Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2003
Volume 6
Issue 2
Series ANIMAL HUSBANDRY

GRYZIŃSKA M. 2003. POLYMORPHISM OF SELECTED PROTEINS OF YOLK AND WHITE OF EGG IN RELATION TO PERFORMANCE TRAITS OF HENS **Electronic Journal of Polish Agricultural Universities**, Animal Husbandry, Volume 6, Issue 2.
Available Online http://www.ejpau.media.pl

POLYMORPHISM OF SELECTED PROTEINS OF YOLK AND WHITE OF EGG IN RELATION TO PERFORMANCE TRAITS OF HENS

Magdalena Gryzińska
Department of Biological Basis of Animal Production, Agricultural University of Lublin, Poland

ABSTRACT

The studies were aimed to establish a connection between polymorphism of egg-yolk and egg-white proteins and selected performance traits of laying hens. Data on performance of the studied breeds of hens were collected from breeding records. The following traits were measured in the analysed hens: body weight at 8, 18, and 20 days of age, age of sexual maturity, initial egg-laying rate, mean egg weight at 33 weeks of age, number of eggs with a complete eggshell, number of eggs with a broken eggshell, number of eggs without an eggshell or with a soft one, and a mean eggshell strength at 33 weeks of age.

The material included the white and yolk of eggs collected from 1024 hens belonging to the following breeds: Green-Legged Partridge from the conservation flock, Rhode Island White, Rhode Island Red, New Hampshire, and Leghorn from pedigree flocks, and Sussex and Rhode Island Red from experimental flocks.

The polymorphism and its association with performance traits indicate that the proteins of the subregions of fast-migrating prealbumins, Pa-F, in yolk and ovoglobulins, G_4, in egg white may have the highest practical importance for genetic improvement of the performance traits of the studied strains.

Key words: hens, proteins, eggs, polymorphism, performance.

INTRODUCTION

Identification of genes that are responsible for quantitative traits is difficult due to their large number and a weak additive effect each of them has. Therefore, a quest has begun to find genetic markers, i.e. traits of simple and clear mechanism of heritability, that would remain unchanged over the entire life of an individual. An analysis of the genetic background of quantitative traits is intended to find the genes of strong effect (so called major genes), or the genes that are coupled with them. O'Brien et al. [7] divided markers in two classes, where one class includes DNA coding sequences, and the other class represents non-coding nucleotide sequences. The markers of the previous class are mostly represented by erythrocytic antigens (blood groups), major histocompatibility complex (MHC) antigens, or polymorphic proteins of milk, or yolk or white of eggs.

An application of the markers belonging to this class depends on results of studies on biochemical polymorphism. Despite the fact that a new class of markers was distinguished, the genes encoding quantitative traits, such as polymorphic proteins of blood plasma or egg content, have still been in use. The facts that make us investigate on this group of markers are as follows: polymorphic variants of proteins are not influenced by environmental factors, they enable evaluating individuals lacking a phenotypic expression of a given trait, and they shorten the time needed for estimating the breeding value of an animal. According to Leenstra et al. [6], a marker a higher polymorphism is easier to identify, which also means better selection performance. Moreover, markers may enhance efficiency of selection for the traits low-heritability. Expected genetic progress is fast if markers are used, unlike that attained in progeny-based selection [4]. Together with the remaining markers, they may be used for creating new, improved genetic programmes.

The aim of this study was to determine a relationship between polymorphic forms of egg yolk and white proteins and selected performance traits of laying hens.

MATERIALS AND METHODS

The material included the yolk and white of eggs from hens of the following breeds: Green-Legged Partridge (GLP), 181 hens, from Agricultural Experimental Unit in Felin; Rhode Island White (RIW), 116 hens, Rhode Island Red (RIR-M), 106 hens, New Hampshire (NH), 119 hens, and Leghorn (Lg), 150 hens, from Mienia; and Sussex (Sx), 189 hens, and Rhode Island Red (RIR-J), 163 hens, from the Polish Academy of Sciences Institute of Genetics and Animal Breeding in Jastrzębiec.

The polymorphism of egg proteins was determined with thin-layer horizontal polyacrylamide (paa) gel electrophoresis, according to the methods given by Gahne et al. [1] and Głuchowski et al. [3]. For the electrophoresis, 10 and 12% paa gel was used.

Each of the studied breeds of hens was derived from a single hatching. The data on the performance of each breed were collected from breeding records. The following traits were determined in the examined hens:

- body weight at 8, 18, and 20 days of weeks, measured with precision to 0.1 g;
- hen's age in days from hatching until laying the first egg – sexual maturity;
- initial egg-laying rate, in percent;
- mean egg weight at 33 weeks of age, measured with precision to 0.1 g;
- number of eggs with cracked eggshell;
- mean strength of eggshell at 33 weeks of age, examined along the long axis using an Instron instrument, in N.

Moreover, those eggs were also weighed to 0.1 whose content was subjected to electrophoresis, studied at 28 weeks for RIW, RIR-M, ad RIR-J, at 33 weeks for NH and GLP, as well as at 47 weeks of age for Lg and Sx.
The hens were assigned to groups depending on polymorphic forms of yolk and white proteins. In so constructed groups, the mean vales of the traits were compared using the Duncan test, based on one-way analysis of variance.

The protein names were adapted according to the notation used by Gahne et al. [1]. The alleles belonging to the same range were denoted as A, B, C, and D, according to decreasing speed of migrating to the anode.

RESULTS AND DISCUSSION

An electrophoregram of hen egg yolk and white proteins, as well as an electrophoregram of blood serum proteins for a comparison, separated with polyacrylamide gel horizontal electrophoresis, are presented in Fig. 1. The paa gel electrophoresis allowed separation of egg-content proteins into 30-35 bands, the polymorphism being found in six subregions of yolk proteins and in five subregions of white proteins. Tables 1-7 present the levels of the examined performance traits in hens assigned into groups depending on the phenotypic form of egg-content proteins, for which statistical significance of differences was confirmed.

Fig. 1. Scheme of electrophoregram of egg yolk and white proteins and blood serum proteins

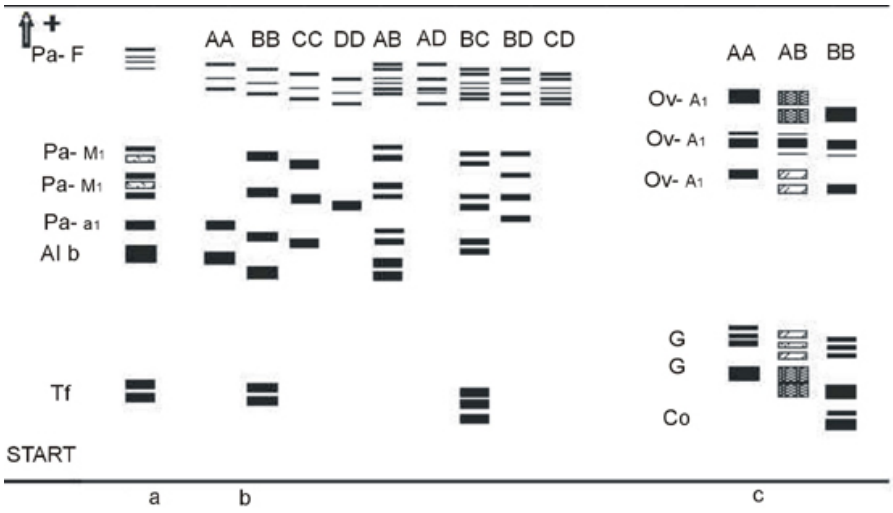

Table 1. Performance traits values in Leghorn hens in relation to phenotypes of egg yolk and white proteins fractions

Egg component	Subregion	Phenotype	N	Sexual maturity (days)		Egg weight (g)	
				$\bar{x}$	*SE*	$\bar{x}$	*SE*
Yolk	**Pa-F**	AB	7	**163.7**	± *1.74*	**66.1**	± *0.87*
		AD	9	**163.5**	± *3.24*	**66.2**	± *1.16*
		BB	51	**163.3**	± *1.59*	**65.4x**	± *0.56*
		BC	3	**166.3**	± *8.35*	**65.7**	± *3.34*
		BD	66	**163.6**	± *1.28*	**65.5x**	*&*± *0.55*
		DD	14	**162.9**	± *2.53*	**62.8y**	± *0.98*
	Pa-M_2	BB	135	**163.6**	± *0.90*	**65.3**	± *0.36*
		BC	15	**165.4**	± *2.45*	**65.5**	± *1.16*
	Pa-S_3	AB	17	**163.7**	± *2.33*	**66.8**	± *9.73*
		BB	133	**163.8**	± *0.91*	**65.1**	± *3.60*
White	**G_4**	AA	56	**163.2y**	± *1.32*	**65.9**	± *0.61*
		AB	82	**163.2y**	± *1.16*	**64.6y**	± *0.39*
		BB	12	**171.0x**	± *2.77*	**67.4x**	± *1.60*

Symbols refer to Tables 1-7.
x. y. z. - means marked with different letters differ statistically significantly at $p \leq 0.05$.
X. Y. Z - means marked with different letters differ statistically significantly at $p \leq 0.01$.

Table 2. Performance traits values in Rhode Island White hens in relation to phenotypes of egg yolk and white proteins fractions

Egg component	Subregion	Pheno–type	N	Body weight at 18 weeks of age (g)		Sexual maturity (days)		Initial egg-laying rate (%)		Egg weight (g)		Eggs with cracked eggshell (pcs.)	
				$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Yolk	**Pa-F**	BB	20	**1673**	*± 19.68*	**166.7x**	*± 2.33*	**87.4**	*± 1.92*	**56.7**	*± 0.59*	**1.45**	*± 0.59*
		BC	1	**1550**	*± 0.00*	**159.0**	*± 0.00*	**87.9**	*± 0.00*	**53.4**	*± 0.00*	**0.00**	*± 0.00*
		BD	39	**1624**	*± 17.45*	**165.4**	*± 1.21*	**89.0x**	*± 1.24*	**56.1**	*± 0.52*	**1.18**	*± 0.27*
		CD	9	**1633**	*± 37.00*	**162.2**	*± 1.07*	**84.7**	*± 2.51*	**57.2**	*± 1.25*	**0.33**	*± 0.24*
		DD	47	**1655**	*± 19.69*	**162.0y**	*± 1.15*	**83.8y**	*± 1.49*	**57.8**	*± 0.50*	**1.13**	*± 0.24*
	Pa-S_3	AA	3	**1733**	*± 16.69*	**161.0**	*± 3.85*	**87.7**	*± 4.95*	**57.9**	*± 2.80*	**1.00**	*± 0.58*
		AB	40	**1640**	*± 16.76*	**163.0**	*± 1.07*	**88.6x**	*± 1.17*	**55.6y**	*± 0.47*	**0.88y**	*± 0.20*
		BB	5	**1710**	*± 59.93*	**163.0**	*± 3.88*	**91.9**	*± 3.19*	**56.2**	*± 1.39*	**0.80**	*± 0.38*
		BC	35	**1645**	*± 20.79*	**167.0**	*± 1.50*	**86.0**	*± 1.54*	**57.1**	*± 0.58*	**1.77x**	*± 0.44*
		CC	33	**1633**	*± 22.11*	**164.0**	*± 1.51*	**82.8y**	*± 1.86*	**57.3x**	*± 0.55*	**0.94**	*± 0.24*
White	**Ov-A_2**	AA	9	**1622**	*± 42.67*	**167.0**	*± 2.30*	**83.2**	*± 3.43*	**55.6**	*± 0.97*	**0.33**	*± 0.21*
		AB	50	**1658**	*± 17.82*	**164.0**	*± 1.31*	**84.2y**	*± 1.41*	**56.9**	*± 0.50*	**1.15**	*± 0.24*
		BB	57	**1637**	*± 14.44*	**164.0**	*± 0.96*	**88.6x**	*± 1.03*	**56.6**	*± 0.39*	**1.26**	*± 0.25*
	Ov-A_3	AA	1	**1400y**	*± 0.00*	**188.0X**	*± 0.00*	**74.0**	*± 0.00*	**63.5x**	*± 0.00*	**1.67**	*± 0.00*
		AB	38	**1646x**	*± 17.52*	**166.0Y**	*± 1.52*	**85.3**	*± 1.74*	**56.4y**	*± 0.46*	**1.36**	*± 0.31*
		BB	77	**1648x**	*± 13.68*	**163.0Z**	*± 0.77*	**87.0**	*± 0.95*	**56.6y**	*± 0.44*	**0.91**	*± 0.18*
	G_4	AA	6	**1658**	*± 71.04*	**167.0**	*± 5.43*	**93.0**	*± 3.63*	**54.8**	*± 0.00*	**3.00**	*± 0.00*
		AB	52	**1650**	*± 17.06*	**164.0**	*± 1.15*	**86.3**	*± 0.94*	**56.2**	*± 0.53*	**1.30**	*± 0.34*
		BB	58	**1639**	*± 14.18*	**164.0**	*± 0.98*	**85.5**	*± 1.42*	**57.2**	*± 0.37*	**1.05**	*± 0.19*

A number of significant relationships between the phenotypic forms of egg-content proteins and performance traits were found for each breed of hens; however, fast-migrating prealbumin (Pa-F) in yolk and ovoglobulin (G_4) in egg white can be considered the most versatile subregions.

The protein phenotypes of fast-migrating prealbumin Pa-F subregion were encoded by four genes, A, B, C, and D, in the Leghorn and New Hampshire hens. Three genes, B, C, and D, were found in the population of Rhode Island White, Rhode Island Red-J, and Sussex. The remaining breeds, Rhode Island Red-M and Green-Legged Partridge had two genes each, B and D.

Significant differences in the Pa-F subregion were demonstrated for Leghorn, Rhode Island White, Rhode Island Red-J, and Sussex. The Leghorn hens (Table 1) of the phenotypes BB and BD, had lower egg weights than the hens of the phenotype DD. For the Rhode Island White hens (Table 3), differences were found for the age of sexual maturity and initial egg-laying rate. The birds with the fast-migrating prealbumin phenotype DD attained maturity five days earlier than those with the phenotype BB, whereas the initial egg-laying rate was different in the hens with the BD phenotype than the DD phenotype of the subregion. For the Rhode Island Red-J (Table 5), differences in the Pa-F subregion were found in mean egg weight at 33 weeks of age, in initial egg-laying rate, and in the weight of the studied eggs. The recorded initial egg-laying rate was different among the birds with the BB, BD, CD, and DD phenotypes. The weight difference between eggs collected from the BB-phenotype hens and those with the BD phenotype was 1.6 g. The weight of the eggs whose content was analysed differed significantly between the BB and CD hens, and between BD and CD, by 1.1 g and 2.5 g, respectively. Statistically significant differences in the subregion of fast-migrating prealbumin in Sussex hens (Table 6) were found for the following six traits: sexual maturity age, initial egg-laying rate, and mean egg weight at 33 weeks of age. The hens with the BB phenotype of the subregion reached sexual maturity at 150 days of age. Those with the CD phenotype laid their first egg at the age of 154 days and had a lower initial egg-laying rate in comparison with the hens with BB and BC phenotypes. The hens with the BD phenotype laid heavier eggs than those of the phenotype BB did. What is more, eggs (whose content was subjected to electrophoresis) laid by BC and BD fast-migrating prealbumin phenotype hens were heavier than the eggs laid by the BB-phenotype hens.

Table 3. Performance traits values in Rhode Island Red - J hens in relation to phenotypes of egg yolk and white proteins fractions

Egg component	Subregion	Phenotype	N	Initial egg-laying rate (%)		Mean egg weight at 33 weeks of age (g)		Egg weight (g)	
				$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Yolk	**Pa-F**	BB	71	**88.4x**	± *0.59*	**60.8x**	± *0.40*	**59.2x**	± *0.41*
		BC	4	**88.6**	± *1.82*	**58.5**	± *0.74*	**56.6**	± *1.30*
		BD	51	**87.5x**	± *0.62*	**59.2y**	± *0.46*	**57.4y**	± *0.50*
		CD	14	**83.7y**	± *3.14*	**61.6**	± *1.88*	**60.3x**	± *1.21*
		DD	21	**87.5x**	± *0.98*	**58.9**	± *1.00*	**57.8**	± *1.05*
	Pa-S_3	AB	5	**90.8**	± *1.24*	**60.1**	± *0.76*	**59.0**	± *0.98*
		BB	158	**87.6**	± *0.45*	**60.0**	± *0.32*	**±58.4**	±*0.34*
White	**Ov-A_2**	AA	72	**87.7**	± *0.62*	**60.8**	± *0.54*	**59.1**	± *0.51*
		AB	62	**87.7**	± *0.84*	**59.4**	± *0.40*	**57.9**	± *0.43*
		BB	29	**87.9**	± *0.84*	**59.4**	± *0.68*	**57.9**	± *0.67*
	Ov-A_3	AA	14	**87.8**	± *1.36*	**59.7**	± *1.07*	**58.6**	± *1.32*
		AB	49	**86.2y**	± *1.06*	**59.2**	± *0.53*	**57.7**	± *0.56*
		BB	100	**88.5x**	± *0.45*	**60.4**	± *0.41*	**58.8**	± *0.37*
	G_4	AA	3	**91.3**	± *1.45*	**59.1**	± *1.40*	**56.6**	± *3.77*
		AB	40	**87.8**	± *0.66*	**59.5**	± *0.51*	**58.0**	± *0.46*
		BB	120	**87.6**	± *0.56*	**60.2**	± *0.39*	**59.6**	± *0.37*

Table 4. Performance traits values in Sussex hens in relation to phenotypes of egg yolk and white proteins fractions

Egg component	Subregion	Phenotype	N	Sexual maturity (days)		Initial egg-laying rate (%)		Mean egg weight at 33 weeks of age (g)		Egg weight (g)		Eggs with cracked eggshell (pcs.)		Eggshell strength at 33 weeks of age (N)	
				$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Yolk	**Pa-F**	BB	79	**150y**	± *0.78*	**82.5x**	± *0.56*	**60.6y**	± *0.25*	**61.9y**	± *0.42*	**0.35y**	± *0.10*	**26.49**	± *7.26*
		BC	36	**153**	± *1.18*	**82.4x**	± *1.12*	**61.5**	± *0.79*	**64.2x**	± *1.12*	**0.63x**	± *0.19*	**27.40**	± *1.57*
		BD	23	**152**	± *1.40*	**81.5**	± *1.37*	**63.5x**	± *0.88*	**65.2x**	± *0.94*	**0.61**	± *0.27*	**24.33**	± *0.98*
		CC	13	**149**	± *2.10*	**83.1**	± *1.70*	**60.6**	± *0.98*	**63.0**	± *1.59*	**0.31**	± *0.13*	**24.72**	± *1.08*
		CD	9	**154x**	± *1.61*	**75.7y**	± *9.24*	**60.0**	± *1.12*	**62.0**	± *1.42*	**0.33**	± *0.23*	**25.21**	± *1.47*
		DD	29	**152**	± *1.23*	**81.3**	± *1.22*	**61.2**	± *0.50*	**63.8**	± *0.93*	**0.72**	± *0.27*	**27.66**	± *1.18*
	Pa-M_2	BB	56	**152**	± *0.95*	**81.6**	± *1.64*	**60.8**	± *0.13*	**62.4**	± *0.57*	**0.39**	± *0.12*	**26.29**	± *8.24*
		BC	86	**151**	± *0.76*	**82.4**	± *0.57*	**61.1**	± *0.38*	**63.3**	± *0.58*	**0.53**	± *0.13*	**26.78**	± *0.98*
		BD	3	**148**	± *3.33*	**86.6**	± *3.26*	**56.8**	± *1.67*	**58.2**	± *1.33*	**0.00**	± *0.00*	**26.09**	± *6.57*
		CC	44	**153**	± *0.97*	**81.2**	± *0.97*	**62.1**	± *0.53*	**63.9**	± *0.73*	**0.56**	± *0.10*	**25.80**	± *3.14*
	Pa-M_3	BB	67	**151**	± *0.80*	**81.9**	± *0.75*	**61.3**	± *0.41*	**63.3**	± *0.67*	**0.50**	± *0.13*	**26.68**	± *0.59*
		BC	78	**151**	± *0.83*	**82.7x**	± *0.67*	**61.2**	± *0.44*	**62.6**	± *0.53*	**0.55**	± *0.14*	**26.09**	± *0.98*
		CC	24	**152**	± *1.48*	**78.4y**	± *3.41*	**61.2**	± *0.78*	**63.5**	± *1.09*	**0.45**	± *0.17*	**26.98**	± *0.78*
	Pa-S_3	AA	7	**150**	± *3.19*	**81.9**	± *1.62*	**62.8**	± *2.09*	**64.8**	± *1.98*	**0.28**	± *0.18*	**27.76**	± *1.77*
		AB	106	**151**	± *0.70*	**81.4**	± *0.94*	**60.9**	± *0.36*	**62.9**	± *0.53*	**0.45**	± *0.10*	**26.58**	± *0.49*
		BB	76	**152**	± *0.72*	**82.6**	± *0.69*	**61.4**	± *0.43*	**63.3**	± *0.50*	**0.56**	± *0.13*	**25.99**	± *0.69*
	Alb	AA	69	**151**	± *0.78*	**82.3**	± *0.72*	**61.5**	± *0.45*	**63.7x**	± *0.69*	**0.60**	± *0.14*	**26.39x**	± *0.59*
		AB	85	**151**	± *0.59*	**81.3**	± *1.10*	**61.0**	± *0.39*	**62.9**	± *0.50*	**0.38**	± *0.11*	**27.17x**	± *0.69*
		BB	35	**152**	± *1.16*	**82.6**	± *1.15*	**61.0**	± *0.65*	**62.3y**	± *0.66*	**0.41**	± *0.12*	**24.62y**	± *0.98*

Table 4. cont.

White	**Ov-A_2**	AA	21	**150**	± *1.48*	**83.1**	± *1.34*	**61.3**	± *1.02*	**64.3**	± *0.97*	**0.85**	± *0.37*	**24.33**	± *1.37*
		AB	100	**151**	± *0.65*	**81.4**	± *0.97*	**60.9**	± *0.34*	**62.8**	± *0.43*	**0.35**	± *0.08*	**27.34**	± *0.59*
		BB	68	**151**	± *0.91*	**82.4**	± *0.74*	**61.5**	± *0.46*	**63.1**	± *0.73*	**0.54**	± *0.13*	**25.70**	± *0.69*
	Ov-A_3	AA	41	**152**	± *1.04*	**79.6**	± *2.08*	**60.5**	± *6.58*	**63.8**	± *0.75*	**0.19**	± *0.06*	**27.37**	± *1.08*
		AB	81	**151**	± *0.81*	**82.4**	± *0.59*	**60.9**	± *0.38*	**63.2**	± *0.61*	**0.48**	± *0.14*	**26.68**	± *0.59*
		BB	67	**151**	± *0.81*	**82.7**	± *0.83*	**61.9**	± *0.48*	**62.6**	± *0.53*	**0.62**	± *0.16*	**25.51**	± *0.69*
	G_4	AA	54	**151**	± *0.95*	**82.3**	± *0.91*	**61.6**	± *0.54*	**63.2**	± *0.56*	**0.45**	± *0.14*	**25.90**	± *0.78*
		AB	97	**151**	± *0.71*	**81.3**	± *1.00*	**61.0**	± *0.36*	**63.0**	± *0.49*	**0.45**	± *0.14*	**26.68**	± *0.59*
		BB	38	**152**	± *1.10*	**82.6**	± *0.75*	**61.4**	± *0.60*	**63.1**	± *1.05*	**0.55**	± *0.14*	**26.19**	± *0.78*

Table 5. Performance traits values in New Hampshire hens in relation to polymorphic fractions of egg content proteins

Egg component	Subregion	Pheno–type	N	Body weight at 18 weeks of age (g)	
				$\bar{x}$	*SE*
Yolk	**Pa-F**	AD	4	**1787**	± *37.50*
		BC	1	**2000**	± *0.00*
		BD	8	**1818**	± *37.72*
		CD	3	**1850**	± *104.10*
		DD	103	**1807**	± *12.62*
	Pa-M_3	AB	9	**1794**	± *33.67*
		BB	100	**1804**	± *13.40*
		BC	10	**1800**	± *23.56*
	Pa-S_3	AB	14	**1810**	± *33.22*
		BB	105	**1802**	± *12.62*
White	**Ov-A_2**	AA	21	**1797**	± *22.76*
		AB	64	**1810**	±*16.26*
		BB	34	**1795**	± *24.01*
	Ov-A_3	AA	29	**1781**	± *26.31*
		AB	56	**1836x**	± *16.93*
		BB	34	**1769y**	± *18.40*
	G_4	AA	24	**1860x**	± *21.90*
		AB	53	**1794y**	± *16.96*
		BB	42	**1783y**	± *21.32*

Table 6. Performance traits values in Rhode Island Red - M hens in relation to phenotypes of egg yolk and white proteins fractions

Egg component	Subregion	Pheno–type	N	Mean egg weight at 33 weeks of age (g)		Egg weight (g)	
				$\bar{x}$	SE	$\bar{x}$	SE
Yolk	**Pa-F**	BD	3	**58.5**	± *3.06*	**67.1**	± *0.63*
		DD	103	**57.5**	± *0.45*	**57.1**	± *0.35*
	Pa-S_3	AB	18	**56.0**	± *0.87*	**57.1**	± *10.70*
		BB	88	**58.0**	± *0.50*	**57.4**	± *0.44*
White	**Ov-A_2**	AA	102	**58.8**	± *1.19*	**58.6**	± *1.06*
		AB	4	**57.0**	± *0.73*	**57.1**	± *0.62*
	G_4	AA	25	**58.8x**	± *0.52*	**58.6x**	± *0.55*
		AB	40	**57.0y**	± *0.66*	**57.1y**	± *0.42*
		BB	41	**57.1y**	± *6.23*	**56.6y**	± *0.93*

In all the studied breeds, three phenotypes in the ovoglobulin G_4 subregion, AA, AB, and BB, were found to occur with varied frequency. The phenotypes of the subregion depended on two genes, A and B.

Significant differences in the subregion of ovoglobulin G_4 were demonstrated for Leghorn, New Hampshire, Rhode Island Red-M, and Green-Legged Partridge.

The age of reaching sexual maturity for Leghorn hens (Table 1) with the phenotypes AA and AB of ovoglobulin G_4 was 164 days. The BB homozygotes needed eight days more to reach maturity than the AA or AB hens. Significant differences in the weight of eggs were found between AB and BB phenotypes. New Hampshire hens (Table 2) of the phenotype AA were heavier than either AB or BB phenotypes in the G_4 subregion. Rhode Island Red-M hens (Table 4) differed in mean egg weight in this subregion. Eggs obtained from homozygous ovoglobulin G_4 AA hens had larger weight than eggs of hens with the AB and BB phenotypes. In the Green-Legged Partridge hens (Table 7), significant differences were found in egg weight. The layers of the BB phenotype laid eggs by 3.5 g lighter than the hens with the phenotype AA, and by 3.8 g lighter than the hens with AB phenotype of ovoglobulin G_4 subregion.

Table 7. Performance traits values in Green Legged Partridge hens in relation to protein fractions of egg content proteins

Egg component	Subregion	Phenotype	N	Body weight at 18 weeks of age (g)		Body weight at 20 weeks of age (g)		Egg weight (g)	
				$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Yolk	**Pa-F**	BB	54	**542**	± *11.60*	**1444**	± *15.70*	**46.4**	± *0.59*
		BD	86	**539**	± *7.79*	**1441**	± *12.30*	**46.7**	± *0.38*
		DD	41	**525**	± *14.40*	**1460**	± *20.50*	**45.6**	± *0.54*
	Pa-M_2	AB	9	**427Y**	± *18.80*	**1372y**	± *47.20*	**47.7**	± *1.14*
		BB	172	**543X**	± *5.94*	**1450x**	± *8.84*	**46.3**	± *0.29*
	Pa-M_3	BB	134	**541**	± *6.80*	**1436**	± *9.51*	**46.7**	± *0.34*
		BC	11	**512**	± *29.80*	**1454**	± *49.30*	**44.9**	± *0.98*
		BD	34	**533**	± *14.50*	**1479**	± *23.10*	**45.5**	± *0.55*
		DD	2	**497**	± *52.80*	**1475**	± *25.0*	**46.1**	± *1.00*
	Pa-S_3	AA	3	**548**	± *36.70*	**1500**	± *28.90*	**45.6**	± *2.57*
		AB	69	**545**	± *9.80*	**1455**	± *14.00*	**46.6**	± *0.49*
		BB	109	**532**	± *7.80*	**1438**	± *11.50*	**46.3**	± *0.35*
	Tf	BB	179	**537**	± *6.10*	**1446**	± *8.87*	**46.3**	± *2.80*
		BC	2	**501**	± *51.00*	**1400**	± *0.00*	**45.6**	± *0.50*
White	**Ov-A_1**	AA	3	**587**	± *37.70*	**1633x**	± *44.00*	**49.0**	± *0.87*
		AB	43	**552**	± *10.90*	**1456y**	± *14.40*	**47.0**	± *0.56*
		BB	135	**531**	± *7.18*	**1438y**	± *10.50*	**46.1**	± *0.33*
	Ov-A_2	AA	85	**523z**	± *8.98*	**1424y**	± *13.50*	**45.7y**	± *0.43*
		AB	86	**546y**	± *8.46*	**1463x**	± *12.00*	**47.0x**	± *0.38*
		BB	10	**573x**	± *21.50*	**1485**	± *24.70*	**46.6**	± *1.20*
	Ov-A_3	AA	72	**524**	± *10.10*	**1432**	± *15.20*	**46.1**	± *0.43*
		AB	85	**542**	± *8.20*	**1446**	± *12.00*	**46.5**	± *0.38*
		BB	24	**558**	± *16.10*	**1485**	± *21.40*	**46.4**	± *1.01*
	G_3	AA	3	**587**	± *37.70*	**1633x**	± *44.00*	**49.0**	± *0.87*
		AB	43	**552**	± *10.90*	**1456y**	± *14.40*	**47.0**	± *0.56*
		BB	135	**531**	± *7.18*	**1438y**	± *10.50*	**46.1**	± *0.33*
	G_4	AA	101	**541**	± *7.14*	**1449**	± *11.30*	**46.5x**	± *0.35*
		AB	67	**534**	± *10.70*	**1441**	± *14.80*	**46.8x**	± *0.39*
		BB	13	**518**	± *30.90*	**1450**	± *38.80*	**43.0y**	± *0.35*

The obtained results indicate that polymorphic forms of yolk and white of eggs can be used in selection of laying hens. The applicability of genetic markers is determined by a number of factors, such as polymorphism degree of the marker, genetic distance between the marker gene and the genes of the given quantitative trait, the proportion of the marked genes in the variability of the trait [2].

In this study, protein phenotypes from nearly all subregions of yolk were considered as genetic markers. The phenotypes of the fast-migrating prealbumin, Pa-F, were connected with the following performance traits: age of sexual maturity, initial egg-laying rate, egg weight, and number of eggs with cracked eggshell. The phenotypes from the subregion of middle-migrating prealbumin, Pa-M_2, were related to body weight, while those of the subregion Pa-M_3 were connected with initial egg-laying rate. The protein phenotypes of slow-migrating prealbumin, Pa-S_3, demonstrated connections with three traits, i.e. initial egg-laying rate, egg weight, and number of eggs with cracked eggshell. The phenotypes of albumin were connected with egg weight and eggshell strength. If we considered the polymorphic proteins of egg white, the phenotypes of all the subregions were related with body weight. Moreover, the phenotypes of the ovoglobulin subregion Ov-A_2 were related with initial egg-laying rate and egg weight; those from the subregion Ov-A_3 with initial egg-laying rate, egg weight, and age of sexual maturity; those from the subregion of ovoglobulin G_4 were connected with egg weight and sexual maturity.

Genetic markers may represent an efficient tool for reading genetic information that is many ways applicable in breeding programmes [9]. An analysis of the markers may be carried out as early as in the initial period of the animal's life, regardless of its sex. This allows early selection, reducing costs of raising and evaluation. In this case, marker information has a double importance; it reduces the duration of the selection process and improve the precision of the appraisal of the animal breeding value [8]. A characteristic of selected markers allows tracking how the selection influences the genetic structure of the given population, and which genes are being eliminated along with the specific traits, negative from the breeder's point of view [5].

It should be kept in mind that collecting information on marker loci in order to improve the precision of genetic evaluation of animals represents just one of the ways they can be used in selection. In comparison with new genetic engineering techniques, analysis of marker loci opens new prospects for improvement of animal products and their quick differentiation according to consumers' needs and, in the future, for creating new traits. Marker studies that lead to reading animal genome contribute to creating new breeding methods.

CONCLUSIONS

1. Finding significant relationships between egg content protein phenotypic forms and performance traits indicates that the proteins of the following subregions can represent markers of the traits: Pa-F (in yolk) and G_4 in Leghorn hens; Ov-A_3 and G_4 (in white) in New Hampshire hens; Pa-F, Pa-S_3 (in yolk), Ov-A_2, and Ov-A_3 (in white) in Rhode Island White; G_4 (in white) in Rhode Island Red-M; Pa-F (in yolk) and Ov-A_3 (in white) in Rhode Island Red-J; Pa-F, Pa-M_3 and A1 (in yolk) in Sussex; Pa-M_2 (in yolk), Ov-A1, Ov-A_2, G_3, and G_4 (in white) in Green-Legged Partridge hens.
2. The polymorphism and its connection with performance traits indicates that the proteins of the subregions of fast-migrating prealbumins Pa-F in yolk and ovoglobulins G_4 in egg white may have the highest practical importance for genetic improvement of the studied strains.
3. The results indicate that polymorphic protein forms in yolk and white of egg can be used in selection of hens.

REFERENCES

1. Gahne B., Juneja R., Grolmus J., 1977. Horizontal polyacrylamide gradient gel electrophoresis for simultaneous phenotyping of transferrin, post-transferrin, albumin and post-albumin in the blood of plasma of cattle. Anim. Blood Groups Bioch. Genet. 8.
2. Geldermann H., 1975. Investigation of inheritance of quantitative characters in animals by gene markers. I. Methods. Theor. Appl. Genet. 46, 319-330.
3. Głuchowski W., Brodacki A., Rupeć Z., Wójcik A., 1985. Metoda utrwalania płyt żelu poliakryloamidowego [A method of polyacrylamide gel plates preservation]. Folia Soc. Sci. Lub. 27, Biol. 2, 141-143 [in Polish].
4. Kashi Y., Hallerman E., Soller M., 1990. Marker-assisted selection of candidate bulls for progeny testing programmes. Anim. Prod. 51, 63-74.
5. Kurył J., 1992. Markery genetyczne [Genetic markers]. Zesz. Nauk. PTZ 6, 48-76 [in Polish].
6. Leenstra P.R., Groen A.F., Aarts H.J., 1994. Marker mapping, marker association studies and their application in poultry production. Proc. 9th European Poultry Conference, Glasgow 7-12 August 1994. 1, World's Poult. Sci. Association.157-160.

7. O'Brien S.J., Womack J.E., Lyons L.A., Moore K.J., Jenkins N.A., Copeland N.G., 1993. Anchored reference loci for comparative genome mapping in mammals. Nat. Genet. 3, 103-112.
8. Szydłowski M., 1994. Wybrane aspekty analizy loci markerowych w doskonaleniu ilościowych cech zwierząt [Selected aspects of marker loci analysis in improvement of quantitative traits of animals]. Pr. Mater. Zootech. 46, 31-40 [in Polish].
9. Wężyk S., 1996. Genetyka stosowana w hodowli zwierząt gospodarskich (w: Mat. symp Aktualne problemy genetyki stosowanej) [Genetics applied in farm animal breeding (in: Mat. of Sci. Symp. Current Problems of Applied Genetic)] Lublin 21-22 November 1996. AR, Lublin. 49-62 [in Polish].

Magdalena Gryzińska
Department of Biological Basis for Animal Production
Agricultural University of Lublin, Poland
Akademicka 13, 20-950 Lublin
phone +48 81 445 66 28
e-mail: maggry@tlen.pl