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Assessment of productivity and egg quality in Rhode Island Red (R-11, R-22) and Rhode Island White (A-33) laying hens

Jolanta Calik

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

Introduction

Rhode Island Red chickens belong to the most typical representatives of utility breeds, commonly used in Poland and earlier known as *Karmazyn*. Rhode Island Red breed was originally developed in the second half of the 19th century in the State of Rhode Island in the United States. This relatively uniform breed was created by cross-breeding of different chicken breeds with Asian birds, like Cochin hens and Malay game fowl and selection for better laying performance (Verhoef & Rijs, 2003). At the beginning, only birds with brown plumage and single crest were recognized as compliant with the breed standard. Later also birds with white plumage were included. Line R-11 was brought to Poland from Great Britain before 1939 while cross-breeding works with Rhode Island Red (K-22) and Rhode Island White (A-33) started here at the end of 1970s.

All the above-mentioned chicken populations are valuable breeds for breeding and rearing in Poland, being a reservoir of unique phenotypic and egg quality traits (Cywa-Benko, 2002; Połtowicz et al., 2004; Calik, 2008, 2014, 2016; Puchała et al., 2014). They are large and calm birds with mild temperament. R-11 and K-22 hens and cocks have red-brown or mahogany plumage while A-33 are white (Photos 1–3). These birds are distinguished by different genetic structure and origin compared with other breeds reared in Poland while bred with other breeds show a high level of heterosis. These breeds are particularly useful for extensive rearing systems, as backyard birds excellently using green runs. It is particularly significant because in the last years consumers are increasingly interested in buying chicken products from extensive rearing systems (organic or free-range)

The aim of the studies was to analyze variability of performance and egg quality traits in three lines of laying hens Rhode Island Red (R-11), Rhode Island Red (K-22) and Rhode Island White (A-33).

Material and methods

The study was conduced on 930 Rhode Island Red R-11 chicks, 1050 Rhode Island Red K-22 chicks and 1080 Rhode Island White A-33 chicks. Hens and cocks were housed at the male-to-female ratio of 1 : 10–12 on the farm in the Experimental Station of the National Research Institute of Animal Production in Chrzelów and Aleksandrowice (IZ PIB). Birds were fed a standard laying feed mixture DJ and had free access to feed and water (*ad libitum)*. Feed mixture contained: 89.11% of dry matter, 11.28% of crude ash, 16.93% of total protein, 2.15% of crude fat, 2.5% of crude fiber, and 3.55% calcium and 0.5% phosphorus. Analyses of basic feed components were performed in the Central Laboratory of IZ PIB. Hens and cocks were housed under optimal environmental conditions: at a temperature of 18–20°C and relative humidity 60–80%, in a litter bedding system, with stocking density of 5 birds per m^2.

The studies were conducted in 2016 both in rearing and laying period. Based on production files kept on farms and measurements and analysis performed during the studies, the following parameters were analyzed: percent survival rate of chicks during rearing and production period, body weight at 20 weeks of age, sexual maturity of flock (as determined by the number of days from hatching till the day when flock achieved 30% and 50% egg laying percentage), egg weight at 33 and 35 weeks of age, the number of eggs laid during the production period.

Also at 33 and 53 weeks of age, internal quality of eggs and shell were examined (30 eggs from each line in each test) using electronic (EQM) Egg Quality Measurement devices (TSS QCS-II). Shell strength (N) was measured using a Stable Micro Systems analyzer.

The obtained results were analyzed for statistical significance using ANOVA. Calculations were conducted using a statistical package 'Statgraphic plus 5.1.

Photo 1. Rhode Island Red (R-11)

Photo 2. Rhode Island Red (K-22)

Photo 3. Rhode Island White (A-33)

Results and discussion

Health status of the studied birds during the rearing period can be assessed as very good (Tab. 1). Zero mortality and health-related cullings were noted in K-22 males, while in the remaining lines these values were low and did not exceed 1.0%. Just like in males, in females mortality and culling levels were low, ranging from 0.40 (R-11) to 1.28% (A-33), thus, survival rate broken down by sex and line was at a very high level from 98.72% to 100%. Also during a 36-week test period, survival rate both in males and females was very high and amounted to from 99.02 (R-11) to 99.13% (A-33) and from 99.40 (A-33) to 99.68% (K-22), respectively.

The obtained data evidence good environmental conditions of birds' housing, appropriate feeding, and most of all, proper veterinary prophylactic measures efficiently protecting the flocks from diseases.

Table 1. Mortality and culling levels in the studied populations during rearing and production with regard to sex

Breed and line	Mortality and health-related cullings (%)			
	0–20 wks		21–56 wks	
	males	females	males	females
Rhode Island Red (R-11)	0.83	0.40	0.98	0.35
Rhode Island Red (K-22)	0.00	0.55	0.92	0.32
Rhode Island White (A-33)	0.71	1.28	0.87	0.60

After the rearing period was finished, all lines were transferred from the rearing house to the laying house and their performance was estimated. Body weight of males and females was measured at 20 and 53 weeks of age. At 20 weeks, the highest body weight was noted in K-22 (2160 g) and R-11 (1955 g) cocks, while A-33 cocks had the lowest body weight (1585 g), the differences were confirmed by statistical analysis (P≤0,05 or P≤0,01). At 53 weeks, R-11 cocks were heavier from K-22 cocks by 113 g and from A-33 cocks by as much as 412 g. The differences both between lines and test dates were statistically significant (P≤0.05 or P≤0.01). In hens, mean body weight at 20 weeks of age ranged from 1271 (A-33) to 1641 g (K-22). At 53 weeks, R-11 hens were the heaviest (2389 g) while A-33 hens were the lightest (1638 g) at P≤0.01 both between lines and measurement dates. Coefficient of variation (V%) for body weight ranged from 6.94 to 11.50%.

At 33 weeks A-33 hens laid the heaviest eggs (56.93 g), while K-22 the lightest ones (54.09 g), the differences between all studied lines were confirmed by statistical analysis (P≤0.05 or P≤0.01). Egg weights evaluated at 53 weeks were more uniform and fluctuated in the range from 60.72 (K-22) to 61.97 g (R-11). Coefficient of variation (V%) on both test dates remained at similar level (7.27–8.82%). Huge differences between the lines were documented in sexual maturity age at laying percentage of 30% and 50%. A-33 and K-22 hens were the first to attain the laying age, i.e. on average at 139 (30%) and 142 (50%) days of age while R-11 hens the same laying percentage achieved as late as at 158 and 165 days of age, respectively. Considerable differences were also noted in mean hen-day egg production and laying percentage. These indices were the highest in A-33 line (184.25 pcs and 72.69%), and the lowest in R-11 line (163,71 pcs and 62,67%).

Table 2. Production results of the studied populations with regard to sex

Trait and unit of measurement		Age of bird (wks)	Breed and line		
			Rhode Island Red (R-11)	Rhode Island Red (K-22)	Rhode Island White (A-33)
Body weight – males (g)	$\bar{x}$ v SD	20	1955 Ba 10.14 198.29	2160 Bb 7.84 169.28	1585 A 6.94 110.17
	$\bar{x}$ v SD significance	53	2898 Ba 8.97 260.24 **	2785 Bb 7.94 221.12 **	2486 A 11.17 277.63 **
Body weight – females (g)	$\bar{x}$ v SD	20	1422 A 10.05 143.02	1641 B 9.02 148.08	1271 C 11.50 146.14
	$\bar{x}$ v SD significance	53	2389 A 9.39 224.51 **	2113 B 11.09 234.41 **	1638 C 10.10 165.50 **
Egg weight (g)	$\bar{x}$ v SD	33	55.65 Aa 7.68 4.27	54.09 B 8.43 4.56	56.93 Ab 7.27 4.15
	$\bar{x}$ v SD	53	61.97 7.43 4.60	60.72 8.82 5.35	61.46 7.76 4.77
Sexual maturity (days)	30% 50%		1.58 165	140 143	138 141
Hen-day egg production (pcs)			163.71	173.47	184.25
Laying percentage			62.67	68.84	72.69

Note: $\bar{x}$ – mean value, v – coefficient of variation (%), SD – standard deviation (g).
A, B – highly significant differences (P<0.01); a, b – significant differences (P<0.05) between hen lines, separately for sexes.

Analysis of egg-laying curve (Fig. 1) indicates that A-33 and K-22 hens attained a high laying percentage (above 64%) already in the first weeks of evaluation, and it remained at a good level until the end of production. In R-11 line, laying percentage was lower in the first four production weeks (25.78%) but after reaching the maximum (75.45%) in the third month of production they showed also good laying percentage till the end of experiment.

Literature reports indicate that statistically significant differences between breeds in body weight and in highly correlated with it egg weight result from genetic predisposition (Anang et al., 2000). Szwaczkowski et al. (2003) reported that heritability coefficient for these traits assumed high values (h^2>0.5–0.6).

Moreover, early maturing hens are also characterized by genetically determined better laying performance which is corroborated by usually negative relationships between sexual maturity age and laying performance.

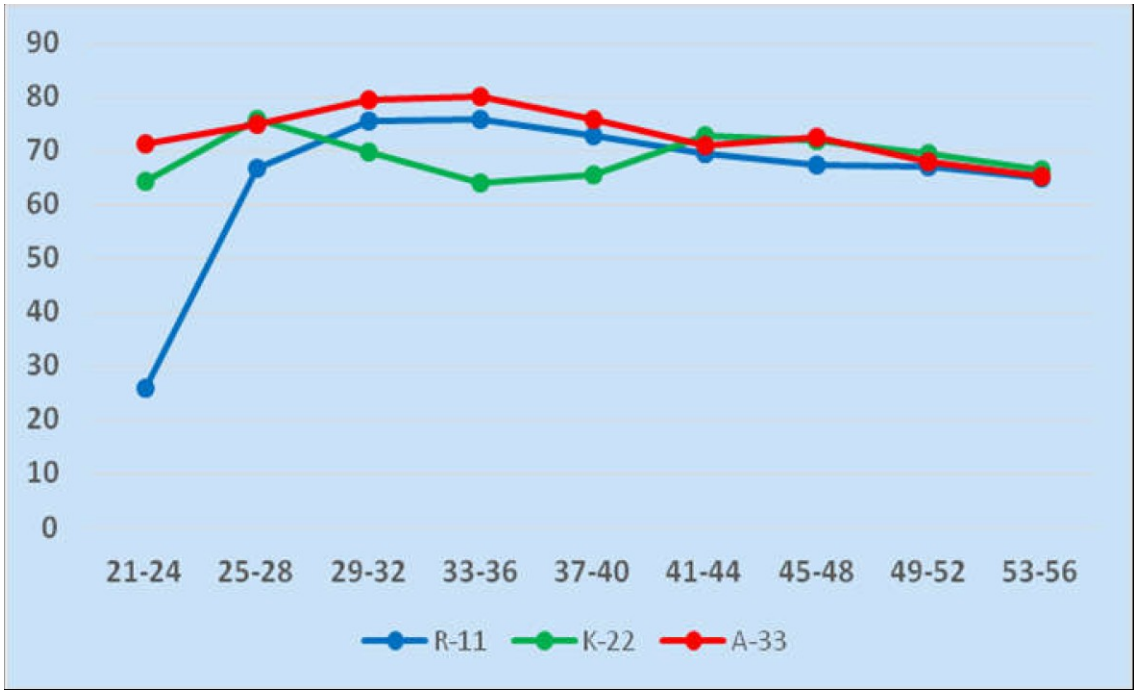

Figure 1. Egg-laying curve (%)

Development of physical egg traits depends on an array of factors. Origin of hens (genotype) is one of them, being, besides age or housing system, of a key significance for nutritional value of eggs (Cywa-Benko, 2002; Basmacioglu & Ergul, 2005; Czaja & Gornowicz, 2006; Calik, 2008, 2016). The present studies demonstrated significant variations in physical traits of eggs derived from different laying hen lines, which is presented in Tab. 3. In these studies, it was observed that as egg size increased, their shape was becoming more and more elongated, as confirmed by a lower shape index. The greatest dynamics of these changes was seen in R-11 line which was confirmed by statistical analysis ($P \leq 0.05$).

Egg weight increased with hen age and ranged from 54.83 (A-33) to 57.23 g (K-22) (33 week), while in the next test (53 week) from 62.60 g (R-11) to 64.31 g (K-22), and the differences both between lines and measurement days were statistically significant ($P \leq 0.05$ or $P \leq 0.01$). The increase in egg weight was accompanied by a significant rise in yolk weight (g) and yolk percentage in the egg. Here eggs from R-11 hens were particularly notable (29.30%), when estimated at 53 weeks of hen age. The lowest yolk percentage (26.74%) was noticed in eggs from A-33 hens.

Coefficient of variation for all the above-mentioned traits was usually low and did not exceed 8.5%. The studied chicken lines markedly differed in egg white quality as estimated by albumen height (mm) and Haugh units (HU). The best egg white quality both at 33 and 53 weeks of hen age was estimated for eggs from R-11 and K-22 hens compared with eggs from A-33 hens which was confirmed by statistical analysis ($P \leq 0.01$). Independently of hen genotype, egg white quality parameters significantly worsened with age ($P < 0.01$). A much greater variability of albumen height (10.50–12.67%) and Haugh units (5.04–6.25%) was recorded.

A significant deterioration of egg white quality with age was also reported by studies of Silversides & Budgell (2004), Czaja & Gornowicz (2006) and Calik (2016). In those studies, hens were fed a mixture unsupplemented with dyes, thus, the above values were mostly determined by genetic factors.

At 33 weeks of hen age, yolk colour estimated according to the La Roche scale was uni-

form and ranged from 7.78 to 8.01 pts. Yolk colour intensity significantly increased with age (P≤0.05) in R-11 hens and decreased in K-22 and A-33 hens which could be related to laying rate. Coefficient of variation of this trait ranged from 8.98 to 13.02%.

Table 3. Egg shape index, weight, and internal quality

Item	Age (wks)	Rhode Island Red (R-11)		Rhode Island Red (K-22)		Rhode Island White (A-33)	
		$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%
Egg shape index (%)	33 53 signif.	76.66±2.67 74.94±2.95 Aa *	3.48 3.96	77.00±2.07 76.39±2.56 b NS	2.69 3.54	77.90±3.39 77.43±2.88 B NS	4.35 3.72
Egg weight (g)	33 53 signif.	56.73±3.64 A 62.60±3.16 a **	6.42 5.01	57.23±2.65 A 64.31±4.53 b **	4.64 7.05	54.83±3.30 B 63.86±5.37 **	5.97 8.34
Yolk weight (g)	33 53 signif.	14.76±1.04 18.32±1.12 **	7.01 6.14	14.79±1.04 18.48±1.41 A **	7.02 7.65	14.23±1.05 17.03±1.38 B **	7.38 8.08
Yolk content (%)	33 53 signif.	26.05±1.72 29.30±2.04 A **	6.62 6.95	25.97±1.96 28.93±2.23 A **	7.54 7.93	25.96±1.54 26.74±1.99 B	5.96 7.44
Albumen height (mm)	33 53 signif.	9.57±1.10 A 8.30±0.87 A **	11.42 10.50	9.41±1.07 A 8.75±0.99 A **	11.36 11.34	7.97±1.01 B 7.64±0.89 B **	12.67 11.64
Haugh units (HU)	33 53 signif.	97.79±4.98 A 90.11±4.84 A **	5.05 5.37	96.82±4.87 A 91.93±5.05 A **	5.04 5.49	90.32±5.44 B 85.72±5.36 B **	6.02 6.59
Yolk colour (pts)	33 53 signif.	8.01±0.93 8.70±0.84 A *	11.55 9.62	7.78±0.79 7.20±0.89 B *	10.15 12.36	7.83±1.02 7.13±0.64 B *	13.02 8.98
Blood spots (%)	3 5 3	0.0 3.3 3		0.0 0.0 0		0.0 3.3 3	
Meat spots (%)	3 5 3	3.3 6.6 6		3.3 6.6 6		0.0 3.3 3	

A, B – values in rows with different letters differ significantly for P<0.01; a, b – for P<0.05.
** – values in columns with different letters differ significantly for P<0.01; * – for <0.05.
NS – non-significant differences marked in columns.

Table 4. Egg shell traits

Item	Age (wks)	Rhode Island Red (R-11)		Rhode Island Red (K-22)		Rhode Island White (A-33)	
		$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%	$\bar{x}$ ±SD	V%
Shell colour (%)	33	51.73±4.58 A	8.71	38.18±2.64 B	7.54	35.83±3.82 C	10.66
	53	52.30±4.50 A	12.84	38.33±4.64 Ba	12.11	36.52±3.89 Bb	10.68
	signif.	NS		NS		NS	
Shell weight (g)	33	5.69±055	9.70	5.74±0.49	8.47	5.66±0.41	7.29
	53	5.99±0.59 A	9.84	6.59±0.61B	9.26	6.47±0.64 B	8.89
	signif.	*		**		**	
Shell density (mg/cm^2)	33	75.82±7.88	10.39	77.78±7.76	9.97	76.62±5.24	6.84
	53	74.52±7.78 A	10.44	80.65±8.66 B	10.73	80.69±8.07 B	9.99
	signif.	NS		NS		NS	
Shell thickness (μm)	33	0.343±0.03	8.74	0.341±0.03	8.79	0.357±0.02	5.60
	53	0.336±0.04 a	11.90	0.357±0.03 b	8.40	0.358±0.03 b	8.37
	signif.	NS		NS		NS	
Shell strength (N)	33	43.93±8.04	18.30	42.31±9.18	21.51	43.71±7.59	17.22
	53	40.77±9.53	23.37	42.11±9.88	23.46	42.53±8.84	20.78
	signif.	NS		NS		NS	

A, B – values in rows with different letters differ significantly for P<0.01; a, b – for P<0.05.
** – values in columns with different letters differ significantly for P<0.01; * – for P<0.05.
NS – non-significant differences marked in columns.

Moreover, in older R-11 and A-33 hens, blood spots were observed more often (3.33%). Frequency of meat spots was at the level 0.00–6.66% and this defect also aggravated with hen age, which was also reported by Cywa-Benko (2002).

From commercial perspective, the most important egg traits include egg weight and shell quality parameters: weight, thickness and density, influencing its strength (Hocking et al., 2003; Premavalli & Viswanagthan, 2004; Roberts, 2004; Hunton, 2005; Calik, 2008). Egg shell quality parameters at 33 and 53 weeks of age of different hen lines are presented in Tab. 4.

The present studies demonstrated genetically determined differences in egg shell colour intensity (35.83–52.30%). Statistically significant (P≤0.05 or P≤0.01) differences were noted between all tested lines, with a tendency towards lightening of the shell colour with hens' age. Shell weight at 33 weeks remained at a similar level while statistically significant (P≤0.05 or P≤0.01) differences were recorded between test days. At 33 weeks of hen age, eggs from R-11 hens showed the highest shell strength (43.93 N) which declined to 40.77 N at the next measurement date, when shell weight, thickness and density were also reduced (P<0.05). In K-22 and A-33 lines, both at 33 and 53 weeks shell quality parameters, i.e. shell density (76.62–80.69 mg/cm^2), thickness (0.341–0.358 μm) and strength (42,31–43,71 N) remained at a high level. Notable is a high coefficient of variation (V = 17.22–23.46%) for shell strength which indicates wide diversity of eggs in terms of this trait.

Conclusions

The obtained results demonstrate the impact of origin of hens (genotype) on their perfor-

mance and egg quality traits. The tested lines are characterized by a high survival rate (above 98%), diverse body and egg weight and laying performance. Birds of R-11 and K-22 lines are characterized by a higher body weight which makes them suitable for both egg and meat production.

On the other hand, A-33 hens are distinguished by a better laying performance and egg weight at a lower body weight, which makes them useful especially for laying eggs. Eggs from R-11 and K-22 hens were characterized by a higher yolk percentage and better egg white quality parameters whereas eggs of A-33 hens presented better shell quality parameters. Moreover, the studies confirmed age-dependency of the changes in many egg and shell quality traits.

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ASSESSMENT OF PRODUCTIVITY AND EGG QUALITY IN RHODE ISLAND RED (R-11, K-22) AND RHODE ISLAND WHITE (A-33) LAYING HENS

Summary

The aim of the study was to analyse variation in productive and egg quality traits in three lines of laying chickens: Rhode Island Red (R-11), Rhode Island Red (K-22) and Rhode Island White (A-33). Based on the results obtained, it was concluded that bird origin (genotype) had an effect on the productive results and egg quality traits. The evaluated lines were characterized by high survival (more than 98%), and differences in body weight, egg weight, and egg production. R-11 and K-22 birds have a higher body weight, which makes them suitable for both egg laying and meat production. Hens of line A-33, which show lower body weight, are characterized by higher egg production and egg weight, which makes them useful mainly for laying eggs. Eggs from R-11 and K-22 hens are characterized by higher yolk percentage and better albumen quality parameters, whereas eggs from A-33 hens showed better shell quality parameters. In addition, the present study confirmed that many egg and shell quality characteristics change as hens grow older.

Key words: laying hens, productive traits, egg quality

Rhode Island Red R-11

Rhode Island White A-33

Phot. J. Calik