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Long-term changes of farmland game populations in a post-socialist country (Hungary)

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Abstract

Agricultural intensification presents a major threat to European biodiversity. This generalisation is largely based on studies from western and northern Europe. Here it is shown that the development of agriculture in a post-socialist country (Hungary) was marked by sudden changes, e.g., a 10-fold increase of fertiliser consumption in the late 1960s as a result of decision-making in the socialist command economic structures, and similar decreases after the collapse of socialism in the 1990s. Hungarian populations of two characteristic farmland species, the brown hare (*Lepus europaeus*) and grey partridge (*Perdix perdix*) are analysed and their collapse over the past four decades is related to agricultural data on production from FAO statistics. This decline was found to be negatively correlated with most measures of agricultural intensification (cereal and milk yields, number of machinery), and positively with cattle density. Multiple regression analyses of intensification measures indicated a similar pattern, although cattle density was not included into the models. Interestingly, farmland diversity in the models was negative predictor of population sizes. The sudden changes in agriculture were not indicated in the population trends of the two species. Probably, the relationship between agricultural intensification and small game species decline may not be as simple as correlation analyses indicated.

Keywords: Brown hare; Grey partridge; Agri-enviromental program; Socialist agriculture; History

1. Introduction

Agricultural intensification is perhaps the largest challenge to nature conservation in Europe (Donald et al., 2001; Firbank, 2005). Empirical evidence for the negative correlation between biodiversity and farming intensity comes from both spatial analyses, i.e., between areas differing in agricultural intensity (e.g., Pärt and Söderström, 1999; Verhulst et al., 2004; Báldi et al., 2005), and time series, correlating biodiversity decline with increasing intensification (e.g., Donald et al., 2001; Robinson and Sutherland, 2002). Most studies thus far, however, have been in western and northern European countries (Kleijn and Báldi, 2005), and it is now well established that patterns of farmland biodiversity depend on the prevailing political and economic systems (Donald et al., 2001; Gregory et al., 2005).

This paper reports on long-term changes in agriculture in an EU-accession country, Hungary, and its effects on two farmland game species, the brown hare (*Lepus europaeus*) and grey partridge (*Perdix perdix*), both characteristic of farmland and both relying on appropriate agricultural management (Faragó, 1998; Smith et al., 2005).

The questions central to this analysis concern how agriculture developed during the socialism and the transition period in Hungary; how populations of farmland species correlate with these changes; and whether there are similarities in the patterns to those described in western

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European countries. Further, can we expect biodiversity to benefit from the recently introduced agri-environmental schemes in Hungary?

2. Materials and methods

Hungary is a flat region with large areas having productive loess and chernozem soils. The country is heavily utilised by agriculture, 86.4% of the total land area is productive land, with 65.5% covered by farmland management (Ángyán et al., 2003). This is the third largest value among 30 European countries (Donald et al., 2002). However, management intensity is lower than in western Europe, e.g., herbicides being applied to 25% only, insecticides and fungicides to 11% the total agricultural land in 2002 (HCSO, 2004). Fertilisers were used on only 5.2% and pesticides and herbicides on less than 1% of grassland (Nagy, 1998).

The most important small game species in Hungary are the grey partridge, brown hare and pheasant (*Phasianus colchicus*), all of which are associated with farmland, and some waterfowl species (Faragó, 2002). The brown hare and the grey partridge were selected for this study because they are native species in Hungary and, unlike the pheasant, are not bred and released in large quantities for hunting purposes. The partridge is bred and released, but the number of released individuals is <10% of the total population compared to ca. 50% in the pheasant. The partridge and the hare prefer farmland and grassland with trees, hedges, woodlots, permanent herbaceous vegetation, edges of large arable fields (Tapper and Barnes, 1986; Faragó, 2002; Sálek et al., 2002) and habitats which cover large part of Hungary (grasslands 12%, arable fields 52%).

Long-term data from the Hungarian Game Management Database, managed by the Department of Wildlife Biology and Management of the Szent István University (Csányi, 2001) were used. It contains population and bag size data on game species and their predators (e.g., fox, corvids) from 1961 onwards. Data quality was tested and correlation of field survey and database data was demonstrated (Heltai and Bíró, personal communication). Data on these two farmland species were analysed for the years 1961–2001.

Table 1 gives the variables used and their description. All data relating to agricultural production are from the FAO database (FAOSTAT, 2004). Intensification was estimated by a number of agricultural measures: yields of milk and cereals, number of machinery, cattle density and fertiliser consumption. Most of these variables were used in Donald et al. (2001), and the preliminary analyses showed a strong explanatory power. Farmland diversity was calculated by applying the Shannon–Wiener diversity measure to landscape composition, using the area of the 16 most important land cover types (grassland, lands withdrawn from cultivation) and crop types (wheat, maize, barley, rye, oat, potato, sunflower, sugar beet, alfalfa, fibre crops, fruits, pulses, vegetables, abandoned land).

First, a hierarchical cluster analysis of years was applied with squared Euclidean distance measure and average linkage between groups. Second, correlation analyses were used to find the relationship between population size of the two studied species and production measures. Third, multiple regression analysis was applied to model the changes of the species. Due to collinearity, however, two

Table 1
The variables used to describe agricultural intensity in Hungary (data from the FAOSTAT database, downloaded in May 2004), and their Pearson correlations with the abundance of brown hare and grey partridge between 1961 and 2001 ($N = 41$ for all cases, two-tailed significances are given). Multiple linear regression models also given for the same period (standardized regression coefficient, t and its significance is given). Significant values are in bold. Missing variables in the regression models were excluded due to collinearity.

Variables and description		Brown hare		Grey partridge		Brown hare			Grey partridge (ln)		
		Correlation	*P*	Correlation	*P*	Regression	*t*	*P*	Regression	*t*	*P*
Cereal yield	Yield of all cereals (t/ha)	**−0.685**	0.000	**−0.750**	0.000	−0.251	−1.709	0.097	**−0.715**	**−5.378**	0.000
Cattle density	Total head of cattle per hectare of pasture	**0.627**	0.000	**0.584**	0.000	−0.105	−0.626	0.535	−0.085	−0.557	0.581
Milk yield	Milk production in hectogram per animal	**−0.835**	0.000	**−0.857**	0.000	–	–	–	–	–	–
Fertiliser use	Total fertiliser consumption divided by total agricultural area	−0.017	0.918	0.002	0.991	−0.215	−1.155	0.256	0.130	0.770	0.447
Number of tractors per economically active agricultural worker		**−0.854**	0.000	**−0.799**	0.000	**−0.872**	**−4.642**	0.000	**−0.493**	**−2.893**	0.007
Number of harvesters per economically active agricultural worker		**−0.832**	0.000	**−0.792**	0.000	–	–	–	–	–	–
Farmland diversity	Shannon–Wiener index of the 16 most important land cover and crop types	0.113	0.487	0.164	0.313	**−0.261**	**−2.114**	0.042	**−0.270**	**−2.410**	0.022

variables (milk yield, number of harvesters), which showed the strongest correlations with other variables were excluded (Graham, 2003), resulting in the use of five agricultural measures as independent variables. All variables were tested for normality and the following transformations were used: square root for fertiliser use and ln for number of tractors and partridges. Variables were not transformed if there were no improvements in normality after transformation. All analyses were carried out using SPSS (SPSS, 1999).

3. Results

Based on the cluster analysis we found three breaks in the development of agriculture in Hungary in the last four decades: low intensity agriculture, and the re-organisation from private to state and co-operative farms characterised the 1960s. Following the introduction of the ‘‘New Economic Mechanism’’ of the socialist countries in 1968, intensification was pronounced in the 1970s, as indicated by, for example, the increase of fertiliser consumption (Fig. 1). Cereal and milk yields then continued to increase over the following decade as intensive socialist agriculture dominated as fertiliser consumption stabilised along with number of tractors and harvesters (Fig. 1). In 1989 the socialism collapsed and a new structure of economy and agriculture evolved. This was probably the most profound change in the second half of the 20th century, with a sudden decline in yields, the loss of half of the livestock and a sudden massive decline in fertiliser consumption to only one-tenth of former levels (Fig. 1). In the 1990s yields again increased, but not cattle density (Fig. 1). Fertiliser consumption again

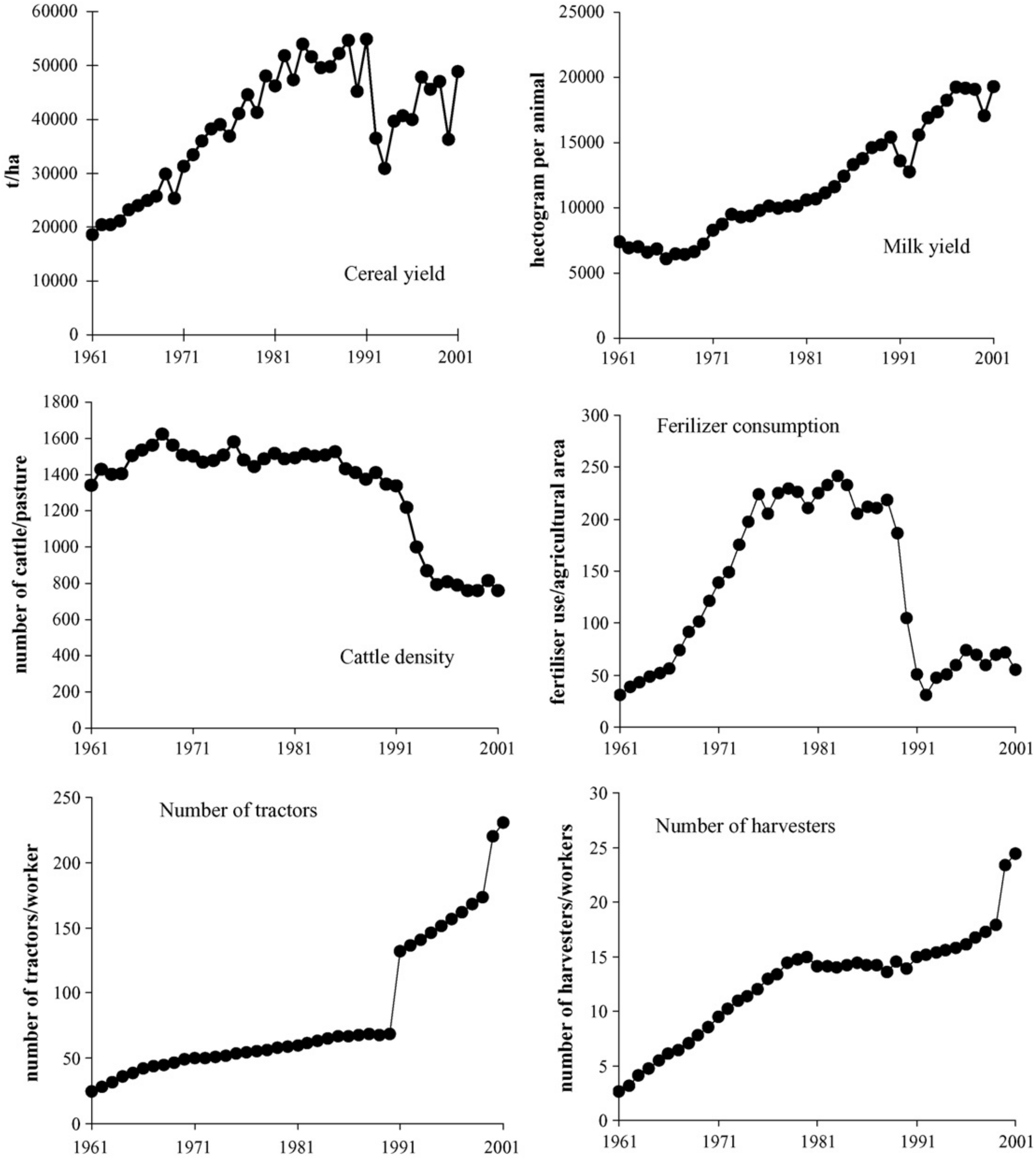

Fig. 1. Changes in agriculture in Hungary, 1961–2001. The *y*-axes are not to the same scale; see Table 1 for explanation.

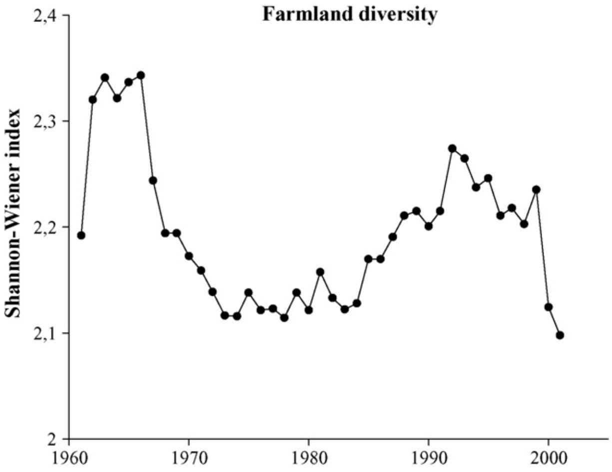

Fig. 2. Diversity of Hungarian farmlands, 1961–2001, based on the 16 most important land use and crop types.

stabilised at a level regulated by the market (at roughly 20% of the socialist fertiliser consumption) although the number of tractors and harvesters began to increase again (Fig. 1).

Farmland diversity sharply decreased from the mid-1960s, had low values for more than a decade and then increased in the 1980s (Fig. 2). Finally, there was a serious decline again in the late 1990s.

Population levels in brown hare and grey partridge were highly correlated (Pearson correlation, $r = 0.938$, $N = 40$, $P < 0.0001$). After an initial period of decline in the 1960s, there was a recovery in population sizes immediately after the introduction of the New Economic Mechanism in 1968 (Fig. 3). However, from the mid-1970s both species went into decline again, this decline being more marked in the partridge, with only 5–10% remaining from the former population (Fig. 3).

The correlations between population sizes and agricultural variables were similar for the two species (Table 1). Population levels were strongly negatively correlated against measures of intensification (yields, machinery), while positively correlated with cattle density. There were no significant correlations for either fertiliser consumption or farmland diversity (Table 1).

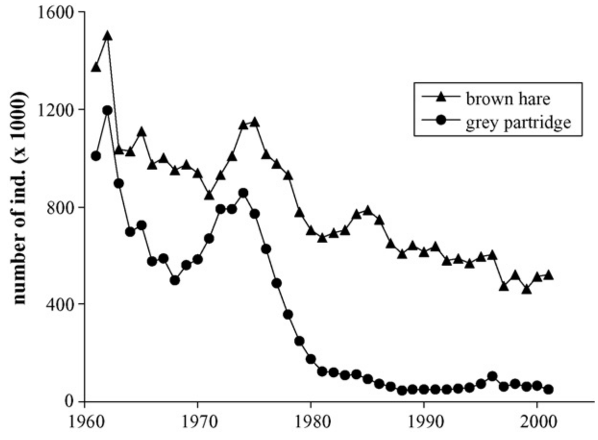

Fig. 3. Changes in the total estimated population size of grey partridge and brown hare in Hungary between 1961 and 2001.

The multiple linear regression model for the brown hare had an $R^2 = 0.832$ ($F = 33.585$, d.f.1 = 5, d.f.2 = 34, $P < 0.0001$), and an $R^2 = 0.862$ ($F = 42.338$, d.f.1 = 5, d.f.2 = 34, $P < 0.0001$) for the grey partridge. That is 83.2 and 86.2% of the variance in population changes were explained by the models. Similarly to the correlations, yield and machinery were significant and negative variables in the models (yield is only marginally significant in the hare). Cattle density, however, was not included into the models, while farmland diversity was a negative variable in both species (Table 1).

4. Discussion

Irrespective of the differences between western and central Europe's farmlands, there are two similar basic patterns. First is the large proportion of area under agricultural management (for 17 western European countries it is 44.35%, for 10 central European countries (8 new EU members plus Romania and Bulgaria) it is 50.80%; $t = -0.900$, $P = 0.377$, NS). Second is the increasing agricultural intensification (Donald et al., 2001). Here we showed that at least two game species suffered a decline, similarly to that recorded in western Europe (Schmidt et al., 2004) and in other central European countries (Figala et al., 2001; Sálek et al., 2002; EEA, 2004). As intensification measures increase, the population sizes decline. A strong positive correlation with cattle density (Table 1) probably indicates the loss of traditionally managed pastures, which are beneficial for farmland game species (Chamberlain and Fuller, 2000; Faragó, 2002).

However, the relationship between intensification and game population decline needs further clarification. The cluster analysis of the years resulted in four groups (extensive agriculture, intensification, intensive socialist agriculture, transitional agriculture). The expectation is that game species population sizes should decrease in the first three periods, but increase in the last, as for common non-game birds (Gregory et al., 2005). However, there was no such pattern.

Another point indicating the complexity of relationship between agriculture and game population sizes is the role of farmland habitat diversity. A strong positive correlation was expected, because game species are known to prefer habitat heterogeneity (Faragó, 2002; Calvete et al., 2004; Vickery et al., 2004). However, population changes of the game species did not correlate with farmland diversity.

Farmland heterogeneity is a key factor in the maintenance of farmland biodiversity (Benton et al., 2003; Verhulst et al., 2004). Therefore, there was an expectation that after re-privatisation of farmland (with ca. 900,000 new landowners in Hungary), there would have been an increase in game populations due to the inevitable increase of landscape heterogeneity. However, game populations did not increase (Fig. 3). Bro et al. (2004) also found a surprising lack of increase in partridge population after increasing spatial heterogeneity with a strip creation scheme.

The agriculture in the new EU countries from central Europe had more or less similar history (Roudna and Dotlačil, 2002; EEA, 2004). As a consequence, the broad trends were similar in, e.g., livestock numbers and yields, but still considerable differences existed (EEA, 2004). It is an urgent task to clarify the specific needs of farmland populations in different central European countries, and to tailor the ongoing design of agri-environmental programs according to it.

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