The effect of holstein bulls'kappa-casein gene genotype on the productive longevity of their female offspring in the republic of Bashkortostan

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Abstract. Increased productivity in the industry can be achieved by breeding for productive longevity through¬ searching and using genetic ¬markers. The study analysed the data of 1476 animals with at least one completed lactation. Depending on the linear affiliation and kappa-casein gene genotype of servicing bulls, their female offspring were divided into 4 groups. The CSN3 A allele frequency in the studied bulls was 81.91%, the CSN3 B allele was 18.09%. The highest frequency of the desired CSN3 B allele in the servicing bulls-producers of the Reflection Sovering line was 20.83%, which is 3.69% more than in the bulls of the Vis Back Ideal line. The animal life length analysis showed that the female progeny of bulls from the Reflection Sovering line (2.46 lactation), especially those with the CSN3 AB genotype (2.59 lactation), had the longest life. The offspring of CSN3AB genotype bulls of the Reflection Sovering line had the highest lifetime milk yield (18490 kg). The CSN3AB genotype cows of the Reflection Sovering line had the highest average milk yield on the 1st day of a cow's life of 9.05 kg.

1 Introduction

The length of dairy cows' productive performance is a biological and economic trait since the expediency of running the dairy industry depends both on the amount of milk yield and the cows' performance period. Dairy cows are characterised by a rather long biological period of productive lifetime of 8 ... 10 or more lactations. However, the production period of high-yielding cows in foreign countries and Russian regions with highly developed dairy animal breeding, as a rule, does not exceed 2.5...3 lactations [1].

With the premature retirement of cows from the herd, the cost of dairy products increases due to significant input in raising young animals. Productive longevity is a determining factor since it directly affects the lifetime milk yield, the number of calves, and

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the progress of the population and the breed as a whole. Therefore, high-yielding dairy cows with long-term productive performance are essential in modern dairy cattle breeding [2].

In recent decades researchers and cattle breeders have shown an increased interest in the productive longevity of dairy cows. The heritability of productive longevity is very low, and this trait variation can result from numerous genetic and paratypic factors [3].

Previous studies have provided abundant evidence on different ways to increase the productive life of livestock by varied animal maintenance and breeding methods [4-6]. It has been established the impact of the first calving time, the milk yield for the first lactation, the calving season, linear affiliation, pedigree, servicing bulls and other factors on the lifespan [7, 8]. The existing data are rather controversial that makes them difficult to use fruitfully in production [9].

Questions have been raised on the effect of genetic factors on the productive longevity of cattle [10-12]. Productive longevity can be forecasted using the information on the structure of subpopulations by polymorphic loci [13]. Molecular markers related to the reproductive characteristics and the lifespan of animals are used in genomic selection [14, 15]. The search and use of genetic markers of productive longevity in cattle is an actual direction of molecular genetic research.

The present study analysed the kappa-casein gen (CSN3) as a genetic marker. There is substantial evidence on the effect of these gene allelic forms on milk productivity. Very little is known about its interaction with lifelong productivity indicators.

The aim of the given research was to study the effect of the kappa-casein genotype of Holstein servicing bulls on the lifespan and productivity life of their female progeny.

2 Materials and methods

The investigation was conducted in the herd of the breeding reproducer Agrofirma Bayramgul LLC in the Uchalinsky district of the Bashkortostan Republic from 2013 to 2019 based on the primary breeding records of retired Holstein cows processed in the SELEX software. The study analysed the data of 1476 animals with at least one completed lactation. Depending on the linear affiliation and kappa-casein gene genotype of the servicing bulls, their female offspring were divided into four groups: Group I-the Vis Back Ideal line with the kappa - casein gene $CSN3^{AA}$genotype, II - the Vis Back Ideal with the $CSN3^{AB}$genotype, III - Reflection Sovering with the $CSN3^{AA}$ genotype and IV - Reflection Sovering with the $CSN3^{AB}$ genotype.

The genotype frequency was determined by the formula:

$$h = \frac{n}{N} \times 100, \quad (1)$$

where h is the genotype frequency; n is the frequency of individuals having a certain genotype; N is the total number of animals examined.

The allele frequency was found by the formula of R. Fischer:

$$p\,(A) = \frac{2nAA + nAB}{2N} \quad (2)$$

$$q\,(B) = \frac{2nBB + nAB}{2N} \quad (3)$$

where p is the allele A frequency; q is the allele B frequency; n is the number of individuals having a certain genotype; N is the total number of animals.

The following productive performance indicators of cows were studied: age and reasons for retirement, milk yield, fat content and milk fat yield for 305 days of lactation, live weight, productive life length of cows, lifetime milk yield and milk yield for one day of life.

Statistical processing of the scientific research results was performed in Microsoft Excel 2007. The reliability of the obtained results was determined by the Student's t-criterion.

3 Results and discussion

Kappa-casein genotype analysis in 47 servicing bulls showed the absence of the desired CSN3 ^{BB} genotype in animals (Table 1). 30 heads had the CSN3^{AA} genotype (63.83%), and 17 animals had the CSN3 ^{AB} genotype (36.17%). The servicing bulls of the Reflection Sovering line had the highest frequency of the CSN3 ^{AB} genotype of 41.67%, which is 7.38% higher than in animals of the Vis Back Ideal line.

The CSN3 ^{A} allele frequency in the studied bulls was 81.91%, the CSN3 ^{B} allele was 18.09%. The servicing bulls of the Reflection Sovering line had the highest frequency of the desired CSN3 ^{B} allele of 20.83%, which is 3.69% more than in the bulls of the Vis Back Ideal line.

To conduct effective breeding, it is important to know the main reasons for the animal departure from the herd. It will reduce culling by organisational, technological and special veterinary measures. The present study analysed the main reasons for the departure of cows from the herd based on the zootechnical and veterinary records (Table 2).

Table 1. Kappa-casein (CSN3) gene polymorphism in bulls.

Bulls'line	The number, heads	Genotype frequency, %			Allele frequency, %	
		AA	AB	BB	A	B
Vis Back Ideal	35	65,71	34,29	0	82,86	17,14
Reflection Sovering	12	58,33	41,67	0	79,17	20,83
Total	47	63,83	36,17	0	81,91	18,09

Table 2. The main reasons for the departure of the female offspring of servicing bulls, depending on the linear affiliation and kappa-casein gene genotype.

Culling reason	Vis Back Ideal			Reflection Sovering		
	total	including		total	including	
		CSN3^{AA}	CSN3^{AB}		CSN3^{AA}	CSN3^{AB}
Group	-	I	II	-	III	IV
The number, heads	1089	891	198	387	298	89
Low productivity, %	15,9	16,2	14,6	16,5	16,8	15,7
Gynaecological disorders, %	28,3	28,7	26,3	24,6	23,8	27,0
Udder diseases,	20,2	20,4	19,2	22,5	21,8	24,7

%						
Limb diseases, %	25,0	24,5	27,3	24,0	25,5	19,1
Other reasons, %	10,6	10,2	12,6	12,4	12,1	13,5

Table 3. Productive life of the female progeny of breeding bulls, depending on the linear inheritance and kappa-casein gene genotype.

Culling reason	Vis Back Ideal			Reflection Sovering		
	total	including		total	including	
		$CSN3^{AA}$	$CSN3^{AB}$		$CSN3^{AA}$	$CSN3^{AB}$
Group	-	I	II	-	III	IV
The number, heads	1089	891	198	387	298	89
Lifepsan, lactation	2,41± 0,048	2,43± 0,045	2,31± 0,057**	2,46± 0,065	2,42± 0,061	2,59± 0,080
Lifelong productivity, kg	17041± 227,9	17018± 240,1**	17147± 359,5*	17717± 325,2	17486± 319,0	18490± 462,4
Average fat content, %	3,83± 0,005	3,83± 0,005	3,82± 0,006	3,82± 0,007	3,82± 0,007	3,81± 0,009
Lifetime milk fat yield	652,4± 8,67	651,8± 9,24**	655,0± 13,30*	676,4± 10,42	668,0± 11,91	704,5± 16,04
Milk yield for the highest lactation, kg	8370± 69,8	8347± 71,4	8471± 106,2	8557± 80,3	8571± 97,0	8509± 122,1
Milk yield for one day of life, kg	8,47± 0,081	8,49± 0,089**	8,40± 0,125***	8,76± 0,133	8,67± 0,106*	9,05± 0,150

Note: one asterisk (*) indicates the difference reliability at $p < 0.05$, two (* *) at $p < 0.01$, three (* * *) at $p < 0,001$.

Analysis of the reasons for culling female offspring of Vis Back Ideal line servicing bulls showed that the animals depart with reproductive impairment (28.3%), limb diseases (25.0%), udder diseases (20.2%), low productivity (15.9%) and other reasons (10.6%).

Considering the reasons for departure in terms of the kappa-casein gene genotypes demonstrated that the female progeny of $CSN3^{AA}$genotype are mostly culled for reproductive function disorders (2.4%), low productivity (1.6%) and udder diseases (1.2%). The offspring of CSN3 ^{AB} genotype bulls depart due to limb diseases (+2.8%) and other reasons (2.4%).

The main reasons for culling the progeny of Reflection Sovering line bulls include reproductive impairment (24.6%), limb diseases (24.0%), udder diseases (22.5%), low productivity (16.5%) and other reasons (12.4%). Female offspring of $CSN3^{AA}$ genotype bulls depart from the herd due to limb diseases (6.4%) and low productivity (1.1%). Young cattle of CSN3 ^{AB} genotype bulls are culled due to gynaecological disorders (+3.2%), udder diseases (+2.9) and other reasons (+1.4%).

The lifespan analysis showed that the female progeny of the Reflection Sovering line bulls (2.46 lactation), especially those with the CSN3AB genotype (2.59 lactation), had the longest life.

According to the studied indicator, cows from this group outperformed the Reflection Sovering line with the $CSN3^{AA}$ genotype by 0.17 lactation, the Vis Back Ideal line with the $CSN3^{AA}$ genotype by 0.16 lactation and with the CSN3 ^{AB} genotype by 0.28 lactation ($p < 0,01$).

In production conditions, the lifetime milk yield of cows is of great importance. The offspring of CSN3^{AB} genotype bulls of the Reflection Sovering line had the highest lifetime milk yield (18490 kg). They left behind animals of the same line but with the CSN3^{AA} genotype by 1004 kg, the Vis Back Ideal line with the CSN3 ^{AA} genotype by 1472 kg ($p < 0,01$), and the CSN3 ^{AB} genotype by 1343 kg ($p < 0,05$).

The linear affiliation of the breeding bulls and the genotype of kappa-casein did not affect the fat content in the milk of their daughters. It ranged from 3.81 to 3.83% in the studied groups.

The highest lifetime yield of milk fat was found in animals of group IV – 704.5 kg, which is more than in group I by 52.7 kg ($p < 0.01$), group II by 49.5 kg ($p < 0,05$) and group III by 36.5 kg.

Female offspring of CSN3^{AA} genotype bulls of the Reflection Sovering line had the highest milk yield per lactation, 8571 kg, which is 62 kg more than in the CSN3 ^{AB} genotype animals of the same line and 224 and 100 kg more than in cows of the Vis Back Ideal line with CSN3^{AA} and CSN3^{AB}genotypes, respectively.

One of the main indicators of productive longevity of cows is the milk yield for 1 day of life, which also indicates the unproductive performance of animals during lactation. The animals of group IV had the highest average milk yield for 1 day, 9.05 kg. They significantly outperformed their peers from groups I, II and III, respectively, by 0.56 ($p < 0.01$), 0.65 kg ($p < 0.001$) and 0.38 kg ($p < 0,05$).

4 Conclusion

A study of longevity and lifelong productivity in female offspring of Holstein servicing bulls with different variants of the kappa-casein genotype showed that animals of the Reflection Sovering line with the CSN3 ^{B} allele in their genotype showed a tendency to longer lifespan and lifelong productivity. Therefore, the genotyping of cattle according to the kappa-casein protein genotype can be considered a promising direction in breeding work to increase the lifetime indicators of dairy productivity.

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