Biotechnology in Animal Husbandry 28 (3), p 405-414 , 2012 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 636.034
DOI: 10.2298/BAH1203405M

EFFECT OF FEATHERING ALLELES (K/K^{+}) ON LAYING PERFORMANCE, HATCHABILITY PARAMETERS AND SOME BODY MEASUREMENTS IN TWO LINES OF WHITE PLYMOUTH ROCK HENS

N. Mincheva, M. Lalev, M. Oblakova, P. Hristakieva, I. Ivanova

Agricultural Institute - Stara Zagora, Bulgaria
Corresponding author:nmincheva@abv.bg
Original scientific paper

Abstract: The study aimed to investigate the effects of sex – linked feathering alleles on laying performance, hatchability parameters and body measurements in hens from two White Plymouth Rock lines (line L and line K) used as maternal lines in broiler production. Four groups of 18-week-old hens were formed, two of each line, with genotype K/W (slow feathering) and k^{+}/W (rapid feathering) respectively. Groups of line L included 72 hens divided into 6 boxes with 1 rooster per 12 hens, whereas line K groups comprised 96 hens of each genotype, housed in 8 boxes with one rooster per 12 hens, totally 192 birds.The K locus alleles had no significant effect on egg production traits ($p>0.05$). The presence of slow feathering allele resulted in lower fertility and hatchability of set eggs in both studied lines ($p<0.05$). A substantial effect of feathering rate alleles was observed with respect to the egg shape index ($p<0.05$), eggshell thickness ($p<0.001$) and albumen index ($p<0.05$). The presence of the slow feathering allele resulted in lower live body weight of birds from line K at the age of 36 weeks ($p<0.05$), but in longer thighs ($p<0.01$) and metatarsi ($p<0.001$) in both lines. The selection for creation of slow feathering lines for feather sexing purposes should take into consideration the effect of the K gene on studied traits.

Key words: feathering genes, egg production, body measurements, hatchability

Introduction

The presence of the K locus in the sex Z chromosome, which determines feathering rate, was established by *Serebrovsky (1922),* and phenotype manifestations of alleles are described in details by Hut *(1949).*

The sexing of one-day-old chicks according to the extent of development of flight feathers (feather sexing) is widely used in the practice, as this method of sexing is more efficient and less stressful *(Harris et al., 1984,; Wilson et al., 2007)*. For this purpose, roosters with k^{+}/k^{+} genotype are mated to K/W hens, resulting in slow feathering of one-day-old male chicks and rapid feathering in female one-day-old chicks. The autosexing allows a rapid identification of the sex of chicks without any special training or sexoscopes, with minimum inaccuracy.

The utilisation of the dominant K allele (slow feathering) in the maternal line for production of autosexing chicks distinguished by feathering rate could, in the belief of some researchers, be linked to an unfavourable effect on sexual maturity (*Verma and Singh, 1983; Harris et al., 1984; O'Sullivan et al., 1991; Ning et al., 2005; Abd El-Rahman, 2006*), egg production (*Lowe and Garwood, 1981; Saleh et al., 1987; Havenstein et al., 1989; Abd El-Rahman. 2006; Wilson et al., 2007; Durmus et. al, 2010*), livability (*Bacon et al., 1988; Alsobayel and Al – Muhlem, 1997*), feed conversion (*Белоречков & Алиуи, 1986*) and reproduction *(O'Sullivan et al., 1991*), although others did not show any differences between slow- and rapid feathering hens in these parameters (*Dunnington and Siegel, 1986; Ning and Chen; 1988; Prijono and Smith, 1994; Холодков, 2004; Younis and Galal, 2006; Ledvinka et al., 2011*).

In the view of *Chambers et al. (1993)* the contradictory results suggest an interaction of the K allele with other genes from the genome. For instance, *Bacon et al. (1988)* established a close relationship between the K slow feathering gene and ev 21 gene in a White Leghorn line and this way explained the lower egg productivity and livability in the offspring of birds with the slow feathering genotype. On the other side, *Dunnington and Siegel (1986)* outline as a possible cause for contradictory results the effect of K gene on some biological factors such as heat insulation properties of vane feathers, and the genetic origin of studied populations.

Our observations have demonstrated the presence of a slow feathering K gene in two White Plymouth Rock lines. One of the main prerequisites of using marker K locus genes is the lack of negative impact on production traits of hybrids, and therefore, the knowledge on effects of K/k^{+} alleles on productivity is essential for breeding programmes.

Taking into consideration the contradictory results, we aimed to establish the effect of sex-related alleles for feathering rate on some production traits, morphological and incubation traits of eggs and exterior traits in hens from these two lines.

Materials and methods

The experiment was performed in the selection base of the Poultry Breeding Unit at the Institute of Agriculture – Stara Zagora in 2009–2010.

Two original White Plymouth Rock lines of chickens were used as maternal forms for broiler production – line L and line K.

In the progeny of these lines, the sex of day-old chicks was determined with sexoscope, the feathering rate was evaluated according to the wing feathering speed, and the chicks were wing - banded. At the age of 10 days their tail feathers were checked. Chicks without tail feathers were slow feathering. For line L, the frequency of slow and rapid feathering genotypes in female chicks was 79.70% and 20.30%, respectively. In female chicks from line K, the rapid feathering genotype was encountered at a frequency of 69.40%, whereas the slow feathering genotype – at 30.60%. Chicks from each line and genotype were housed uniformly, on a deep wood shavings litter according to the technology requirements implemented in the selection base until the age of 18 weeks. At that time, four groups were formed – two of each line with genotypes K/W (slow feathering) and k^+/W (rapid feathering). Groups of line L included 72 hens divided into 6 boxes with 1 rooster per 12 hens, whereas line K groups comprised 96 hens of each genotype, housed in 8 boxes with one rooster per 12 hens, totally 192 birds.

The hens were housed until 48 weeks of age on deep litter with uniform conditions with regard to density, feeding and drinking widths. Restricted feeding was practiced with weekly rations according to the age and egg production. The compound feed contained: metabolizable energy 1810.005 kcal/kg, crude protein – 16.012%, crude fat – 6.836%, crude fibers – 5.889%, lysine 0.75%, methionine 0.38%, calcium 3.2%, phosphorus 0.81%

During the experiment, the following traits were evaluated:

- **Age of sexual maturity (days)** – age when 50% of egg production was attained in the different groups;
- **Egg production –** daily from egg lay beginning to 48 weeks of age. On the basis of these data, the hen-day and hen-housed egg production percentages were established;
- **Average egg weight –** by weighing eggs laid by each group for the day at 2-week interval between 32 and 48 weeks of age
- **Morphological traits of eggs –** 10% of the daily egg yield during 3 consecutive days at 40 weeks of age was analysed. The individual egg weight, shape index, albumen index, yolk index, Hough units, yolk colour by the La Roche scale and eggshell thickness were determined.
- **Incubation traits of eggs –** they were investigated at 48 weeks of age by collection of eggs over 7 days. The fertility was evaluated as the relative share of fertilized to eggs set in the incubators; the hatchability of eggs set (HS) – the relative share of hatched chickens from eggs set; the hatchability of fertile eggs (HF) – the relative share of hatched chickens from fertilised eggs, embryonic death rate – for the

incubation intervals 0–6 days, 7–18 days and 19–21 days – as relative proportions of dead embryos from fertilised eggs.

- **Live body weight and exterior traits at 36 weeks of age –** the live body weight was determined by weighing on a balance with precision of 5 g. The following body parts were measured with a centimetre tape: body length (between the last cervical vertebra and the tail root), breast circumference (between the last cervical vertebra behind and under the wings to the anterior end of the keel bone ridge); keel bone length (between the anterior and posterior ends of keel bone ridge), thigh, drumstick and metatarsus lengths (between the end points of respective bones); the chest depth between the last cervical vertebra and the anterior keel bone border) – with compasses.

Data were statistically processed by lines and by genotypes by means of ANOVA/MANOVA and LSD post hoc test with Statistica 8 software (StatSoft, 2009). Percentage data were arcsine transformed prior to be analysed.

Results and discussion

The analysis of results in table 1 showed that the age of sexual maturity in hens from line L did not differ significantly between both genotypes as also reported by *Holodkov (2004), Ledvinka et al. (2011)*. This tendency was not valid for line K, where the beginning of egg lay in the group with rapid feathering genotype k^+/W occurred 6 days earlier ($p<0.05$). Similar results were reported by *Harris et al., (1984); O'Sullivan et al., (1991); Ning et al., (2005)* and *Durmus et al. (2010)*.

Table 1. Laying performance of hens as affected by feathering genotype

Traits	Line				Significance P - value
	K		L		
	Feathering genotype				
	k^+/W	K/W	k^+/W	K/W	
Age at sexual maturity (day)	177,38c	183,13b	189,83a	190,17a	0,135
Hen – housed egg production (%)	62,28a	67,73a	62,46a	61,99a	0,317
Hen – day egg production (%)	65,71a	68,81a	64,89a	64,73a	0,498
Average egg weight (g)	65,35a	65,35a	62,30b	63,46b	0,286
Average consumption of feed for one egg (g)	240,71	226,42	249,37	250,02	0,412
Livability (%)	90,63	96,88	94,45	93,06	0,442

a–c statistically significant differences (p<0,05) in row are indicated by different superscripts

The hen-housed and hen-day egg production, the feed expenditure per one egg produced and the livability during the period of lay were not influenced by the feathering rate genotype. With this regard, our results confirmed the conclusions of *Prijono and Smith (1994), Holodkov (2004)* and *Younis and Galal (2006).*

Table 2 presents the data from ANOVA statistical analyses about the effect of K locus genotype on morphological traits of eggs. The feathering genotype had a significant impact on the shape index ($p<0.05$), eggshell thickness ($p<0.001$) and albumen index ($p<0.05$). The shape index values in hens carrying the slow feathering gene in both lines were higher, meaning that their eggs were of a more round shape. A similar conclusion was attained by *Belorechkov & Aliui (1986)* and *Ledvinka et al (2011)*. Chickens with the rapid feathering genotype (k^{+}/W) from both lines produced eggs with thicker eggshells with statistically significant differences between genotypes within the line (($p<0.05$). In this connection, our results were in agreement with those of *Abd El-Rahman (2006)*, who concluded that eggs produced by slow feathering layers exhibited a marked deterioration of eggshell quality, but not with data reported by *Belorechkov & Aliui (1986)* and *Ledvinka et al. (2011)* about thinner eggshells in rapid feathering hens. The albumen index was higher for slow feathering birds from line L (K/W) – 9.01 vs 8.04 ($p<0.05$), as also demonstrated by *Belorechkov & Aliui (1986)*, while the values were almost identical in both genotypes within line K.

Table 2. Egg quality measurements of hens at 40 weeks of age as affected by feathering genotype

Traits	Line				Significance P - value
	K		L		
	Feathering genotype				
	k^{+}/W	K/W	k^{+}/W	K/W	
Egg weight (g)	66,13a	66,00a	63,03b	62,27b	0,624
Shell (%)	12,12	11,86	12,23	11,68	0,086
Yolk (%)	30,85a	30,30a	29,20b	29,34b	0,583
Albumen (%)	57,15b	58,23b	60,15a	60,96a	0,059
Shape index (%)	76,08a,c	77,17a	76,97a	78,03a,b	0,035
Shell thickness (mm)	0,378a	0,360c	0,373b	0,338d	0,000
Yolk index (%)	42,35b	42,60b	44,54a	43,41a	0,427
Albumen index (%)	7,38c	7,76c	8,04b	9,01a	0,038
Haugh unit	75,14b	76,97b	78,72a	81,37a	0,141

a–d statistically significant differences ($p<0,05$) in row are indicated by different superscripts

The effect of the K locus genotype on fertility and hatchability of eggs (table 3), a significant impact was established ($p<0.05$). These parameters had higher values in chickens with the k^{+}/W rapid feathering genotype from both lines studied. The embryonic death rate during the different incubation periods was not influenced by the feathering genotype in this study. Having compared hens with slow and rapid feathering of Line 54 layers, *Durmus et al. (2010)* demonstrated a pronounced effect of K locus alleles on fertility, early embryonic death and hatchability of fertile eggs, but unlike our results, the fertility, early and late embryonic death rates were higher in slow feathering birds, whereas the hatchability of fertile eggs – in rapid feathering birds. The hatchability of incubated eggs was similar. On the other hand, *Alsobayel and Al – Muhlem (1997)* did not report any significant differences with regard to fertility rate, hatchability and embryonic death rate between slow and rapid feathering Baladi chickens.

Table 3. Hatchability traits of hens as affected by feathering genotype

Traits	Line				Significance P - value
	K		L		
	Feathering genotype				
	k^+/W	K/W	k^+/W	K/W	
Fertility (%)	92,88a	86,73b	92,19a	85,84b	0,022
Early embryonic mortality (%)	0,42	0,00	0,68	1,40	0,631
Middle period embryonic mortality (%)	6,29	3,75	5,73	6,76	0,701
Late embryonic mortality (%)	3,61	8,28	5,52	4,56	0,302
Hatchability /fertile eggs/, %	92,65	92,98	94,66	89,94	0,364
Hatchability /set eggs/, %	87,50a	80,77b	88,79a	81,01b	0,044

a–b statistically significant differences (p<0,05) in row are indicated by different superscripts

The data presented in table 4 showed a substantial effect of the studied factor on live body weight at 36 weeks of age (p<0.001). Differences between genotypes were present in line K with rapid feathering hens being heavier than slow feathering hems – 3874.70 g vs 3546.20 g (p<0.001). Lower body weight of slow feathering chickens was also reported by *Abd El – Rahman (2006)* – at the age of 40 weeks; by *Nakamura et al. (2010)* – at 250 days of age. *Ning et al. (2005), Durmus et al.(2010)* and *Ledvinka et al. (2011)* believed that slow feathering chickens were heavier than others. In the research of Younis *and Galal (2006)* there were no differences related to the genotype with regard to live body weight. This was the case with line L in the present investigation, where the chickens from line L were with similar live body weight.

Exterior traits allowed making a more detailed evaluation and characteristics of the type and body structure of birds (table 4). The thigh and metatarsus length were significantly influenced by the feathering genotype, at levels of significance p<0.01 and p<0.001, respectively. The slow feathering genotype was better with regard to in agreement with the findings of *Khosravinia (2008)*.

Table 4. Body weight and body measurements of hens at 36 weeks of age

Traits	Line				Significance P - value
	K		L		
	Feathering genotype				
	k^{+}/W	K/W	k^{+}/W	K/W	
Body weight (g)	3874,7a	3546,20b	3327,90c	3377,14c	0,000
Body length (cm)	21,30a	21,17a	19,90b	20,70b	0,346
Breast circumference (cm)	39,83	38,30	39,70	39,07	0,080
Breast depth (cm)	12,67a	12,60a	12,90a	11,93b	0,081
Keel length (cm)	14,03a	14,30a	13,37c	14,23a,b	0,050
Thigh length (cm)	14,03a	14,23a	13,20b	14,30a	0,003
Drumstick length (cm)	15,90a	16,20a	14,40b	14,83b	0,055
Metatarsus length (cm)	8,43d	9,03c	9,60b	10,13a	0,000

a–d statistically significant differences ($p<0,05$) in row are indicated by different superscripts

Conclusion

K locus alleles had no significant effect on egg production traits ($p>0.05$). The presence of slow feathering allele resulted in lower fertility and hatchability of incubated eggs in both studied lines ($p<0.05$). A substantial effect of feathering rate alleles was observed with respect to the egg shape index ($p<0.05$), eggshell thickness ($p<0.001$) and albumen index ($p<0.05$). The presence of the slow feathering allele resulted in lower live body weight of birds from line K at the age of 36 weeks ($p<0.05$), but in longer thighs ($p<0.01$) and metatarsi ($p<0.001$) in both lines.

The selection for creation of slow feathering lines for feather sexing purposes should take into consideration the effect of the K gene on studied traits.

Uticaj alela operjalosti (K/K^{+}) na nosivost, parametre izvođenja i pojedine telesne mere kokoši nosilja dve linije rase beli plimut rok

N. Mincheva, M. Lalev, M. Oblakova, P. Hristakieva, I. Ivanova

Rezime

Cilj istraživanja je bio da se ispita uticaj pola – povezan sa alelima operjavanja, na nosivost, parametre izvođenja i telesne mere kokoši nosilja dve linije rase beli plimut rok (linija L i linija K) koje se koriste kao majčinske linije u

proizvodnji brojlera. Četiri grupe kokoši nosilja uzrasta 18 nedelja, dve grupe po liniji, genotipova K/W (sporo operjavanje) i k^+/W (brzo operjavanje), respektivno. Grupe linije L su sadržavale 72 kokoši podeljene u 6 bokseva sa 1 petlom na 12 kokoši, dok su grupe linije K imale 96 kokoši svakog genotipa, smeštene u 8 boksova sa jednim petlom na 12 kokoši, ukupno 192 grla.

K locus alela nije imao značajan uticaj na osobine proizviodnje jaja (p> 0,05). Prisustvo alela za sporo operjavanje je rezultiralo u slabijoj plodnosti i procentu izleženih jaja u obe ispitivane linije (p <0,05). Značajan uticaj alela za operjavanje/perje je registrovan kod indeksa oblika jajeta (p <0,05), debljine ljuske (p <0,001) i indeksa belanca (p <0,05). Prisustvo alela za sporo operjavanje je rezultiralo nižim telesnim masama grla linije K u uzrastu od 36 nedelja (p <0,05), ali dužim karabatakom (p <0,01) i metatarzusima (p <0,001) u obe linije.

Prilikom selekcije na stvaranje linija sa sporijim operjavanjem u svrhu seksiranja, trebalo bi uzeti u obzir uticaj K gena na ispitivane osobine.

References

ABD EL-RAHMAN. (2006): The effects of slow feathering gene (k) on productive performance of Dandarawi chickens under subtropical conditions. Egypt Poult. Sci. Vol (26), 713 - 731

ALSOBAYEL, A.A., and AL-MULHEM,A.A. (1997): Effect of Sex-Linked Feathering Genes on Body Weight,Age at Sexual Maturity,Feed Intake and Subsequent Laying Performance of Baladi Chickens. Sultan Qabus Univ. J. for Scientific Research- Agricultural Sciences-, Vol.2, 37-42.

ALSOBAYEL, A.A., and AL-MULHEM,A.A.(1997): Effect of Sex-Linked Feathering Genes on Fertility and Hatchability Parameters of Baladi Chickens. J. King Saud Univ.,Vol.9,Agric. Sci., (2), 199-207

BACON, L.D., E. SMITH, L.B. CRITTENDEN, G.B. HAVENSTEIN. (1988): Association of the slow feathering K and an endogenous viral (ev21) gene on the Z chromosome of chickens. Poult. Sci. 67(2): 191 – 7

BELORECHKOV, D. & M. ALIUI. (1986): Pleiotropy related to K locus alleles in two layer hen lines from the RA-4 combination. Proc. of the International Scientific Technical Conference on Problems of Domestic Poultry Selection, Varna, pp. 361 – 371

CHAMBERS, J. R., E. J. SMITH, E. A. DUNNINGTON, SIEGEL, P. B. (1993): Sex-linked feathering (*K, k+*) in chickens: A review. Poult. Sci. Rev. 5:97–116.

DUNNINGTON, E. A. and P. B. SIEGEL. (1986): Sex – linked feathering alleles (K, k^+) in pullets of diverse genetic backgrounds. Archiv Fur. Geflugelkunde. 51: 70 – 72

DURMUS, I, H. GOGER, S.E. DEMITRAS, S. YURTOGULLARI. (2010): Comparison of Rapid and Slow Feathering Egg Layers with Respect to Egg

Production and Hatchability Parameters. Asian Journal of Animal and Veterinary Advances 5 (1): 66-71.

HARRIS, D. L., V. A. GARWOOD, P. C. LOWE, P. Y. HESTER, L. B. CRITTENDEN, A. M. FADLY. (1984): Influence of sex-linked feathering phenotypes of parents and progeny upon lymphoid leukosis virus infection status and egg production. Poult. Sci. 63:401–413.

HARRIS, D. L., V. A. GARWOOD, P. C. LOWE, P. Y. HESTER, L. B.CRITTENDEN, FADLY, A. M. (1984): Influence of sex-linked feathering phenotypes of parents and progeny upon lymphoid leukosis virus infection status and egg production. Poult. Sci. 63:401–413.

HAVENSTEIN, G.B., V. D. TOELLE, R. H. TOWNER, A. EMSLEY. (1989): Effects of genetic strain, slow verus rapid - feathering maternal genotype and cage density on the performance of Single Comb White Leghorns. Poultry Sci.68 : 596-607.

HOLODKOV, V. (2004): Productivity of meat type hens carrying of the *K* and *k* genes Scientific and practical experience in poultry breeding (VNITP) 1. Sergiev Posad, pp. 4-5

HUTT, F.B. (1949): Genetics of fowl. McGraw, Hill Book Company, Inc. New York

LEDVINKA, Z, L. ZITA, M. HUBENY, E. TUMOVA, M. TYLLER, P. DOBROVOLNY, M. HRUSCA. (2011): Effect of genotype, age of hens and K/k allele on egg shell quality. Czech. J. Anim. Sci., 56 (5): 242-249

LOWE, P. C. and V. A. GARWOOD. (1981): Independent effects of K and k^{+} alleles and maternal origin on mortality and performance of crossbred chickens.Poult. Sci. 60: 1123 – 1126

NING, G. J. and S. Q.CHEN. (1988): The influence of genotype on the performance of layers. Chinese Journal of Animal Science No. 3 pp. 3-5

NING, Z. H., W. ZONG, P. DANFANG, H. ZHUOCHENG. (2005): Effect of avian leukosis and sex-linked feather gene on performance of White Leghorn hens. Chinese Journal of Animal Science Vol. 41 No. 10 pp. 23-25

O'SULLIVAN, N. P., E. A. DUNNINGTON, E. J. SMITH, W. B. GROSS, P. B. SIEGEL. (1991): Performance of early and late feathering broiler breeder females with different feeding regimens. Br. Poult. Sci. 32:981–995.

PRIJONO, S. N. and W. K., SMITH. (1994): The effect of divergent selection for the performance of broiler chickens. Sustainable animal production and the environment. Proceedings of the 7th AAAP Animal Science Congress, Bali, Indonesia, 11-16 July, 1994. Volume 2: pp 197-198

SALEH, K., FARGHALY, M. ,ALI M. M.. (1987): The effect of feathering rate and housing system on some economic traits of layers. Archiv. Geflugelk. 51: 153 – 157.

SEREBROVSKY, A. S. (1922): Crossing-over involving three sexlinked genes in chickens. Am. Nat. 56:571–572.

VERMA, S. K. and P. SINGH. (1983): Effect of slow and rapid – feathering genes on economic traits in WL x RIR crosses. Indian J. Anim. Sci. 53: 105 – 106

WILSON, H.R., J.P. JACOP, F. B. MATHER. (2007): Method of sexing day – old chicks. University of Florida, Cooperative Extension Service, USA

YOUNIS, H. H. and A.GALAL. (2006): Impact of dwarf (dw), rapid feathering (k^+) and naked neck (Na) genes on growth and egg production parameters of laying hen chickens. Egyptian Poultry Science Journal, Vol. 26 No. 1 pp. 17-38

Received 14 August 2012; accepted for publication 21 August 2012