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LINE EFFECT AND PHENOTYPIC CORRELATIONS AMONG EGG QUALITATIVE TRAITS IN JAPANESE QUAIL EGGS SELECTED ON YOLK CHOLESTEROL CONTENT

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ABSTRACT

Birds of S_{18} generation of line 11 selected for low- and line 12 for high yolk cholesterol content and line 13 as unselected control were used for this experiment. 14-week old quail hens of each of the three-yolk cholesterol lines were used for the analysis. Egg quality characters were obtained from three consecutively laid eggs of each hen, 60 hens were tested from each line. We measured egg weight, yolk weight, shell weight, albumen weight and edible part of egg (g), yolk egg proportion (%) and egg shape index (length .100/with in %). Yolk cholesterol content (mg/100 g of fresh yolk) was estimated according to enzymatic hydrolysis and oxidation method (Cholesterol liquicolor test of Human Gesellschaft für Biochemica und Diagnostica GmbH, Germany). We also calculated cholesterol content in edible part of egg (mg/100 g).

Presented results showed the effectiveness of genetic selection towards yolk cholesterol content of both direction but the selection was more effective in low cholesterol line as in the high cholesterol line. The differences between both lines were high and very highly significant. Also the differences of the yolk cholesterol content between selected lines and unselected control were considerable. The correlations between yolk cholesterol content and other investigated egg quality traits were mainly negative and weak or moderately strong but there were evident differences between investigated lines especially between line 11 selected for low- and line 12 selected for high yolk cholesterol content.

Key words: Japanese quail, egg, yolk, cholesterol content, genetic selection

INTRODUCTION

Eggs are an excellent low fat source of protein, vitamins and minerals. However, the high cholesterol content in yolk has often been considered as a cause for concern in relation to the control of blood cholesterol levels and coronary diseases (Washburn, 1993, Baumgartner, 1995, Hargis 1998). Even if the role of dietary cholesterol on coronary diseases was revised, Šobra, (1996), Pospišilová (2000) and Daniška (1998, 2000) recently confirmed the harmfulness of excessive dietary cholesterol in human nutrition from medical point of view and welcomed the possibility of lowering egg table cholesterol content by selection. Some evidence exists also with the high dietary cholesterol intake and other diseases like prostate-, breast- and colon cancer. Basmacioúlu and Erg (2005) reported the factors affecting cholesterol content and some other characteristics of eggs in laying hens. Accordingly in 1992 we started the divergent selection on yolk cholesterol content (Baumgartner and Simenonovova, 1991). We used Japanese quail as pilot animal for poultry research (Baumgartner, 1990).

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The purpose of this paper was to evaluate the differences in investigated egg quality traits including yolk cholesterol content between the selected lines in the 18th selected generation and to evaluate the phenotypic correlation between the egg quality traits including yolk cholesterol content.

MATERIAL AND METHODS

Animals and selection procedure

The outbred, egg type, wild colour plumage stock 07 in Poultry Breeding Station Ivanka at Danube, Slovakia since 1984 (Baumgartner, 1990) was the base population for this divergent selection experiment. After yolk cholesterol estimate of 60 adult females in year 1991, 25 females in whose eggs had the lowest cholesterol concentration in yolk were selected to establish low cholesterol- (line 11) and 25 females whose eggs had the highest yolk cholesterol concentration were selected to establish high cholesterol (line 12) line. Sufficient quail chickens were hatched to provide approximately 60 females per line at 8 weeks of age. In each generation approximately 20 females from both lines were selected to form the further generation. The criterion for selection was concentration of cholesterol in mg/g of fresh yolk and was based on family, ancestors and individual records. One male was mated with two females; the males were selected based on sib performance of their sisters. Birds of S_{18} generation of line 11 selected for low- and line 12 for high yolk cholesterol content and line 13 as unselected control were used for this experiment.

Rearing and nutrition

The quail-chicks were grown in deep litter floor upto 35 day of age and then were caged individually (Baumgartner and Hetényi, 2001). They received a starter grower ration for turkey rearing HYD-13 containing 260 g NL/kg and ME 11.5 MJ/kg diet for the first 4 weeks, from 4th to 5th week the mixture ration (grower + layer diet) containing 220 mg NL/kg and after 5th week received a layer ration O-16 for pheasant hens with 180 mg NL/kg and ME 11 MJ of diet.

Laboratory analysis

14-week old quail hens of each three-yolk cholesterol lines were used for the analysis. Egg quality characters were obtained from three consecutively laid eggs of each hen, 60 hens were tested in each line. We measured egg weight, yolk weight, shell weight, albumen weight and edible part of egg (g), yolk egg proportion (%) and egg shape index (length .100/with in %). Yolk cholesterol content (mg/100 g of fresh yolk) was estimated according to enzymatic hydrolysis and oxidation method (Cholesterol liquicolor test of Human Gesellschaft für Biochemica und Diagnostica GmbH, Germany). We also calculated cholesterol content in edible part of egg (mg/100 g).

RESULTS AND DISCUSSION

Means, standard deviations, standard errors and coefficient of variability in investigated traits in selected and control lines and effect of line (F test) and difference between lines (Tukey test) are shown in Table 1.

We can see that yolk cholesterol content in mg/100 g of fresh yolk was in low cholesterol selected line 11 significantly lower at 429.28 mg/100 g yolk in comparison with high cholesterol selected line and at 261.07 mg/100 g yolk lower than in control line. The line effect and also all the differences were statistically very highly significant. Similar observations were made also for the cholesterol content in edible part of egg, the line effect and all the differences were statistically significant. The line effect was very highly significant also in all other investigated traits with the exception of albumen weight in which the line effect was the smallest but still significant.

Phenotypic correlation between yolk cholesterol content and cholesterol content in edible part of egg and other egg quality investigated traits are shown in Table 2. The correlation between egg weight and yolk cholesterol content was in line 11 insignificant but in line 12 and 13 was moderately strong, negative and significant. Correlation in the set of all the three lines together was negative and very highly significant. The correlation between egg weight and cholesterol content in edible part of egg was very similar as in yolk cholesterol content. These findings were also valid between cholesterol content in edible part of egg and other investigated egg quality traits.

Phenotypic correlation between yolk weight and yolk cholesterol content was in lines 11 and 13 small, negative and insignificant but in the line 12 was middle strong and significant. Correlation in the all three lines together set was negative and very high significant.

Albumen weight correlation with the yolk cholesterol content was in line 11 small, positive and significant but in the line 13 small, negative and also significant. The correlation in the line 12 was moderately strong, negative and very highly significant. Correlation in the set of all the three lines together was negative and very highly significant.

Correlations between shell weight and yolk cholesterol content was similar to the albumen weight but the correlations were largely smaller and insignificant in exception of line 13. Correlation in the set of all three lines together was very small, negative and insignificant.

Table 1: Characteristics of variability, effect of line (F-test) and significance of means of differences (Tukey test) of egg quality traits in Japanese quail cholesterol lines

Variable	Statistical value	Number of line			F test (n_1,n_2) (2, 537)	Difference between lines	Tukey test between lines
		11	12	13			
	n	180	180	180			
Yolk cholesterol content (mg/100 g)	$\bar{x}$	1501.99	1931.26	1763.06	147.1+++	-429.28	11 - 12+
	s	183.24	268.04	257.67		-261.07	11 - 13+
	$s_{\bar{x}}$	13.658	19.979	19.21		168.20	12 - 13+
	v (%)	12.20	13.88	14.61			
Cholesterol content in edible part of egg (mg/100 g)	$\bar{x}$	522.60	660.84	622.19	114.0+++	-138.24	11 - 12+
	s	59.45	105.69	96.90		-99.59	11 - 13+
	$s_{\bar{x}}$	4.431	7.878	7.22		38.65	12 - 13+
	v (%)	11.38	15.99	15.57			
Egg weight (g)	$\bar{x}$	10.65	10.39	10.79	11.50+++	0.257	11 - 12+
	s	0.90	0.79	0.74		-0.150	11 - 13 ns
	$s_{\bar{x}}$	0.067	0.059	0.055		-0.407	12 - 13+
	v (%)	8.47	7.61	6.88			
Yolk weight (g)	$\bar{x}$	3.37	3.20	3.44	20.74+++	0.177	11 – 12+
	s	0.36	0.414	0.305		0.238	12 - 13+
	$s_{\bar{x}}$	0.027	0.031	0.228		-0.061	11 - 13 ns
	v (%)	10.78	12.94	8.88			
Albumen weight (g)	$\bar{x}$	6.27	6.16	6.28	3.14+	0.114	11 - 12 ns
	s	0.58	0.508	0.47		-0.009	11 - 13 ns
	$s_{\bar{x}}$	0.043	0.038	0.035		-0.124	12 - 13+
	v (%)	9.246	8.251	7.55			
Shell weight (g)	$\bar{x}$	1.017	1.056	1.081	10.25+++	-0.039	11 - 12+
	s	0.091	0.189	0.104		-0.064	11 - 13+
	$s_{\bar{x}}$	0.007	0.014	0.008		-0.025	12 - 13 ns
	v (%)	8.96	17.91	9.68			
Edible part of egg (g)	$\bar{x}$	9.63	9.34	9.71	12.60+++	0.292	11 - 12+
	s	0.833	0.721	0.681		-0.085	11 - 13 ns
	$s_{\bar{x}}$	0.062	0.054	0.051		-0.377	12 - 13+
	v (%)	8.65	7.72	7.01			
Yolk/egg proportion (%)	$\bar{x}$	31.54	30.56	31.83	25.96+++	0.970	11 – 12+
	s	1.623	1.873	1.72		-0.294	11 –13 ns
	$s_{\bar{x}}$	0.121	0.140	0.13		-1.265	12 - 13 +
	v (%)	5.15	6.128	5.42			
Egg shape index (g)	$\bar{x}$	76.41	75.70	77.19	12.59+++	0.710	11 - 12+
	s	2.604	2.906	2.910		-0.776	11 - 13 +
	$s_{\bar{x}}$	0.1941	0.2166	0.2169		-1.486	12 - 13+
	v (%)	3.41	3.84	3.77			

F0.05 (2.537) = 2.99, F0.01 (2.537) = 4.60, F0.001 (2.537) = 6,91

The correlations between edible part of egg and yolk cholesterol content was very similar as of albumen in all three lines taken separately and also together.

Yolk egg proportion correlated with the yolk cholesterol content in line 11 was found to be negative, moderately strong and very highly significant but in lines 12 and 13 the correlation was small and insignificant. Egg shape index correlation with yolk cholesterol content was very small and the correlation was significant only in line 12.

The correlation between yolk cholesterol content and cholesterol content in edible part of egg was naturally very strong and very highly significant in all the three investigated lines.

The correlations between other egg quality traits are shown in Tables 2 and 3. We can see that albumen weight is very strongly correlated with egg weight and moderately correlated with yolk weight in all the three lines. The correlations were positive and very high significant. Similar picture exists for shell weight and edible part of egg and also between egg weight and yolk weight. Correlation of yolk egg proportion with egg weight was very small and insignificant but with egg weight naturally strong and very highly positive. Egg shape index correlated with egg weight and yolk weight negatively in all three lines but the correlation was significant only with egg weight in line 12 and 13. Edible part of egg correlated with albumen weight positively, very strongly and was very highly significant. With shell weight was the correlation similar but little stronger. Egg shape index correlated with albumen weight and shell in line 11 poorly and was insignificant and in line 12 and 13 negatively, moderately and was significant. Egg shape index correlation with shell weight was very small and insignificant.

The comparison of our results in presented paper with domestic fowl (Baumgartner et al., 1998) showed the similarity of the correlation between egg yolk cholesterol content and egg weight of both the avian species. Also, correlation between yolk weight and yolk cholesterol content was similar as in Japanese quail and domestic chickens. Some other correlations were also similar although there exists some differences between the correlations found in Japanese quail and in domestic fowl (Baumgartner et al., 1998). The small positive but insignificant correlation of yolk cholesterol content with egg weight in line 11 found in the present paper was similar with the results of Beyer and Jensen (1989), who investigated the cholesterol content of commercially produced eggs in Georgia, USA. The similarity of our results and results of Beyer and Jensen (1989) is also in the correlation between yolk cholesterol content and yolk weight.

Table 2: Phenotypic correlations between egg quality traits in Japanese quail cholesterol lines

Variable	Line 11 n=180		Line 12 n=180		Line 13 n=180		Lines 11, 12 and 13 together n=540	
	Yolk cholesterol content	Cholesterol content in edible part of egg	Yolk cholesterol content	Cholesterol content in edible part of egg	Yolk cholesterol content	Cholesterol content in edible part of egg	Yolk cholesterol content	Cholesterol content in edible part of egg
	(mg/100 g)		(mg/100 g)		(mg/100 g)		(mg/100 g)	
Egg weight (g)	0.065	0.053	-0.474 +++	-0.351 +++	-0.240 ++	-0.196 ++	-0.246 +++	-0.198 +++
Yolk weight (g)	-0.142	0.048	-0.351 +++	-0.049	-0.174	0.081	-0.268 +++	-0.065
Albumen weight (g)	0.152 +	0.022	-0.446 +++	-0.493 +++	-0.186 +	-0.312 +++	-0.191 +++	-0.277 +++
Shell weight (g)	0.096	0.064	-0.165 +	-0.091	-0.293 +++	-0.256 +++	-0.039	-0.009
Edible part of egg (g)	0.058	0.049	-0.477 +++	-0.357 +++	-0.217 ++	-0.175	-0.260 +++	-0.212 +++
Yolk/egg proportion (%)	-0.337 +++	0.099	-0.008	0.394 +++	0.014	0.375 +++	-0.171 +++	0.168 +++
Egg shape index (g)	-0.161	-0.119	0.200 ++	0.221 ++	0.040	0.050	-0.003	0.041
Cholesterol content in edible part of egg (mg/ 100 g)	0.900 +++	-	0.836 +++	-	0.915 +++	-	0.902 +++	-

+ P < 0.05 ++ P < 0.01 +++ P < 0.001

Table 3: Phenotypic correlations between egg quality traits in Japanese quail cholesterol lines

Variable	Line 11 *n*=180		Line 12 *n*=180		Line 13 *n*=180		Lines 11, 12 and 13 together *n*=540	
	Egg weight (g)	Yolk weight (g)	Egg weight (g)	Yolk weight (g)	Egg weight (g)	Yolk weight (g)	Egg weight (g)	Yolk weight (g)
Albumen weight (g)	0.956 +++	0.482 +++	0.906 +++	0.432 +++	0.902 +++	0.483 +++	0.922 +++	0.469 +++
Shell weight (g)	0.787 +++	0.459 +++	0.324 +++	0.252 +++	0.642 +++	0.425 +++	0.483 +++	0.316 +++
Edible part of egg (g)	0.998 +++	0.660 +++	0.995 +++	0.667 +++	0.993 +++	0.796 +++	0.995 +++	0.708 +++
Yolk/egg proportion (%)	-0.003	0.456 +++	0.080	0.495 +++	0.030	0.634 +++	0.094	0.557 +++
Egg shape index (g)	-0.044	-0.069	-0.277 +++	-0.136	-0.199 ++	-0.140	-0.054	-0.165 +++

+ P < 0.05 ++ P < 0.01 +++ P < 0.001

Table 4: Phenotypic correlations between egg quality traits in Japanese quail cholesterol lines

Variable	Line 11 *n*=180		Line 12 *n*=180		Line 13 *n*=180		Lines 11, 12 and 13 together *n*=540	
	Albumen weight (g)	Shell weight (g)	Albumen weight (g)	Shell weight (g)	Albumen weight (g)	Shell weight (g)	Albumen weight (g)	Shell weight (g)
Edible part of egg (g)	0.956 +++	0.744 +++	0.917 +++	0.289 +++	0.909 +++	0.547 +++	0.927 +++	0.429 +++
Yolk/egg proportion (%)	-0.264 +++	-0.124	-0.320 +++	0.104	-0.344 +++	-0.111	-0.258 +++	0.003
Egg shape index (g)	-0.077	0.006	-0.300 +++	-0.038	-0.203 ++	-0.083	-0.165 ++	-0.021

+ P < 0.05 ++ P < 0.001 +++ P < 0.001

CONCLUSION

Presented results showed the effectiveness of genetic selection towards yolk cholesterol content of both direction but the selection was more effective in low cholesterol line as in the high cholesterol line. The differences between both lines were highly and very highly significant. Also the differences of the yolk cholesterol content between selected lines and unselected control were considerable. The correlations between yolk cholesterol content and other investigated egg quality traits were mainly negative and weak or moderately strong but there were evident differences between investigated lines especially between line 11 selected for low- and line 12 selected for high yolk cholesterol content.

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