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Dispersal of the European hare, *Lepus europaeus* in South America

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Abstract. We provide an updated distribution and dispersal rate of the European hare (*Lepus europaeus* Pallas, 1778) introduced in South America, with georeferenced record localities. According to our results the current geographic distribution of the European hare, would cover practically all of Argentina, Chile and Uruguay, southeastern Peru, southwestern Bolivia, southeastern Paraguay, and central part of southern Brazil. During the process of invading new areas, the hare has occupied very dissimilar environments, from the bushy steppes and Andean deserts of Bolivia and Peru to the dry and humid forests and wooded savannahs of Paraguay and Brazil. This would explain the variation observed in the dispersal rates that varied between 10 and 37 km/year.

Key words: dispersal rate, exotic species, geographic distribution, range expansion

Introduction

The natural habitat of the European hare (*Lepus europaeus* Pallas, 1778) covers most of Europe except for Ireland, northeastern Great Britain and a large part of the Iberian and Scandinavian peninsulas. It has expanded its range across the continent, naturally and through translocations, to Siberia and the western Russian coast and has been successfully introduced to Australia, New Zealand as well as North and South America (Long 2003, Alves & Hackländer 2008).

In South America, the species was first introduced to Argentina in 1888 when 36 individuals from Germany were liberated in the proximity of Cañada de Gómez (32º 50'S, 61º24'W), Santa Fe province; a second introduction took place in 1897 close to Tandil (37º19'S, 59º08'W), Buenos Aires province, with hares originating from France (Carman 1976). Moreover, Carman (1976) mentioned an introduction to the Santa Cruz province that occurred in 1930, and Navas (1987) reported an introduction in Las Isletas, San Luis province; neither of these provided an origin for the hares.

For Chile, according to Grigera & Rapoport (1983), the hare was introduced to the south (Ultima Esperanza, Region XII) towards the end of the 19th century, although some authors (Howard 1969, Markham 1971) claim instead that this introduction actually occurred on Argentine territory. Grigera & Rapoport (1983) also noted that a subsequent liberation occurred in Valdivia and Osorno (Region X).

Since these introductions, the European hare has dispersed throughout various South American countries where, at the beginning of the 1980s, it occupied practically all of Argentina (except for Tierra del Fuego island), a large part of Chile up to the Copiapó river in the north, all of Uruguay, the southern part of the Tarija district in Bolivia, the Rio Grande do Sul and Santa Catarina states in southern

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Brazil, and a large part of Paraguay (Grigera & Rapoport 1983).

As determined 25 years ago by Grigera & Rapoport (1983), the European hare has continued to disperse and invade into new areas, expanding its geographical distribution; evidence of this is the first record of hares in southern Peru in 2002 (Cossíos 2004). Therefore, the objectives of this study are to update the geographic distribution of the European hare in South America, and to estimate the dispersal rate of this invasive species.

Material and Methods

The geographic distribution of the European hare was determined through complementary means: review of the published literature, consulting scientific institutions, non-governmental organizations and government agencies that manage wildlife, and field surveys. We performed field surveys on the basis of the map of hare distribution of Grigera & Rapoport (1983). We applied interviews to rural inhabitants, mainly in Peru and Brazil, about the presence or absence of hares in the surrounding area; simultaneously we surveyed the land searching by direct sightings or signs of individuals such as feces and carcasses. All the information was georeferenced using a GPS unit. Afterwards, this information was entered into a digitalized map in order to determine the respective geographic distribution and the velocity of the dispersion of this invasive species.

Results

Argentina

In this study, hares were found in several places not reported by Grigera & Rapoport (1983) such as the central and northwestern provinces and several sites in the Andean Cordillera from Mendoza to Jujuy (Table 1) at altitudes that can surpass 3 500 meters above sea level (Rinconada, Susques, Cerro Aconcagua, Reserva Laguna Brava, Socompa). In conclusion, the only Argentine region currently free of hares is the Tierra del Fuego province (an island shared with Chile).

The hare has practically occupied all the environments available in this country, from humid forests and shrub steppes in the south region to gramineous steppes and scrublands in the central one, and wooded savannahs and bushy steppes in the north region.

Chile

The hare had not yet reached the most northern Regions I and II of Chile when Grigera & Rapoport (1983) reported their northern limit as the Copiapó river in Region III. Yet soon afterwards, by the early 1990's, the hare had advanced into northern Chile from Bolivia (Iriarte 2008). Thus, today this exotic species inhabits the entire country with the exception of Tierra del Fuego island. In Chile the hare also invaded similar environments to those of Argentina.

Peru

Grigera & Rapoport (1983) did not record presence of hare in Peru since their census only included Argentina and bordering countries. The first registered sightings were in 2002 (Cossíos 2004); this author mentioned various sites with hares in Tacna county and a site in Arequipa county: both counties are located in southern Peru along the Pacific coast. In the current census, hares were recorded in other sites within these two counties. New records were also obtained in the Moquegua, Cusco and Puno counties, the last one being located west of Lake Titicaca, at the Bolivian border.

Interestingly, in Peru, the presence of hares was registered in places located in Tacna county, where altitudes vary from sea level (La Yarada, Los Palos) up to 4 400 meters above sea level (Jijuaña) (Cossíos 2004).

In conclusion, the boundary of the distribution of this exotic species in Peru can be drawn by an imaginary line that unites Jaguay

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(Arequipa county) and Yauri (Cusco county) (coordinates in Table 1). The main invaded habitats in this country are the bushy steppes and desertic areas from the coast to the Andean mountains.

Bolivia

Grigera & Rapoport (1983) reported hare in the vicinity of Tarija in Tarija county. According to a recent paper describing the distribution of the European hare in Bolivia (Salomone 2006), the current distributional area borders the counties of Potosí and Oruro and the southern part of the counties Chuquisaca, Cochabamba and La Paz. The northern distributional border is located at the meridian 14º48'S, close to the Peruvian border.

It is very likely that the hares recorded in Azangaro, Peru (Table 1) came from an expansion of the population present in the southern part of La Paz county, Bolivia. In this country, the hare occupied environments similar to those in Peru (bushy steppes and desertic areas).

Table 1. New localities of South America where the presence of hares was reported.

Country	Province/Department/State	Locality	Geographic coordinates
Argentina	Jujuy	Susques	23º25'34"S, 66º29'31"W
„	„	Rinconada	22º26'14"S, 66º10'47"W
„	Salta	Socompa	24º27'13"S, 68º17'18"W
„	Catamarca	Fiambalá	27º41'35"S, 67º37'19"W
„	„	Antofagasta de la Sierra	26º03'38"S, 67º24'26"W
„	La Rioja	Reserva Laguna Brava	28º24'00"S, 69º05'00"W
„	Tucumán	Monteros	27º12'10"S, 65º30'22"W
„	„	Tafí Viejo	26º45'14"S, 65º16'04"W
„	San Juan	Cerro Mercedario	31º57'59"S, 70º07'17"W
„	„ „	Reserva San Guillermo	29º25'00"S, 69º25'00"W
„	Mendoza	Cerro Aconcagua	32º39'18"S, 70º01'39"W
„	„	Valle Hermoso	35º06'19"S, 70º11'55"W
„	Chaco	Fuerte Esperanza	25º11'30"S, 61º55'09"W
„	„	Juan José Castelli	25º56'37"S, 60º37'41"W
„	Santiago del Estero	Campo Gallo	26º35'24"S, 62º52'41"W
„	„ „ „	Los Telares	28º59'16"S, 63º27'09"W
Peru	Tacna	La Yarada	18º11'01"S, 70º35'29"W
„	„	Los Palos	18º17'59"S, 70º25'59"W
„	„	Pacía	17º53'48"S, 70º09'18"W
„	„	Tarata	17º39'00"S, 70º01'47"W
„	„	Candarave	17º18'31"S, 70º17'28"W
„	Moquegua	Samegua	17º10'24"S, 70º54'23"W
„	„	Torata	17º03'35"S, 70º51'00"W
„	Arequipa	Jaguay	15º26'30"S, 71º05'12"W
„	„	Callalli	15º30'51"S, 71º27'30"W
„	„	Yura	16º13'57"S, 71º41'51"W
„	Puno	Chichillapi	16º55'47"S, 69º48'19"W

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,,	,,	Ancomarca	17º34’38”S, 69º32’37”W
,,	,,	Cairani	16º22’42”S, 70º21’32”W
,,	,,	Ucumani	15º52’14”S, 70º11’50”W
,,	,,	Azangaro	14º55’43”S, 70º13’09”W
,,	Cusco	Yauri	14º47’29”S, 71º24’45”W
Paraguay	Alto Paraná	Santa Rita	25º46’09”S, 55º04’28”W
,,	,, ,,	Colonia Yacubó	26º16’08”S, 55º59’11”W
,,	Itapúa	Pirapó	26º50’59”S, 55º32’23”W
,,	,,	Nueva Gambach	26º38’13”S, 55º39’50”W
,,	,,	Coronel Bogado	27º10’11”S, 56º15’01”W
,,	,,	Reserva San Rafael	26º40’00”S, 54º53’00”W
,,	Canindeyú	Reserva Biol. Carapá	24º16’00”S, 54º22’00”W
,,	Ñeembucú	Estancia Aquino	26º58’03”S, 57º53’25”W
,,	,,	Estancia Santa Rosa	26º40’33”S, 56º13’05”W
,,	Presidente Hayes	Estancia Santa Asunción	23º52’50”S, 58º33’56”W
Brazil	Paraná	Curitiba	25º25’49”S, 49º17’03”W
,,	,,	Medianeira	25º18’31”S, 54º04’21”W
,,	,,	Paranavaí	23º05’21”S, 52º29’17”W
,,	,,	Piraquara	25º25’59”S, 49º04’00”W
,,	,,	Ponta Grossa	25º11’13”S, 50º08’32”W
,,	São Paulo	Icém	20º20’38”S, 49º11’47”W
,,	,, ,,	Nantes	22º30’59”S, 51º14’59”W
,,	,, ,,	Pirapozinho	22º16’10”S, 51º29’27”W
,,	,, ,,	Presidente Epitácio	21º45’56”S, 52º06’17”W
,,	,, ,,	Rancharia	22º13’49”S, 50º53’04”W
,,	,, ,,	Sandovalina	22º27’21”S, 51º45’35”W
,,	,, ,,	Teodoro Sampaio	22º31’34”S, 52º10’10”W
,,	Minas Gerais	Planura	20º08’26”S, 48º42’11”W
,,	,, ,,	Frutal	20º01’45”S, 48º56’06”W
,,	,, ,,	Capinópolis	18º40’44”S, 49º34’00”W

Paraguay

Grigera & Rapoport (1983) recorded the presence of hares in only one site, Fort General Díaz, which is located a few kilometers from the Argentine border in the extreme south of Boquerón county. However, doubt is cast upon this record as our study did not find any presence of hare in the western area of Paraguay where Boquerón county is located. Instead, hare presence was confirmed in several counties of the eastern region of the country (Table 1). The habitat of this region is characterized mainly by forests and wooded savannahs, generally with a great alteration of anthropic origin.

Brazil

Grigera & Rapoport (1983) found the hare to be restricted to the states of Rio Grande do Sul and Santa Catarina in the south of Brazil. In this study, an important expansion was observed particularly towards the north of the country, invading all the state of Paraná

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and the western part of Sao Paulo and Minas Gerais states. Currently, from these two states, there are no expansion movements towards the east. Considering the state of Mato Grosso do Sul, located at northwest of Paraná and west of Sao Paulo states, invasions of the hare have not been noted too; this could be due to the presence of the Paraná river, which would act as a geographical barrier. The northern border of the current distribution of hare in Brazil would be located in the area of Capinópolis (Table 1), in the northwest of the state of Minas Gerais, near the border with the state of Goiás. The areas invaded by the hare in the south of Brazil are principally those originated by the deforestation of the subtropical forests.

Finally, we can say that the current geographic distribution of the European hare in South America would cover practically all of Argentina, Chile and Uruguay, southeastern Peru, southwestern Bolivia, southeastern Paraguay, and the central part of southern Brazil (Fig. 1).

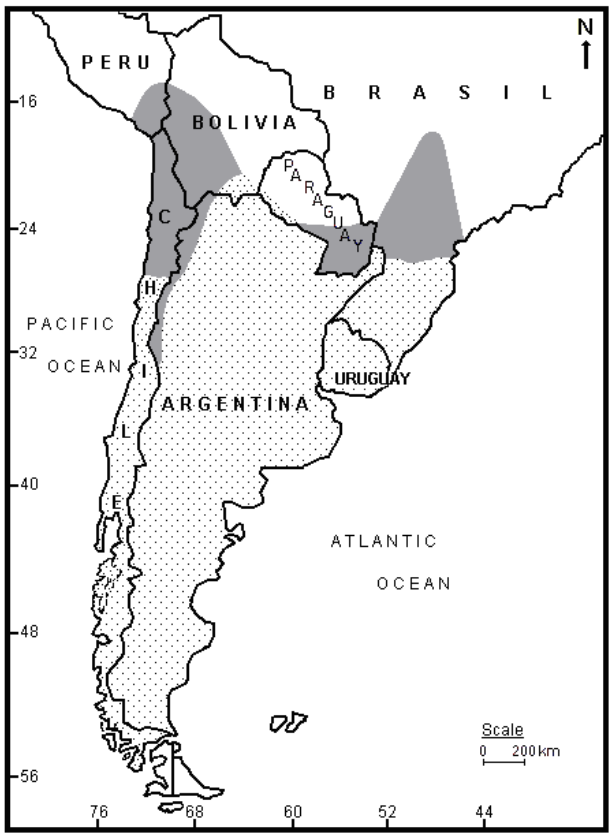


Fig. 1. Current distribution of the European hare in South America (the dotted area shows the distribution according to Grigera & Rapoport 1983; the grey area represents dispersal during the 1983-2006 period).

In this study, the dispersal rate varied according to the area under consideration. In Brazil, when using Santa Catarina as the border for the distribution in 1982 (Grigera & Rapoport 1983), the average dispersal rate was approximately 37 km/year. For Peru, if the county of Tarija in Bolivia is considered as the starting point, as did Cossíos (2004), then the average dispersal rate was 34 km/year, slightly less than the estimate for Brazil. Salomone (2006) didn't give any values for the expansion of hare in Bolivia, and in this survey we estimate an average rate of approximately 30 km/year. Finally, in Paraguay the dispersal rate varied between 10 and 17 km/year, depending on the region of country being evaluated.

Discussion

During the process of dispersing to and invading new areas in South America, the hare has occupied very dissimilar environments, from the bushy steppes and Andean deserts of Bolivia and Peru to the dry and humid forests and wooded savannahs of Argentina, Paraguay and Brazil. Thus, the European hare would show to have a great ecological plasticity. Therefore we expected that this species continue to disperse towards the northern part of South America, particularly the western portion where the Andean region would serve as a corridor, which is not a geographic or ecological barrier to the dispersion of this species, as was already demonstrated in Chile (Jaksic et al. 2002). In contrast, in the central and eastern part of the continent, the Amazon rainforest would create a barrier to the hare's expansion.

While the role of human intervention in the process of dispersion is not well understood, it could indirectly support such a process. For example, the profound transformation of the subtropical forests of southern Brazil and Paraguay to a cattle ranching-farming landscape (Hueck 1978) would have facilitated the invasion of this exotic species.

Regarding the rate of dispersal, in this study the registered values varied between 10 and 37 km/year. Grigera & Rapoport (1983)

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estimated values that varied between 18.6 and 20 km/year, depending on the area invaded (to northern and southern Argentina) and what site of liberation was considered (Buenos Aires province, Argentine or the region of Ultima Esperanza, Chile). Cossíos (2004), who regarded the Tarija county, Bolivia, as the place of origin from where the hare invaded Peru, recorded a dispersal velocity of approximately 44 km/year. This variation between the dispersal values registered by different authors could be originated by one or more factors, such as geographic barriers, hare density, habitat disponibility (Drake et al. 1989, Williamson 1996).

It does more than 100 years that hares are established in Argentina and Chile where they has obtained a self-sustaining population and supplement the food base of the top carnivores, such as *Puma concolor* (Pessino et al. 2001, Rau & Jiménez 2002), *Pseudalopex culpaeus* (Jaksic et al. 1983, Pía et al. 2003), *P. griseus* (Novaro et al. 2004), *P. gymnocercus* (García & Kittlein 2005), and *Oncifelis geoffroyi* (Manfredi et al. 2004, Novaro et al. 2000). Only for Argentina there are data on population density: in the central region (Province of Buenos Aires) the mean density is 50 hares/km^2 (Parisi, pers. comm.) and in the south region (Province of Neuquen) the mean value is 47 hares/km^2 (Novaro et al. 2000).

The European hare is catalogued as a pest species in Argentina and Chile where is known that cause economic and ecological damages (Bonino 1995, Jaksic 1998). It has also been reported to damage crops and orchards in Bolivia (Salomone 2006) and in Peru (Cossíos 2004). Commercial and sport hunting are the methods most often used to control the hare populations in some countries. In Argentina, approximately 2.5 million hares were shot annually for their meat in the last decade, since they were exported to Europe; pelts and furs were also shipped abroad as well as live animals for restocking Old World hunting areas (A. García Riva, pers. comm.). Chile and Uruguay export approximately 200 and 100 tons/year of hare meat, respectively (N. Soto Volkart, pers. comm.). In the remaining countries commercial hunting does not exist. Only Bolivia has reported subsistence hunting of hare by the rural communities (Salomone 2006).

Conclusions

Our results show a notable increase of the European hare distribution in South America. Therefore, regular monitoring is necessary for the early detection and management of newly established populations. Field surveys to determine the current status of this exotic species in each country, as well as its biology and ecology, must be carried out. According to the obtained data, this invasive species could be a potential threat to agriculture, livestock, forestry, and natural ecosystems. Nevertheless, there is almost no information regarding the economic and environmental costs of the European hare in South America.

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