ACTA SCIENTIARUM POLONORUM
ISSN 1644-0714
ISSN 2300-6145 (online)
DOI:10.21005/asp.2016.15.3.03
www.asp.zut.edu.pl
Acta Sci. Pol. Zootechnica 15(3) 2016, 27–42

PRODUCTIVE TRAITS AND EGG QUALITY IN THREE STRAINS OF LAYING HENS

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Abstract. The objective of this study was to investigate variation in productive traits and egg quality in three strains of laying hens: Rhode Island Red (strains R-11 and K-22) and Rhode Island White (strain A-33). The present study confirmed that hen origin (genotype) has an impact on performance, reproductive results, and egg quality traits. The results showed that the analysed strains were in good health during both rearing and production. R-11 and K-22 strains were found to differ considerably from A-33 in terms of the evaluated productive traits, in particular the body weight, the egg weight, and hatchability parameters. The results also demonstrated differences in the quality of eggs from hens of the compared strains. This particularly concerned traits such as shell colour, weight of egg, shell and yolk, and shell quality parameters. It was also confirmed that many of the egg and shell quality traits change with age of the birds. All of the results reported here provide valuable information for characterizing these unique breeding strains.

Key words: laying hens, productive traits, egg quality

INTRODUCTION

The last half-century has witnessed remarkable advances in poultry breeding [Jankowski et al. 2012]. Considerable progress has been made in laying performance and feed conversion, with significant improvements in the quality of the products obtained. This results from the achievements not only in population genetics, but also in broadly defined animal and veterinary sciences being implemented into breeding practice [Szwaczkowski 2015]. Since 1999, there has been a

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decline in the contribution of native poultry breeds to pedigree breeding in Poland. This was due to fierce competition in the distribution of breeding material. At the same time, the analysis of national pedigree flocks of laying hens demonstrates that we have very rich and genetically interesting breeding material that can be used in extensive production systems [Cywa-Benko 2002, Krawczyk and Calik 2010].

Some strains of hens kept on Polish farms were excluded from selection for productive traits while maintaining their genetic and phenotypic diversity, which makes them more attractive for backyard farming. These included the valuable Rhode Island Red hens. The breed was developed in the latter half of the 19th century in the USA, in the State of Rhode Island. Strain R-11 was brought to Poland from Great Britain prior to 1939, and breeding work on strains K-22 and A-33 was started in Poland in the late 1970s. As part of the breeding programme, four groups from Hungarian farms were brought together at the pedigree farm in Pawłowice. Breeding work resulted in two closed populations designated as K-22 (paternal strain) and A-33 (maternal strain). These strains are particularly suited to extensive backyard farming as they make efficient use of pasture. The birds are large, not fearful, and have a gentle disposition. R-11 and K-22 hens and cocks have reddish brown or mahogany feathers, whereas A-33 birds are white. By 12–13 weeks of age, R-11 cockerels housed with free-range access reach a body weight of 1300–1800 g and good dressing percentage [Połtowicz et al. 2004], whereas hens, after 12 months of productive life, are perfectly suited for stewing meat [Puchała et al. 2014]. Strains K-22 and A-33 are distinguished by different genetic structure and origin compared to other strains kept in Poland, and show a high level of heterosis when crossed with other strains [Calik 2008, 2014].

As indicated by Hocking et al. [2003], measurable parameters of animals such as body weight, body dimensions and productivity at sexual and somatic maturity, lifespan, or shape of the growth curve show considerable variation between genetically different populations of the same species. In the case of laying hens, the combined effects of bird genotype, housing conditions and survival should translate into farm practice guidelines that account for differences between populations not only in the level of production traits but also in the relationships between them. Thanks to long-running research, table egg quality traits and the possibility of their modification are well explored in pedigree and commercial flocks. On the other hand, it is interesting to analyse the age and laying performance of hens as related to their hatchability and egg quality, in unselected birds from flocks that have been kept in small populations for many generations.

The objective of this study was to investigate variation in productive traits and egg quality in three strains of laying hens: Rhode Island Red (strains R-11 and K-22) and Rhode Island White (strain A-33).

MATERIAL AND METHODS

The experiment used 930 Rhode Island Red (R-11), 1050 Rhode Island Red (K-22) and 1080 Rhode Island White (A-33) birds. Throughout rearing and egg production, they were fed complete standard diets ad libitum. The diet contained 89.11% dry matter, 11.28% crude ash, 16.93% crude protein, 2.15% crude fat, 2.5% crude fibre, 3.55% calcium, and 0.5% phosphorus. Hens and cocks were kept on litter under optimal environmental conditions (temperature 18–20°C, relative humidity 60–80%), at a stocking density of 5 birds/m^2. Birds were kept at a sex ratio of 1 male to 10–12 females. The study encompassed both the rearing and egg production periods.

The following parameters were determined based on the farm records and the performed measurements and analyses:

1. survival rate (%) of cocks and hens during rearing and production;
2. body weight of cockerels and pullets at 20 weeks of age (g);
3. sexual maturity of the flock (days of age from hatching to attainment of 30% and 50% egg production);
4. egg weight at 33 and 53 weeks of age (g);
5. number of eggs (per hen) laid during production and rate of lay (%);
6. egg hatchability parameters (percentages of egg fertility, hatchability of set eggs, hatchability of fertile eggs).

At 33 and 53 weeks of age, 30 eggs per strain per test were randomly collected from each population. After 24 h of cold storage at 4°C and 55% humidity, the eggs were subjected to quality evaluation using the EQM (Egg Quality Measurements) system (TSS QCS-II). The evaluation accounted for the following parameters: egg weight (g), shell colour (%), height of thick albumen (mm), Haugh units, yolk colour (pts.), shell weight (g), shell thickness (mm), and shell density (mg/cm^2). Shell strength (N) was measured with a Stable Micro Systems analyser.

The strains were also evaluated for hatchability parameters by determining egg fertility rate (%) and hatchability of set and fertile eggs. The evaluation covered the entire reproduction period from March to May 2015. Three hatches were performed in strains R-11 and A-33, and two hatches in strain K-22. A total of 16 500 hatching eggs were studied, including 7440 eggs from strain R-11, 4430 from K-22, and 4630 from A-33. After preliminary candling, eggs with cracked shells were removed and the remaining eggs were sprayed with Virkon disinfectant and placed in a storage room for a maximum of 7 days. Hatches were conducted in a Petersime hatcher (Belgium) according to the temperature and relative humidity recommendations.

The results were statistically analysed with analysis of variance (ANOVA). Calculations were made using Statgraphic plus 5.1.

RESULTS AND DISCUSSION

The R-11, K-22 and A-33 strains of hens are valuable for Polish breeders as they form a reserve of unique phenotypic and egg quality traits. As is evident from Table 1, the health of birds during rearing was at a good level. In K-22 males there were no deaths and health cullings, and in the other strains mortality was low and ranged from 2.50 (R-11) to 2.86% (A-33). The values observed in hens also did not exceed 3.00%. Therefore, the rate of survival was very high and varied from 97.12 to 100% depending on strain and sex. Towards the end of the rearing period at 20 weeks of age, both males and females were evaluated for body weight. The body weight of cocks averaged from 1886 g (A-33) to 2262–2271 g (R-11, K-22), with statistically significant differences between the strains ($P \leq 0.01$). A-33 hens had around 160 g lower body weights compared to R-11 and K-22 hens ($P \leq 0.01$). The coefficient of variation (V%) for body weight was lowest in K-22 cocks and hens (V% = 5.99–9.97), and highest in strain R-11 (V% = 11.92–13.24).

Table 1. Body weight and health of the studied populations during rearing (0–20 weeks)

Tabela 1. Masa ciała i zdrowotność badanych populacji w okresie wychowu (0–20 tyg.)

Studied trait and unit of measurement Badana cecha i jednostka pomiaru		Age of bird in weeks Wiek ptaka w tyg.	Name and symbol of strain – Nazwa i symbol rodu		
			Rhode Island Red (R-11)	Rhode Island Red (K-22)	Rhode Island White (A-33)
Mortality and health cullings, males, % Padnięcia i brakowania zdrowotne, samce, %		0–20	2.50	0.00	2.86
Mortality and health cullings, females, % Padnięcia i brakowania zdrowotne, samice, %		0–20	2.00	1.18	2.88
Body weight, males, g Masa ciała, samce, g	$\bar{x}$ ±SD	20	2262 ±269.63 A	2271 ±136.04 A	1886 ±166.67 B
	V%		11.92	5.99	8.83
Body weight, females, g Masa ciała, samice, g	$\bar{x}$ ±SD	20	1610 ±213.17 A	1634 ±163.01 A	1461±173.70 B
	V%		13.24	9.97	11.89

A, B – significant differences ($P < 0.01$); a, b, – significant differences ($P < 0.05$) – between strains of hens, separately for sexes.
A, B – różnice istotne ($P < 0,01$); a, b, – różnice istotne ($P < 0,05$) – między rodami kur, oddzielnie dla płci.

At the end of the rearing period, all the strains were moved from the growing facility to the poultry house and subjected to evaluation of productive traits from 21 to 57 weeks of age. Flock health status during the production period is shown in Table 2. Throughout the production period, survival rate was 100% as no deaths and health cullings were observed in the males. During the 36-week evaluation period, survival rate in females was also very high and ranged from 98.72 (A-33) to 99.54%. It should be noted, however, that in the context of an earlier study by Krawczyk and Calik [2010], the improved flock health observed during the last few years in K-22 and A-33 hens resulted from the improvement of the birds' environmental conditions. These flocks had previously been kept at the farm in Duszniki and their transfer to the Chorzelów Experimental Station had a beneficial effect on both their health and production parameters. Our results are evidence that the birds were kept in good environmental conditions, received balanced diets, but above all were provided with appropriate veterinary prophylaxis involving a number of vaccinations which prevented the flock against diseases during both the rearing and egg production periods.

Table 2. Health of the studied populations during the production period (21–56 weeks)
Tabela 2. Zdrowotność badanych populacji w okresie produkcji (21–56 tyg.)

Studied trait and unit of measurement Badana cecha i jednostka pomiaru	Name and symbol of strain – Nazwa i symbol rodu		
	Rhode Island Red (R-11)	Rhode Island Red (K-22)	Rhode Island White (A-33)
Mortality and health cullings, males, % Padnięcia i brakowania zdrowotne, samce, %	0.00	0.00	0.00
Mortality and health cullings, females, % Padnięcia i brakowania zdrowotne, samice, %	0.46	0.53	1.28

Figures 1 and 2 present the egg-laying curve and the age of sexual maturity of the flock (days of age from hatching to attainment of 30 and 50% egg production). Considerable differences were found between the analysed strains in the age of sexual maturity. While A-33 and K-22 layers had 30 and 50% laying rate at an average of 140 and 145 days, R-11 hens achieved the same rate of lay as late as at 149 and 163 days of age, respectively. This had a direct effect on the level of egg production (Table 3), which was highest in strains A-33 and K-22 (an average of 186.5 eggs/hen and 73.83%), and lowest in strain R-11 (160.9 eggs/hens and 62.56%). Analysis of the laying curve shows that A-33 and K-22 hens reached peak egg production at the third month of evaluation and R-11 hens at the fourth month, with comparable egg production in the analysed strains from the 6th month of production.

In our study we found significant differences between the strains in egg weight (Table 3), which ranged from 55.01 do 56.17 g (V% = 7.18–7.88) at 33 weeks and from 60.78 do 62.13 g (V% = 2.67–4.72) at 53 weeks of age. As indicated by Hocking et al. [2003], the weight of eggs from young hens is not consistent but levels off when layers reach stable production and the coefficient of variation decreases, which was also observed in our study. Sharma et al. [1998] and Singh

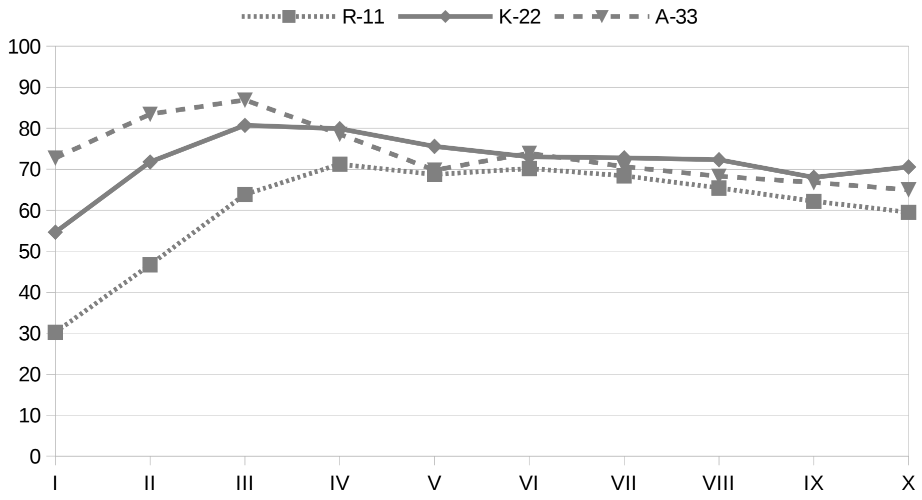

Fig. 1. Laying curve (%)

Rys. 1. Krzywa nieśności (%)

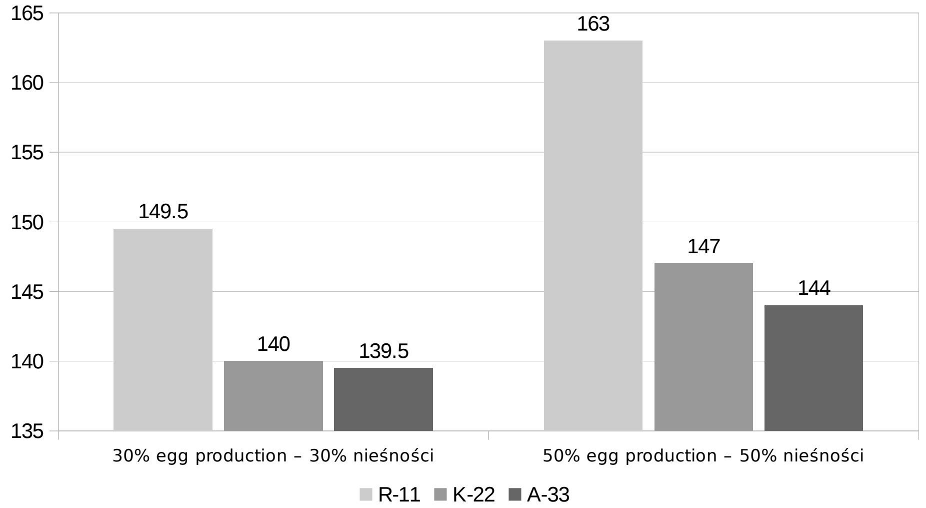

Fig. 2. Sexual maturity (days)

Rys. 2. Dojrzałość płciowa (dni)

Table 3. Productive traits of the studied populations during the production period (21––56 weeks)

Tabela 3. Cechy użytkowe badanych populacji w okresie produkcji (21–56 tyg.)

Studied trait and unit of measurement Badana cecha i jednostka pomiaru		Name and symbol of strain – Nazwa i symbol rodu		
		Rhode Island Red (R-11)	Rhode Island Red (K-22)	Rhode Island White (A-33)
Production period, weeks Okres produkcji, tyg.		36	36	36
No. of eggs from housed hen Liczba jaj od nioski stanu średniego, szt.		160.90	185.95	187.07
Laying rate, % Procent nieśności, %		62.56	73.79	73.87
Egg weight at 33 weeks, g Masa jaja w 33 tyg., g	$\bar{x}$ ±SD	55.91 ±4.41	55.01 ±4.04 a	56.17 ±4.03 b
	V%	7.88	7.34	7.18
Egg weight at 53 weeks, g Masa jaja w 53 tyg., g	$\bar{x}$ ±SD	61.12 ±1.71 A	60.78 ±2.87 A	62.13 ±1.66 B
	V%	2.80	4.72	2.67

For explanations, see Table 1.
Objaśnienie: patrz Tabela 1.

et al. [2000] concluded that hen's growth is a complex of traits shaped by genetic and environmental factors that are dependent on age. It is held in the literature that statistically significant between-breed differences in birds' body weight and the highly correlated egg weight have a genetic cause [Masso et al. 1998]. A study by Szwaczkowski [2003] showed that the coefficient of heritability for these traits has high values ($h^2 > 0.5–0.6$). As demonstrated by Anang et al. [2000], early maturing hens at the same time have a genetically determined higher egg production, which is indicated by mostly negative correlations between age at sexual maturity and number of eggs. In addition, younger hens at first egg generally produce lighter eggs.

Our study revealed significant differences in the physical characteristics of eggs from different strains of laying hens (Table 4). Average egg weight varied from 55.31 (A-33) to 55.55–55.91 g (R-11 – K-22) at 33 weeks of age and from 60.76 (K-22) to 62.57 g (A-33) at the next evaluation at 53 weeks of age. During the observations, the average egg weight increased by 5.36 g in strains R-11 and K-44 and by 7.26 g in strain A-33, with significant differences between both the analysed strains and evaluations. As the size of eggs increased they became more elongated, which is indicated by the decrease in egg shape index. In all the populations under study, the increase in egg weight was paralleled by a significant increase in yolk weight (g) and percent egg yolk content; this was especially noticeable in eggs from R-11 hens (above 31.5%), which were evaluated at 53 weeks of age. As indicated by Nys [1995], Anang et al. [2000] and Calik [2008], egg weight is dependent upon genetic and environmental factors, including mainly thermal and bird feeding conditions. Likewise, studies by Silversides and Budgell [2004], Czaja and Gornowicz [2006], Krawczyk and Calik [2006] conclusively confirm the effect of bird genotype on physical characteristics of eggs, including the weight of egg, yolk and shell. Furthermore, Basmacioglu and Ergul [2005] report that one of the factors affecting the weight of eggs is the rate of lay. Lower egg production allows birds to store more material needed to build eggs and increase their weight.

Table 4. Egg shape index and egg content quality

Tabela 4. Indeks kształtu oraz jakość treści jaj

Item Wyróżnienie	Age, weeks Wiek, tyg.	Rhode Island Red (R-11)		Rhode Island Red (K-22)		Rhode Island White (A-33)	
		x̄ ±SD	V%	x̄ ±SD	V%	x̄ ±SD	V%
Shape index, % Indeks kształtu, %	33	76.45 ±2.12	2.77	75.79 ±2.29	3.02	76.18 ±2.29	3.01
	53	74.72 ±2.75	3.68	74.73 ±2.47	3.31	74.93 ±2.61	3.48
signif. – istotności		*		NS		NS	
Egg weight, g Masa jaja, g	33	55.91 ±4.24	7.58	55.55 ±4.07	7.31	55.31 ±2.26	4.08
	53	61.42 ±2.86	4.66	60.76 ±3.33 a	5.48	62.57 ±2.75 b	4.40
signif. – istotności		**		**		**	
Yolk weight, g Masa żółtka, g	33	14.39 ±1.01 A	7.04	14.18 ±0.95 a	6.68	13.94 ±0.89 Bb	6.40
	53	19.46 ±1.37 B	7.09	17.39 ±1.41 A	8.13	17.38 ±1.02 A	5.88
signif. – istotności		**		**		**	
Yolk content, % Zawartość żółtka, %	33	25.82 ±1.88	7.29	25.63 ±2.21	8.65	25.24 ±1.88	7.46
	53	31.74 ±2.58 A	8.15	28.68 ±2.54 B	8.86	27.84 ±2.11 B	7.57
signif. – istotności		**		**		**	
Albumen height, mm Wysokość białka, mm	33	9.79 ±1.03 A	10.49	8.93 ±0.93 B	10.44	8.00 ±1.16 C	14.44
	53	8.01 ±1.15 A	14.37	7.68 ±1.17 A	15.21	6.82 ±1.12 B	16.38
signif. – istotności		**		**		**	
Haugh units, jH Jednostki Haugha, jH	33	99.05 ±4.17 Aa	4.21	95.15 ±4.27 Ab	4.49	91.10 ±5.76 B	6.32
	53	88.06 ±6.49 A	7.36	86.47 ±6.42 A	7.43	78.88 ±7.33 B	9.29
signif. – istotności		**		**		**	
Yolk colour, pts. Barwa żółtka, pkt.	33	7.13 ±1.17	16.35	7.27 ±1.14	15.72	7.33 ±1.27	17.30
	53	7.30 ±1.15	15.74	7.13 ±0.73	10.23	7.63 ±1.19	15.57
signif. – istotności		NS		NS		NS	
Blood spots, % Plamy krwiste, %	33	0.00		0.00		0.00	
	53	6.66		0.00		0.00	
Meat spots, % Plamy mięsne, %	33	0.00		0.00		0.00	
	53	3.33		3.33		3.33	

A, B… – values in rows with different letters differ significantly (P<0.01); a, b... for P < 0.05.
** values in columns with different letters differ significantly (P<0.01); * – for P < 0.05.
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** wartości w kolumnach oznaczone różnymi literami różnią się istotnie (P < 0,01); * dla P < 0,05.
NS – różnice nieistotne oznaczone w kolumnach.

In our study we found no significant differences in yolk colour. As demonstrated by Nys [2000], egg yolk colour is determined mainly by the feed, including dietary carotenoids, and the rate of lay. The evaluated strains differed in albumen quality expressed as albumen height (mm) and Haugh units. Best albumen quality at both 33 and 53 weeks of age was characteristic of eggs from R-11 hens. In addition, albumen quality parameters were found to deteriorate significantly ($P \leq 0.01$) in all the strains under study. According to Świerczewska (cited from Biesiada-Drzazga and Janocha [2009]), the quality of albumen in fresh egg should exceed 60 Haugh units, which allows a conclusion that all the eggs, even those from older hens aged 53 weeks, were characterized by high albumen quality. Our study also established a higher proportion of blood spots in the eggs from R-11 hens on the second evaluation date. A higher incidence of blood spots in R-11 hens was also reported by Cywa-Benko [2002]. As regards meat spots, this defect was found in 3.33% of all the strains on the second evaluation date.

The shell quality parameters for different strains at 33 and 53 weeks of age are presented in Table 5. As indicated by Roberts [2004], the most correlated trait with hen genotype is shell colour, the intensity of which depends on hen's age. Our study also revealed genetically determined differences in shell colour intensity. Shell colour differed significantly between strain R-11 (45.8%) and strains A-33 and K-22 (36.2–36.5%), and showed a tendency for lightening with the age of the hens, amounting to 49.8, 37.9 and 38.9%, respectively, with variation ranging from 7.56 to 14.05%. Dark shell colour is caused by the brown pigment ooporphyrin or protoporphyrin, which originates from blood hemin, and shell colour intensity is inversely proportional to laying performance [Basmacioglu and Ergul 2005].

It is often stated in the literature that eggshell quality deteriorates with the age of the hen, because the increase in egg content weight is not accompanied by an increase in shell weight, which reduces its strength [Hocking et al. 2003, Roberts 2004]. This is also indicated by our results, where shell quality parameters, including shell strength, thickness and density decreased as hens aged. At 33 weeks of age, the greatest shell strength (46.93 N) was noted in R-11 hens. At the same time, the shells of these eggs were thickest (0.357 mm) and the eggs were characterized by the highest shell density (80.03 mg/cm^2). In the other strains, shell strength was also high (44.2 N on average), with shell thickness ranging from 0.350 to 0.356 mm and shell density ranging from 78.86 to 79.33 mg/cm^2. On the next evaluation date, we observed shell strength to decrease, especially in strain R-11 (37.40 N), with a concurrent significant decrease in both shell thickness and density, and the differences in these ranges were statistically confirmed. It is worth noting the high coefficient of variation (V% = 11.71–26.02) for shell strength, which indicates that the analysed groups of eggs were widely dispersed

Table 5. Egg shell quality

Tabela 5. Jakość skorupy jaj

Item Wyróżnienie	Age, weeks Wiek, tyg.	Rhode Island Red (R-11)		Rhode Island Red (K-22)		Rhode Island White (A-33)	
		x̄ ±SD	V%	x̄ ±SD	V%	x̄ ±SD	V%
Shell colour, % Barwa skorupy, %	33	45.8 ±4.23 A	9.23	36.5 ±4.30 B	11.78	36.2 ±5.08 B	14.05
	53	49.8 ±3.76 A	7.56	38.9 ±3.72 B	9.54	37.9 ±5.31 B	14.00
signif. – istotności		**		NS		NS	
Shell weight, g Masa skorupy, g	33	5.87 ±0.57 A	9.76	5.62 ±0.60 a	10.65	5.32 ±0.35 Bb	6.59
	53	6.23 ±0.45 a	7.24	6.28 ±0.57	9.08	6.53 ±0.46 b	7.04
signif. – istotności		**		**		**	
Shell density, mg/cm² Gęstość skorupy, mg/cm²	33	80.03 ±4.83	6.04	78.86 ±7.81	9.90	79.33 ±6.75	8.51
	53	76.10 ±9.68	12.72	78.19 ±7.81	9.99	79.69 ±4.87	6.12
signif. – istotności		NS		NS		NS	
Shell thickness, mm Grubość skorupy, mm	33	0.357 ±0.029	8.12	0.350 ±0.031	8.86	0.356 ±0.029	8.14
	53	0.330 ±0.042 a	12.72	0.343 ±0.030	8.75	0.350 ±0.028 b	8.01
signif. – istotności		*		NS		NS	
Shell strength, N Wytrzymałość skorupy, N	33	46.93 ±5.49	11.71	43.78 ±7.70	17.58	44.62 ±6.78	15.19
	53	37.40 ±9.42	25.17	40.09 ±7.62	18.99	41.41 ±10.78	26.02
signif. – istotności		**		NS		NS	

A, B… – values in rows with different letters differ significantly ($P < 0.01$); a, b... for $P < 0.05$.
** – values in columns with different letters differ significantly ($P < 0.01$); * for $P < 0.05$.
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NS – różnice nieistotne oznaczone w kolumnach.

with regard to this trait. The fact that shell strength and thickness are positively correlated to shell density was suggested by Premavalli and Viswanagthan [2004], who found that hen's age has an effect on the incidence of inner shell cracks and egg weight is negatively correlated to shell thickness. Pantheleux et al. [1999] demonstrated that thicker eggshell is only partly responsible for its greater strength. As reported by Hunton [2005], mechanical properties of eggshell are influenced mainly by its structure and the concentration of shell matrix proteins, whereas the age-related changes in mechanical properties of the shell are associated with lower availability of calcium and phosphorus to the hen from the diet and the slowing of the mineralization process. The results obtained are highly interesting but the high variation in shell quality traits, particularly in shell strength, requires this phenomenon to be observed in successive generation of the hens.

The data collected on hatchability are shown in Figures 3–5. As is evident from Figure 3, strains R-11 and A-33 were characterized on each evaluation date (March–May) by very good and similar egg fertility ranging from 92.12 to 92.47 and from 90.45 to 92.00%, respectively. In strain K-22, egg fertility was also high

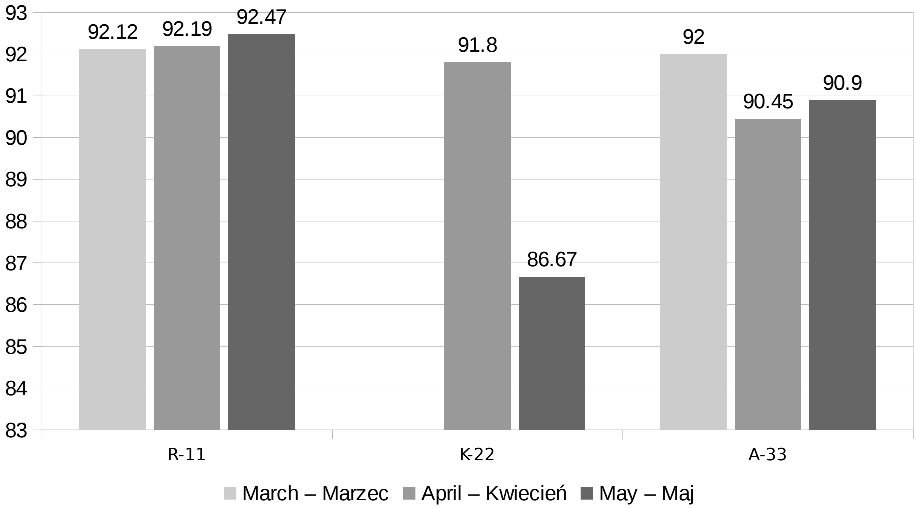

Fig. 3. Egg fertility (%)

Rys. 3. Zapłodnienie jaj (%)

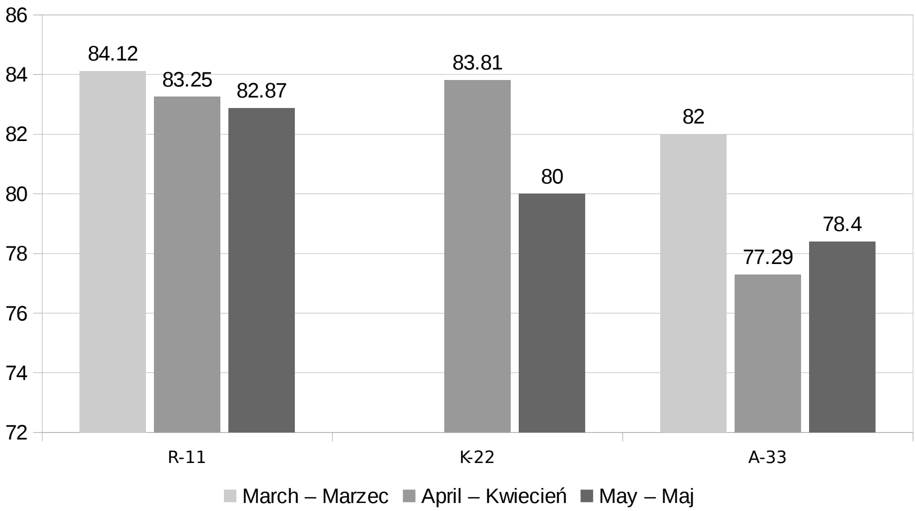

Fig. 4. Hatchability of set eggs (%)

Rys. 4. Wyląg piskląt z jaj nałożonych (%)

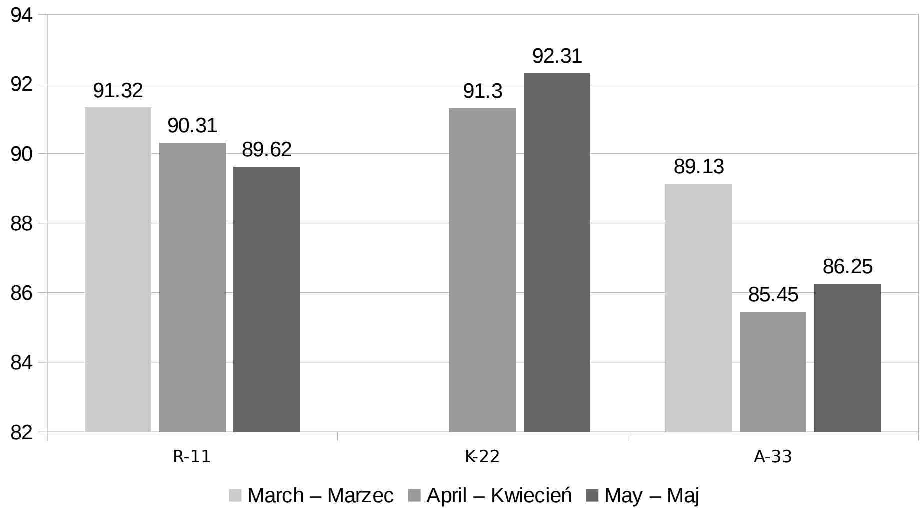

Fig. 5. Hatchability of fertile eggs (%)

Rys. 5. Wyląg piskląt z jaj zapłodnionych (%)

(91.80% in April), but it decreased to 86.67% at the next hatching (May). In all the strains under study, hatchability of healthy chicks from set eggs was satisfactory and the best parameters were obtained from the March hatching in strains R-11 and A-33, and from the April hatching in strain K-22. As reported by Borzemska and Kosowska [1997], depending on species, breed and production type of birds, hatching losses of 7.5 to 20% are considered physiological. A study by Niedziółka [1997] shows that 20% artificial incubation failures were caused by improper storage of eggs, 20% losses were due to deaths resulting from poor environmental conditions in the incubator, and another 20% losses were due to improper turning of eggs during incubation. In over 40% of the cases, decreased hatchability of chicks was caused by genetic factors, reproductive capacity of the parents, the effect of their feeding, the improper setting of eggs in the incubator, as well as various types of infections, which shows the complexity of different factors that influence hatchability parameters. Because the hatching eggs were laid under the same environmental conditions and the incubation took place in a modern incubator, the differences in fertility and hatchability rates may be determined by bird genotype and age. Zgłobica et al. [1995] as well as Cywa-Benko and Krawczyk [2003] stress that one of the main factors affecting the efficiency of egg hatching is the genotype of birds. However, according to Szwaczkowski [2003] hatchability traits are characterized by low coefficients of heritability ($h^2 < 0.2$). Analysis of the data shows that better hatchability parameters, especially for hatchability of chicks from set eggs, were obtained for earlier hatching dates.

CONCLUSIONS

The R-11, K-22 and A-33 strains of hens are valuable for Polish breeders as they form a reserve of unique phenotypic and egg quality traits. The present study confirmed that hen origin (genotype) has an impact on performance, reproductive results, and egg quality traits. The results showed that the analysed strains were in good health during both rearing and production. R-11 and K-22 strains were found to differ considerably from A-33 in terms of the evaluated productive traits, in particular the body weight, the egg weight, and hatchability parameters. The higher body weight of R-11 and K-22 hens and cocks makes these birds especially suited for both egg and meat production (general-purpose type), whereas Rhode Island White (A-33) light hens are characterized by the highest egg production, persistency of egg production, and high egg weight, especially on the second evaluation date. The results also demonstrated differences in the quality of eggs from hens of the compared strains. This particularly concerned traits such as shell colour, weight of egg, shell and yolk, and shell quality parameters. It was also confirmed that many of the egg and shell quality traits change with age of the birds. All of the results reported here provide valuable information for characterizing these unique breeding strains.

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KSZTAŁTOWANIE SIĘ CECH UŻYTKOWYCH I JAKOŚCI JAJ W TRZECH RODACH KUR NIEŚNYCH

Streszczenie. Celem badań była ocena kształtowania się zmienności cech użytkowych i jakości jaj w trzech rodach kur nieśnych tj. Rhode Island Red rody: R-11 i K-22 oraz Rhode Island White ród A-33. W badaniach potwierdzono wpływ pochodzenia kur (genotypu) na kształtowanie się wyników użytkowości i reprodukcji, a także cechy jakości jaj. Na podstawie uzyskanych wyników odnotowano dobrą zdrowotność ocenianych rodów zarówno w okresie wychowu jak i produkcji. Stwierdzono także duże zróżnicowanie, pomiędzy rodami: R-11 i K-22 a A-33 w zakresie ocenianych cech użytkowych, a zwłaszcza masy ciała i jaja oraz parametrów wylęgowości. Uzyskane wyniki wskazują, także na zróżnicowaną jakość jaj pochodzących od kur porównywanych rodów. Szczególnie dotyczyło to takich cech jak: barwa skorupy, masa jaja, skorupy i żółtka oraz parametrów jakości skorup. W badaniach potwierdzono także, że wiele cech jakości jaj oraz skorupy zmienia się wraz z wiekiem kur. Wszystkie zebrane wyniki badań stanowią cenne informacje do charakterystyki tych unikalnych rodów hodowlanych.

Słowa kluczowe: kury nieśne, cechy użytkowe, jakość jaj

Accepted for print: 15.10.2016

For citation: Calik, J. (2016). Productive traits and egg quality in three strains of laying hens. Acta Sci. Pol. Zootechnica, 15(3), 27–42. DOI: 10.21005/asp.2016.15.3.03