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ANALYSIS OF PRODUCTIVE TRAITS AND EGG QUALITY IN OLD NATIVE BREEDS OF GREENLEG PARTRIDGE AND YELLOWLEG PARTRIDGE HENS

Józefa Krawczyk✉

Department of Animal Genetic Resources Conservation, National Research Institute of Animal Production, Krakowska 1, 32-083 Balice n. Kraków, Poland

Abstract. The objective of the study was to analyse productive traits and quality of eggs in two native breeds of laying hens: Greenleg Partridge (Z-11) and Yellowleg Partridge (Ż-33). The populations of these old native breeds of hens are valuable for breeders as a reserve of unique traits, which are not found in the lines selected for increased egg production. The productive results and egg quality of these two breeds showed considerable differences, which confirms their genetic distinctiveness. Yellowleg Partridge hens were characterized by higher body weight, higher egg weight, earlier attainment of sexual maturity, and better egg production and hatchability compared to Greenleg Partridge hens. Age of hens was found to have a significant effect on egg internal quality and egg shell quality, and on reproductive performance of both breeds. The present study confirmed the known relationship of decreasing egg quality with increasing age of hens of both breeds. Much better hatchability of set and fertile eggs was obtained for Greenleg Partridge hens, and for both breeds from eggs set from younger hens (March and April).

Key words: laying hens, native breeds, productivity, egg quality

INTRODUCTION

Greenleg Partridge (Z-11) are one of the oldest native breeds of laying hens in Poland. Once commonly used in peasant farms, they are resistant to disease and well adapted to extensive free-range conditions. They lay small, cream-coloured

✉jozefa.krawczyk@izoo.krakow.pl

eggs that weight 55 g and have a relatively high yolk percentage, thereby imparting a good taste [Krawczyk et al. 2012].

Yellowleg Partridge (Ż-33) are multipurpose hens developed by crossing Greenleg Partridge females with New Hampshire males. They have distinctive yellow shanks and skin, and partridge-like plumage with a brown coating. Because of its ability to utilize large free-range spaces, this breed is recommended for backyard farming. Yellowleg Partridges have a higher body weight than Greenleg Partridge hens, which means that under extensive conditions of grass paddocks, they can also be used as Label Rouge broilers. Hens from conservation flocks are not selected for productive traits because their purpose is to conserve the genotype

The aim of the study was to analyse variation in productive traits and quality of eggs in two old native breeds of laying hens: Greenleg Partridge (Z-11) and Yellowleg Partridge (Ż-33).

In the present study, we hypothesized that Yellowleg Partridge hens (Ż-33), which are derived from the Greenleg Partridge breed, differ in phenotypic traits, and have for many years been kept under the same environmental conditions, will maintain their genetic distinctiveness.

MATERIAL AND METHODS

The study was performed in 2015 year. The experiment used Polish native hens Yellowleg Partridge (Ż-33) and Greenleg Partridge (Z-11), n = 1130 for each breed. Birds were kept in confinement on a litter floor at a male to female ratio of 1:10–12. During the egg production period, they were fed *ad libitum* mash feed containing 16.1% crude protein and 11.3 MJ · kg^{-1}. The feed was supplemented with a premix (94 g · kg^{-1}), which contained, among others, 11.2 g calcium, 0.85 g phosphorus, 1.9 g lysine and 1.12 g methionine.

Hens were kept in a windowed poultry house at a stocking density of 5.5 birds · m^{-2}, mean temperature of 15–20°C, 60–70% humidity, and photoperiod length of 16 h during the production period.

Data on productive traits (body weight, mortality, egg production, egg weight, sexual maturity, egg internal quality and egg shell quality) were collected based on farm records, measurements and analyses, and presented in tables. Hatchability results were evaluated based on 6120 eggs set from Yellowleg Partridge hens (3220 in March, 1000 in April, 1900 in May) and 9840 eggs set from Greenleg Partridge hens (6140 in March, 1400 in April, 2300 in May). Hatches were performed in a Petersime incubator (Zulte, Belgium).

At 33 and 53 weeks of age, all eggs laid on a single day by 120 hens of each breed were individually weighed. Next, 30 eggs were randomly selected from each genetic group for analysis of egg internal quality and egg shell quality. Egg quality

was analysed using the EQM electronic device (Egg Quality Measurements, TSS QCS-II). Egg shape index was determined as the ratio of the short axis to the long axis, measured with a caliper. Shell strength [N] was determined by an Egg Crusher device. The following parameters were included in the evaluation: egg and yolk weight (g), albumen height (mm), Haugh units, eggs with blood and meat spots (%), yolk colour (pts.), egg yolk content (%), shell weight (g), colour (pts.), thickness (μm), density (mg/c^2) and crushing strength (N).

Statgraphics 5.0 statistical software (Duncan's test and one-way analysis of variance) was used to calculate the studied traits and significant differences between the mean values of the studied lines of hens of different age.

RESULTS AND DISCUSSION

As can be seen from the data in Table 1, the body weight of 20-week-old Yellowleg Partridge hens and cockerels is significantly higher compared to that of Greenleg Partridge hens, with a high coefficient of variation for this trait (V > 10%). This situation also persisted in the years 2004–2008 [Krawczyk and Calik 2010], when a clear upward trend for the body weight of cockerels was observed. In this connection, over the last 5 years the body weight of cockerels of both breeds increased by approximately 100 g, while the body weight of pullets decreased by 80–100 g compared to the study period mentioned above. The body weight of breeding birds is specified in the breed standard and its change in response to environmental factors should not be considerably different from this standard [Cywa-Benko, 2002]. Therefore, this trait should be monitored during the next years to find out if this is a steady trend or a coincidence.

Table 1. Body weight and health of the studied population

Tabela 1. Masa ciała i zdrowotność badanych populacji

Trait and unit of measure Badana cecha i jednostka pomiaru		Age of birds, weeks Wiek ptaków, tygodnie	Breed and line – Nazwa i symbol kur			
			Greenleg Partridge (Ż-33) żółtonóżka kuropatwiana (Ż-33)		Yellowleg Partridge (Z-11) zielononóżka kuropatwiana (Z-11)	
			♂	♀	♂	♀
Body weight, g Masa ciała, g	$\bar{x}$	20	1972^{a}	1439^{A}	1830^{b}	1357^{B}
	V%		10.5	10.7	11.3	11.5
	SD		207.0	154.0	206.4	156.5
Mortality and health related culling, % Padnięcia i brakowania zdrowotne, %	$\bar{x}$	0–20	0.0	0.48	0.71	0.16
Mortality and health related culling, % Padnięcia i brakowania zdrowotne, %	$\bar{x}$	21–56	1.56	0.76	0.78	0.38

Notes: $\bar{x}$ – mean value, v – coefficient of variation (%), SD – standard deviation; A,B,C – highly significant differences ($P \leq 0.01$), a,b,c – significant differences ($P \leq 0.05$) between lines of hens, separately for sexes.
Objaśnienie: $\bar{x}$ – wartość średnia, v – współczynnik zmienności (%), SD – odchylenie standardowe; A,B,C – różnice wysoko istotne ($P \leq 0,01$), a,b,c – różnice istotne ($P \leq 0,05$) między rodami kur, oddzielnie dla płci.

Both breeds of hens showed very good health, much better than in the 1990s [Cywa-Benko 2002], while the level of mortality during the production phase did not exceed 1%, similarly to the years 2004–2008 as reported by Krawczyk and Calik [2010].

The number of eggs produced by Yellowleg Partridges was higher by 2.3 percentage points than in Greenleg Partridges. At the same time, a very high coefficient of variation was observed for different months of egg production (V > 26%). As is evident from Figure 1, during the first three months hens of both breeds had low egg production, which after the peak of egg production fluctuated around 70%, and from the seventh month until the end of the trial egg-laying curves showed a slight downward trend. Due to this pattern of percent egg production, Z-11 hens laid 9 less eggs compared to Ż-33 hens (Table 2). Similar relationships between the laying curve, age at sexual maturity, and percent egg production were reported by Anang et al. [2000], Cywa-Benko [2002] and Calik [2011, 2014].

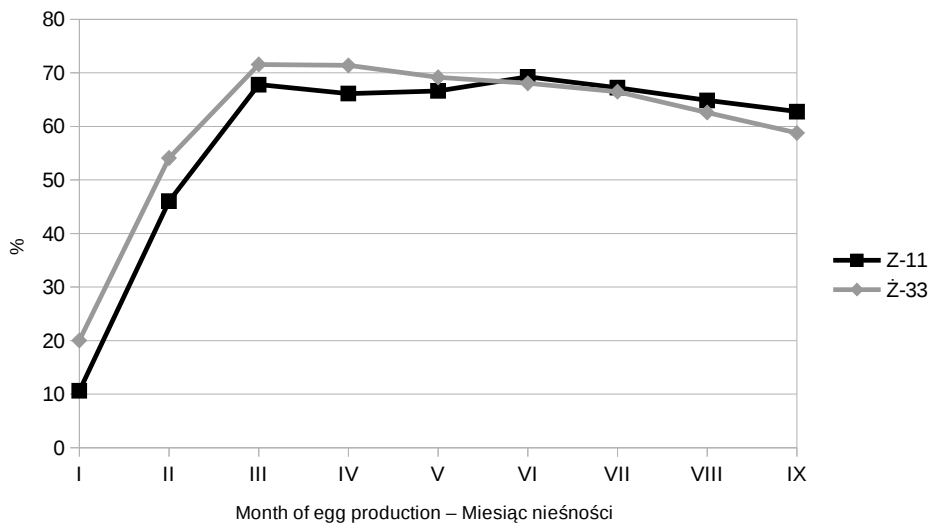

Fig. 1. Rate of lay, %

Rys.1. Nieśność, %

Greenleg Partridge hens laid much heavier eggs than Yellowleg Partridge hens at both 33 and 53 weeks of age, with statistically significant differences ($P \leq 0.01$). Comparison of these results with those reported by Cywa-Benko [2002] revealed a decrease in the weight of eggs from Z-11 hens. The variation of this trait was small; at 33 weeks it was 7.21 for Ż-33 and 8.83% for Z-11, and at 53 weeks it decreased to 1.60 in line Ż-33 and to 1.98% in line Z-11. The results of other studies [Hocking et al. 2003, Calik 2014] with commercial hybrids

Table 2. Productive traits of the studied populations during production period (21–56 weeks)

Tabela 2. Cechy użytkowe badanych populacji w okresie produkcyjnym (21–56 tyg.)

Trait and unit of measure Badana cecha i jednostka pomiaru		Breed and line – Nazwa i symbol kur	
		Greenleg Partridge (Ż-33) żółtonóżka kuropatwiana (Ż-33)	Yellowleg Partridge (Z-11) zielononóżka kuropatwiana (Z-11)
Egg production, % Nieśność, %	$\bar{x}$	60.2	57.9
	V%	26.8	32.9
	SD	16.2	19.0
Number of eggs (hen-day egg production) Liczba jaj (szt/kurę stanu średniego)	$\bar{x}$	156.2	147.8
Egg weight at 33 weeks, g Masa jaja w 33 tyg., g	$\bar{x}$	54.39^{A}	51.23^{B}
	V%	7.21	8.82
	SD	3.92	4.52
Egg weight at 53 weeks, g Masa jaja w 53 tyg., g	$\bar{x}$	59.13^{A}	57.15^{B}
	V%	1.60	1.98
	SD	0.95	1.13

For notes see Table 1.
Objaśnienie: patrz tabela 1.

of laying hens confirm that the weight of eggs from young hens is less uniform, but it levels off after the layers reach stable egg production, and the coefficient of variation decreases, which was also observed in our study. What is more, the findings of Singh et al. [2000] and Calik et al. [2016] confirm that significant differences in body weight and egg weight result from the hens' genotype, and according to Szwaczkowski [2003] the coefficient of heritability for these traits is high and exceeds 0.5. Calik [2011], when analysing trends in the performance of New Hampshire chickens, observed relatively high variation between the years for the heritability coefficient of body weight, which ranged from 0.38 to 0.52.

The lower egg production in Greenleg Partridge hens also arises from the fact that these hens are late to reach puberty. As can be seen from Figure 2, Yellowleg Partridge hens reach 30% egg production on day 157 and 50% egg production on day 169 of age, compared to days 164 and 177, respectively, for Greenleg Partridge hens.

Egg quality is determined by a number of factors, the most important of which is the origin and age of the hens. Many studies have confirmed that hen genotype has a considerable effect on physical characteristics of the eggs [Cywa-Benko et al. 2003, Silversides and Budgell 2004, Czaja and Gornowicz 2006]. Eggs from Greenleg Partridge hens are very popular with consumers, and under organic or backyard conditions their quality changes favourably [Krawczyk 2009].

Egg shape is an inherited trait. It is measured by the shape index, which is the ratio of the short axis to the long axis expressed in percent. The lower the index value the more elongated the eggs. As can be seen from Table 3, the eggs from 33-week-old Greenleg Partridge hens were more elongated than those from

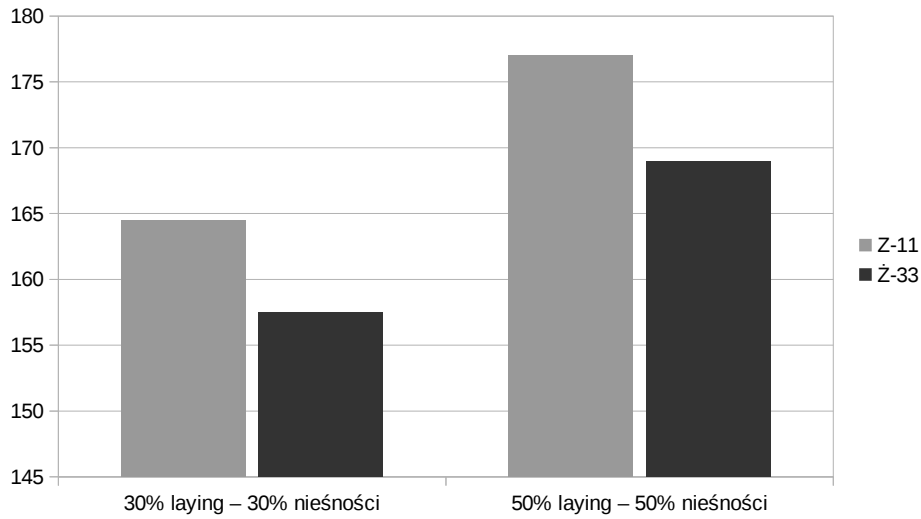

Fig. 2. Sexual maturity of hens (days)

Rys. 2. Dojrzałość płciowa kur (dni)

Yellowleg Partridge hens, with statistically significant differences ($P \leq 0.05$). As layers aged, the eggs from Ż-33 hens became slightly longer while those from Z-11 birds did not change their shape and in this way the differences decreased to a non-significant level. Regardless of hens' breed and age, this trait showed small variation (3.1–3.9%).

The weight of eggs randomly selected for quality analyses from 33-week-old birds was 4 g lower for Greenleg Partridge compared to Yellowleg Partridge hens, with highly significant differences and a high coefficient of variation (Table 3). This situation applies to eggs during early egg production and also occurs in commercial flocks. As hens age, the weight of eggs increase, which is also confirmed by our findings [Cywa-Benko et al. 2003]. The weight of eggs from hens aged 53 weeks was more uniform (V = 5.5–5.7%), and eggs from Greenleg Partridge hens were heavier by 1.5 g compared to Yellowleg Partridge hens.

Egg freshness is the most important characteristic for the consumers. It is measured by the height of thick albumen and Haugh units (HU). The higher the albumen and HU value, the fresher the egg, and this trait is mainly determined by the storage conditions [Bell et al. 2001]. Research has confirmed the well-known relationship that egg equality deteriorates as hens age [Solomon 1991, Cywa-Benko et al. 2003]. The height of albumen and HU value decreased, but variation in the height of albumen (13.1–16.6%) was greater than for HU (5.6–9.5%) (Table 3). Unfortunately, the eggs of Z-11 hens are characterized by lower albu-

Table 3. Egg internal quality

Tabela 3. Jakość treści jaj

Item Wyszczególnienie cech	Week of age Tygodnie życia kur	Greenleg Partridge (Ż-33) Żółtonóżka kuropatwiana (Ż-33)		Yellowleg Partridge (Z-11) Zielononóżka kuropatwiana (Z-11)	
		$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%
Egg weight, g	33	52.2 ±4.22 ^{A}	8.1	48.2 ±3.27 ^{B}	6.8
Masa jaja, g	53	59.7 ±3.42	5.7	61.2 ±3.39	5.5
		**		**	
Shape index, %	33	76.4 ±2.37 ^{a}	3.1	74.8 ±2.93 ^{b}	3.9
Indeks kształtu. %	53	74.1 ±2.90	3.9	74.9 ±2.39	3.2
		**		NS	
Albumen height, mm	33	8.25 ±1.08 ^{a}	13.1	7.68 ±1.04 ^{b}	13.5
Wysokość białka, mm	53	7.14 ±1.19	16.6	7.25 ±0.98	13.6
		**		NS	
Haugh units	33	92.5 ±5.45	5.9	90.6 ±5.03	5.6
JH	53	83.8 ±7.97	9.5	84.3 ±5.95	7.1
		**		**	
Yolk weight, g	33	14.7 ±1.26 ^{A}	8.6	13.3 ±0.94 ^{B}	7.0
Masa żółtka, g	53	18.9 ±1.53	8.1	18.6 ±1.60	8.6
		**		**	
Roche yolk colour (points)	33	6.9 ±1.21 ^{A}	17.6	5.76 ±1.30 ^{B}	22.6
Barwa żółtka (pkt w skali	53	7.5 ±1.19	15.9	7.3 ±1.37	18.7
La'Roche'a)		NS		**	
Egg yolk content, %	33	28.2 ±1.76	6.3	27.8 ±1.88	6.8
Zawartość żółtka w jaju, %	53	31.6 ±2.01	6.3	30.5 ±2.68	8.8
		**		**	
Eggs with blood spots, %	33	3.33		0.00	
Jaja z plamami krwawymi, %	53	0.00		3.33	
Eggs with meat spots, %	33	3.33		0.00	
Jaja z plamami mięsnymi, %	53	0.00		0.00	

Notes: values in rows with different capital letters differ highly significantly ($P < 0.01$), small letters significantly ($P < 0.05$); values in columns marked with ** differ highly significantly ($P < 0.01$), those with * differ significantly ($P < 0.05$), NS – not significant.

Objaśnienia: wartości w wierszach oznaczone różnymi dużymi literami różnią się wysoko istotnie ($P < 0,01$), a małymi istotnie ($P < 0,05$); wartości w kolumnach oznaczone ** różnią się wysoko istotnie ($P < 0,01$), oznaczone * różnią się istotnie ($P < 0,05$), ^{a} oznaczone NS nie różnią się istotnie.

men height and lower storage value compared to other lines of hens [Krawczyk and Sokołowicz 2015], which are also quicker to decrease during storage.

The presence of blood or meat spots in eggs is an important issue for the consumer, although this trait is in no way detrimental to their nutritive value. Among the 30 eggs from each breed of hens, over two periods of life of Greenleg Partridge hens, only one small blood spot was observed in an egg from a 53-week-old bird. Among the eggs from young Yellowleg Partridge hens, there was 1 egg with blood spots and 1 egg with meat spots. The number of eggs with spots was much smaller compared to the populations studied 10 years earlier [Cywa-Benko et al. 2003].

Egg yolk is rich in vitamins, minerals, and unsaturated fatty acids. Therefore, eggs with a higher proportion of yolk in total weight not only have a better taste, but are also of higher nutritive value, and those with natural yellow yolk are more

Table 4 Egg shell quality traits

Tabela 4. Cechy jakości skorup jaj

Item Wyszczególnienie cech	Week of age Tygodnie życia kur	Greenleg Partridge (Ż-33) Żółtonóżka kuropatwiana (Ż-33)		Yellowleg Partridge (Z-11) Zielononóżka kuropatwiana (Z-11)	
		$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%
Shell colour, % Barwa skorupy, %	33	55.9 ±4.58 ^{A}	8.2	69.4 ±3.47 ^{B}	5.0
	53	56.9 ±4.43 ^{A}	7.8	68.7 ±2.97 ^{B}	4.3
		NS		NS	
Shell thickness, µm Grubość skorupy, µm	33	334 ±32.0	9.6	331 ±3.05	9.2
	53	330 ±27.8 ^{a}	8.4	312 ±31.6 ^{b}	10.1
		NS		*	
Shell weight, g Masa skorupy, g	33	5.39 ±0.58 ^{a}	10.8	5.04 ±0.52 ^{b}	10.4
	53	5.92 ±0.52 ^{A}	8.8	5.51 ±0.51 ^{B}	9.2
		**		**	
Shell density, mg · cm^{-2} Gęstość skorupy, mg · cm^{-2}	33	76.6 ±8.54	11.2	74.7 ±8.21	11.0
	53	77.9 ±7.39 ^{A}	9.5	69.8 ±8.19 ^{B}	11.7
		NS		*	
Crushing strength, N Wytrzymałość na zgniecenie, N	33	53.4 ±14.6	27.3	47.1 ±12.4	26.4
	53	46.7 ±12.7 ^{A}	27.1	34.3 ±10.4 ^{B}	30.3
		NS		**	

*for notes see Table 1 and 3.
*objaśnienia przy tabeli 1 i 3.

willingly purchased by consumers. In general, yolk weight increases with egg weight, and indirectly with the age of the hens; this relationship is supported by the results of our study (Table 3). In the situation where the same rearing and feeding conditions were provided to hens during this study, the differences are due to the genotype of hens.

The yolks of eggs from Z-11 hens were significantly lighter than those from Ż-33 hens ($P \leq 0.01$), and much lighter yolks were found in the eggs of both breeds at 33 weeks compared to 53 weeks of age ($P \leq 0.01$). A similar relationship was observed for egg yolk percentage, but with a lack of statistical significance. Yolk colour is influenced mainly by the diet and access to grass paddocks [Krawczyk 2009]. Yolk colour showed high variation in the hen breeds under study (Table 3). This situation points to considerable differences between birds in the assimilation of xanthophyll pigments from the diet. The mean Roche yolk colour score for the eggs of 33-week-old Z-11 birds was small (5.76) and significantly lower than in Ż-33 birds. As hens grew older, yolk colour improved (especially in Z-11 birds) and the differences in this respect between the breeds were small and statistically not significant, which concurs with the findings of Kuchta et al. [1999] and Czaja and Gornowicz [2006].

Egg shell colour is an inherited, breed-specific trait [Roberts 2004]. In our study, we found that this trait differed highly significantly between the breeds at both 33 and 53 weeks of age (Table 4). The egg shells from Greenleg Partridge hens were lighter by more than a dozen points compared to those from Yellowleg

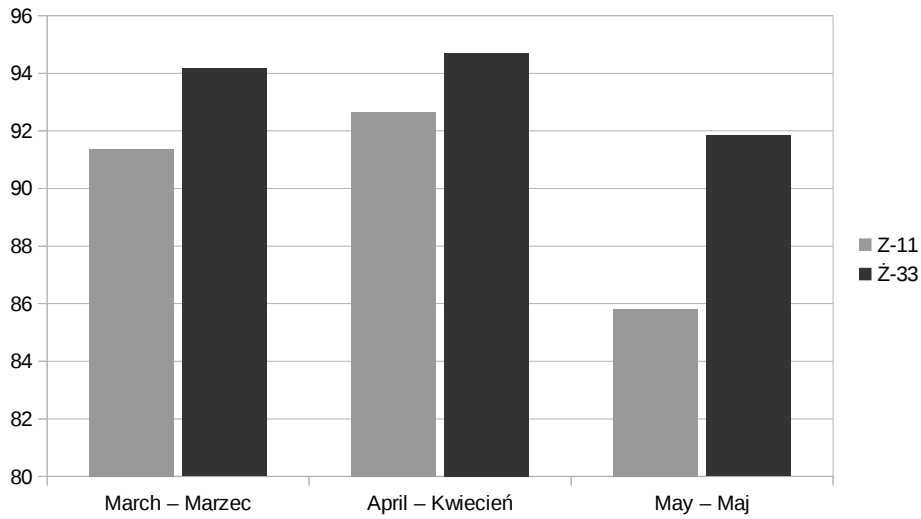

Fig. 3. Percent egg fertility

Rys. 3. Zapłodnienie jaj, %

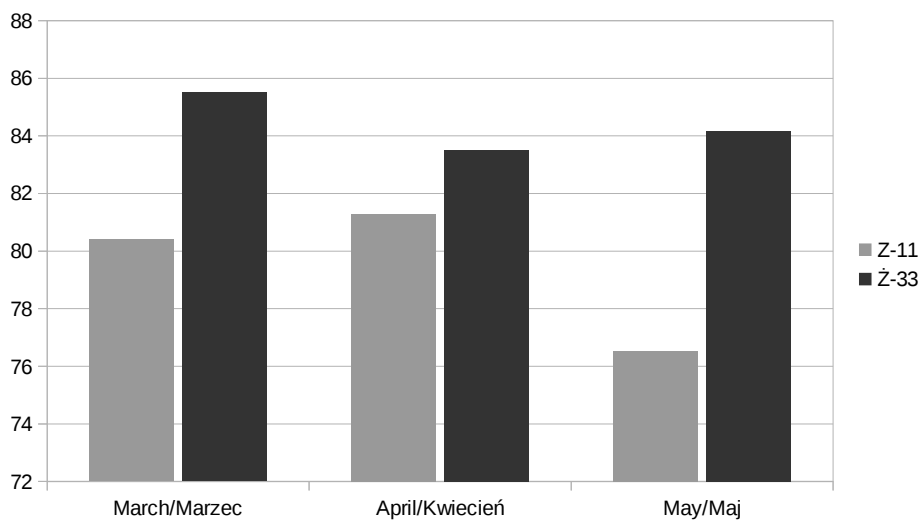

Fig. 4. Hatchability of set eggs, %

Rys. 4. Wylęg z jaj nałożonych, %

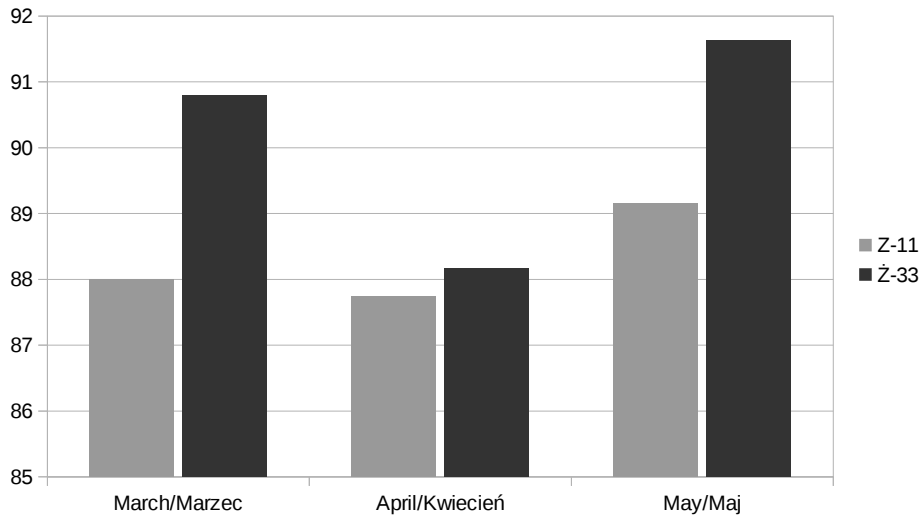

Fig. 5. Hatchability of fertile eggs, %

Rys. 5. Wyląg z jaj zapłodnionych, %

Partridge hens. Our study failed to confirm the well-known relationship reported in the literature that in commercial flocks, the shells of eggs laid during autumn and winter have a darker colour compared to those laid during spring and summer [Hutt 1968].

Shell thickness is another genetically determined trait, although it is also known to be influenced to a slight extent by the age and environment. In the eggs of Z-11 hens, shell thickness and density decreased with the age of the hens, which reduced their crushing strength, and the differences in this respect were statistically significant (Table 4). A similar relationship was reported by Hocking et al. [2003] and Sokołowicz and Krawczyk [2004]. Egg shell weight in both breeds increased considerably with the age of the hens ($P \leq 0.01$). Because thin-shelled eggs often break when marketed, causing tangible economic losses, this issue has been the subject of many studies. It can therefore be stated that the eggs from Greenleg Partridge hens, the shells of which are thinner and more brittle compared to those from Yellowleg Partridge hens, may be more prone to breaking when marketed. The high coefficient of variation for crushing strength ($V\% > 25$) means that the results for individual eggs were widely divergent from the group average.

Good reproductive performance is essential for the small populations to survive. In the populations under study, birds are kept at a male to female ratio of 1:10–12, which, as can be seen from Figure 3, produced good fertility results (>90%), comparable to those in the commercial flocks. Good fertility results in

both analysed breeds have remained at a high level since the 1990s [Cywa-Benko 2002, Krawczyk et al. 2012]. However, they deteriorated with the age of the birds, especially in the group of Z-11 hens.

Much better hatchability of set and fertile eggs was obtained for the eggs from Yellowleg Partridge hens, and for set eggs of both breeds originating from younger hens aged 50 weeks (in March) compared to hens aged 56 weeks (in April) (Figs. 3 and 4). Assuming that the hen housing conditions were identical and the hatches were conducted in a modern incubator, it is interesting to achieve such differences in the results of reproduction, which is influenced by both semen quality and quality traits of hatching eggs, as confirmed by the findings of Cywa-Benko and Krawczyk [2003].

CONCLUSIONS

The Greenleg Partridge and Yellowleg Partridge populations are old native breeds of hens valuable for breeders as a reserve of unique traits, which are not found in the lines selected for high egg production. The productive results and egg quality of these two breeds showed considerable differences, which confirms their genetic distinctiveness. Yellowleg Partridge hens were characterized by higher body weight, higher egg weight, earlier attainment of sexual maturity, and better egg production and hatchability compared to Greenleg Partridge hens.

Age of hens was found to have a significant effect on egg internal quality and egg shell quality, and on reproductive performance of both breeds. The present study confirmed the known relationship of decreasing egg quality with increasing age of hens of both breeds. Much better hatchability of set and fertile eggs was obtained for Greenleg Partridge hens, and for set eggs of both breeds from younger hens aged 50 weeks (in March) compared to hens aged 56 weeks (in April)

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ANALIZA CECH UŻYTKOWYCH I JAKOŚCI JAJ STARYCH RODZIMYCH RAS KUR ZIELONONÓŻKA I ŻÓŁTONÓŻKA KUROPATWIANA

Streszczenie. Celem badań była analiza kształtowania się cech użytkowych oraz jakości jaj dwóch starych, rodzimych ras kur nieśnych tj. zielononóżki kuropatwianej (Z-11) i zółtonóżki kuropatwianej (Ż-33). Populacje tych kur to cenne dla polskiej hodowli stare, rodzime rasy, stanowiące rezerwuar unikalnych cech, których nie posiadają rody selekcjonowane na wysoką nieśność. Potwierdzono duże zróżnicowanie w wynikach produkcyjnych i jakości jaj obydwu ras kur, co potwierdza ich odrębność genetyczną. U żółtonóżek kuropatwianych stwierdzono wyższą masę ciała w wieku 20 tygodni, masę jaj, wcześniejsze osiągnięcie dojrzałości płciowej oraz lepszą nieśność i wylęgowość w porównaniu do zielononóżek kuropatwianych. Wykazano także istotny wpływ wieku kur na jakość treści i skorup jaj oraz wyników reprodukcji obydwu ras kur. Badania potwierdziły znaną zależność o pogorszeniu się jakości jaj wraz z wiekiem kur u obydwu ras. Znacznie lepsze wyniki wylęgu z jaj nałożonych i zapłodnionych uzyskano z jaj kur żółtonóżek kuropatwianych oraz dla obydwu ras z nakładów od kur młodszych tj. 50-tygodniowych (w marcu) niż 56-tygodniowych (w kwietniu).

Słowa kluczowe: kury nieśne, rodzime rasy, użytkowość, jakość jaj

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