

Gender and age structure as well as body weight of partridge (*Perdix perdix* L.) during periods of high and low population density in the Lublin Upland

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Abstract: *Gender and age structure as well as body weight of partridge (*Perdix perdix* L.) during periods of high and low population density in the Lublin Upland. Studies upon structure of gender and age as well as body weight of partridges were carried out in the Lublin Upland in 1988 and 2015, different in relation to the levels of these animals population density. These features were evaluated in 104 individuals culled in early October. Nearly four-fold decrease in the population density of this species was recorded between the compared periods. Over 80-fold decrease in the hunting acquisition of partridge occurred the same period. A decrease in the share of females in the population after the breeding period was also found, which probably resulted from an increase in this gender mortality during the breeding season. Proportions of the number of juveniles to adult animals (2.4 and 1.7), and to adult males (4.0 and 1.7) in two subsequent study years, i.e. indicators of the young partridges production, did not differ significantly, but it could be mainly due to a small sample in the latter year. The gender structure of juvenile partridges was 0.94 male per female in 1988 and 0.71 male per female in 2015, which did not significantly differ between periods ($\chi^2 = 0.178$). Among adult individuals, 1.5 male per female were recorded in 1988, while only males were reported in 2015. Body weight of young partridges decreased between the years of research by 22.5 g, i.e. 6%, while adult animals by 12.5 g, which indicates the decrease in bird*

size, and thus the individual condition, presumably due to limited food resources. Differences in body weight between periods were statistically significant only at young animals. Such situation can cause enhanced mortality of young partridges in autumn and winter, therefore worsen the existing regress in this species population. The results confirmed that the previous assessment of the causes of the decline in partridges population in Poland, showing an increase in losses during the breeding season, as the main demographic mechanism, were valid also for the second decade of the 21st century. It follows that improving the environmental conditions during the breeding season, besides reducing the number of predators, should be an essential part of the partridge active protection programs.

Key words: grey partridge, body mass, age, sex, population density, Lublin Upland

INTRODUCTION

In recent decades, there has been a sharp decrease in the number of small animals in the most of hunting grounds in Poland, as well as in other European countries. The most drastic decrease concerned hares and partridges (Dziedzic et al. 2002, Smith et al. 2005, Kamieniarz and

Panek 2008, Flis 2009a, Kuijper et al. 2009). The increase in predators' pressure and progressive transformation of the agricultural landscapes are counted to the main reasons for the decreasing number of these species in Poland in previous decades. Increased mortality of hares and partridges as an effect of predation resulted mainly from a significant increase in fox population (Panek 2005, Panek et al. 2006, Wasilewski 2007), which in turn was conditioned by the introduction of annual preventive vaccination of this species against rabies (Flis 2010, 2013). Transformation of the agricultural landscape manifested mainly as simplifying its structure (increase in the field sizes, elimination of places excluded from crops and overgrown with wild vegetation), changes in the share of individual plant species in the structure of crops, and intensification of agricultural production (Panek 1997, Panek and Kamieniarz 1998, 1999, Wübbenhorst and Leuschener 2006, Jezierski 2007, Motyl 2007, Flis 2009a).

Previous studies conducted in Poland and other European countries indicate that the combination of these adverse changes in the environment caused a decline in the number of partridges affecting mainly through a negative impact on the course and results of these birds breeding (Potts 1986, Panek 2005, Kuijper et al. 2009). In Poland, this concerned mainly the breeding success deteriorating as a result of limiting the availability of nesting sites and increased mortality of adult individuals during breeding, especially hatching females (Panek and Kamieniarz 2000, Panek 2002a, 2005). Additionally, there was some decrease in the survival of chick partridges (Panek

2005) in connection with the reduction of their food resources used during the first weeks of life, i.e. decrease in the abundance of some groups of insects, which is negatively affected by an intensive use of chemical plant protection means and simplified structure of the agricultural landscape (Rands 1985, Potts 1986, Panek 1997).

In order to reverse the negative trend of the partridge population situation in Poland, various activities of active conservation of this species are undertaken. One of such measures is to reduce or suspend the hunting gaining in areas, where the decline was deep and density of partridges reached a low level, which in the first decade of the 21st century concerned the majority of hunting grounds, especially in the west and north of the country (Kamieniarz and Panek 2008, Budny et al. 2011). Since the late 1990s of the 20th century, the settlement using birds coming from captive breeding has been also applied in many areas (Kamieniarz and Panek 2008). The research upon the survival and reproduction of discharged partridges has been conducted as well, i.e. an assessment of the reintroduction effectiveness, as well as measurements of potential resources availability for these birds in their reintroduction sites (Kamieniarz and Panek 2011, Nasiadka and Świtalska 2014). The attempt to modify habitats in a direction of their optimization taking into account the ecology of this species should be an important element of programs for the reconstruction of partridge population (Kamieniarz and Panek 2008, Flis 2009a). However, to carry out the activities to improve the living conditions of partridges, a thorough knowledge about the causes of their

decline is needed. While the phenomena leading to a significant reduction in these birds population in the 1990s have been the subject of detailed analysis (Panek 2005), conditions of their situation during the first 10 years of the 21st century remain poorly known. Nevertheless, results of the national monitoring of partridges show that after a period of relative stabilization of their population in the first decade of the 21st century, further decrease in the average density of these birds in Poland occurred at the turn of the first and second decade (Budny et al. 2011). One of the reasons for poor recognition of conditions of current partridge situation is undoubtedly the limited availability of the research material because of their low densities and the widespread suspension of hunting.

From the above review of the causes of the partridge population decline in Poland in previous decades follows that it should be accompanied by changes in the structure of gender and age in the populations of these birds after the breeding period, resulting from deterioration of the results of breeding and chicks survival. In addition, since limiting the food resources was pointed as the main cause of the increase in chicks losses, it can also be expected to reduce the weight of young partridges that survived a critical period of dependence on insects as a food.

The aim of the study was to test of the above predictions about the causes and consequences of the partridge number decline in relation to the current situation of these birds. Therefore, the structure of gender and age and body weight of partridges during the period with relatively high density before falling of their num-

bers in 1990s, as well as in the second decade of the 21st century, i.e. a period with significantly lower their density, was compared. The evaluation was carried out on the basis of material collected in the game shooting district located in the Lublin Upland.

THE STUDY AREA

Lublin Upland is characterized by chernozem soil type, and thus it is one of the most fertile areas in the country (Witek 1991). It determines the dominance in the field cultivation of plants with high soil requirements. At the same time, this area is characterized by a rather low intensification of agricultural production. In the areas of research, the farmlands were almost entirely owned by individual farms, which was associated with high fragmentation of fields (the average size of individual field area amounted to 1.1 ha) and mosaicism of crops, i.e. considerable diversity of agricultural landscape. The crop structure was dominated by cereals, root crops, and in recent years an increasing share accounted for rape cultivation. In addition, field cultures of soft fruits increasingly appeared. The differentiation of the field environment occurring in the area of research seemed to be beneficial for partridges, the species preferring the heterogeneous agrocoenoses (Popławski 1962).

Material about gender, age and weight of partridges was collected in 1988 and 2015 in two game shooting district located in the Lublin Upland. In 1988, it was the district formerly referred to as No 59, which was the Centre for Animal Breeding, Polish Hunting Association in Wierzchowiska, located in the

present counties of Lublin and Świdnik. The area of this district was 9,700 ha, of which the forest land accounted for 17%. In 2015, the research was conducted in two adjacent game shooting districts: No 202 and No 219, leased by the hunting association and located in the district of Opole Lubelskie. The total area of these districts was 13,600 ha, and the share of forest land amounted to 25%. These were ones of the last districts in Lublin region, where the hunting acquisition of partridges was still conducted at that time. Similar agricultural landscapes, typical for this region dominated in both areas of the research. Mean maximum air temperature in the vicinity of Lublin during the main period of partridge chicks conduction (the second half of June and the first half of July) (Panek 2002b) was similar in the study years (21.7 in 1988 and 21.9 in 2015, data from the Institute of Meteorology and Water Management), thus the weather conditions, known as a factor affecting the living conditions and survival of chick partridges (Potts 1986, Panek 1992) should not have resulted in differences in their situation between the years of the research.

MATERIAL AND METHODS

Data on the number and acquisition of partridges in the area of research in five-year periods preceding the years of collecting the materials about sex, age and weight of these birds, i.e. 1984–1988 and 2010–2014, came from the hunting reports (sheets ŁOW-2, annual hunting plans) and referred to the former Lublin province or present Lublin PZŁ district (areas of these units overlap to a large extent). In the case of population number,

there were estimates made each spring (March) by the tenants and managers of hunting grounds. Based on these data, density of partridges and their acquisition per field unit area in each year, was calculated.

Data on gender, age and body weight were collected for a sample of 85 partridges obtained through the so-called foreign exchange hunting on 11–12 October 1988 and 19 partridges acquired while hunting conducted on 4 October 2015. Age and gender was determined for each acquired partridge. The age was assessed on the basis of appearance and shape of the primary quills. An additional element helpful for the evaluation was the color of legs (Popławski 1962). Based on this, birds were qualified as this year's young and adult ones (over one-year old). Gender of partridges was rated on a basis of the look and shape of the outer shoulder feathers and wing covers, as well as the presence or absence of characteristic thoraco-abdominal feathers pigmentation, known as horseshoe (Popławski 1962). Body weight of birds was determined by weighing directly in the field, on the laboratory scale to the nearest 1 g accuracy.

All the material, i.e. total of 104 partridges acquired in two periods of study, was divided into gender-age groups, which allowed for determining the rate of gender (male per female) and age structure (young per adult) of obtained birds. To determine the effect of time, age, and gender on the weight of animals, a multi-factor and single-factor analysis of variance was applied. The proportions were compared using χ^2 test. Analyzes were performed using Statistica software.

RESULTS

During the five years preceding the first period of study, the spring density of partridges in game shooting districts of Lublin region decreased from 14.4 to 6.8 animal/100 ha, while hunting acquisition of the species was 0.8–2.6 animal/100 ha (Table 1). During the five years preceding the second period of study, density of partridge population in Lublin region showed subsequent decreasing trend from 3.4 to 2.5 animal/100 ha. The hunting acquisition amounted then 0.04–0.01 animal/100 ha. Average density of partridges decreased 3.8 times between the two periods (from 10.5 to 2.8 animal/100 ha), while the average acquisition 80 times (from 1.6 to 0.02 animal/100 ha). In the five-year period preceding the study, in the mid-1980s, the indicator of the hunting population exploitation averaged to 14.8%. On the other hand, in the years preceding the second period of study, this indicator was over 21 times lower and was at an average level of 0.7%.

The number of partridges qualified for each gender-age category and data of average body weight for each category in both study periods are given in Table 2. Structure of young partridges gender was 0.94 male per female in 1988, and 0.71 male per female, which did not significantly differ between periods ($\chi^2 = 0.178$, $P = 0.7$). Among adults, 1.5 male per female was found in 1988, while in 2015 only males were recorded and the difference between male and

TABLE 1. Indicators of population density and obtaining of partridges in the Lublin Upland

Years of assessment		Density (n/100 ha)	Hunting acquisition (n/100 ha)	Indicator of hunting exploitation of the population (%)
Period I	1984	14.4	2.6	18.1
	1985	13.2	1.6	12.1
	1986	9.7	1.6	16.5
	1987	8.2	0.8	9.8
	1988	6.8	1.2	17.6
Period II	2010	3.4	0.04	1.2
	2011	3.0	0.02	0.7
	2012	2.6	0.01	0.4
	2013	2.6	0.01	0.4
	2014	2.5	0.02	0.8

TABLE 2. Characteristics of grey partridges shot during two years in Lublin Upland (1988, 2015) the number of individuals, body weight (g), standard device

Specification		Age			
		young		adult	
		1988	2015	1988	2015
Male (♂)	<i>n</i>	29	5	15	7
	\bar{x}	376.4	355.0	394.0	377.1
	<i>SD</i>	32.1	12.3	22.1	10.8
Female (♀)	<i>n</i>	31	7	10	–
	\bar{x}	369.7	347.1	383.0	–
	<i>SD</i>	20.6	18.0	17.8	–
Total	<i>n</i>	60	12	25	7
	\bar{x}	372.9	350.4	389.6	377.1
	<i>SD</i>	26.8	15.7	20.8	10.8

female proportions in two periods proved to be significant ($\chi^2 = 4.073$, $P = 0.04$), thus the share of females decreased the in last period.

The age structure (young per adult) was 2.4 in 1988 and 1.7 in 2015, not differing statistically between periods ($\chi^2 = 0.402$, $P = 0.5$). Proportion of juvenile to adult males number was 4.0 in 1988 and 1.7 in 2015 (which was equal to the previous indicator, due to the absence of females in a sample from that year), and neither did not differ significantly between periods ($\chi^2 = 2.399$, $P = 0.1$).

The variance analysis of partridge body weight (Table 1) according to period, gender, and age revealed differences between study period ($F = 10.98$, $P = 0.001$) and bird's age ($F = 11.14$, $P = 0.001$), whereas there were no statistically significant differences between genders ($F = 3.14$, $P = 0.08$). Therefore, weight of adults and juveniles (both genders altogether) within two periods was compared separately using a single-factor variance analysis, that showed no significant differences in the case of adult animals ($F = 2.296$, $P = 0.1$), yet it confirmed differences in body weights of young birds between study periods ($F = 7.877$, $P = 0.006$). Average body weight of young individuals between 1988 and 2015 decreased by 22.5 g, i.e. by 6% (Table 1).

DISCUSSION

Almost four-fold decrease in density of partridges occurred within nearly 30 years in the area of research. The indicator of partridge acquisition per unit area was higher in the 1970s in the region of Lublin Upland than the current spring density of these birds (Pielowski et al. 1993).

Comparison of partridge gender and age structure during former high densities of birds and in the last period, to low states of their populations, at least partially confirmed the predictions aris-

ing from the results of earlier analyzes of the causes of the decline in this species population in Poland. First of all, a significant change in the gender structure of adult partridges after the breeding period, i.e. decrease in females share, has been shown. The research material consisted of birds acquired in the course of hunting, meanwhile in Poland, it was found a higher susceptibility of adult males rather than other gender-age groups of partridges to hunting, thus their greater participation among culled individuals than in population present in the area during the hunting season (Olech 1971). Nevertheless, in both years of study, the material was collected by means of the same method. Therefore, reducing of the females share among acquired adult birds undoubtedly resulted from a decrease in the proportion of this gender in the population at the end of summer. This should be associated with increased mortality of females during reproduction, identified for this species in previous years in Poland, and also in some other European countries (Potts 1986, Bro et al. 2001, Panek 2002a). For example, up to 48% of female partridges acceding to breed were dying in the late 1990s in western Poland within three main months of the breeding season (in large part during hatching, mainly caught by carnivores, mainly foxes), while only 11% of males were lost in the same period (Panek 2002a). Any decrease in the ratio of the number of juveniles to adults after a period of reproduction between two periods of study, i.e. reduction in the rate of production of young in partridge populations, was not observed in Lublin Upland. The observed decrease in the share of females among adults meant, however, that recently the number of juveniles reared

within a given year was shared by a relatively smaller number of adults than in the case of samples from the past. Hence the potential reduction in the production of young between two periods of tests can be masked by changes in the survival of adult individuals. However, calculation of the percentage of young birds to the number of adult males (which can be regarded as an indicator of the number of breeding pairs accessing to hatching) (Potts 1986), although resulted in over two-fold difference of this parameter between periods, did not allow for rejection of statistical hypothesis on equality of that proportion for two study periods. Undoubtedly, the results of comparisons were significantly affected by small sample for the last period, which was a significant factor limiting the possibility of concluding on the basis of collected material. In the second half of the 1960s, within a large sample of partridges culled in different parts of Poland, the proportion of young to adult males ranged in each year from 1.9 to 3.5, with an average of 2.85 (Olech 1971). For Lublin Upland, the indicator was even higher in 1988 yet clearly lower than in 2015. Achieved data suggest therefore that the production of young in partridge populations in Lublin Upland in recent years was lower than in the past. Thus, the conclusions from previous studies indicating some increase in losses during the breeding season, and consequently reducing the production of young, as an important cause of the decline and the persistence of low states of partridges in Poland (Panek 2002a, 2005) were likely to be relevant in relation to the situation of these birds in Lublin Upland in the second decade of the 21st century, as well. It should be noted that the material of 2015 came from one of the

last areas in the region, where hunting of partridge population was continued. This means that density of these birds were probably higher, thus processes leading to its reduction possibly weaker than in other regions of the country.

Average body weight of different gender-age partridges groups during the autumn hunting, according to previous studies in Poland and neighboring countries, included within 300–440 g (Pul-liainen 1965, 1968, Szwykowska 1969, Olech 1971, Chlewski 1980). The values obtained in Lublin Upland in both periods were within this range, even in its central part, and thus they were typical for the species.

The observed differences in body weight of young partridges between two periods confirmed the predictions arising from prior knowledge about the causes of the decline in this species population in Poland. Material was acquired in similar terms, and significant changes in phenology of partridge breeding seem unlikely, so in both cases, young birds were rather at the same stage of ontogenetic development. Therefore, decrease in the average weight of young indicates a reduction in their size or individual condition. The most likely cause appears to be the same factor that led to the decline in survival of chick partridges in Europe in recent decades, i.e. reducing their food resources, decreased abundance of insects in fields mainly due to the intensive use of pesticides (Rands 1985, Potts 1986, Kuijper et al. 2009). Relatively small decrease in the survival rate of chick partridges was observed in Poland, in the 1990s and this phenomenon was a secondary reason for that decrease in the number of these birds (Panek 2005). However, at the beginning of the 21st century, the negative trend of chick partridges

survival had apparently continued as the results of national monitoring showed a progressive decrease in the average number of young birds in family flocks of birds observed after reproduction period. In the early 1990s, it ranged within 8–10, while at the end of the first decade of 21st century, only 6–8 young birds per flock were recorded (Budny et al. 2011). At the same time in recent decades, the increase in the use of chemical pesticides and fertilizers in agriculture occurred in Poland (Flis 2009b, GUS 2014). Results achieved during this study suggest that depletion of food resources for partridges during breeding not only leads to a decrease in chick survival and production of young, but also to reduce the weight of juveniles, which may adversely affect their survival in the subsequent months.

CONCLUSION

The obtained data allow to formulate the following statements and conclusions:

1. In less than a 30-year period, the density of partridges in Lublin Upland decreased almost 4-fold, and values found in the second decade of the 21st century should be assessed as very low. This resulted in a drastic reduction in hunting partridges acquisition in this region.
2. Comparison of gender structure of adult partridges between two periods of research indicates a reduction in the share of females in population after the breeding period, which probably was associated with an increase in mortality of this gender during the breeding season. Proportion of young to adults number did not differ statistically between periods, but this apparently was due to the small sample for the last period. Thus, the findings suggest that the decrease in density of partridges in the area of study was accompanied by an increase in losses during breeding period and possibly lowering the production of young.
3. Body weight of young partridges decreased between the periods of study. Such results of the research may suggest a reduction in their individual condition, probably due to limited food resources for chicks, i.e. abundance of insects in the fields (and therefore factor hitherto known from mainly negative effects on the survival of chick). This condition may result in increased mortality of young birds in autumn and winter, and thus deepen the regression of the species population. The subject of the study requires further investigation.
4. Achieved results give rise to a statement of the need to undertake action of active conservation of this species, primarily leading to the improvement in the conditions during breeding season, by optimizing the living environments, control and reduction of predators. Such activities should be accompanied by partridges settlement, often run by hunters to supply the local populations of this species.

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Streszczenie: *Struktura płci i wieku oraz masa ciała kuropatw (Perdix perdix L.) w okresach dużego i małego zagęszczenia ich populacji na Wyżynie Lubelskiej.* Badania struktury płci i wieku oraz masy ciała kuropatw prowadzone były na Wyżynie Lubelskiej w latach 1988 i 2015, w których był różny poziom zagęszczenia tych zwierząt. Wymienione cechy oceniono u 104 osobników odstrzelonych na początku października. Między porównywanymi okresami odnotowano prawie czterokrotny spadek poziomu zagęszczenia populacji tego gatunku. W tym samym okresie wystąpił ponad 80-krotny spadek łowieckiego pozy-

skania kuropatw. Stwierdzono także zmniejszenie się udziału samic w populacji po okresie rozrodu, co prawdopodobnie wynikało ze zwiększenia się śmiertelności tej płci w sezonie lęgowym. Proporcje liczby osobników młodych do dorosłych (2,4 i 1,7) oraz do dorosłych samców (4,0 i 1,7) w dwóch kolejnych latach badań, czyli wskaźniki produkcji młodych, nie różniły się istotnie, choć mogło to wynikać głównie z małej próby w drugim z tych lat. Struktura płci młodych kuropatw wynosiła 0,94 (samiec : samica) w 1988 roku oraz 0,71 (samiec : samica) i nie różniła się istotnie między okresami ($\chi^2 = 0,178$). Struktura płci osobników dorosłych wyniosła w 1988 roku 1,5 (samiec : samica). W 2015 roku odnotowano jedynie samce. Masa ciała młodych kuropatw zmniejszyła się między latami badań o 22,5 g, tj. 6%, zaś osobników dorosłych o 12,5 g. Wskazuje to na zmniejszenie wielkości ptaków, a tym samym kondycji osobniczej, prawdopodobnie na skutek ograniczenia zasobów pokarmowych. Różnice masy ciała między okresami były istotne tylko u osobników młodych. Tego rodzaju sytuacja może powodować zwiększoną śmiertelność młodych kuropatw jesienią i zimą, a tym samym pogłębiać trwający regres liczebności tego gatunku. Uzyskane wyniki potwierdziły, że wcześniejsze oceny przyczyn spadku liczebności kuropatw w Polsce, wskazujące wzrost strat w sezonie rozrodczym jako główny mechanizm demograficzny, były aktualne także w odniesieniu do drugiej dekady XXI wieku. Wynika stąd, że poprawianie warunków środowiskowych podczas sezonu rozrodczego, oprócz redukcji drapieżników, powinno być zasadniczą częścią programów czynnej ochrony kuropatw.

Słowa kluczowe: kuropatwa, masa ciała, wiek, płeć, zagęszczenie populacji, Wyżyna Lubelska

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