BioOne DIGITAL LIBRARY

Distribution, abundance and density of the wild boar on the Iberian Peninsula, based on the CORINE program and hunting statistics

Authors: Bosch, Jaime, Peris, Salvador, Fonseca, Carlos, Martinez, Marta, Torre, Ana De la, et al.

Distribution, abundance and density of the wild boar on the Iberian Peninsula, based on the CORINE program and hunting statistics

Jaime BOSCH[1]*, Salvador PERIS[2], Carlos FONSECA[3], Marta MARTINEZ[1], Ana DE LA TORRE[1], Irene IGLESIAS[1] and Maria J. MUÑOZ[1]

[1] Epidemiology and Environmental Health, CISA-INIA, 28130 Valdeolmos (Madrid), Spain;
  e-mail: jaime.bosch@inia.es
[2] Department of Zoology, Faculty of Biology, University of Salamanca, 37071 Salamanca, Spain
[3] CESAM and Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal

Abstract. Wild boar population size in the Iberian Peninsula was estimated using hunting bag statistics from Spain and Portugal. Density was estimated assigning the wild boar population size to the "potential resources" or suitable habitats categorized by their importance to provide food and/or shelter to wild boars. Land uses were selected from CORINE, the EU database for land cover, using scientific literature and statistical significance for wild boar presence from published data.
The hunting bag was 176245 and 15167 in Spain and Portugal, respectively. The average density was $0.373/km^2$ (min 0.014-max 2.22) in Spain and $0.13/km^2$ (min 0.00048-max 1.99) in Portugal, being $0.31/km^2$ (0.00048-2.22) over the entire Peninsula. Statistical analysis showed that wild boar presence was significantly ($p < 0.05$) associated to thirteen of the seventeen CORINE land uses selected. Agro-forestry, moors and heathland land use were not statistically significant but were included in the model due to their biological importance. Suitable habitats and distribution of wild boar were mapped for the Iberian Peninsula. This approach is a preliminary step intended to be useful in environmental management and animal health.

Introduction

Over the last century, wild boar populations in many areas of the Palearctic, including the Iberian Peninsula (I.P.), have grown continuously (Rosell 1995, Leránoz & Castién 1996, Spitz 1999, Rosell et al. 2001, Acevedo et al. 2006, Gortázar et al. 2007). Species growth on the I.P. has been linked to the disappearance of traditional agriculture due to emigration from rural areas, which has led to a marked decline in forestry activities; an increase in the number of shelter areas, mostly scrub and wooded areas; and an increase in the total amount of food available (Tellería & Sáez-Royuela 1985, Sáez-Royuela & Tellería 1986, Salces & Markina-Lamonja 1992a, Sáenz de Buruaga 1995). Some of the main reasons for the considerable increase in the wild boar

population are: (1) the remarkable adaptability of the wild boar to diverse environments (Genov 1981a, Boitani et al. 1994, Massei et al. 1996, Acevedo et al. 2006, Jansen et al. 2007, Schley et al. 2008); (2) its high reproductive rate (Rosell et al. 2001, Fonseca et al. 2011); (3) an increase in areas dedicated to certain crops, in particular maize, as observed in European countries such as Poland, Sweden and Switzerland (Baettig 1980, Fruzinski 1995, Neet 1995, Saïd et al. 2011, Thurfjell 2011); (4) its varied trophic diet (Mackin 1970, Lemel et al. 2003, Herrero et al. 2006, Schley et al. 2008, Saïd et al. 2011, Thurfjell 2011); (5) warmer winter temperatures (Schley 2000, Melis et al. 2006).
Today, the wild boar constitutes a valuable economic and hunting resource for some countries like Spain and

* Corresponding Author

138

Portugal; for example, the 2006-2007 hunting season in Spain generated 29.3 million Euros in revenues (MARM 2007). Furthermore the wild boar is a key element of numerous ecosystems, contributing to soil mixing, nutrient recycling, and dissemination of spores and seeds smaller than 4 mm, thereby assisting the first stages of vegetal succession (Bratton 1975, Genard & Lescourret 1985, Grimal 1987, Onipchenko & Golikov 1996, Schmidt et al. 2004). However, over the last few years, some negative aspects of its expansion have begun to be noted, such as changes in vegetal succession (Onipchenko & Golikov 1996). Recent studies have also linked wild boar movements to decreased ground cover, with serious consequences for livestock grazing (Bueno et al. 2010); to traffic accidents (Vassant et al. 1993, Rosell et al. 2001, Peris et al. 2005, Marques et al. 2010, Sävberger 2010); to invasion of urban areas, attacks on people and pets, and health problems (Tilson & Nyhus 1998, Packer & Birks 1999, Cahill et al. 2003, Jansen et al. 2007, López et al. 2010); and to damage of irrigated crops (Herrero 2003, Schley & Roper 2003).

The need for better knowledge of the wild boar populations has also become more urgent because the species acts as a host of certain economically important diseases that affect domestic pigs, such as African swine fever, classical swine fever and Aujeszky's disease. They also serve as hosts of diseases that affect other mammals, including humans, such as tuberculosis, salmonellosis and brucellosis. Preventive measures to control and eradicate diseases present in wild boars must be a top priority, especially if their population growth makes contact with farm animals more likely, which can lead to transmission and maintenance of diseases in animal populations (Spiecker 1969, Höfle et al. 2004, Gortázar et al. 2007, Vicente et al. 2010).

Despite the importance of understanding wild boar population dynamics, population data are rare, in part because of the difficulty of direct counting in the field. The use of hunting statistics to estimate population indirectly has become a common practice; in fact, several authors recommend this approach (Spitz et al. 1984, Sáez-Royuela & Tellería 1988, Abaigar 1990, Biotema 1990, Garzón 1991, Spitz & Vallet 1991, Lancia et al. 1994).

Many efforts have been made to improve the use of hunting statistics to estimate the boar population, radiotracking to estimate wild boar movements or home range (Markina-Lamonja & Telletxea 2006), indirect measures like paw prints, tracks and traces, fecal drop counts, evidence of bedding (Rosell 1998, Rosell et al. 1998, Hererro 2003, Herrero et al. 2006) and other data as land cover supporting habitats and food of animal. Favored habitats of the wild boar have been identified in Spain (Abaigar et al. 1994, Rosell 1998, Herrero 2001, Rosell et al. 2001) and other European countries (Sodeikat & Pohlmeyer 2004, Keuling et al. 2008, 2009). Land uses favoring the presence of the animal have been identified in the I.P., both in the north (Sáez-Royuela 1989, Sáenz de Buruaga et al. 1991, Herrero 2001) and south (Fernández-Llario 1996). Information is also available on the preferred diet of the wild boar, such as oak woods, agricultural fields (Abaigar 1990, Sáenz de Buruaga 1995, Herrero et al. 2006), plantations of maize and conifers, and scrub (Schley 2000, Herrero et al. 2006, Schley et al. 2008).

The objective of this study was to estimate the distribution of the wild boar population on the I.P. using a combined approach that took into account hunting data (H), animal movement patterns (home range, HR) and ground cover (CORINE, the EU database for land cover) associated to the presence of the animal. The method proposed in this study may be useful for estimating animal density and distribution in other territories of the European Union and such data can inform diverse types of studies in environmental management and animal health.

Material and Methods

As a first step, a bibliographical and documentary survey was conducted in order to determine the number of wild boar harvested (MARM 2007, Autonomous Community Administrations and National Forestry Authority), potential resource value (PRVs, i.e. land uses favourable to the presence of wild boar), sizes of individual wild boar populations and their home range (HR). To estimate their density on the I.P., an analysis was conducted using Excel (Microsoft® Office 2003-2007) and SPSS v15.0 (SPSS Inc., 1989-2006). Spatial analysis and mapping results on hunting statistics and land use, were performed using ArcGIS 9.3 (ESRI®).

Study area and hunting data
The study area comprised Spain and Portugal, which together make up the I.P. Both countries contain two biogeographic regions, Atlantic and Mediterranean bioclimatic levels, with latitudes between 35° and 45° N, a mean altitude of approximately 660 m above sea level (SD 1041.34), a maximum altitude of 3479 m and a total peninsular length of 582603.84 km² (SD 4832.18); of this total length, 493519.54 km² belong to Spain and 89084.3 km² to Portugal.

The province is the administrative unit in Spain, with surface ranging from 1980.35 km² to 21766.3 km² and averaging 10500.41 km² (SD 4699.77), while the unit for Portugal is the district, with areas ranging from 2255 km² to 10225 km² and averaging 4941.33 (SD 2116.27).

Hunting data for each Spanish province was gathered from the Statistical Yearbook of Forestry (MARM 2007), estimated to be 176245 individuals. In Portugal, the hunting data in each administrative district was obtained from the National Forestry Authority (AFN), estimated to be 15167 individuals. Data from 2007 was used in this study for Spain and Portugal, corresponding to the 2006-2007 hunting season (Tables 1, 2), a total of 191412 wild boars for the I.P.

Potential wild boar habitats based on potential resources value (PRVs)

To estimate potential resources used by the wild boar, and how well habitats on the I.P. can provide those resources, a literature review was conducted for ground cover and wooded areas that could be suitable as wild boar habitat (Baettig 1980, Tellería & Sáez-Royuela 1985, Fruzinski 1995, Neet 1995, Schley 2000, Herrero et al. 2006), for the surface area of land used for agriculture (Massei & Genov 2004) and for the wild boar's preferred habitats (Santos et al. 2004). The species is omnivorous, though it relies on a vegetable diet more than an animal one, making it essentially a primary consumer (Groot Bruinderink et al. 1994). Stomach and fecal content analyses in various studies indicate that vegetable matter, principally fruits, seeds, roots and tubers, constitutes about 90-99.99 % of the diet (Valet 1994, Rosell 1998, Herrero 2001, 2003). Numerous studies have sought to determine environmental characteristics that determine the presence of the wild boar in Spain and Europe, and these are based on analysis of stomach contents, tracks, markings, bathing areas, rooting holes and feces (Puigdefábregas 1980, Rosell 1998, Herrero 2001, 2003). In Spain, studies have been carried out in the Western Pyrenees (Vericad 1971), Doñana National Park (Garzón et al. 1983, Venero 1984), Sierra Morena (Rodríguez Berrocal et al. 1982), the Almerian Alpujarra (Abaigar 1993, Sáenz de Buruaga 1995), northern Navarra (Leránoz & Castién 1996), Montseny (Valet et al. 1994, Rosell 1998), Vizcaya (Laskurian et al. 1991), Aragón (Herrero 2001, 2003, Herrero et al. 2006) and wetland habitat Aiguamolls Empordà Natural Park (Giménez-Anaya et al. 2008). In Europe, studies have been

Table 1. *Number of wild boars hunted and estimated populations, by Spanish province.*

Autonomous Community	Province	Wild boars hunted (2006-2007)
Andalucía	Almería	1673
Andalucía	Cádiz	3797
Andalucía	Córdoba	5311
Andalucía	Granada	3072
Andalucía	Huelva	3388
Andalucía	Jaén	5278
Andalucía	Málaga	1137
Andalucía	Sevilla	3921
Aragón	Huesca	15832
Aragón	Teruel	4695
Aragón	Zaragoza	6618
C. Valenciana	Alicante	2500
C. Valenciana	Castellón	650
C. Valenciana	Valencia	4360
Cantabria	Cantabria	1242
Castilla la Mancha	Albacete	3500
Castilla la Mancha	Ciudad Real	8245
Castilla la Mancha	Cuenca	1200
Castilla la Mancha	Guadalajara	2500
Castilla la Mancha	Toledo	9174
Castilla y León	Ávila	1628
Castilla y León	Burgos	4520
Castilla y León	León	1685
Castilla y León	Palencia	1074
Castilla y León	Salamanca	3542
Castilla y León	Segovia	972
Castilla y León	Soria	1397
Castilla y León	Valladolid	398
Castilla y León	Zamora	2192
Cataluña	Barcelona	7160
Cataluña	Gerona	8575
Cataluña	Lérida	5517
Cataluña	Tarragona	2807
Extremadura	Badajoz	6122
Extremadura	Cáceres	8136
Galicia	La Coruña	1077
Galicia	Lugo	3366
Galicia	Orense	2466
Galicia	Pontevedra	838
La Rioja	La Rioja	2386
Madrid	Madrid	2279
Navarra	Navarra	6434
P. de Asturias	Asturias	8356
País Vasco	Álava	1978
País Vasco	Guipúzcoa	700
País Vasco	Vizcaya	1013
R. de Murcia	Murcia	1534
Total		176245

Sources: MARM 2007, Andalusian Institute of hunting and Inland Fisheries, IREC, DMAH, hunting Areas, Xunta Galicia.

140

Table 2. Number of wild boar hunted and estimated population, by Portuguese district.

District	Wild boars hunted (2006-2007)
Aveiro	9
Beja	3284
Braga	15
Bragança	206
Castelo Branco	1346
Coimbra	142
Évora	2180
Faro	1987
Guarda	206
Leiria	122
Lisboa	105
Portalegre	2697
Porto	19
Santarém	1407
Setúbal	1183
Viana do Castelo	47
Vila Real	101
Viseu	111
Total	15167

Source: National Forest Authority (Autoridade Florestal Nacional), Portugal.

done in the Savoy Alps (Baubet et al. 1997), central European Atlantic mixed forests (Groot Bruinderink et al. 1994) and Western Europe (Schley & Roper 2003). Wild boar populations in Europe prefer broad-leafed forests, especially evergreen oak forests, open habitats such as steppe, Mediterranean scrubland, farmland, and areas with nearby water and tree cover Spitz (1999). They are found at altitudes ranging from sea level to 2400 m in the Pyrenees (Palomo & Gisbert 2002). Some important studies in I.P. and France point out that the wild boar occupies nearly all forest habitats (Sáez-Royuela 1987) and has a varied diet (Varin 1980, Valet et al. 1994). Those authors concluded that the animal's distribution is more affected by structural characteristics of vegetation than by other factors, except for human impact (Markina-Lamonja 1998).

Since the wild boar is found in a wide variety of habitats, estimating the population in specific regions requires accurate assessment of that region's ability to support the animals. To this end, we prioritized necessary resources for population survival and determined to what extent possible habitats on the I.P. are likely to provide these resources. Using the CORINE 2000 program (Coordination of Information on the Environment, Land Cover 2000, European Commission), the territory was divided into cells with a surface area of 10000 m² (1 ha = 0.01 km²). An advantage of CORINE is that it contains ground cover information standardized to European Union guidelines. Layers of land use over agricultural, forest and seminatural areas were taken into account since these areas might constitute suitable habitat for the wild boar. For example, the following vegetation constitutes a valuable food resource for wild boar on the I.P. (Rosell 1998, Herrero 2001, 2003) and in other places of Western Europe (Genov 1981, Massei et al. 1996, Schley & Roper 2003): *Quercus ilex*, *Q. suber*, *Q. humilis*, *Fagus sylvatica*, *Castanea sativa*, *Pinus pinea*, *P. communis*, *Juniperus communis*, *Sambucus* sp., and different species of thicket, bushes and gramineous plants such as *Festuca ovina*, *F. arundinacea*, *Agrostis capillaris*, *Brachipodium* sp., *Cyperus rotundus*, *Pteridium aquilinum*, *Tamarix gallica*. Forest zones containing *Pinus* sp. and scrubland containing *Espartium* sp. and *Erica* sp. have also been found to provide food or shelter to wild boar. In order to identify potential wild boar habitats, we assessed the ability of specific regions to support wild boar populations by assigning them a potential resource value (PRV). These PRVs were estimated in two steps: 1) First, selection to the potential resources used by the wild boar, and identification of habitats on the I.P. which can provide those resources was conducted. All the land uses selected from CORINE are based on a literature review including forest and semi natural areas (ground cover and wooded areas) (Baettig 1980, Tellería & Sáez-Royuela 1985, Fruzinski 1995, Neet 1995, Schley 2000, Herrero et al. 2006) and pastures and heterogeneous agricultural areas (Massei & Genov 2004, Herrero et al. 2006). A statistical analysis of association with the CORINE land uses selected and the presence of wild boars estimated by Palomo & Gisbert (2002) in Spain were performed using the Kruskal-Wallis and the Mann-Whitney U tests in SPSS v15.0 (SPSS Inc., 1989-2006). Variables significantly associated ($P < 0.05$) were included as a potential resource in the model. 2) Secondly, a categorical value was assigned to each potential resource according to the literature and expert opinion. A value of 2 was given to a location if it had resources suitable for use as both food and shelter, a value of 1 if it had resources to provide only one or the other, and 0 if it did not possess either type of resource (Fig. 1).

Home range and unified habitat (HR and UH)
In order to establish a reliable and conservative HR, which extends from the shelter over the area where
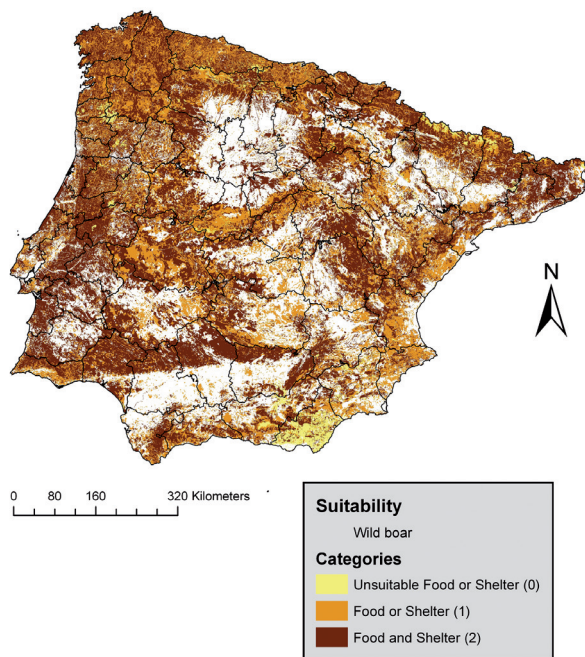
141

Fig. 1. *Map of potential habitats for wild boar on the Iberian Peninsula, based on analysis of potential resources. Suitability for supporting wild boar was assessed in CORINE by assigning potential resource values (PRVs) of 0 (unlikely suitable for food or shelter), 1 (suitable for food or shelter), or 2 (suitable for both food and shelter). White areas represent locations with no available data.*

the wild boar may roam under normal conditions, the literature on species movements based on radiolocation, radiotelemetry and nesting habits was reviewed (Janeau & Spitz 1984, Russo et al. 1997, Herrero 2001, Markina-Lamonja & García 2006). The surface used

was estimated by quadratic modeling of each home range for comparing different measures of length provided by different authors (Table 3). Authors of the studies were contacted in some cases to discuss whether the data were exceptional or normal, to ensure that we selected the most "natural" data not biased by anthropic factors, such as intense pressure from hunting, or by seasonal biological necessities such as mating, searches for food or searches for water under drought conditions. In some studies, home range data were not collected under normal conditions but under hunting conditions; in these cases, the authors measured the mean distance between the shooting site (radiomarking) and the capture site (Table 3). The distance roamed by wild boar under normal conditions was defined as 2 linear km (Boisaubert & Klein 1984, Briedermann 1990, Maillard & Fournie 1995, Caley 1997, Soidekat & Pohlmeyer 1999, 2004, Markina-Lamonja & Telletxea 2006, Keuling et al. 2010). Therefore land uses that CORINE 2000 situated at a distance of 2 km or less were merged together into a unified habitat (UH) providing a more realistic identification of areas where wild population is distributed.

Model

Population density (PD) was calculated using hunting data (H) and PRVs. The abundances of wild boar were projected onto territorial units according to the extension of the potential resources in each province (Spain) or district (Portugal). A common denominator was obtained by summing the areas of all cells in CORINE with a given PRV (0, 1 or 2). To estimate an index, these PRVs were multiplied by 0.1, 0.5 and 1,

Table 3. *Measurements of wild boar home range (HR) and lineal distance between two point.*

Reference	(HR) (km^2)	Lineal distance between two point (km)
Janeau & Spitz (1984)	120[a]♂-150[a]♂ 40[a]♀-60[a]♀	12.36*♂-13.8*♂ 7.13*♀-8.74*♀
Briedermann (1990)		♂ 4.5[c], ♀ 2.8[c]
Markina-Lamonja & Garcia (2006)	4.55-11[b]	2.13*-3.31*
Sodeikat & Pohlmeyer (1999)		P < 4.7[c], Y < 10[c]
Sodeikat & Pohlmeyer (2004)		0.2-4.6
Vicente et al. (2010)		< 12 per day
Keuling et al. (2010)		♀ 1.8[c], ♂ 3.2[c]
Herrero (2001)	3.6-12.3[a]	1.89*-3.51*
Caley (1997)		♀ 1.6[c], ♂ 3.8[c]
Boisaubert & Klein (1984), Spitz et al. (1984)		< 10[a]
Russo et al. (1997)	0.029[d]-1.081[d]	0.192[d]*-1.17[d]*
Maillard & Fournie (1995)		2.010[b]-2.63[b]

* Equivalence to diameter of the length of the square area model (estimated data), [a] HR without indication of season (annual HR), [b] HR with indication of season, [c] Mean distances between capture and shooting site of marked wild boar, [d] Daily movement size with indication of season, P, piglet; Y, yearling; ♂, male; ♀, female, HR: surface used.

respectively. For each province/district i, PD was estimated using the formula:

$$PD_i = \frac{\sum H_i}{\sum [(A''2''*1)+(A''1''*0.5)+(A''0''*0.1)]}$$

where PD_i refers to the PD of wild boar in the province or district, H is the number of animals hunted and A is the number of cells assigned a PRV of 0, 1, or 2. PD was distributed throughout each province or district according to land use. In other words, populations were assumed not to be present throughout a province or district, but rather to be restricted to areas with a PRV of 0, 1 or 2.

Ranges of PDs were calculated for each territorial unit based on H_i and PRV. The resulting population distribution map was compared with one based on the presence/absence of wild boars in Spain (Palomo et al. 2007), with a more recent distribution map for Portugal (Vingada et al. 2010) and a recent distribution map for the Euroasiatic zone (Oliver & Leus 2008).

Results

The density and unified habitat of the wild boar population on the I.P. were estimated. Three parameters were obtained and were illustrated in three maps:

Potential wild boar habitats based on potential resources value (PRVs)

Statistical analysis showed that wild boar presence was significantly associated to thirteen out of the seventeen CORINE land uses (Kruskall-Wallis test P < 0.05, Mann-Whitney U test P < 0.05) and these were subsequently included in the model. Two more CORINE land uses (agro-forestry areas and moors, and heathland) were also considered in the model due to their biological significance. Table 4 summarized the total 15 land uses included in the study together with their surface area on the I.P. and their PRVs. It shows a total of 17 potential resources with a surface of 324821.12 km² for Spain, and 16 resources with a surface of 66002.84 km² for Portugal. The highest PRV of two was assigned to code numbers 23, 24, 28 and 29, with 28 (sclerophyllous vegetation) being

Table 4. *Land uses selected in the CORINE program as potential resources (Grid_Code) for wild boar, together with their surface areas and potential resource values (PRV).*

Potential Resource (Grid Code)	Land use	PRVs*	Surface area (km²)		
			Spain	Portugal	Entire Iberian Peninsula
18	Pastures	1	6181.03	378.13	6559.16865
19	Annual crops associated with permanent crops	1	296.32	4204.93	4501.256
20	Complex cultivation patterns	1	38091.94	6227.84	44319.782
21	Land principally occupied by agriculture, with significant areas of natural vegetation	2	24317.48	6807.93	31125.41
22	Agro-forestry areas	2	24444.48	5592.05	30036.53
23	Broad-leafed forest	2	37718.79	12213.08	49931.87
24	Coniferous forest	2	38343.37	6901.91	45245.28
25	Mixed forest	2	14852.07	5255.88	20107.95
26	Natural grasslands	1	26082.5	1851.07	27933.57
27	Moors and heathland	1	9078.33	3364.97	12443.3
28	Sclerophyllous vegetation	1	49648.41	1951.43	51599.84
29	Transitional woodland-shrub	2	44214.45	9631.37	53845.82
30	Beaches, dunes, sands	0	286.75	97.42	384.17
31	Bare rocks	0	1697.6	438.28	2135.88
32	Sparsely vegetated areas	0	8813.22	770.77	9583.99
33	Burned areas	0	751	315.78	1066.78
34	Glaciers and perennial snow	0	3.36	0	3.36
Total area (km²)			324821.117	66002.84	390823.957

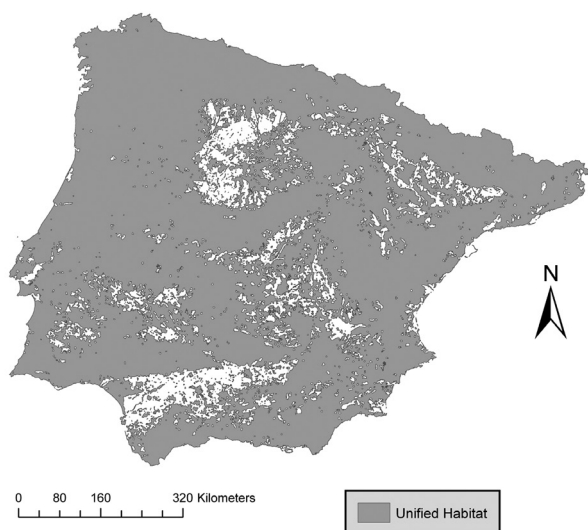** See Material and Methods for interpretation of PRVs.*

143

Fig. 2. *Map of unified habitat of the wild boar on the Iberian Peninsula, obtained by applying a home range of 2 km to potential resource.*
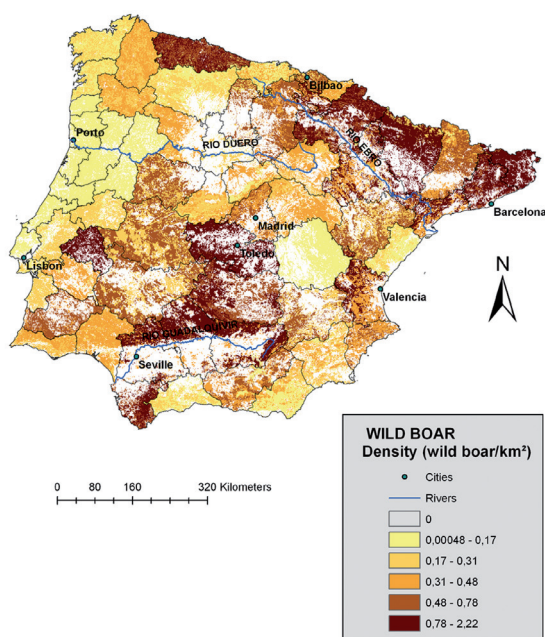

Fig. 3. *Population density of wild boar on the Iberian Peninsula based on potential resource values (PRVs) by province (Spain) or district (Portugal).*

the most extensive in Spain and 23 (broad-leafed forest) the most extensive in Portugal. The least extensive land use in both countries was 34 (glaciers and perpetual snow), with only 3.36 km² in Spain and none in Portugal (Table 4). Potential habitat for wild boar on the I.P. based on potential resources value were mapped (Fig. 2).

Unified habitat of the wild boar on the I.P.
Results shows that the species is spread over more than two-thirds of Spain and is absent or less abundant in 34.05 % (167820.46 km²) of the territory (Fig. 2).

Population density (PD) of wild boar on the I.P.
The mapping of PD according to potential habitats in Fig. 3 may give the most realistic estimate so far of population density on the I.P. by administrative level. The average density of wild boars within their potential habitat is 0.38 per km² (min 0.014-max 2.22 and SD 0.398) in Spain, 0.13 per km² (min 0.00048-max 1.99 and SD 0.313) in Portugal, and 0.31 per km² (min 0.00048-max 2.22 and SD 0.39) on the I.P. as a whole. There are some differences between adjoining territories that share the same potential resources and therefore would be expected to form part of the same habitat. For example, in the central region of I.P. (Ávila and Toledo), two neighboring units had similar resource types and areas (transitional woodland-shrub, code 29; 5.17 and 5.34 km²), but the results show different PD (0.39 and 1.88). In the eastern region of I.P. (Navarra and Huesca), two neighboring units had similar resource type (coniferous forest, code 24) and areas (167.62 and 165.47 km²), but different PD (1.09 and 2.22). In the southern region of I.P. (Málaga and Cádiz), two neighboring units had broad-leafed forest (code 23) over areas of 204 and 250 km², but substantially different population densities of 0.31 and 1.23. In the western region of I.P. (Santarem and Portalegre), two neighboring units had transitional woodland-shrub over areas of 61.30 and 72.95 km², with densities of 0.22 and 1.99. These differences between neighboring provinces (Spain) or districts (Portugal) with the same potential resources were observed throughout both countries.

Discussion
An analytical model combining data on hunting and potential resources (land use) was developed in order to assess the population size and density of the wild boar on the I.P. In this approach, raw hunting data are adjusted to the potential habitats. A unified habitat was provided to get a more reliable estimate of distribution. The model sacrifices some local precision in order to take into account the heterogeneity of environmental parameters and hunting behavior across the I.P. However, we assumed the bias to working on a scale as large as the I.P., since the data come from regions with different hunting traditions, which can translate into different approaches and techniques for generating hunting statistics. The use of this method at small

144

scales is limited since, some important local variables, such as the availability of maize crops or whether or not there is hunting in this area, are not considered into the analyses due to the lack of applicable data registered in some provinces or district. This is the reason why the map shows areas without densities where in reality they are locally dense such as the Duero-Ebro-Guadalquivir basin (Fig. 3). On the other hand, several unexpected differences in densities have been shown between adjoining territories that share the same potential resources. This fact, which corresponds with geopolitical provincial borders, is related to the use of hunting bag statistics. This bias derives from data provided by each regional administration in Spain and Portugal, where hunting techniques and management vary. Direct sampling of the wild boar population is one way to obtain a reliable estimate of the population's size and distribution (Franzetti et al. 2010). However, such a direct approach is complex and costly due to the rarity of direct observation, the limited areas in which it can be conducted and the primarily nocturnal habits of the species (Briedermann 1971, Mauget & Sempere 1978, Singer & Ackerman 1981, Janeau & Spitz 1984, McIlroy 1989, Boitani et al. 1992, Boitani et al. 1994, Lemel et al. 2003, Keuling et al. 2008). As a result, estimating the population based on hunting data has become a generalized practice in many countries, and the availability of these data has made this a tool of choice when estimating wild boar populations (Plhal et al. 2010).

The CORINE program has proven useful for analyzing potential distribution of vertebrate fauna (Acevedo et al. 2010). Version 2000 (EEA 2008) was used in this study, which is more complete for our purposes than the more updated previous version (EEA 2007). In any event, the similarity between the two versions is 97.3 % for Spain and 97.84 % for Portugal. In addition, version 2000 allows us to extrapolate the method to other EU countries, since its data are more homogeneous and uniform, making it easier to conduct comparisons. For studies on a more limited scale, it may be preferable to supplement CORINE with local studies in order to increase the accuracy of the relationship between vegetation cover and wildlife (Sáez-Royuela 1987, Markina-Lamonja 1998, Vargas et al. 2006).

The present study used 2 linear km as the minimum distance between separate roaming areas in order to create a UH. This approach led, in several cases, to the fusion of habitat areas that previously were considered separate. Although 2 km is a conservative estimate, our strategy gives a more biologically correct definition of habitat (Fig. 2), which may also provide

valuable information for other goals related to reserve management, such as road design to avoid collisions with wild boar, identification of appropriate areas for hunting management and fencing, creation of animal trails or evaluation of crop damage in proximity to wild boar shelter areas.

In this study significant statistical association among the presence of wild boar and the forest and agriculture land uses was found. This finding is consistent with studies of Markina-Lamonja (1998), where the wild boar's distribution is mainly affected by structural characteristics of vegetation. Land use 22 (agro-forestry areas) and 27 (moors and heathland) showed no significant association to presence of wild boar, however both were included in the analysis. Land use 22 represents agro-forestry areas and is widely distributed in Spain covering a 5 % of the total area, and that could be the reason of the non associate result, but its relation with presence of wild boar was described by Herrero (2003) and (Herrero et al. 2006). Land use 27 represents moors and heathland areas that are clustered in a small area in North of I.P. with high quantity of wild boar, and Nores (2010) described a high association in this region between altitude wild boar presence and abundance coinciding with areas of moors and heathland.

Our species distribution maps reflect the extensive presence of Iberian *Quercus* spp. forests, which provide a valuable food resource for wild boar. However, since these forests produce seeds following a masting pattern, they are not a stable food source over time, especially during the summer. In such inversion of shortage and agriculture are secondary food sources for ungulates (Abaigar 1993, Sáenz de Buruaga 1995, Herrero et al. 2006). The presence of such secondary food sources on the I.P. has increased due to the cultivation of maize (*Zea mays*), which provides a stable source of food and land cover for an average of 5-7 months each year when there is a shortage of food or fruits (Briedermann 1976, Onida et al. 1995, Schley & Roper 2003, Herrero et al. 2006, Schley et al. 2008), although these are not the 'traditional' habitats of wild boars. Unfortunately, as mentioned above, CORINE landcover cannot distinguish among types of irrigated crops, and the extent of cornfields is underestimated, especially at river basins such as the Duero-Ebro-Guadalquivir basin in Spain. It is precisely in these areas that the wild boar population has increased in close association with this crop, leading to an increase in hunting and highway collisions (Peris et al. 2005). For these reasons, due to the lack of information about

145

difference in land use and the existence of secondary food sources (e.g. maize crops), the map shows areas without wild boar, where in reality their presence has been observed (Fig. 1). As more information becomes available about maize and other food sources, we can further improve the population distribution maps of wild boar. Despite the lack of the some data, the information included in this study is in fact extensive. Of particular note, comparing the resuts of this study (Figs. 1, 2) with the results of Palomo et al. (2007), based on the presence/absence of wild boar in Spain, we note that wild boar habitat distribution patterns are similar in both studies. Our current study however presents a larger area of potential habitat, most likely derived from a more accurate scale range data.

Our map of wild boar population density shows differences between adjacent territories within the same province or district (Fig. 3). This is surprising, since adjacent territories can be expected to share similar habitats and therefore similar resources. Such territories would therefore be expected to show the same hunting potential, but in fact, differences in hunting capacity (e.g. number of licenses) and intensity of hunting practices appear to give rise to observable differences in density. At the same time, the apparent differences between adjacent territories may reflect, at least in part, variations in hunting effectiveness that has been shown to differ from one region to another on the I.P. (Herrero 2003). Hunting effectiveness varies from northern to southern Iberia as a function of several factors including orography, traditions, or different hunting techniques (e.g. battue and monteria, race and number of dogs),

however these factors have not been considered in this paper because the information is not available. In the same way some types of hunt management (i.e. supplementing feed to wild boars) have not been considered in the study but could increase the density of this species disproportionately. To summarize, all of the factors mentioned, combined with the lack of accurate data and information provided by different regions collected in different ways, could be a significant source of variation in the results. This point could not be adressed in this paper. This work has aimed to offer a first analysis of the population size, density and distribution of the wild boar on the I.P., sacrificing some local precision in order to model the effects of environment and hunting across the entire Peninsula. The approach developed here may be applicable to other EU countries and may help generate a population density and distribution map across Europe, allowing comparisons between countries. This approach and the specific results reported here for the I.P., may prove useful for guiding the monitoring and control of diseases for which the wild boar acts as a reservoir (e.g. epidemiological purposes such as target surveillance).

Acknowledgements

Literature

Abaigar T. 1990: Características biológicas y ecológicas de una población de jabalíes (*Sus scrofa* L., 1758) en el SE Ibérico. *Ph.D. Thesis, University of Navarra, Navarra, Spain.*

Abaigar T. 1993: Régimen alimentario del jabalí (*Sus scrofa*. L. 1758) en el sureste ibérico Doñana. *Doñana, Acta Vertebrata 20: 35–48.*

Abaigar T., del Barrio G. & Vericad J.R. 1994: Habitat preferente of wild boar (*Sus scrofa* L.,1758) in a mediterranean environment. Indirect evaluation by signs. *Mammalia 58: 201–210.*

Acevedo P., Escudero M.A., Munoz R. & Gortázar C. 2006: Factors affecting wild boar abundance across an environmental gradient in Spain. *Acta Theriol. 51: 327–336.*

Acevedo P., Ruiz-Fons F., Estrada R., Márquez A.L., Miranda M.A., Gortázar C. & Lucientes J. 2010: A broad assessment of factors determining *Culicoides imicola* abundance: modelling the present and forecasting its future in climate change scenarios. *PLoS ONE 5 (12): e14236. doi:10.1371/journal.pone.0014236.*

Baettig M. 1980: Contribution à la biologie et écologie du sanglier (*Sus scrofa* L.) dans le canton de Vaud. *Diplome en Zoologie, Université de Bale, Basel, Switzerland.*

Baubet E., Touzeau C. & Brandt S. 1997: Les lombriciens dans le régime alimentaire du sanglier (*Sus scrofa* L.) en montagne. *Mammalia 61: 371–383.*

Biotema S.L. 1990: El jabalí (*Sus scrofa*) en Guipúzcoa. *Informe Técnico Diputación Foral de Guipúzcoa, San Sebastián.*

Boisaubert B. & Klein F. 1984: Contribution a l'étude de l'ocupation de l'espace chez le sanglier (*Sus scrofa*) par capture et recapture. *Les colloques de l'INRA 22. Toulouse, France.*

Boitani L., Mattei L., Morini P. & Zagarese B. 1992: Experimental release of captivity reared wild boar (*Sus scrofa*). In: Ongulés/Ungulates 91. *Proceedings of the International Symposium, Toulouse: 413–417.*

Boitani L., Mattei L., Nonis D. & Corsi F. 1994: Spatial and activity patterns of wild boar in Tuscany, Italy. *J. Mammal. 75: 600–612.*

Bratton P.S. 1975: The effect of the European wild boar, *Sus scrofa*, on Gray Beech forest in the Great Smoky Mountains. *Ecology 566: 1350–1366.*

Briedermann L. 1971: Zur Reproduktion des Schwarzwildes in der DDR. *Tag-Ber. Dt. Akad. Landwirtsch. Wiss. Berlin 113: 169–186.*

Briedermann L. 1976: Ergebnisse einer Inhaltsanalyse von 665 Wildschweinmäyer. *Zool. Gart. 46: 157–185.*

Briedermann L. 1990: Schwarzwild. VEB Deutscher Landwirtschaftsverlag, 2nd edn. *Neumann-Neudamm, Melsungen, Berlin.*

Bueno C.G., Barrio I., García-González R., Alados C.L. & Gómez-García D. 2010: Does wild boar rooting affect livestock grazing areas in alpine grasslands? *Eur. J. Wildlife Res. 56: 765–770.*

Cahill S., Llimona F. & Gràcia J. 2003: Spacing and nocturnal activity of wild boar *Sus scrofa* in a Mediterranean metropolitan park. *Wildlife Biol. 9 (Suppl. 1): 3–13.*

Caley P. 1997: Movement, activity patterns and habitat use of feral pigs (*Sus scrofa*) in a tropical habitat. *Wildlife Res. 24: 77–87.*

EEA, European Environment Agency 2008: Dominant landscape types of Europe, based on CORINE land cover 2000. *European Environment Agency, Copenhagen. Accessed on 26 November 2010. http://www.eea. europa.eu/data-and-maps/figures/dominant-landscapetypes-of-europe-based-on-corine-land-cover-2000-1*

EEA, European Environment Agency 2007: CLC2006 technical guidelines. EEA Technical report No 7/2007. *European Environment Agency, Kongens Nytorv 6, 1050 Copenhagen K., Denmark. ISBN 978-92-9167-968-3. Accessed on 26 November 2010. http://www.eea.europa.eu/publications/technical_report_2007_17*

Fernández-Llario P. 1996: Ecología del jabalí en Doñana: parámetros reproductivos e impacto ambiental. *Ph.D. Thesis, University of Extremadura, Cáceres, Spain.*

Fonseca C., Silva A., Alves J., Vingada J. & Soares A.M.V.M. 2011: Reproductive performances of the wild boar population in Portugal. *Eur. J. Wildlife Res. doi: 10.1007/s10344-010-0441-6.*

Franzetti B., Scacco M., La Morgia V., Calmanti R., Calabrese A., Focardi S. & Riga F. 2010: Mission accomplished: assessment of wild boar populations across Italy. In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 37. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/ bookOfAbstracts.cfm*

Fruzinski B. 1995: Situation of wild boar populations in western Poland. *Ibex J. Mt. Ecol. 3: 186–187.*

Garzón P. 1991: Biología y ecología del jabalí (*Sus scrofa* L., 1758) en el Parque Natural de Monfragüe. *Ph.D. Thesis, Universidad Autónoma de Madrid.*

Garzón P., Palacios F. & Ibáñez C. 1983: Primeros datos sobre la alimentación del jabalí (*Sus scrofa baeticus* Thomas, 1912) en el Parque Nacional de Doñana. II Reunión Iberoamericana. *Cons. Zool. Vert. Cáceres: 466–475.*

Genard M. & Lescourret F. 1985: Le sanglier (*Sus scrofa scrofa* L.) et les diasporas dans le sud de la France. *Revue d'Ecologie (Terre Vie) 40: 343–353.*

Genov P. 1981a: Food composition of wild boar in north-eastern and western Poland. *Acta Theriol. 26: 185–205.*

Genov P. 1981b: Significance of natural biocenoses and agrocenoses as the source of food for wild boar (*Sus scrofa* L.). *Ekologia Polska 29: 117–136.*

Giménez-Anaya A., Herrero J., Rosell C., Couto S. & García-Serrano A. 2008: Food habits of wild boars (*Sus scrofa*) in a Mediterranean Coastal Wetland. *Wetlands 28: 197–203.*

Gortázar C., Ferroglio E., Hofle U., Frölich K. & Vicente J. 2007: Diseases shared between wildlife and livestock: a European perspective. *Eur. J. Wildlife Res. 53: 241–256.*

Grimal S. 1987: Production et devenir des faines, chataignes et glands de chênne vert en relation avec le sanglier dans le sud du Massif Central. *Mémoire de 3ème année, Toulouse.*

Groot Bruinderink G.W.T.A., Hazebroek E. & Voet H.V.D. 1994: Diet and condition of wild boar, *Sus scrofa scrofa*, without supplementary feeding. *J. Zool. 233: 631–648.*

Herrero J. 2001: Adaptación funcional del jabalí (*Sus scrofa*) a un ecosistema forestal y a un sistema agrario intensivo en Aragón. *Ph.D. Thesis, Complutense University of Madrid, Spain.*

Herrero J. 2003: Adaptación funcional del jabalí *Sus scrofa* L. a un ecosistema forestal y a un sistema agrario intensivo en Aragón. *Publicaciones del Consejo de Protección de la Naturaleza de Aragón. Serie Investigación 41: 159.*

Herrero J., García-Serrano A., Couto S., Ortuño V. & García-González R. 2006: Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agroecosystem. *Eur. J. Wildlife Res. 52: 245–250.*

Höfle U., Gortázar C., Ortíz J.A., Knispel B. & Kaleta E.F. 2004: Outbreak of trichomoniasis in a woodpigeon (*Columba palumbus*) wintering roots. *Eur. J. Wildlife Res. 50: 73–77.*

Janeau G. & Spitz F. 1984: L'espace chez le sanglier (*Sus scrofa* L.). Occupation et mode d'utilisation. *Gibier Faune Sauvage 1: 73–89.*

Jansen A., Luge E., Guerra B., Wittschen P., Gruber A.D., Loddenkemper C., Schneider T., Lierz M., Ehlert D., Appel B., Stark K. & Nockler K. 2007: Leptospirosis in urban wild boars, Berlin Germany. *Emerg. Infect. Dis. 13: 739–742.*

Keuling O., Lauterbach K., Stier N. & Roth M. 2010: Hunter feedback of individually marked wild boar *Sus scrofa* L.: dispersal and efficiency of hunting in northeastern Germany. *Eur. J. Wildlife Res. 56: 159–167.*

Keuling O., Stier N. & Roth M. 2008: How does hunting influence activity and spatial usage in wild boar *Sus scrofa* L.? *Eur. J. Wildlife Res. 54: 729–737.*

Keuling O., Stier N. & Roth M. 2009: Commuting, shifting or remaining? Different spatial utilisation patterns of wild boar *Sus scrofa* L. in forest and field crops during summer. *Mamm. Biol. 74: 145–152.*

Lancia R., Nichols J.D. & Pollock K.H. 1994: Estimating the number of animals in wildlife populations. In: Bookhout T.A. (ed.), Research and management techniques for wildlife and habitats. *The Wildlife Society, Bethesda, Maryland, USA: 215–253.*

Laskurian N.A., Egileor E. & Irizar I. 1991: El jabalí (*Sus scrofa*) en Bizkaia. Estimación del censo y distribución. *Informe interno de la Diputación Foral de Bizkaia.*

Lemel J., Truvé J. & Söderberg B. 2003: Variation in ranging and activity behaviour of European wild boar *Sus scrofa* in Sweden. *Wildlife Biol. 9 (Suppl.): 29–36.*

Leránoz I. & Castién E. 1996: Evolución de la población del jabalí (*Sus scrofa* L., 1758) en Navarra (N Península Ibérica). *Miscel. lània Zoológica. 19: 133–139.*

López R., López J., Gavela J., Bosch J. & Ballesteros C. 2010: Wild boar capture methodology (*Sus scrofa* Linnaeus 1758) in a suburban area: the case of Las Rozas de Madrid 2009 (central Spain). In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 62. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/bookOfAbstracts.cfm*

Mackin R. 1970: Dynamics of damage caused by wild boar to different agricultural crops. *Acta Theriol. 25: 447–459.*

Maillard D. & Fournier P. 1995: Effects of shooting with hounds on size of resting range of wild boar (*Sus scrofa* L.) groups in Mediterranean habitat. *Ibex J. Mt. Ecol. 3: 102–107.*

Markina-Lamonja F.A. 1998: Estudio de las poblaciones de corzo (*Capreolus capreolus* L.) y jabalí (*Sus scrofa* L.) y análisis de su explotación cinegética en el territorio histórico de Álava. *Ph.D. Thesis, Departamento Biología Animal, Universidad de León, España.*

Markina-Lamonja F.A. & Telletxea I. 2006: Ecología y territorialidad del jabalí en Álava. *Revista de la Asociación de Cotos de Caza de Álava 11: 54–61. Accessed on 27 September 2010. http://www.accazalava.es/Pdf/revista11/Jabal%ED.pdf*

MARM 2007: Statistical Yearbook of Forestry 2007 from the Spanish Ministry of Environment, Rural and Marine Affaires (MARM). *Accessed on 29 September 2010. http://www.marm.es/es/biodiversidad/temas/montes-y-politica-forestal/estadisticas-forestales/produccion_2007.aspx*

Marques S., Fonseca C., Rodrigues R. & Cancela J. 2010: Impact of roads on wild boar (*Sus scrofa*) populations in Central and Northern Portugal. In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 56. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/bookOfAbstracts.cfm*

Massei G. & Genov P. 2004: The environmental impact of wild boar. *Galemys 16: 135–145.*

Massei G., Genov P. & Staines B.W. 1996: Diet, food availability and reproduction of wild boar in a Mediterranean coastal area. *Acta Theriol. 41: 307–320.*

Mauget R. & Sempere A. 1978: Comportement locomoteur determine par radiotraking chez deux ongulés sauvages en liberté: le chevreuil (*Capreolus capreolus* L.) et le sanglier (*Sus scrofa* L.). *Biol. Behav. 3: 331–340.*

McIlroy J.C. 1989: Aspects of the ecology of feral pigs *(Sus scrofa)* in the Murchison area; New Zealand. *N. Z. J. Ecol. 12: 11–22.*

Melis C., Szafranska P., Jedrzejewska B. & Barton K. 2006: Biogeographical variation in the population density of wild boar (*Sus scrofa*) in western Eurasia. *J. Biogeography 33: 803–811.*

Neet C.R. 1995: Population dynamics and management of *Sus scrofa* in western Switzerland: a statistical modelling approach. *Ibex J. Mt. Ecol. 3: 188–191.*

Nores C. 2010: Wild boar abundance and altitude. In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 47. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/bookOfAbstracts.cfm*

Oliver W. & Leus K. 2008: *Sus scrofa.* In: IUCN 2010, IUCN Red List of Threatened Species. Version 2010.4. *Accessed on 01 December 2010. http://www.iucnredlist.org/apps/redlist/details/41775/0*

Onida P., Garau F. & Cossu S. 1995: Damages caused to crops by wild boars (*S. scrofa meridionalis*) in Sardinia (Italy). *Ibex J. Mt. Ecol. 3: 230–235.*

Onipchenko V.G. & Golikov K.A. 1996: Microscale revegetation of alpine lichen heath after wild boar digging: fifteen years of observations on permanent plots. *Oecologia 5: 35–39.*

Packer J.J. & Birks J.D.S. 1999: An assessment of British farmers' and gamekeepers' experiences, attitudes and practices in relation to the European polecat *Mustela putorius. Mammal Rev. 29: 75–92.*

Palomo L.J. & Gisbert J. 2002: Atlas de los mamíferos terrestres de España. *Dirección General de Conservación de la Naturaleza, 588. SECEM-SECEMU, Madrid, Spain.*

Palomo J.L., Gisbert J., Blanco J.C. (eds.) 2007: Atlas de los Mamíferos terrestres de España. *Dirección General de Conservación de la Naturaleza, 586. SECEM – SECEMU, Madrid, Spain.*

Peris S., Baquedano R., Sánchez A. & Pescador M. 2005: Mortalidad del jabalí (*Sus scrofa*) en carreteras de la provincia de Salamanca (no de España): influencia de su comportamiento social? *Galemys 17 (1–2): 13–23.*

Plhal R., Kamler J. & Homolka M. 2010: Comparison of four methods for estimation of wild boar population density in forest environment. In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 41. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/bookOfAbstracts.cfm*

Puigdefábregas J. 1980: Observaciones sobre la horadura del jabalí en ambiente forestal. *Publicaciones del centro Pirenaico de Biología Experimental 12: 7–16.*

Rodríguez Berrocal J., Zamora Lozano J. & Media Blanco M. 1982: Hábitos alimenticios del jabalí: un condicionamiento para su explotación cinegética racional. *Archivos de Zootecnia 31: 149–154.*

Rosell C. 1995: Wild boar *Sus scrofa.* In: Ruiz-Olmo I. (ed.), The large mammals of Catalonia and Andorra. *Lynx Edicions: 139–145. (in Catalan)*

Rosell C. 1998: Biology and ecology of wild boar (*Sus scrofa* L., 1758) in two populations of the northeastern Iberian. *Ph.D. Thesis, Facultat de Biología, Departament de Biología Animal. Universidat de Barcelona, España. Accessed on 26 November 2010. http://www.minuartia.com/public/arees-de-biodiversitat-i-territori/pag,20/ (in Catalan)*

Rosell C., Carretero M.A. & Bassols E. 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 (NE): 59–73.*

Rosell C., Fernández-Llario P. & Herrero J. 2001: El jabalí (*Sus scrofa* Linnaeus, 1758). *Galemys 13: 1–25.*

Russo L., Massei G. & Genov P.V. 1997: Daily home range and activity of wild boar in a Mediterranean area free from hunting. *Ethol. Ecol. Evol. 9: 287–294.*

Sáenz de Buruaga M. 1995: Alimentación del jabalí (*Sus scrofa castilianus*) en el norte de España. *Ecología 9: 367–386.*

Sáenz De Buruaga M., Costa L. & Purroy F.J. 1991: Distribution and abundance of three wild ungulates in the Cantabrian Mountains of Northern Spain. In: Bobek B., Perzanowski K. & Regelin W.L. (eds.), Global trends in wildlife management. *18th IUGB congress, Jagielloinan University, Krakow, Poland: 627–630.*

Sáez-Royuela C. & Tellería J.L. 1988: Las batidas como método de censo en especies de caza mayor: aplicación al caso del jabalí (*Sus scrofa L.*) en la provincia de burgos (Norte de España). *Doñana, Acta Vertebrata 15: 215–223.*

Sáez-Royuela C. 1987: Biología y ecología del jabalí (*Sus scrofa*) en Castilla La Vieja. *Ph.D. Thesis, Universidad Complutense Madrid, Spain.*

Sáez-Royuela C. 1989: Biología y ecología del jabalí (*Sus scrofa*). *Ph.D. Thesis, Universidad Complutense Madrid, Spain.*

Sáez-Royuela C. & Tellería J.L. 1986: The increased population of the wild boar (*Sus scrofa* L.) in Europe. *Mammal Rev. 16: 97–101.*

Saïd S., Tolon V., Brandt S. & Baubet E. 2011: Sex effect on habitat selection in response to hunting disturbance: the study of wild boar. *Eur. J. Wildlife Res. Doi: 10.1007/s10344-011-0548-4.*

Salces J. & Markina-Lamonja F.A. 1992a: Revisión histórica de la caza en la Comunidad Autónoma Vasca. *Sustrai 25: 62–64.*

Santos P., Mexia-de-Almeida L. & Petrucci-Fonseca F. 2004: Habitat selection by wild boar *Sus scrofa*, L. in Alentejo, Portugal. *Galemys 16: 167–184.*

Sävberger L. 2010: National wildlife accident council. *Ph.D. Thesis, University of Agricultural Science Umeå, Sweden. (in Swedish)*

Schley L. 2000: The badger *Meles meles* and the wild boar *Sus scrofa*: distribution and damage to agricultural crops in Luxembourg. *Ph.D. Thesis, University of Sussex, Sussex, United Kingdom.*

Schley L., Dufrêne M., Krier A. & Frantz A.C. 2008: Patterns of crop damage by wild boar (*Sus scrofa*) in Luxembourg over a 10-year period. *Eur. J. Wildlife Res. 54: 589–599.*

Schley L. & Roper T.J. 2003: Diet of wild boar *Sus scrofa* in western Europe, with particular reference to consumption of agricultural crops. *Mammal Rev. 33: 43–56.*

Schmidt M., Sommer K., Kriebitzsch W.U., Ellenberg H. & Oheimb G. 2004: Dispersal of vascular plants by game in northern Germany. Part I: roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). *Eur. J. Forest 123: 167–176.*

Singer F.J. & Ackerman B.B. 1981: Food availability, reproduction and condition of European wild boar in Great Smoky Mountais National Park. *Research Resources Management Report 43: 1–52.*

Sodeikat G. & Pohlmeyer K. 1999: Untersuchungen zum Wanderverhalten des Schwarzwildes in schweinepestgefärdeten Gebieten im östlichen Niedersachsen, Sachbericht 1998 an das Niedersächsische Ministerium für Ernährung, Landwirtschaft und Forsten. *Institut für Wildtierforschung an der Tierärztlichen Hochschule Hannover.*

Sodeikat G. & Pohlmeyer K. 2004: Escape movements of wild boar piglets (*Sus scrofa* L.) after trapping, marking and releasing. *Galemys 16: 185–193.*

Spiecker D. 1969: Verlauf und Ausbreitung der Schweinepest (*Pestis suum*) in der Eifel in den Jahren 1963 und 1964. *Z. Jagdwiss. 15: 144–151.*

Spitz F. 1999: *Sus scrofa*. In: Mitchell-Jone A.J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P.J.H., Spitzenberger F., Stubbe M., Thissen J.B.M., Vohralík V. & Zima J. (eds.), The atlas of European mammals, 1999. *Academic Press, London, UK: 380–381.*

Spitz F., Janeau G. & Vallet G. 1984: Elements de démographie du sanglier (*Sus scrofa*) dans la région de Grésigne. *Acta Oecol. 5: 43–59.*

Spitz F. & Vallet G. 1991: Etude démographique du langedoc. *Bull. Mens. De la O. N. C. 159: 29–39.*

Tellería J.C. & Sáez-Royuela C. 1985: L'évolution démographique du sanglier (*Sus scrofa*) en Espagne. *Mammalia 49: 195–202.*

Thurfjell H. 2011: Spatial behaviour of wild boar. *Ph.D. Thesis, Faculty of Forest Sciences Department of wildlife, Fish, and Environmental Studies, Swedish University of Agricultural Sciences Umeå, Sweden. Accessed on 17 May 2011. http://pub.epsilon.slu.se/8077/*

Tilson R. & Nyhus P. 1998: Keeping problem tigers from becoming a problem species. *Conserv. Biol. 12: 261–262.*

Valet G., Rosell C., Chayron L., Fosty P. & Spitz F. 1994: Régime alimentaire automnal du sanglier (*Sus scrofa*) en Ariège, France, et Catalogne, Espagne. *Gibier Faune sauvage 11: 313–326.*

Vargas J.M., Farfán M.A. & Guerrero J.C. 2006: Comarcalización cinegética a escala regional: La experiencia piloto de Andalucía (Sur de España). *Ecología 20: 415–434.*

Varin E. 1980: Chevreuil, Cerf, Sanglier. *De L´Oree. Bourndeax.*

Vassant J., Brant S. & Jullien J.M. 1993: Influence du passage de l´autoroute A 5 sur les populations cerf-sanglier du Massif d´Arc-en-Barriois. 2 et dernière partie: cas population sanglier. *Bulletin Mensuel de l'Office National de la Chasse 184: 24–33.*

Venero J.L. 1984: Dieta de los grandes fitófagos silvestres del Parque Nacional de Doñana. *Doñana, Acta Vertebrata 2: 19–130.*

Vericad J.R. 1971: Estudio faunístico y biológico de los mamíferos del Pirineo. *Ph.D. Thesis, Publicaciones del Centro Pirenaico de Biología Experimental.*

Vicente J., Maio E., Acevedo P., Barasona J.A., Soriguer R. & Sánchez Vizcaíno J.M. et al. 2010: Habitat use, field epidemiology and risk factors related to wild boar-livestock interactions in Spain. In: Defra & Fera (eds.), Book of 8th international symposium on wild boar and other suids, 12. *The Food and Environment Research Agency, York, United Kingdom. Accessed on 27 October 2010. https://secure.fera.defra.gov.uk/wildboar2010/bookOfAbstracts.cfm*

Vingada J., Fonseca C., Cancela J., Ferreira J. & Eira C. 2010: Ungulates and their management in Portugal. In: Apollonio M., Andersen R. & Putman R.J. (eds.), European ungulates and their management in the 21st century, 2011. *Cambridge University Press, Cambridge, United Kingdom: 392–418.*

151