Investigation on the frequency of alleles at the k locus and their effect on the growth of two lines of Plymouth Rock chickens

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SUMMARY

The research was performed with the goal of establishing the frequency of alleles for fast or slow feathering at the K locus in two lines of White Plymouth Rock hens (maternal forms) – lines L and K, as well as their influence on the birds' live weight during growth. The rate of feathering was determined at one day of age according to the length of the primary and secondary wing feathers. The birds' weight development was controlled through individual weighing at 2, 4, 6, 8, 10, and 12 weeks of age.

In male chickens of the L and K lines, a higher frequency of the slow-feathering allele was found, respectively, 0.676 and 0.503 against 0.203 and 0.306 in females. Male and female chickens of the L line with a rapid-feathering genotype had higher live body weight than those with alternative genotype at ages of 2 to 12 weeks. There were no differences between the feathering genotypes for female chickens of the K line, whereas in males there was a tendency for higher live body weight with the rapid-feathering genotype. Slow-feathering chickens of both sexes of the same line were by 81.20 g (4.10%) lighter than rapid-feathering ones at the age of 12 weeks ($p<0.05$).

The effect of slow- or rapid-feathering alleles was not identical for both sexes and the studied lines.

Keywords: slow-feathering alleles, rapid-feathering alleles, gene frequency, growth.

INTRODUCTION

Day-old chicks sexing is an important element of selection work and of breeders' reproduction. The separate-sex rearing of growing birds allows achieving a better homogeneity with respect to live weight and high production traits.

Of particular interest is the fact that the sex of hatched chicks can be established by the rate of feathering, using the marker genes K – k, located in

the Z sex chromosome. To this end, it is necessary that breeders possess a genotype of k^+k^+ and *KW* for males and females, respectively. When hatching, male chicks exhibit slow feathering *K_*, whereas the females – rapid feathering k^+W. Sexing when using the K locus allows for the processing of birds of the same color in cases when the traditional methods of sex identification were low-productive or inflict trauma on the chicks. The simplicity, high accuracy, and speed of sex determination in chicks make this method viable for industrial-scale poultry breeding.

Many studies have shown that the influence of sex-related genes of feathering rate is not the same for both sexes (Lowe and Merkley, 1986, Chervenkov, 1990) and different populations, and that the K gene for slow feathering influenced the entire organism (Katanbaf et al., 1988, Chambers et al., 1994, Mahnach, 1996, Zerehdaran et al., 2004).

The influence of the alleles at the K locus on the growth performance has been examined by a number of authors, yet their results were rather inconsistent. Some researchers (Bacon et al., 1985, Dunnington and Siegel, 1986, Alsobayel and Al-Abdullatif, 1997, Khosravinia, 2008) have confirmed the advantage of rapid-feathering k^+k^+, k^+W birds compared to the alternative genotype. On the other hand, Dunnington et al. (1987) found out that slow-feathering male K/K chickens were heavier than the rapid-feathering k^+k^+ at the ages of 24, 38 and 52 days at limited feeding, but not when fed *ad libitum*. The results of Verma and Prasad (1981) regarding growth of rapid- and slow-feathering chickens have shown an advantage in favour of the latter. According to Nahashon et al. (2004), slow-feathering chickens exhibited higher growth rates compared to those with a rapid-feathering genotype at the age of 8 weeks. Fotsa et al. (2001) did not establish a major effect of the genotype in locus K on the live body weight from 4 to 10 weeks of age in both male and female chickens.

In the gene pool of the Poultry hybrid centre, there is no specialised slow-feathering broiler breeder line, nor an autosexing broiler hybrid. This necessitated to establish the frequency of alleles for slow and rapid feathering at the K locus in both breeder White Plymouth Rock lines (maternal form) – L and K, as well as their influence on the birds' live weight during the growth period.

Material and Methods

During the reproduction of lines L and K, 480 and 356 day-old sexed chicks respectively were checked for the rate of feathering by the length of the primary and secondary flight feathers and wing - banded. Revision and

correction of the accuracy of the established feathering rate was done on the 10^{th} day.

The frequency of genes and genotypes for rapid or slow feathering was determined by a formula derived from the Hardy-Weinberg law:

$$(pA+qa)^2 = p^2AA+2pqAa +q^2aa = 1$$

The different genotypes were reared under the same conditions in accordance with the technology practiced in the Poultry hybrid centre – floor rearing on permanent litter of wood shavings. Up to 4 weeks of age, the chickens were fed freely, after which a limited feeding programme was introduced with weekly rations according to the age. The weight of the birds was controlled through individual weighing at 2, 4, 6, 8, 10, and 12 weeks of age.

The data were processed statistically with the Statistica software package of StatSoft Inc., 1993.

Table 1. Frequencies of alleles and genotypes at locus K in female broiler type chickens.

Lines	Gene frequency		Genotypes ratio in %	
	p(K)	q(k^+)	K/_	k^+/_
Line L	0.203	0.797	20.30	79.70
Line K	0.306	0.694	30.60	69.40

Table 2. Frequencies of alleles and genotypes at locus K in male broiler type chickens.

Lines	Gene frequency		Genotype frequency			Genotypes ratio in %		
	p(K)	q(k^+)	KK (p^2)	Kk^+ (2pq)	k^+k^+ (q^2)	KK	Kk^+	k^+k^+
Line L	0.676	0.324	0.456	0.439	0.105	45.60	43.90	10.50
Line K	0.503	0.497	0.253	0.500	0.247	25.30	50.00	24.70

RESULTS AND DISCUSSION

The genetic analysis at the K locus revealed the presence of alleles for rapid and slow feathering in both sexes from both lines (Table 1 and Table 2). In male chicks of lines L and K there was a higher frequency of the slow-feathering allele, 0.676 and 0.503 respectively vs. 0.203 and 0.306 in females. Based on this, the frequency of slow-feathering genotypes in males from the L line was 0.895 or 89.50 %, of which the heterozygous genotype K/k^+ was 0.439 or 43.90 %, whereas for the males from the K line it was 0.753 or 75.30 %, of which the genotype K/k^+ (2pq) was 0.500 or 50.00 %. In the female k^+/_ and male k^+/k^+ chick of the L line, the frequency of rapid-feathering genotype was 0.797 (79.70 %) and 0.105 (10.50 %). For the K line the established frequency

of rapid-feathering genotypes was 0.694 (69.40 %) and 0.247 (24.70 %), for males and females, respectively.

Table 3. LSD test results between mean live body weights depending on the line, sex and genotype

Line	Sex	Genotype	Average body weights (g) per age (weeks)					
			At 2 weeks of age, LS±SE	At 4 weeks of age, LS±SE	At 6 weeks of age, LS±SE	At 8 weeks of age, LS±SE	At 10 weeks of age, LS±SE	At 12 weeks of age, LS±SE
Line L	female	k^+W	270.95± 2.40	535.47± 4.55	810.29± 7.93	1163.08± 10.64	1402.78± 12.05	1754.69± 15.31
		KW	263.17± 2.89	512.09± 6.20**	759.14± 9.69***	1115.34± 13.79**	1330.00± 14.88**	1661.92± 18.17***
	male	k^+k^+	303.00± 7.94	588.53± 15.39	932.14± 32.67	1361.67± 44.11	1675.00± 64.69	2110.00± 70.74
		K_	278.09± 4.93*	557.48± 8.49	890.00± 13.79	1322.73± 20.24	1621.92± 24.83	2046.64± 33.68
Line K	female	k^+W	243.91± 3.04	511.94± 6.75	812.70± 11.63	1073.24± 13.71	1646.85± 22.37	1825.79± 25.18
		KW	238.41± 3.25	501.83± 6.88	806.94± 11.13	1074.60± 14.09	1651.61± 21.48	1849.57± 23.43
	male	k^+k^+	263.00± 7.70	598.32± 17.20	983.33± 25.88	1346.05± 30.78	2142.11± 37.17	2400.00± 45.08
		K_	257.02± 6.14	564.62± 11.21	918.21± 15.97*	1271.56± 20.05	2029.00± 34.44*	2298.98± 42.87

Statistically significant *** - p<0.001; ** - p<0.01; * - p<0.05;

Table 3 presents the mean live body weight values in the different age periods for both genotypes depending on the sex and the line. Overall, different tendencies were observed in the studied lines. The results from the t–test between the sexes with regard to the K locus showed that the rapid-feathering genotype k^+W was significantly superior to the *KW* genotype (slow feathering) in female birds of the L line. In most cases the level of significance was p<0.01 and p<0.001, with the exception of the age of 2 weeks when the live weight of both genotypes was approximately the same. At 12 weeks of age rapid-feathering female chickens exhibited a higher live body weight by 92.77 g than slow-feathering ones (p<0.001), which constituted a difference of 5.29 %. The data show a unidirectional tendency for superiority of the rapid-feathering genotype in both males and females of this line, even though the differences were significant only for the age of 2 weeks. At the end of the experiment, the rapid-feathering males were heavier by 63.36 g (p>0.05) or by 3%. These results corresponded to reports of a number of authors (Dunnington and Siegel, 1986, Alsobayel and Al-Abdullatif, 1997, Khosravinia, 2008), who confirmed the advantage of rapid-feathering birds k^+k^+ ,k^+W to the alternative genotype. Such an advantage could be explained with the fact that rapid-feathering genotypes have lower energy needs to maintain their body temperature and thus more of the energy is allocated for growth. There are

however studies whose results were contrary to ours in which slow-feathering birds showed the same (Fotsa et al. 2001) or even higher growth potential at an early age compared to rapid-feathering ones (Verma and Prasad ,1981; Nahashon et al., 2004). Results similar to these reports were established for the females from line K, where we found no differences between the two genotypes. As for the males from the same line, there was a tendency towards higher live body weight in the rapid-feathering genotype. The difference of 65.12 g at the age of 6 weeks and 113.11 g at the age of 10 weeks was significant ($p<0.05$).

Table 4. LSD test LSD test results between mean live body weights depending on the line and genotype.

Line	Genotype	Average body weights (g) per age (weeks)					
		At 2 weeks of age, LS±SE	At 4 weeks of age, LS±SE	At 6 weeks of age, LS±SE	At 8 weeks of age, LS±SE	At 10 weeks of age, LS±SE	At 12 weeks of age, LS±SE
Line L	$к^{+}к^{+}$, $к^{+}W$	273.06± 2.37	538.93± 4.45	817.94± 7.95	1176.34± 10.85	1421.17± 12.85	1778.59± 16.15
	К_, KW	268.07± 2.57	526.93± 5.22	801.88± 9.03	1184.00± 13.34	1427.31± 16.24	1792.77± 21.04
Line K	$к^{+}к^{+}$,$к^{+}W$	246.23± 2.87	522.95± 6.70	833.73± 11.63	1108.50± 14.66	1711.30± 24.33	1901.03± 27.79*
	К_, KW	243.71± 2.96	519.57± 6.22	839.89± 9.89	1132.00± 13.36	1760.06± 22.33	1982.23± 26.16

Statistically significant * - $p<0.05$

LSD comparisons between the mean live body weight values (Table 4) showed that, during the first weeks, the two genotypes of chickens from the L line increased their live weight to a greater extent than those from line K. Contrary results were observed after 8 weeks of age, when line K was at an advantage ($p<0.05$).

The average differences in live body weight between the two genotypes with different feathering rate were insignificant for both sexes from line L (Table 4). Similar to ours were the results of Chervenkov (1990), according to whom for both sexes, the average live weight of chickens carrying the slow-feathering allele was not lower than the live weight of chickens with rapid-feathering alleles at the age of 6 months. Even though we found no significant differences between both genotypes in the K line, we should note that there was a tendency towards a higher live body weight in the slow-feathering genotype at the age of 12 weeks. In average, for both sexes, the superiority of slow-feathering chickens was by 4.10 % ($p<0.05$).

The results from the performed ANOVA (Table 5) showed that genotype with regard to the K locus, line, and sex had a significant influence on the growth rate of birds during the growth period.

Table 5. F – test results for the effect of studied factors on the live body weight

Source of variation	Significance per variable					
	2 w	4 w	6 w	8 w	10 w	12 w
1. Line	95.65***	5.21*	9.29**	26.04***	409.03***	74.10***
2. Genotype	8.59**	14.26***	14.86***	7.18**	10.01**	7.90**
3. Sex	23.64***	58.09***	112.61***	199.39***	291.85***	322.27***
1 x 2	0.63^{ns}	0.83^{ns}	3.42^{ns}	2.04^{ns}	2.77^{ns}	5.42*
1 x 3	0.03^{ns}	3.88*	0.27^{ns}	0.85^{ns}	14.08***	9.56**
2 x 3	1.23^{ns}	1.05^{ns}	1.07^{ns}	1.12^{ns}	1.32^{ns}	0.88^{ns}
1 x 2 x 3	1.15^{ns}	0.26^{ns}	1.75^{ns}	1.62^{ns}	2.37^{ns}	2.12^{ns}

Statistically significant *** - p<0.001; ** - p<0.01; * - p<0.05; ns – Non significant

CONCLUSIONS

The presence of alleles for fast and slow feathering in both sexes of the White Plymouth Rock lines allows us to conclude that by means of selection for the K locus, it is possible to create specialized breeder lines whose breeding would result in an autosexing offspring in accordance with feathering rate (feather sexing).

Both male and female chickens of the L line with a rapid-feathering genotype were distinguished from the alternative genotype by their higher live weight between the ages of 2 – 12 weeks, with no significant differences between the two genotypes for both sexes.

There were no differences between the feathering genotypes in female chickens of the K line, but a tendency towards higher live body weight in the rapid-feathering genotype in males. Slow-feathering chickens from both sexes of the same line were heavier by 81.20 g than those with rapid feathering at the age of 12 weeks ($p<0.05$).

The influence of rapid- or slow-feathering alleles was not identical for both sexes and both studied lines.

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