Title: A quantitative assessment of the release of farm-reared red-legged partridges (*Alectoris rufa*) for shooting in central Spain

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Abstract

The release of farm-reared game is considered a conflictive management tool because of its potential harmful ecological effects on wildlife and associated habitats. Estimates of the number of animals released and the area where this game management takes place could give an idea of the magnitude of their potential impacts. We aimed to quantitatively assess the release of farm-reared red-legged partridges (*Alectoris rufa*) in the province of Ciudad Real (central Spain), one of the main hunting areas in this country. We analysed the official permits that the regional government granted to the hunting estates to release farm-reared partridges between 2006 and 2012. Our results show that an average of 800000 partridges was released annually in the study area. A decrease in the number of hunting estates that used this game management practice, as well as in the number of red-legged partridges officially released, was observed during the last years within the study period. This might be a consequence of the current economic crisis, rather than a change in management styles. Release intensity was

spatially heterogeneous, being higher in the south-east of the study area, where historically red-legged partridge was more abundant. Most of the red-legged partridges released came from only four farms placed in northern Spain. Our results suggest that this management activity should be better monitored and that spatial regulations should also be considered.

Key-words: Game management; Iberian Peninsula; Partridges; Restocking; small game species

Introduction

Release of captive-reared animals is a management tool increasingly used in Europe for different purposes, including reinforcement of declining populations and game management (Gortázar et al. 2006; Park et al. 2008; Sokos et al. 2008; Champagnon et al. 2012). At present, game management based on releases is considered conflictive for its potential harmful ecological effects on wildlife and their associated habitat (Larsen et al. 2007; Bicknell et al. 2010; Chazara et al. 2010).

Estimates of the number of animals released give an idea of the magnitude of their potential impacts on biodiversity. For example, it has been estimated that game managers release annually approximately 35 million pheasants (*Phasianus colchicus*) and 6.5 million red-legged partridges (*Alectoris rufa*) in UK (PACEC 2006), and that about 1400000 and 400000 mallards (*Anas platyrhynchos*) are annually released in France and Denmark, respectively (Mondain-Monval and Girard 2000; Noer et al.

2008). The 68000 quails (*Coturnix coturnix*) restocked annually in Northeast Spain greatly exceeds the breeding population (Sanchez-Donoso et al. 2012).

The red-legged partridge is numerically the most important game bird species in several countries like Spain, where official statistics estimate that 2-4 million birds are shot every year in the last two decades (MAAMA 2013). Nevertheless, it has been suggested that these numbers may be underestimated (e.g. Garrido 2012). Red-legged partridge hunting is socially and economically important in Spain, involving both local and foreign hunters (González-Redondo 2004; Díaz-Fernández 2012). This species also plays a remarkable ecological role as prey of several raptors of conservation concern (Ontiveros and Pleguezuelos 2000; Valkama et al. 2005). Most of its world population, estimated on 2.2-4.5 million pairs, is concentrated in Spain (BirdLife International 2004), where the highest abundances are found in farmland areas within the Central and Southern part of the country (Blanco-Aguilar et al. 2003). Iberian red-legged partridge populations have markedly declined over recent decades (e.g. >50% between 1973 and 1992), mainly as a consequence of changes in agricultural practices and overhunting (Blanco-Aguilar et al. 2004). This population decline has led to an increase in the use of some management actions, including the release of farm-reared red-legged partridges, which increased exponentially in numbers since 1990s (Blanco-Aguilar et al. 2008; Duarte et al. 2011). However, the deep economic crisis affecting the country in recent years may have supposed a reduction in hunting activity, as occurred in other European Mediterranean countries (Liordos in press), and thus probably in the number of released partridges, but no data have been provided to support this.

To date, official information about the number of red-legged partridges released is available as a total sum for most provinces (e.g. MARM 2010). Additionally, it is known that national official figures are generally inaccurate (see Gortázar 2012), and often considered an underestimate of the real number (Garrido 2012). However, accurate quantitative and spatial information on releases is critical to predict and assess the potential impacts of this tool. Indeed, Various studies have highlighted the potential negative effects of released red-legged partridges on wild populations, e.g. facilitating anthropogenic hybridizations, spreading parasites and diseases in the wild or reducing productivity of wild populations, therefore contributing to depress the viability of wild populations (e.g. Villanúa et al. 2007; Blanco-Aguilar et al. 2008; Díaz-Fernández et al. 2012; Díaz-Sánchez et al. 2012).

In this paper, we use official detailed quantitative data on farm-reared red-legged partridge releases in a province of central Spain (Ciudad Real), one of the most important partridge hunting areas in Spain (Ríos-Saldaña 2010; Díaz-Fernández 2012), to assess temporal and spatial trends between 2006 and 2012 in the use of this management practice. We discuss our results in terms of the likely evolution of this activity, and its potential impacts on the environment.

Methods

Study area and context

The study was carried out in the province of Ciudad Real, one of the five comprising the Region of Castilla-La Mancha, in central Spain (Fig. 1). Hunting there is not only an important recreational activity (Ríos-Saldaña 2010), but also a relevant industry with direct and indirect benefits mainly on local economies (Díaz-Fernández 2012, Garrido

2012). In the province of Ciudad Real, approximately 1500 game estates cover ca. 17000 km² (84.7% of the total area), and red-legged partridge hunting occurs in almost all of these estates (96.9%; Ríos-Saldaña 2010).

Farm-reared partridges are normally released into the estates before the hunting season, with the aim of increasing the hunting population (i.e. ‘population reinforcement’), or gradually during the hunting season to provide immediate stock, a practice often known as ‘put and take’ (Byers and Burger 1979). In our study area, this strategy is only permitted in ‘intensive hunting estates’, which are a special case of commercial hunting estates where farm-reared red-legged partridges are legally released without numerical limits throughout the hunting season (Arroyo et al. 2012). Intensive estates represent a low proportion of all estates in the whole Region (<3% Ríos-Saldaña 2010), but the number of red-legged partridges released in them exceeds several orders of magnitude that released in the rest of the estates (Arroyo et al. 2012). All game estates require a special permit to release farm-reared animals, and this has to be granted by the regional government (Junta de Comunidades de Castilla-La Mancha), which is in charge of hunting issues.

Information Source

We analysed the information contained in the official permits granted in the province of Ciudad Real to release red-legged partridges between 2006 and 2012. We restricted our analyses to this province, as accurate quantitative and spatial information on releases for other provinces was not available. In total 429 permits were considered in this study. Each permit included the number of red-legged partridges released, the locality in which the game estate was placed and the farm of origin of released partridges. Using this

information, we estimated: i) the number of hunting estates that performed releases in the study period; ii) the total number of red-legged partridges released each year, and the average number of red-legged partridges released per permit; iii) the total area where this game management took place (as the sum of the areas of all hunting estates involved), and the release intensity (estimated as of red-legged partridges released per km²); and iv) the locality of origin of the released red-legged partridges (i.e. where the farm was placed). Thirty-three of the permits were asked jointly for several hunting estates (between two and ten). In these cases, we estimated the number of red-legged partridges released in each of the estates as a proportion of the total red-legged partridges released in that permit based on the percentage area covered by each game estate.

Finally, we also assessed whether the geographical variation in number of partridges released (see results) was related to abundance of red-legged partridge in the 1960s, i.e., before the use of this game management in the study area. For this purpose, we used game species abundance maps (scale 1: 2000000) that were produced by the Mainland Spanish Fish, Game and National Parks Service, using hunting bag data (Ministerio de Agricultura 1968). These maps showed the abundance of game species in a 1-5 nominal scale, in which 1='absent' (category not present in our study area), 2='rare', 3='frequent', 4='abundant', and 5='very abundant', (see more details in Delibes-Mateos et al. 2012). We calculated partridge abundance in each municipality using QGIS 1.8.0 software (QGIS Development Team 2013), as a reliable SIG layer of the hunting estates within the study areas was not available. We subsequently grouped the 4 and 5 categories for analyses, as sample size for both were small. We also calculated the

sum of red-legged partridges released (between 2006 and 2012) in hunting estates of each municipality.

Statistical analyses

We used Mann-Whitney U tests to assess differences in the number of red-legged partridges released per estate and average release intensity (partridges/km²) between intensive and non-intensive hunting estates. We used a Negative Binomial Generalized Linear Model (NBGLM) with Poisson error (and a logit link function) to compare the sum of partridges released per municipality between 2006 and 2012 with the estimated partridge abundance in that municipality in the 1960s. We initially used a General Linear Model for this analysis, but it was affected by overdispersion, accepting dispersion parameter levels between 0.5-1.5, so the error structure was corrected using a NBGLM (Zuur et al. 2013). The pseudo R² (difference between the null and residual deviances divided by the null deviance, values between 0 and 1) was calculated as a measure of the predictive power of the model (Zuur et al. 2009). Temporal relationships between the number of small-game hunting estates that released partridges per year and the number of red-legged partridges released per year were examined with linear regressions (Sokal and Rohlf 1995). NBGLM and linear regressions were carried out with the R-function 'glm.nb' (library mass; Venable and Ripley 2002) and 'lm' (library stats; R development Core Team 2013), respectively.

Results

Overall, 122 different small-game hunting estates officially released farm-reared of red-legged partridges at least once between 2006 and 2012 in the province of Ciudad Real (Fig. 1), which corresponds to ~12.5% of all small-game hunting estates. Among these,

30 were intensive estates and 92 non-intensive estates. Hunting estates where this game management activity took place during the study period covered a surface of ~3249 km² (range 1501-2210 km² per year), 16.4 % of land within the study area.

Not all of these estates released red-legged partridges annually. In fact, the permit to release them was requested by ca. half of those estates each year (mean=57.86±8.57 SD, range 45-69, Fig. 2a). The number of hunting estates requesting the permit slightly increased between 2006 and 2007 and then declined about 40 % until 2011, with a slight increase on the last study year (Fig. 2a). A similar pattern was observed when looking at non-intensive estates alone, but not in intensive estates, where the number of permit requests remained more or less stable during the study period (Fig. 2a).

The average number of red-legged partridges released per estate and permit was 8465.6 (SD=13826; range= 20-90000), but this significantly varied between both types of estates: 21408.8 ± 22633.6 for intensive estates, and 5223.8 ± 7678.6 for non-intensive estates (Mann-Whitney U Test, Z= 9.717, P<0.001 n=679). Average release intensity was 652 partridges/km² (SD=1590; range: 0.07-11830 partridges/km²), and this also largely varied between intensive (2248.6 ± 2919.6) and non-intensive estates (252.1 ± 489.5) (Mann-Whitney U Test, Z= 13.016, P<0.001 N=679). Release intensity also varied strongly geographically, being higher in the south-east of the province (Fig. 1). The geographical variation was significantly related to partridge abundance in the 1960s. Partridge releases were significantly more intense in those municipalities where partridges were 'abundant or very abundant' at that time than where they were either 'frequent' or 'rare' (Table 1).

Overall, 5748145 red-legged partridges were officially released from 2006 to 2012, 2836545 in non-intensive estates and 2911600 in intensive estates. An average of 821163 partridges (SD=191010; range: 536280-1021350) were released annually in the study area, 405220 (SD=233940) in non-intensive estates and 415943 (SD= 91020) in intensive estates (Fig. 2b). The number of red-legged partridges released per year was significantly and positively related to the number of hunting estates that released partridges in each year ($n=7$, $r^2=0.868$, $P=0.002$). Temporal trends within the study period showed an increase of red-legged partridges released during the first two years. Since then, it decreased from over one million of partridges released to ca. half (Fig. 2b). Trends, however, were different when looking at each type of estate separately: there was a notable decrease in the number of partridges released annually for non-intensive estates, and an early increase and then stability for intensive estates (Fig. 2b).

The place of origin of red-legged partridges released was shown in 402 of the permits. According to these, most of the red-legged partridges released in Ciudad Real (~75%) came from only four farms placed in northern Spain, whereas only 1.5% of them had been reared in farms located in the same province (Fig. 3).

Discussion

Numbers released and trends

According to official national figures, partridges released in Spain amounted to 1763915 in 2006 (MARM 2008) and 1652893 in 2011 (MAAMA 2013). These figures are clearly inaccurate, as we have observed that around half of that amount was released only in the Ciudad Real province, whereas releases are also widespread in many other areas all over Spain (e.g. Angulo 2003). Indeed, in the neighbouring provinces of our

study area (Toledo and Albacete), the number of farm-reared red-legged partridges released could be at least alike to that observed in Ciudad Real, as traditionally these are among the main partridge hunting areas in the country (Ríos-Saldaña 2010). Other different rough estimates have suggested that in Spain between 3.5 and 5 million red-legged partridges are released every year for shooting (Lucio and Purroy 1992; Vargas and Duarte 2002; Millán et al. 2004). However, our results also suggest that the figures for the whole country could be even much higher than those mentioned above, at least, in the 2010s. In any case, the number of partridges released is higher than that of the Spanish wild breeding population, estimated in 1.7-3.7 million pairs (Blanco-Aguilar et al. 2004).

In addition, we only considered the permits officially granted by the regional government, whereas illegal partridge releases are also carried out in Spain, possibly frequently (Delibes 1992, Díaz-Fernández et al. 2012), as it occurs with other game species. For example, in central-southern Spain, Delibes-Mateos et al. (2008) observed that nearly half of those managers who carried out European rabbit (*Oryctolagus cuniculus*) translocations admitted that they did not apply for the required official permit. According to the official permits reviewed in this study, farm-reared partridges were released in the study period in only ~12.5% of the small hunting estates within the province of Ciudad Real. However, previous studies have shown that the percentage of hunting estates that unofficially claim to release partridges is considerably higher than that obtained here (see Angulo 2003; Delibes-Mateos 2006; Blanco-Aguilar et al. 2008; Ríos-Saldaña 2010; Arroyo et al. 2012; Díaz-Fernández 2012). For example, Ríos-Saldaña (2010) observed that more than 40% of the hunting estates of Ciudad Real considered releasing partridges in their 5-year management plan ('Technical Hunting

Plans'), although this intention-statement is not necessarily implemented subsequently.

It is, however, more likely that illegal releases occur more frequently in non-intensive estates, which do not release annually and frequently in small numbers, as massive releases that take place in intensive estates are more easily detectable by the authorities.

Nevertheless, even a small proportion of non-intensive estates releasing illegally would amount to a relevant number of additional released red-legged partridges (see results).

Our results also evidenced a decrease in the number of red-legged partridges officially released since 2008 and this was caused by a decline in the number of hunting estates that used this game management practice, rather than by a decline in the number of partridges released in each state that carries out this practice. This decrease might be a consequence of the current economic situation in Spain, which could have reduced hunters' purchasing power, as well as money available for management. The fact that the decline in releases was far stronger in non-intensive than intensive hunting estates, which generates far more income, as daily prices for hunting there are much higher (Diaz-Fernandez 2012), seems to support this hypothesis. It is also known that the price requested for shooting partridges has declined during the last years (S. Ballesteros personal communication). It would be important to evaluate what will happen when the economic crisis in Spain reaches a halt.

Spatial variations and impacts

Our results show that there is a wide variation in both the number of partridges released and the release intensity among estates, and this may be explained by the different interests of such estates. Thus, for example, in some hunting estates only a few red-legged partridges were released for falconry display (generally less than 50 individuals),

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271 while in intensive estates massive releases (up to 6000 partridges/km²) took place to
272 support commercial hunting (see also Arroyo et al. 2012). However, in the last case,
273 partridges are released gradually throughout the hunting season to provide immediate
274 stock on each shooting day. This among-estate variation was not homogeneously
275 distributed in space, with release intensity being overall higher in the south-east areas of
276 the province (Fig. 1). The geographical variation in release intensity was significantly
277 related to areas where historically red-legged partridge had been more abundant, and
278 thus where its hunting had also had great value, socially and economically. After the
279 widespread decline partridge wild populations (Blanco-Aguilar et al. 2004), it is likely
280 that game managers have used releases more frequently in these traditional hunting
281 areas than in others to maintain the hunting activity. In any case, and regardless of the
282 cause, this spatial variation is likely to have local consequences on the potential harmful
283 impacts of releases on biodiversity that have been documented in the literature (see
284 introduction).

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286 Our results show that most of the red-legged partridges released in central of Spain
287 came from only four partridge farms, located very far from release sites (Fig. 3). On the
288 one hand, this particular situation is likely to facilitate to find consensual solutions
289 between producers and those generally interested in wildlife conservation. This also
290 highlights the strong need to control the genetic and sanitary quality of farm-reared red-
291 legged partridges, as one single inadequate farm may have very detrimental
292 consequences on large areas of the territory. In addition, this game management activity
293 should be better regulated in areas with high conservation value, like Special Protection
294 Areas (SPA), Important Bird Areas (IBA), Natural Parks, etc. This is already happening

in the case of other conflictive actions associated with hunting, such as the use of lead shot for hunting in European countries (Mateo et al. 2013).

Conclusions

According to our results, releases of farm-reared red-legged partridges are more widespread than official figures would indicate. Also, their use in a representative area of Spain has been apparently affected by the current economic crisis, which suggests that this industrial activity may be linked to hunting estate economics rather than hunter's preference (Arroyo et al. 2012; Delibes-Mateos et al. 2013). Given the high estimate of released partridges arising from our data and the lack of knowledge about the contribution of released birds to annual hunting statistics, we recommend much caution when using current bag data to infer wild partridge abundance (see Blanco-Aguar et al. 2012; Moleón et al. 2013). It would be desirable to know if the recent decline observed in the study area is extensible to other Spanish provinces. Currently, the control and regulations for game releases in Spain is carried out by provincial governments, and the quality and extent of existing information is therefore highly variable among areas, as some provinces do not collect systematically this information.

Our results also highlight that there is a strong spatial heterogeneity in the intensity of the implementation of this technique, and on the origin of the released birds, which may have regional consequences on the potential negative impacts of releases. Despite the decline of partridge releases observed in recent years, we recommend that the use of this management activity should be better monitored and its potential negative effects on wild red-legged partridge populations and other fauna controlled and minimized. Better monitoring could also be done through, for example, marking released red-legged

partridges, which is currently missing, and labelling these estates where releases take place. Also, spatial regulation of this technique would be useful to minimize ecological and genetic effects on wild stock on the long run. Overall, given the extension that releases have reached, and the well reported detrimental ecological effects they may have, this game management technique probably should be restricted, at least in some areas (i.e. areas with conservation values, or areas where wild stock is still abundant), including also a minimum buffer of influence to avoid dispersion of released partridges to neighbouring areas.

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Table 1. Parameter estimates and standard errors (SE) for the categories of the
explanatory variable (partridge abundance in the 1960s) used in the model explaining
the geographical variations of the current partridge release intensity in Ciudad Real.
Category 'abundant or very abundant' is included in the intercept.

	Estimate	SE	Z value	P
Intercept	12.3246	0.7798	15.804	<0.001
Rare	-3.3259	0.9358	-3.554	<0.001
Frequent	-2.7880	1.0421	-2.675	0.007

The pseudo R^2 for the model is 0.15, residual deviance is 97.65 on 97df.
Differences in LS Means were significant between 'abundant or very abundant' and
both 'frequent' ($P=0.02$) and 'rare' ($P=0.001$), but not between the latter two categories
($P=0.8$).

Figure 1. Study area, location of estates that released red-legged partridges between 2006 and 2012, and the total number of red-legged partridges released in them.

Figure 2. Number of small-game hunting estates that released partridges (A) and total number of partridges released (B) in Ciudad Real between 2006 and 2012.

Figure 3. Place of origin of red-legged partridges released between 2006 and 2012. The percentage of partridges coming from each farm is shown.