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EXPANSION OF THE INTRODUCED WILD BOAR *(Sus scrofa)* IN THE ANDEAN REGION, ARGENTINEAN PATAGONIA

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Abstract

Wild boar (*Sus scrofa*) from Siberia were introduced into Patagonia (Argentina) between 1904 and the 1920s. Wild boar were first observed in the Lanín National Park in the 1980s. Their invasion pattern follows rivers and lakes, moving vertically from the original release site in the eastern steppes to the western hillsides. During the last 20 years, the area occupied by wild boar has increased throughout the park from 10% in 1985 to nearly 30% two decades later, mainly in *Araucaria-Nothofagus* forests and scrubland. These landscapes hold 83% of the current wild boar distribution, with a statistically significant three-fold increase (Sr = 0.891, $p<0.01$). Pine plantations, grassland–steppe and bare ground are less favoured by the species, with only a two-fold increase or less during the last two decades. Its distribution range has increased to over 70000 ha during the last 20 years, with an average increase of about 3500 ha/y. At this rate, the species would need 50-60 years to cover the entire Lanín National Park, but cold winters, years with poor *Araucaria-Nothofagus* seed production, increasing predation by puma (*Puma concolor*), and the possible appearance of new parasites and diseases as the population increases could limit wild boar dispersal to a lower rate.

Key words: Exotic species, expansion, wild boar, Patagonia.

Resumen

*Expansión del jabalí (*Sus scrofa*) en la región andina de la Patagonia argentina*

El jabalí (*Sus scrofa*) fue introducido en Patagonia (Argentina) desde 1904 hasta la década de 1920, principalmente con animales importados de Siberia. Las primeras observaciones de jabalí en el Parque Nacional Lanín fueron realizadas en los años 80 del pasado siglo. La pauta de la invasión de la especie se desarrolla por ríos y lagos, moviéndose hacia arriba en altitud, desde los

puntos de liberación original en las estepas orientales hacia las laderas occidentales de la cordillera andina. La superficie ocupada por jabalí ha aumentado en el Parque, durante los últimos 20 años, entre un 10% en 1985, a cerca del 30% de su superficie, principalmente en los bosques de *Araucaria-Nothofagus* y en zonas de matorral. Estos paisajes mantienen el 83% de la distribución actual del jabalí, con un aumento estadísticamente significativo, y triplicando su utilización (S_r = 0,891, p<0.01). Las plantaciones de pino, zonas de estepas y suelo descubierto son menos preferidas por la especie; con sólo el doble, o un menor aumento entre las dos décadas. El jabalí ha expandido su distribución más de 70.000 ha durante los últimos 20 años, con un promedio de 3.500 ha/año. Con dicha tasa de expansión, la especie necesitaría de 50 a 60 años para cubrir el área del P.N. Lanín. Sin embargo, inviernos fríos, años con escasa producción en semillas de *Araucaria-Nothofagus*, la depredación creciente por Puma (*Puma concolor),* y la posible aparición de nuevos parásitos y enfermedades debido al aumento poblacional, podrían limitar la dispersión de jabalí en la región.

Palabras Clave: especie exótica, expansión, jabalí, Patagonia.

Introduction

The wild boar (*Sus scrofa* Linnaeus, 1758) has been introduced in many regions of the world. In Argentina, the first feral populations were derived from several breeds of domestic pigs released after the Spanish colonization (Crosby 1986), and currently large herds of feral animals are established in Buenos Aires province (Merino and Carpinetti 2003). In addition, pure Eurasian wild boars have been introduced into Patagonia, southern Argentina. These first pure boars -with Siberian origin- were introduced into the La Pampa province from 1904 to 1906. In 1917 and 1922 some individuals from this stock were moved to northern Patagonia (Neuquén province). A third introduction from the old La Pampa-breed stock was done in the south -in the Río Negro province- during 1924 and 1926 (Daciuk 1978). Since these latter two introductions, the wild boar has expanded throughout the Andes and nearby hillsides, invading other provinces in Patagonia and Chile (Navas 1987, Bonino 1995, Jaksic *et al.* 2002). This invasive trend does not seem to be stabilized since there are potential habitats still awaiting occupancy.

Currently there is little information about this species in Patagonia. According to previous hunting records and dispersed observations, wild boars occur the Patagonian provinces of Neuquén, Rio Negro, Chubut and Santa Cruz, as well as nearby the Chilean border.

The objective of the present work is to prospect the colonization by wild boars across a large area of Argentina, namely the Lanín National Park in Neuquén province. The research covers 20 years from the first observations of the species in the Park. This area includes most of the Patagonian landscape types and could provide information concerning the expansion of the species throughout the region.

Material and methods

Study Area

The Lanín N. P. (39-41º S, 70-72º W), created in 1937, covers about 380000 ha in the northern Patagonian region (Figure 1). Annual average rainfall decreases abruptly from west to east, with more than 3000 mm per year on the western side of the Andes and only 200 mm on the steppe (Barros *et al.*, 1983). Rain mainly occurs during the colder period of the year (April to September) and the summer (December to February) are often very dry. Much of the winter precipitation falls as snow. Average January (summer) temperatures are 17-19ºC, whereas average July (winter) temperatures ranged 7-8ºC (De Fina 1972, Heusser *et al.* 1988).

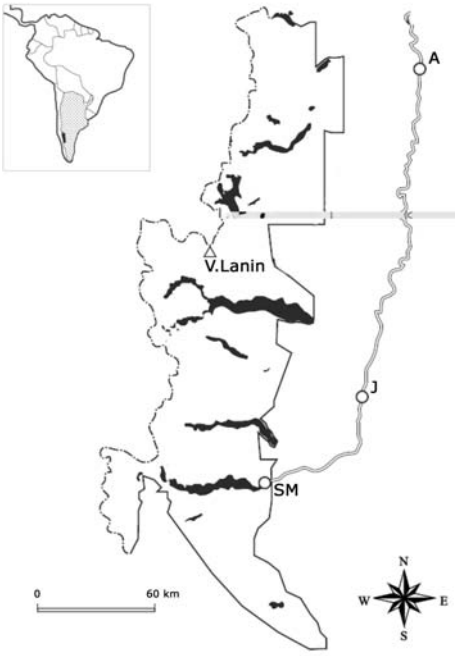

Figure 1. Study area of Lanín National Park, Patagonia, Argentina. V.Lanin Lanín Volcano, A Aluminé, J Junín de los Andes, SM San Martín de los Andes.

Área de estudio en el Parque Nacional Lanín, Patagonia, Argentina. V.Lanin Volcán Lanín, A Aluminé, J Junín de los Andes, SM San Martín de los Andes.

The vegetation varies considerably along the precipitation gradient. On the rainy western sides, a native forest of broad-leaved trees, such as the Pellin, Raulí, Ñire and Coihué (*Nothofagus spp.*) and Maitén (*Maytenus boari*) within

dense shrubs of Coligüe cane (*Chusquea culeou*), predominates. Many shrubs from Europe, such as *Rubus*, *Rosa* and *Crataegus*, account for large patches of the native forest. Within the National Park and nearby Chile, are the Pehuén forest (*Araucaria araucana*), forming pure or mixed stands with the native oaks (*Nothofagus* spp.*)* from 1000 to 1800 m.a.s.l. (Laclau 1997). The Araucaria produce large seeds, with sizes similar to those of the European oak *Quercus* spp., and are highly palatable for the wild boars (Rosell *et al.* 2001). In any case, the extension of the Pehuén forest in the region is low in comparison with the huge surface covered by *Nothofagus spp*. In the south of Lanín National Park, another conifer -*Austrocedrus chilensis* - increases its cover, mixed with *Nothofagus* spp., although this species does not have large seeds.

In places with rains between 1500 and 700 mm, a transition landscape exists from the native forest to the Patagonian steppe. These areas have open forest located on humid sites such as valleys, south-facing slopes, or riparian habitats. Humid natural pastures -known locally as "*mallines*"- occur in valleys on temporary floodplains near rivers and creeks, from 700 to 1000 m.a.s.l. On some slopes and valleys, exotic plantations of pine (*Pinu*s spp.) under 30 years old cover small patches of the landscape.

The driest places of the region, with less than 500 mm, are dominated by thorny shrubs and herbaceous species (*Stipa* spp. *Poa* spp. *and Festuca spp*.) at 600-700 m.a.s.l. Humid sites with green pastures are scarce and are restricted to the floodplain sections of only a few large rivers in this area. The grassland surface covers 22740 ha of the Park.

According to P.N. staff, main native mammal species of the park, include Coypu *Myocastor coypus,* Huiña Cat *Felis guigna,* Pudu deer *Pudu pudu,* Mountain lion *Puma concolor* and Red Fox *Dusicyon culpaeus,* and introduced species such as Red Deer *Cervus elaphus,* Mink *Mutela vison*, Hare *Lepus europaeus* and Rabbit *Oryctolagus cunniculus.*

Distribution and relative abundance of wild boar

Although observations of wild boar in and around the region date back to the 40´s, the first regular observations of the species at the Lanín N. P. come from the beginning of the 80´s. An initial study regarding the presence and the relative abundance of wild boar was undertaken in 1985 and repeated in 2005,

taking into account most of the methodology employed in that first study carried out in 1985. In both years, observations were made by biologists and ranger-members of the Park staff (ranging from 9 in 1985 to 12 people in 2005), who regularly went to the same tracks on foot a distance of 4-6 km, once a month from September to May. From June to August heavy snow limited sampling. Observed animals alive, hunted specimens, and/or their tracks, such as number of droppings per sampled area and signs of rooting were registered. All data took into account the type of landscape where the observation was done. Any direct or indirect observation on the species, was represented as presence into a 1:10000 map. In order to analyze the data, the different landscapes of the Park were grouped as follows: 1) *Araucaria* forest, 2) broad-leaved forest of *Nothofagus* spp, 3) shrubland or brushwood, 4) exotic pine plantation, 5) grassland-steppe and 6) bare soil or with a short grass cover (<2 cm). Possible relationships between years and area colonized, was analyzed by a Spearman Correlation Test.

Comparison between the distribution of wild boars and landscape colonization integrates data from different collaborators, because the rangers on duty during 2005 were different from those who were there in 1985. In any case, the comparison is compatible with the goal of the work, namely the spread of wild boar over a fairly long time and the relative dispersal between years according to landscape types.

Results

The invasion pattern and spread rate of the species were appreciable along rivers and lakes, moving upwards along an east-west direction, from the original eastern steppes and bare grounds to the western hillsides and mountains. The surface occupied by wild boar has increased over the last 20 years in all landscape types, but especially in the *Araucaria*, *Nothofagus* forests and shrubland; landscapes with a statistically significant three-fold increase in occupation over this period ($S_r = 0.891$, $p<0.01$) (Figure 2).

The wild boar was present in over 10% of the Park in 1985, but increased nearly 30% of its cover area two decades later. This increase was basically supported by the three above-mentioned landscapes, which support 83% of the current wild boar distribution, whereas the others - first occupied from the eastern side of the

range: pine plantations, grasslands-steppes and bare grounds - are currently less preferred by the species, with only a two-fold or lower occupation during the last two decades.

According to the present data, the wild boar has increased its distribution area by approximately 70,000 ha during the last 20 years, - from nearly 39000 in 1985 to 114,000 in 2005 - with an annual average of about 3,500 ha.

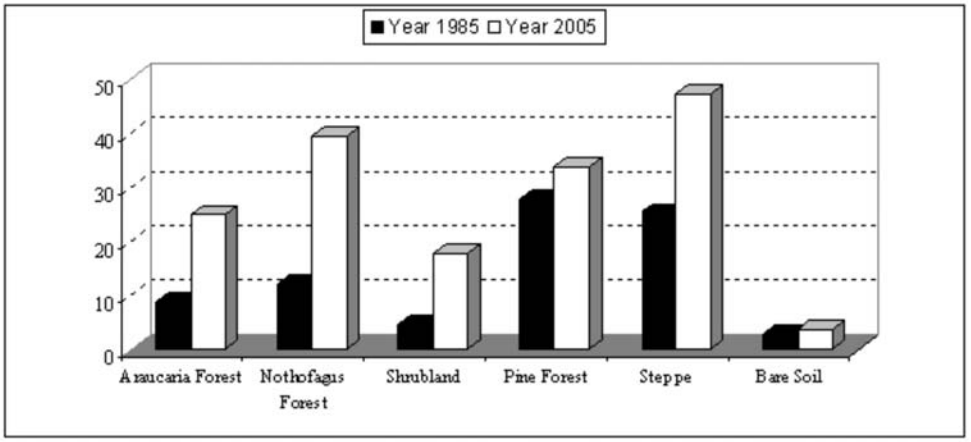

Figure 2. Percentage of occupation of the wild boar in different landscape types of the Lanín N. P. during the years 1985 and 2005, respectively.

Porcentaje de ocupación por el jabalí de los diferentes paisajes del P. N. Lanín, en 1985 y 2005, respectivamente.

Discussion

Natural populations of animals are regulated by forces controlling "Top-Down" or "Bottom-Up" processes (Hairston *et al.* 1960, Andrzejewski and Jezierski 1978, Dardaillon and Beugnon 1987). The "Bottom-Up" forces that regulate wild boar populations are the availability of food, water and refuge (Crawley 1992, Mclaren and Peterson 1994). In contrast, "Top-Down" regulations may involve the activities of predators, outbreaks of disease, or hunting (Silman *et al.* 2003). Patagonia and European countries differ as regards the identity and strength of these forces applied to wild boar.

In most European countries, the availability of food and refuge for the wild boar has contributed significantly for the population increasing during the XX century, related to a reduction in the livestock that browse the forest under-story and eat the acorns of different species of oaks *Quercus* spp., thereby altering their natural regeneration (Massei and Genov 2004). Also, the socioeconomic changes that have taken place in Europe in this period have led to the abandonment of rural farming practices and increases the areas devoted to crops, such as maize, and brushwood and conifer plantations (Herrero *et al.* 2006). Currently, wild boars occupy most of Europe, even spreading into Scandinavian countries (Rosvold and Andersen 2008), but also in dry countries such as Spain, where they occupy more than 2/3 of the country, mainly the Mediterranean shrubby landscape, with a recovery pattern and spread rate of 20% from the 60´s onwards (Sáez-Royuela and Tellería 1986, Rosell and Herrero 2007).

The important extent of European oak *Quercus spp*. forests provides a valuable food resource for wild boar. Since these forests produce seeds following a masting pattern, they are not a stable source over time and, in periods of dearth, agricultural fields offer a secondary source for this ungulate, providing food constantly year by year and especially during summer, when no food from oaks is available (Abaigar 1993, Sáenz de Buruaga 1995, Herrero *et al.* 2006). The system has been improved due to the appearance of new croplands, such as maize (*Zea mays*), which provides a stable source of food that is not influenced by weather conditions, since most of it is grown on irrigated land. In fact, the increase of this culture in recent years has led to an increase in wild boar hunting as well as in highways collisions (Peris *et al.* 2005).

In contrast, in Patagonia the species appears on a land that has been used for cattle ranching from the middle of the XIX century, although this activity has been reduced in most of the region owing to the creation of huge National Parks that cover nearly half of the study area. Additionally, the number of settlements was reduced during the first half of the XX century. So, when *S. scrofa* was introduced into Patagonia, the condition of the habitat was optimal for the species, providing unlimited opportunities for refuge and food.

Nevertheless, Patagonia has fewer forest tree producers of large seeds, although it probably has more food in terms of biomass because of greater precipitation, although probably of lower quality in comparison with European countries

(Groves 1991). Also, most sources have a varying food availability, related to weather cycles and predator competition. Thus, in each Austral autumn (March-April), wild boar consume about 78% of the *Araucaria* seeds produced and about 11% of those from *Nothofagus* spp (Sanguineti and Kitzberger 2008). In any case, seed production in both genera of trees is highly variable among years, and competition for seeds by native predators -rodents- seems to be high (Pelliza *et al.* 2001).

The steep precipitation gradient in Patagonia could influence the preference of wild boar for forest and brush-land at high altitude, although cold conditions in winter and at the beginning of spring could be critical (Erkinaro *et al.* 1982). According to hunters, the species show seasonal movements towards lower altitudes during the winter season, as occur in European mountain areas (Rosell *et al.* 2006). On the drier eastern side, the limitation in water supply during winter and spring is probably, the main factor affecting food availability- and the species only occurs in floodplain and riparian habitats (Massei *et al.* 1997).

Worldwide, the population density of wild boar is highly variable and depends on intra-specific competition for food -resulting in fluctuations in mast production of acorns- and on the influence of the weather (Matschke 1967, Singer and Ackerman 1981, Cahill and Llimona 2004, Uzal and Nores 2004). Thus, the species population density has passed from 0.2 to 43 animals/100 ha worldwide (Massei and Genov 2004); 0.4 to 12 animals/100 ha in Spain, the country with the highest densities, in close relationship with the dense presence of Mediterranean shrubs (Rosell *et al.* 2001). At present, no data on the wild boar population densities in the Lanín area are available, but taking in account the currently occupied area of the most suitable habitats (native forest with seasonal acorns and shrub-land) and a conservative average density of 8-2 animals/100 ha, the current population at Lanin NP could be estimated about 7,000-12,000 animals.

Wild boar hunting is an important cause of mortality of the species in Europe, in which between 25 to 37% of the population is usually eliminated, although this is not enough to stabilize population levels (Leránoz and Castién 1996). In contrast, in Patagonia the hunting of *S. scrofa* is not significant, with less than 110-130 animals hunted -legal and poached together- per year (author's data).

In places of Europe where the wolf (*Canis lupus)* is abundant, predation on young animals and piglets reduces reproductive capacity, with a two-year period and a delay time in reproductive recruitment, by reducing body size in the population (Meriggi *et al.* 1996). In Patagonia, wild boar predation by the mountain lion (*P. concolor*) may be high, considering the wide distribution and increased abundance of this species, which is also sustained by a new source of abundant food from introduced herbivores such as the red deer *C. elaphus*, hare *L. europaeus,* rabbit *O. cunniculus,* and the domestic livestock (Novaro *et al.* 2000). Own information about *Puma* predation on wild boar indicates that the felines mainly prey on young animals (< 2 years old). The predator would take advantage of the spatial aggregation of boars during autumn, when *Araucaria* acorns and other resources are concentrated (Sanguinetti and Kitzberger 2008). Pumas may have an especially strong predation effect on wild boar populations in years with heavy snow and when weather conditions have reduced food availability. In fact, in other countries the wild boar is largely predated by large felines such as the tiger (*Panthera tiger*), and its density remains low until a reduction in predator numbers has occurred by culling, when prey species may jump from 1 ind/km^2 to 27-48 ind/km^2 in some countries (Reddy *et al.* 2004).

In Europe, wild boar -particularly young animals- are affected by Coccidae infections such as *Eimeria*, *Toxoplasma* and *Pasterella* as well as by viruses (Gerard *et al.* 1991). However, for the time being these parasites have not been observed in Patagonia.

At the current rate of spread, the species will need at least 50-60 years to cover the whole area, but snowy winters, years with poor acorn production, increasing predation by pumas and the possible appearance of new parasites and diseases as its population increases could mean that colonization of the area by the wild boar may occur at a slower rate.

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