Influence of new irrigated croplands on wild boar (*Sus scrofa*) road kills in NW Spain

V. J. Colino–Rabanal, J. Bosch, Mª J. Muñoz & S. J. Peris

Abstract

*Influence of new irrigated croplands on wild boar (*Sus scrofa*) road kills in NW Spain.*— In recent decades, wild boar populations have increased both in number and distribution. This rise is partly related to the increase in cropland devoted to maize (*Zea mays*) cultivation, as wild boar find food and refuge in these areas. This population expansion has led to an increase in the number of wild boar vehicle collisions (WBVCs). The goal of the present study was to evaluate a set of spatio–temporal factors that influence WBVCs related to maize crops on the Northern Spanish Plateau (the region of Castile and Leon). We compared the maize pattern with the factors related to total WBVC numbers. We observed that whereas the total occurrence of WBVCs usually increased with forest cover and speed and traffic volumes, maize areas were one of the main explanatory variables in plateau models. To avoid collisions in these areas in future, a number of mitigation measures are outlined.

Key words: Maize, Wild boar, Road–kill, Northern Spanish plateau, Population increase, Shelter areas.

Resumen

*Influencia de los nuevos cultivos en regadío sobre las colisiones de vehículos con jabalí (*Sus scrofa*) en el Noroeste de España.*— Las poblaciones de jabalí han aumentado en número y distribución en las últimas décadas en España. En dicho aumento, interviene la mayor extensión de los cultivos de maíz (*Zea mays*); donde la especie encuentra refugio y alimento. La expansión de la especie, provoca un aumento de colisiones de jabalí con vehículos (WBVC). El presente trabajo trata de la distribución espacio–temporal del WBVC en la meseta norte española. Normalmente, el WBVC se relaciona con la velocidad, el volumen de tráfico y/o cubierta forestal. Sin embargo, el maizal resulta la variable más relacionada en atropellos con jabalí en la meseta norte. Se dan algunas recomendaciones para evitar futuras colisiones en esta área.

Palabras clave: Maíz, Jabalí, Atropellos en la carretera, Meseta Norte española, Incremento población, Refugios.

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Introduction

The wild boar *Sus scrofa* has an excellent capacity for adaptation and occupies an extremely wide range of habitat types. These features, together with its high reproductive rate and low hunting and predator pressure, explain the recent widespread increase in both the populations and their geographical range (Saez–Royuela & Telleria, 1986). They are currently found in more than two thirds of the Iberian peninsula and populations seem to be increasing in parallel with the increase in new irrigated land (Herrero, 2003). Such newly irrigated areas now make up more than 21.4% of Iberian croplands, and they are mainly devoted to maize (*Zea mays),* a crop which has increased by 10% in the past 15 years and now covers 349.163 ha (2008 data). Wild boars use these croplands as feeding and resting areas for up to 8 months of the year —from June to March, depending on prevailing agricultural practices— especially if other nearby resources are scarce. The population increase causes important economic losses and damage to croplands (Calenge et al., 2004; Herrero et al., 2006; Schley et al., 2008). Moreover, it has led to a growing number of wild boar vehicle collisions (WBVCs). In many parts of Europe, animal–vehicle collisions are an increasing traffic safety problem (Groot Bruinderink & Hazebroek, 1996). Together with roe deer, *Capreolus capreolus,* in many parts of Mediterranean countries wild boar is the main species involved in vehicle accidents (Colino–Rabanal, 2011). WBVCs tend to be concentrated in distribution and tend to occur close to feeding or resting sites on road segments with certain characteristics (Primi et al., 2010). They are also concentrated in time, with higher collision rates at night, during the rutting season, and during litter dispersion (Peris et al., 2005). WBVC distribution is related to the sex ratio, and the percentage of juveniles and adults is representative of the population structure (Groot Bruinderink & Hazebroek, 1996). To reduce WBVCs, several mitigation measures have been proposed (Huijser et al., 2009). Aiming to identify road segments where mitigation measures might be implemented, previous research has focused on identifying the variables involved in WBVCs (Primi et al., 2010). In such studies, WBVCs have been considered as a whole and the possibility of different WBVC patterns has not been taken into account. Different patterns , are to be expected owing to the wide range of habitats the species is able to occupy. The most suitable mitigation measures may therefore vary depending on these patterns.

We hypothesized that the spatio–temporal variables involved in WBVCs in relation to maize croplands may differ from those involved in WBVC located in other areas. Knowledge of the specific factors involved in this particular pattern would enable road planners and environmental managers to improve mitigation measures based on the specific conditions of WBVCs in maize areas. In a previous study, we defined several WBVC patterns in the region of Castile and Leon (NW Iberian peninsula, 94,223 km^2, 26.57 inhabit./km^2) using WBVC traffic reports and neural networks (Colino–Rabanal, 2011). One pattern was related to maize crops on the plateau (at least 10% of all WBVCs within the region were clearly related to maize crops). The goal of this study was thus to describe the spatio–temporal distribution of WBVCs related to irrigated maize croplands and to compare it with the results for total WBVCs.

Material and methods

We worked with WBVC traffic reports from 2002 to 2008 made by the Spanish traffic safety authorities (Guardia Civil). Each report included at least the WBVC location (the name of the road and the kilometer point) and the time

it took place (date and hour). Accuracy of the WBVC location is ± 50 m (data recorded in hectometers). This accuracy helps to eliminate misleading results (Gunson et al., 2009). We used a dataset from a geographical information system. The software used was ArcGis 9.0.

The WBVC location sites for both total numbers and maize patterns were modeled using stepwise logistic regressions. We compared the WBVC spatial distribution (n = 2,347 WBVC) with a random–point distribution with the same number of control points. Before modeling, we checked for multicolinearity between variables. If the correlation coefficient was higher than 0.70, we removed one of the variables. We included variables related to traffic, human disturbances, and landscape uses. The variables included in the models are explained in table 1. The traffic parameters came from traffic intensity maps provided by the Regional Government of Castile and Leon and the Spanish Ministry of Public Works. We obtained land use data from the Forest Map of Spain (scale = 1:50,000) drawn up by the Spanish Ministry of the Environment during 2002 and 2003. As a sample unit for landscape variables we used a circular surface with a 1,000–meter radius around the WBVC localities. For the maize crops, we used the proportion of area occupied in the municipality where the WBVC took place. These data, the number of hectares for each regional municipality, were provided by the Agricultural Department of the Regional Government of Castile and Leon. Figure 1 shows the spatial distribution of irrigated crops in Spain and the WBVC within the region of Castile and Leon.

Results

Recent trends and temporal patterns

WBVCs have increased both on croplands and within the whole region (fig. 2). WBVCs were not equally distributed during the year but tended to concentrate during autumn, from October to January, for both total WBVC numbers (χ^2 = 55.67, d.f. = 11, *p* < 0.001) and maize patterns (χ^2 = 114.51, d.f. = 11, *p* < 0.001). In the case of WBVCs related to maize, this trend was even more pronounced for November and December (the percentage of WBVCs occurring in these months for maize pattern was higher than for the total) (fig. 3).

Table 1. Traffic, environmental and anthropogenic variables measured regarding both wild boar vehicle collision (WBVC) locations and a random distribution of the same number of points as control sites.

Tabla 1. Variables del tráfico, ambientales y antropogénicas medidas tanto en los puntos donde se han registrado colisiones de jabalí con vehículos (WBVC) como en aquellos que se corresponden con la distribución de puntos al azar.

Variable	Variable explanation
Traffic volume	Volume of vehicles on the road per day (vehicle/day)
Slope	Average speed of vehicles (km/h)
Road density	Road length per unit surface area (km road/km^2)
Railway density	Railroad length per unit surface area (km railway/km^2)
Sinuosity	Relationship between real and Euclidean distance
Slope	(25–metre resolution)
Distance from water	Euclidean distance to nearest river or stream (m)
Anthropogenic distance	Euclidean distance to nearest anthropogenic structure (m)
Forest	Proportion of natural forest coverage (percentage)
Reforestation	Proportion of reforestation coverage (percentage)
Wooded pasture	Proportion of wooded pasture coverage (percentage)
Riparian forest	Proportion of riparian forest coverage (percentage)
Crops	Proportion of crop coverage (percentage)
Maize crops	Area occupied in the municipality (hectares)
Scrub	Proportion of scrub coverage (percentage)
Pasture	Proportion of pasture coverage (percentage)
Mosaic landscape	Proportion of mosaic landscape coverage (percentage)
Edge density	Density of ecotones (km/km^2)
Landscape diversity	Diversity of land uses (Shannon index)

Likewise, regarding the time of the day WBVCs were concentrated during the first hours of the night in both patterns (from 19:00 to 23:00 h) (fig. 3).

Spatial patterns

WBVCs were uncommon in agricultural landscapes except around irrigated maize crops. Table 2 shows the results of the best model for this WBVC pattern. Apart from the maize area, other variables included in the models were traffic volume and edge density. The results were different from those obtained for the total number of WBVCs, where traffic variables and the proportion of forest and mosaic landscapes were seen to be the main explanatory factors.

Discussion

Wild boars show high densities in irrigated maize croplands in the surroundings of the main rivers on the Spanish Northern Plateau. In maize croplands, wild boar populations have good access to food resources, with stable year–round food availability (Herrero, 2003). Although in recent years the number of hectares devoted to maize growing has tended to stabilize, the recent increase in this crop has led to serious increases in WBVCs. This WBVC pattern has been given little attention in previous research and the mitigation measures proposed for other areas might not be the appropriate for the region studied here. Huijser et al. (2007) published a good review on available mitigation measures. It would stand to reason that not all measures are equally appropriate for each specific situation. We observed that WBVC increasee more in maize–growing areas than in areas with forest cover and/or highest speed and traffic volumes; maize was the main explanatory variable in the models. Moreover, apart from the proportion of maize crops on the landscape, other factors not considered in the models may contribute to explaining the occurrence and seriousness of WBVCs. For example, croplands in close proximity to the roadside probably increase the risk of WBVCs because they
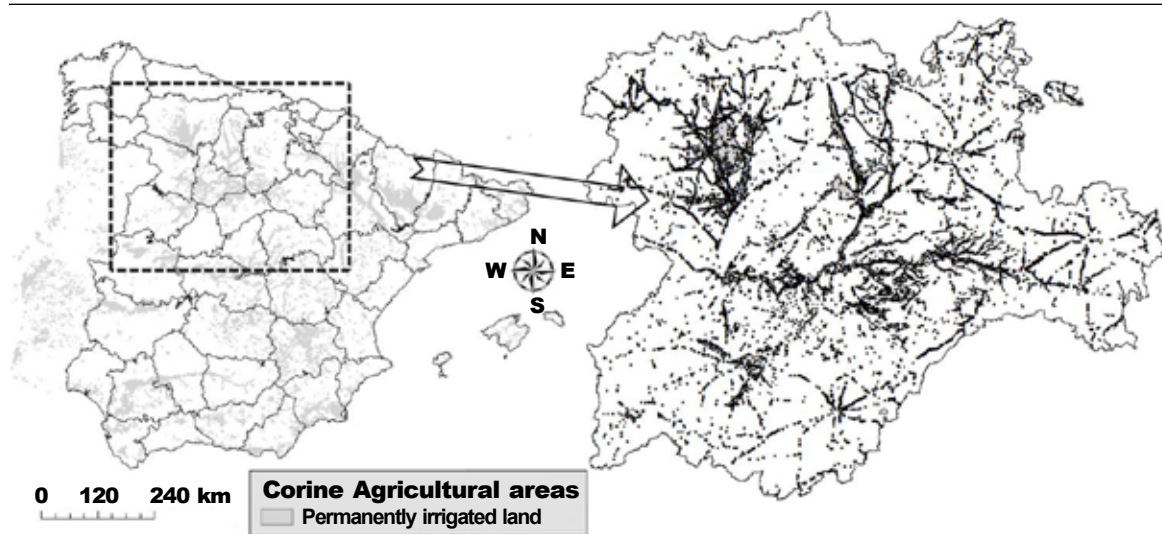
Fig. 1. Spatial distribution of irrigated croplands within the Iberian peninsula wild boar vehicle collisions (WBVC) in the study area (Castile and Leon). Surfaces covered by irrigation lands are depicted in grey.

Fig. 1. Distribución espacial de las zonas de regadío en la península ibérica y de las colisiones de jabalí con vehículos (WBVC) en el área de estudio (Castilla y León). En ambos, las zonas de regadío se representan en gris.
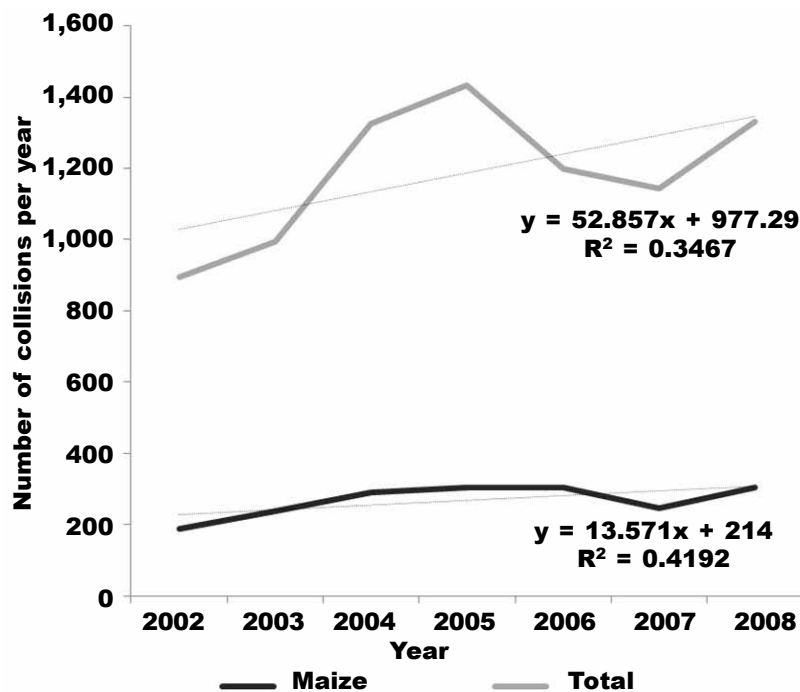

Fig. 2. Comparison between the temporal evolution of total wild boar vehicle collisions (WBVC) and those related to maize croplands.

Fig. 2. Comparación entre la evolución temporal del total de las colisiones de jabalí con vehículos (WBVC) y de las relacionadas con los cultivos de maíz.
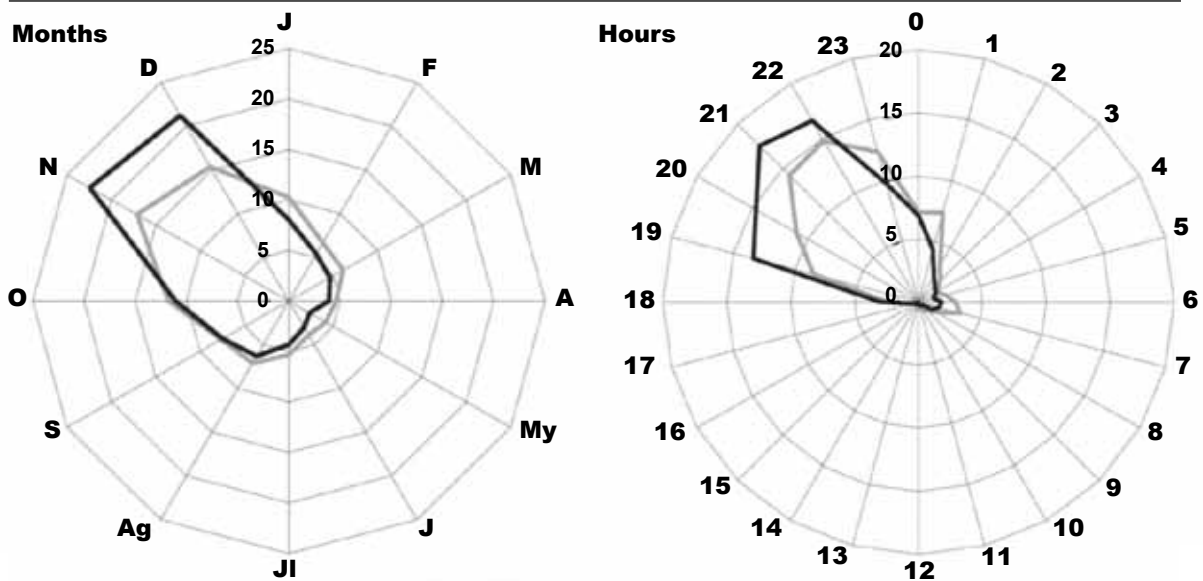
Fig. 3. Temporal distribution of wild boar vehicle collisions (WBVC): by months and by the time of day. The black line refers to the maize pattern and the grey one to total WBVCs.

Fig. 3. Distribución temporal de colisiones de jabalí con vehículos (WBVC): por meses (A) y por hora del día (B). La línea negra indica cultivos de maíz y la línea gris el total de WBVCs.

limits drivers' vision, and at the same time, they may attract more animals to areas close to roads.

We acknowledge that the way in which we quantified the 'maize' variable, *i.e.*, as the proportion of municipal area dedicated to maize cultivation could introduce some bias to the analysis. Previous research has usually measured the distance to a specific habitat or the proportion of habitat within a buffer of a certain radius. Moreover, crop rotation adds a temporal bias, which makes it more difficult to create precise maize maps. In these intensive agricultural areas farmers usually cultivate species in rotation, mainly maize and alfalfa.

We suggest that to reduce the number of collisions in the futre, apart from other more common mitigations such as road fencing, measures should be implemented to prevent sowing maize within a band of a certain width along roadsides in order to decrease the presence of the species and increase driver reaction time. The economic costs of this maize–free band could be calculated in terms of harvest loss; each 1 m of band–width, for example, amounts to a maximum of 1,200–1,500 kg of harvest loss per 100 m of road segment (with an average 4–6 plants/m^2). At a cost of 12 €/1 Tm (data from September 2011, Spanish agriculture market),

Table 2. Variables included in the most parsimonious model for wild boar vehicle collisions (WBVC): A. Total WBVC data within the region. B. Maize crop patterns on the northern plateau.

Tabla 2. Variables incluidas en el modelo más simple para las colisiones de jabalí con vehículos (WBVC): A. Total de WBVC en la región; B. Cultivos de maíz de la meseta norte.

A

	B	SE	Wald	p–value
Slope	−0.029	0.005	32.827	0.001
Traffic volume	0.001	0.001	174.810	p < 0.001
Speed	0.045	0.006	66.021	p < 0.001
Forest	0.322	0.032	100.955	p < 0.001
Mosaic	0.109	0,015	56.309	p < 0.001

B

	B	SE	Wald	p–value
Traffic volume	0.765	0.190	16.126	p < 0.001
Maize	2.452	0.283	75.260	p < 0.001
Edge density	−1.204	0.382	9.915	0.002

the reduction in cropland due to the band would reach 18–20 €/100 m road for each meter of band–width. This could be more affordable than other mitigation measures such as bridges, underpasses and so on. Cost–benefit analysis can be used to define the road segments where the installation of mitigation measures would be most profitable. In the present analysis, we compared the monetary costs and benefits of a certain mitigation measure, obtaining such benefits by combining the effectiveness of the measure in reducing the number of WBVCs and the costs associated with average WBVCs (Huijser et al., 2009). In this sense, farmers should be compensated for not planting in this band. In the region of Castile and Leon the costs associated with WBVCs are assumed by drivers if they do not obey the traffic code, by the hunting club if the animal comes from a private hunting preserve, or by the Regional Government if the WBVC is located within a natural park or if the risk of collision is not correctly signposted. In certain WBVC hotspots, either hunting clubs or the Regional Government will find it profitable to compensate farmers for not planting maize near the road rather than to cover r the economic damage derived from WBVCs. Future research should focus on identifying the best mitigation measures for collisions related to maize crops.

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