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CORRELATIONS BETWEEN PHENOTYPIC ASSOCIATIONS Hb/K AND QUANTITATIVE PRODUCTION TRAITS IN THE BOTOSANI KARAKUL SHEEP

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Abstract

The existence of a linkage between the determinant loci of haemoglobin and blood potassium in the ovine species suggested to us the approach of correlations between various combinations of haemoglobin and potassium phenotypes and the quantitative production parameters (meat, wool, milk) in the Botosani Karakul breed. The electrophoretic and flame photometric tests pointed out four phenotypic combinations (of the six possible) between the haemoglobin and potassium types: HbAB/LK, HbAB/HK, HbBB/LK and HbBB/HK. The four phenotypic combinations Hb/K are characterized by different levels of their production metabolism according to the age and sex of animals. The experimental data show that the subpopulations of animals with phenotypic combinations HbAB/HK and HbBB/HK are more productive than the subpopulations of animals with phenotypic combinations HbAB/LK and HbBB/LK. These correlational aspects recommend the use of phenotypic combinations Hb/K as biochemical genetic markers to improve the production traits of the Botosani Karakul breed.

Key words**:** *haemoglobin phenotype, potassium phenotype, production traits, sheep*

INTRODUCTION

Potassium is an important chemical element for the erythrocyte physiology having considerable implications on the biophysical and biochemical mechanisms of ionic transport from the cell membrane level (4, 6).
There have been reported a number of studies showing that between the determinant loci of haemoglobin (Hb) and potassium (K) there is a linkage, phenomenon that influence the intermediate metabolism, which, in its turn, reflects on the production metabolism of farm animals (2, 4,5, 6, 7).
In a previous paper, we found some associations of different combinations of haemoglobin and potassium phenotypes with the qualitative features of lamb pelts (shape and size of hair curls, quality, lustre and colour of hair fibres) in sheep belonging to the Botosani Karakul breed (2).
The present study tries to find such correlations between the phenotypic combinations Hb/K and the quantitative production traits (meat, wool, milk) of the same sheep breed.

MATERIAL AND METHOD

The correlational analysis of phenotypic combinations Hb/K and production traits was carried out on three sheep populations belonging to the Botosani Karakul breed, differentiated among them by age and sex: 156 lambs (0-3 months), 162 adult ewes and 129 adult rams.
The haemoglobin and potassium phenotypes of animals were identified from samples of venous blood obtained by jugular venipuncture.
The sheep haemotypifying at the Hb locus was performed by the starch gel electrophoresis method (1).
The discontinuity of kalemic system at the locus K was revealed by the flame photometric method (3).
The quantitative production parameters, specific to age and sex, were estimated by

weighing and measuring methods, as follows:
In lambs 0-3 months: body weight at birth, lamb pelt surface at birth, body weight at weaning, body weight gain at 90 days and daily average gain;
In adult ewes: body weight at mating, wool production, milk production, milking period and daily average milk production;
In adult rams: body weight at mating and wool production.
In terms of statistics, there were calculated the arithmetical average ($\bar{x}$), standard deviation (s) and variability coefficient (v%); the Student test (t) was used to compare the production differences among the subpopulations constituted depending on the phenotypic combinations Hb/K of the individuals.

RESULTS AND DISCUSSIONS

As a result of different migration speed of haemoglobin, the patterns of haemoglobin electrophoregrammes show that in the haemoglobin system of the Botosani Karakul breed are expressed only two haemoglobin phenotypes: HbAB (intermediate type) and HbBB (slow type); the fast type HbAA is missing (2).
Depending on the levels and discontinuity of potassium ion distributions, the flame photometry revealed in the Botosani Karakul sheep existence of two potassium phenotypes: LK (low potassium type) and HK (high potassium type) (2).
Theoretically, in ovine species, there are six possible phenotypic combinations among the genetic variants of haemoglobin and potassium: HbAA/LK, HbAA/HK, HbAB/LK, HbAB/HK, HbBB/LK and HbBB/HK. In the Botosani Karakul breed, because of the absence of haemotype HbAA, only four such combinations are expressed (HbAB/LK, HbAB/HK, HbBB/LK and HbBB/HK) (2).
The four phenotypic combinations Hb/K are particularized by different levels of their production metabolism according to the age and sex of animals.
a) Correlations between phenotypic combinations Hb/K and quantitative production traits in lambs (Table 1,Table 2).
The weighting most lambs at birth were those which had in their genetic structure the phenotype HbAB and phenotype HK. Also, the lambs on type HBB/LK recorded a considerable body weight at birth. The slighter newborn lambs are those with the phenotypic combination HbBB/HK. The body weight of lambs of type HbAB/HK is close to the average populational level.
As a result, both the lambs HbAB/HK and the HbBB/LK differ significantly compared to lambs HbBB/LK in terms of body weight at birth. Also, the body weight difference between the lambs HbAB/LK and HbAB/HK is appreciable, the value of “t” being situated in the adjacency of the first critical threshold of significance (5%). Body weight differences among the groups of lambs with the other phenotypic associations Hb/K are small and unsignificant.
According to the Brody method, there is a relative linearity between the surface of lamb pelts and body weight at birth. The only significant difference among the body surfaces of the different lamb groups is noted only between the lambs HbAB/HK and those HbBB/HK, and the difference between the lambs HbBB/LK and those HbBB/HK just approaching the first critical threshold of significance.
Correlative aspects of phenotypic associations Hb/K with production parameters that define the growth rate of lambs (body weight at weaning, body weight gain at 90 days and daily average gain) have revealed that this rhythm is influenced by body weight at birth and their hereditary endowment concerning the haemoglobin and potassium types. Thus, the highest growth rate is of the lambs HbAB/HK, and the lowest growth rate occurs in the lambs HbBB/LK. In the case of the growth rate too, the statistical aspects concerning the production differences among lamb groups with different phenotypic combinations Hb/K are identical to those found among the same groups of lambs at their birth.

Table 1. Production traits in lambs belonging to the Botosani Karakul breed

Production trait	Statistical parameter	Phenotypic combination			
		HbAB/LK n=18	HbAB/HK n=25	HbBB/LK n=25	HbBB/HK n=88
Body weight at birth (kg)	$\bar{x} \pm s_{\bar{x}}$	4.20±0.14	4.54±0.17	4.05±0.13	4.36±0.07
	s	0.70	0.70	0.65	0.70
	v%	16.54	15.49	16.07	16.11
Lamb pelt surface at birth (cm^2)	$\bar{x} \pm s_{\bar{x}}$	2616±61	2759±68	2552±61	2677±32
	s	302.93	288.87	306.75	302.77
	v%	11.58	10.47	12.02	11.31
Body weight at weaning (kg)	$\bar{x} \pm s_{\bar{x}}$	14.86±0.82	16.59±0.61	14.80±0.48	15.94±0.28
	s	4.09	2.58	2.39	2.61
	v%	27.51	15.55	16.15	16.37
Body weight gain at 90 days(kg)	$\bar{x} \pm s_{\bar{x}}$	10.66±0.74	12.05±0.44	10.75±0.35	11.58±0.20
	s	3.68	1.88	1.74	1.90
	v%	34.48	15.57	16.18	16.40
Daily average gain (g/day)	$\bar{x} \pm s_{\bar{x}}$	118±8	134±5	119±4	129±2
	s	39.79	20.98	19.33	21.34
	v%	33.72	15.66	16.24	16.54

Table 2. Testing the production differences between haemoglobin/potassium phenotypic combinations in the Botosani Karakul lambs

Production trait	**Phenotypic combination**	**"t"**	**Liberty degrees**
Body weight at birth	HbAB/LK – HbAB/HK	1.71^{+}	41
	HbAB/LK – HbBB/LK	0.71	41
	HbAB/LK – HbBB/HK	0.89	104
	HbAB/HK – HbBB/LK	2.57*	48
	HbAB/HK – HbBB/HK	1.13	111
	HbBB/LK – HbBB/HK	2.07*	111
Lamb pelt surface at birth	HbAB/LK – HbAB/HK	1.56	41
	HbAB/LK – HbBB/LK	0.68	41
	HbAB/LK – HbBB/HK	0.78	104
	HbAB/HK – HbBB/LK	2.46*	48
	HbAB/HK – HbBB/HK	1.24	111
	HbBB/LK – HbBB/HK	1.80^{+}	111
Body weight at weaning	HbAB/LK – HbAB/HK	1.45	41
	HbAB/LK – HbBB/LK	0.06	41
	HbAB/LK – HbBB/HK	1.08	104
	HbAB/HK – HbBB/LK	2.55	48
	HbAB/HK – HbBB/HK	1.11	111
	HbBB/LK – HbBB/HK	2.06	111
Body weight gain at 90 days	HbAB/LK – HbAB/HK	1.47	41
	HbAB/LK – HbBB/LK	0.10	41
	HbAB/LK – HbBB/HK	1.03	104
	HbAB/HK – HbBB/LK	2.54*	48
	HbAB/HK – HbBB/HK	1.10	111
	HbBB/LK – HbBB/HK	2.08*	111
Daily average gain	HbAB/LK – HbAB/HK	1.56	41
	HbAB/LK – HbBB/LK	0.10	41
	HbAB/LK – HbBB/HK	1.14	104
	HbAB/HK – HbBB/LK	2.63*	48
	HbAB/HK – HbBB/HK	1.05	111
	HbBB/LK – HbBB/HK	2.23*	111

b) Correlations between phenotypic combinations Hb/K and quantitative production traits in adult ewes (Table 3,Table 4). The adult females which have achieved the biggest body weight at mating were those who presented the phenotypic combination HbBB/LK. Also, the body weights of adult ewes of types HbAB/HK and HbBB/HK are close to those of females HbBB/LK. Subpopulation of ewes with phenotypic combination HbAB/LK recorded a significantly lower body weight than the other three groups of ewes, the difference to the females HbBB/HK being even distinctly significant.

Females with intermediate haemoglobin in association with high serum potassium (HbAB/HK) produced the largest quantity of wool, and the smallest quantity of wool was obtained from females that also have intermediate haemoglobin but associated with low potassium level (HBAb/LK). The females with haemoglobin of type B in association with both types of blood potassium have also achieved important quantities of wool, especially those with phenotypic combination HbBB/HK. Therefore, in terms of wool production, the females HbAB/LK are clearly distinguishable to the other three subpopulations of females, significantly compared to ewes HbBB/LK and distinctly significantly compared to females which have high potassium levels associated with both haemoglobin types (HbAB/HK and HbBB/HK). Wool production differences among the female groups with the other phenotypic combinations give unsignificant values of the Student test.

The highest milk production was obtained from females HbAB/HK, and the lowest milk production is given by females HbAB/LK. Also, from females with slow haemoglobin associated with both potassium types, important milk quantities are obtained. In the case of milk production too, ewes with phenotypic combination HbAB/LK are significantly different compared to ewes with high potassium level associated with both haemoglobin types (HbAB/LK and HbBB/HK), and the difference between females with low potassium level associated with both haemoglobin types (HbAB/LK-HbBB/LK) is close to the 5% significance threshold. The production differences among the other phenotypic combinations Hb/K are unsignificant.

The total milk production is determined mainly by the lactogen potential of animal and less by the milking period. However, low milk production of females HbAB/LK is correlated with the shortest milking duration. The longest period of lactation does not occur in females HbAB/HK (with the highest milk production), but in females HbBB/LK. Females HbBB/LK give more milk than ewes HbBB/HK because their lactation period is more prolonged. Females with the highest milk production (HbAB/HK) have a shorter lactation period than that of ewes with slow haemoglobin associated with both potassium types (HbBB/LK and HbBB/HK).

Consequently, the daily average milk production for each ewe subpopulation Hb/K is dependent on the total milk production and milking period.

Table 3. Production traits in adult ewes belonging to the Botosani Karakul breed

Production trait	Statistical parameter	Phenotypic combination			
		HbAB/LK n=14	HbAB/HK n=22	HbBB/LK n=16	HbBB/HK n=110
Body weight at mating (Kg)	$\bar{x}$ ±s $\bar{x}$	43.73±0.88	48.63±2.03	49.14±1.72	47.40±0.58
	s	4.14	7.60	6.87	6.06
	v%	9.47	15.62	13.98	12.78
Wool production (Kg)	$\bar{x}$ ±s $\bar{x}$	1.90±0.14	2.60±0.17	2.40±0.16	2.49±0.07
	s	0.64	0.63	0.66	0.69
	v%	33.90	24.23	27.50	27.71
Milk production (l)	$\bar{x}$ ±s $\bar{x}$	52.94±4.92	77.04±7.90	68.54±5.62	67.17±2.53
	s	23.09	29.54	22.50	26.55
	v%	43.62	38.34	32.83	39.52
Milking period (days)	$\bar{x}$ ±s $\bar{x}$	156±7	166±7	177±5	171±3
	s	32.44	23.76	18.75	29.01
	v%	20.77	14.31	10.59	16.96
Daily average milk production (ml/day)	$\bar{x}$ ±s $\bar{x}$	339±27	464±51	387±31	393±19
	s	124.99	192.19	125.46	204.28
	v%	36.87	41.42	32.42	51.98

Table 4. Testing the production differences between haemoglobin/potassium phenotypic combinations in the Botosani Karakul ewes

Production trait	Phenotypic combination	"t"	Liberty degrees
Body weight at mating	HbAB/LK – HbAB/HK	2.50*	34
	HbAB/LK – HbBB/LK	2.65*	28
	HbAB/LK – HbBB/HK	2.94**	122
	HbAB/HK – HbBB/LK	0.22	36
	HbAB/HK – HbBB/HK	1.29	130
	HbBB/LK – HbBB/HK	0.96	124
Wool production	HbAB/LK – HbAB/HK	3.23**	34
	HbAB/LK – HbBB/LK	2.11*	28
	HbAB/LK – HbBB/HK	3.22**	122
	HbAB/HK – HbBB/LK	0.94	36
	HbAB/HK – HbBB/HK	0.74	130
	HbBB/LK – HbBB/HK	0.51	124
Milk production	HbAB/LK – HbAB/HK	2.73*	34
	HbAB/LK – HbBB/LK	1.87^{+}	28
	HbAB/LK – HbBB/HK	2.13*	122
	HbAB/HK – HbBB/LK	1.01	36
	HbAB/HK – HbBB/HK	$1.44^{?}$	130
	HbBB/LK – HbBB/HK	0.22	124
Milking period	HbAB/LK – HbAB/HK	1.00	34
	HbAB/LK – HbBB/LK	2.13*	28
	HbAB/LK – HbBB/HK	1.65^{+}	122
	HbAB/HK – HbBB/LK	1.59	36
	HbAB/HK – HbBB/HK	0.87	130
	HbBB/LK – HbBB/HK	1.10	124
Daily average milk production	HbAB/LK – HbAB/HK	2.36*	34
	HbAB/LK – HbBB/LK	1.05	28
	HbAB/LK – HbBB/HK	1.40	122
	HbAB/HK – HbBB/LK	1.49	36
	HbAB/HK – HbBB/HK	1.56^{+}	130
	HbBB/LK – HbBB/HK	0.16	124

c) Correlations between phenotypic combinations Hb/K and quantitative production traits in adult rams (Table 5, Table 6)

The most weighting adult rams at mating are those with phenotypic combination HbAB/HK. An important body weight is recorded in rams with high potassium level but associated with slow haemoglobin (HbBB/KH), too. The groups of adult males with low potassium level associated with both haemoglobin types recorded the same body weight, both groups being the slightest of population. Therefore, in statistical terms, the groups of rams with big body weights (HbAB/HK and HbBB/HK) are significantly differentiated compared to the groups of rams with small body weights (HbAB/LK and HbBB/LK).

In the case of wool production too, the most productive rams were those which have had in their biochemical genetic dowry the intermediate haemoglobin type AB associated with potassium type HK, but also those which had high potassium levels but associated with slow haemoglobin (HbBB/HK). The smallest productions of wool were obtained from rams with low potassium levels associated either with heterozygous haemoglobin type (HbAB/LK) or, especially, with homozygous haemoglobin type (HbBB/LK). But, statistically, the most important difference occurs between the two groups of rams that have the highest wool productions. Also, between the males HbBB/HK (with low production) and males HbAB/HK (with high production) the production difference is considerable, being situated in the adjacency of the 5% threshold.

Table 5. Production traits in adult rams belonging to the Botosani Karakul breed

Production trait	Statistical parameter	Phenotypic combination			
		HbAB/LK n=13	HbAB/HK n=17	HbBB/LK n=10	HbBB/HK n=89
Body weight at mating (Kg)	$\bar{x} \pm s_{\bar{x}}$	71.06±2.14	79.59±2.37	71.01±3.11	76.79±1.26
	s	8.81	8.55	9.82	11.88
	v%	12.40	10.74	13.83	15.47
Wool production (Kg)	$\bar{x} \pm s_{\bar{x}}$	4.14±0.21	4.64±0.36	3.93±0.31	4.54±0.12
	s	0.89	1.28	0.97	1.14
	v%	21.40	27.59	24.68	25.11

Table 6. Testing the production differences between haemoglobin/potassium phenotypic combinations in the Botosani Karakul rams

Production trait	**Phenotypic combination**	**"t"**	**Liberty degrees**
Body weight at mating	HbAB/LK – HbAB/HK	2.67*	28
	HbAB/LK – HbBB/LK	0.01	21
	HbAB/LK – HbBB/HK	2.09*	100
	HbAB/HK – HbBB/LK	2.30*	25
	HbAB/HK – HbBB/HK	1.15	104
	HbBB/LK – HbBB/HK	1.73^{+}	97
Wool production	HbAB/LK – HbAB/HK	1.27	28
	HbAB/LK – HbBB/LK	0.54	21
	HbAB/LK – HbBB/HK	1.47	100
	HbAB/HK – HbBB/LK	1.63	25
	HbAB/HK – HbBB/HK	2.71**	104
	HbBB/LK – HbBB/HK	1.85^{+}	97

*

The correlation analysis of combinations of haemoglobin and potassium phenotypes (Hb/K) with quantitative production traits (meat, wool, milk) in the Botosani Karakul breed revealed, generally, irrespective of age and sex, the productive superiority of sheep which contain in their biochemical genetic dowry the phenotypic combination HbAB/HK. Also, important productions are obtained from animals which possess slow haemoglobin associated with high potassium level (HbBB/HK). On the other hand, from sheep with low blood potassium associated either with intermediate haemoglobin (HbAB) or with slow haemoglobin (HbBB) there were obtained (as the case) lower productions. Statistically speaking, the values of Student test show that, generally, between the animal groups with high productions and the animal groups with low productions, there are differences that have various significance degrees.

On the occasion of this paper, in the Botosani Karakul sheep, we found some peculiarities regarding the specific of correlations or associations of phenotypic combinations Hb/K with the quantitative production traits (meat, wool, milk), on the one hand, or with the qualitative traits (shape and size of hair curls, quality, lustre and colour of hair fibres of lamb pelts), on the other hand. If in case of quantitative productions, the phenotypic combinations HbAB/HK and HbBB/HK are correlated with the highest production levels, then, relating to the qualitative productions, the phenotypic combination HbBB/HK is the best associated with the most valuable morphological and histochemical features of lamb pelts and the phenotypic combination HbBB/LK with the largest range of colours of hair fibres (2).

Therefore, in the selection of Botosani Karakul sheep, some biochemical markers, as the combinations of haemoglobin and potassium phenotypes, can be used to improve their productions depending on the purpose: the combinations HbAB/HK and HbBB/HK for the quantitative productions (meat, wool, milk), the combination HbBB/HK for the morphological and physicochemical features of lamb pelts and

the combination HbBB/LK for colour varieties and their shades.

CONCLUSIONS

In the Botosani Karakul sheep, four phenotypic combinations between the haemoglobin electrophoretic patterns and the blood potassium levels (HbAB/LK, HbAB/HK, HbBB/LK and HbBB/HK) are found; the combinations HbAA/LK and HbAA/HK are missing.

Some correlations were established between the four combinations of the haemoglobin and potassium phenotypes existing in this breed, on the one hand, and the quantitative production traits (meat, wool, milk), on the other hand.

Irrespective of age and sex, the quantitative production capacity of the Botosani Karakul sheep is higher in subpopulations of animals with phenotypic combinations HbAB/HK and HbBB/HK and lower in subpopulations of animals with phenotypic combinations HbAB/LK and HbBB/LK.

Many of these production differences among the animal groups with different phenotypic combinations Hb/K present statistical assurance having various significance degrees.

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