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Problematic Wildlife II

New Conservation and Management Challenges in the Human-Wildlife Interactions

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Chapter 9
What Do We Know About Wild Boar in Iberia?

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9.1 Introduction

Wild boar *Sus scrofa* L. has one of the largest distributions among terrestrial mammals (Oliver and Leus 2008), which include the entire Iberian Peninsula (Bosch et al. 2012) where it has had a significant impact on ecosystems (Barrios-Garcia and Ballari 2012). Both in its native range and in areas where it has been introduced the wild boar can act as an ecosystem engineer (Barrios-Garcia and Ballari 2012;

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Ballari and Barrios-García 2014), modifying habitat conditions for other organisms (Puigdefábregas 1980; Rosell et al. 2004; Sforzi and Tonini 2004; Engeman et al. 2007; Herrero et al. 2008; Bueno 2011) and, in some cases, affecting the viability and conservation of sensitive species (Canut 2006; Bertolero 2007; Lecomte 2007; Giménez-Anaya et al. 2008; Santaeufèmia 2008; Navàs et al. 2010). For instance, wild boar can modify the productivity and human use of natural, semi-natural, and human-made ecosystems (Markina 1999; Mayer et al. 2000; Cahill et al. 2003; Cahill and Llimona 2004; Malo et al. 2004; Fernández-Bou et al. 2006; Gortázar et al. 2006; Gómez and Hódar 2008; Fillat et al. 2008; Rosell et al. 2008; Santos et al. 2009; Bueno et al. 2010; Langbein et al. 2011; Cahill et al. 2012; Colino et al. 2012; Duarte et al. 2012; Lagos et al. 2012; Rodríguez-Morales et al. 2012; García-Jiménez et al. 2013; Rosell et al. 2013; Burrascano et al. 2014; Burrascano et al. 2015; Torrellas 2015; García-Jiménez et al. 2016; Torrellas et al. 2016). Despite the importance of wild boar, the knowledge about the species is limited, which is the current case in Mediterranean areas. In recent decades, wild boar has gone from a huntable species that lives in populations that range widely in density to the wild ungulate that has the largest distribution and density throughout the Iberian Peninsula (Bosch et al. 2012). This represents an important conflict with human activities (Markina 1999; Mayer et al. 2000; Cahill et al. 2003; Malo et al. 2004; Gortázar et al. 2006; Gómez and Hódar 2008; Rosell et al. 2008; Santos et al. 2009; Bueno et al. 2010; Colino et al. 2012; Lagos et al. 2012; Matilde 2012; Rodríguez-Morales et al. 2012; García-Jiménez et al. 2013; Torrellas 2015; Giménez-Anaya et al. 2016; Torrellas et al. 2016) and biodiversity conservation (Rosell et al. 2004; Sforzi and Tonini 2004; Engeman et al. 2007; Muñoz and Bonal 2007; Fernández-Bou et al. 2006; Herrero et al. 2008; Bueno et al. 2010; Rosell et al. 2016). Those changes have made applied research a priority, which should focus on minimizing the conflicts that the species has already posed.

This review focused on gathering the information available on wild boar in the Iberian Peninsula (Portugal and Spain), including historical aspects of the research, ecology (behaviour, distribution, habitat use, expansion, reproduction, demography, and diet), environmental impact, and management. To be able to evaluate the effects of wild boar population fluctuation, the species' impact on ecosystems and human activities related to global trends in climate, and to followed changes in biodiversity, we identified priority for future fields of research.

9.2 Study Area

Continental Portugal and Spain cover 582,459 km^2. Andorra was not included in the review because no research was reported on wild boar in this country. Portugal comprises 18 districts, and Spain has 15 regions (Fig. 9.1). The average elevation of the Iberian Peninsula is 600 m (maximum = 3482 m). The Pyrenees act as a natural barrier on the north of the peninsula and with its geographic position, its

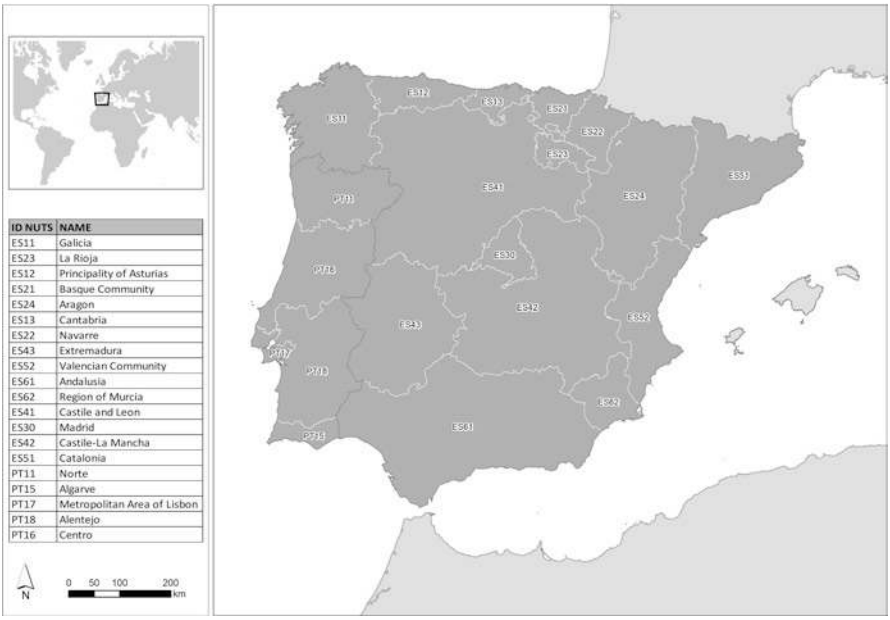

Fig. 9.1 Regions (Spain) and departments (Portugal)

mountainous topography, and environmental characteristics, it distinguishes itself from elsewhere in Europe.

The human population density was about 93 inhabitants per km^2, and most of it was concentrated in large cities, while large areas had densities of <5 km^2 because of human abandonment. This, in turn, has promoted the recovery of wild ungulate, particularly wild boar, populations.

9.3 History of Research

The first scientific research on wild boar in the peninsula, a description of the Iberian subspecies, was published in the early twentieth century (Cabrera 1914). Scientists did not return to it until the late 1970s and early 1980s, which included studies on rooting (Puigdefábregas 1980), reproduction (Vericad 1971, 1983), diet (Rodríguez Berrocal et al. 1982), estimation of abundance and habitat use (Rogers and Myers 1980), social behaviour in captivity (Martínez-Rica 1980), and natural history (Morais 1979; Vericad 1971).

In the 1980s, Serôdio (1985) and Sáez-Royuela (1989) did their PhD on natural history of wild boar (Saez–Royuela and Telleria 1986, 1987, 1988; Tellería and Sáez-Royuela 1984, 1985, 1986). Magalhães (1983) and Bugalho et al. (1984) described the historical populations of wild boars in Portugal. Garzón et al. (1983)

and Venero (1983) studied the diet, and Venero (1984) described grouping patterns. Braza and Álvarez (1989) studied habitat use and social organization, and Cuartas (1987) investigated activity patterns. Leránoz (1983) focused on diet, and Sáenz de Buruaga (1987) described the historical evolution of wild ungulate populations. In the 1990s, regional administrations became interested in wild boar because of the population increase and the new management and conservation problems that the species posed. This led to several reports and a more practical research approach. In Portugal, wild boar has spread throughout the country (Morais 1979; Serôdio 1985; Santos 1994; Fonseca 1999), and the hunt has become generalized. Research has focused on the interaction between wild boar and red partridge*Alectoris rufa*, demography, diet, and physical condition (Santos 1994; Fonseca 1996, 1999). Herrero's (2003) PhD research investigated the effects of wild boar battues on a relict population of brown bears *Ursus arctos* and on agricultural damage and culling. Another PhD thesis focused on demography (Markina 1998) and car accidents (Markina 1999). Other PhD thesis described the species ecology (Abaigar 1990; Garzón 1991; Rosell 1998) and Arroyo Nombela et al. (1990) published the first genetic study. Other research focused on diet (Abáigar 1993; Valet et al. 1994; Sáenz de Buruaga 1995), demography (Nores et al. 1995), caused damages (Nores et al. 1994), reproduction (Abáigar 1992), and habitat uses (Abáigar et al. 1994).

In the twenty-first century, research focused on habitat use (Santos et al. 2004; Fernández-Llario 2005; Rosell et al. 2006, 2010, 2012b; Bueno 2011), reproduction and demography (Fernández-Llario and Mateos-Quesada 2003; Uzal and Nores 2004; Herrero et al. 2008; Fonseca et al. 2004b, 2011), population management (Fonseca 2006), genetics (Ferreira et al. 2009; Pérez-González et al. 2014), diet (Giménez-Anaya et al. 2008), range expansion (Santos et al. 2004; González et al. 2013), and long-term population monitoring in protected areas (PA) and game reserves (Rosell et al. 2007; Herrero et al. 2008, Pita 2012). Moreover, the first analysis on the evolution of hunted wild boars and hunters in Europe, including Portugal and Spain, was done (Massei et al. 2015). The last decade has been marked by the conflicts caused by wild boars, such as car accidents, urban wild boars, culling in PA, and caused damage to agriculture and pastures (Putman et al. 2014; Rosell et al. 2004, 2008; Herrero et al. 2006; Bueno et al. 2011a; Cahill et al. 2012; Colino et al. 2012; Duarte et al. 2012; Lagos et al. 2012; Rodríguez-Morales et al. 2012; Sáenz de Santamaria and Tellería 2015). Further, an effort was made to standardize methods used to estimate population size (Acevedo et al. 2007; Nores et al. 2010; Gonçalves et al. 2013; Nores 2013).

Among the infectious diseases that can affect wild boar, research on tuberculosis *Mycobacterium tuberculosis*(TB) has been particularly of interest with an emphasis on the role of the species as a reservoir and transmitter to livestock, especially cattle (García-Jiménez et al. 2013; García-Jiménez et al. 2016). Focusing on livestock management but also evaluating other risk factors, such as co-infection with other pathogens or parasites, TB in wild boar was studied from multiple perspectives (Vieira-Pinto et al. 2011; Risco et al. 2013; Risco et al. 2014). In addition to TB other diseases were described in wild boar which traditionally were rather associated with domestic pigs, like swine erysipelas (Risco et al. 2011), salmonellosis

Salmonella sp. (Navarro-González et al. 2012), Glasser disease *Haemophilus parasuis* (Cuesta-Gerveno et al. 2013), virosis (Vicente et al. 2002; Ruiz-Fons et al. 2006), and parasitosis (García-Sánchez et al. 2009; García-González et al. 2013; Navarro-González et al. 2013). Common diseases that affect intensive breeding of domestic pigs also affect wild boar populations irrespective of population density (Risco 2011).

9.4 Population Development

The wild boar was considered a relatively scarce species during the nineteenth century and early twentieth century (Magalhães 1983; Bugalho et al. 1984; Gortázar et al. 2000; Carranza 2010). In recent decades, however, it is the native wild ungulate whose population has expanded the most in Iberia (Saez–Royuela and Telleria 1986; Gortázar et al. 2000; Fonseca et al. 2008). Its range currently covers the whole Iberian Peninsula (Rosell and Herrero 2007) except for some coastal, semi-desert, and high-elevation areas. In summer, wild boars were even found to occur at elevations of >2000 m (Rosell et al. 2016). Further, they even expanded into large towns (Fonseca and Correia 2008; Carranza 2010; Cahill et al. 2012) which was a recent phenomenon also elsewhere in Europe (Ferreira et al. 2009; Bosch et al. 2012; Stillfried et al. 2016).

In Iberia, wild boar is the main big-game species as reflected by the number of animals harvested each year (Lopes and Borges 2004). The estimated annual hunting bag was about 240,000 animals in 2010 (Carranza 2010; Vingada et al. 2010; Massei et al. 2015), although the actual number probably is much higher. Several interrelated factors have contributed to the increase in abundance including, among others: rural abandonment, increase in shrub and forest cover (Fonseca 2004); ageing of rural human populations (Nores et al. 1995); climate change, expressed through milder winters (Carranza 2010); captive breeding (Fernández-Llario et al. 1996); adaptability to habitats and foods (Rosell et al. 2001); and an exceptionally high reproductive potential (Table 9.1), which allows them to reproduce even in their first year of life (Herrero et al. 2008; Rosell et al. 2012). Easy year-round access to food through feeding and intensified agriculture realized this high growth potential, and the control of population abundance and expansion became a major challenge (Giménez-Anaya et al. 2016). In addition, polygyny, female parental care, and parturition in matriarchal groups increase piglet survival (Fernández-Llario and Mateos-Quesada 1998), which was reported to contribute to the problem.

In northern Iberia, wild boar densities typically ranged between 1 and 10 animals per km^2 and are influenced by climate, orography, forest cover, and land use (Nores 2010). In recent years, however, in some areas, density increased to >15 individuals per km^2 (García-Jiménez et al. 2013; Risco et al. 2013). In southern Iberia, management practices, sometimes including supplementary feeding within hunting grounds, and highly favourable habitats, have even led to densities of 40 individuals per km^2 (Table 9.2).

Table 9.1 Wild boar litter size in Iberia

Locality	Average	References
Empordà, Catalonia	5,0	Rosell et al. (2012)
Valle del Ebro, Aragon	4,5	Herrero et al. (2008)
Burgos, Castile and Leon	4,3	Saez–Royuela and Telleria (1987)
Western Pyrenees, Aragon	3,3	Vericad (1983)
Western Pyrenees, Aragon	4,2	Herrero et al. (2008)
Portugal	4,2	Fonseca et al. (2004a, b)
Portugal, Central Region	4,2	Fonseca et al. (2011)
Andalusia	4,1	Abáigar (1992)
Castile-La Mancha	3,9	Ruiz Fons et al. (2006)
Extremadura	3,9	Garzón (1991)
Montseny, Catalonia	3,8	Rosell et al. (1998)
Extremadura	3,7	Fernández-Llario and Mateos-Quesada (2005)
Andalusia	3,0	Fernández-Llario y Carranza (2000)

Table 9.2 Iberian wild boar densities

Locality	Density km^{-2}	References
Western Pyrenees, Aragon	3,3	Herrero (2003)
Navarre	2,6–3,0	Leránoz and Castién (1996)
Burgos, Castile and Leon	1,9–4,2	Tellería and Sáez-Royuela (1986)
León, Castile and Leon	1,7–11,4	Purroy et al. (1988)
Extremadura	3	Garzón (1991)
Álava, Basque Country	0,4–6,1	Markina (1998)
Asturias	3,8–10	Nores, own data
Pre-Pyrenees, Aragon	7,0	Marco et al. (2011)
Garrotxa, Catalonia	3,6–8,5	Rosell et al. (2001)
Alt Empordà, Catalonia	7–12,5	Rosell et al. (2001)
Catalonia	2–17	Departament Agricultura, Ramaderia i Pesca (2016)
Extremadura	10	Fernández-Llario et al. (1996)
Extremadura	6,5–32[a]	Risco et al. (2013)
Extremadura	>40	Gonçalves (in prep)

[a]Fenced hunting grounds with supplementary feeding

9.5 Diet and Environmental Impacts

Diet has been studied through analyses of stomach contents, typically collected during the hunting season, which roughly goes from September to February (Herrero et al. 2006). However, in population control programs, samples could be collected year-round (Herrero et al. 2005; Giménez-Anaya et al. 2008). Results indicate a generalist, opportunistic, and mainly phytophagous diet (Giménez-Anaya et al. 2008). Wild boars consume a wide variety of trophic resources, which was

influenced by food abundance and availability (Herrero et al. 2005; Giménez-Anaya et al. 2008). As an omnivore, it also consumes animal matter, but the basis of its diet was hard mast of Fagaceae acorns *Quercus* sp., beechnuts *Fagus sylvatica*, and chestnuts *Castanea sativa*, as well as agricultural products (Irizar et al. 2004; Herrero et al. 2006, 2008). In some areas and periods cultivated plants were in fact the main food (Herrero et al. 2006; Giménez-Anaya et al. 2008), which also represents the main basis for the conflict with human interests.

The underground parts of plants (roots, bulbs, rhizomes) and, to lesser extent, insect larvae, small vertebrates, and worms can be an important part of the diet as well (Herrero et al. 2006, Giménez-Anaya et al. 2008). If hard mast was scarce, the proportion of the diet that is aboveground plant matter increased and included agricultural (Leránoz 1983) and wild plants (Herrero et al. 2005).

The impact of wild boar on biodiversity was based on the species capacity to act as an ecosystem engineer by transforming habitats, mostly through rooting (Barrios-Garcia and Ballari 2012; Ballari and Barrios-García 2014). Those effects cannot always be classified as damages, because, in some cases, they only make up a small amount of the many factors that cause changes in the composition and structure of living communities (Muñoz and Bonal 2007; Fernández Bou et al. 2008; Bueno et al. 2010; Rosell et al. 2016).

Rooting can be an important perturbation that acts on multiple scales (Bueno 2011). For instance, on alpine and subalpine pastures, wild boar looked for areas that had dense vegetation, deep soils, and specific pastoral use (Bueno et al. 2009). At that scale, rooting modified the structure of vegetal communities (Burrascano et al. 2014, 2015). It reduced diversity and heterogeneity between communities, but increased it within them (Bueno 2011; Fillat et al. 2008; Fernández-Bou et al. 2006). Furthermore, rooting can modify the physical and chemical structure of soils (Bueno et al. 2013) and their biotic components, like the seed bank (Bueno et al. 2011a), the bulb community (Palacio et al. 2013), and earthworms (Bueno and Jiménez 2014). In addition, rooting can alter the relationships between species, like mycorrhizae (Puigdefábregas 1980). This can affect important ecosystem interactions, alter the regeneration capacity of the affected communities, and lead to a recovery of vegetal diversity within 1 year following rooting (Bueno 2011). In subalpine environments, recovery after rooting can take as long as 3 years (García-González, unpublished data). Generally rooting can be an annual recurrence, especially in sensitive habitats that are not adapted to soil perturbations and where natural revegetation is ineffective (Bueno et al. 2011a). The intensity of rooting fluctuated and appeared to be influenced by factors associated with wild boar abundance, aerial food availability, the kind of forest, and its proximity (García-González et al. 2003; Bueno 2011). In addition, the pastoral value of subalpine meadows that have a high cattle density, and therefore tend to be dominated by matgrass *Nardus stricta* that is avoided by cattle, can be improved through rooting, as it creates new opportunities for other plant species to colonize these patches (Fernández-Bou et al. 2006).

In other cases, wild boar was a threat to the conservation of some endangered species, especially in wetland areas (Herrero et al. 2006). For instance, ground breeding bird species like the purple swamphen *Porphyrio porphyrio* or the Eurasian

bittern *Botaurus stellaris* were especially sensitive to the impact of wild boar (Giménez-Anaya et al. 2008). Another example were endangered orchids, from which wild boar like to consume the bulbs and for which there are already recovery plans in action (Lecomte 2007; Santaeufèmia 2008; Navàs et al. 2010). Other research found negative effects of wild boar, on eggs and juveniles of Mediterranean tortoise *Testudo hermanni* (Bertolero 2007), ptarmigan *Lagopus muta* (Canut 2006), and brown bear (Nores et al. in prep). More abundant species that might be affected include rabbit *Oryctolagus cuniculus* (Carpio et al. 2014b), red partridge (Carpio et al. 2014c), and invertebrates (Carpio et al. 2014a). Thus, wild boar was perceived as a threat to biodiversity in some protected areas and subsequently monitored and culled intensively, especially in some wetlands (Rosell et al. 2004; Sforzi and Tonini 2004; Engeman et al. 2007; Herrero et al. 2008; Giménez-Anaya et al. 2016).

9.6 Behaviour and Habitat Use

In part because it is a nocturnal species, only few studies have investigated the behaviour of the wild boar in Iberia. New techniques such as camera trapping and drone-based thermal cameras helped to increase the knowledge about certain unknown aspects of the wild boar's biology (Sarmento et al. 2010; Casas-Díaz et al. 2011; Cahill et al. 2012).

Social organization was studied based on diurnal direct sighting and indicated a matriarchal system (Braza and Álvarez (1989; Fernández-Llario et al. 1996). Changes in group composition occurred during rut, as during this time adult and expelled young males joined the sounders (Fernández-Llario et al. 1996). After the rut, males abandoned the matriarchal groups again (Fernández-Llario et al. 1996).

Night cameras provided a means of quantifying activity rhythms of individual groups and their behaviour (Gonçalves, pers. comm., Rosell et al. in prep.). Males change the timing of their activity to adapt to the activity of a matriarchal group that has 5–6-month-old piglets; i.e. they are less active in the night hours and become more active at dawn and dusk (Gonçalves, pers. comm.). Another study has shown that hunting causes wild boars to concentrate in areas where there is no hunting during the hunting period (Rosell et al. in prep.). Molecular genetic studies showed that more than 20% of the litters had more than one father (Delgado et al. 2008).

Activity rhythms were also reflected in habitat use. In the south of the peninsula, wild boar movements were based on food availability; specifically, animals focus mainly on areas that have acorns and avoid or select sunny or shaded areas, depending on the season. In summer and early autumn, shaded areas that had water available were preferred as resting and feeding areas. In winter, the animals moved to sunny, high-slope areas, which allowed them to avoid soils where water had accumulated (Fernández-Llario 2004). In the north, in addition to the factors described above, hunting activity influenced the activity rhythms of the animals (Nores 2010; Rodrigues et al. 2016).

9.7 Conflicts with Human Activities

At moderate densities, and if limited to forest areas, the social and economic conflict potential was low. Conflicts mainly occurred, if they exceeded social carrying capacity, in agricultural lands, in urbanized areas, or in sensitive habitats such as high pastures or wetlands (Giménez-Anaya et al. 2016).

Among the social and economic conflicts, agricultural damage to field crops and pastures caused the most complaints and damage claims. Rooting in pastures can affect extensive grazing by livestock (Bueno et al. 2010) and its environmental and productive value (Bueno et al. 2011a). Among agricultural products, corn *Zea mays*, fruit trees, and vegetables are the most frequently damaged. No global estimates are available; however, in Asturias, in 2008, the regional government paid €1,215,573 in compensation, which is equivalent to € 115 per km^2. In addition, wild boars caused damage to forest regeneration and, particularly, to forest restoration, based on seed and seedling consumption, which obliged a new plantation and the use of proper protection (Mayer et al. 2000; Gómez and Hódar 2008).

In the case of livestock breeding, high density of wild boar can influence disease transmission (Gortázar et al. 2006; Santos et al. 2009; García-Jiménez et al. 2013). In the south, some infectious diseases, particularly bovine tuberculosis (TB), have become one of the main threats to the sustainability of extensive livestock farms because the wild boar is the main reservoir of the disease (García-Jiménez et al. 2016). Some populations showed this TB prevalence at >50%, and the species role in the transmission of bacillus to other species has been demonstrated (Hermoso de Mendoza et al. 2006; Santos et al. 2009; Rodríguez Campos 2013). Interbreeding with domestic pigs can occur, but it did not have a significant impact on wild boars. This however might occur with the interbreeding with Vietnamese pigs *Sus scrofa domestica*, which have produced crossed populations (Delibes–Mateos and Delibes 2013).

The presence of wild boars on the outskirts of and within large cities is another important source of conflicts (Cahill et al. 2003). These conflicts were difficult to control if there was no rapid action to eliminate habituated wild boars. These boars were no longer 'suited' to living freely (Cahill and Llimona 2004; Cahill et al. 2012; Duarte et al. 2012). Given that a city's outskirts are not huntable areas, other methods to avoid their presence have to be used, e.g. non-lethal battues (Tolon 2010), trapping, and anaesthetic captures, together with proper protocols. These methods have to be sustainable, and they require neighbourhood training, regarding the behaviour of these animals, whom can also be seen during the day, searching for food in dustbins and gardens, or receiving food directly from humans, which causes potentially dangerous situations.

Car accidents caused by wild boars have increased in recent years. Although they are a small proportion of the damages caused by ungulates in Europe (Langbein et al. 2011), in Spain, the amount of damage increased by 30% between 2007 and 2011 (Matilde 2012). In Catalonia, > 85% of all accidents that involved wildlife (about 1000 accidents, annually) involved wild boars (Departament de Territori i

Sostenibilitat 2015). That report estimated an average damage of €3787 per car although others have reported per capita amounts of €2700 (Colino et al. 2012) and €9119 (Sáenz de Santamaria and Tellería 2015). The complexity of the management of the problem and the complications derived from the damage claims that do not include insurance companies often blame the presence of hunting grounds for the accident (Markina 1999; Malo et al. 2004; Rosell et al. 2008; Colino et al. 2012; Lagos et al. 2012; Rodríguez-Morales et al. 2012; Torrellas 2015; Torrellas et al. 2016).

The frequency of car-boar accidents is highest between September and January and between dusk and twilight. The measures taken to prevent car crashes alter the behaviour of wild boar, and certain aspects must be considered, such as perimetral closing, which needs fauna passages (Rosell et al. 2008). In Catalonia, the map with the locations of car crashes involving ungulates and the concentration of hotspots has recently been updated, and a plan to reduce these accidents has been implemented. This plan includes fences and fauna passes on highways and other measures used on conventional roads with accord with the temporality shown by these events (Rosell et al. 2013).

9.8 Hunting Management

In northern Iberia, wild boar have been the cornerstone of big-game hunting, which brings together the hunting crew. In the north, it has been the most hunted and the most expensive species to manage. In Asturias, for example, the damages caused by huntable and protected species were paid by the regional government, and wild boars are the one that caused the most damage, more than wolf *Canis lupus*, red deer *Cervus elaphus*, or brown bear *Ursus arctos*. In 2008, the cost of damage was over €1.5 million, which is equivalent to €152/km^2. The cost of damage per wild boar within the hunting grounds was €25.5 per animal, and the cost per hunted wild boar was €37–187.

In the north, where the species has existed historically (Leránoz and Castién 1996; Markina 1998; Herrero 2003, Nores unpublished data), most hunts have occurred within small 10–600 ha battues (Table 9.3), covering an average size of 131–150 ha, with 11–16 hunters, 2–7 beaters, and 5–13 dogs. Hunting was in open grounds, which guaranteed gene flow and natural movements of predators. In Asturias, each year 20–25% of the total population was harvested (C. Nores unpublished data). There was no management beyond hunting and protection of field crops, and population density was more strongly influenced by environmental and intrinsic factors, rather than by human intervention (Uzal and Nores 2004; Nores et al. 2010).

In the south, the most popular hunting method were and are large battues, in which the hunter waits for the wild boars to appear, after they have been forced to move by packs of at least 20 dogs who are guided by one beater. Legally, the area must be more than 500 ha and, except in special circumstances, can be hunted only

Table 9.3 Characteristics of hunting battues with dogs in Iberia. Average values

Locality	Surface (ha)	Hunters	Beaters	Dogs	Efficiency (%)	References
Western Pyrenees, Aragon	168	9,5	2,5	5,4	25	Herrero (2004)
Navarre	151	15,4		8,1	31	Leránoz and Castién (1996)
Burgos, Castile and Leon	75	19,7	16	15,4	15,4–18	Saez–Royuela and Telleria (1988)
Leon, Castile and Leon	122,7		9,8			Sáenz de Buruaga et al. (1987)
Asturias	131	12,6	6,4	7,3	21	Nores et al. (2010)
Alava, Basque Country	142	12	6	10		Markina (1998)
Middle Ebro Valley, Aragon		6	1	10	39	Giménez-Anaya et al. (2016)
Central Region, Portugal	163	64	7.6	21		Fonseca (unpublished data)

once during the hunting season. About 30 hunters stay in fire lines around the beaten area. Effectiveness has been about 30%, which is similar to the effectiveness of battues in the north (Table 9.3). In the south, to achieve these results, management developed all year long. Control by rangers involved artificial feeding (Fernández-Llario and Mateos-Quesada 1998) and increasing the availability of water points (Fernández-Llario 2004), which promoted an increase of wild boar density.

Canned hunt (fenced grounds) of private areas is widespread in the South of Spain and is associated with watering, artificial feeding, high densities of wild boar, and high prevalence of several diseases (Fernández-Llario and Mateos-Quesada 1998; Fernández-Llario 2004; Risco et al. 2011).

In Portugal, battues were the most common traditional and widespread hunting method. Dog packs averaged 25 animals were driven by more than one beater. The area covered could be of <500 ha, and the number of hunters was very variable (i.e. dozens to hundreds). Night waiting during full moon was another traditional method, which could be used year-round, particularly in the period when agricultural damage was worst.

9.9 Survey Methods

The population dynamics of wild boar is complex because of its demographic adaptability, which makes it difficult to estimate population size (Barrett 1982), the factors that influence populations (Uzal and Nores 2004), and to obtain information from population change models, the data series must be several decades long (Turchin 2003).

The main methods used to monitor wild boar, in regard to its demography on the long term, are battues (Rosell et al. 1998; Giménez-Anaya et al. 2016), direct sightings (Nores et al. 2000), and hunting bags (Bosch et al. 2012). For sanitary purposes necropsies and sera analysis are performed (Risco et al. 2014). For short periods of time, radiotelemetry (Santos et al. 2004) and faecal counts (Rodrigues et al. 2016) are used. Most populations are not monitored and hunting bags are not a reliable method as they are based on the voluntary declaration by the owners of their hunting rights.

9.10 The Future

Wild boar has been living in the Iberian Peninsula, with more or less abundant populations, since the Middle Pleistocene (Groves 1981). It has, however, never been an important economic resource, possibly because of the limited resources that have been dedicated to the research and management of the species. That is in contrast to the important and diverse problems posed by the species (social, economic, and for biodiversity conservation) in many areas of the peninsula, because of the increase in the extent and size of wild boar populations. For that reason more interest and demand for a better understanding of the species and more research on management and control are needed.

A species with such a reproductive and ecosystem transformation potential should receive particular attention and monitoring within the context of natural area management. The species' extraordinary capacity to adapt to a wide variety of natural and cultural environments has allowed it to become established in urban areas, as well as to colonize agricultural lands which have higher productivity compared to forest environments (Herrero 2003). The basis for an agile and effective adaptive management must be created. Delayed response and low efficacy has caused high socioeconomic costs. There has been an increase in the frequency of interactions between humans and wild boars. Problems that have arisen will probably worsen in the near future (Cahill et al. 2012) and should be addressed by actions taken on wild boar, but also through the education of the public, to avoid risky situations. The response to the increase in wild boar in urban areas and the risk of car accidents should include environmental education, which has not been needed, until now.

There are several aspects of the species ecology that are still unknown and many questions that will have to be addressed in the near future. In Iberia, there has been long-term population research, which has shed light on population knowledge. Some important aspects are trends (Leránoz and Castién 1996), environmental impacts, foods particularly in summer (outside the hunting season) (Herrero et al. 2006; Giménez-Anaya et al. 2008), rooting recurrence and its effect on the capacity of ecosystems to recover (Bueno 2011), trend in management and hunt (hunting efficiency) to control populations and reduce damages (Giménez-Anaya et al. 2016), as well as cross-breeding with domestic breeds (Delibes–Mateos and Delibes 2013). We emphasize that, in the context of change in the composition and

distribution of biodiversity caused by climate change, research on ecosystem engineer species should be a priority for evaluating the species' future impact on ecosystems and on human-affected productive activities. Accordingly, a clear commitment for research on wild boar ecology is essential and urgent for the development of sound proactive management measures that should identify possible irreversible perturbations on ecosystems.

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