

Habitat use of grey partridge in agricultural landscapes (the case of Ukrainian forest steppe)

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We investigated the influence of habitat and climatic parameters on Grey partridge populations in natural and agricultural landscapes of Ukrainian forest steppe. In all the studied provinces, the general population trends of Grey partridge did not have the concerted correlation with climatic factors, though in Steppe left bank natural-agricultural province, LS-3 there was registered negative correlation between the number of birds and average rainfall in June; in Steppe Right bank natural-agricultural province, LS-2 we fixed positive correlation with average annual humidity. We also revealed the persistent negative relationship between the density of roads and partridge abundance in hunting lands of study area. We also founded that number of agriculture variables which limited the number of grey partridges, was higher, then in central and left-bank forest-steppe of Ukraine. Thus, we registered strong negative correlation between the square of sown lands and cultivated crop area (namely with corn, sunflower, and soy), dwelling space, norms of mineral fertilizers/pesticides and the number of birds. The same variables had low and medium positive correlation coefficients with bird abundance in western part of study regions. This could indirectly indicate the forced usage of arable land by birds as the reduction of mediocrity and natural mosaic of agricultural landscapes along the gradient from the west to the east of Ukrainian steppe. This should be considered in the hunting management of agricultural landscapes in study region, like identifying of the plots for the introduction of artificially reared birds, selection of reproductive areas and other ecological and economic measures for the protection and rational exploitation of grey partridge.

Key words: grey partridge, habitats, environmental factors, correlation, regression analysis, Ukrainian steppe.

Introduction

In Ukraine, the grey partridge (*Perdix perdix* Linnaeus, 1758) is considered as a useful hunting and agricultural species. The results of monitoring of hunting grounds and its size now used by scientists in the aggregate with GSD index (generalized species diversity), to assess the ecological state of the environment ([Fedyushko et al., 2011](#); [Aebischer & Ewald, 2010](#); [Bro et al., 2003](#); [Panek, 1997a](#)). Grey Partridge is the only representative of sedentary native species of hunting Galliformes, which commonly inhabits semi-open landscapes of Ukraine except for serried forests of Polissia, the Carpathians and the Crimea, where the altitude exceeds 900 m ([Fedyushko et al., 2011](#); [Bro et al., 2012](#); [Buner et al., 2005](#)). The above-mentioned circumstances, including bioindicating meaning of species ([Ioannon et al., 2008](#); [Orłowski et al., 2011](#); [Panek, 1997a, 1997b](#)), was the main reason to study influence of habitat and environmental factors on grey partridge life in modern Ukrainian steppes.

Material and methods

Prior to research initiation we selected statistical reporting data model of the four administrative regions: Western Steppe natural agricultural province (LS-1) - Ternopil region; Steppe Right bank natural-agricultural province (LS-2) – Khmelnytsky and Vinnytsia regions; Steppe Left bank natural-agricultural province (LS-3) - Poltava region. To form the database of species abundance in some natural agricultural provinces steppes of Ukraine we used official state statistical reports "2-tp (hunting)", which were prepared during 2000-2012 by State Statistics Service of Ukraine. Mathematical and statistical processing of the results was carried out by *MS Excel* 2010 and *SPSS Statistics* 17.0.

Results and discussion

At the initial stage of the task we calculated ratio of linear pair correlation between the number of birds and key expert factors in natural and agricultural provinces of Ukrainian steppe. This allow to determine the direction and intensity of the relationships between effective and factorial signs (Table 1).

We were not able to obtain statistically significant correlation between bird abundance and climatic factors, except for LS-3, where we marked negative correlation between the number of birds and average rainfall in June, and LS-2, where we fixed positive correlation between bird abundance and average annual humidity. It should be noted probable relationship partridges number of environmental factors and agricultural genesis was relatively mild in two of the three studied provinces and distributed as follows: LS-1 – 0, LS-2 – 5, LS-3 – 1 indicator. However, the negative correlation was registered with acreage, including grains in general, corn, sunflower, intensive use of pesticides, squares and norms of mineral fertilizers in LS-2, LS-3 – intensively tilled provinces respectively on 10.3% and 25.3% (as of 2012) compared to the LS-1 region, which intensively used more than a half (57.4%) of its area.

Table 1. Pair linear correlation (r) between the number of grey partridge and ecological factors in natural and agricultural habitats of Ukrainian forest steppe in 2000-2012

Ecological factors			Number of birds in natural and agricultural habitats (provinces)					
			LS - 1		LS - 2		LS - 3	
			r	p	r	p	R	p
Winter average temperature, °C			-0.320	-	0.297	-	0.204	-
Winter average precipitations, mm			-0.075	-	-0.131	-	0.221	-
June average rainfall, mm			0.313	-	-0.198	-	-0.825	0.100
Average humidity, %			0.314	-	0.649	0.050	0.011	-
Forest cover, %			-0.779	-	-0.287	-	-0.225	-
Shelter forest cover, %			0.556	-	-0.700	0.050	0.738	-
Number of red fox cenopopulations			0.024	-	0.331	-	-0.210	-
Cost of artificial breeding wildfowl, UAH / ha ³ of hunting areas			0.852	0.100	0.826	0.010	-0.232	-
Sown area, ha ³			0.394	-	-0.723	0.050	-0.326	-
Crops	Grain		0.556	-	-0.814	0.010	-0,642	-
	Maize		0.469	-	-0.738	0.050	-0,529	-
	Legumes		-0.659	-	0.451	-	0,585	-
	Sunflower		0.596	-	-0.897	0.010	-0,489	-
Fertilizers	mineral	ha ³	0.596	-	-0.732	0,050	-0,590	-
		cwt/ha	0.409	-	-0.313	-	-0,570	-
		ha ³	-0.443	-	0.405	-	0,274	-
	organic	cwt/ha	0.021	-	-0.122	-	0,832	0.100
Pesticides, kg / ha			0.330	-	-0.026	-	-0.535	-
Road density, km /km ² 10 ³			-0.791	0.050	-0.762	0.050	-0.225	-

Research has confirmed persistent negative relationship between the density of roads and partridge habitats in all the provinces. Only in LS-3 it had no statistical significance, however, and maximum values of the density of roads here were lower by 15.6 and 13.9% compared to those of LS-1 and LS-2, respectively. In our view, this is due to bird species feature, it accumulates along roads in winter period, where they obtaining food. In this regard, partridge birds are more likely to become victims of predators and road-poachers during the winter period.

During installation variables correlating significantly direct influence of environmental factors on the gray partridge population in the Ukrainian steppe by multivariate regression analysis with subsequent determination of the coefficient of elasticity (E) were obtained the following results. Thus, in the LS-1 both factors are of anthropogenic origin and had links with effective multi-vector variable. In our opinion, reducing the density of roads accompanied by proportionately increasing numbers of partridges in the grounds of a percentage ratio 1:13.9 ($E = -13.93$), while the cost of breeding game to a much lesser extent positively influenced the dynamics of birds (1:0.22). It should be noted multiple indicators (R^2) and normalized (R^2_{adj}) coefficient of determination showed that the number of species in the LS-1 had an obvious linear impact of environmental factors not included in the correlation matrix. These parameters of regression only 53.2% ($R^2_{adj} = 0.532$) of cases determined by changes in the number of birds, regardless of further expanding the list of factor variables.

In the LS-2 linear regression relationship with the number of birds in the 14 grounds were statistically significant only by eight environmental factors that are not characterized by intercorrelation properties. The biggest negative relationship was marked between the number of birds and density of highways ($E = -221.9$), while the most stimulating effect in funding artificial breeding game was in 11 times less than the ratio ($E = 19.8$) with the number of partridges. Thus, as in the LS-1 the costs for artificial breeding of this fowl and related economic activities can be considered as currently one of the known number of local recovery tools of grey partridge cenopopulations.

In the LS-3, like in the LS-1 linear relationship varied with the number of birds in the grounds had only two factors. The decrease of organic fertilizers accompanied by proportionately decline in the number of grey partridge habitats in the ratio of 1:0.31 ($E = -0.31$), which, in our opinion, is associated with a sharp reduction in livestock over the period. Unfavourable crop rotations, especially reduced area of perennial grasses, over-tilled natural pastures and meadows, which are the main winter bird habitats caused declining of partridge abundance. Moreover, the average rainfall in June was associated with negative density of birds in the ratio of 1: 0.15 ($E = -0.15$).

Among those, indicators and multiple normalized coefficient determination showed that the number of species in the LS-3 also had a linear effect on environmental factors not included in the correlation matrix. These parameters regression only in 87.7% ($R^2_{adj} = 0.877$) cases determined by changes in the number of animals, regardless of further expanding the list of factor variables.

Conclusions

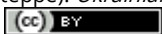
We revealed persistent negative relationship between the density of roads and bird abundance in hunting areas of all the investigated provinces. The influence of climatic and habitat factors in agricultural lands on bird abundance was higher in central and left-bank part of Ukrainian forest steppe. The principal factors were the square of sown area and areas under crops (namely corn, sunflower, and soy), dwelling space and norms of mineral fertilizers/pesticides had negative influence on the number of birds. These factors had low and medium positive effect on bird abundance in western part of studied regions. This could indirectly indicate the forced introduction of birds into the arable lands caused by the reduction of mediocrity and natural mosaic of agricultural landscapes along the gradient from the west to the east of the modern Ukrainian steppe. These conclusions should be taken into consideration for hunting management in agricultural landscapes, like plots' identifying places for introduction of artificially reared birds, planning of reproductive areas and other ecological and economic measures for the protection and rational exploitation of birds.

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