Rock partridge (*Alectoris graeca graeca*) population density and trends in central Greece

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Abstract

*Rock partridge (*Alectoris graeca graeca*) population density and trends in central Greece.*— The rock partridge is an emblematic species of the Greek avifauna and one of the most important game species in the country. The present study, which combined long term *in–situ* counts with distance sampling methodology in central Greece, indicated that the species' population in Greece is the highest within its European distribution, in contrast to all prior considerations. Inter–annual trends suggested a stable rock partridge population both within hunting areas and wildlife refuges, whereas during summer, the species presented significantly higher densities in altitudes of more than 1,000 m, most probably due to the effect of predation at lower zones. The similarity of population structure between wildlife refuges and hunting zones along with the stable population trends demonstrate that rock partridge harvest in the country is sustainable.

Key words: Rock partridge, *Alectoris graeca graeca*, Greece, Population trends, ANOVA models, Constrained ordination, Sustainable harvest.

Resumen

*Densidad de población y tendencias de la perdiz griega oriental (*Alectoris graeca graeca*) en Grecia central.*— La perdiz griega es una especie emblemática de la avifauna griega y una de las especies cinegéticas más importantes del país. En este estudio, en el que combinamos recuentos *in situ* a largo plazo con la metodología de muestreo a distancia, en Grecia central, indicó que la población de dicha especie en Grecia es la mayor de toda la zona de distribución europea, contrastando con todos los estudios anteriores. Las tendencias interanuales sugirieron la existencia de una población de perdiz griega estable tanto en los cotos de caza como en los refugios de fauna, mientras que en verano, esta especie presentaba densidades significativamente más altas a altitudes de más de 1.000 m, probablemente debido a los efectos de la depredación en las zonas inferiores. La similitud de la estructura de la población entre los refugios de fauna y las zonas de caza, junto a las tendencias poblacionales estables, demostraron que la caza de la perdiz griega en el país es sostenible.

Palabras clave: Perdiz griega, *Alectoris graeca graeca*, Grecia, Tendencias poblacionales, Modelos ANOVA, Ordenación constreñida, Caza sostenible.

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Introduction

The rock partridge is a Palearctic species with a limited geographical distribution in central and south Europe (Cattadori et al., 1999; Randi, 2006). Within this distribution range, the rock partridge occurs with four different subspecies: *Alectoris graeca saxatilis* can be found in discrete and often isolated populations in mountainous regions of various countries which share the Alps, such as the Italian Dolomitic Alps (Cattadori et al., 1999, 2003), the French Alps (Bernard–Laurent, 1991, 2000), the Austrian Alps (Bednar–Field et al., 2011), and the Dinaric Alps of the southwestern Balkans (Vogrin, 2001); *Alectoris graeca whitakeri* is strictly endemic and present only in the island of Sicily in Italy (Corso, 2010); *Alectoris graeca orlandei* has a distribution in the central and southern Appenines in Italy (Amici et al., 2009; Rippa et al., 2011); and finally, *Alectoris graeca graeca* which is distributed in the Balkan peninsula and mainly in southern Bulgaria (Dragoev, 1974; Nikolov & Spasov, 2005; Boev et al., 2007), Albania (Lucchini & Randi, 1998; Randi, 2006), some states of the Former Republic of Yugoslavia (Muzinic, 1995; Stevanovic et al., 2005), and large part of Greece.

In Greece specifically, the species is encountered in all mountainous continental regions from eastern Macedonia to Peloponnesus including the Ionian islands of Lefkada and Kefalonia (Papaevangelou et al., 2001; Manios, 2002; Manios et al., 2002a, 2002b; Triantafyllidis et al., 2005, 2007) and the Aegean island of Euboea (Manios, 2002). It is present at altitudes higher than 400m with a few exceptions below that, whereas the lowest breeding altitude is recorded at 120m (Vavalekas et al., 1993).

The rock partridge is one of the most important game species in the country. The hunting season runs from 1 X to 15 XII. Hunting is allowed only three days a week (Wednesday, Saturday and Sunday), with a daily bag limit of two birds per hunter. Despite its popularity as a game species, the only previous information on its population status in Greece is available in Papaevangelou et al. (2001).

The main goals of this study, the first of its kind carried out in the country, were to: (i) estimate rock partridge population density and trends from a broad geographical area in central Greece, (ii) study population fluctuations, both inter–annually and intra–annually, (iii) study population variability between hunting and no hunting areas, (iv) define the effect of various environmental gradients on the variability of rock partridge density during the study years, and (v) determine population stability and sustainability of harvest.

Material and methods

Study area

Sterea Hellas extends from the Ionian Sea in the west, to the Aegean Sea in the east, covering approximately 2,400,000 ha (fig. 1). Within this geographical region, the typical habitat of rock partridge, comprises a total of 402,996 ha which is our study area, according to GIS analysis and the CORINE Land Cover 2000 (EEA) Programme, as defined above the 400 m mark. The study area is approximately 17% of Sterea Hellas (fig. 2). Within these 402,996 ha where the species is currently found, 77,000 ha are wildlife refuges where hunting is not allowed (fig. 2), covering approximately 19% of the study area. The typical habitat of rock partridge in the Sterea Hellas region comprises 25% of the species' total habitat at a national level (1,571,450 ha).

Since typical rock partridge habitat extends throughout the region of Sterea Hellas and part of Euboea Island, it includes various habitat types, such as transitional zones between shrubs and woodland (68%), moors, heathland and sclerophylous vegetation (5.6%), natural grasslands (17.5%), sparsely vegetated areas (6.4%), pastures (1%) and bare rocky areas (0.8%).

Field methods

Monitoring the rock partridge population in central Greece began in 2005 as a continuous research programme financed by the Hunting Federation of Sterea Hellas. The data presented here are for the first seven years of the programme (2005–2011). A total of 65 line transects were located within wildlife refuges and 80 line transects within hunting areas, spread throughout the study area, both in latitude and altitude. The mean length of each transect was 2.5 km, ranging from 1.9 to 3.3 km (95% CI: 2,405–2,632 m). Line transects did not vary during the seven years of study. Monitoring was carried out according to the line transect method (Buckland, 2001) by gamekeepers using pointing dogs (Sara, 1989; Cattadori et al., 2003; Besnard et al., 2010). Each year two counts were conducted on each line transect. One count was conducted during the last two weeks of March because in that period the formation of rock partridge pairs is complete and the breeding season is about to begin. The second count was conducted during the last two weeks of August because in that period the breeding season is over and it is the best time to distinguish and record the number of younglings (Manios, 2002).

During the counts, one gamekeeper walked the line transect and two others covered the area to the left and right of the line with pointing dogs. When partridges were flushed, the perpendicular distance of individuals from the line transect was recorded. Along with the number of individuals flushed each time, we also recorded number of pairs during March and the number of individuals per flock during August (Buckland, 2001). In addition, number of adults and juveniles was also recorded during counts in late summer. During the seven years of the study, a total census of 1,275 km was done within hunting areas and 1,050 km within wildlife refuges. Vegetation type, vegetation cover and grazing intensity were also recorded as environmental variable categories.

Statistical analyses

The species' population density was calculated using Distance 6.0 Release 2 (Buckland et al., 2008; Fewster et al., 2009; Thomas et al., 2010). Rock partridge density was calculated for each year, season, area and altitudinal zone. In order to test for variability in rock partridge population trends between years and between seasons, and also between wildlife refuges and hunting areas, a three–way full factorial ANOVA was constructed. The first factor of predictor variables was the year (2005–2011), the second factor was the season (early spring *vs.* late summer) and the third factor was the area (wildlife refuges *vs*. hunting areas). Moreover, in order to explore any possible altitudinal effect on rock partridge density, another two–way full factorial ANOVA model was constructed with the first factor of predictor variables being the season and the second factor the altitude. Altitude was divided into two zones, a low zone from 400 m to 1,000 m and a high zone from 1,001 m to 2,000 m.

Altitude was not included in the first ANOVA model as the fourth factor of predictor variables because in order to run such a model at least two values of rock partridge density (ind/ha) should be produced for each combination of the four factors' levels: year (2005–2011), season (spring–summer), area (wildlife refuges–hunting areas) and altitude (low zone–high zone). Density values, however, were calculated using Distance software which has a minimum threshold of 40 species encounters during field counts, for each level combination, in order to produce results (Buckland et al., 2001, 2008). This limitation occurred on certain occasions when building a four–way ANOVA, and thus the effect of altitude and its interaction with season was explored in the present study using a second ANOVA model.

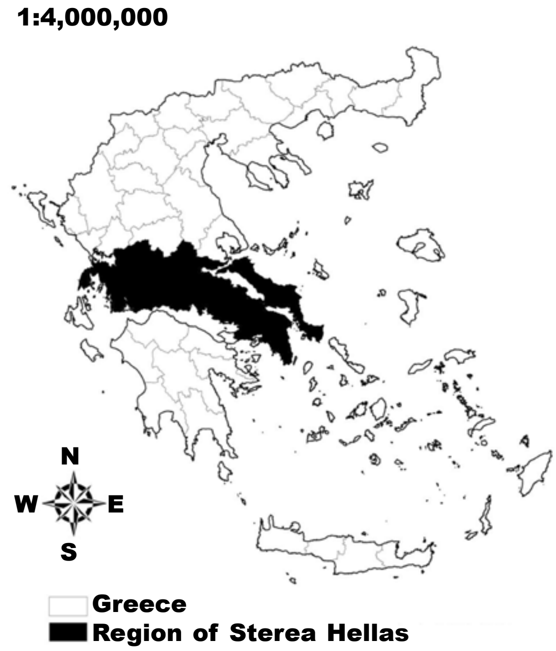

Fig. 1. Map of Greece showing the Sterea Hellas region.

Fig. 1. Mapa de Grecia mostrando la región de Sterea Hellas.

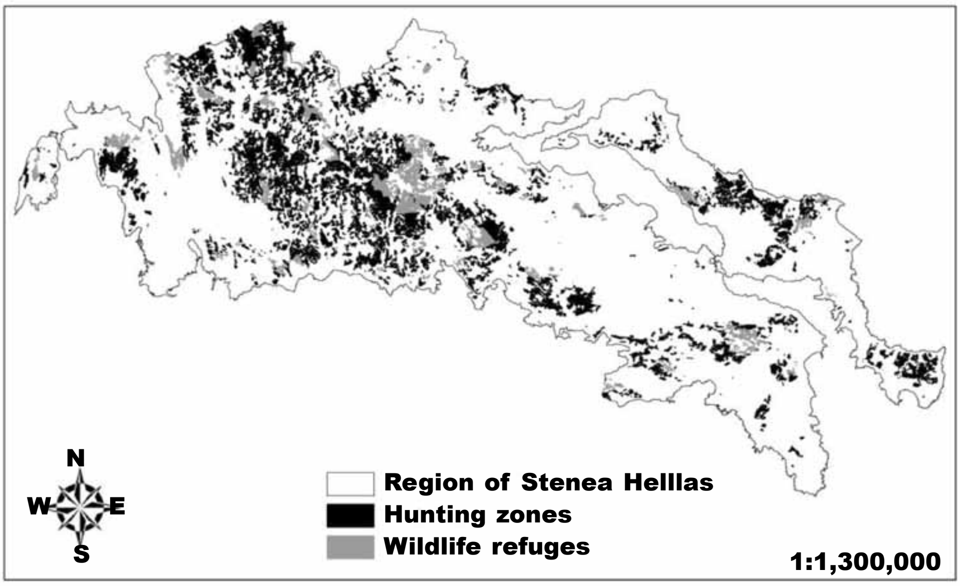

Fig. 2. Map of the Sterea Hellas region (central Greece) indicating the total typical habitat of rock partridge. Hunting zones in the total study area are indicated in black and wildlife refuges in grey.

Fig. 2. Mapa de la región de Sterea Hellas (Grecia central) indicando el total del hábitat típico de perdiz griega. Las zonas de caza en el área total de estudio se indican en negro, y los refugios de fauna en gris.

Table 1. Mean rock partridge density (ind/ha) in the Sterea Hellas region (central Greece) from 2005 to 2011, according to season, area and altitudinal zone.

Tabla 1. Densidad media de perdiz griega (ind/ha) en la región de Sterea Hellas (Grecia central) del 2005 al 2011, según la estación, el área y la franja altitudinal.

	Wildlife refuge	Hunting zones	Low altitude 400–1,000 m	High altitude 1,000–2,000 m
Spring (SD)	0.185 (0,048)	0.123 (0,026)	0.145 (0,038)	0.164 (0,058)
Summer (SD)	0.468 (0,094)	0.367 (0,116)	0.348 (0,106)	0.486 (0,079)

The effect of habitat type, vegetation cover, grazing density and altitude upon the rock partridge density during spring and summer was also analyzed using a multivariate approach through constrained ordination and Generalized Linear Models (Leps & Smilauer, 2003). A 'response' variables matrix was constructed at first, including rock partridge absolute count numbers in spring and summer as recorded in each line transect and their repeated results each year of the study. Then, a similar 'predictor' variables matrix was constructed including habitat type, vegetation cover, grazing density and altitude as recorded in each line transect, season and year. Except altitude, which is a continuous variable, the remaining environmental variables were recorded in a categorical form. Thus they were obligatory transformed through fuzzy coding in order to be expressed with binomial values (absence: 0, presence: 1), so that they could be included in the multivariate analysis (Leps & Smilauer, 2003). Once both matrices were introduced in the software, a Detrended Correspondence Analysis was firstly applied only on the “response” matrix. This type of indirect analysis considers only the variability of response variables and calculates length gradient values which are actually measurements of beta diversity in community composition. According to their value (less than 3 or more than 4), these results indicate the kind of multivariate approach —linear or unimodal analyses— to be followed, respectively. The indicated analysis was then applied to both matrices, in order to produce a constrained ordination which represents the variability in rock partridge population composition that can be explained by the measured predictor variables. In constrained ordination specifically, the produced axes are weighed sums of the predictor variables, and thus these methods of direct gradient analysis resemble a model of multivariate multiple regression. The significance of the model is then tested with Monte Carlo simulations, and if significant, various hypotheses can be explored with the use of GLMs and the criterion of Akaike (AIC).

The percentage of juveniles with respect to the total number of individuals during late summer in each monitoring effort was also calculated. Differences between wildlife refuges and hunting areas were explored with a one–way ANOVA model in order to test whether the reproductive outcome varies among them. In order to apply all the ANOVA models, absolute counts and density values were log–transformed to meet the assumptions of the analysis.

Results

Based on the species’ mean density (ind/ha) from all the years of the study (table 1) the rock partridge population in Sterea Hellas, was estimated at a mean of 31,000 breeding pairs in early spring (95% CI: 28,052 to 34,358).

Table 2. Results of full factorial model for three–way ANOVA on rock partridge population density in the Sterea Hellas region (central Greece) from 2005 to 2011. The first factor in the model is the year of the study, the second factor is the season (early spring–late summer) and the third factor is the area (wildlife refuges–hunting areas): Df. Degrees of freedom.

Tabla 2. Resultados del modelo factorial completo para una ANOVA de tres factores sobre la densidad de población de perdiz griega en la región de Sterea Hellas (Grecia central) del 2005 al 2011. El primer factor del modelo es el año de estudio, el segundo es la estación del año (principios primavera–finales del verano), y el tercero es la zona (refugios de fauna–áreas de caza): Df. Grados de libertad.

	Df	*F*	*P*
Year	6,28	0.336	0.911
Season	1,28	116.635	$< 10^{-6}$
Area	1,28	11.280	0.002
Year*Season	6,28	0.146	0.988
Year*Area	6,28	0.508	0.796
Season*Area	1,28	0.273	0.604
Year*Season*Area	6,28	0.288	0.937

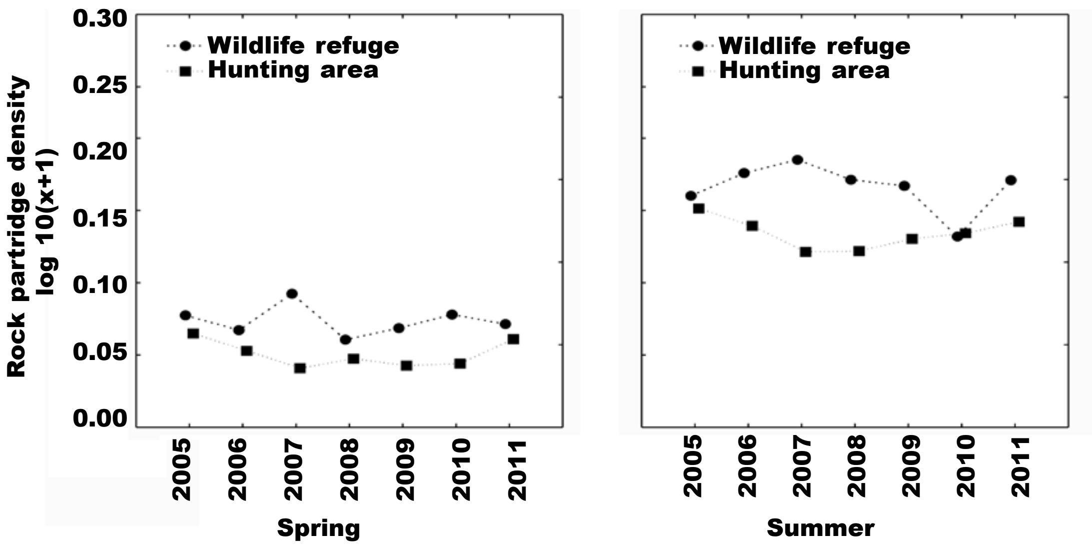

Fig. 3. Variability of rock partridge density from 2005 to 2011, in spring and summer, within wildlife refuges and hunting areas in the Sterea Hellas region (central Greece).

Fig. 3. Variabilidad de la densidad de la perdiz griega desde el año 2005 al 2011, en primavera y en verano, dentro de los refugios de fauna y en las zonas de caza de la región de Sterea Hellas (Grecia central).

The year factor played no significant role in the inter–annual variability of the rock partridge density in the study area (table 2). Similarly, no significant variance occurred in rock partridge inter–annual population trends in different seasons, or within hunting areas and wildlife refuges (table 2). On the other hand, we found a strong intra–annual seasonal effect due to higher densities during summer both within hunting areas and wildlife refuges (table 2, fig. 3). Finally, there was also a significant difference in rock partridge density; it derived from higher densities within wildlife refuges than in hunting areas, which was not as strong as the seasonal effect but it was constant during all the years of the study, both during spring and summer (table 2, fig. 3).

Rock partridge density also increased significantly along the altitudinal gradient (table 3). Nonetheless, the significant interaction between seasonal and altitudinal effects showed that altitude had a significant effect on the increase in the species' density only during summer, because during spring, rock partridge density presented no difference between low and high altitudinal zones (fig. 4).

The positive effect of altitudinal gradient upon the rock partridge density was also verified by the constrained ordination. Detrendend Correspondence Analysis (DCA) on the "response" variables dataset produced a length gradient of less than 3 for the first axis, indicating that linear methods should be used in continuation and specifically an RDA (Redundancy Analysis). Direct gradient analysis through RDA upon both predictor and response variables' datasets produced a significant model (*F*–ratio = 5,953, *p* = 0.002), from which the first produced constrained canonical axis explained 99% of the variability in rock partridge density (table 4). Forward selection results of the produced multivariate model, according to both marginal and conditional effects, indicated 'Altitude' as the most important variable. In the two–dimensional representation of rock partridge variability during spring and summer and its position in ordinational space, altitude defined the horizontal axis upon which the vectors of the rock partridge density increased, and specifically that of summer. Environmental variables 'Low grazing', 'Shrubs' and 'Phrygana' occupied the 4th quadrant of the graph, 'High grazing' and 'Medium grazing' occupied the upper and lower parts of the bi–plot and 'Subalpine' occurred alone in the second quadrant (fig. 5).

Rock partridge population structure in central Greece was similar both within hunting zones and wildlife refuges (one–way ANOVA: $F_{1,12} = 0.020$; $p = 0.890$). The average ratio of juveniles to adults within hunting areas was 1.6 (range 1.2–1.9; SD 0.29) and within wildlife refuges it was 1.5 (range 1.2–1.8; SD 0.22).

Discussion

The rock partridge population in Greece has been estimated at between 7,000 and 13,000 breeding pairs by Handrinos & Akriotis (1997) and Handrinos & Papoulia (2004), with a claim of being even lower (Handrinos & Katsadorakis, 2009). These same authors also consider the species to be extremely rare and definitely declining and disappearing from most parts of Greece. The authors state, however, that

Table 3. Results of the full factorial model for two–way ANOVA on rock partridge population density in the Sterea Hellas region (central Greece) from 2005 to 2011. The first factor is the season of the counts (early spring–late summer) and the second factor is the altitude (low altitude: 400–1000 m; high altitude: 1,001–2,000 m): Df. Degrees of freedom.

Tabla 3. Resultados del modelo factorial completo para una ANOVA de dos factores sobre la densidad de población de perdiz griega en la región de Sterea Hellas (Grecia central) del 2005 al 2011. El primer factor es la estación de los recuentos (principios primavera–finales del verano) y el segundo es la altitud (baja altitud: 400–1.000 m; gran altitud: 1.001–2.000 m): Df. Grados de libertad.

	Df	*F*	*P*
Season	1,52	183.817	$< 10^{-6}$
Altitude	1,52	14.579	$< 10^{-3}$
Season*Altitude	1,52	7.857	0.007

these estimations are not based on specific scientific data on rock partridge populations (Handrinos & Katsadorakis, 2009). These estimations were based on an older publication of Papaevangelou et al. (2001) in which rock partridge population in Greece was estimated at between 7,000 and 13,000 pairs, without any clear indication of the methodological approach used to determine these numbers, or any reference concerning the mathematical procedure used to calculate the total number of breeding pairs at a national level.

In contrast, according to our study, the first to be carried out in such an extended study area and on such a long term basis, Greece holds the highest *Alectoris graeca graeca* population in the Balkans. Moreover, Greece also holds the highest population among all other countries within the species' European distribution range. Sterea Hellas alone holds an estimated total of 31,000 breeding pairs.

Furthermore, attempting a simple extrapolation of the species' mean density on the total rock partridge typical habitat in the country (1,571,450 ha), the breeding population of the species in Greece is potentially estimated at approximately 121,000 pairs (95% CI: 109,338 to 133,979), which is much higher than any previously published estimations. Although in certain regions of the country the rock partridge density may vary from the one calculated in Sterea Hellas (table 1), the present findings provide a solid base for an estimation of national rock partridge population. According to our data, the minimum estimated number of rock partridge breeding pairs in Greece is 104,000, which is much higher from the species' maximum European breeding population, as it was previously estimated at 78,000 individuals (Burfield & Bommel, 2004).

According to the results of Project ARTEMIS, since 2007 when the bag limit was set at two birds per hunter and outing, harvest of rock partridge in the Sterea Hellas region is stable and calculated (Thomaides et al., 2011) at a mean of 26,000 individuals per year (95% CI: 22,954 to 29,423). This further attests to harvest sustainability and population stability of the species.

Apart from the fact that our data give a completely different picture concerning the rock partridge population status in Greece, they also demonstrate that there has been no declining trend for rock partridge in the seven years of the study. The species' populations are stable both within wildlife refuges and hunting zones, as well as during the monitoring seasons, early spring and late summer (table 2, fig. 3). The constant difference in rock partridge density between hunting zones and

Table 4. Results of constrained ordination analysis (RDA) for the rock partridge density dataset during spring and summer, and for the environmental variables dataset in the Sterea Hellas region (central Greece) from 2005 to 2011.

Tabla 4. Resultados del análisis de ordenación constreñida (RDA) del conjunto de datos sobre la densidad de perdiz griega durante la primavera y el verano, y el conjunto de datos de las variables ambientales de la región de Sterea Hellas (Grecia central) del 2005 al 2011.

	Axes			
	1	2	3	4
Eigenvalues	0.075	0.001	0.634	0.289
Species–environment correlations	0.330	0.056	0.0	0.0
Cumulative percentage variance of species data	7.5	7.6	71.1	100.0
Cumulative percentage variance of species–environment relation	98.7	100.0	0.0	0.0

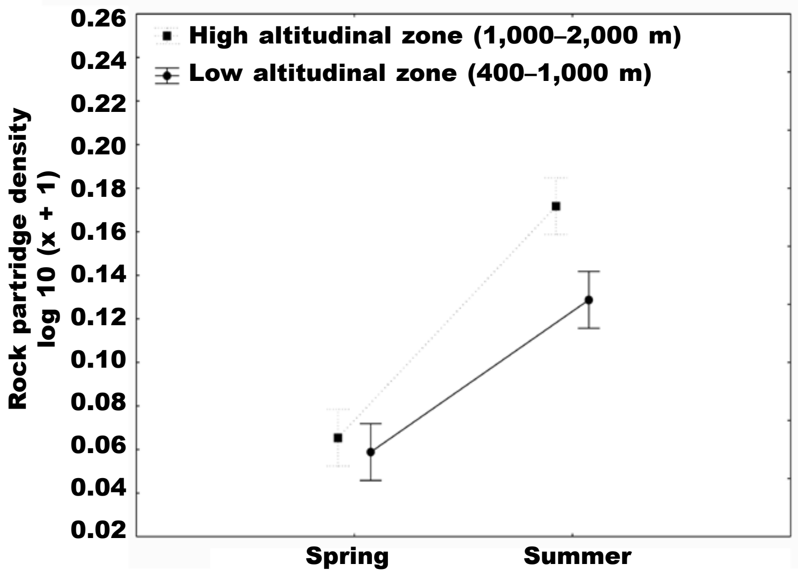

Fig. 4. Variability of rock partridge density from 2005 to 2011, in low and high altitudinal zones, during spring and summer, in the Sterea Hellas region (central Greece).

Fig. 4. Variabilidad de la densidad de perdiz griega desde 2005 a 2011, en zonas altitudinales bajas y altas, durante la primavera y el verano, en la región de Sterea Hellas (Grecia central).

wildlife refuges is only contradicted during the summer of 2010, when the species' density within wildlife refuges was at its lowest (fig. 3). Although the species' interannual population trends are stable according to our results, this finding could be a first indication for cyclic fluctuations of rock partridge in Greece.

Cattadori et al. (1999) first recorded rock partridge fluctuations in the Dolomitic Alps, after analysing harvest data over 40 years, defining a cyclic period of four to seven years. Of course, more than seven years of data need to be taken into consideration to reach a safe conclusion for Greece. However, the fact that rock partridge showed their lowest density value in our study after five years of summer counts, and that this was reversed the following year, probably points to a similar conclusion. It is also important that this phenomenon was observed only in wildlife refuges and not within hunting zones. Nevertheles, more in depth research concerning demographic parameters should be conducted to give specific answers to this issue. Although hunting zones and wildlife refuges are adjacent, as indicated in figure 2, the strong territorial nature of rock partridge and the species' small range movements lend meaning to statistical comparisons between the two areas (Manios, 2002; Manios et al., 2003). In addition, line transects were not placed near the borders of hunting zones and wildlife refuges. Moreover, wildlife refuges in Greece include very large areas of various habitat types or biogegographical units such as whole mountains, and thus we can safely support that there are no rock partridge movements between refuges and hunting areas.

The significant effect of season upon rock partridge density (table 2) was expected, because reproductive output contributed towards a significant increase in rock partridge density, both within hunting zones and wildlife refuges (fig. 3). On the other hand, the significant effect of altitude on the increase of rock partridge density during summer and specifically on the higher altitudinal zones (table 3, fig. 4) is probably due to the effect of predation upon rock partridge nests and nestlings at lower altitudes. As recorded by Manios (2002) in Greece, 72% of the located rock partridge nests were destroyed, mainly by beech marten (*Martes foina*) and weasel (*Mustela nivalis)* in lower altitudes, probably accounting for the significantly higher density values in the 1,000m to 2,000 m zone in summer (fig. 4). Lower altitudes sustain more densely vegetated ecosystems with higher canopy cover, habitats that are ideal for predators such as marten and weasel (Spencer et al., 1983; Cavallini & Lovari, 1991; Clevenger, 1994; Sachhi & Meriggi, 1995; Lucherini et al., 1995), whereas at higher altitudes where vegetation is sparse, open areas sustain poorer assemblages in respect to these two species and thus predation upon rock partridge nests and nestlings decreases significantly. It is also possible that rock partridges move in accordance with climatic conditions during each season. In the French Alps, it was recorded that the species tried to reach its preferred habitats during summer, these being habitats located at higher altitudes. Specifically, rock partridges moved several kilometres away from their breeding sites during winter in order to avoid heavy snowfall,

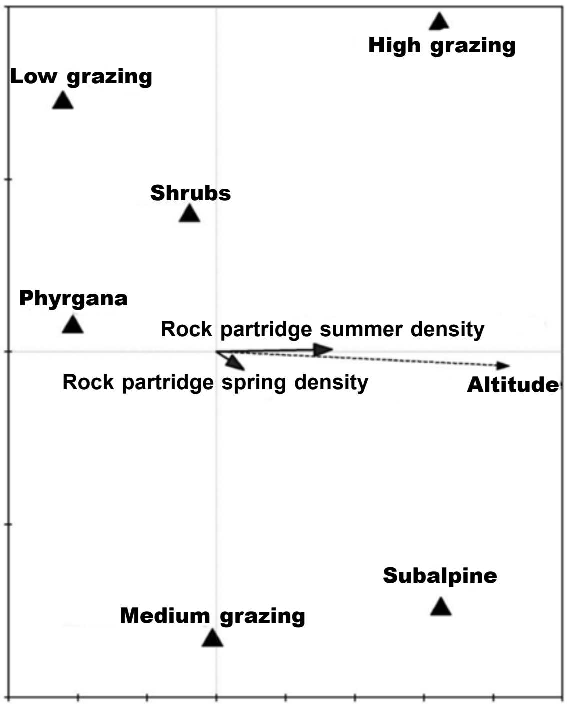

Fig. 5. Variability in rock partridge density from 2005 to 2011 in the Sterea Hellas region (central Greece) during spring and summer (response variables) explained by environmental gradient variability (predictor variables), presented in two–dimensional space produced by RDA. Triangles represent qualitative environmental variables, the dashed vector represents the increase of altitude which is the only continuous variable, and black vectors indicate increase density of rock partridge in spring and summer (ind/ha). The proximity of a black vector towards a triangle or the direction of the dashed vector indicates density increase upon this gradient, whereas distance or opposite direction indicate density decrease and negative gradient effect, respectively.

Fig. 5. Variabilidad de la densidad de perdiz griega del 2005 al 2011 en la región de Sterea Hellas (Grecia central) durante la primavera y el verano (variables de respuesta) explicada por la variabilidad del gradiente ambiental (variables predictivas), presentada en un espacio bidimensional producido mediante RDA. Los triángulos representan las variables ambientales cualitativas, el vector punteado representa el aumento de altitud, la única variable continua, y los vectores negros indican el aumento de la densidad de perdiz griega durante la primavera y el verano (ind/ha). La proximidad de un vector negro a un triángulo, o la dirección del vector punteado indican un aumento de la densidad hacia el gradiente, mientras que la distancia o la dirección opuesta indican un descenso de la densidad y un efecto de gradiente negativo, respectivamente.

and returned to the same sites during summer when these became accessible (Bernard–Laurent, 1991).

The altitudinal effect on rock partridge density in summer is also verified from the constrained ordination and the significance of the model that is shown in the ordination bi–plot (fig. 5). The large vector length of the environmental variable 'Altitude' indicates its importance in explaining rock partridge variability in the model. Moreover, since the vector is almost parallel to the horizontal axis, it is the environmental variable which actually defines it. The importance of altitude in the model is also confirmed from RDA results, which indicate that the first produced constrained axis, which is defined by 'Altitude', explains almost 99% of rock partridge variability in the model. In addition, from the response variables' dataset only the rock partridge density during summer has a large vector length and is parallel to the horizontal axis, indicating that altitude mainly affects the species' density during summer, which increases along the gradient.

The other environmental variables explain only the remaining 1% of the species' variability. Specifically, 'Low grazing', 'Shrubs' and 'Phrygana' are clustered in the fourth quadrant of the graph, in the opposite direction of the increasing density of rock partridge, possibly demonstrating a negative effect. This could be an indication that the rock partridge in Greece prefers early succession ecosystems with open areas, but with just 1% of explained variance such an argument is not fortified. Nonetheless, such behavior has been recorded previously in Greece by Manios (2002) and in Italy by Rippa et al. (2011), where higher grazing intensity created more open habitats which proved to be more suitable for the species.

Finally, the fact that inter–annual rock partridge density trends demonstrate a stable population, both within hunting areas and wildlife refuges, as well as the fact that the species' population structure is almost identical in both areas through the years, suggest that the species' harvest is sustainable and the reproductive output compensates for the hunting take. The average productivity ratio (juveniles/adults) as calculated in central Greece both in hunting zones and wildlife refuges, is similar to that provided by Bernard–Laurent (1994) and Sara (1989). According to Sara (1989), it is characterized as a medium productivity, but in our study higher densities per land unit are demonstrated (table 1).

In conclusion, since hunting appears to have no negative effect on the species' population, the limiting factors for rock partridge population, as recorded by other authors, are: genetic hybridization (Triantafyllidis et al., 2005, 2007), predation (Manios, 2002; Vavalekas et al., 1993), the abandonment of traditional agriculture and livestock practices leading to increased canopy cover in mountainous areas (Papaevangelou et al., 2001; Manios, 2002; Rippa et al., 2011), and the effect of parasites (Manios et al., 2002b; Rosa et al., 2011).

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