547A96480010.en.

Ballesteros F (2007) *Lepus castroviejoi* (Palacios 1977). In: Palomo LJ, Gisbert J, Blanco JC (eds) Atlas y Libro Broom Hare Lepus castroviejoi Palacios, 1977 11 Rojo de los Mamíferos Terrestres de España. Ministerio de Medio Ambiente, Madrid, pp 479–483

Balza U (2021) Ecología y conservación del carancho austral (*Phalcoboenus australis*) en Isla de los Estados: factores asociados a su vulnerabilidad a distintas escalas espacio-temporales. Universidad de Buenos Aires. 10.13140/RG.2.2.30976.35841.

Barbar F, Hiraldo F, Lambertucci A (2016) Medium-sized exotic prey creates novel food webs: the case of predators and scavengers consuming lagomorphs. Peer J. https://doi.org/10.7717/peerj.2273

Barbar F, Ignazi GO, Hiraldo F, Lambertucci SA (2018) Exotic lagomorph may influence eagle abundances and breeding spatial aggregations: a field study and meta-analysis on the nearest neighbor distance. Peer J. https://doi.org/10.7717/peerj.4746

Barbar F, Lambertucci A (2018) The roles of leporid species that have been translocated: a review of their ecosystem effects as native and exotic species. Mammal Review, 48:245-260. https://doi.org/10.1111/mam.12126

Barbar F, Lambertucci SA (2019) Introduced lagomorph produce stronger potential apparent competition in invaded communities than any other species in a similar but native food web. Biol Invasions 21(12):3735–3740. https://doi.org/10.1007/s10530-019-02082-x

Barbar F, Lambertucci SA (2023) Invasive herbivores shape food web structure: European rabbit and hare acting as primary prey are conservation challenges. Biol Conserv 281:1-9. https://doi.org/10.1016/j.biocon.2023.110016

Barstow M, Baldwin H, Rivers MC (2017) *Nothofagus dombeyi*. The IUCN Red List of Threatened Species 2017: e.T34852A67806877. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T34852A67806877.en

Barstow M, Baldwin H, Rivers MC (2017) *Nothofagus pumilio*. The IUCN Red List of Threatened Species 2017: e.T61918143A61918170. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T61918143A61918170.en.

Barstow M, Rivers MC, Baldwin H (2017) *Nothofagus obliqua*. The IUCN Red List of Threatened Species 2017: e.T61918092A67806956. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T61918092A67806956.en.

Berríos P (2005) Virus como control biológico del conejo silvestre europeo (*Oryctolagus cuniculus*). TecnoVet (Santiago, Chile) 11(3):15-20. https://tecnovet.uchile.cl/index.php/RT/article/view/39004

Bidau CJ (2019) *Ctenomys magellanicus*. The IUCN Red List of Threatened Species 2019: e.T5812A22193726. https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T5812A22193726.en. Accessed on 30 June 2023.

BirdLife International (2016) *Buteo ventralis*. The IUCN Red List of Threatened Species 2016: e.T22695936A93535276. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22695936A93535276.en. Accessed on 30 June 2023.

Bobadilla SY, Olivares ET, Jaksic FM, Ojeda RA, Cuevas MF (2023) European rabbit (*Oryctolagus cuniculus*) as seed disperser in arid ecotones of Argentina: Non-native herbivore facilitation of native plants. Mammal Research: in press.

Bonino N (2006) Interacción trófica entre el conejo silvestre europeo y el ganado doméstico en el noroeste de la Patagonia Argentina. Ecología Austral 16(2):135-142. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1667-782X2006000200005

Bonino N, Soriguer R (2009) The invasion of Argentina by the European wild rabbit *Oryctolagus cuniculus*. Mammal Review 39(3):159-166. https://doi.org/10.1111/j.1365-2907.2009.00146.x

Camus P, Castro S, Jaksic F (2008) El conejo europeo en Chile: Historia de una invasión biológica. Historia. 41(2): 305-339. http://dx.doi.org/10.4067/S0717-71942008000200001

Camus P, Castro SA, Jaksic FM (2021) European Rabbit (*Oryctolagus cuniculus* L.) in Chile: The human dimension behind a biological invasion. In: Jaksic FM, Castro SA (Eds) Biological invasions in the South American Anthropocene: Global causes and local impacts. Springer Nature, Cham, pp. 171-185 https://doi.org/10.1007/978-3-030-56379-08

Cassola F (2016) *Ondatra zibethicus*. The IUCN Red List of Threatened Species 2016: e.T15324A22344525. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T15324A22344525.en.

Castro S, Bozinovic F, Jaksic FM (2008) Ecological efficiency and legitimacy in seed dispersal of an endemic shrub (*Lithraea caustica*) by the European rabbit (*Oryctolagus cuniculus*) in central Chile. Journal of Arid Environments, 72(7):1164-1173. https://doi.org/10.1016/j.jaridenv.2007.12.012

CONAF (2019) CONAF - Corporación Nacional Forestal. Chile. http://www.conaf.cl/parques-nacionales/. Accessed 8 Jul 2023

Correa-Cuadros JP, Flores G, Muñoz-Rodríguez MA, Briceño C, Díaz M, Strive T, Vásquez F, Jaksic FM (2022) History, control, epidemiology, ecology, and economy of the invasion of European rabbits in Chile: A comparison with Australia. Biol Invasions 25:309-338. https://doi.org/10.1007/s10530-022-02915-2

Correa-Cuadros JP, Flores-Benner G, Gübelin P, Ávila-Thieme MI, Muñoz M, Duclos M, Soto N, Briceño C, Vásquez F, Díaz M, Jaksic FM (2023) La invasión del conejo europeo en Chile. Ediciones CAPES-UC, Santiago https://b8c408.a2cdn1.secureserver.net/wp-content/uploads/2023/04/LIBRO_CONEJO_16_WEB.pdf

Crespin L, Lima M (2006) Supervivencia adulta y dinámica poblacional del lauchón orejudo *Phyllotis darwini* en Chile central. Revista chilena de historia natural, 79(3):295-308. http://dx.doi.org/10.4067/S0716-078X2006000300002

Csardi G, Nepusz T (2006) The igraph software package for complex network research. InterJournal, Complex Systems, 1695. https://igraph.org.

De Ruiter PC, Wolters V, Moore JC (2005) Dynamic food webs: Multispecies assemblages, ecosystem development and environmental change. Elsevier, Amsterdam

Deferrari G (2007) Biología y ecomorfología poblacional de la rata almizclera (*Ondatra zibethicus*) en Tierra del Fuego. Doctoral dissertation, Universidad Nacional de La Plata

D'elia G (2016) *Abrothrix lanosus*. The IUCN Red List of Threatened Species 2016: e.T740A22337685. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T740A22337685.en. Accessed on 30 June 2023.

D'elia G (2016) *Phyllotis darwini*. The IUCN Red List of Threatened Species 2016: e.T17224A22341324. https://dx.doi.org/10.2305/IUCN.UK.20162.RLTS.T17224A22341324.en.

D'elia G, Pardinas U, Patterson B (2016) *Abrothrix longipilis* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T743A115048280. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T743A22337497.en.

D'elia G, Pardinas U, Patterson B (2016) *Geoxus valdivianus* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T9089A115089444.https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T9089A22339247.en.

Delibes R, Delibes-Mateos M (2015) Linking historical ecology and invasion biology: Some lessons from European rabbit introductions into the new world before the nineteenth century. Biol Invasions 17:2505-2515. https://doi.org/10.1007/s10530-015-0905-4

Duclos M, Sabat P, Newsome SD, Galbán C, Pavez EF, Jaksic FM, Quirici V (2020) Latitudinal patterns in the diet of Andean Condor (*Vultur gryphus*) in Chile: Contrasting environments influencing feeding behavior. Science of the Total Environment 741(140220). https://doi.org/10.1016/j.scitotenv.2020.140220

Dunne J (2009) Food Webs. In: R.A Meyers (Ed.) Encyclopedia of complexity and systems science. Springer, New York, pp 3661-3682

Dunne J, Williams R, Martinez ND (2002a) Network structure and biodiversity loss in food webs: Robustness increases with connectance. Ecology Letters. 5(4):558–567. https://doi.org/10.1046/j.1461-0248.2002.00354.x

Dunne J, Williams R, Martinez ND (2002b) Food-web structure and network theory: The role of connectance and size. PNAS 99 (20):12917-12922. https://doi.org/10.1073/pnas.192407699

Ebensperger L, Mella J, Simonetti J (1991) Trophic-Niche Relationships among *Galictis cuja, Dusicyon culpaeus*, and *Tyto alba* in Central Chile. Journal of Mammalogy. 72(4):820–823. https://doi.org/10.2307/1381849

Everett R (2000) Patterns and pathways of biological invasions. Trends in Ecology and Evolution. 15: 177-178. https://doi.org/10.1016/S0169-5347(00)01835-8

Fasola L, Zucolillo P, Roesler I, Cabello J (2021) Foreign Carnivore: The Case of American Mink (*Neovison vison*) in South America. In: Jaksic FM, Castro SA (Eds) Biological Invasions in the South American Anthropocene. Springer, Cham. https://doi.org/10.1007/978-3-030-56379-0_12

Feijoo M, D'Elía G, Pardiñas U and Lessa E (2010) Systematics of the southern Patagonian-Fueguian endemic *Abrothrix lanosus* (Rodentia: Sigmodontinae): Phylogenetic position, karyotypic and morphological data. Mammalian Biology - Zeitschrift Für Säugetierkunde. 75(2):122–137. https://doi.org/10.1016/j.mambio.2008.10.004

Fernández A, Sáiz F (2007) The European rabbit (*Oryctolagus cuniculus* L.) as seed disperser of the invasive opium poppy (*Papaver somniferum* L.) in Robinson Crusoe island, Chile. Mastozoología Neotropical 14:19-27. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S0327-93832007000100003

Figueroa R, Corales S, Martínez D, Figueroa R, González-Acuña D (2006) Diet of the Rufous-legged Owl (*Strix rufipes*, Strigiformes) in an Andean Nothofagus–Araucaria Forest, southern Chile, Studies on Neotropical Fauna and Environment. 41(3):79-182. https://doi.org/10.1080/01650520600630667

Figueroa R, Jiménez J, Bravo C, Corales E (2000) The diet of the Rufous-tailed Hawk (*Buteo ventralis*) during the breeding season in southern Chile. Ornitología Neotropical. 11:349-352.

Figueroa R, Corales ES (2005) Seasonal diet of the Aplomado Falcon (*Falco femoralis*) in an agricultural area of Araucanía, southern Chile. Journal of Raptor Research. 39:65-60.

Figueroa RA, Rau JR, Mayorga S, Martínez DR, Corales SES, Mansilla A, Figueroa MR (2009) Rodent Prey of the Barn Owl *Tyto alba* and Short-Eared Owl *Asio flammeus* During Winter in Agricultural Lands in Southern Chile. Wildlife Biology. 15(2):129–136. https://doi.org/10.2981/08-005

Figueroa Rojas RA, Corales Stappung ES (2004) Summer diet comparison between the American Kestrel (Falco sparverius) and Aplomado Falcon (*Falco femoralis*) in an agricultural area of Araucanía, southern Chile. El hornero, 19(2), 53-60.

Figueroa Rojas RA, Alvarado Orellana SB, Vivanco C, Corales Stappung ES, González BA, Ibarra-Vidal H (2004) Prey Characteristics of the Chilean Hawk (*Accipiter chilensis*) in the Southern Temperate Forest. El hornero. 19(2): 77-82

Figueroa R, Jiménez J, Bravo C, Corales ES (2000) The diet of the Rufous-tailed Hawk (*Buteo ventralis*) during the breeding season in southern Chile. Ornitología Neotropical. 11:349-352.

Figueroa-Rojas RA, Corales ES, Alvarado S (2003) Diet of the Red–Backed Hawk (*Buteo polyosoma*) in a forested area of the Chilean Patagonia and its relation to the abundance of rodent prey. El Hornero. 18(1):43-52.

Formoso A, Agüero L and Sauthier D (2019) Diet of the Southern Caracara in a near-shore insular system in southern Patagonia, Argentina. Journal of King Saud University-Science, 31(4):1339-1343.

García Esponda C, Carrera J, Moreira G, Cazón A, De Santis L (2009) Microvertebrates preyed by *Leopardus pajeros* (Carnivora: Felidae) in southern Mendoza province, Argentina. Mastozoología neotropical 16(2):455-457.

García-Perea R (1994) The Pampas cat group (genus Lynchailurus Severtzov, 1858) (Carnivora, Felidae): a systematic and biogeographic review. American Museum novitates; 3096:1-35

González-Acuña D, Rebolledo P, Skewes O, Moreno L, Castro D (2005) Parásitos de la liebre (*Lepus europaeus* Pallas, 1778): estudio en dos zonas geográficas de Chile. Parasitología latinoamericana, 60:174-177. http://dx.doi.org/10.4067/S0717-77122005000200013

Gübelin P, Correa-Cuadros JP, Ávila-Thieme MI, Flores-Benner G, Duclos M, Lima M, Jaksic FM (2023) European Rabbit Invasion in a Semi-Arid Ecosystem of Chile: How Relevant Is Its Role in Food Webs? Life 13:916. https://doi.org/10.3390/life13040916

Hacklander K, Schai-Braun S (2019) Lepus europaeus. The IUCN Red List of Threatened Species 2019: e.T41280A45187424. https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T41280A45187424.en.

Helgen K, Schiaffini M (2016) Galictis cuja. The IUCN Red List of Threatened Species 2016: e.T41639A45211832. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41639A45211832.en.

Huertas-Herrera A, Toro-Manríquez M, Borrelli L, Martinez-Pastur G (2022) Forage offering and seasonal intake comparisons to evaluate European rabbit threat in Nothofagus forests of southern Patagonia. Ecol Process 11(45):1-14 https://doi.org/10.1186/s13717-022-00389-7

Iriarte A, Jaksic F (2022) Los carnívoros de Chile. Tercera edición revisada. Ediciones CAPES/Flora & Fauna, Santiago.

Iriarte A, Rivas-Fuenzalida T, Jaksic F (2019) Las aves rapaces de Chile. Ediciones CAPES/Flora & Fauna, Santiago.

Iriarte JA, Feinsinger P, Jaksic FM (1997) Trends in wildlife use and trade in Chile. Biological Conservation 81:9-20. https://doi.org/10.1016/S0006-3207(96)00150-4

Iriarte JA, Jaksic FM (1986) The fur trade in Chile: An overview of seventy-five years of export data (1910 - 1984). Biological Conservation 38:243-253. https://doi.org/10.1016/0006-3207(86)90124-2

Iriarte JA, Johnson WE, Franklin, WL (1991) Feeding ecology of the Patagonia puma in southernmost Chile. Revista Chilena de Historia Natural. 64:145-156.

Jaksic F, Iriarte J, Jiménez J (2002) The raptors of Torres del Paine National Park, Chile: biodiversity and conservation. Revista Chilena de Historia Natural. 75(2):449-461.

Jaksic F, Yáñez J (1983) Rabbit and fox introductions in Tierra del Fuego: History and assessment of the attempts at biological control of the rabbit infestation. Biological Conservation. 26:367–374. https://doi.org/10.1016/0006-3207(83)90097-6

Jaksic FM (2023) Historical ecology and current status of the European hare Lepus europaeus in South America: A new species in new countries. Studies on Neotropical Fauna Environment. https://doi.org/10.1080/01650521.2023.2217064.

Jaksic FM, Castro SA (2021) Biological invasions in the South American Anthropocene: Global causes and local impacts. Springer Nature, Cham, Switzerland. https://www.researchgate.net/publication/350555545

Jaksic FM, Yáñez JL, Rau JR (1983) Trophic Relations of the Southernmost Populations of Dusicyon in Chile. Journal of Mammalogy 64(4):693–697. https://doi.org/10.2307/1380529

Jaksic F, Rau J, Yáñez J (1978) Oferta de presas y predación por *Bubo virginianus* (Strigidae) en el Parque Nacional "Torres del Paine". Anales del Instituto de la Patagonia, 9:199-202

Jaksic FM, Iriarte JA, Jiménez JE (2002) The raptors of Torres del Paine National Park, Chile: biodiversity and conservation. Revista chilena de historia natural. 75(2):449-461. https://dx.doi.org/10.4067/S0716-078X2002000200014

Jiménez E, Jaksic FM (1988) Ecology and behavior of southern South American Cinereous Harriers, Circus cinereus. Revista Chilena de Historia Natural 61:199 208.

Kelt D, Pardiñas, U, Schiaffini M, González-Maya JF (2016) *Lyncodon patagonicus*. The IUCN Red List of Threatened Species 2016: e.T41647A45212747. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41647A45212747.en.

Kryštufek B, Palomo L, Hutterer R, Mitsainas G, Yigit N (2021) *Rattus rattus* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2021: e.T19360A192565917. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T19360A192565917.en.

Lambertucci S, Trejo A, Di Martino S, Sánchez-Zapata J, Donázar J, Hiraldo F (2009) Spatial and temporal patterns in the diet of the Andean condor: ecological replacement of native fauna by exotic species. Animal Conservation 12(4):338–345. https://doi.org/10.1111/j.1469-1795.2009.00258.x

Laurie E (1946) The reproduction of the house-mouse (Mus musculus) living in different environments. Proceedings of the Royal Society of London. Series B - Biological Sciences, 133:248–281. https://doi.org/10.1098/rspb.1946.0012

Lees A, Bell D (2008) A conservation paradox for the 21st century: the European wild rabbit *Oryctolagus cuniculus*, an invasive alien and an endangered native species. Centre For Ecology, Evolution and Conservation, School Of Environmental Sciences, Singapore 38:304–320.

Lever C (1985) Naturalized mammals of the world. Longman, London.

Lima M, Julliard R, Stenseth N, Jaksic F (2001) Demographic dynamics of a neotropical small rodent (*Phyllotis darwini*): feedback structure, predation and climatic factors. Journal of animal Ecology, 70:761-775. https://doi.org/10.1046/j.0021-8790.2001.00536.x

Lobos G, Ferres M, Palma E (2005) Presencia de los géneros invasores Mus y Rattus en áreas naturales de Chile: un riesgo ambiental y epidemiológico. Revista chilena de historia natural, 78(1):113-124. https://dx.doi.org/10.4067/S0716-078X2005000100008

Long J (2003) Introduced mammals of the world. Their history, distribution and influence. CSIRO Publishing, Victoria, Australia.

Lowe S, Browne M, Boudjelas S, De Poorter M (2000) 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN)

Lucherini M (2016) *Lycalopex griseus* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T6927A111975602. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T6927A86440397.en.

Lucherini M, Eizirik E, de Oliveira T, Pereira J, Williams RSR (2016) *Leopardus colocolo*. The IUCN Red List of Threatened Species 2016: e.T15309A97204446. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T15309A97204446.en. Accessed on 24 June 2023.

Mann G (1978) Los pequeños mamíferos de Chile: marsupiales, quirópteros, edentados y roedores. Gayana, Concepción.

Martinez D (1993) Food habits of the Rufous legged Owl (*Strix rufipes*) in southern Chile temperate rainforests. Journal of Raptor Res. 27:214-216

Martínez D, Rau J, Murua R and Tilleria M (1993) Depredación selectiva de roedores por zorros chillas (*Pseudalopex griseus*) en la pluviselva valdiviana, Chile. Revista Chilena de Historia Natural, 66:419-426

Martinez D, Jaksic F (1997) Selective predation on scansorial and arboreal mammals by rufous-legged owls (*Strix rufipes*) in southern Chilean rainforest. Journal of Raptor Research 31:370-375

Martinez DR, Jaksic F M (1996) Habitat, relative abundance, and diet of rufous-legged owls (*Strix rufipes* King) in temperate forest remnants of southern Chile. Ecoscience, 3:259-263

Martinez DR, Figueroa RA, Ocampo C, Jaksic F (1998) Food habits and hunting ranges of Short-eared owls (*Asio flammeus*) in agricultural landscapes of southern Chile. Journal of Raptor Research. 32:111-115.

Martinez DR (2018) The summer diet of the magellanic horned owl (*Bubo magellanicus*, Gmelin, 1778) at the easternmost projection of continental Chile, Punta Dungeness. Anales del Instituto de la Patagonia. 46:67-71.

Martinic M (1957a) Fauna magallánica V: Los felidos. Boletín ganadero, 10-12

Martinic M (1957b) Fauna magallánica: Los cánidos. Boletín ganadero, 21-22

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (16to proceso) *Lyncodon patagonicus*. Clasificación de especies

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (8to proceso) *Geoxus valdivianus*. Clasificación de especies

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (10o proceso) *Myocastor coypus*. Clasificación de especies

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (8to proceso) *Microcavia australis*. Clasificación de especies

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (8to proceso) *Irenomys tarsalis*. Clasificación de especies

Ministry of the Environment (2019) Actas de las Reuniones del Comité de Clasificación (9o proceso) *Ctenomys magellanicus*. Clasificación de especies

MMA, Ministry of the Environment (2017) El problema de especies exóticas invasoras en Chile. Santiago, Chile. https://especies-exoticas.mma.gob.cl/el-problema-de-eei-en-chile/ Accessed 30 July 2023

MMA, Ministry of the Environment (2020) Inventario nacional de especies. Santiago, Chile. http://especies.mma.gob.cl/CNMWeb/Web/WebCiudadana/Default.aspx

Molina W (2011) Identidad regional en Magallanes, sus expresiones simbólicas y territoriales. Magallania (Punta Arenas) 39(1):59-69. https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-22442011000100003

Montoya JM, Pimm SL, Solé RV (2006) Ecological networks and their fragility. Nature 442:259–264. https://doi.org/10.1038/nature04927

Muñoz-Pedreros A, Gil C, Yáñez J, Rau, JR, Möller, P (2016) Trophic ecology of two raptors, Barn Owl (*Tyto alba*) and White-tailed Kite (*Elanus leucurus*), and possible implications for biological control of Hantavirus reservoir in Chile. The Wilson Journal of Ornithology, 128(2):391–403. https://doi.org/10.1676/wils-128-02-391-403.1

Museo de Historia Natural de Concepción (2021) Tuco tuco de magallanes, Museo de Historia Natural de Concepción. https://www.mhnconcepcion.gob.cl/cartelera/tuco-tuco-de-magallanes. Accessed 26 July 2023

Musser G, Hutterer R, Kryštufek B, Yigit N, Mitsainas G (2021) *Mus musculus* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2021: e.T13972A197519724. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T13972A197519724.en.

Nielsen C, Thompson D, Kelly M, Lopez-Gonzalez CA (2015) *Puma concolor* (errata version published in 2016). The IUCN Red List of Threatened Species 2015: e.T18868A97216466. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T18868A50663436.en.

Núñez F, Cisterna P (1991) Roedores domésticos I. Caracterización morfológica conductual y sanitaria. Monografías de Medicina Veterinaria, 13(1).

ODEPA, Oficina de Estudios y Políticas Agrarias (2021) Informativo regional Magallanes y la Antártica chilena. Ministerio del Medio Ambiente. Santiago, Chile. https://bibliotecadigital.odepa.gob.cl/bitstream/handle/20.500.12650/8968/FichaMagallanesInformativa.pdf

Ofusori DA, Caxton-Martins EA, Komolafe OO, Oluyemi KA, Adeeyo OA, Ajayi SA, Oluwayinka PO, Adelakun EA, Keji ST, Adesanya OA (2008) A Comparative Study of the Ileum in Rat (*Rattus norvegicus*), Bat (*Eidolon helvum*) and Pangolin (*Manis tricuspis*) as Investigated Using Histological Method. International Journal of Morphology, 26(1):137-141. https://dx.doi.org/10.4067/S0717-95022008000100023

Palacios R, Walker RS, Novaro AJ (2012) Differences in diet and trophic interactions of Patagonian carnivores between areas with mostly native or exotic prey. Mammalian Biology 77(3):183-189. https://doi.org/10.1016/j.mambio.2012.01.001

Pardinas, U, D'Elia G, Patterson B, Teta P (2016) *Loxodontomys micropus* (errata version published in 2017). The IUCN Red List of Threatened Species 2016:e.T2396A115061763. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T2396A22367715.en.

Pardinas U, Jayat JP, D'Elia G (2016) *Reithrodon auritus* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T19399A115150621. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T19399A22367966.en.

Pardinas U, Patterson B, D'elia G, Teta P (2016) *Irenomys tarsalis* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T10851A115100042. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T10851A22359147.en.

Patterson B, Pardinas U, D'Elia G (2017) *Abrothrix olivaceus*. The IUCN Red List of Threatened Species 2017

Pereira J, Lucherini M, Trigo T (2015) *Leopardus geoffroyi*. The IUCN Red List of Threatened Species 2015: e.T15310A50657011. https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T15310A50657011.en.

Pimm SL, Lawton JH, Cohen JE (1991) Food web patterns and their consequences. Nature. 350:669-674. 10.1038/350669a0

Pisano E (1985) La estepa patagónica como recurso pastoril en Aysén y Magallanes. Ambiente y Desarrollo. Amb. y Des. 1:45-59.
PNUD, Programa de las Naciones Unidas para el Desarrollo (2017) Valoración económica del impacto de siete especies exóticas invasoras sobre los sectores productivos y la biodiversidad en Chile. Santiago, Chile. https://especies-exoticas.mma.gob.cl/wp-content/uploads/2018/12/1.-LIBRO-Valoracion-economica-EEI-FINAL.pdf
Polop F, Sepúlveda L, Pelliza Sbriller A, Polop J, Provensal M (2014) Food habits of *Oligoryzomys longicaudatus* (Rodentia) in a steppe-forest transitional area of Argentinean Patagonia. Ecología austral. 24(3):304-310.
Prevosti FJ, Teta PV, Pardiñas UFJ (2009) Distribution, natural history, and conservation of the Patagonian Weasel *Lyncodon patagonicus*. Small Carnivore Conservation. 41:29-34.
Rabadá JC (2008) Los primeros conejos llegaron a América iniciado noviembre de 1493. Información Veterinaria. 9:21-24. https://dialnet.unirioja.es/servlet/articulo?codigo=4613756
Rau J, Martínez D, Low J,Tillería M (1995) Depredación por zorros chillas (*Pseudalopex griseus*) sobre micromamíferos cursoriales, escansoriales y arborícolas en un área silvestre protegida del sur de Chile. Revista Chilena de Historia Natural. 68:333-340.
Rau J, Mansilla A (2019) Dieta primaveral del tucúquere magallánico *Bubo magellanicus* (Gmelin, 1788) en la Patagonia chilena sur. Anales del Instituto de la Patagonia. 47:35-37. http://dx.doi.org/10.4067/S0718-686X2019000200035
Reid F, Schiaffini M, Schipper J (2016) *Neovison vison*. The IUCN Red List of Threatened Species 2016: e.T41661A45214988. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41661A45214988.en.
Riga F, Trocchi V, Randi E, Toso S (2001) Morphometric differentiation between the Italian hare (*Lepus corsicanus* De Winton, 1898) and the European brown hare (*Lepus europaeus* Pallas, 1778). Journal of zoology, 253(2):241-252.
Roach N (2016) *Microcavia australis*. The IUCN Red List of Threatened Species 2016: e.T13319A22189827. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T13319A22189827.en.
Salinas P (2016) Diagnóstico del estado y tendencia de la biodiversidad: Región de Magallanes y de la Antártica Chilena. Ministerio del Medio Ambiente. Santiago.
Sánchez A, Morales R (2002) Las regiones de Chile: espacio físico y humano-económico, Universitaria. SA, Santiago de Chile.
Schiaffini M I (2017) Niche overlap and shared distributional patterns between two South American small carnivorans: *Galictis cuja* and *Lyncodon patagonicus* (Carnivora: Mustelidae). Mammalia, 81:1-9 https://doi.org/10.1515/mammalia-2015-0158
Schüttler E, Carcamo J, Rozzi R (2008) Diet of the American mink Mustela vison and its potential impact on the native fauna of Navarino Island, Cape Horn Biosphere Reserve, Chile. Revista chilena de historia natural, 81(4):585-598.
Silva C, Saavedra B (2008) Knowing for controlling: Ecological effects of invasive vertebrates in Tierra del Fuego. Revista Chilena de Historia Natural 81:123-136.
Skewes O, Moraga C, Arriagada P Rau J (2012) El jabalí europeo (*Sus scrofa*): Un invasor biológico como presa reciente del puma (*Puma concolor*) en el sur de Chile. Revista chilena de historia natural, 85(2):227-232. http://dx.doi.org/10.4067/S0716-078X2012000200009
Smith AT, Boyer AF (2007) *Oryctolagus cuniculus* (Europe assessment). The IUCN Red List of Threatened Species 2007: e.T41291A10414811. Accessed on 24 June 2023.
Smith-Ramesh LM, Moore AC, Schmitz OJ (2016) Global synthesis suggests that food web connectance correlates to invasion resistance. Global Change Biology 23(2):465–473. https://doi.org/10.1111/gcb.13460
Spotorno AE, Palma RE, Valladares JP (2000) Biología de roedores reservorios de hantavirus en Chile. Revista chilena de infectología, 17(3):197-210
Tobar C, Rau J, Santibáñez A, Arriagada A, Sade S, Araneda R, Tello F (2014) Dieta del tiuque (*Milvago chimango*) en agroecosistemas de la ciudad de Osorno, sur de Chile. Boletín Chileno de Ornitología. 20:13-16
Travaini A, Donázar JA, Ceballos O, Hiraldo F (2001) Food habits of the Crested Caracara (*Caracara plancus*) in the Andean Patagonia: the role of breeding constraints. Journal of Arid Environments, 48:211–219. https://doi.org/10.1006/jare.2000.0745
Trejo A, Guthmann N, Lozada M (2005) Seasonal selectivity of Magellanic horned owl (*Bubo magellanicus*) on rodents. European Journal of Wildlife Research, 51:185-190.
Utrovicic M, Lagos N, Pacheco JC, Rivera A, Vergara P (2020) Confirmación de la presencia de gato del pajonal (*Leopardus colocolo*) en la Región de Magallanes y la Antártica Chilena, Chile. Notas Sobre Mamíferos Sudamericanos, 2. https://doi.org/10.31687/saremNMS.20.0.41

Valenzuela AEJ (2023) Lagomorpha: European hare and rabbit, liebre y conejo europeos. In: Valenzuela AEJ, Anderson CB, Ballari SA, Ojeda RA, (eds) Introduced invasive mammals of Argentina. Mendoza, Argentina: Sociedad Argentina para el Estudio de los Mamíferos. SAREM Mamological Research, Buenos Aires, pp 311-317.

Venegas C, Sielfeld W (1998) Catálogo de los vertebrados de la Región de Magallanes y Antártica Chilena. Ediciones de la Universidad de Magallanes, Punta Arenas.

Vera J (2008) Magallanes: dinámica económica y demográfica 1960-2006; leyes de excepción para el desarrollo; qué hacer y qué evitar. Magallania (Punta Arenas). 36(2):63-78. http://dx.doi.org/10.4067/S0718-22442008000200004

Villafuerte R, Delibes-Mateos M (2019) *Oryctolagus cuniculus* (errata version published in 2020). The IUCN Red List of Threatened Species 2019: e.T41291A170619657. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T41291A170619657.en.

Williams RJ (2010) Network 3D: Visualizing and modelling food webs and other complex networks. Microsoft Research, Cambridge, UK. http://research.microsoft.com/en-us/um/cambridge/groups/science/tools/network3d/netwo rk3d.htm

WSC (n.d) Especies: ZORRO CULPEO. WSC Chile. https://chile.wcs.org/Especies/Zorro-culpeo.aspx Accessed 1 July 2023

Xercavins A (1984) Notas sobre el clima de Magallanes (Chile). Revista de Geografía. 18(1):95-110.

Yoon I, Williams R, Levine E, Yoon S, Dunne J, Martinez N (2004) Webs on the Web (WoW): 3D visualization of ecological networks on the WWW for collaborative research and education. Proceedings of the International Society for Optical Engineering. 5295:124-132. DOI: 10.1117/12.526956

Yodzis P (1988). The indeterminacy of ecological interactions as perceived through perturbation experiments. Ecology, 69(2), 508-515.

Zapata SC, Travaini A, Martínez-Peck R (2001) Seasonal feeding habits of the Patagonian hog-nosed skunk *Conepatus humboldtii* in southern Patagonia. Acta Theriologica, 46(1):97–102. doi:10.1007/bf03192421

Zurita C, Soto N, Jaksic FM (2023) Historical ecology and current abundance of the translocated Chilla or Grey fox *Lycalopex griseus* on the large Tierra del Fuego Island shared by Argentina and Chile. Austral Ecology 48:481–497. https://doi.org/10.1111/aec.13285

Zurita C (2021) Antecedentes de la invasión de la especie exótica *Lycalopex griseus* (Zorro Gris o Chilla) en Isla Grande de Tierra del Fuego, Chile. Facultad de Ciencias Biológicas Pontifica Universidad Católica de Chile, Santiago. https://doi.org/10.7764/tesisUC/BIO/62913

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- JPCMannetalSMaterial.pdf