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HATCHABILITY OF SELECTED BREEDS OF HENS MAINTAINED AS POLISH CONSERVATION FLOCKS

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ABSTRACT

The aim of the study was to evaluate the hatching results of selected Polish conservation chicken breeds: Rhode Island Red (RIR), Sussex (Sx), Greenleg Partridge (GP) and Polbar (Pb) during four consecutive hatching seasons. A total of 41 487 of eggs were collected from 34-week-old hens. Standard incubation conditions were maintained. The fertility, hatchability, periodical embryonic mortality and number of crippled chicks were also calculated.

The highest ratio of fertile eggs was observed in Pb (≈89%), followed by RIR (≈85%) and Sx (≈81%), while the smallest ratio was noted for GP. The percentage of chicks hatched out of the total number of the set eggs was highest in Pb (almost 90%). In all groups the fewest embryos died up to the 6th day of incubation, and the most in the hatching period (days 18–21). This proportion was considerably higher in RIR. The most embryos died in Sx eggs, while the GP eggs had the highest livability, followed by Pb and RIR. Despite a relatively high hatchability of eggs (fertile and set), the eggs from RIR hens were characterized by the highest number of crippled chicks (5.66%), compared to GP (1.31%), Sx (1.88%) or Pb (1.99%). The hatchability characteristics of hen breeds kept in Poland as conservation flocks differed significantly between breeds. However, apart from a few isolated cases, they were not influenced by the hatching season. This indicates the stability of reproductive traits, as well as a genetic potential of these birds, and allows Polish genetic resources being considered as an important pool of genes contributing to the global biodiversity.

Key words: hatchability, breeds, Polish conservation flocks.

INTRODUCTION

The success of poultry reproduction depends on many factors, including environment, physiology [27], cold stress during transportation [25] preincubation and incubation conditions, such as temperature, humidity, ventilation, and egg position and turning, genetic constitution of the embryo, diseases, nutrition and the age of the parental flock, egg size, and shell quality [15, 22]. Genetic factors, especially the breed or strain of hens, can influence not only productive traits but also reproduction parameters, such as hatching indicators, quality and quantity of hatched chicks, and embryo mortality rate. However, with increasing intensification of poultry production old breeds of chickens have been replaced by high-performance hybrids which have lost many natural behaviours and characteristics, such as resistance to

diseases, adaptability to variable environmental conditions, or maternal instinct. Not only for scientific purposes is it important to preserve valuable genes responsible for these traits and to exploit the genetic potential, biodiversity and cultural heritage of old breeds of chickens. The main method of protecting indigenous breeds that are unique in the world is to maintain them as conservation flocks.

Breeds belonging to Polish genetic resources include Rhode Island Red and Sussex, as well as native breeds, such as Greenleg Partridge (GP) and Polbar (Pb). Threatened by extinction, they was added to World Watch List for Domestic Animal Diversity by the Food and Agricultural Organization [8]. GP is a native Polish breed with characteristic green legs and partridge-like plumage. The species is perfectly adapted for rearing in open ranges or pastures in natural environmental conditions. Moreover, it is largely resistant to low temperatures and diseases and extensive feeding and lays valuable eggs with lower cholesterol levels [18, 23]. Pb is an original Polish autosexing breed, developed by professor Laura Kaufman in the years 1946–1954 in the Department of Breeding Biology of the Institute of Animal Breeding in Pulawy. GP hens and Plymouth Rock cocks were used to create a new breed. The main goal in the breeding of Pb was sex determination shortly after hatching [10, 14]. Adult Polbar birds occur only in one color variety [14]. The world's only population of these birds is maintained at the Laura Kaufman Didactic and Research Station of Small Animals, belonging to the University of Life Sciences in Lublin (Poland).

Poultry reproduction results are important in all aspects of poultry performance. In conservation flocks the breeding for improvement of reproductive traits is not conducted, so the cyclic control of birds hatching results is important. Esspecilly, that birds are crossed exclusively within stock which can resulted in inbreeding increase. The aim of the study was to evaluate the hatching results evaluation of selected Polish conservation breeds of chicken: Rhode Island Red (RIR), Sussex (Sx), Greenleg Partridge (GP) and Polbar (Pb), during four consecutive hatching seasons.

MATERIAL AND METHODS

The research material consisted of hatching eggs of four Polish hen breeds – Greenleg Partridge (GP), Polbar (Pb), Sussex (Sx) and Rhode Island Red (RIR) – during four consecutive hatching seasons. The hens were kept on deep litter with a sex ratio of 1♂:10♀. They were fed *ad libitum* with a balanced feed mixture for reproductive laying hens (ME 11.45–11.55 MJ, crude protein 17.0–18.0%, crude fiber 3.9%, lysine 0.88–0.92%, methionine 0.3–0.4%, Ca 3.8%, P 0.55%). During the egg production period (from 22nd week of life) following light programme was used: 15 hrs of light, with intensity 15–20 lx. The birds were kept in deep litter system with density 7 hens/m^2. The eggs were collected from 34-weeks-old hens. The total number of eggs used in the research is presented in Table 1.

Table 1. Total number of eggs used in the research

Breed	Hatching season				Total
	I	II	III	IV	
Pb	5017	4437	3744	6106	19 304
GP	2540	3051	2761	1248	9600
Sx	2212	2012	1920	–	6144
RIR	2910	–	3529	–	6439
Total	12 679	9500	11 954	7354	41 487

All eggs were disinfected by fumigation with formaldehyde and permanganate before being placed in the incubator. They were hatched artificially using a BIOS hatching apparatus. The eggs were turned 8 times a day during the incubation period. On the 6th and 18th days the eggs were candled to test for fertilization and to determine the number of dead embryos. After 18 days of incubation the eggs were moved from the setter to the hatching compartment. Standard conditions of incubation were maintained; the temperature was 37.6–38.0°C with 50–65% relative humidity in the setting compartment, and 37.0–37.5°C with 75–80% relative humidity in the hatching compartment. After 21 days of incubation normal, crippled and dead chicks were counted. Fertility, hatchability and periodical embryonic mortality were also calculated.

The data obtained were statistically analyzed using one-way analysis of variance with Duncan's test. The statistical package SPSS ver. 20.0 was used [12].

RESULTS

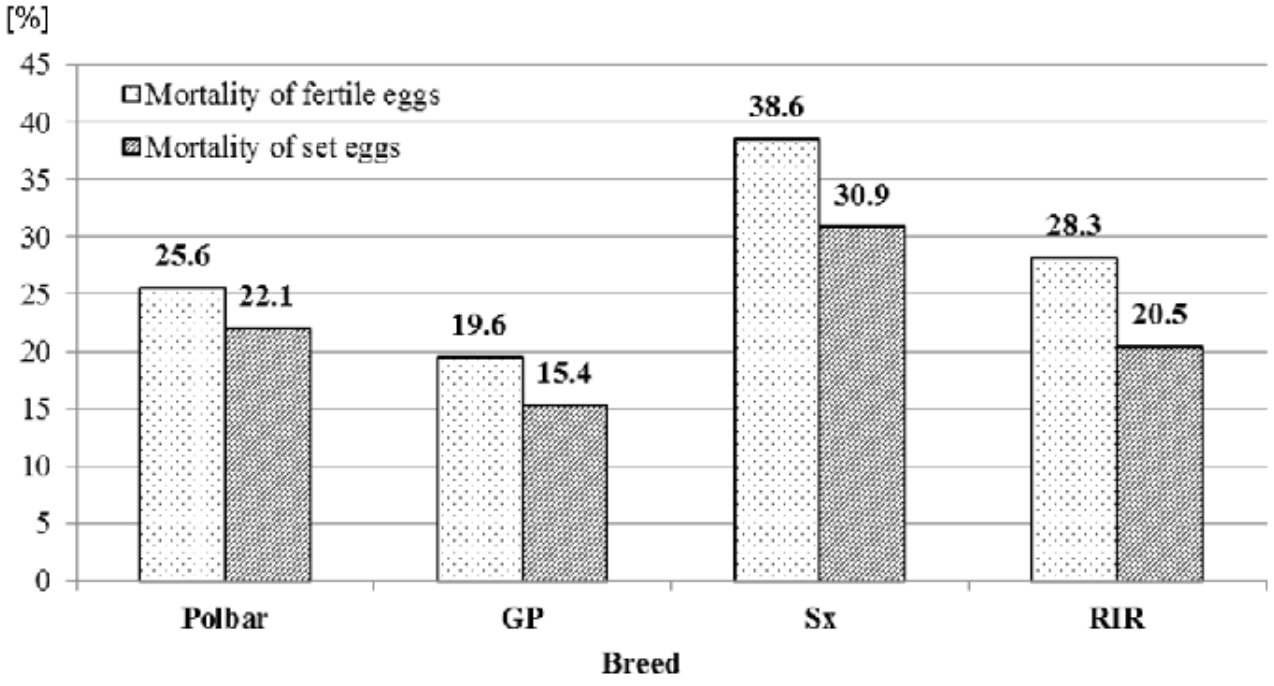
Table 2 presents the fertility and hatchability results. The effect of hatching season was found only in GP hens, however, generally the breed significantly influenced ($p \leq 0.015$) the mean value of this parameter independently of hatching season. The highest proportion of fertile eggs was found in Pb (over 89%), followed by RIR (nearly 85%) and Sussex (81%). The lowest proportion was noted in the GP hens. The highest proportion of chicks hatched from fertile eggs was noted in GP, which was the only breed in which hatchability was influenced by hatching season, with the

lowest hatchability registered in the 2nd season. This dependency was not observed in other breeds. The highest percentage of chicks hatched from the total number of set eggs was noted for the Polbar hens (almost 90%). This result may correspond with fertility results in this breed. Generally, the mean hatchability of set eggs ranged from 59.67% to 67.57%. The influence of the season on this parameter was observed in the Sx breed ($p \leq 0.025$). Considerably more chicks hatched from Pb than GP eggs in the 3rd season.

Table 2. Fertilization and hatchability results in particular breeds

Trait	Breed	Hatching season $(\bar{x})$				Mean	*p-value*	SEM
		I	II	III	IV			
Fertility [%]	Polbar	86.07	89.42	97.36	87.63	89.60	*0.446*	1.877
	GP	73.08	86.68	74.55	68.10	75.03	*0.020*	
	Sx	85.02	71.07	92.51		81.31	*0.213*	
	RIR	77.18		96.20		84.79	*0.248*	
	p-value	*0.436*	*0.056*	*0.086*	*0.007*	*0.015*		
Hatchability of fertile eggs [%]	Polbar	68.91	69.48	87.56	82.24	74.48	*0.621*	3.150
	GP	82.92	60.58	91.95	86.49	80.39	*0.021*	
	Sx	66.44	62.36	86.89		71.40	*0.119*	
	RIR	61.30		87.25		71.68	*0.369*	
	p-value	*0.500*	*0.364*	*0.179*	*0.289*	*0.141*		
Hatchability of set eggs [%]	Polbar	60.42	62.93	85.24	72.21	67.57	*0.544*	3.017
	GP	60.22	53.18	68.77	58.80	59.67	*0.511*	
	Sx	56.92	57.22	80.38		65.39	*0.025*	
	RIR	51.18		83.92		64.28	*0.277*	
	p-value	*0.937*	*0.114*	*0.286*	*0.030*	*0.253*		

Graph 1 illustrates total mortality during incubation and the hatching period in relation to the total number of eggs and the number of fertile eggs. The most embryos died in Sx eggs, while two times lower mortality and the highest livability were noted in the eggs from GP, followed by Polbar and Rhode Island Red.



Graph 1. The total mortality of embryos during incubation in each breed

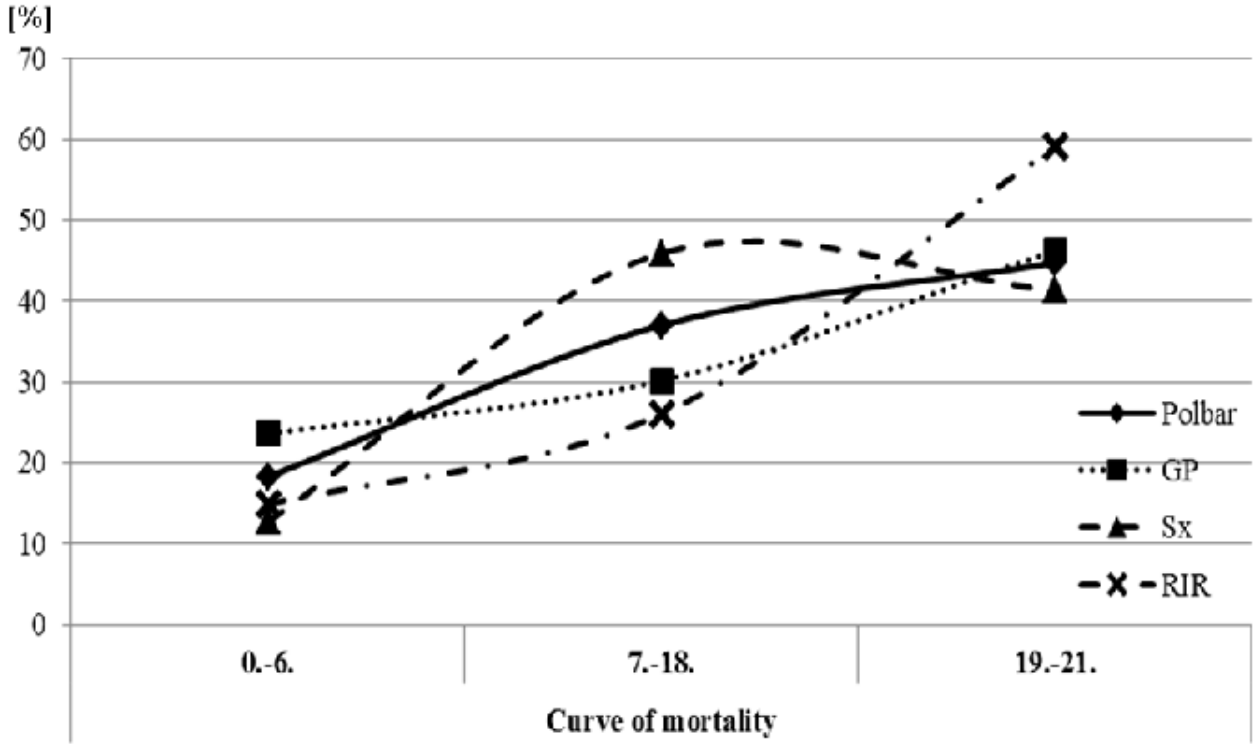
Table 3 presents periodical embryo mortality. No clear differences in embryonic mortality were observed between breeds, whereas in the case of this parameter calculated for set eggs in the 4th season there was a significant difference between the Polbar and GP breeds ($p \leq 0.035$). Analysis of periodical mortality allow to see the regularity in all concerned breeds. The values of mortality proportion was highest in the third phase of incubation. The variability of periodical mortality also seems to be interesting; it ranged from 1.10 (GP, 3rd phase of incubation, 3rd season) to 20.49 (RIR, 2nd phase of incubation, 1st season). The lowest mean for this parameter was noted for Greenleg Partridge eggs,

irrespective of the season.

Table 3. Periodical mortality during incubation in each breed of hens

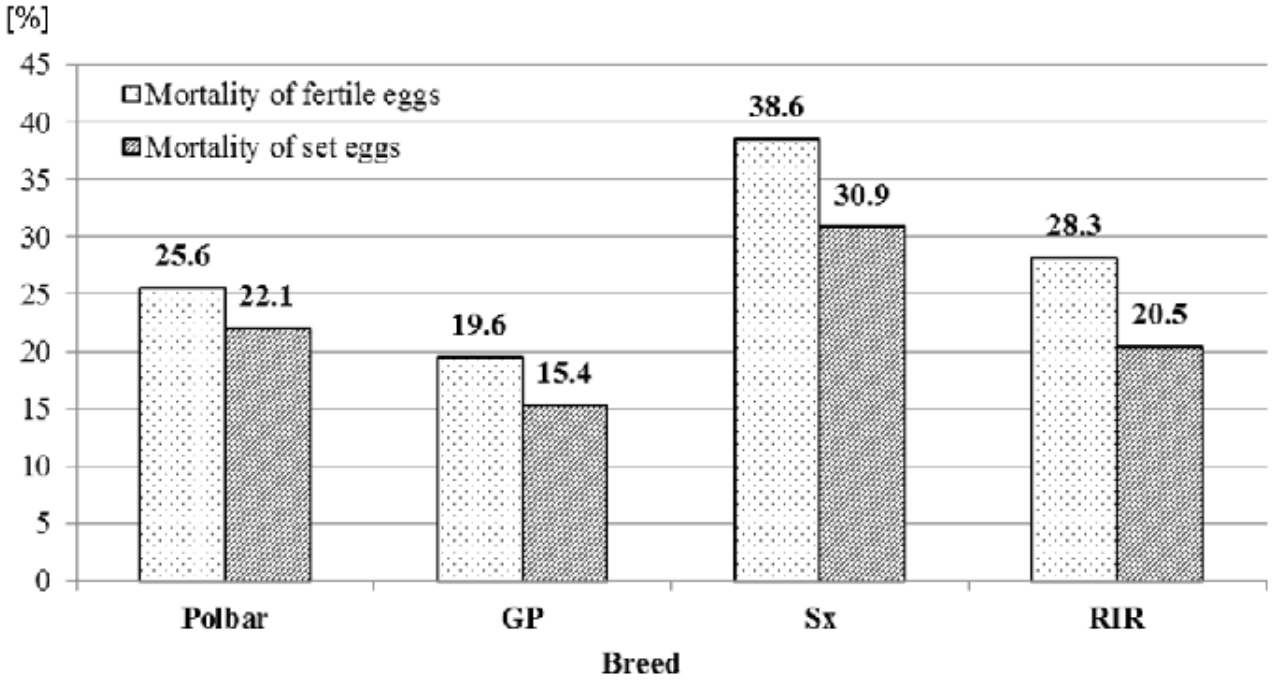
Trait	Breed	Hatching season				Mean	*p-value*	SEM
		I	II	III	IV			
Mortality from days 0 to 6 of hatching [% of fertile eggs]	Polbar	3.36	2.89	3.08	5.30	3.44	*0.335*	0.239
	GP	2.56	2.55	4.10	3.20	3.09	*0.435*	
	Sx	3.21	5.43	1.57		3.72	*0.091*	
	RIR	2.80		2.43		2.65	*0.726*	
	p-value	*0.884*	*0.053*	*0.409*	*0.094*	*0.613*		
Mortality from days 0 to 6 of hatching [% of set eggs]	Polbar	2.83	2.54	2.99	4.74	3.06	*0.337*	0.177
	GP	1.94	2.18	2.87	2.23	2.29	*0.685*	
	Sx	2.63	3.61	1.45		2.77	*0.171*	
	RIR	2.16		2.34		2.23	*0.864*	
	p-value	*0.783*	*0.184*	*0.515*	*0.035*	*0.313*		
Mortality from days 7 to 18 of hatching [% of fertile eggs]	Polbar	13.81	17.60	5.05	4.78	12.42	*0.798*	2.628
	GP	7.83	14.57	2.54	3.11	6.81	*0.534*	
	Sx	20.03	14.21	1.97		14.10	*0.218*	
	RIR	20.49		1.88		13.05	*0.468*	
	p-value	*0.755*	*0.376*	*0.070*	*0.399*	*0.135*		
Mortality from days 7 to 18 of hatching [% of set eggs]	Polbar	10.85	14.94	4.91	4.00	10.42	*0.789*	2.300
	GP	5.77	11.96	1.80	2.13	5.25	*0.493*	
	Sx	16.69	13.46	1.83		11.60	*0.337*	
	RIR	12.24		1.81		8.07	*0.460*	
	p-value	*0.697*	*0.473*	*0.013*	*0.218*	*0.127*		
Mortality from days 19 to 21 of hatching [% of fertile eggs]	Polbar	13.91	10.20	4.32	7.68	9.73	*0.249*	1.194
	GP	6.68	22.30	1.40	7.20	9.71	*0.026*	
	Sx	10.32	12.00	9.57		10.80	*0.617*	
	RIR	15.30		8.44		12.56	*0.151*	
	p-value	*0.017*	*0.273*	*0.047*	*0.889*	*0.910*		
Mortality from days 19 to 21 of hatching [% of set eggs]	Polbar	11.96	9.16	4.21	6.68	8.62	*0.325*	1.042
	GP	5.15	19.36	1.10	4.95	7.82	*0.019*	
	Sx	8.78	8.77	8.86		8.79	*0.999*	
	RIR	11.55		8.13		10.18	*0.151*	
	p-value	*0.028*	*0.251*	*0.040*	*0.485*	*0.931*		

Proportions of mortality in each incubation period are presented in Graph 2. In Polbar and GP eggs the curves were very similar. In all groups fewer embryos died up to the 6^{th} day of incubation, and the most in the hatching period (days 19–21). However, it is clearly visible that this proportion was considerably higher in Rhode Island Red eggs than in the other breeds. The mortality curve for the Sussex breed is slightly different, as the most embryos died in the second phase of incubation.



Graph 2. The proportions of mortality in each incubation periods for each breed of hen

Graph 3 shows the proportion of crippled chicks as a percentage share of hatched chicks. Despite the relatively high hatchability of both fertile and set eggs, eggs from RIR hens were characterized by the highest number of crippled chicks. This parameter was more than 3 times higher than in Greenleg Partridge (1.31%), Sx (1.88%) or Polbar (1.99%). The difference was statistically significant ($p \leq 0.05$).



Graph 3. The proportions of crippled chicks for each breed of hen

DISCUSSION

The results of this study pointed at the presence the differences in hatchability parameters among the studied breeds. The values of these parameters varied depending on genetic ability of the hens [6]. Compared to high-producing commercial flocks, native breed hens, unselected for many generations, are characterized by considerably lower egg production and lower egg weight [16]. Hatchability results, however, are the most important indicators of the efficiency of breeding methods [20]. The heritability of fertility and hatchability is relatively low ($h^2 < 0.2$) [26]. In case of Polish conservation flocks the occurrence of extremely low or extremely high reproduction traits was not stated [19]. Cywa-

Benko [7], analysing the hatchability of 6 native breeds, did not find any statistically significant effect of genotype on reproductive performance. Thus, when these characteristics are strongly influenced by environmental conditions, it becomes important to preserve chicken breeds with stable reproductive indicators.

Such breeds as Sussex and Rhode Island Red, as well as their hybrids, are very popular all over the world. They attain high reproduction results independently of environmental (climate) conditions [1] or feed regime [2]. Islam et al. [13] demonstrated fertility of Rhode Island Red eggs at a level of 88.98%. Even this value, however, was considerably lower than in other breeds, such as White Leghorn (94.78%), White Rock (92.16%) and Barred Plymouth Rock (88.80%). Hrnčár et al. [11] link the hatchability of eggs from pure chicken breeds with shell thickness and conductivity in eggs from these hens. They found no significant effect of breed on egg fertility. However, hatchability from fertile eggs was lower in Sussex Light (80.83%) and higher in New Hampshire (91.87%) in comparison to Oravka, Plymouth Rock and Rhode Island Red hens. The conclusion was that the lower values of eggshell thickness and eggshell percentage in Sussex Light may significantly decrease the number of hatching chicks. Indirect confirmation of these relations can be found in a study by Krawczyk [16], on the basis of which the breeds included in the present research can be classified as follows: according to increasing shell thicknesses, Sx and RIR (315 μm) and GP (323 μm), and according to shell density, RIR (73.6 mg/cm^2), Sx (73.9 mg/cm^2) and GP (76.2 mg/cm^2). In another study [21] the shell density of eggs from the Sussex breed was also considerably lower than in GP or RIR eggs.

The embryo mortality curve is an important diagnostic indicator for the detection of some pathological disorders. The determination of embryo death has diagnostic significance for both pathological and genetic research [4]. Natural waste in artificial incubation ranges between 17–20%, including 6% of unfertile eggs, up to 12% of dead, up to 20% of weak and crippled chicks [3, 5]. Genetic and reproductive parental potential, the impact of nutrition, incorrect egg position in the hatching compartment, and infections are responsible for decreasing hatching results in 40% [24]. However, the lowest embryo mortality and proportion of crippled chicks noted for the GP breed indicates the natural adaptability of these birds to local environmental conditions, vitality and disease resistance. This is also consistent with the main principles of protection of poultry conservation flocks. In these flocks the choice of birds for the parental flock of the next generation is determined solely by their appearance, conformity to the pattern of the breed, and health status. The aim of the programme is for the population to survive in good health, and the most important considerations in evaluating the usefulness of the birds is their health and the biological value of the eggs [17].

CONCLUSIONS

The hatchability characteristics of hen breeds maintained in Poland as conservation flocks, such as Polbar (Pb), Greenleg Partridge (GP), Sussex (Sx) and Rhode Island Red (RIR), differed significantly between breeds. However, apart from individual cases, they were not influenced by the hatching season. This indicates the stability of reproductive traits as well as the genetic potential of these birds, and allows Polish genetic resources to be considered as an important pool of genes contributing to global biodiversity.

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