



Artículo

HISTORY OF THE INTRODUCTION AND PRESENT DISTRIBUTION OF THE EUROPEAN WILD BOAR (*Sus scrofa*) IN CHILE

Oscar Skewes¹ and Fabián M. Jaksic²

¹ Laboratorio de Vida Silvestre y Ecología, Facultad de Ciencias Veterinarias, Universidad de Concepción, Casilla 537, Cod. Postal 3812120, Chillán, Chile. [Correspondence: Oscar Skewes <oskewes@udec.cl>]

² Center of Applied Ecology & Sustainability (CAPES), Universidad Católica de Chile, Santiago, Chile.

ABSTRACT. The European wild boar (*Sus scrofa*) is an alien even-toed ungulate in Chile and little is known about its introduction and current distribution. The data contributed by this study are the result of interviews and fieldwork conducted between 1986 and 1990; this information was brought up to date between 2010 and 2012. The collected data indicate that the oldest wild boar population on Chilean soil dates back to 1950, with ancestors that were imported directly from Germany. Later on, between 1956 and 1970, wild boars migrated from Argentina across Andean mountain passes. The present populations were also initiated by wild boars that were deliberately released or that escaped accidentally from clandestine farms between 2002 and 2009, mainly in the central region of Chile. The most likely reason for the release of these animals is the establishment of a species for sport hunting. In addition, the largest part of the current population in the south of Chile has been fueled by wild boars entering from Argentina, crossing the border for reasons yet unknown. At present, the wild boar inhabits an area of 27 600 km² in Chile, which represents an increment of 51.6% in the occupied area since 1990. The ecological attributes of this invasive mammal, its value for hunting, and changes in the land use, indicate that the wild boar will increase its distribution towards central and southernmost Chile, which will affect biodiversity, agriculture, and livestock of this extensive area.

RESUMEN. Historia de la introducción y distribución actual del jabalí europeo (*Sus scrofa*) en Chile. El jabalí europeo (*Sus scrofa*) es un artiodáctilo exótico en Chile de cuya historia de introducción y distribución actual se sabe poco. Los datos aportados por este estudio son el resultado de entrevistas y trabajo de campo realizados entre 1986 y 1990; esta información se actualizó entre 2010 y 2012. Los datos recopilados indican que la población de jabalí silvestre más antigua en suelo chileno se remonta a 1950, con antepasados importados directamente de Alemania. Más tarde, de 1956 a 1970, los jabalíes emigraron de Argentina a través de pasos cordilleranos de los Andes. Las poblaciones de jabalíes presentes en Chile también son el resultado de liberaciones intencionales o escapes accidentales de criaderos clandestinos entre 2002 y 2009, principalmente en la región central de Chile. La razón más probable de la liberación de estos animales es el establecimiento de una especie para la caza deportiva. No obstante, la mayor parte de la población actual en el sur de Chile ha sido impulsada por jabalíes inmigrantes de Argentina, que cruzaron la frontera por razones aún desconocidas. En la actualidad, los jabalíes habitan un área de 27 600 km² en Chile, lo que representa un incremento de 51.6% con respecto al área ocupada en 1990. Los atributos ecológicos de este mamífero invasivo, su valor para la caza y los cambios en el uso del suelo, indican que aumentará su distribución hacia el centro y sur de Chile, lo que afectará la biodiversidad, la agricultura y la ganadería de esta extensa área.

Key words: Andes. Boar-farms. Dispersal. Escapees. Invasive.

Palabras clave: Andes. Criaderos. Dispersión. Escapees. Invasora

INTRODUCTION

The European wild boar (*Sus scrofa scrofa*), an even-toed ungulate (Artiodactyla), is an opportunistic omnivore native of Eurasia that inhabits a wide variety of habitats, both in its native range and in the different continents where it has been introduced (Long, 2003). Over the last decades, populations of wild boars have increased considerably in size (Sáez-Royuela and Tellería, 1986), due to biological, environmental, and anthropogenic factors (Genov, 1981). The latter have made it possible for this species to advance as far north as latitude 60°N, including Scandinavian countries and Russia. Overall, the natural expansion of the wild boar towards new areas is associated with new food sources raised by humans and it is not restricted by climatic boundaries (Rosvold and Andersen, 2008). On the other hand, the presence of predators such as wolves (*Canis lupus*) has a weak impact on the density of wild boars at a bio-geographical level in Eurasia (Melis et al., 2006).

In South America, the European wild boar was introduced for hunting purposes in Argentina, Uruguay, Chile, Brazil, and Paraguay (De Oliveira, 2012). Records about the origin and dates of establishment of this species in Chile are scant (Skewes, 1990; Jaksic et al. 2002; Skewes et al., 2007) or conflicting (Jaksic and Castro, 2010), and there is no updated information about its current distribution. Because wild boars can exert a negative impact on natural ecosystems, agriculture, and public health (Lowe et al., 2000; Gortázar et al., 2007; Barrios-García and Ballari, 2012), there is a need to assess the spread of this invasive species, both to prevent its expansion towards new areas and to design management plans. This study intends to provide information about the history of the introduction and expansion of the wild boar in Chile.

MATERIALS AND METHODS

Analysis of the geographical distribution of the wild boar was based on the records compiled by Skewes (1990), in addition to an exhaustive literature review. Likewise, from 2010 to 2012, this information was brought up to date through surveys asking about

the presence of wild boar, age and origin of those populations, and damages and factors that would regulate those populations. These surveys were conducted among Chilean State organisms (n=75) related to agriculture and forestry throughout the country—Corporación Nacional Forestal CONAF (National Forestry Corporation), Instituto de Desarrollo Agropecuario INDAP (Institute of Agricultural Development), and Servicio Agrícola y Ganadero SAG (Agricultural and Livestock Service)—in addition to interviews with wild boar hunters across the country (n=108). Inhabitants of the piedmont of the Andes range in the administrative regions of O'Higgins to Aysén were also consulted regarding the presence of wild boars (n=315) (Fig. 1). In the areas where the interviewees mentioned that the presence of wild boars was relatively recent, such as in the central regions of O'Higgins and El Maule, this was verified with images of the species supplied by residents and with 26 random marching transects through paths or cross country of variable length (from 6 to 18 km, totaling 225 km) in search of signs of the species (e.g., tracks, marks, excrements). We mapped all the positive records of wild boar (past or present) using satellite images (Google Earth, Google Inc., Data SIO, NOAA, U.S. Navy, NGA, GEBCO ©2014 Mapcity Image Landsat, ©2014 Inav/Geosistemas SRL) and we calculated the invaded area using the minimum convex polygons, a standard method for estimating species' ranges (Burgman and Fox, 2003). Polygons contained all positive points indicating the presence of wild boar, including areas without information but where mountain range and forests were considered key elements for boar dispersal (Virgós, 2002).

RESULTS

History of wild boar introductions

Results show four different origins of the present populations of wild boars in Chile: (1) direct import from Germany (1938-1950), (2) natural immigration from Argentina (1956-1970), (3) release of wild boars into the environment (2002-2009), and (4) escape from boar farms (2008-2009) (Table 1).

Direct import of wild boars occurred in 1938 when Mr. Carlos Haverbeck traveled to Germany and imported an unknown number of wild boars (*Sus scrofa*) to populate his property in Allipén, near the city of Villarica (Mrs. L. Allende-Haverbeck, granddaughter

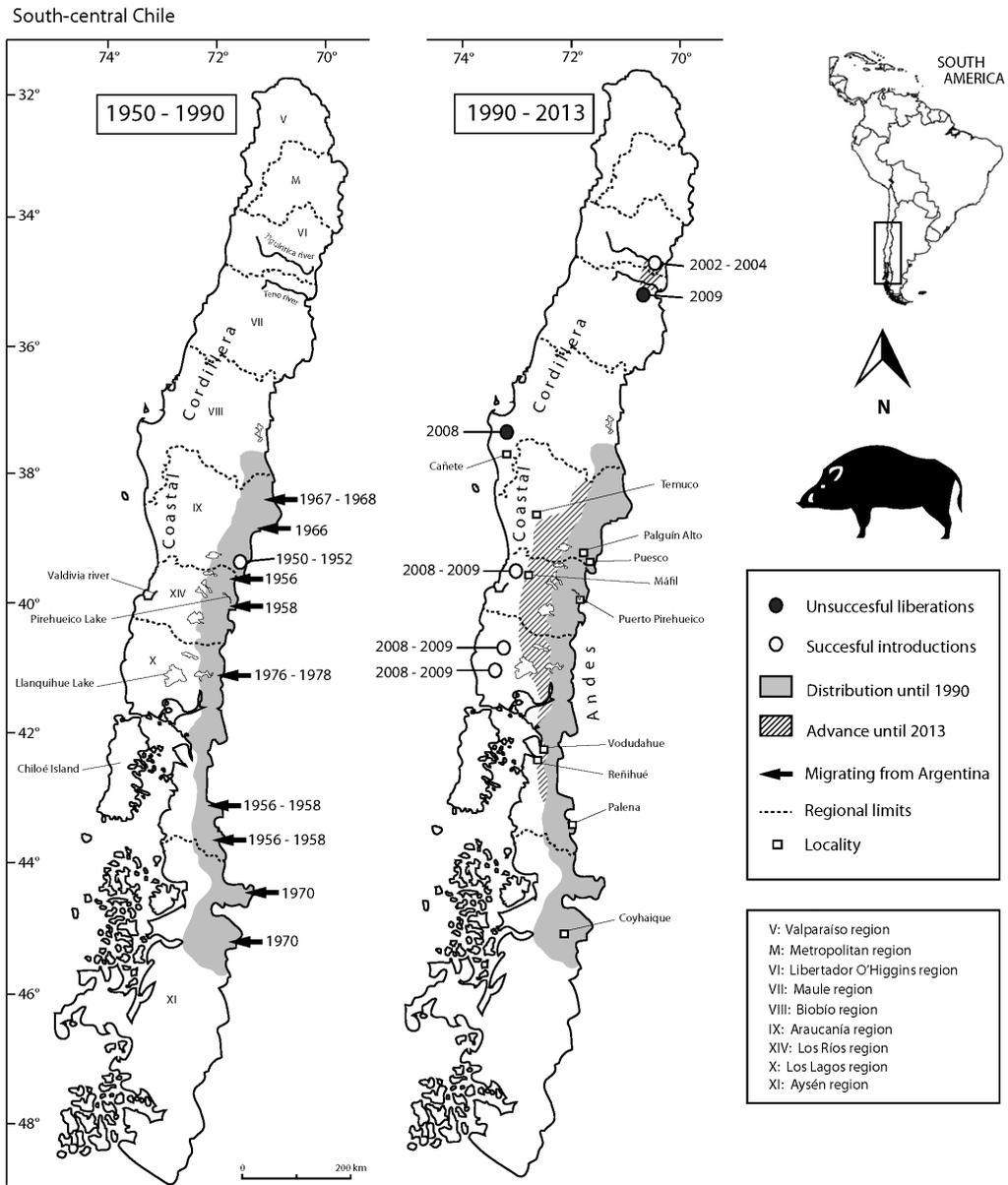


Fig. 1. Past and present distribution of wild boar populations in Chile, indicating their origin.

of C. Haverbeck, personal communication in Allipén Ranch, 1988). In 1935 he had already imported wild animals from Germany, including 44 pheasants (*Phasianus colchicus*), 15 roe deer (*Capreolus capreolus*), and 6 red deer (*Cervus elaphus*) (Correo de Valdivia, 1935). After their introduction in 1938, the wild

boars escaped from the property and caused damage in neighboring fields. From 1946 to 1948, Mr. Haverbeck arranged the capture of 24 females and 3 males, which were then transported by truck and released in the area of Puesto in Villarrica National Park (Gómez Luna, 1984) (Fig. 1). A settler of this area

Table 1

Summary of dates and locations of first sightings of European wild boar in Chile, indicating its most likely origin. Records from 1950-1978 were taken from Skewes (1990), recent ones were documented in this study.

Period	Region	Location area	Likely origin	Lat S/Long W
PIONEER OR OLDER POPULATIONS (> 30 YEARS)				
1950-52	Araucanía	Palguín Alto	Germany	39°24' -71°46'
1956	Los Ríos	Rañientulelfu	Argentina	39°45' -71°47'
1958	Los Ríos	Pirehueico port	Argentina	40°01' -71°43'
1956-58	Los Lagos	Futaleufú	Argentina	43°11' -71°49'
1956-58	Los Lagos	Palena	Argentina	43°36' -71°45'
1966	Araucanía	Icalma	Argentina	38°49' -71°15'
1967-68	Araucanía	Alto Biobío	Argentina	38°36' -70°57'
1967-68	Araucanía	Río Ranquil	Argentina	38°26' -71°04'
1970	Aysén	Lago Verde	Argentina	44°14' -71°50'
1970	Aysén	La Tapera	Argentina	44°30' -71°22'
1970	Aysén	Coihaique Alto	Argentina	45°27' -71°37'
1976-78	Los Lagos	Valle Esperanza	Argentina	41°13' -71°58'
RELATIVELY RECENT POPULATIONS (<10 YEARS) ALL WITH ORIGIN IN CHILE				
2002-04	O'Higgins	Sierra Bellavista	Release	34°51' -70°40'
2004-05	El Maule	Río Teno	R. O'Higgins	34°57' -78°50'
2008-09	Los Ríos	Valdivia	Escape farm	39°46' -73°11'
2008	Biobío	L. Álamos-Cañete	Escape farm	37°37' -73°21'
2008-09	Los Lagos	Purranque	Release	40°52' -73°20'
2008-09	Los Lagos	Río Frío	Release	41°13' -73°24'
2009	El Maule	Río Lontué	Release	35°20' -70°54'

corroborated that this release was at the root of the first sightings of boars on Chilean wild soil between 1950 and 1952 (Saavedra and Matus, 2000).

In subsequent years, wild boars were sighted in the port of Pirehueico and in Palena, 500 km apart from each other, from 1956 to 1958 (**Fig. 1**). Years later (1967-1970) wild boars were observed for the first time in the National Reserve of Alto Biobío (La Araucanía region) and in Coyhaique (Aysén region) (**Fig. 1**). In all these cases, informants pointed out that the animals came from Argentina and that they had arrived by their own means (without being purposely released in Chile).

In the administrative region of O'Higgins, wild boars were sighted between 2002

and 2004 in the area Sierras de Bellavista (34°46'S-70°46'W), 400 km from their recorded occupancy southward. Settlers are divided about the origin of this population: intentional release or escapes from boar farms. This population has grown since and presently reaches the basin of the Teno river in the region of El Maule (**Fig. 1**). In this region, on August 26th 2009, unidentified people were seen transporting wild boars in helicopter, and releasing them in the piedmont of the Andes range, in the country estates El Baúl (35°20'S, 70°54'W) and Los Chacayes (35°19'S, 70°58'W), lands that border the Lontué river from the north and south, respectively (**Fig. 1**). This is recounted by residents, Carabineros (the Chilean uniformed police) of the Agua Fría

station, and it is recorded in official inspection reports of SAG-Maule (Ediap and Villanueva, 2009; Villanueva, 2009). After being released this population was dramatically reduced in size by local hunters who were encouraged by SAG and local land owners who did not want to have wild boars in the area (Villanueva, 2009). Nevertheless, in February 2010, wild boars were sighted in Radal Siete Tazas National Park, 16 km to the south of their release site, and the administrative authority of the Park (CONAF) immediately established a program for monitoring and eradicating the species (Skewes and Aravena, 2011). The monitoring, which involved marching transects by specialists and park rangers and camera trapping (Barassi et al., 2011) did not confirm the presence of wild boars in the Park, and therefore it was assumed that this population became extinct. In the administrative region of Los Lagos, hunters informed that wild boars were released into the wild in 2008 and 2009 in the area of Río Frío and between Crucero and Riachuelo (Purranque), areas that to this day are home to wild boars (Fig. 1).

After escaping from a farm in 2008, wild boars were seen roaming freely in the mountainous area between the cities of Los Álamos and Cañete, in the Biobío administrative region (Fig. 1). However, in 2012 the last two male wild boars of this escape were hunted down in the area of Quiapo. To date, official reports of SAG-Biobío-Arauco indicate that there are no free wild boars nor claims of damages caused by them in the area. Around 2008-2009, wild boars escaped from a clandestine farm located on route T 313 (39°46'S-73°11'W), upstream from the Valdivia river, in Los Ríos administrative region (Fig. 1); only part of the escapees were hunted down and to the present date there are reports of sightings of boars with offspring.

Current distribution

At present, the boar is found in the wild in the central and southern regions of Chile, encompassing from north to south the administrative regions of O'Higgins, El Maule, Biobío, La Araucanía, Los Ríos, Los Lagos, and Aysén (Fig. 1). The whole area invaded most

to the north covers 500 km² on the piedmont of the Andes in the region of O'Higgins, from the Tinguiririca river (34°40'S) southward to the Teno river (34°58'S) in El Maule region (Fig. 1). The western border and height of the area inhabited by these animals is marked by forests, and the eastern limit by mountains next to the depression of the central valley. Some individuals ventured into the central valley and caused damage to crops of corn (*Zea mays*).

In the south, distribution of wild boars expanded to the west in the regions of La Araucanía, Los Ríos, and Los Lagos, and reached into the intermediate depression (Fig. 1). Thus, it is possible to find wild boars less than 20 km from the city of Temuco in the surroundings of Niágara (38°47'S, 72°25'W), Caivico (38°50'S, 72°25'W), Quepe (38°55'S, 72°35'W), and Suevia (38°56'S, 72°30'W). More southwards, wild boars inhabit both the Andean and Coastal mountain ranges, from the city of Lanco to Máfíl (39°29-39'S, 72°47-53'W) since 2007. This means that the wild boar is close to colonizing the Coastal mountain range of Los Ríos region. The first wild boar sighting in the frontier with Argentina, close to Máfíl, occurred in the port of Pirehueico (in 1958) at a distance of 115 linear kilometers, therefore, the species probably advanced 2.3 km/year in the last 50 years. According to the records of Palguín Alto in 1952 and Lanco (39°27'S, 72°43'W) in 2007 there is an advance over a distance of 90 km in 60 years (1.5 km/year). In the region of Los Lagos, besides the older population in the Andes, there are newer populations of anthropogenic origin west from meridian 73°. In the southern part of this region, wild boars arrived early on (1988) at the mouths of the Vodudahue and Reñihué rivers and later colonized part of Pumalín private park (Gastó et al., 2000). In Aysén, the southernmost boundary of distribution of the species is the Simpson river basin and this area extends northwards through the mountain range, including part of the Queulat National Park (always east of meridian 72°W). That is to say, the area populated by wild boars has increased by 51.6% in the last 20 years, and presently spans a surface of 2760 km² (Table 2).

Table 2

Approximate past (Skewes, 1990) and present (this study) surface occupied by wild boar in Chile.

Region	Occupancy in 1990 (km ²)	Occupancy in 2012 (km ²)	% increase since 1990	Occupancy per region* (%)
O'Higgins	0	400	100	2.4
El Maule	0	100	100	0.3
Biobío	0	10	100	0.03
La Araucanía	5100	10000	96.1	31.4
Los Ríos	3700	6000	62.2	32.9
Los Lagos	9000	10650	18.3	21.9
Aysén	400	440	10.0	0.9
Total	18200	27600	51.6	9.5

* Surface of region according to INE (2006)

DISCUSSION

Origin of wild populations

The location of the first sighting of wild boars (1950-52) is relatively close (20 km) to the place where they had been released in 1948-50 in Villarrica National Park. In Europe, wild boars moved away an average of 5 km from the place of capture (Briedermann, 1986) or they dispersed up to 16.6 km from their place of birth (Truvé and Lemel, 2003). Most likely, the released wild boars started their dispersion westwards descending from vast extensions of forests to Chile and not to Argentina, which is more arid and located at higher elevation. The number of released animals (24 females and 3 males) seems appropriate for the establishment of a population. Leaper et al. (1999) applied models that took into account demographic and environmental stochasticity for reintroduction of wild boar in Scotland and concluded that 25 individuals would ensure <5% risk of extinction. On the other hand, it is unlikely that the boars first sighted in Chile's Palguín Alto descend from those released in 1917-22 in the Collun-có ranch, at a distance of 70 km in the neighboring Argentinean province of Neuquén (Daciuk, 1978), as the species spread relatively slowly in that region from east to west, and the forests in the Andean summits that border Chile were the last habitat to be colonized by these animals (Pescador et al., 2009). This contradicts previous studies (Daciuk, 1978;

Jaksic et al., 2002) that assumed that the wild boar entered Chile in the 1920s or 1930s, considering that at the time it inhabited the borderland Argentinean provinces of Neuquén and Río Negro. However, spread in Argentina (Godoy, 1963; Sanguinetti, 2008; Pescador et al., 2009) suggests that the wild boar was present in these provinces but not necessarily in the frontier with Chile.

One likely reason why the wild boar invaded Chile later on, in 1956-58, is their intense persecution in Argentina. In 1951 the wild boar was officially categorized in Argentina as a species highly detrimental for agriculture (Decree N° 14.638, July 27th 1951) and in 1953, it was considered harmful fauna in the whole Argentinean territory (Decree N° 15.501 of law N° 13.908; Godoy, 1963). In the province of Río Negro, an attractive bonus was offered as stimulus for hunting all sized wild boars (Law N° 12 of 18.08.1958, 4th article), and the Dirección de Ganadería de La Pampa estimated that 8366 boars were eliminated between 1955-1960 under official control campaigns. This might have led to an intense hunting of wild boars, and its effects can be gathered from what we know of the sport hunting of this species in Europe (Sodeikat and Pohlmeier, 2007; Keuling et al., 2009; Scillitani et al., 2010). Wild boar hunting takes place during a maximum of 3.5 months per year (Maillard and Fournier, 1995) and the frequency of drives and losses of specimens depends on the territorial stability of the

species. Frequent hunting (more than 3 times every fortnight) causes temporary (Maillard and Fournier, 1995) or definitive (Scillitani et al., 2010) distancing of the wild boar from its home range to avoid hunters and their dogs, and their looking for safe areas.

Lastly, it is possible that these thrusts of immigration were motivated by other factors, such as climate and/or food. In Europe and Asia, massive migrations have been recorded of a few to hundreds of wild boars, due to unfavorable feeding and climatic conditions (Briedermann, 1986). However, no information regarding these aspects is available for our case study.

In recent years (1990-2012) the area invaded by the wild boar in Chile has increased by 51.6%. Coincidentally, in Argentina there is also an expansion of the territory colonized by wild boars between 1985 and 2005 in Lanín National Park, with an increment of 160% (Funes et al., 2006). More recently, Jaksic and Castro (2010) citing Gay (1847) stated that the wild boar was probably present in Llanquihue a long time before is presently thought and that the date of its introduction should be reconsidered. However, Gay (1847) points out explicitly that this concerns domestic swine that have turned wild, and says specifically: "Everywhere [domestic swine] are in domestic state, except in the surroundings of the Yanquihue lake; in its department, for about 25 years and due to the continuous wars of independence, some specimens have escaped from their ranches, penetrated in these extensive woods and become completely wild." Domestic swine were raised extensively and in large quantities in the 18th and 19th century from Valdivia to the south (Molina, 1809; Cuadra, 1866) and represented an important resource for Chiloé's colonial economy (Torrejón et al., 2004). In Argentina there are also early sightings of animals mistaken for wild boars (Moreno, 1879; Daciuk, 1978). Though it cannot be discarded that some domestic swine escaped and became wild in Chilean forests, if these populations had lasted, it would have been mentioned by some of the many interviewees who were consulted for this study.

In central Chile (34°S), wild boar immigration from neighboring Argentine populations

(Cuevas et al., 2013), should be discarded because the Andes mountain range—here—serves as a barrier to wild boars crossing. In Europe, wild boar populations of the Iberian (Alves et al., 2010) and Italian (Scandura et al., 2008) peninsulas showed signs of genetic isolation derived from the physical barriers formed by the mountain ranges of the Pyrenees and the Alps, respectively. The mountain range of the Alps is comparatively lower (10% and 1.7% above 2600 and 3000 m elevation, respectively; Körner, 2007) than the Andes in central Chile between 32° and 35°S, where it presents peaks of altitude over 4000 m elevation, and the average width above 2000 and 3000 m elevation is 160 and 90 km, respectively (Garreaud and Rutllant, 1997). Thus, the central Andes would act as a barrier for the wild boar, unlike the mountain range in the southern Andes, where available crossings at low height allow for a natural exchange of alien vertebrates between Chile and Argentina (Jaksic et al., 2002).

Presumably, both the wild boar population of the O'Higgins and El Maule regions derive from releases by sport hunters, given that they are the only interest group that could benefit from them. Sport or recreational hunters have initiated populations of wild pigs in North America (Gipson et al., 1998), Australia (Spencer and Hampton, 2005), Brazil (de Oliveira, 2012), Uruguay (García et al., 2011), and Argentina (Daciuk, 1978; Navas, 1987).

Causes of expansion

Intense hunting of wild boars in mountainous locations can be one of the causes of their relatively recent expansion from the Andes to the intermediate depression in the regions of La Araucanía, Los Ríos, and Los Lagos (Faúndez, 2011). The number of licenses issued in Chile for the hunting of larger species—mainly wild boars and red deer (*Cervus elaphus*)—has practically duplicated from 124 in 2008 to 240 in 2010 (SAG, 2010). However, land use in these regions must also be considered. The regions of La Araucanía and Los Ríos have similar extensions of native forest (9000 km² each) and shrub and meadows (6000 km²) but different extensions of agricultural areas

and forestry plantations. In comparison to Los Ríos, La Araucanía has almost 50 times more agricultural areas (8000 km²) and almost three times the surface of forestry plantations (6000 km²), which represents 47% of the region (Lara et al., 2012). This heterogeneous combination of agricultural areas, meadows, forests and forestry plantations is a good habitat for the wild boar. In Europe, the wild boar uses areas with these characteristics, where it finds food in the agricultural areas and shelter in adjoining woods or shrubs (Fruzinski and Labudzki, 2002; Lemel et al., 2003; Sodeikat and Pohlmeyer, 2007). The forest provides wild boar with thermal comfort, shelter and bushy spots to nest while farrowing (Dardaillon, 1987; Rosell et al., 2001).

Colonization of the Coastal mountain range is imminent in La Araucanía and Los Ríos, as there are already specimens inhabiting the intermediate depression. The extensive forestry plantations of *Pinus radiata* can favor expansion. In Argentina, the wild boar prefers pine plantations (*Pinus ponderosa* and *P. contorta*) instead of native forests in the ecotone of Neuquén, which contributes to their expansion (Lantscher et al., 2013). The surface of pine plantations sums 3647 km² (INFOR, 2009) in the regions of La Araucanía and Los Ríos. Chilean wineberry (*Aristotelia chilensis*) and blackberry (*Rubus constrictus*) predominate in the undergrowth of these forests (Ramirez et al., 1984) and are consumed by wild boars in Chile (Skewes pers. obs.; see also Skewes et al., 2007) and Spain (Peredo et al., 2013). In Spain, changes in the landscape, like the increase in forest surface and rural depopulation, favored the expansion of the wild boar (Saez-Royuela and Tellería, 1986; Rosell et al., 1998). Something similar happens in Chile, where there has been extensive reforestation and depopulation in 23 000 km² in the Biobío and La Araucanía regions during the last decades (Aguayo et al., 2009). Thus, given that the wild boar is a successful invader, it is highly likely that it will advance northwards through the Coastal mountain range.

The environmental characteristics of the areas presently inhabited by the wild boar are those of the ecoregion of Valdivia, which includes deciduous, Andean Patagonian forests,

with *Laurus nobilis* and evergreens (Gajardo, 1994), with average annual temperatures of 13.4 to 9.0°C from north to south, and annual rainfall of 777 to 2000-3000 mm, respectively. In short, the wild boar in Chile inhabits areas with a temperate climate, from warm with rainy winters in the central zone, to rainy and cold with no dry season in Aysén (Hajek and di Castri, 1975).

Due to the impact of wild boar on ecosystems, it is considered to be one of the 100 most harmful alien species in the world (Lowe et al., 2000). There is abundant literature about the negative consequences on the functionality and structure of ecosystems, both natural and cultivated, where this species has been introduced (Jacob and Esther, 2011; Barrios-García and Ballari, 2012). In North America, wild boar causes losses to agriculture for US\$ 800 million per year (Pimentel et al., 2005). In three different Patagonian forests, belowground foraging by wild boar had impact on plant community structure and biomass (Barrios-García et al., 2014). In a study carried out in the south of Chile (from the regions of La Araucanía to Aysén) 75% of respondents (n = 128) acknowledged the wild boar as a harmful agent for agriculture, especially on sown fields, meadows and fruit trees (Bonacic et al., 2010). Thus, the expansion of the wild boar to agricultural areas—as is happening in La Araucanía—will probably have a detrimental impact on this activity and also on the protected native coastal areas in the south of Chile. As for the central zone, it must be considered that the wild boar can act as reservoir or disseminator of diseases to cattle and humans (Gortázar et al., 2007; Boqvist et al., 2012; Schöning et al., 2013). The Metropolitan and O'Higgins regions host more than 2.6 million wild pigs, 89% of all pigs in Chile (INE, 2007). The wild boar shares infectious diseases with feral pigs, and that is why their presence in areas close to the pig industry represents a potential epidemiologic danger (Ruiz-Fons et al., 2008; Kukushkin et al., 2008; Costard et al., 2013) that could have serious sanitary and economic consequences. For instance, in Denmark, where there are no wild boars, attempts of hunters to introduce this species into the wild have been met with

opposition of sanitary and scientific authorities, because the control of an outbreak of an infectious disease in a population of wild *Sus scrofa* would lead to enormous additional costs for that country (Boklund et al., 2008).

Management and control

Wild boars are raised in captivity for purposes of production in all the regions of Chile except in Arica and Magallanes (INE, 2007). By 2005 less than half (47%) of these boar farms were officially registered at SAG in compliance with the law (Skewes and Morales, 2006). Clandestine farms with defective safety conditions are more likely to suffer animal escapes (De Oliveira, 2012). In the region of La Araucanía, escapes of wild boars have been reported as sporadic or permanent events (Bonacic et al., 2010). In areas where there is no natural presence of the species, escapes from boar farms should hardly be tolerated. In this regard, in 1998 the Brazilian Institute of Environment and Renewable Natural Resources banned the creation of new wild boar farms in Brazil and restricted the transference of animals between farms, while at the same time increasing conditions for their safe maintenance so as to avoid escapes that could lead to new populations in other parts of the country (IBAMA, 1998). In Chile, this measure must be considered, particularly for the island of Chiloé, where environmental conditions and the absence of predators such as the puma (*Puma concolor*) are favorable for *Sus scrofa*; in the past domestic pig breeding used to be an important resource for the colonial economy of the island (Torrejón et al., 2004). According to official records, by 2011 there were five wild boar farms with a total of 45 heads in Chiloé (SAG, 2011).

The wild boar is considered to be a harmful species in Chilean legislation (DL 19473, article 6, DS 5). However, the district attorney of SAG-Maule was not able to impose a criminal sentence for the notorious release of the species in 2009 near the Lontué river. This should make us pause because SAG is the main administrative authority in charge of applying the laws and regulations in force about terrestrial alien species (Iriarte et al., 2005). The frailty shown by governmental institutions

regarding the implementation of regulations and the inspection of events involving wild boars is a tendency that exists in Brazil as well (De Oliveira, 2012). The administrative authorities of Chile should be more concerned with the deliberate introduction of this species, especially in areas where it is not present yet. Chile is also signatory of the Convention on Biological Diversity promoted by the United Nations Environment Programme (UNEP), to “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species” (UNEP/CBD/S BSTTA/6/INF/11). Early detection is crucial to implement quick, viable offensive strategies (early eradication) (De Poorter et al., 2005). The relatively new and small wild boar population in the O’Higgins region could pose such a threat; that is why it is urgent to implement an eradication plan.

ACKNOWLEDGMENTS

We thank I. Aravena, M. Barrientos, L. Barrios, B. Carmona, H. Carrasco, C. Castro, H. Ludwig, R. Montory, J.P. Muñoz, O. Peña y E. Schuster. Also to Marco Barrientos from Naviera Haverbeck y Skalweit, Valdivia. OS was funded by Dirección de Investigación Universidad de Concepción DIUC 209.153.019-1.0, CONAF-Maule Region, and Asociación de Productores de Cerdo ASPROCER. FMJ was funded by CONICYT FB 0002.

LITERATURE CITED

- AGUAYO M, A PAUCHARD, G AZÓCAR, and O PARRA. 2009. Cambio del uso del suelo en el centro sur de Chile a fines del siglo XX. Entendiendo la dinámica espacial y temporal del paisaje. *Revista Chilena de Historia Natural* 82:361-374.
- ALVES CP, I PINHEIRO, R GODINHO, J VICENTE, C GORTÁZAR, and M SCANDURA. 2010. Genetic diversity of wild boar populations and domestic pig breeds (*Sus scrofa*) in south-western Europe. *Biological Journal of the Linnean Society* 101:797-822.
- BARASSI O, H CARRASCO, and O SKEWES. 2011. Tras la huella del Jabalí. [http://www.guardaparquesenaccion.org/Articulos/TRAS LA HUELLA DEL JABALÍ](http://www.guardaparquesenaccion.org/Articulos/TRAS%20LA%20HUELLA%20DEL%20JABALÍ).
- BARRIOS-GARCIA MN and SA BALLARI. 2012. Impact of wild boar (*Sus scrofa*) in its introduced and native range: A review. *Biological Invasions* 14:2283-2300.
- BARRIOS-GARCIA MN, AT CLASSEN, and D SIMBERLOFF. 2014. Disparate responses of above- and belowground properties to soil disturbance by an invasive mammal. *Ecosphere* 5(4), article 44.
- BOKLUND A, SG GOLDBACH, B UTTENTHAL, and L ALBAN. 2008. Simulating the spread of classical

- swine fever virus between a hypothetical wild-boar population and domestic pig herds in Denmark. *Preventive Veterinary Medicine* 85(3-4):187-206
- BONACIC C, O OHRENS, and F HERNÁNDEZ. 2010. Informe Final "Estudio de distribución y estimación poblacional de las especies exóticas invasoras: jabalí y ciervo rojo en Chile." Servicio Agrícola y Ganadero SAG Dpto. Recursos Naturales Renovables, Santiago.
- BOQVIST S, K BERGSTRÖM, and U MAGNUSSON. 2012. Prevalence of antibody to six *Leptospira servovar*s in Swedish wild boars. *Journal of Wildlife Diseases* 48(2):492-496.
- BRIEDERMANN L. 1986. *Schwarzwild*. VEB Deutscher Landwirtschaftsverlag, 1040 Berlin-DDR, 539 pp.
- BURGMAN MA and JC FOX. 2003. Bias in species range estimates from minimum convex polygons: Implications for conservation and options for improved planning. *Animal Conservation* 6(1):19-28.
- CORREO DE VALDIVIA. 1935. 15 Corzos, 44 faisanes y 6 ciervos trajo desde Alemania vapor "Alberto Haverbeck". *El Correo de Valdivia*, 25 de septiembre de 1935, p. 5.
- COSTARD S, BA JONES, B MARTÍNEZ-LÓPEZ, L MUR, A DE LA TORRE et al. 2013. Introduction of African Swine Fever into the European Union through illegal importation of pork and pork products. *PLoS One* 8(4):e61104. doi:10.1371/journal.pone.0061104.
- CUADRA PL. 1866. Apuntes sobre jeografía, física i política de Chile. Parte 1. Imprenta Nacional, Santiago, Chile.
- CUEVAS MF, RA OJEDA, and FM JAKSIC. 2013. Multi-scale patterns of habitat use by wild boar in the Monte Desert of Argentina. *Basic and Applied Ecology* 14:320-328.
- DACIUK J. 1978. Estado actual de las especies de mamíferos introducidos en la subregión Araucana (Rep. Argentina) y grado de coacción ejercido en algunos ecosistemas surcordilleranos. *Anales de Parques Nacionales (Argentina)* 14:105-130.
- DARDAILLON M. 1987. Seasonal feeding habits of the wild boar in a Mediterranean wetland: The Camargue (southern France). *Acta Theriologica* 32(23):381-401.
- DE OLIVEIRA CHS. 2012. Ecología e manejo de javalí (*Sus scrofa* L.) na América do Sul. Tese programa de Pós-graduação em Ecologia da Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.
- DE POORTER M, M BROWNE, S LOWE, and M CLOUT. 2005. The ISSG Global Invasive Species Database and other aspects of an early warning system. In: *Invasive Alien Species: A New Synthesis* (HA Mooney, RN Mack, JA McNeelley, LE Neville, PJ Schei, and JK Waage, eds.). (SCOPE 63). Island Press, Washington.
- EDIAP A and LA VILLANUEVA. 2009. Informe de Fiscalización, Ref.: Denuncia sobre liberación clandestina de jabalíes en precordillera de Curicó. Servicio Agrícola y Ganadero SAG Oficina Regional del Maule, Curicó, 11 de Septiembre de 2009.
- FAÜNDEZ NS. 2011. Revisión de los aspectos cinegéticos del jabalí europeo (*Sus scrofa* L.) en Chile. Memoria de título presentada a la Facultad de Ciencias Veterinarias de la Universidad de Concepción, Concepción, Chile.
- FRUZISKI B and L LABUDZKI. 2002. Management of wild boar in Poland *Z. Jagdwiss.* 48 Supplement, 201-207.
- FUNES MC, J SANGUINETTI, P LACLAU, L MARESCA, L GARCÍA, F MAZZIERI, L CHAZARRETA, D BOCOS, F DIANA LAVALLE, P ESPÓSITO, A GONZÁLEZ, and A GALLARDO. 2006. Diagnóstico del estado de conservación de la biodiversidad en el Parque Nacional Lanín: su viabilidad de protección en el largo plazo. Informe final. Parque Nacional Lanín, San Martín de los Andes, Neuquén.
- GAJARDO R. 1994. La vegetación natural de Chile. Clasificación y distribución. Editorial Universitaria, Santiago, Chile.
- GARCÍA G, J VERGARA, and R LOMBARDI. 2011. Genetic characterization and phylogeography of the wild boar *Sus scrofa* introduced into Uruguay. *Genetics and Molecular Biology* 34(2):329-337.
- GARREAU R and J RUTLLANT. 1997. Precipitación estival en los Andes de Chile central: aspectos climatológicos. *Atmósfera* 10:191-211.
- GASTÓ J, A RETAMAL, and D GUZMÁN. 2000. Proyecto Pumalín. Informe Técnico Santuario de la Naturaleza. Pontificia Universidad Católica de Chile, Facultad de Agronomía e Ingeniería Forestal. Programa de Ecología y Medio Ambiente, Santiago, Chile.
- GENOV P. 1981. Die Verbreitung des Schwarzwildes (*Sus scrofa* L.) in Eurasien und seine Anpassung an die Nahrungsverhältnisse. *Zeitschrift für Jagdwissenschaft* 27:221-231.
- GIPSON PS, B HLAVACHIK, and T BERGER. 1998. Range expansion by wild hogs across the central United States. *Wildlife Society Bulletin* 26(2):279-286.
- GODOY JC. 1963. Fauna silvestre. Evaluación de los recursos naturales de Argentina. CFI, Buenos Aires.
- GÓMEZ LUNA S. 1984. Plan de manejo del Parque Nacional Kilapillán. CONAF Santiago, Chile.
- GORTÁZAR G, E FERROGLIO, U HÖFLE, K FRÖLICH, and J VICENTE. 2007. Diseases shared between wildlife and livestock: A European perspective. *European Journal Wildlife Research* 53:241-256.
- HAJEK ER and F DI CASTRI. 1975. Bioclimatografía de Chile. Dirección de Investigación, Vice-Rectoría Académica, Universidad Católica de Chile, Santiago, Chile.
- IBAMA. 1998. Portaria IBAMA N° 102/98 adrt. 20 de 15 julio 1998.
- INE. 2006. Instituto Nacional de Estadísticas, Compendio estadístico 2006 (PDF). URL: <http://www.ine.cl> [accedido marzo de 2013].
- INE. 2007. Instituto Nacional de Estadísticas, Censo Agropecuario y Forestal por comunas. URL: http://www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07_comunas.php [accedido marzo 2013].
- INFOR. 2009. Superficie de plantaciones forestales regiones de Coquimbo a Aysén; e inventario plantaciones PYMP regiones Bio bio y Araucanía. Actualización a diciembre de 2008. Informe Técnico Instituto Forestal, Gobierno de Chile, Chile.
- IRIARTE JA, GA LOBOS, and FM JAKSIC. 2005. Especies de vertebrados invasores en Chile y su control y monitoreo por agencias gubernamentales. *Revista Chilena de Historia Natural* 78:143-154.
- JACOB J and A ESTHER, Eds. 2011. 8th European Vertebrate Pest Management Conference Berlin,

- Germany, 26-30 September 2011 Symposium: Wild boar biology and management.
- JAKSIC FM y SA CASTRO. 2010. Ecología y biodiversidad de vertebrados de Chile: Análisis comentado de la Zoología de Claude Gay. *Revista Chilena de Historia Natural* 83:323-333.
- JAKSIC FM, JA IRIARTE, JE JIMÉNEZ, and DR MARTÍNEZ. 2002. Invaders without frontiers: Cross-border invasions of exotic mammals. *Biological Invasions* 4:157-173.
- KEULING O, N STIER, and M ROTH M. 2009. Commuting, shifting or remaining? Different spatial utilization pattern of wild boar *Sus scrofa* L. in forest and field crops during summer. *Mammalian Biology* 74:145-152.
- KÖRNER C. 2007. The use of 'altitude' in ecological research. *Trends in Ecology and Evolution* 22(11); doi:10.1016/j.tree.2007.09.006.
- KUKUSHKIN S, A KANSHINA, A TIMINA, T BAYBIKOV, and V MIKHALSHIN. 2008. Investigation of wild boar (*Sus scrofa*) for porcine reproductive and respiratory syndrome in some territories of Russia. *European Journal Wildlife Research* 54:515-518.
- LANTSCHNER MV, V RUSCH, and JP HAYES. 2013. Do exotic pine plantations favour the spread of invasive herbivorous mammals in Patagonia? *Austral Ecology* 38:338-345; doi:10.1111/j.1442-9993.2012.02411.xec_2411 1
- LARA A, ME SOLARI, MR PRIETO, and MP PEÑA. 2012. Reconstrucción de la cobertura de la vegetación y uso del suelo hacia 1550 y sus cambios a 2007 en la ecorregión de los bosques valdivianos lluviosos de Chile (35° - 43° 30' S). *Bosque* 33(1):13-23.
- LEAPER R, G MASSEI, M GORMAN, and R ASPINALL. 1999. The feasibility of reintroducing wild boar (*Sus scrofa*) to Scotland. *Mammal Review* 29(4):239-259.
- LEMEL J, J TRUVÉ, and B SÖDERBERG. 2003. Variation in ranging and activity behaviour of European wild boar *Sus scrofa* in Sweden. *Wildlife Biology* 9 (Suppl. 1):29-36.
- LONG J. 2003. *Introduced Mammals of the World. Their history, distribution and influence.* CSIRO Publishing, Australia.
- LOWE S, M BROWNE, S BOUDJELAS, and M DE POORTER. 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).
- MAILLARD D and P FOURNIER. 1995. Effects of shooting with hounds on size of resting range of wild boar (*Sus scrofa* L.) groups in Mediterranean habitat. *Ibex, Journal of Mountain Ecology* 3:102-107.
- MARKOV NI, ND NEIFELD, and AA ESTAF'EV. 2004. Ecological aspects of dispersal of the wild boar, *Sus scrofa* L., 1758, in the northeast of European Russia. *Russian Journal of Ecology* 35(2):131-134.
- MELIS C, PA SZAFRAŃSKA, B JĘDRZEJEWSKA, and K BARTOŃ. 2006. Biogeographical variation in the population density of wild boar (*Sus scrofa*) in western Eurasia. *Journal of Biogeography* 33(5):803-811.
- MOLINA JI. 1809. *The geographical, natural, and civil history of Chile (1st ed.,1782).* Translated from the Italian, London, Vol. 2.
- MORENO FP. 1879. *Exploración de la Patagonia sur I: Por las cuencas del Chubut y del Santa Cruz: 1876-1877.* Ediciones Continente 2007, Buenos Aires, Argentina.
- NAVAS J. 1987. Los vertebrados exóticos introducidos en la Argentina. *Revista del Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Zoología* 14:7-38.
- PEREDO A, D MARTÍNEZ, J RODRÍGUEZ-PÉREZ, and D GARCÍA. 2013. Mammalian seed dispersal in Cantabrian woodland pastures: Network structure and response to forest loss. *Basic and Applied Ecology* 14:378-386.
- PESCADOR M, J SANGUINETTI, H PASTORE, and S PERIS. 2009. Expansion of the introduced wild boar (*Sus scrofa*) in the Andean region, Argentinean Patagonia. *Galemys* 21:121-132.
- PIMENTEL D, R ZUÑIGA, and D MORRISON. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics* 52:273-288.
- RAMÍREZ C, H FIGUEROA, R CARRILLO, and D CONTRERAS. 1984. Estudio fitosociológico de los estratos inferiores en un bosque de pino (Valdivia, Chile). *Bosque* (5)2:65-81.
- ROSELL C, MA CARRETERO, and E BASSOLS. 1998. Seguimiento de la evolución demográfica del jabalí (*Sus scrofa*) y efectos del incremento de presión cinegética en el parque natural de la zona volcánica de la Garrotxa. *Galemys* 10:59-74.
- ROSELL C, P FERNÁNDEZ-LLARIO, and J HERRERO. 2001. El jabalí (*Sus scrofa* Linnaeus, 1758). *Galemys* 13(2):1-25.
- ROSVOLD J and R ANDERSEN. 2008. Wild boar in Norway – is climate a limiting factor? NTNU Vitesnskapsmuseet Rapp. Zool. 1:1-23.
- RUIZ-FONS F, D VIDAL, J VICENTE, P ACEVEDO, IG FERNANDEZ-DE-MERA, V MONTORO, and C GORTÁZAR. 2008. Epidemiological risk factors of Aujeszky's disease in wild boars (*Sus scrofa*) and domestic pigs in Spain. *European Journal Wildlife Research* 54:549-555.
- SAAVEDRA M and A MATUS. 2000. Impacto de poblaciones de jabalí (*Sus scrofa*) y ciervo rojo (*Cervus elaphus*) en los parques nacionales Villarrica y Conguillío IX región, Chile. Informe de la Corporación Nacional Forestal Ug. Patrimonio Silvestre IX Región, Unidad Planificación/Operación Sección Flora – Fauna.
- SAEZ-ROYUELA C and JL TELLERIA. 1986. The increased population of the wild boar (*Sus scrofa* L.) in Europe. *Mammal Review* 16:97-101.
- SAG. 2011. Registro Nacional de Tenedores de Fauna Silvestre, año 2011. Santiago, Chile.
- SAG. 2010. Registro de cazadores de caza mayor años 2008, 2009 y 2010. Santiago, Chile.
- SANGUINETTI J. 2008. Producción y predación de semillas, efectos de corto y largo plazo sobre el reclutamiento de plántulas. Caso de estudio: *Araucaria araucana*. Tesis Doctoral, Universidad Nacional del Comahue, 139 pp.

- SCANDURA M, L IACOLINA, B CRESTANELLO, E PECCHIOLI, MF DI BENEDETTO, V RUSSO, R DAVOLI, M APOLLONIO, and G BERTORELLE. 2008. Ancient vs. recent processes as factors shaping the genetic variation of the European wild boar: Are the effects of the last glaciation still detectable? *Molecular Ecology* 17:1745-1762.
- SCHÖNING JM, N CERNY, S PROHASKA, MM WITTENBRINK, NH SMITH et al. 2013. Surveillance of Bovine Tuberculosis and risk estimation of a future reservoir formation in wildlife in Switzerland and Liechtenstein. *PLoS One* 8(1):e54253. doi:10.1371/journal.pone.0054253
- SCILLITANI L, A MONACO, and S TOSO. 2010. Do intensive drive hunts affect wild boar (*Sus scrofa*) spatial behaviour in Italy? Some evidences and management implications. *European Journal Wildlife Research* 56:307-318.
- SKEWES O. 1990. Status des Wildschweines, *Sus scrofa* L., in Chile. Dokumentation einer Fremdansiedlung von europäischem Wild. Dissertation Doktorgrades der Forstl. Fakultät, Georg-August Universität zu Göttingen, Germany.
- SKEWES O and P ARAVENA. 2011. Estudio de distribución, estimación poblacional y vigilancia epidemiológica de las especies exóticas invasoras: jabalí y ciervo rojo, en la Región del Maule, Chile. Informe Final Convenio ASPROCER-Universidad de Concepción. Chillán, Chile.
- SKEWES O and R MORALES. 2006. Crianza de jabalí (*Sus scrofa* L.) en Chile. Distribución, tamaño y aspectos básicos de manejo. *Agro-Ciencia* 22(1):29-36.
- SKEWES O, R RODRIGUEZ, and FM JAKSIC. 2007. Ecología trófica del jabalí europeo (*Sus scrofa*) silvestre en Chile. *Revista Chilena de Historia Natural* 80:295-307.
- SODEIKAT G and K POHLEMYER. 2007. Impact of drive hunts on daytime resting site areas of wild boar family groups (*Sus scrofa* L.). *Wildlife Biology in Practice* 1(3):28-38.
- SPENCER PB and JO HAMPTON. 2005. Illegal translocation and genetic structure of feral pigs in western Australia. *Journal of Wildlife Management* 69:377-384.
- TORREJÓN F, M CISTERNAS, and A ARANEDA. 2004. Efectos ambientales de la colonización española desde el río Maullín al archipiélago de Chiloé, sur de Chile. *Revista Chilena de Historia Natural* 77:661-677.
- TRUVÉ J and J LEMEL. 2003. Timing and distance of natal dispersal for wild boar *Sus scrofa* in Sweden. *Wildlife Biology* 9 (Suppl. 1):51-57.
- UNEP/CBD/S BSTTA/6/INF/11. Convention on biological diversity. URL <http://www.cbd.int/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-11-en.pdf>
- VILLANUEVA LA. 2009. Informe N° 2 y 3 Ref.: Segunda Denuncia sobre presencia de jabalíes en precordillera de Curicó. Servicio Agrícola y Ganadero SAG Oficina Regional del Maule, Curicó, Chile.
- VIRGÓS E. 2002. Factors affecting wild boar (*Sus scrofa*) occurrence in highly fragmented Mediterranean landscapes. *Canadian Journal of Zoology* 80(3):430-435.