Wildl. Biol. Pract., 2013 September 9(3): 19-26
doi:10.2461/wbp.2013.ibeun.3

ORIGINAL PAPER

Recorded Dispersal of Wild Boar (*Sus scrofa*) in Northeast Spain: Implications for Disease-Monitoring Programs

E. Casas-Díaz[1,*], F. Closa-Sebastià[1], A. Peris[2], A. Miño[2], J. Torrentó[2], R. Casanovas[3], I. Marco[1], S. Lavín[1], P. Fernández-Llario[4] & E. Serrano[1, 5]

[1] Servei d'Ecopatologia de Fauna Salvatge. Facultat de Veterinària. Universitat Autònoma de Barcelona. 08193 - Bellaterra, Barcelona, Spain. Tel. +34 935811923. Fax +34 935812006.

[2] Oficina Tècnica de Parcs Naturals. c/ Urgell 187. Edifici del Rellotge, 3ª planta. 08036 – Barcelona, Spain. Tel. +34 934022484. Fax +34 934022429.

[3] Direcció General del Medi Natural i Biodiversitat. Departament d'Agricultura, Ramaderia, Pesca, Alimentació i Medi Natural. c/ Doctor Roux 80, 08017 Barcelona. Tel. +34 935674133. Fax +34 935674184.

[4] Red de Recursos Faunísticos, Universidad de Extremadura, 10071 Cáceres, Spain. Tel. +34 927257150. Fax +34 927257110.

[5] Estadística i Investigació Operativa, Departament de Matemàtica, Universitat de Lleida, Av. Alcalde Rovira Roure, 191. 25198 Lleida, Spain.

* Corresponding author: Encarna Casas-Díaz. Servei d´Ecopatologia de Fauna Salvatge (SEFaS), Departament de Medicina i Cirurgia Animals, Facultat de Veterinària, Universitat Autònoma de Barcelona (UAB), 08193, Bellaterra, Barcelona, Spain. Tel. + 34 935811923. Fax: + 34 935812006, e-mail: encarna.casas@uab.cat.

Keywords
Cage-traps;
Disease spread;
Dispersion;
Ear tags.

Abstract

The wild boar population in Spain has increased in recent decades due to a number of factors, including increased food availability, the abandonment of crops, as well as through hybridization with the domestic pig. Studying dispersal is useful for understanding the ecology of a species and the spread of diseases in wildlife. In the case of the wild boar (*Sus scrofa*), its dispersal depends on environmental changes, food availability, population density, and hunting pressure. The goal of this study was to describe the dispersal of wild boars captured with cage-traps, anesthetized and marked with ear tags between 2008 and 2012 in Catalonia (northeast Spain). Six of 40 wild boars (16 males and 24 females) were recaptured at a mean linear distance of 45.8 km (min. 30, max. 89.8) from their origin. Surprisingly, females dispersed more than males, 57.7 km on average, a distance 1.7 times greater than females in other parts of the world. These dispersal patterns can be partially explained by the need for new territories. This mammal has experienced a huge increase in both distribution range and status throughout the Iberian Peninsula, probably due to an increase in vegetation cover and a lack of predators. Hence, any information about its dispersal patterns is of special interest to specific management plans. Despite to our moderate sample size, it is clear that the impressive dispersal ability of wild boar should be taken into account in the design of health surveillance programs of wildlife diseases.

Introduction

Dispersal - the movement of species away from their parent source – is currently considered vital in the understanding of the spread of wildlife diseases [1,2]. However, one of the main challenges in evaluating the causes and consequences of dispersal is the lack of "long-distance dispersal" records for most living species [3]. Existing information about dispersal patterns of living organisms is likely biased by the type of habitat in which dispersal surveys were carried out.

Knowledge of host dispersal rates can improve the success of wildlife disease-surveillance programs, especially in cases of highly adaptable host species such as the wild boar (*Sus scrofa*). This species shows one of the widest geographic distributions of all terrestrial mammals, partially due to human agency. It occurs throughout the steppe and broadleaved forest regions of the Palaearctic, the Mediterranean Basin and the Middle East, throughout India, Indo-China, Japan, Taiwan, southeast Asia and North Africa. In the Iberian Peninsula, this wild swine is capable of inhabiting semi-desert areas at sea level to the high Pyrenees. In addition, wild boar is known to be a reservoir for a plethora of pathogens transmissible to animals and humans [4,5]. This fatal combination (i.e., high dispersal ability and efficient reservoir for zoonotic pathogens) can facilitate the spread of directly transmitted diseases carried by wild boar [6]. Nevertheless, the consequences of this significant ability to disperse diseases have been largely ignored by most sanitary plans.

In the present work we report on several records of dispersion of wild boars from one natural area.

Methods

From April 2008 to June 2012, 40 wild boars (16 males - 6 adults, 2 juveniles, 8 piglets - and 24 females - 10 adults, 4 juveniles, 10 piglets) were captured in the Sant Llorenç del Munt i l'Obac Natural Park (41º 39'-41º 42' N; 1º 53'-2º 09' E, Catalonia, NE Spain) with cage-traps (2 x 1 x 1 m) baited with corn. Captured boars were anesthetized with a combination of tiletamine-zolazepam + xilazyne (Zoletil®, Virbac, Esplugues de Llobregat, Spain + Xilagesic 20%®, Laboratorios Calier, Les Franqueses del Vallès, Spain). Once immobilised, sex was determined by visual inspection of genitalia and age by means of tooth replacement [7]. Subsequently, the boars were marked with ear tags (Allflex, Gepork, Masies de Roda, Spain). Animal care activities and study procedures were conducted in accordance with the guidelines of Good Experimental Practices, with the approval of the Hunting Activities Area of the Catalan government.

Distances of dispersal were estimated by measuring the minimum straight distance (in km) from the capture site to the harvesting place using the online maps provided by the Cartographic Institute of Catalonia (Institut Cartogràfic de Catalunya, www.icc.cat).

In addition, to summarize the existing records of wild boar dispersion we performed a review of the literature on Web of Knowledge (Thompson Reuters) since 1972 using the following key words: "*dispersal*", "*dispersion*", "*wild boar*", "*home*

range", "*space use*". We also reviewed non-indexed publications related to wild boar dispersal (e.g., local reports, books, monographs).

Despite that observed raw distances were positively skewed (Skew = 2.32, Z = 2.8, p-value = 0.005), they did not differ from normal distributions after their logarithmic transformation (W = 0.97, p-value = 0.84). Thus, several independent Student's tests were performed for comparing mean dispersion distances among sexes and locations (i.e., from the literature review). To compare our records to those found in the literature we used the maximum dispersal distances. All analyses were conducted in R version 3.0.1 [8].

Results

Six wild boars released as piglets or subadults (Fig. 1) were hunt harvested or collected after a road accident at an average of 45.8 km from the capture location (min. = 30, max. = 89.8, Table 1 and Fig. 2).

Fig. 1: Wild boars captured: (a) Piglet female #3; (b) Subadult female #23.

Table 1: Wild boars dispersed from the Natural Park of Sant Llorenç del Munt i l'Obac (NPSLMO), northeast Spain. Id = code number on the ear tag, Distance = distance from the place of capture (in km).

ID	Capture				Recapture			
	Date	Sex	Age (Months)	Weight (Kg)	Date	Age	Mode	Distance
2	07/06/2008	Male	15	42	21/01/2011	4 years	Hunted	33.3
3	02/07/2008	Female	2.5	7	01/12/2010	3 years	Hunted	46.7
9	13/08/2008	Male	4.5	16	01/03/2011	3.5 years	Road accident	30.0
10	13/08/2008	Female	4.5	13	11/11/2010	3 years	Hunted	36.7
23	24/05/2010	Female	12	42	03/03/2012	3 years	Hunted	89.8
36	03/05/2012	Male	14	42	13/10/2012	19 months	Hunted	38.5

From the literature review (Table 2), the mean dispersal distance (considering the maximum dispersal distances, Table 2) of wild boar was 63 km (min. = 600 m, max. = 250 km), with most of the dispersal records between 1 to 40 km. In comparison to other places in Europe or America (Mean distance = 33.75 km, SE = 11.8, min. = 9, max. = 100, n = 8), females from our study site showed greater dispersion (Mean distance = 57.73 km, SE = 16.29, min. = 36.7, max. = 89.8, see Table 1), dispersing on average 23.98 km more than their counterparts (t-test (log transformed distances) = -1.48, p-value = 0.17). Concerning dispersal distances of males, no differences were detected between our study and those recorded in the literature (t-test = 0.54, p-value = 0.59).

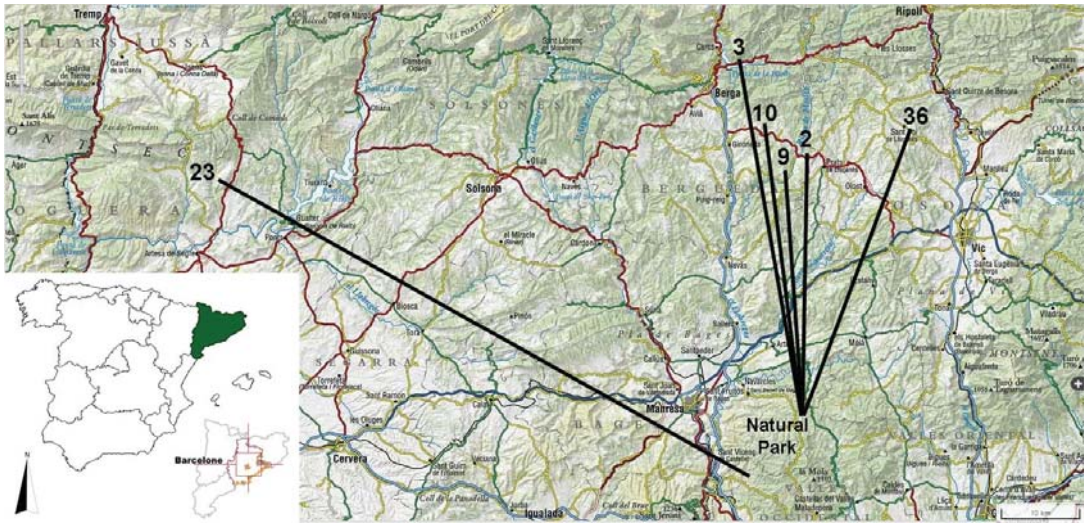

Fig. 2: Capture and recapture locations.

Table 2: Records of wild boar dispersal (in km) from a literature review (1950 – 2010). Environmental features indicate both landscape type and climatic conditions. Mixed groups were typically made up by young animals, adult females and her piglets.

Time required	Distance		Country	Environmental features	Reference
	Mean	Maximum			
-	-	200 ♂	Europe	-	[9]
-	1.1 ♂	-	USA (South)	-	[10]
-	-	200 ♂	Poland	-	[11]
-	-	250 ♂	Germany	-	[12]
10 years	0.6	2.4 (mixed)	USA (Georgia)	Mixed forest (oaks, pines, palms, magnolias) and fields of corn	[13]
-	-	50 ♀	France	-	[14]
8 years	-	<10 (mixed)	France	Mixed forest (oaks and coniferous)	[15]
-	20 (mixed)	68 (mixed)	France	-	[16,17]
-	4.5 ♂	NA	-	-	[18]
-	1.4 (mixed)	3 (mixed)	Spain	Mixed forest (oaks, pines, beeches, firs, shrubs) and grasslands	[19]
-	-	>15 ♂	France	Mixed forest (oaks and coniferous)	[20]
-	3.2 ♂	22 ♂	Australia	-	[21]
-	-	17 ♂	Germany	-	[22]
-	-	23 ♂	Germany	-	[23]
16 months	8.9 ♂	10 ♂	Spain	Mixed forest (oaks, pines, beeches, firs, shrubs) and grasslands	[24]
3 years	3. 8 (mixed)	7.8 (mixed)	Germany	Mixed forest (pines, spruces, oaks, larches and beeches)	[25]
2 years	16.6 ♂	> 50 ♂	Sweden	Mixed forests (coniferous) and farmlands	[26,27]
2 years	-	59 ♂	Sweden	Mixed forests, farmlands and wetlands	[28]
-	-	75 (mixed)	Slovenia	-	[29]
-	-	< 10 (mixed)	France	Mixed forests and farmlands	[30]
39 months	4.6 (mixed)	-	Germany	Mixed coniferous low human settlements, meadows and pastures	[31]
19 months	0.5 (mixed)	-	USA (South)	Old-growth and bottomland hardwood forests	[32]
56 months	3.8 ♂	42 ♂	Germany	Mixed forest (coniferous) and crops, low human settlements	[33]
2 years	15.6 ♂	42-72 ♀	Slovenia	-	[34]

Discussion

Dispersal in wild boar is commonly sex-dependent [26], with young males being the most common disperser [18,33]. However, some females in our study showed the opposite pattern, with a female demonstrating the greatest dispersal distance (Table 1) and, although the mean dispersal was higher than in other reports, this result was not statistically significant probably due to our moderate sample size and two extraordinary records of female dispersion reported in Slovenia (Table 2, [34]). On the other hand, dispersal distances in our two males were within the range of dispersion values shown by males from the literature review. However, and since we measured the minimum straight distance from the capture site to the harvesting place, we must consider that our dispersal distances were probably underestimated.

It is assumed that piglets stay with their mother at least during the first year of life [35], with males usually excluded from their mother's group [27] at the age of 16-17 months (i.e., coinciding with parturition of new piglets [33]). Wild boar dispersal has been linked to environmental changes including hunting [25] and high population densities [36]. Wild boar density in our study area in the year of trapping (2.5 – 5.78 boars/100 ha in 2008 [37]) did not differ from other areas in Catalonia (6.08 ± 4.8/100 ha on average 1 – 18.5 boars/100 ha) [38]. However, at least 30 different piglets accompanying marked females were observed in the study area in the year of trapping. This punctual increase of local density would have favoured the dispersal of young animals as suggested by Truvé and Lemel [26].

Hampton and colleagues [6] highlighted the danger of wild boar dispersal and the risk of pathogen spreading. Despite showing no clinical sings of disease, wild boars in our study area were seropositive for porcine respiratory and reproductive syndrome virus, porcine influenza A virus, porcine parvovirus, porcine circovirus type 2, *Mycoplasma hyopneumoniae*, *Erysipelothrix rhusiopathiae*, *Salmonella, Brucella suis* and *Toxoplasma gondii* [39, 40]. Our animals crossed roads, urban areas, open fields and croplands without any apparent difficulty and as such may facilitate the spread of pathogens to neighbouring areas in which there are a number of pig farms.

The movement of wild boars and, especially, their dispersal should be taken into account in the design of disease monitoring programs as these animals can affect the rate of spread, the expansion of infection and the probability of new outbreaks. These programs applied in restricted areas such as natural parks and hunting reserves have little purpose if they include no information from surrounding regions. In the case of the wild boar, it is important that authorities apply these programs over a wide geographical area in order to gain a better overall picture of transmissible diseases. The knowledge of mean dispersal distances of wild boar will be helpful for defining the size of control or actuation units for implementing specific disease-monitoring programs in this area.

Acknowledgements

This work has been done with the help of Agents Rurals de la Generalitat de Catalunya, Park Rangers of Sant Llorenç del Munt i l'Obac and hunters in the study area. E. Serrano is supported by the Beatriu de Pinós programme (BP-DGR 2011) of the Catalan Science and Technology System, Spain.

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