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SHORT COMMUNICATION

New data on mortality, home range, and dispersal of red-legged partridges (*Alectoris rufa*) released in a mountain range

Jesús Duarte · Miguel Ángel Farfán · J. Mario Vargas

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Abstract We tested the success, dispersal, and home range of 20 radio-tagged farm-reared red-legged partridges that were released into typical Mediterranean scrubland on a coastal mountain in southern Spain. Partridges were kept in two acclimatization pens separated by 1 km for 4 weeks. Mortality was 25% during the first 10 days, 51.9% at the end of the second month, and stopped by the 14th week after release. The overall survival rate was 20.6%. Mean dispersal distance was 832 m; home range (MPC 95%), 16.6 ha; and activity centers (Kernel 60%), 15.1 ha. Two released females paired with wild males and one of them successfully nested.

Keywords Partridge · Restocking action · Success · Survival · Territory size

Introduction

Release and restocking programs using farm-reared animals are among the most commonly used management tools employed with game species in Europe (Gortázar 1998; Gortázar et al. 2006). In Spain, the red-legged partridge (*Alectoris rufa*) is one of the most popular small-game species and is of important socioeconomic value in several rural areas (Vargas 2002). Most of the European red-legged partridge population is found in the Iberian Peninsula (Aebischer and Lucio 1997), where the species occurs in a large variety of Mediterranean habitats up to a height of 1,500 m; however, the species has suffered a notable decline during the last two decades and thus there has been a significant reduction in hunting yields (Blanco-Aguiar et al. 2003). Restocking with farm-reared birds has been widely practiced to alleviate this decline (Vargas and Duarte 2002). It is worth noting that in Spain between 3.5 and 5 million farm-reared partridges are released every year (Lucio and Purroy 1992; Vargas 2002).

There is a rich literature on the release and success of this species as well as well-documented scientific data; however, there are wide variations in the type of release, with or without acclimatization; variations in the age of released birds; releases conducted in different seasons; releasing birds at different points; or implementing habitat improvements around the release points [see Gortázar et al. (2000); Alonso et al. (2005) or Pérez et al. (2004) in Spain; and Capelo and Castro-Pereira (1996) and Castro-Pereira et al. (1998) in Portugal]. One of the crucial variations is the habitat type into which the birds are released and its effect. Most of the available studies report releases on plains or mixed farmland areas.

In the case of Andalusia, partridge release areas have a temperate Mediterranean climate with a diversity of landscapes that range from the agrosystems of the Guadalquivir valley to low coastal mountain ranges with Mediterranean scrubland, or to high inland mountains and forests (Vargas et al. 2006). In this study, we present data on the survival, dispersal, and home range of radio-tagged farm-reared red-legged partridge released in a low mountain range where the main features are managed forests and scrubland.

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J. Duarte (✉) · M. Á. Farfán
Biogea Consultores,
Calle Navarro Ledesma 243,
29010, Málaga, Spain
e-mail: jddbiogea@gmail.com

J. Duarte · M. Á. Farfán · J. M. Vargas
Departamento de Biología Animal, Facultad de Ciencias,
Universidad de Málaga,
29071, Málaga, Spain

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Material and methods

The fieldwork was conducted in the private La Algaida hunting estate (surface area, 6.4 km^2), located in the southern extreme of Málaga province (Andalusia, southern Spain; 5°0.3′W 36°31′N). This area is on a coastal mountain (10 km from the sea) where the main rock and soil type is peridotitic. Mixed limestones and gneisses are also present in marginal areas of the estate. Elevation ranges from 165 m to 760 m. It has a temperate subtropical Mediterranean climate, with average temperatures of 11.7°C in January and 25°C in July. Annual average rainfall ranges from 0.0 mm to 1,068 mm (Capel-Molina 1981).

The area consists of Mediterranean scrubland, with a scattering of pines (*Pinus pinaster*), carob trees (*Ceratonia siliqua*), wild olive trees (*Olea europaea*), gum rockroses (*Cistus ladanifer*), European fan palm (*Chamaerops humilis*), mastic tree (*Pistacia lentiscus*), and short grassland (79% of the surface area). Cork oaks (*Quercus suber*), oaks (*Quercus faginea*), and Strawberry tree (*Arbutus unedo*) are only found on low elevations with gentle slopes (18% of the surface area). A well-established forest, mainly consisting of *Salix* spp, grows along and close to the river (3% of the surface area). Less than 1% of the estate is used for livestock (sheep and cows) or farming. Forestry and hunting are the main uses. The game species harvested consists of wild rabbits, red-legged partridges, wood pigeons, thrushes, and wild boar. In this area, the potential predators of partridges are Bonelli's eagle (*Aquila fasciata*), golden eagle (*Aquila chrysaetos*), goshawk (*Accipiter gentilis*), red fox (*Vulpes vulpes*), common genet (*Genetta genetta*), and rock marten (*Martes foina*).

At the end of January 2000, we radio-tagged a total of 20 partridges (ten females and ten males, farm-reared, between 9 months and 10 months old) with 11-g TW 3 necklaces (Biotrack, UK) equipped with activity sensors and placed five males and five females in each of two release areas separated by 1 km. Each area had identical release points equipped with an acclimatization pen composed of a circular area (10-m radius by 2 m high) enclosed by 2-cm wire mesh. The pens were provided with water and feeding points as well as natural vegetation (from the scrubland) and herbaceous plants. The partridges were kept in the release areas for 4 weeks for acclimatization (i.e., in February). The aim was to release the birds at the start of the breeding season to improve the wild partridge breeding population. In early March, all the partridges were released by leaving the pen door open. No partridges died during the period they were in the pens. We located the partridges on a daily basis during the first 2 weeks and then between two and three times weekly to estimate their survival rate (Kenward et al. 1993). To locate the radio-tagged birds, we used a GPS eTrex Vista Cx (Garmin, USA), a portable Yagi antenna, and a Yaesu FT-290 receiver (Wagener Telemetrie, Germany). We used LOCATE II software (Nams 2000) for the triangulation procedure in fixed locations. To avoid bias caused by bird inactivity, locations were performed at dawn and dusk, which are the main times partridges are active. We used the homing-in technique (White and Garrott 1990) as the standard procedure in all locations. We directly estimated the survival rate by recovering transmitters from partridge carcasses and estimating the Kaplan–Meier product limit. The consumption of partridges by mammals and raptors was distinguished by the presence of feces, feathers, and footprints around the carcasses or by inspecting tooth marks or other relevant signs on the partridge feathers, carcasses, and transmitters. We used RANGES 6 software for Windows (Kenward et al. 2003) to calculate bird dispersion after release and the home range of each bird, applying the minimum convex polygon criterion (i.e., 95% of locations excluding the release point) to estimate the home ranges and the 60% Kernel contours to identify activity centers and core areas [see Buenestado et al. (2008) for a similar procedure]. Means are given with their standard errors. All the experiments complied with current laws on wildlife care, protection, and conservation in Spain and the community of Andalucía.

Results

Between March and September, a total of 318 radio locations were conducted over 68 days comprising 306 field-effort man hours. The overall survival rate was 20.6%; mean dispersal distance, 832.5±139.5 m (ranging from 362 to 2,688 m); home range (MPC 95%), 16.6±2.7 ha (range, 5.6–77.1); and activity centers (Kernel 60%), 15.1±4.9 ha (range, 3.3–27.8). Mortality was 25% during the first 10 days, 31.2% at the end of the first month, 51.9% at the end of the second month, and 65.6% at the end of the third month. By the 14th week, mortality stopped at 79.4% (see Fig. 1). Terrestrial carnivores (mainly red foxes) were responsible for 40% of deaths and raptors for 60%. We found one buried partridge that had been killed by a fox. Two released female partridges paired with wild males and one nested successfully.

Discussion

This study focuses on releases in a low mountain area, a habitat that has been little studied from the point of view of partridge releases; however, the release success was similar to that reported in previous release experiments in other habitats (Alonso et al. 2005; Castro-Pereira et al. 1998; Pérez et al. 2004). These studies have consistently reported

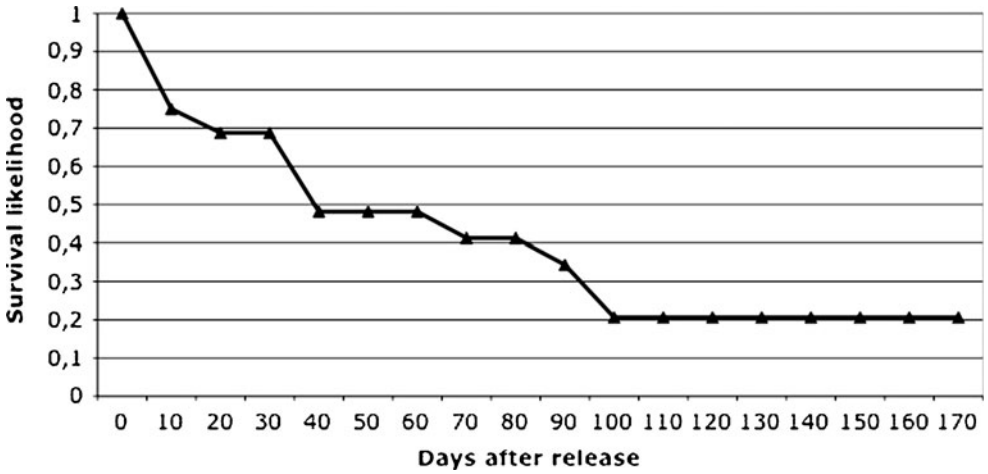

Fig. 1 Kaplan–Meier survival function for red-legged partridge in the study area

low survival and high mortality rates during the first 2 weeks (ranging from 34–90%) with only a few partridges surviving beyond the first month; however, Capelo and Castro-Pereira (1996) suggested that partridges were likely to survive for more than 2 months following release, and Gortázar et al. (2000) described better survival rates (25% at 120 days). Our results agree with those reported by the latter authors; we observed a survival rate of 48.1% at the beginning of the second month and 20.6% after the fourth month.

All the authors cited above also report average dispersal distances ranging from 450 to 890 m and maximum dispersal distances ranging from 1,600 to 2,590 m. Our results on dispersal also agree with previously reported data.

Previous studies have reported home ranges of 6 to 100 ha for wild partridges (Buenestado et al. 2008) and up to 29 ha for released partridges, but with very low survival rates (Alonso et al. 2005; Pérez et al. 2004). Our results were also within this interval. The home ranges found in this study were even smaller than those reported for wild partridges in autumn in other areas, but are similar to those expected in the period from the end of winter to the start of spring (Berger and Marchandeau 1988; Ricci 1985).

The percentages of partridges consumed by raptors or terrestrial carnivores were similar to those found in previous experiments (Gortázar et al. 2000). Most release studies define a postrelease period during which the species adapts to the habitat. This period is used to identify when mortality is no longer due to release-related problems and when it is only due to natural mortality or real predation. During this period, predators mainly consume a surplus of partridges instead of predating on them.

All these results (low survival rates, low dispersal distances, limited home range, and consumption by predators instead of real predation) indicate that the released species faces great difficulties in its attempts to adapt to the territory. This conclusion seems apply to a wide variety of habitats, areas, and different types of release operations. Thus, it is of great importance to discourage this type of wildlife management operation.

Partridge release is widely used in Spain and has at least three serious consequences: (1) the economic value of the partridges undergoes a marked decrease during release. Considering the mean mortality rate reported by many studies, the cost of each surviving partridge that is of use for hunting purposes undergoes a fourfold to fivefold increase. Thus, the real economic cost of the release operation and its profitability has to be taken into account; (2) a general outcome of these operations is that the opportunistic predator community takes advantage of the situation, consuming a surplus of partridges and likely posing an additional risk to the long-term survival of natural partridges in the release area; (3) given the fact that some farm partridges can mate and also breed with wild ones, the normal reproductive activity of the natural population could be impacted. Therefore, releases are not only barely profitable but may cause greater damage among the natural population than in the original situation that the operation attempts to rectify.

Finally, although hunters assume that hand-reared red-legged partridges breed when released in the wild, this has only been confirmed by a few studies (Duarte and Vargas 2004; Casas 2008). Direct observation has normally been prevented by the high mortality during the first 2 weeks, the low survival rate over time, and the fact that some studies have been conducted outside the breeding season; however, Borralho et al. (1997) and Carvalho et al. (1998) found significant increases in partridge breeding populations after restocking. It is worth considering that if the number of released birds is increased then there may be more breeding attempts by the released partridges. Although the percentages of released breeding females are always low, large sample sizes may lead to hybrid genotypes in the wild, thereby compromising natural reproduction activity.

In conclusion, although the habitat and the predator community described in this study may differ from those reported in previous release studies, the overall success of this experiment was the same. Low partridge survival rates are always reported. Partridge releases can introduce new parasites into the field (Villanúa et al. 2008) and are also of great value to the predator community, since they rapidly take advantage of the situation (also see Millán et al. 2003). In terms of population restocking and improvement, the advantages to hunters may be few; however, no advantage is gained regarding partridge conservation. Furthermore, the existence of gene admixture and widespread hybridization between farm-bred partridge and wild population lineages, as reported by Blanco-Aguiar (2007), suggests that a combination of time and millions of farm partridge releases may have affected the Iberian wild partridge genotype.

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