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Relationship between the genetic variants of kappa-casein and prolactin and the productive-biological characteristics of cows of the black-motley breed

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Abstract.

The article shows the results of monitoring the occurrence of the genotype of milk protein kappa-casein (CSN3) and the pituitary hormone prolactin (PRL) among cows of the black-motley breed of Russian origin, as well as the comparative characteristic of various genotypes by biological and productive qualities. Monitoring has shown that the highest frequency of occurrence was characteristic of genotypes CSN3AA – 0.70, PRL^{AA} - 0.49, PRL^{AB} – 0.49, and multiloci $CSN3^{AA}PRL^{AA}$ – 0.35 and $CSN3^{AA}PRL^{AB}$ - 0.33. By the results of the studies, minor differences have been found in the antigenic spectrum of blood groups between cows of various genotypes. Carriers of the genotype $CSN3^{AB}$, unlike homozygotes by allele A, were characterized by the absence of erythrocytic antigens G`` and Y`. Antigens Q` and Y2 were found more frequently among cows with genotype PRL^{AA}, than in heterozygotes. It has been found that cows that are carriers of genotypes homozygous by alleles A of the studied genes showed the highest yield, homozygous by alleles B – favorably differed in chemical composition of milk and the reproductive traits, and animals of the complex genotype $CSN3^{AB}PRL^{AB}$ – differed by the maximum duration of productive life and the lifetime milk yield.

Keywords: genotype; kappa-casein gene; prolactin gene, blood antigen; black-and-white breed, milk yield; duration of productive life.

INTRODUCTION

In the practice of livestock breeding, DNA diagnostics is being increasingly used. DNA markers are used as selection criteria to improve the productive characteristics, to increase resistance to diseases, for identifying genetic abnormalities and determining the degree of kinship and genetic heterogeneity [7]. Genotype of milk protein kappa-casein (CSN3) is considered one of the genetic markers. In many countries, breeding for genotypes of kappa-casein is included into cattle breeding programs [8, 11]. Alleles A and B of the gene of kappa-casein in cattle are most prevalent, they differ in two amino acid substitutions (Thr 136 →Iso 148 and Asp →Ala) [17, 20]. The results of studying this gene show that animals of genotype $CSN3^{BB}$ are characterized by high protein-lactescence, their milk has good cheese-making qualities; however, the information about the mass fraction of fat and the quantity characteristics of milk production are very contradictory[9, 6, 15]. The gene of the prolactin (PRL) pituitary hormone is less popular, unlike the kappa-casein gene. This hormone is involved in differentiation of the epithelial tissues of the mammary gland, maintaining lactation; expression of genes of caseins occurs through the prolactin receptors [16, 18]. Alleles A and B of the prolactin gene differ in a single amino acid substitution that occurs in codon 103 (103 Ala → Gly) [1, 2]. Studies of the relationships between genotypes of prolactin and the productive features of cows of the black-motley breed showed that animals with genotype PRL^{BB} feature high fat and milk yield [4, 12]; however, the information about milk yield of cows that are the carriers of various genotypes of the hormone is highly controversial.

Our goal was to monitor the occurrence rate of genotypes of kappa-casein and prolactin in cows of the black-motley breed of Russian origin, and to provide the comparative description of animals of various genotypes by their biological and productive qualities. The studies of this nature were first performed on the cows of the black-motley breed grown in the Northern Trans-Urals.

METHODS.

The research was performed between 2010 and 2014 at the Federal State Unitary Enterprise "Educational-Experimental Farm of the Tyumen State Agricultural Academy" in the Tyumen region. The study was focused on cows of the black-motley breed of Russian origin. The first stage of work was the monitoring of the occurrence rate of the genotype of the kappa-casein milk protein and of the prolactin hormone. For this purpose, blood samples from 100 cows (first group – cows of second lactation, second group – mature cows) were studied at the Laboratory of Biotechnology of the State Scientific

University of the Siberian R&D Institute of cattle breeding of the Russian Academy of Agricultural Sciences (GNU SibNIIZH RASKhN) (2010). The allelomorphic variants of genes were determined by the method of the polymerase chain reaction with the subsequent analysis by the polymorphism of the lengths of restrification fragments (PCR-RFLP) of the products of genes amplification [19]. Blood group of cows by the hemolysation reaction have been determined [10, 21-23].

The occurrence rate of alleles and genotypes of the studied genes have been determined by commonly adopted formulas [10]. The theoretical occurrence rates of the genotypes of kappa-casein and prolactin were calculated by the formula of binomial decomposition in accordance with the law of Hardy-Weinberg:

$$(p_A + q_B)^2, \qquad (1)$$

where p_A was the occurrence rate of allele A of the gene;
q_B was the occurrence rate of allele B of the gene.

Criterion χ^2 was used as the criterion of assessing conformity of the theoretical and actual alleles' occurrence rate.

The second stage included comparative characterization of cows of various genotypes by their biological and productive qualities, and the third stage - by the duration of productive life and lifetime productivity. Databases of the "Selex" application were used for this purpose. The coefficient of reproductive ability (CRA) was determined by the standard formula, the fecundity index (FI) - by the Doha formula [5, 24, 25]:

$$FI = 100 – (K + 2\times I), \qquad (2)$$

where K was the age of 1st calving, months;
I was the period between calvings, months.

At the Laboratory of Breeding Milk Quality Check of the State Agrarian University of Northern Trans-Urals (Tyumen), the weight and the diameter of the micelles of casein in the milk of cows were determined by the method of light scattering on spectrometer PE-5300 under the method of P. Dyachenko; the content of dry matter, milk solids-non-fat (MSNF), mass fraction of fat, mass fraction of protein, lactose and mineral substances, density (ºA) were determined on ultrasonic analyzer "Klever-2M".

RESULTS AND DISCUSSION

Polymorphism of genes.

The results of DNA-diagnostic of the kappa-casein gene showed that 70% of cows had genotype $CSN3^{AA}$, 25% had genotype $CSN3^{AB}$, and only 5% had genotype $CSN3^{BB}$. The occurrence rate of allele A of the kappa-casein gene was significantly higher than that of allele B, and was 82.5% against 17.5% (Table. 1).

The results of diagnostics of the prolactin hormone gene showed that genotypes PRL^{AA} and PRL^{AB} were characteristic of the same number of animals - 49%, and only 2% of cows were characterized by the homozygous genotype PRL^{BB}. With that, allele A of the prolactin hormone gene was found in most cows - 73.5%, and allele B - in 26.5% of the animals (Table 1).

Calculation of the theoretical occurrence rate of kappa-casein genotypes allowed establishing that genetic equilibrium was maintained in the analyzed herd. Comparison of the actual and theoretical occurrence rate of prolactin genotypes showed a statistically significant shift of genetic equilibrium towards the heterozygous genotype PRL^{AB} (χ^2= 6.66; p<0.01). Probably, genetic disbalance could be caused by using breeders - carriers of allele B of prolactin hormone, but since bulls were not tested for the presence of the studied gene, this could not be stated definitely.

In the studied population, animals of seven out of nine complex genotypes were found by two genes (Table 2).

Complex genotypes $CSN3^{AA}PRL^{AA}$ and $CSN3^{AA}PRL^{AB}$ were among the most commonly met ones – 35% and 33% of the bions, respectively. Animals with genotypes $CSN3^{AB}PRL^{AA}$ and $CSN3^{AB}PRL^{AB}$ were met more rarely – 12% and 13%, respectively, and homozygotes by alleles B - very rarely. So, carriers of genotype $CSN3^{BB}PRL^{AB}$ were 3% of the bions, and of genotypes $CSN3^{AA}PRL^{BB}$ and $CSN3^{BB}PRL^{AA}$ - 2% each. In the analyzed herd, animals with complex genotypes $CSN3^{AB}PRL^{BB}$ and $CSN3^{BB}PRL^{BB}$ were absent; their theoretical occurrence was predicted at 2% of the total population, under the condition of free and random combinations of the parental genotypes. Calculation of criterion χ^2 allowed establishing the fact that in the analyzed herd genetic balance by complex genotypes of kappa-casein and prolactin was preserved.

Table 1 – Polymorphism of genes of kappa-casein and prolactin

Genotype	*n*	Occurrence rate		Allele	*n*	Occurrence rate, p_{act}±*Sp*	χ^2
		p_{act}±*Sp*	p_{th}				
$CSN3^{AA}$	70	0.70±0.046	0.68	A	95	0.825±0.027	1.94
$CSN3^{AB}$	25	0.25±0.043	0.29	B	30	0.175±0.027	
$CSN3^{BB}$	5	0.05±0.022	0.03				
PRL^{AA}	49	0.49±0.050	0.54	A	98	0.735±0.031	6.66*
PRL^{AB}	49	0.49±0.050	0.39	B	51	0.265±0.031	
PRL^{BB}	2	0.02±0.014	0.07				

Note: *– p<0.01; $_{act}$ – actual occurrence rate; – theoretical occurrence rate

Table 2 – Actual and theoretical distribution of occurrence rate of complex genotypes of kappa-casein and prolactin

Genotype	Heads	Occurrence rate		χ^2
		p_{act}±Sp	p_{th}	
$CSN3^{AA}PRL^{AA}$	35	0.35±0.048	0.369	
$CSN3^{AA}PRL^{AB}$	33	0.33±0.047	0.261	
$CSN3^{AA}PRL^{BB}$	2	0.02±0.014	0.048	
$CSN3^{AB}PRL^{AA}$	12	0.12±0.032	0.155	
$CSN3^{AB}PRL^{AB}$	13	0.13±0.034	0.112	9.90
$CSN3^{BB}PRL^{AA}$	2	0.02±0.014	0.016	
$CSN3^{BB}PRL^{AB}$	3	0.03±0.017	0.012	
$CSN3^{AB}PRL^{BB}$	0	0.00	0.020	
$CSN3^{BB}PRL^{BB}$	0	0.00	0.002	

Antigenic blood spectrum.

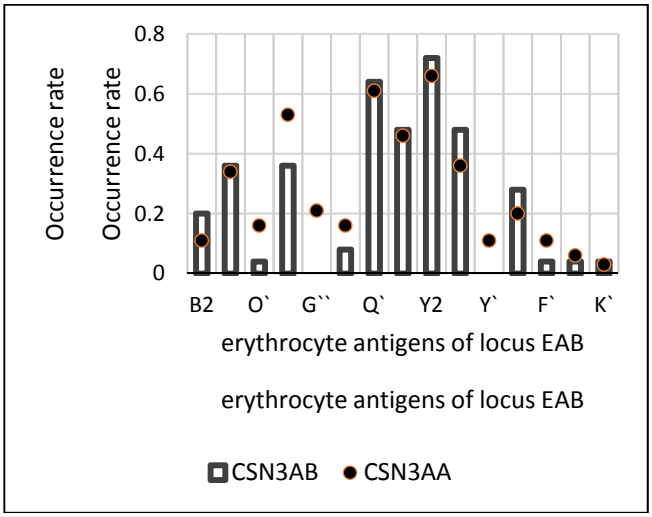
In cows of various genotypes, antigenic blood spectrum was studied for 7 systems, 29 antigens were established. The results of monitoring showed slight differences in the occurrence rates of erythrocyte antigens between the homozygotes by alleles A and heterozygotes (Fig. 1). Thus, factors G` and Y` (locus EAB) were not detected among heterozygous cows ($CSN3^{AB}$), while in homozygous cows their occurrence rate was 0.21 and 0.11, respectively. Among homozygous cows ($CSN3^{AA}$) antigens O` (locus EAB) and C_2 (locus EAC) were detected more frequently, with frequencies 0.16 and 0.41 vs. 0.04 (-0.12; R<0.05) and 0.20 (-0.21; p<0.05) among heterozygous cows, respectively.

Among the homozygous cows by allele A of prolactin, high occurrence rate of factors Q` and Y_2 (the locus of EAV) was detected - 0.73 and 0.80, respectively; in heterozygous cows these antigens were found significantly less frequently – 0.51 (-0.22; R<0.05) and 0.58 (-0.22; R<0.05), respectively.

Milk yield and milk quality.

Among cows of the two groups during various lactations the highest milk yield (7,426-8,012 kg), quantity of milk fat (281-308 kg) and protein (249-252 kg) in 305 days of lactation were shown by native genotypes $CSN3^{AA}$ and $CSN3^{AB}$ with the advantage of 394-1,382 kg (R<0.05-0.001), 17-57 kg (R<0.05-0.01), and 38-41 kg (R<0.05), as compared to genotype $CSN3^{BB}$, respectively. On the average, within two lactations in the first group of cows, the difference between homozygous genotypes was 858 kg (R<0.001) of milk, 32 (R<0.01) of milk fat, and 21 kg (R<0.05) of milk protein, while animals of the heterozygous genotype were superior to the homozygous animals for allele CSN3B by 862 kg (R<0.05) in terms of milk yield and by 35 kg (R<0.05) in terms of milk fat (Table 3).

Cows of the second group with genotype $CSN3^{BB}$ were superior to peers of genotypes $CSN3^{AA}$ and $CSN3^{AB}$ in terms of mass fraction of fat by 0.11% (R<0.05) and 0.13 % (R<0.05) on the average for three lactations, respectively.



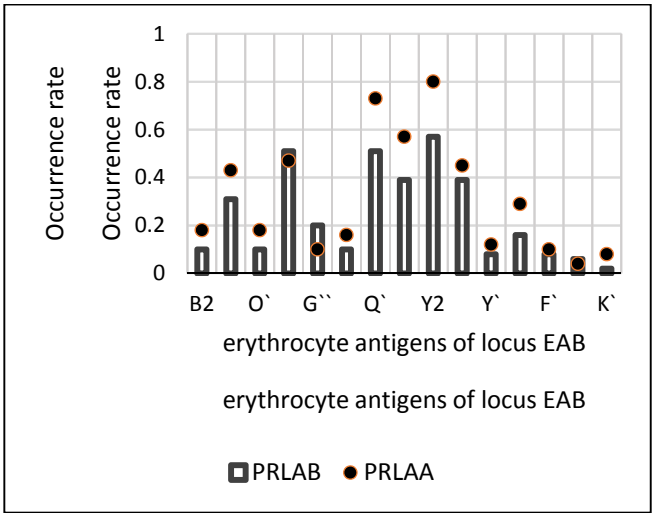


Figure 1 – Occurrence rate of erythrocyte antigens of locus EAV in cows of various genotypes

The highest mass fraction of protein averaged over lactations in both groups was typical for homozygous cows for allele $CSN3^{B}$, but the statistically significant difference occurred in the second group, where protein and milk yield for the 305 days in the third lactation was 3.18±0.010%

with the advantage over the homozygous genotype $CSN3^{AA}$ by 0.03% ($p<0.05$).

Cows of genotypes PRL^{AA} and PRL^{AB} in the second group, on the average for three lactations were superior to their peers of genotype PRL^{BB} in terms of milk yield by 1,403 ($p<0.01$) and 1,066 kg ($p<0.05$), in terms of amount of milk fat – by 51 ($p<0.01$) and 39 kg ($p<0.01$), and in terms of milk protein – by 42 kg ($p<0.01$) and 33 kg ($p<0.05$), respectively. Cows of genotype PRL^{BB} on the average over three lactations differed in the mass fraction of protein (+0.03; $p<0.001$) from the homozygous cows' PRL (Table 4), and over 305 days of the third lactation had relatively high mass fraction of fat in the milk (4.0±0.04%), compared to other genotypes (+0.14; $p<0.05$) [13, 14].

Among complex genotypes, carriers of the heterozygous one by two genes $CSN3^{AB}PRL^{AB}$ (first group) in the 305 days of the second lactation had higher milk yield (8,840±385 kg) and higher amount of milk protein (278±12.9 kg), compared to genotypes $CSN3^{AA}PRL^{AA}$, $CSN3^{AB}PRL^{AA}$, $CSN3^{BB}PRL^{AA}$, by 1,013-1,931 kg ($p<0.05$) and 32-55 kg ($p<0.05$), respectively. Cows of genotype $CSN3^{AA}PRL^{AA}$ (second group) featured the highest amount of milk fat (292-318 kg) and protein (258-260 kg), compared to genotypes $CSN3^{AB}PRL^{AA}$, $CSN3^{AV}PRL^{AA}$, by 29-72 kg ($p<0.05$-0.001) and 30-56 kg ($p<0.05$-0.01) by the symptoms, respectively. The highest mass fraction of fat in the first group was characteristic of cows of genotypes $CSN3^{AA}PRL^{AA}$ (3.82 - 3.87%) and $CSN3^{AB}PRL^{AA}$ (3.88%), and the lowest - of cows of genotype $CSN3^{AA}PRL^{AB}$ (3.74 - 3.75%). Thus, the advantage of animals of genotype $CSN3^{AA}PRL^{AA}$ was 0.08-0.13% ($p<0.05$) during the second lactation and on the average for two lactations, and of genotype $CSN3^{AB}PRL^{AA}$ - 0.14% ($p<0.05$) during the second lactation.

Examination of the composition and properties of milk from cows of various genotypes of kappa-casein during the six months of lactation showed that in carriers of genotype $CSN3^{BB}$ during the second lactation mass fraction of dry matter and MSNF was more than those in cows with genotype $CSN3^{AB}$ by 0.42% ($p< < 0.05$) and by 0.26% ($p<0,01$), respectively (Table 5).

Relatively high rates of dry matter and MSNF indicated superiority of cows of genotype $CSN3^{BB}$, compared to their peers in terms of nutritional value of milk, due to the increased protein and milt productivity. Thus, mass fraction of total protein and casein in cows of genotype $CSN3^{BB}$, compared to their peers of genotype $CSN3^{AA}$, was more by 0.12% ($p<0.05$) and 0.10% ($p<0.05$), and, compared to peers of genotype $CSN3^{AB}$ - by 0.13% ($p<0.01$) and 0.10% ($p<0.01$), respectively. No statistically significant difference had been found in terms of mass fraction of fat, lactose and mineral substances.

Chemical composition of milk influenced its density; cows with genotype $CSN3^{BB}$, due to the increased content of dry matter in milk, were superior in terms of milk density than their peers of genotypes $CSN3^{AA}$ and $CSN3^{AB}$ by 1.0 ºA ($p<0.05$) and 0.9 ºA ($p<0.01$), respectively.

Table 3 – Milk yield of cows of various genotypes of kappa-casein ($\bar{x} \pm S_{\bar{x}}$)

Indicator	First group[5]			Second group[6]		
	$CSN3^{AA}$	$CSN3^{AB}$	$CSN3^{BB}$	$CSN3^{AA}$	$CSN3^{AB}$	$CSN3^{BB}$
Heads	44	14	3	26	11	2
Milk yield, kg	7,689±105	7,693±194	6,831±218[3,4]	7,616±166	7,553±330	7,394±463
Mass fraction of fat, %	3.79±0.02	3.82±0.03	3.79±0.02	3.87±0.02	3.85±0.04	3.98±0.04[1.4]
Milk fat, kg	291±3.9	294±7.9	259±8.6[2.4]	295±6.7	291±10.8	294±15.4
Mass fraction of protein, %	3.14±0.005	3.15±0.007	3.22±0.030	3.15±0.005	3.14±0.005	3.19±0.030
Milk protein, kg	241±3.2	242±6.2	220±9.7[1]	240±5.1	237±10.3	236±17.6

Note: [1]– $p<0.05$; [2]– $p<0.01$; [3]– $p<0.001$ compared to $CSN3^{AA}$; [4]– $p<0.05$, compared to $CSN3^{AB}$; [5]– average productivity for two lactations; [6] – for the three lactations

Table 4 – Milk yield of cows of various genotypes of prolactin ($\bar{x} \pm S_{\bar{x}}$)

Indicator	First group[6]		Second group[7]		
	PRL^{AA}	PRL^{AB}	PRL^{AA}	PRL^{AB}	PRL^{BB}
Heads	34	27	15	22	2
Milk yield, kg	7,580±112	7,733±149	7,849±217	7,512±189	6,446±372[2.4]
Mass fraction of fat, %	3.83±0.02	3.76±0.02[1]	3.86±0.02	3.88±0.02	3.91±0.06
Milk fat, kg	290±4.4	291±5.6	303±8.1	291±7.2	252±10.4[2.5]
Mass fraction of protein, %	3.15±0.007	3.15±0.006	3.14±0.006	3.15±0.006	3.17±0.001[3]
Milk protein, kg	239±3.5	244±4.6	246±6.8	237±5.8	204±11.7[2.4]

Note: [1]– $p<0.05$; [2]– $p<0.01$; [3]– $p<0.001$ compared to PRL^{AA}; [4]– $p<0.05$; [5]– $p<$, compared to PRL^{AB}; [5]– average productivity for two lactations; [6] – for the three lactations

Table 5 – Chemical composition and properties of milk from cows of various genotypes of kappa-casein ($\acute{x} \pm S_{\acute{x}}$)

Indicator	Genotype		
	$CSN3^{AA}$	$CSN3^{AB}$	$CSN3^{BB}$
Cows' population, heads	34	9	2
Daily milk yield, kg	27.9±1.17	28.1±2.95	24.5±3.30
Dry matter, %	12.46±0.191	12.23±0.154	12.65±0.088[2]
MSNF, %	8.59±0.115	8.55±0.045	8.81±0.053[3]
Mass fraction of fat, %	3.87±0.086	3.68±0.134	3.84±0.044
Mass fraction of protein, %	3.17±0.042	3.16±0.019	3.29±0.023[1.3]
Mass fraction of casein, %	2.46±0.033	2.46±0.015	2.56±0.018[1.3]
Mass fraction of lactose, %	4.59±0.049	4.66±0.029	4.66±0.095
Mineral substances, %	0.73±0.009	0.74±0.009	0.76±0.035
Weight of casein micelles, million units of molecular weight	134.7±7.60	107.9±7.76[1]	92.4±44.75
Diameter of casein micelles, nm	66.8±1.77	61.0±1/35[1]	56.2±10.82
Density, ºA	29.1±0.38	29.2±0.18	30.1±0.16[1.3]

Note: [1]–$p<0.05$ compared to genotype $CSN3^{AA}$; [2]–$p<0.05$; [3]–$p<0.01$, compared to genotype $CSN3^{AB}$

Table 6 – Correlation between the complex genotypes and the productive life of cows ($\acute{x} \pm S_{\acute{x}}$)

Indicator	$CSN3^{AA}PRL^{AA}$ (n=25)	$CSN3^{AA}PRL^{AB}$ (n=23)	$CSN3^{AB}PRL^{AA}$ (n=10)	$CSN3^{AB}PRL^{AB}$ (n=11)
Duration of productive life, days.	1,291±77.9	1,354±86.6	1,269±141.8	1,671±158.5[1]
Finished lactations	2.9±0.19	3.2±0.26	3.4±0.40	3.9±0.47[1]
Lifetime milk yield, kg	26,178± 1,315.9	27,625± 1,828.2	26,598± 3,015.9	34,593± 3,572.2[1]
Milk fat, kg	966±57.4	1,025±74.8	987±118.0	1,312±133.0[1]
Milk protein, kg	794±46.5	843±59.5	811±98.3	1,077±111.8[1]

Note: [1]–$p<0.05$ compared to genotype $CSN3^{AA}PRL^{AA}$

The weight and diameter of casein micelles in cows with various genetic forms of kappa-casein varied with certain regularity. The largest micelles were characteristic of cows of genotype $CSN3^{AA}$, finer ones - of cows of genotype $CSN3^{BB}$. In terms of the weight of micelles, the difference between genotypes $CSN3^{AA}$ and $CSN3^{AB}$ was by 26.8 million units of molecular weight ($p<0.05$), and in terms of diameter - by 5.8 nm ($p<0.05$), with the advantage of the homozygous ones.

During the mature lactation, in terms of kappa-casein, chemical composition and properties of milk from cows of various genotypes were not significantly different, except for the parameters of casein particles. Thus, in cows of genotype $CSN3^{AA}$ the weight of casein micelles was 128.7 million units of molecular weight and their diameter was 66.7 nm, which was higher by 59.6 million units of molecular weight ($p<0.01$) and by 13.5 nm ($p<0.05$) higher than in cows of genotype $CSN3^{BB}$, respectively. The difference in the size of micelles in cows with various genotypes of kappa-casein was due to the inverse relationship between the share of kappa-casein fraction and the size of micelles [3].

By means of one-factor dispersion analysis the share of the genotype influence on the parameters of casein particles was determined. During the second lactation the influence of genetic form of kappa-casein on the weight and diameter of casein micelles was 9.5% ($p<0.05$), during mature lactation it was greater and reached 26.1% ($p<0.05$) for the weight of the micelles and 29.1% ($p<0.05$) for their diameter. Thus, the difference in the size of casein micelles was more pronounced in cows during mature lactation.

Reproductive qualities.

Cows of genotype $CSN3^{BB}$ were characterized, on the average, during two reproductive cycles by shorter duration of the service period (83±6.4 days) and the highest fertility index (49.5±2.20), compared to homozygotes $CSN3^{A}$ by 85 days ($p<0.001$) and 5.3 ($p<0.05$), to heterozygotes - by 53 days ($p<0.01$) and 3.0 ($p<0.01$), respectively. Cows of genotype PRL^{BB} also had better reproductive qualities on the average during the three periods between calving. The duration of their service period was 66±18.5 days, with the difference of 72 days ($p<0.01$) and 67 days ($p<0.01$), compared to homozygotes (PRL^{A}) and heterozygotes, respectively. Among complex genotypes, $CSN3^{AB}PRL^{AA}$, $CSN3^{BB}PRL^{AA}$, $CSN3^{BB}PRL^{AB}$ and $CSN3^{AA}PRL^{BB}$ were favorably different. Thus, the duration of the service period in carriers of these genotypes was lower, compared to animals of genotype $CSN3^{AA}PRL^{AA}$, by 73-120 days ($p<0.05$-0.001), and on the

average was 130 - 201 day in the latter. Thus, the best reproductive qualities were characteristic of cows with homozygous B-allelic variants of genes of kappa-casein and prolactin.

Duration of productive life and lifetime productivity of cows.

Cows of the black-motley breed of various genotypes of kappa-casein were not different in the duration of productive life and lifetime productivity. The homozygous by prolactin allele B animals featured duration of economic use equal to 4.5±0.50 lactations, and surpassed genotype PRL^{AA} by 1.4 lactations ($p<0.01$). Carriers of genotype PRL^{BB} showed the tendency to high lifetime productivity, but the amount of milk and milk fat in one productive day, which was 18.6±0.01 kg to 0.67±0.02 kg, was inferior to that of homozygotes (PRL^{AA}) by 2.1 kg ($p< < 0.001$) and 0.09 kg ($p<0.01$), and to heterozygotes (PRL^{AB}) – by 1.8 kg ($p>0.001$) and 0.09 kg ($p<0.001$), respectively.

Among the complex genotypes, heterozygous genotype $CSN3^{AV}PRL^{AV}$ deserved the greatest attention, the carriers of which were characterized by the greatest duration of the productive life (+380 days; $p<0.05$), lifetime milk yield (+8,415 kg; $p<0.05$), the amount of milk fat (+346 kg; $r<0.05$) and protein (+283 kg; $p<0.05$) compared to cows of the most common genotype $CSN3^{AA}PRL^{AA}$ (Table 6).

The influence of complex genotypes on the lifetime milk yield, milk fat and protein calculated by one-factor dispersion analysis was 11.0% ($p<0.05$). In turn, the impact on lifetime performance of genotypes of only kappa-casein or prolactin was statistically not significant.

CONCLUSIONS

The analyzed herd of cows of the black-motley breed was dominated by homozygous A-allele genotype of milk protein kappa-casein and hormone prolactin. The occurrence rate of B alleles was not high, and amounted to 0.175±0.027 for gene of kappa-casein, and 0.260±0.031 - for gene of prolactin. No selection was made in the herd by genotypes of cattle in terms of loci of kappa-casein and prolactin.

The cows that were homozygous by A allele of the studied genes were characterized by higher milk yield, and homozygous by B allele – by high mass fraction of fat and protein. Among complex genotypes, the highest milk yield was observed in carriers of $CSN3^{AA}PRL^{AA}$ $CSN3^{AB}PRL^{AB}$. The detailed assessment of milk chemical composition and properties showed that in terms of the main studied parameters, cows-carriers of allele $CSN3^{B}$inhomozygous state- were most favorable.

The best reproductive qualities were found in cows carriers of B-allelic variants of gene of kappa-casein and prolactin in the homozygous state.

The greatest length of productive life and lifetime milk yield was found in cows with heterozygous complex genotype $CSN3^{AB}PRL^{AB}$.

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