Twenty years of the grey partridge population in the LAJTA Project (Western Hungary)

S. Faragó, G. Dittrich, K. Horváth–Hangya & D. Winkler

Faragó, S., Dittrich, G., Horváth–Hangya, K. & Winkler, D., 2012. Twenty years of the grey partridge population in the LAJTA Project (Western Hungary). *Animal Biodiversity and Conservation*, 35.2: 311–319.

Abstract

Twenty years of the grey partridge population in the LAJTA Project (Western Hungary).— The LAJTA Project covers 3,065 ha. Within this area crop cultivation is dominant. Fields are separated from each other by forest belts and tree rows, extending altogether over roughly 120 ha. This habitat structure characterized by cultivation of 12–15 field crops sustained partridge population with densities of 1.75 birds/km^2 (1991). The Project started in 1991/1992 and aimed to increase the carrying capacity for grey partridge and other small game species living in the area. A full–time gamekeeper was employed and habitat improvements were initiated. Four years later, the breeding population increased to 10.1 birds/km^2. Besides increased numbers of nesting pairs, the number of reared chicks also increased, from 5.1–11.2 individuals/km^2 in 1990 to 27.3–38.4 individuals/km^2 in 1994. However, field sizes did not change significantly. Although the lengths of field margins increased by approximately 25 % (from 82 m/ha to 115 m/ha) under the influence of habitat management, they still reached only half those found in the countries of Central Europe where private ownership of land properties is dominant. After the privatisation of fields in 1995 as part of the political change in Hungary —affecting approximately 50% of the project area— the possibilities of habitat improvement decreased, and the technological pressure on large–scale farming area increased. Following these processes the grey partridge population again decreased to 1.43 birds/km^2 in 1997. As a result of the new management strategy applied in the project since 1996 we observed a slow increase in the breeding population, which stabilized at around 5 birds/km^2, between 2007 and 2009. The August density increased in the same period from 4.5 birds/km^2 to 13–17 birds/km^2. During the two decades in which this research was conducted, chick mortality and winter mortality were extremely high. The key factors influencing grey partridge population dynamics in our study area seem to be clutch and chick losses and winter mortality. To determine the relationship between environmental factors and the grey partridge population parameters, principal component analysis (PCA) was used. August grey partridge density was positively associated with ecotone density and bags of red fox and avian predators (magpie and hooded crow). The density of grey partridge in spring and August also correlated with feral dog bag and feral cat bag. Habitat parameters showed a positive correlation with the density of grey partridge both in spring and in August. The levels of abundance of feral dog and feral cat populations also correlated negatively with winter losses.

Key words: Grey partridge, Long–term monitoring, Predators, Habitat, LAJTA Project, Hungary.

Resumen

Veinte años de la población de perdiz pardilla en el Proyecto LAJTA (Hungría occidental).— El Proyecto LAJTA cubre 3.065 ha. En esta área dominan las tierras de cultivo. Los campos están separados entre sí por cinturones forestales e hileras de árboles, que tienen en conjunto una superficie aproximada de 120 ha. Esta estructura de hábitat, caracterizada por el cultivo de 12–15 cosechas, mantenía una población de perdices con densidades de 1,75 aves/km^2 (1991). El Proyecto empezó en 1991/1992 con el propósito de aumentar la capacidad de carga para la perdiz pardilla y otras especies de caza similares que vivían en la zona. Se contrató a un guardabosques a jornada completa y se inició la mejora del hábitat. Cuatro años más tarde, la población de cría había aumentado a 10,1 aves/km^2. Además del aumento de parejas nidificantes, también aumentó la cantidad de pollos criados, de 5,1–11,2 individuos/km^2 en 1990 a 27,3–38,4 individuos/km^2 en 1994. No obstante, el tamaño de los campos no cambió significativamente. Aunque la longitud de los márgenes de los campos aumentó aproximadamente en

ISSN: 1578–665X

un 25% (de 82 m/ha a 115 m/ha) por la influencia de la gestión del hábitat, solamente se alcanzó la mitad de los que se encuentran en los países de Europa central, donde predomina la propiedad privada de la tierra. Tras la privatización de los campos en 1995, como parte del cambio político húngaro —lo que afectó aproximadamente al 50% del área del proyecto— las posibilidades de mejorar el hábitat disminuyeron, y aumentó la presión tecnológica sobre la agricultura a gran escala. Como consecuencia de este proceso la población de perdiz pardilla volvió a decrecer hasta 1,43 aves/km^2 en 1997. Como resultado de una nueva estrategia de gestión aplicada al Proyecto desde 1996, observamos un lento incremento de la población de cría, que se estabilizó alrededor de 5 aves/km^2 del 2007 al 2009. La densidad en el mes de agosto aumentó durante el mismo periodo de 4,5 aves/km^2 a 13–17 aves/km^2. Durante las dos décadas en las que se llevó a cabo este estudio, la mortalidad de las crías y la mortalidad invernal eran extremadamente altas. Los factores clave que influencian la dinámica de poblaciones de la perdiz pardilla en nuestra área de estudio parecen ser las pérdidas de huevos y pollos, y la mortalidad invernal. Con el fin de determinar la relación entre los factores ambientales y los parámetros de la población de la perdiz pardilla, se utilizó un Análisis de Componentes Principales (ACP). La densidad de la perdiz pardilla en el mes de agosto se asociaba positivamente con la densidad del ecotono y la caza de zorros comunes y otros depredadores de aves (cornejas cenicientas y urracas). La densidad de las perdices también se correlacionaba en primavera y agosto con la caza de gatos y perros cimarrones. Los parámetros del hábitat tenían una correlación positiva con la densidad de la perdiz pardilla tanto en primavera como en agosto. Los niveles de abundancia de las poblaciones de gatos y perros cimarrones también se correlacionaron negativamente con las pérdidas invernales.

Palabras clave: Perdiz pardilla, Monitorización a largo plazo, Predadores, Hábitat, Proyecto LAJTA, Hungría.

Received: 22 XII 11; Conditional acceptance: 10 II 12; Final acceptance: 30 IV 12

Sándor Faragó, Gábor Dittrich, Katalin Horváth–Hangya & Dániel Winkler, Inst. of Wildlife Management and Vertebrate Zoology, Univ. of West Hungary, Fac. of Forestry, H–9400 Sopron, Ady Endre út 5, Hungary.

Corresponding author: S. Faragó. E–mail: farago@emk.nyme.hu

Introduction

The decrease of farmland wildlife and the negative impact of intensive agricultural technologies has become evident over the last decades (Donald et al., 2001; De Leo et al., 2004; Verhulst et al., 2004; Vickery et al., 2004.) The change has particularly influenced grey partridges (*Perdix perdix),* which are the most sensitive species in the areas and their populations have decreased throughout Europe (Bro et al., 2000; BirdLife International, 2004; Kuijper et al., 2009). The situation is no different in Hungary (Faragó, 1988; Báldi & Faragó, 2007).

When studying this phenomenon it is clear that the extent of the changes differs in the various countries of Europe depending on the ecological conditions, political factors and economic possibilities. As a result, a research and management program was started in Hungary to maintain farming and support the conservation of grey partridge, in particular (Faragó, 1997a, 1998). The LAJTA Project became the flagship of the Hungarian Partridge Conservation Program.

We started the LAJTA Project in 1992, in order to implement complex monitoring of sma ll game species and their environment (Faragó, 1991). The key species of this project is the grey partridge because it is the indicator species of the farmlands and the changes in its population reflect the positive and negative effects in the environment in the fastest way (Faragó, 1997b; Faragó & Buday, 1998). In the Project's operation we followed the newly composed (Robertson, 1991) directives of wise use involving habitat development and predator control.

We wanted to answer the following questions: how has the size/density of the grey partridge population changed? How have parameters of the population such as natality, chick survival rate and mortality changed? What are the mortality periods that basically determine population dynamics? What environmental parameters influence the population change, and what are the most important ones?

Methods

Study area

The area of the LAJTA Project is 3,065 ha in Kisalföld (Little Hungarian Plain), Western Hungary (fig. 1). Until 1995, the Lajta–Hanság Co. had managed the area exclusively. However, in 1995, due to compensations/privatization, 50% of the area was in the hands of smallholders. This area has a continental climate (mean annual temperature is 9.6ºC, annual precipitation is 504 mm, mean relative humidity is 73%) where the main crops are grain and maize. About 40% of the farming is large scale (Lajta–Hanság Joint Stock Company, average field size 50 ha) and 60% is small scale (small holders, average field size 2 ha). In both cases, there is intensive technology, which, from the point of view of mechanization and the use of chemicals, has not changed in the past twenty years. Fields are separated from each other by forest belts, tree rows and similar, extending over roughly 120 ha. Pasturing did not take place in the Project territory and the fodder demand of animal husbandry was supplied by growing alfalfa and silo maize.

Study design

During the study we used the following methods: for the grey partridge population we used total population

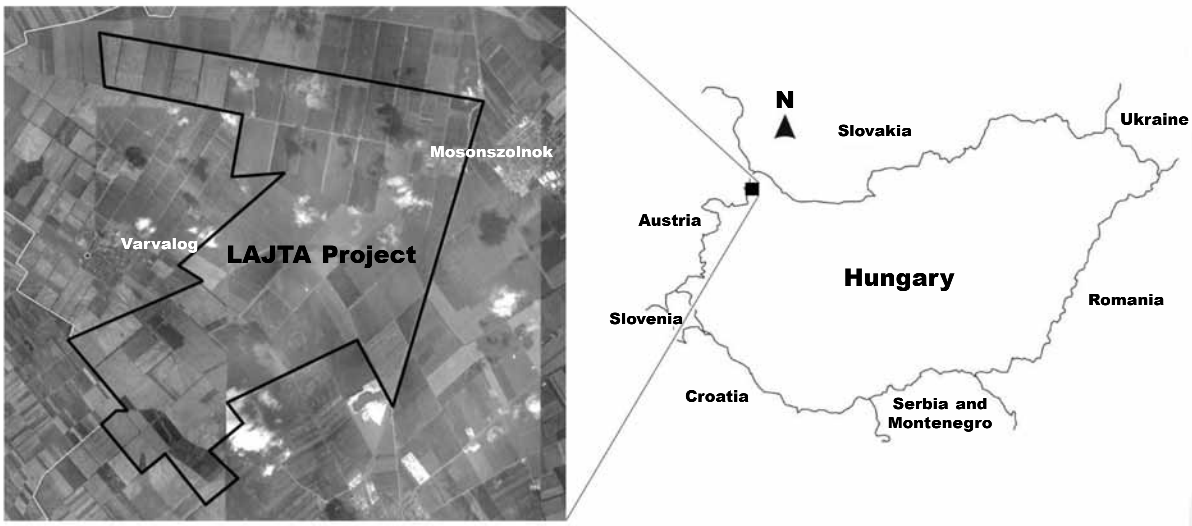

Fig. 1. Location of the study area in Hungary.

Fig. 1. Localización del área de estudio en Hungría.

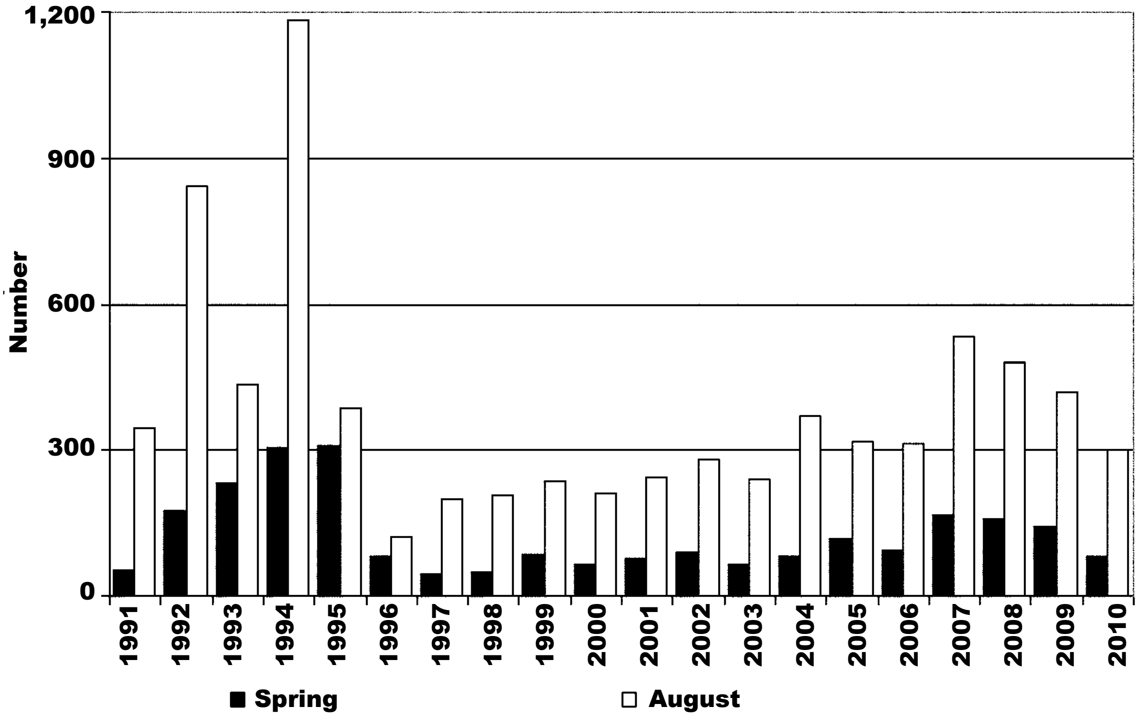

Fig. 2. Dynamics of the grey partridge population in the LAJTA Project.

Fig. 2. Dinámica de la población de perdiz pardilla en el Proyecto LAJTA.

assessment with a mapping method during weekly records. In the case of birds of prey (marsh harrier, *Circus aeruginosus;* goshawk, *Accipiter gentilis*), red fox (*Vulpes vulpes*) and European badger (*Meles meles*) we mapped nests and burrows. We carried out total population assessments every two weeks to calculate the number of birds of prey. We also calculated the monthly average. We recorded/mapped habitats on the 15^{th} day of each month, and we also mapped habitat–improvements. Every year, the following habitat improvements are carried out in the LAJTA Project: chemical–free field margins, weedy strips between two crop fields, harrowed strips and unmown margins of grassland and alfalfa fields were left; mowing of cereal field margins was postponed. The partridge fields were set aside (Faragó & Buday, 1998). The game–keeper of the Project continuously controls predators, especially before and during the breeding period of grey partridge.

We collected climatic data from the meteorological station of Mosonmagyaróvár City. The game–keeper of the Project keeps a record of the predator control data.

Data analyses

The chick survival rate was calculated using Potts' model (1986). We determined the most important mortality period by key–factor analysis (Chlewski & Panek, 1988). Farmland diversity was calculated by applying the Shannon–Wiener diversity index H' to measure the composition of the landscape, using the territorial data of the land cover types.

To reduce the number of variables in the environmental data matrix, principal component analysis (PCA) was performed on 14 selected variables including habitat, predator and meteorological variables and excluding variables which had no equal data (fox burrows and birds of pray monitoring results). All variables were tested for normality and homogeneity of variances. Only PCA factors with eigenvalues more than 1.0 were selected (Kaiser Criterion). Factor loadings were rotated with a varimax raw transformation. Next, linear regression was performed on the principal components derived to examine the correlation between the components describing the environment and grey partridge population data (spring and August density, chick survival rate and key factors). All statistical analyses were carried out using the SPSS (SPSS, 1999).

Results

The grey partridge population

The original habitat structure was able to support the grey partridge population with densities of 1.8 birds/km^2

(1991). After four years, the breeding population increased to 10.1 birds/km^2. Besides increased numbers of nesting pairs, the number of reared chicks increased from 5.1–11.2 individuals/km^2 in 1990, to 27.3–38.4 individuals/km^2 in 1994. After field privatization in 1995 as part of the political changes in Hungary affecting approximately 50% of the project area, the possibilities of habitat improvement decreased, and the agricultural technological pressure of large scale farming area increased. At the same time, the grey partridge population decreased again to 1.4 birds/km^2 in 1997. With the management strategy applied in the project since 1996, the breeding population increased slowly and stabilized at around 5 birds/km^2 between 2007 and 2009. The August population density increased in the same period from 4.5 to 13–17 birds/km^2 (fig. 2).

During the last two decades, egg, chick and winter losses were extremely high. The values of the former changed between 44–90%; winter population declined between 30–81%. The losses of adult birds in summer were lower, between 7–51%. Chick survival rate changed in inverse ratio with egg and chick losses. According to the key factor analysis, the most important mortality factors influencing the grey partridge population dynamics seem to be clutch and chick losses (k_1) and winter mortality (k_3) (fig. 3).

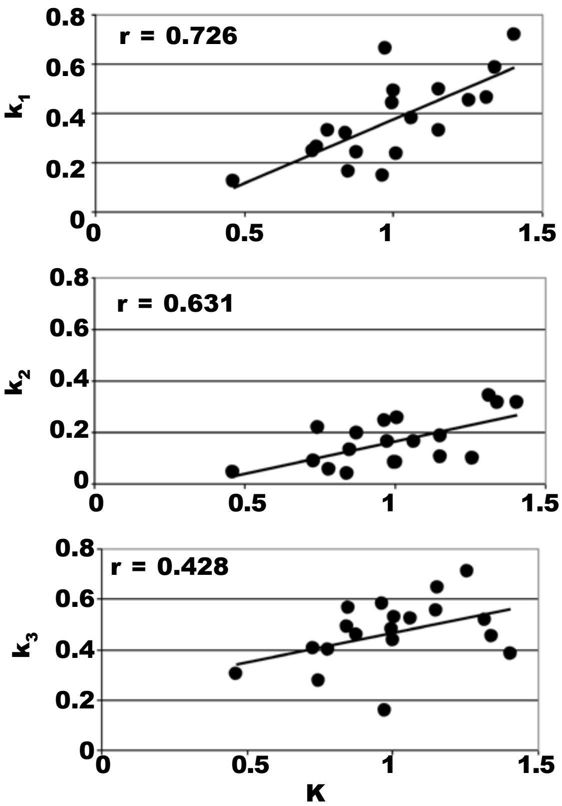

Fig. 3. Correlations between three individual mortalities and total mortality.

Fig. 3. Correlaciones entre tres mortalidades individuales y la mortalidad total.

The most important ecological parameters

Although the above statements define the strength and timing of mortality factors, they do not focus on their cause. Only detailed ecological investigations can bring this to light.

The mid–month habitat mapping clearly shows the dynamic change from month to month in the habitat structure due to the agricultural growing cycles and technological processes. The changes in the May positions recorded during the 20 years showed that the dominance of spring crops in the early 2000s was replaced by the dominance of autumn crops with the low and nearly permanent level of perennial plants. From the point of view of nesting possibilities for grey partridge, we may evaluate this kind of process as advantageous. Habitat diversity has increased in the last five years, after a slow 15–year decrease (fig. 4). This can be explained by the increased number of cultivated plants and by the relations of an equal dominance.

Another important characteristic of the habitat quality is the length and the density of ecotones. Due to the decrease in field size, the density of ecotones grew 65% from 82 m/ha to 135 m/ha. The habitat improvement resulted in a further increase with annual values of 11–45 m/ha. Consequently, the ecotone density increased from 106 m/ha to 174 m/ha by 64% during the 20 years (fig. 5).

Predator pressure is one of the most important factors influencing the grey partridge population. The number of nesting pairs of raptors in the Project showed a decreasing or stagnant tendency, and the same occurred in the case of hooded crow (*Corvus cornix*) –13→1–2 pairs —decreasing, and magpie (*Pica pica*), 1–3 pairs—stagnant. Based on the breeding and non–breeding raptor censuses carried out every two weeks in the LAJTA Project, only the marsh harrier, the hen harrier (*Circus cyaneus*) and the goshawk can be regarded as effective predators of the grey partridge in Hungary (Faragó, 2002). The goshawk can be observed in 1–2 exemplars all year round (max. 0.06 birds/km^2). During the breeding period (April–August), the marsh harrier appears with increasing density (0.16–0.45 bird/km^2), although its nesting was not demonstrated in the Project. In the same way, the winter permanent appearance of the hen harrier is important (average of 0.19 birds/km^2).

Due to the work of the game–keeper, the number of inhabited burrows of the key predator, red fox, decreased from the initial 27 burrows (0.9 burrow/km^2) to 5 burrows (0.16 burrow/km^2). Nevertheless, the European badger population showed a slow increase despite the fact that in 2001 this formerly protected species returned to huntable status again. The density of inhabited European badger burrows was 0.23 burrows/km^2 in 2010, exceeding that of red fox.

The regulation of six predator species is important. There was an increase in the bags of the red fox, magpie, hooded crow and Eurasian jay (*Garrulus glandarius*). The feral dog population decreased while the feral cat

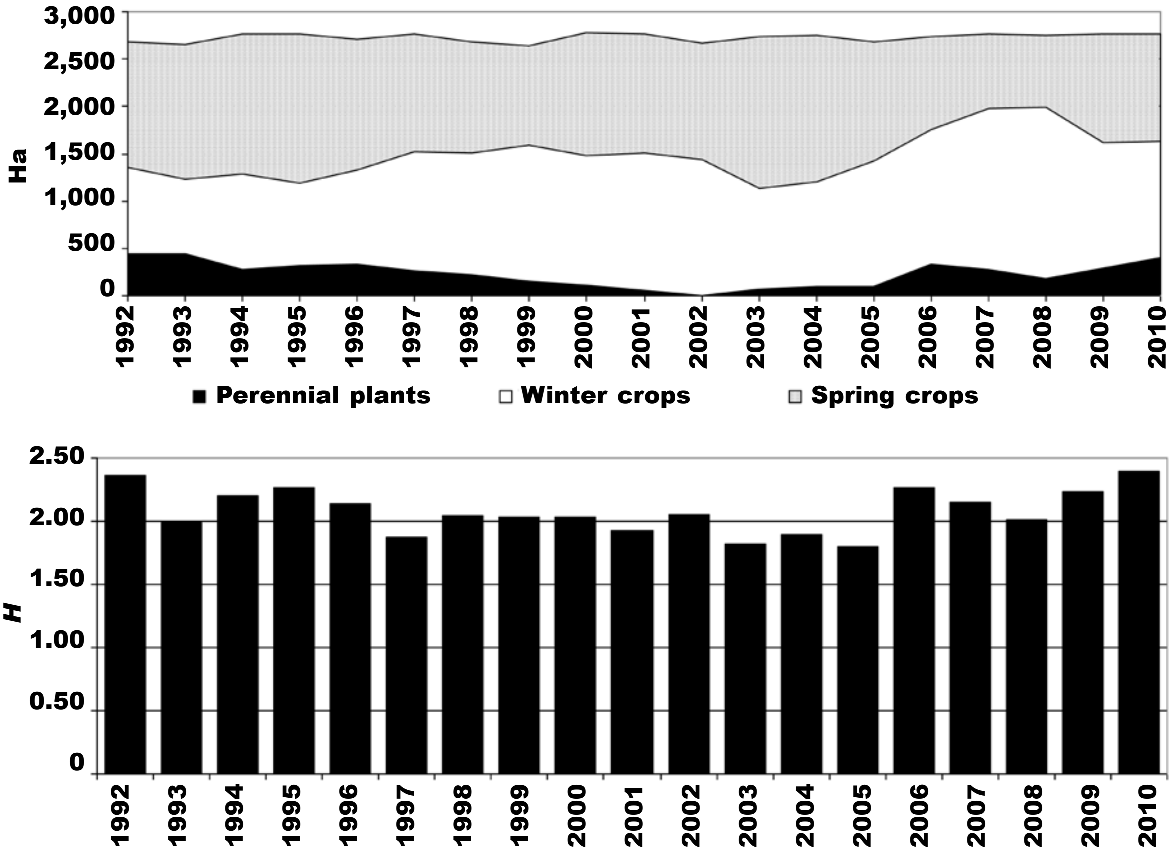

Fig. 4. Dynamics of yearly habitat availability and habitat diversity in the breeding season in the LAJTA Project.

Fig. 4. Dinámica de la disponibilidad anual de hábitat y diversidad de hábitats durante la estación de cría en el Proyecto LAJTA.

population stagnated. Because of the immunization against rabies in 1992, the red fox population has increased everywhere in the Project area. This increment appeared in the population size and later in the bag as well. The immunization may have caused the population rise of protected small mammal predator species, but we do not have any information on this. On the whole, both the censuses and the bag records show predator pressure increased.

As well as the above–mentioned findings, important variations in weather conditions had to be considered, especially climate change. During the breeding period temperatures below the average (16.3°C) were recorded only in 1997, and in the other years temperatures were sometimes 2°C higher. As compared to the normal 316 mm precipitation, there was often drought; rainfall was only heavy in 1996 and 2010. The winter season was colder than the 3°C average in three years only and was over 3°C higher in other years. The mean winter precipitation (264 mm) occurred only in the winter of 1999/2000 and 2008/2009. In the other years it was always less.

For the partridge, which is very much adapted to the continental climate, the above changes are favourable. In the juvenile/adult ratio, which shows the success of reproduction, the rise of temperature caused a slight increase, while the change in precipitation did not show any significant impact.

Connections between grey partridge population and environmental factors

The PCA performed on the 14 selected variables yielded five new variables that together explain 76.08% of the total variance (table 1). The first component accounted for 29.22% of the total variance and it was positively correlated with ecotone density and with the bags of red fox, magpie and hooded crow. The second component accounted for an additional 13.43% of the total variance. This component was positively correlated with the bags of feral dog and feral cat. The third component accounted for nearly the same proportion (12.55%) of the total variance as the previous one. With the exception of the ecotone density, all habitat

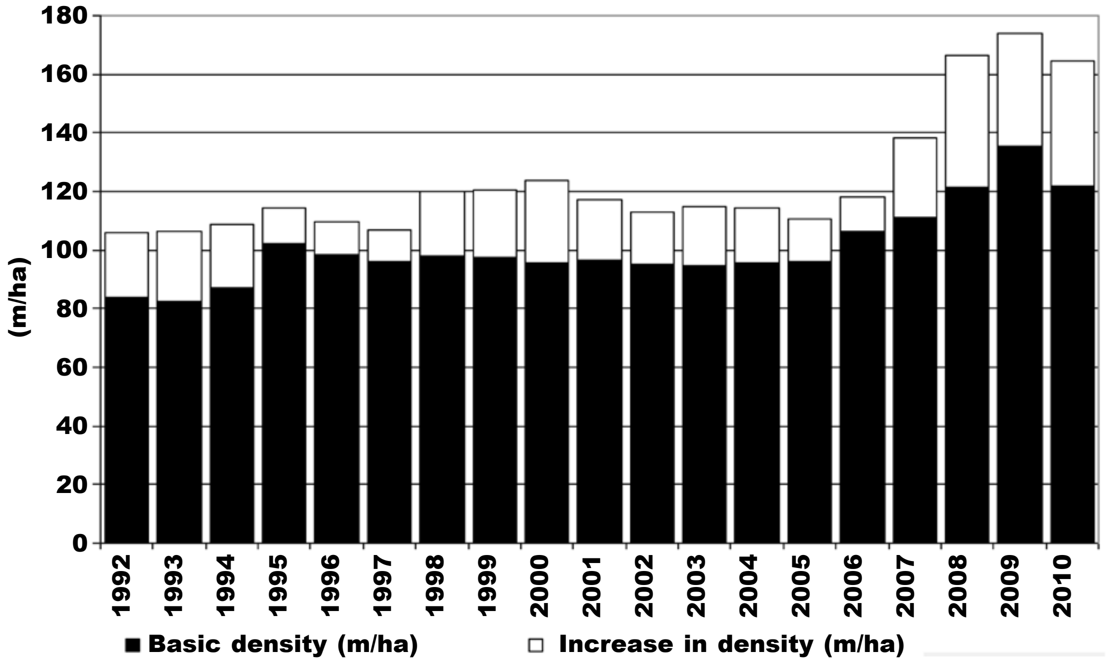

Fig. 5. Long–term change of length of ecotones in the LAJTA Project.

Fig. 5. Cambio a largo plazo de la longitud de los ecotonos en el Proyecto LAJTA.

variables made a prominent contribution. This third component axis was positively correlated with habitat diversity and with the proportion of perennial plants and spring crops, while winter crops had a negative score. The fourth and fifth components each accounted for about 10% of the total variance. The fourth component was mostly determined by the meteorological variables for the period October–March while the fifth component showed a stronger correlation with the meteorological parameters of the April–August period. In both cases, average temperature had positive scores and precipitation had negative scores.

For further analysis, the final PCA components were used as independent variables in the regression analyses with grey partridge population parameters as response variables. Several significant models were obtained.

August grey partridge density was positively associated with PCA factor 1 ($R^2 = 0.368$; $F = 9.901$; $p < 0.01$), a component mainly determined by the ecotone density and bags of red fox and avian predators (magpie and hooded crow). Grey partridge density was also correlated with PCA factor 2 mainly determined by the feral dog bag and the feral cat bag (model for spring density: $R^2 = 3.481$; $F = 9.076$; $p < 0.01$; model for August density: $R^2 = 0.210$; $F = 4.512$; $p < 0.05$). PCA factor 3, mostly characterized by habitat parameters, showed a positive correlation with both the spring and August grey partridge density (model for spring density: $R^2 = 0.220$; $F = 4.808$; $p < 0.05$; model for August density: $R^2 = 0.208$; $F = 4.457$; $p < 0.05$). The effect of feral dog and feral cat populations also manifested in the next model, forasmuch as winter losses (K_3) it was negatively correlated with PCA factor 2 ($R^2 = 0.251$; $F = 5.357$; $p < 0.05$).

Discussion

Our investigations suggest a strong link between habitat diversity and population density of grey partridge in spring and autumn. Earlier analysis (Báldi & Faragó, 2007) in regard to Hungarian small game populations characteristically showed the decrease of farmland diversity. Manifold investigations have justified that farmland heterogeneity is a key factor in the maintenance of farmland biodiversity (Benton et al., 2003; Verhulst et al., 2004). In an agricultural environment managed in an intensive way as in the LAJTA Project, there is an opportunity to maintain the grey partridge population if habitats in the territory are improved. If we can increase crop diversification and reduce pesticide use, this will increase the carrying capacity of the territory (Sotherton, 1991; Henderson et al., 2009). It might help if we can also apply the wide spectrum of agri–environment schemes (arable flora management, beetle banks, conservation headlands, crop management, field corner management, grass strips, grassland and scrub management, spring cropping, wild bird cover and overwinter stubble) (Ewald et al., 2010). In general, we can say that a framework of ecologically enhanced

Table 1. Factor loadings for the first five principal components in PCA on the environmental variables used.

Tabla 1. El peso de cada factor (factor loadings) para las cinco primeras componentes principales en el ACP sobre las variables ambientales utilizadas.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Habitat diversity	0.254	0.228	0,806	0.118	0.091
Perennial plants	–0.158	0.099	0,772	–0.073	–0.245
Winter crops	0.367	0.025	–0,755	0.295	–0.119
Spring crops	–0.322	0.172	0,589	–0.351	0.325
Density of ecotones	0.967	-0.031	0,191	–0.022	0.109
Red fox bag	0.842	0.197	–0,117	0.052	0.02
Feral dog bag	–0.225	0.907	0,181	–0.03	–0.026
Feral cat bag	0.273	0.816	0,216	0.242	–0.106
Magpie bag	0.871	-0.093	–0,076	0.239	0.168
Hooded crow bag	0.779	-0.041	–0,101	–0.064	0.015
Average temperature (Apr–Aug)	0.379	-0.068	–0,035	–0.007	0.852
Precipitation (Apr–Aug)	0.398	0.02	0,243	–0.033	–0.614
Average temperature (Oct–March)	–0.029	0.195	–0,156	0.873	0.125
Precipitation (Oct–March)	0.023	0.323	–0,283	–0.606	0.168
Eigen values	4.09	1.88	1.76	1.53	1.39
Explained variance %	29.22	13.43	12.55	10.94	9.94
Cumulated variance %	29.22	42.65	55.20	66.14	76.08

areas is a key habitat structure for grey partridges (Buner et al., 2005). Earlier, the use of a set–aside system was a tool for this implementation. However, in recent years, processes in the agricultural policy of EU have been less favorable. Little emphasis is given to the importance of preserving the carrying capacity and ecotones —such as grassy strips, weedy strips, tree and shrub rows, forest belts and similar. (Faragó, 1998)— and maintaining and protecting wasteland patches (Šálek et al., 2004).

Another important question of habitat management is the impact of predators on grey partridge population (Potts, 1986; Kalchreuter, 1991; Tapper et al., 1996; Bauer & Berthold, 1997; Faragó, 1997c; Potts, 2009; etc.). Our results suggest that the key predator red fox has indeed a negative effect on population density. It is also confirmed that the other predators can cause mortality in different periods.

Grey partridge population dynamics are generally are determined by many different factors such as economic possibilities, agriculture policies and climatic factors. To adapt to or compensate for these factors, habitat management and predator control should be increased and made more effective in the future in the LAJTA Project.

Acknowledgements

We wish to thank LAJTA–HANSÁG Co for all the support they provided throughout the twenty years of the project, and also the Ministry of Rural Develo-pment for supporting our work for fifteen years. We also thank TÁMOP 4.2.1.B within the Sopron Regional University Knowledge Centre for the grant that made our research possible in the last two years.

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