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Hunting management in relation to profitability aims: red-legged partridge hunting in central Spain.

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Abstract

Game management is widely implemented in Spain, affecting more than 70 % of land cover. Management intensity may be linked to the financial aims of hunting estates, but no study of these aspects has been developed in Spain, where commercial hunting is common. Through interviews with game managers and field surveys, we quantified physical and economic traits, management techniques and hunting methods in a sample of 59 small game hunting estates located in south-central Spain (where Red-legged partridge hunting has the highest socio-economic importance in the country). We compared non-commercial estates (aimed for leisure, managed mainly by local hunting societies) and commercial estates (aimed at financial benefit); among the latter, we also assessed "intensive" estates (a special category of commercial estates licensed to release farm-reared partridges without temporal or numerical limits throughout the hunting season). Commercial estates had more intensive management, including more and larger partridge releases, higher density of supplementary feeders and more intensive predator control. Thus, any positive or negative effects on biodiversity of these management techniques would be higher in commercial than in non-commercial estates. Commercial estates also retained more natural vegetation, which may help to enhance the landscape and biodiversity value of farmland in central Spain. On the other hand, differences in management and hunting styles were most marked between intensive and other type of estates (both commercial and non-commercial); this indicates that intensive estates are qualitatively different from other small game estates, both ecologically (hunting based on releases and driven shooting) and economically (higher inputs and outputs). It would be desirable to find ways to quantify the environmental or social costs and benefits of different management techniques, and integrate them in the economics of hunting estates.

Keywords: *Alectoris rufa***;** Farm-reared partridge releases; Hunting pressure; Predator control; game commercialization.

Introduction

Hunting is an important socio-economic activity, practiced traditionally by many people over wide areas either for recreation or subsistence (Mileson, 2009; Reboussin, 1991; Rose, 2001), and currently including an important economic dimension (Bernabéu, 2002; Chardonet et al., 2002; Fontoura, 1992; Rao et al., 2010). Additionally, hunting interacts with local biodiversity both through hunting activities and through game management practices, which are employed broad-scale, and therefore fulfils also an ecological function. Game management commonly implemented in Europe involves controversial practices, such as predator control or releasing captive-reared animals (e.g. Barbanera et al., 2010; Fletcher et al. 2010; Reynolds and Tapper, 1996), as well as habitat management which can facilitate the preservation of natural ecosystems and improve the ecological value of anthropogenic ones (Duckworth et al., 2003; Robertson et al., 2001; Tapper, 1999).

Game management intensity (and thus its effects on the environment) may vary with the economics of hunting estates (Sotherton et al., 2009). More intensive game management is sometimes linked to estates that aim to make financial profit from hunting (commercial estates), because game managers on these estates may try to boost the numbers of game species to increase income, and re-invest some of this income in management. Additionally, different forms of hunting may generate different financial profit for managers and lead to variation in management intensity. For instance, in Britain, driven red-grouse (*Lagopus lagopus scoticus*) shooting (where hunters remain in blinds while the grouse are driven by beaters walking towards them) leads to larger bags of grouse, has a higher market value and involves more intensive management than walked-up shooting (Thirgood et al., 2000).

In Spain, hunting is an important socioeconomic activity, with more than one million hunters (FACE, 2005), and attracts more than 70000 foreign hunters each year (Mulero, 1991; Rengifo, 2008). Hunting regimes in Spain changed at the end of the 1960s, from mostly open access hunting to the current situation where approximately 75 % of Spain (~ 350000 km^2) is divided into hunting estates managed privately, by hunter associations or individual managers (Grau, 1973; López-Ontiveros, 1986; MARM, 2006). These private game estates may be managed with the objective of obtaining financial benefit from the hunting rights. Hunting currently constitutes a major income in some rural areas (Bernabéu, 2002), and seems to be an expanding economic activity (Garrido, 2009). Small game hunting, particularly of rabbits (*Oryctolagus cunniculus*) and red-legged partridges (*Alectoris rufa*), is of particular relevance numerically and socio-economically (MARM, 2006; Ríos-Saldaña, 2010). However,

populations of these two species have strongly decreased in recent decades (Blanco-Aguiar, 2007; Delibes-Mateos et al. 2009). As a result, small-game management is often and increasingly associated with the release of captive-reared animals, to maintain harvest following the decline in wild stock (Blanco-Aguiar et al., 2008; Delibes-Mateos et al., 2008a). Since early 1990s, some red-legged partridge commercial hunting estates may even ask for a special permit to release farm-reared birds without temporal or numerical limits throughout the hunting season (referred in Spanish law as "*cotos intensivos de caza*", i.e. "intensive hunting estates"). This variation in approach (from non-commercial to commercial hunting, and from wild to farm-reared stock) is probably linked to differences in game management or the most frequently used forms of hunting, but such information is scarce. However, knowledge about these issues may be useful to understand the extent to which game management practices support the commercial objectives of estates and the consequences that commercialization of hunting may have for the conservation of nature.

In this paper, we assess variation in characteristics, hunting styles or pressure and game management between red-legged partridge hunting estates with different commercial objectives, as a basis to discuss the potential contribution of each type of hunting to the conservation of biodiversity and rural economies. We specifically focused on red-legged partridge hunting in central Spain, which is the main hunting area in this country (Ríos-Saldaña 2010).

Methods

Data collection

We studied management and hunting practices on 59 small game hunting estates within central Spain, covering a total land surface of ca 209000 ha (Fig. 1). The main small game species in these estates was red-legged partridge. We selected estates representing the whole range of management intensity gradient. Data about different quantitative and qualitative aspects of every estate, characteristics and management were gathered through 'face to face' in-depth interviews with game managers, conducted between 2006 and 2009. In addition, field surveys were carried out in each estate to gather habitat data and estimates of partridge abundance. Data were recorded using point-count methods (Bibby et al., 1992), where observers drove along transects, stopping every 700-750 m (exact point depending on visibility of the surrounding area). On each point, partridge numbers and locations were recorded during 10

minutes. Surveys took place in summer (mid June to early August). We calculated a partridge abundance index as the sum of recorded partridges within 300 m at each observation point, divided by the number of observation points monitored in each estate. More details can be found in Díaz-Fernández et al. (2012). Additionally, habitat cover at each observation point was noted, and then averaged for each estate. Habitats described included agricultural land, the presence of natural vegetation, mainly scrubland and grasslands, which are known to add biodiversity value to farmland habitats in Mediterranean contexts (Olivero et al., 2011), or the presence of *dehesa* (sparse oak woodland with ground vegetation cultivated or used for livestock forage), which is also of conservation value (Blondel and Aronson, 1999; Halladay and Gilmour, 1995).

Variables analyzed were grouped into three main blocks. The first block included variables related to the *physical and economic characteristics* of the estate (Table 1). Land surface of the estates, the main land uses to which the estate was devoted, and the percentage of the land that belonged to the owner of the hunting rights were obtained from the interviews, whereas habitat and partridge abundance were obtained from the field surveys. Additionally, we specifically asked the managers about their economic objectives in the hunting estates.

The second group included *game management variables* (Table 2), obtained from interviews: partridges released per km^2, number of years prior to the survey in which releases were carried out, predator control, provision of supplementary feeding and water, and presence of game crops, the management techniques most commonly employed in the study area (Delibes-Mateos et al., 2008b; Ríos-Saldaña, 2010). In addition, we collected information on the number of gamekeepers per estate, which we present also per km^2.

The third block included *variables concerning hunting methods, hunting pressure and hunting bags* (Table 3), also obtained through interviews. Methods typically used for shooting partridges in central Spain include: 1) driven shooting, where assistants beat the land to flush partridges and drive them towards a strategically arranged line of hunters; 2) walked-up shooting, where hunters (with or without dogs) shoot the birds as they encounter them (Buenestado et al., 2009); 3) decoy shooting, where a male partridge decoy is placed in a territory to attract wild partridges. Partridge bags were expressed as the number of birds harvested on each estate during a hunting season, divided by the surface area of the estate. Annual hunting pressure was calculated as the number of hunters per day and km^2, multiplied by the number of hunting days in the hunting season.

Statistical analyses

The 59 hunting estates were categorized to three types:

a) Non-commercial estates (n = 14); this included estates identified legally as "social", and "private" ones where the stated aim was recreational hunting by a group of friends.
b) Commercial estates with restricted releases (n = 37); this included private estates where the stated aim was to obtain economic benefit from the hunting rights, but without an administrative permit for unrestricted releases.
c) Commercial estates with the "intensive" legal label, and thus no restriction on releases (n = 8).

For simplicity, we hereafter call these types "non-commercial" (a), "commercial-1" (b) and "commercial-2" (c).

We tested whether each of the variables mentioned above varied among the three types of estates using GLM for quantitative variables (log transformed, or arc-sine transformed in the case of habitat variables, to normalize the variables), and chi-square tests for proportions. Significant pair-wise differences among each pair of categories were evaluated through Tukey tests of LSMeans. Analyses were performed with SAS 9.2.

Results

Physical and economic characteristics

Non-commercial estates were much larger than commercial estates, but less of the land was owned by those with the hunting rights (Table 1). A very large proportion of estates of all types had other land uses, mainly agricultural, but the proportion of land covered by agricultural habitats was significantly smaller in commercial estates (mainly because of a lower proportion of permanent crops, i.e. olive trees and vineyards) and livestock was less common. In contrast, the proportion of non-productive land covered by natural vegetation (scrubland or uncultivated grasslands) was twice in commercial than non-commercial estates (Table 1). *Dehesas* were most common in some commercial-1 estates, but overall differences were not significant among groups (Table 1). No significant differences were found in summer partridge abundance between commercial and non-commercial estates (Table 1), although highest densities were found in commercial-1 estates (Fig. 2).

Game management characteristics

The intensity of all management techniques increased significantly from non-commercial to commercial-1 to commercial-2 estates (Table 2). As expected, this was particularly marked in terms of the frequency and intensity of partridge releases. The number of partridges released per km^2 was 10 times higher in commercial-1 than in non-commercial estates, and 1000 times higher in commercial-2 estates. Moreover, the frequency of releases also increased from non-commercial to commercial-1 to commercial-2 estates (where partridges were released every year). Similar significant gradients were found for the number of feeding and water points per km^2. Additionally, similar gradients but with less marked differences were found for the density and investment in gamekeepers, the number of red foxes (*Vulpes vulpes*) or magpies (*Pica pica*) killed, and the proportion of estates that used game crops as a management tool. Significant differences were mainly found between commercial-2 estates and the other two types, except for density of gamekeepers, where differences were found mainly between non-commercial and both types of commercial estates (Table 2).

Hunting methods, pressure and hunting bags

There were also major differences in relation to the methods of hunting used in each estate type (Table 3). A large majority of non-commercial and commercial-1 estates did not carry driven shooting at all, whereas this was the most common method in commercial-2 estates. The amount of decoy shooting offered was also significantly larger in commercial-2 estates, but was also important in non-commercial ones. The density of hunters was significantly lower in commercial-2 estates but, because the number of hunting days per year was also much higher there, annual hunting pressure was very similar among the three types of estates. Annual harvest was 30-70 times larger in commercial-2 estates, where driven shooting was more common. Annual harvest was twice as large in commercial-1 as in non-commercial estates, although this was not statistically significant (Table 3).

Discussion

Our study demonstrates that there are differences in the physical characteristics, management practices and style of hunting offered between estates managed for commercial and non-commercial reasons: commercial estates are associated with a higher proportion of natural habitats and more intensive management, and are able to offer greater numbers of birds to be

shot, although differences for the latter when excluding estates with no restrictions for captive-reared bird releases were not significant. Additionally, differences in management between commercial and non-commercial estates were much less marked when excluding these "intensive" estates, which are thus markedly different from the other estates. We discuss these results below.

Commercial vs. non-commercial estates.

Game bird shooting can be a primary source of income, as occurs with grouse shooting in some areas of the uplands in the UK (Sotherton et al., 2009). In contrast, in our study area more than 85 % of even the most intensive estates had agriculture too, which indicates that hunting there is generally a complementary activity to other land uses (Martínez et al., 2002).

In general, game management was more intensive in commercial than in non-commercial small game estates, and this was true for most variables even when excluding intensive estates. The management variables that were more frequently employed in commercial estates as compared to non-commercial estates were predator control, partridge releases, supplementary feeders and water points. Commercial estates also employed more gamekeepers per unit surface. These differences are not surprising, as all these management techniques represent a high economic investment for managers (both in infrastructure, salaries, or direct expenses as food or captive-reared birds) and are less likely to occur in those estates that do not produce economic profit. These results suggest that any positive or negative effects on biodiversity of these management techniques would be higher in commercial than not-commercial estates. It is increasingly accepted that farm-reared partridge releases damage biodiversity conservation: supplemental stocking practices may threaten the integrity of the wild partridge population gene pool (Barbanera et al., 2010; Blanco-Aguiar et al., 2008) or may pose a risk to wild populations by introducing parasites (Villanúa et al., 2008), which can threaten other species of conservation concern such as the little bustard (*Tetrax tetrax*; Villanúa et al., 2007). Predator control is a source of social conflict when illegally implemented, and has caused a reduction in the geographic range of several endangered predators (e.g. Rodríguez and Delibes, 2004; Villafuerte et al., 1998; Virgós and Travaini, 2005), but it may have positive effects on other species (Fletcher et al., 2010). Supplementary food or water provided for partridges may have also positive effects on other species (authors unpublished data), although this has been scantly studied.

Additionally, our results indicate that areas managed for commercial hunting have more scrubland or uncultivated grasslands compared to non-commercial estates, where most of the area was occupied by farmland. Scrubland and uncultivated grasslands are positively associated with higher natural value of farmland in Mediterranean Spain (Olivero et al., 2011). In addition, game crops, which are known to increase biodiversity in farmland (Parish and Sotherton, 2004), were more common in commercial estates. Hunting has been claimed to be associated with the retention of natural habitats (Otero, 2000; Duckworth et al., 2003; Robertson et al., 2001). Our data do not allow us to ascertain whether hunting activities have directly contributed to the retention of natural habitats in small game estates in Spain. However, our results indicate that managing for commercial hunting may have advantages over non-commercial estates in terms of farmland habitat quality. Moreover, land property and hunting rights were more often tied in commercial than in non-commercial estates. In the latter, land ownership was highly fragmented, often not including the owner of the hunting rights, and management decisions about land use including hunting resources are often made by different persons there. In contrast, the owner of the hunting rights in commercial estates was also often the landowner, which suggests that retention of natural habitats in private hunting lands might be a consequence of game management instead of just a reflection of where commercial estates are located, but more research is needed to confirm this.

The more intensive management in commercial estates, however, did not necessarily lead to higher abundance of wild stocks or higher annual harvest, and hunting pressure was similar between non-commercial and commercial estates. Annual harvest was significantly higher in intensive estates, which reflects the markedly higher investment in releases (Table 2, and see Díaz-Fernández et al., in press). The fact that summer abundance in intensive estates was similar than in other estates despite the much higher level of released partridges also must reflect the extremely high mortality of released birds (Gortázar et al., 2000; Alonso et al., 2005). Non-intensive commercial estates tended to have higher annual harvest and summer partridge abundances (the highest densities were observed in those types of estates) than non-commercial ones, but differences were not statistically significant, probably due to the high variance of both variables. Further studies should investigate the relationship between abundance and harvest quotas, to assess the sustainability of wild partridge populations under the different management regimes.

In summary, our results suggest that non-commercial hunting, due to fewer releases, could contribute to the conservation of the genetic pool of wild partridge populations in Spain. However, commercial hunting was also associated with more natural vegetation within the

farmland matrix, suggesting positive relationships between hunting commercialization and biodiversity. Furthermore, commercial estates generate more jobs than non-commercial estates, and could thus have social benefits in rural communities (Bernabéu, 2002; Caro et al., 2011). It is now urgent to determine the cost-efficiency of management techniques to identify management to promote the optimal combination of social, economic and conservation benefits of hunting.

Intensive vs non-intensive estates

Administratively labelled « *intensive* » estates were indeed more intensive in their management than other commercial estates. Most striking differences related to both the frequency and number of partridge releases, but intensive estates also invested proportionally more in the use of supplementary feeders and water points, as well as in growing crops devoted to game cover. This is not surprising because 1) supplementary food and water are considered necessary to improve the short-term survival in inexperienced recently released partridges (Gortázar et al., 2000); 2) feeders and watering points create “attraction points” to retain released partridges linked to the estate, reducing dispersal, and are also useful as medication points to control diseases associated with farm-reared partridges (Villanúa et al., 2008). The high densities of captive-reared released birds in intensive estates probably attract carnivores, which are a primary cause of death in recently released partridges (Alonso et al., 2005), which may explain why more foxes were killed on intensive estates than on the other two types of estates (either because there are more foxes, or because higher effort is made to control this mortality factor for released birds). The higher level of magpie control in intensive units is however surprising, as these corvids are usually killed because they prey on partridge eggs (Díaz-Ruiz et al., 2010), and consequently do not present a risk for released birds. This suggests that there is a culture of controlling any potential predator as an index of perceived good management that may be not necessarily linked to increasing profitability (authors, unpublished data).

Intensive estates were also different from others in relation to hunting styles. Driven shooting was the main method of hunting partridges there, but secondary on the other two types of estates. It has been suggested that driven shooting is more harmful for wild partridge populations than walked-up shooting (Buenestado et al., 2009), because this form of hunting may be associated with higher disturbance, although the evidence for this is lacking. Intensive estates also offered a much higher number of decoy shooting days than the other estates.

Hunting with decoys is controversial because it may interfere with breeding. It would be necessary to know whether birds hunted with decoys in intensive estates are potential breeders or captive-reared released birds, and thus the potential impact of this hunting method on wild populations.

The number of birds harvested was notably higher in intensive estates, suggesting that income generated on these estates is higher. Driven grouse shooting in Britain is estimated to generate roughly 10 times the revenue of walked-up shooting (Sotherton et al., 2009), although it is offset to some extent by the cost of employing higher number of gamekeepers and the associated management carried out. Expenditure in intensive estates in central Spain was also much higher than in non-intensive estates for the same reasons. What is now needed is to compare the cost-revenue ratio and the variation in these measures among non-intensive and intensive units.

At present, there are still very few intensive game estates in central Spain (3 %; Ríos-Saldaña, 2010), but their economic and social impact could be very high, at least judging from hunting bags or jobs created, and their numbers could thus increase as a way to contribute to rural development. However, our results suggest that this industrialization of hunting is linked to a marked increase in the use of controversial management practices and could lead to conflicts over land management in these areas.

Increasingly, there is pressure to develop incentives and support schemes that promote management practices that provide effective conservation and social benefits and enhance employment and economic growth. In order to inform such policies more work is needed to quantify the externalities (environmental or social costs and benefits) of different management techniques, and to integrate them in the economics of hunting estates (Hennart 1986). For example, hunting estates with conservation and social benefits (e.g. those promoting employment and financial benefits, but associated with environmental benefits through preservations of wild stocks and/or natural habitats) could benefit from tax relief or be eligible for financial support through and accreditation scheme were they demonstrate their social, economic and environmental sustainability. Further studies (including socio-economic ones) should be implemented to determine the feasibility and acceptability of such schemes, and thus their efficiency in promoting conservation-friendly hunting and game management.

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Table 1. Mean ± SD (sample size in brackets) values of the variables used to characterize small-game estates in central Spain, and results of tests for statistical differences among groups (GLM tests were used for continuous variables, Chi-square tests for proportions). Similar letters indicate categories that were not significantly different through Tukey LSMeans comparisons.

		Non-commercial	**Commercial-1**	**Commercial-2**	F (* Chi^2)	P
Physical and economic characteristics	Surface (km^2)	81.5 ± 77.9 (14) a	18.0 ± 25.0 (37) b	34.8 ± 15.9 (8) a	16.21	0.0001
	% of agricultural habitats	73.5 ± 25.3 (13) a	39.0 ± 24.7 (34) b	47.8 ± 33.4 (6) a	7.42	0.001
	% of annual crops	44.6 ± 25.8 (13) a	32.6 ± 22.6 (34) a	32.4 ± 23.4 (6) a	1.12	0.33
	% of permanent crops	28.8 ± 18.5 (13) a	6.5 ± 13.0 (34) b	15.3 ± 15.9 (6) a	14.1	0.0001
	% natural vegetation (grasslands or scrubland)	20.1 ± 21.0 (13) a	42.1 ± 21.8 (34) b	44.6 ± 27.9 (6) ab	4.78	0.01
	% *dehesa*	1.3 ± 2.5 (13) a	11.1 ± 24.4 (34) a	3.4 ± 3.3 (6) a	1.31	0.28
	% of the land that belonged to the owner of the hunting rights	20.4 ± 36 (13) a	68.7 ± 47 (23) b	45.6 ± 43 (8) ab	5.81	0.006
	% of estates with agricultural use	92.9 (14)	88.9 (36)	87.5 (8)	0.22*	0.9
	% of estates with livestock use	92.9 (14)	67.6 (37)	42.9 (7)	6.11*	0.05
	% of estates with forestry use	23.1 (12)	10.8 (37)	16.7 (6)	1.23*	0.6
	Partridge abundance estimate (Partridges/observation point)	0.78 ± 0.79 (13) a	2.40 ± 3.50 (34) a	1.61 ± 1.19 (6) a	1.52	0.23

Table 2. Mean ± SD (sample size in brackets) values of the variables used to characterize small-game estates in central Spain, and results of tests for statistical differences among groups (GLM tests were used for continuous variables, Chi-square tests for proportions). Similar letters indicate categories that were not significantly different through Tukey LSMeans comparisons.

		Non-commercial	**Commercial-1**	**Commercial-2**	F (* Chi^2)	P
Management variables	Partridges released per km^2	1.6 ± 6. (14) a	15.6 ± 34.1 (37) b	2142.1 ± 1972.2 (8) c	40.70	0.0001
	Number of years (considering the last 9 years prior to the survey) in which releases were employed	0.7 ± 2.4 (14) a	2.1 ± 3.3 (37) a	9.0 ± 0.0 (8) b	18.98	0.0001
	Density of gamekeepers (gamekeeper/km^2)	0.01 ± 0.01 (14) a	0.14 ± 0.17 (37) b	0.11 ± 0.07 (8) b	4.25	0.01
	Investment in gamekeepers (k€)	12.8 ± 14.2 (12) a	19.3 ± 43.6 (33) b	74.1 ± 57.9 (8) c	6.37	0.003
	Foxes killed/km^2	0.78 ± 0.8 (13) a	1.64 ± 4.3 (34) a	2.69 ± 2.3 (8) b	3.02	0.056
	Magpies killed/km^2	11.4 ± 31.1 (13) a	15.9 ± 18.3 (33) b	17.0 ± 15.3 (8) b	3.96	0.02
	Supplementary feeders/km^2	0.05 ± 0.16 (14) a	5.3 ± 5.6 (36) b	29.6 ± 35.6 (8) c	21.73	0.0001
	Supplementary water points/km^2	0.47 ± 0.9 (14) a	6.4 ± 10.7 (34) b	11.7 ± 11.8 (8) c	14.30	0.0001
	% of estates with crops for game species	28.6 (14)	54.1 (37)	62.5 (8)	3.3*	0.15

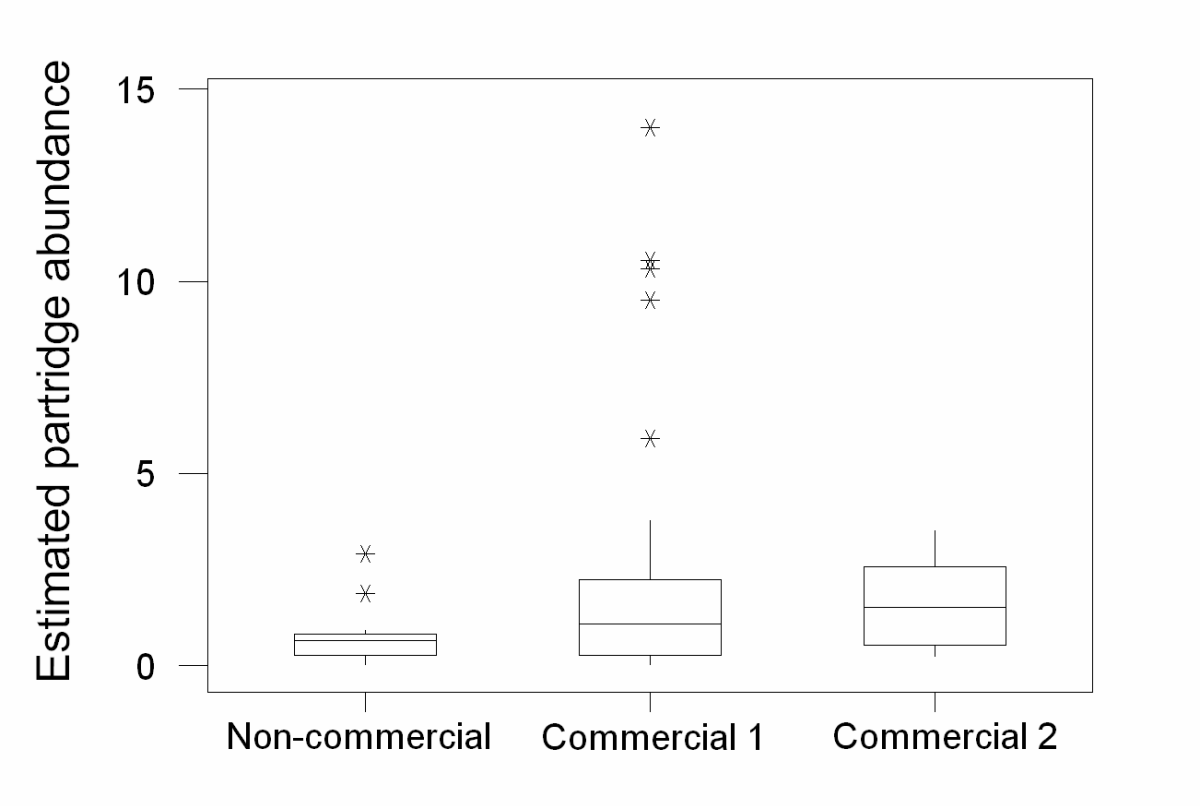
Table 3. Mean ± SD (sample size in brackets) values of the variables used to characterize small-game estates in central Spain, and results of tests for statistical differences among groups (GLM tests were used for continuous variables, Chi-square tests for proportions). Similar letters indicate categories that were not significantly different through Tukey LSMeans comparisons.

		Non-commercial	**Commercial-1**	**Commercial-2**	F (* Chi^2)	P
Hunting variables	% of estates offering only driven shooting	14.3 (14)	13.5 (37)	12.5 (8)	0.014*	0.9
	% of estates offering driven and walked-up shooting	7.1 (14)	16.2 (37)	87.5 (8)	21.2*	0.0001
	% of estates offering only walked-up shooting, or walked-up shooting and hunting with decoy	78.6 (14)	70.3 (37)	0.0 (8)	15.8*	0.0001
	Driven shooting days/year	0.7 ± 1.5 (14) a	1.5 ± 3.6 (33) a	50.6 ± 32.3 (8) b	57.08	0.0001
	Walked-up shooting days/year	8.78 ± 5.26 (14) a	9.43 ± 8.49 (32) a	13.14 ± 14.8 (8) a	0.16	0.84
	Decoy shooting days/year	7.61 ± 11.22 (14) a,b	3.06 ± 6.08 (32) b	16.7 ± 15.8 (8) a	4.17	0.02
	Number of hunters/km^2 and day	1.23 ± 0.22 (14) a	1.25 ± 0.14 (34) a	0.26 ± 0.30 (8) b	6.56	0.003
	Annual hunting pressure (Hunters/km2/yr)	18.6 ± 19.0 (14) a	16.8 ± 14.5 (34) a	16.8 ± 9.8 (8) a	0.76	0.47
	Partridges harvested/km^2	18.2 ± 9.9 (13) a	39.0 ± 33.8 (33) a	1270.1 ± 990.0 (8) b	46.90	0.0001
	% of partridges harvested in driven shooting	16.7 ± 38.9 (12) a	23.7 ± 41.4 (30) a	95.4 ± 5.6 (6) b	9.78	0.0001

Figure 1. Municipalities (light grey) where the hunting estates studied are located and their situation in peninsular Spain (top left).

Figure 2. Boxplot of the estimates of summer partridge abundance in the three different types of estates.


180000 220000 260000 300000 340000 380000 420000 460000 500000 540000 580000
4440000 4400000 4360000 4320000 4280000 4240000
MADRID
CASTILLA LA MANCHA
EXTREMADURA
Municipalities
Administrative Regions
[European Datum 1950_UTM30N]


Estimated partridge abundance
15
10
5
0
Non-commercial
Commercial 1
Commercial 2