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EFFECT OF GENOTYPE, FEATHER GROWTH-RATE GENE AND THE AGE OF HENS ON THE EGG QUALITY

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Abstract

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The study monitored the effect of genotype, feather growth-rate gene and the age of hens on egg quality parameters of laying type hens Dominant. The following genotypes were used for the needs of this experiment: Barred Plymouth Rock strain, slow- and fast-feathering; Blue Plymouth Rock strain, slow- and fast-feathering and the crossbreds of the above mentioned strains in the F_1 generation (strain Blue in the paternal position). The observation showed a significant effect of age on the selected parameters, conclusive effect of genotype (with the exception for egg weight and yolk colour) and notable effect of the feather growth-rate gene on the egg weight, the ratio of yolk, white and eggshell, Haugh's unit, eggshell strength and colour. Most of the parameters were influenced by the interactions between the age of hens and the genotype, between the age of hens and the representation of the K/k alleles and between the genotype and the representation of the K/k alleles. There was also interaction between the age of hens and the genotype and the representation of the K/k alleles.

Key words: laying type hens, Dominant, age, genotype, allele K/k, yolk, albumen, eggshell

Introduction

Some of the breeding programmes employ the use of adaptation genetics (with respect to interactions between the genotype and environment) in order to produce hybrids able to reach satisfying egg quality parameters even when subjected to variable farming conditions (Tyller and Holoubek, 2003). Such layer hens are able to sustain several production cycles and fitt into free range farms as well as to the small farmers.

The relationship of sex-linked feathering genes with egg production have been studied by Merat (1967), Lowe and Garewood (1981), Kotaiaht (1981), Dunnington and Siegel (1986), Katanbaf et al. (1989), O'Sullivan et al. (1991), Abd El-Rahman (2006), Durmus et al. (2010) and Mincheva et al. (2012). The effect of feather growth-rate gene on the egg quality remains an intensely discussed topic. Concerning this aspect Máchal et al. (1999) state, that this gene exerts a certain influence over the number of laid eggs as well as their weight. Lowe and Garwood (1981) reported that feathering genotype did not affect egg weight in Rhode Island Red and White leghorn hybrids. However, Durmus et al. (2010, 2012) and Mincheva et al. (2012) demonstrated that egg weight was higher in rapid feathering hens. Tůmová et al. (1997) observed certain differences concerning the yolk, albumen and eggshell quality in fast- and slow-feathering lines of Rhode Island Red hens. Arent et al. (1997) report, that they discovered a significant difference in the yolk ratio between slow- and fast-feathering subpopulation of Rhode Island Red hens in favour of fast-feathering layers. Simultaneously they state that with increasing egg weight the albumen ratio decreases with no regard for the particular genotype. Hens with the rapid feathering genotype produced eggs with thicker eggshells and albumen ratio, albumen index, Haugh units were lower

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(Mincheva et al., 2012). Fotsa et al. (2001) did not observe any influence of the feather growth-rate gene on the layer's adaptability to higher temperatures in a given environment.

The objective of the present paper is to evaluate the influence of the genotype, the feather growth-rate gene and the age of layers on the egg quality.

Material and Methods

The experiment took place over a period of 12 months in the laying hall of a farm breeding layer hens. A total of 450 pullets were divided at the age of 16 weeks into six groups of 75 chickens according to genotype and the feather growth-rate gene (Table 1).

The hens were housed in individual cages in a traditional three-deck battery system. The farming conditions corresponded to the regular requirements of poultry farming using battery cages. The hens were fed from the 20th week of age with a feed mixture for hens in the first production cycle NP_1 and from the 42nd week of age with a feed mixture NP_2. The layers had ad libitum access to both feed and water. The feed mixture compositions and nutrient contents are listed in Table 2.

At 20 weeks of age, the birds were provided with 14 hours of light, extended gradually to 16 hours at 24 weeks of age. The average light intensity was 10 lx at the level of the middle battery deck.

Eggs were collected for the purpose of determining shell quality parameters at the ages of 27, 35 and 56 weeks. The eggs were always collected at these ages on four consecutive days. For each analysis, 225 eggs were collected from each group, i.e., 675 eggs at three analytic dates. Each analysis was thus performed for 1350 eggs from six groups of hens, i.e., 4050 eggs for the entire experiment.

Parameters taken on each of these eggs were their weight, the yolk, albumen, eggshell ratio to egg, Haugh's unit, yolk and albumen index, eggshell strength and colour of eggshell. The eggs were weighed by using an electronic scale with 0.01 g sensitivity. Eggshell colour was evaluated by an objective photometric method using a QCR reflectometer, also by TSS England, operating on the principle of determining the percentage of light reflected by the eggshell surface within the interval from 0 to 100%. Higher values correspond to lighter eggshell shades. The eggshell strength was evaluated using the QC-SPA device (TSS England). The colour of the yolk was determined according to the La Roche scale (scores 1-15). The proportions of yolk, albumen, and eggshell were calculated in relation to egg weight and expressed as percentages. The Haugh units score, albumen and yolk index were also computed.

The data obtained were subjected to the analysis of variance using general linear model procedure. The statistical

Table 2
Composition of feed mixtures

Component, %	NP_1	NP_2
Wheat	36.45	46.00
Wheat bran	-	3.00
Wheat feed flour	-	5.00
Barley	3.00	-
Maize	27.50	22.30
Maize gluten	0.60	-
Soybean meal	20.10	13.00
Vegetable oil	2.10	0.30
Natural rock salt	0.25	0.30
VPN 306	0.30	0.30
Premix Lysine 100	0.10	0.10
Methionine premix	0.15	0.10
Dicalcium phosphate	1.40	1.10
Calcium carbonate	7.90	8.40
Sodium bicarbonate	0.15	0.10
Analyzed content of nutrients		
Crude protein, %	16.64	15.02
Metabolizable energy, MJ	11.50	11.09
Methionine, %	0.41	0.33
Lysine, %	0.88	0.71
Ca, %	3.40	3.51
P total, %	0.64	0.59

Table 1
Scheme of the experiment

Group	Genotype		Number of hens	Number of eggs
1	Barred Plymouth Rock (BPR)	D 951 (K)	75	675
2		D 901 (k)	75	675
3	Blue Plymouth Rock (BLPR)	D 594 (K)	75	675
4		D 894 (k)	75	675
5	F_1 hybrid (F_1)	D 107 (K)	75	675
6		D 107 (k)	75	675

K – slow-feathering strains, k – fast-feathering strains analysis was processed by the computer application SAS 9.2 (SAS Institute Inc., Cary, NC, USA). The statistical model was:

$$y_{ijkl} = \mu + A_i + G_j + K_k + AG_{ij} + AK_{ik} + GK_{jk} + AGK_{ijk} + e_{ijkl},$$

where y_{ijkl} was the value of trait, μ was the overall mean, A_i was the effect of age (27, 35 and 56 weeks), G_j was the effect of genotype (BPR, BLPR, F_1), K_k was effect of K/k allele (K, k), AG_{ij} was the effect of the age x genotype interaction, AK_{ik} was the effect of the age x K/k allele, GK_{jk} was the effect of the genotype x K/k allele interaction, AGK_{ijk} was the effect of the age x genotype x K/k allele interaction, e_{ijkl} was the random residual error.

Results

As it is evident from the Table 3, the average egg weight was significantly (P≤0.001) affected mainly by the age of hens. The egg weight increased with increasing age of the layers for all genotypes (with the exception of F_1 – K – 56 weeks). Another factor conclusively (P≤0.05) affecting the egg weight was the feather growth-rate gene, even though its specific effect varied in different genotypes. This parameter was influenced by the interaction between the age of hens and the genotype. There was also interaction (P≤0.05) between the genotype and the representation of the K/k alleles.

The eggshell ratio was also notably (P≤0.001) affected by the age of hens, genotype and feather growth-rate gene. A higher proportion of eggshell was observed in fast-feathering hens of all three genotypes (with the exception of Barred Plymouth Rock at 56 weeks of age). The eggshell ratio was influenced (P≤0.05) by the interaction between the age of hens and the genotype and (P≤0.001) by the interaction between the genotype and the representation of the K/k alleles. There was also interaction (P≤0.001) between the genotype and the representation of the K/k alleles. Similar conclusions could be drawn from the results concerning the eggshell strength, where was higher eggshell strength observed in the fast-feathering population with the exception of Barred Plymouth Rock hens aged 56 weeks. There was also interaction (P≤0.001) between the genotype and the representation of the K/k alleles. The eggshell colour was significantly influenced by the age of hens (P≤0.001), where despite of notable deviations, the colour intensity decreased with increasing age. The eggshell colour was also affected by the genotype (P≤0.001) and feather growth-rate gene. The eggshell colour in slow-feathering hens of the F_1 generation was almost identical to the one observed in the slow-feathering hens of the Blue Plymouth Rock line represented in the paternal position. Similar conclusions were observed in the case of fast-feathering hens of the F_1 generation, where the eggshell colour corresponded to the one displayed by fast-feathering hens of the Blue Plymouth Rock line.

Table 4 shows that the yolk ratio to the total egg weight increased substantially (P≤0.001) with increasing age of hens (with the exception of Barred Plymouth Rock – K – 56 weeks) and was also significantly (P≤0.001) influenced by

Table 3
Results of the egg weight and some parameters of the eggshell quality

Parameter	Age, weeks	Genotype						Age	Significance					
		BPR		BLPR		F_1			Genotype	Allele K/k	Age* genotype	Age * allele K/k	Genotype * allele K/k	Age* genotype* allele K/k
		K	k	K	k	K	k							
Egg weight, g	27	54.47	53.81	53.86	52.93	53.95	55.96							
	35	62.03	62.61	62.91	62.79	61.48	62.95	***	NS	*	*	NS	*	NS
	56	63.80	64.59	63.52	65.41	61.34	64.61							
Eggshell ratio, %	27	54.47	53.81	53.86	52.93	53.95	55.96							
	35	62.03	62.61	62.91	62.79	61.48	62.95	***	***	***	*	NS	***	*
	56	63.80	64.59	63.52	65.41	61.34	64.61							
Eggshell strength, $g.cm^{-2}$	27	4433	4494	4720	5031	4485	5009							
	35	4003	4042	4220	4670	4188	4607	***	***	***	NS	NS	***	NS
	56	4113	3876	4341	4608	4113	4319							
Colour of eggshell, %	27	32.71	35.51	40.93	50.53	40.55	51.39							
	35	41.80	39.89	47.42	53.47	48.96	57.82	***	***	***	NS	***	***	NS
	56	42.24	38.23	48.36	52.36	49.29	54.82							

NS – non-significant; *P≤0.05; ***P≤0.001; K – slow-feathering strains, k – fast-feathering strains the genotype and feather growth-rate gene (P≤0.001). There was also interaction (P≤0.05) between the age of hens and the genotype. For all the monitored groups the yolk ratio was found to be higher in the fast-feathering hens.The yolk index was significantly affected by the age of hens (P≤0.001), by the genotype and the representation of the K/k alleles. This parameter was influenced by the interactions between the age of hens and the genotype and the genotype and the representation of the K/k alleles. There was also interaction (P≤0.001) between the age of hens, the genotype and the representation of the K/k alleles. The yolk colour was markedly influenced (P≤0.001) by the age of hens (where in most cases it decreased with increasing age) and by the feather growth-rate gene (P≤0.001), where for the Barred Plymouth Rock there was observed more intense yolk colour in the fast-feathering populations while for the Blue Plymouth Rock line and F_1 generation the results were inconclusive. The yolk colour was affected (P≤0.05) by the interactions between the age of hens and the genotype and the genotype and the representation of the K/k alleles (P≤0.01). There was also interaction (P≤0.001) between the age of hens, the genotype and the representation of the K/k alleles.

The albumen ratio was significantly (P≤0.001) influenced by the age, the genotype and the feather growth-rate gene of hens. The ratio of albumen decreased with increasing age and it was observed that the ratio tends to reach higher values in slow-feathering populations. The albumen index was significantly (P ≤ 0.001) affected by the age of laying hens, the genotype (P ≤ 0.01) and the feather growth-rate gene of hens (P ≤ 0.001). The albumen index was infuenced (P≤0.01) by the interactions between the age of hens and the genotype and the age of hens and the representation of the K/k alleles (P≤0.01). There was also interaction (P≤0.001) between the genotype and the representation of the K/k alleles. The age of hens, genotype (P≤0.001) and feather growth-rate gene (P≤0.05) were also found to have a significant effect on the Haugh's units score. The egg quality decreased with increasing age of hens. This parameter was affected (P≤0.001) by the interactions between the age of hens and the genotype and the age of hens and the representation of the K/k alleles (P≤0.05), and the genotype and the representation of the K/k alleles (P≤0.01). There was also interaction (P≤0.05) between the age, the genotype and the representation of the K/k alleles.

Table 4
Results of some parameters of the yolk and albumen quality

Parameter	Age, weeks	Genotype						Significance						
		BPR		BLPR		F_1		Age	Genotype	Allele K/k	Age* genotype	Age * allele K/k	Genotype * allele K/k	Age* genotype* allele K/k
		K	k	K	k	K	k							
Yolk ratio, %	27	25.68	26.47	26.27	27.91	24.66	24.98	***	***	***	*	NS	NS	NS
	35	29.93	30.29	30.36	30.98	29.21	29.72							
	56	29.60	31.03	30.97	32.23	29.98	31.22							
Yolk index, %	27	50.80	52.27	52.51	52.82	46.74	48.85	***	***	***	***	NS	***	***
	35	45.78	47.50	45.93	47.74	46.53	45.79							
	56	40.23	43.94	40.91	40.77	42.60	39.86							
Colour of yolk, %	27	7.05	7.16	6.98	6.95	6.75	7.08	***	NS	***	*	NS	**	***
	35	6.97	7.28	7.09	7.26	7.02	7.18							
	56	5.51	6.19	6.33	6.04	6.53	5.96							
Albumen ratio, %	27	63.18	62.35	62.35	60.41	64.37	63.24	***	***	***	NS	NS	NS	NS
	35	59.61	58.97	58.81	57.44	59.87	59.10							
	56	59.29	58.12	58.10	56.30	59.18	57.66							
Albumen index, %	27	9.38	9.88	10.53	9.70	11.54	11.36	***	**	***	**	**	***	NS
	35	8.31	8.74	8.63	8.48	8.26	9.00							
	56	6.59	8.80	6.85	6.74	6.95	7.78							
Haugh unit score	27	83.69	86.57	87.77	86.58	94.16	92.59	***	***	*	***	*	**	*
	35	81.88	82.30	82.88	82.54	81.90	83.78							
	56	74.80	84.46	76.71	75.04	77.16	80.92							

NS – non-significant; *P≤0.05; **P≤0.01; ***P≤0.001; K – slow-feathering strains, k – fast-feathering stra

Discussion

The increase in egg weight found with increasing age in all the genotypes is in accordance with the numerus published works (Rizzi and Chiericato, 2005; Johnson and Gous, 2007; Odabasi et al., 2007; Tůmová and Ledvinka, 2009 and Mitrovic et al., 2010). The influence of the feather growth-rate gene is also reported by many authors (Lowe and Garwood, 1981; Merat et al., 1992; Arent et al., 1997; Máchal, 1999 and Ledvinka, 2003). Our results are partially in agreement with Durmus et al. (2010, 2012) and Mincheva et al. (2012), who reported a higher egg weight in rapid feathering hens.

The results shown for the eggshell quality do not correspond with the data published by Hamilton et al. (1979) and Jelínek (1996), stating that the eggshell quality tends to be lower at the beginning of the production cycle and then increases over the course of the cycle, reaching maximum values in the middle and then slowly decreasing again. Our results found only partial correspondence with the findings of Roland (1984), Tůmová and Ledvinka (2009), Mitrovic et al. (2010), who observed decreasing eggshell strength with age. Mincheva et al. (2012) showed a thicker eggshell in hens with the rapid feathering. There are also observations published by Szczerbinska (1997) and Zhang et al. (2005), who found that the eggshell colour decreases with increasing age of the hens, which corresponds with our results only in the case of the crossbreed F_1 generation.

In agreement with our results, a number of authors point out the trend observed in yolk ratio, which rises with increasing age of layers (Krawczyk, 2009; Sekeroglu and Altuntas, 2009 and Mitrovic et al., 2010).

The significant effects of genotype and feather growth-rate gene on the albumen ratio from the total egg weight do not correspond to the results of some published authors (Vračar et al., 1992; Tůmová et al., 2007; Zita et al., 2009; Mincheva et al., 2012), who all congruently state that the origin of hens (contrary to their age) does not affect any quality of egg parts. Simultaneously, Mincheva et al. (2012) reported a declining trend of the albumen index and Haugh unit scores.

Conclusion

Our observation confirmed a significant effect of the age and genotype on most of the egg quality parameters and also showed a marked effect of the feather growth-rate gene on these characteristics.

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