

# **Genetic diversity of Russian native cattle breeds on the genes associated with milk production**

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Estimation of the genetic diversity of local cattle breeds is an important component of their preservation and rational use in stockbreeding and husbandry. **The number of Russian breeds** of domestic animals has decreased by 50% in recent years. About **33 native breeds have been preserved to date** in Russia. But the numbers of animals of some currently existing breeds have decreased to a critical point. At the same time, **some of them are unique and have no analogues anywhere in the world.**



One example is **Yakut cattle** occupying the northernmost part of the range of *Bos taurus*. This breed lives in the severe Arctic climate and is well adapted to drastic oscillations of air temperature and to coarse fodder. The milk of these cattle has a fat content as high as 9%. Life of various peoples inhabiting the modern Yakutia (Sakha) Republic, Russia, has been related to these cattle for several thousand years. Yakut cattle lived in this region as early as 3.5–4 thousand years ago. The number of these cattle had dropped from several hundred thousands to about five hundreds during the past 100 years.



**Yaroslavl cattle**, formed as a result of **native selection** in the **16th century**, has the **highest milk yield** (from 6000 to 11700 kg) and the **best milk composition** among all native Russian breeds. **High fat content** (4.6%) of the milk is combined with a **considerable protein content** (3.5-3.6%) and dry matter content (13.6%). **The cheeses** made from the milk of **Yaroslavl cows** are noted for **high quality** (Yaroslavl, Uglich cheeses and others). The name Yaroslavl cattle first appeared in the literature in the mid-19th century. Yaroslavl is a dairy breed



CATTLE  
Bestuzhev



♀



♀

Two other Russian breeds dealt with in this study, **Kostroma** and **Bestuzhev**, are dual-purpose breeds.

The breeding of **Bestuzhev cattle** began **in the late 18th century**;

**Kostroma cattle** - in the **20th** century.

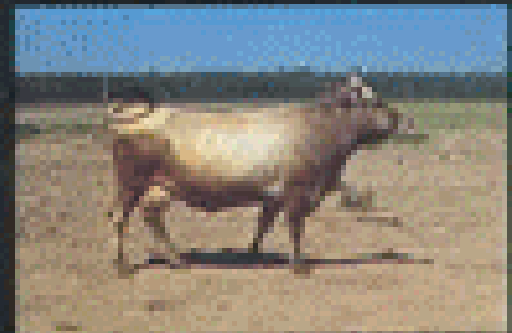
Both breeds are raised in central Russia.



CATTLE  
Kostroma



♀



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Russian native breeds of farm animals have been studied insufficiently using DNA technology.

**The main goal of this study was to analyze the genetic polymorphism of four native Russian cattle breeds with respect to the kappa-casein (*CSN3*), prolactin (*bPRL*), growth hormone (*bGH*), and transcription factor Pit1 (*Pit1*) genes.**

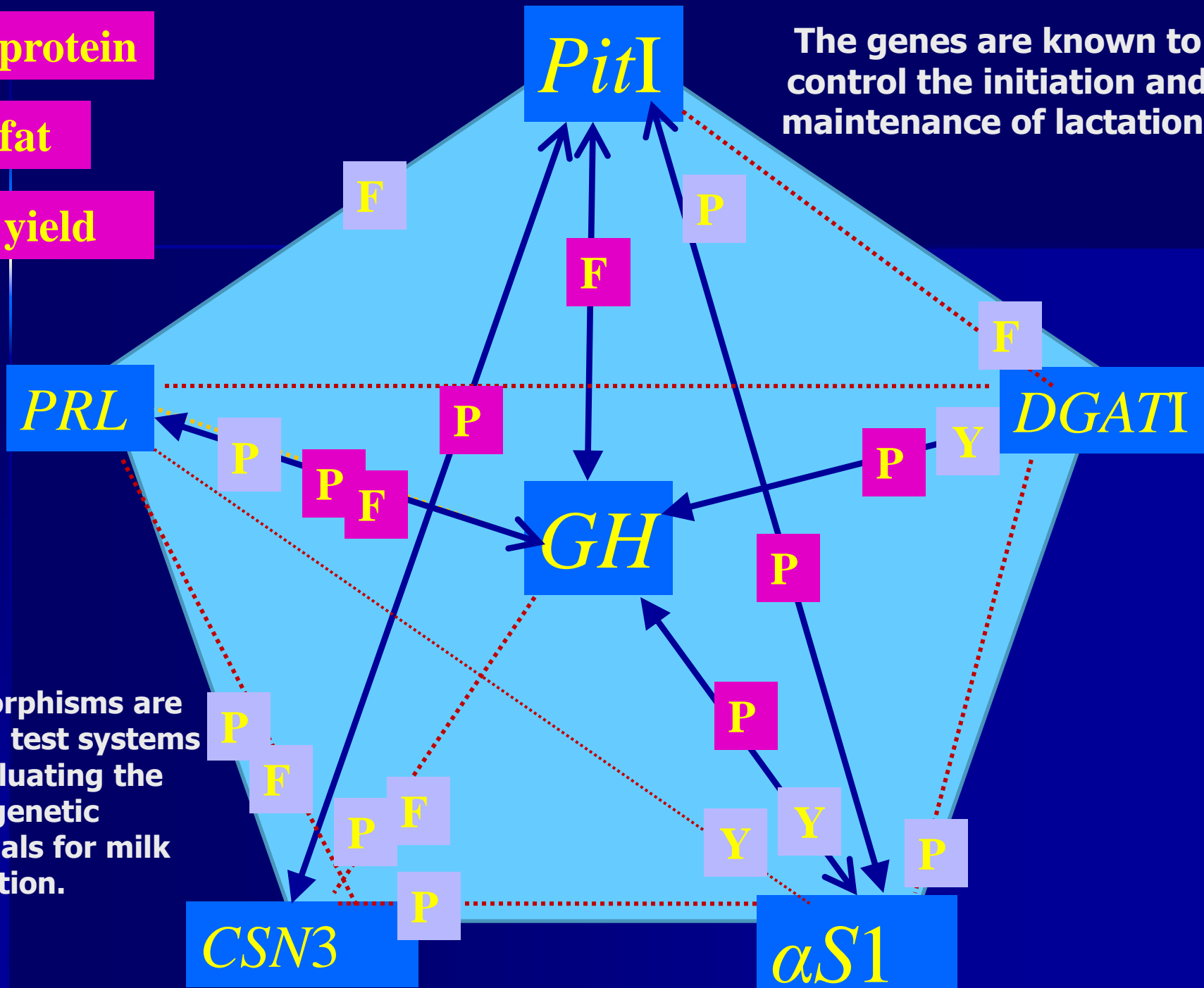
**These genes are known to control the initiation and maintenance of lactation.**

**P - protein**

**F - fat**

**Y - yield**

The genes are known to control the initiation and maintenance of lactation.



## MATERIALS AND METHODS

The PCR–RFLP technique was used to detect single nucleotide polymorphisms in exons 4, 3, 6, and 5 of genes *CSN3* (*Hind*III), *bPRL* (*Rsa*I), *bPif*I (*Hinf*I), and *bGH* (*Alu*I), respectively, in Bestuzhev, Yakut, Kostroma, and Yaroslavl cattle breeds.

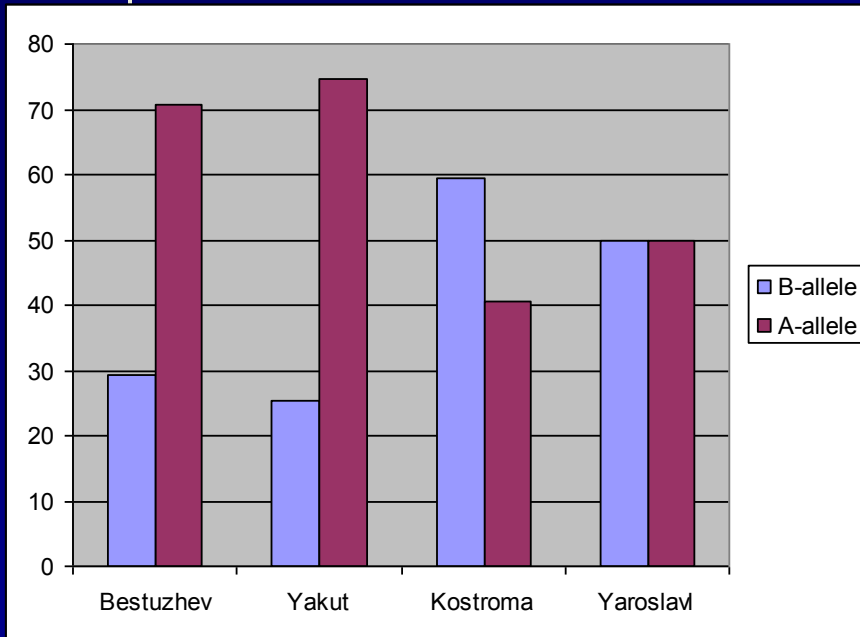
Statistical analysis was performed with the use of the Popgene 1.32 and Statistica 6.0 software.

Cumulative effect of the coupled genotypes of the genes studied on the milk fat and protein content was revealed using two-way ANOVA.

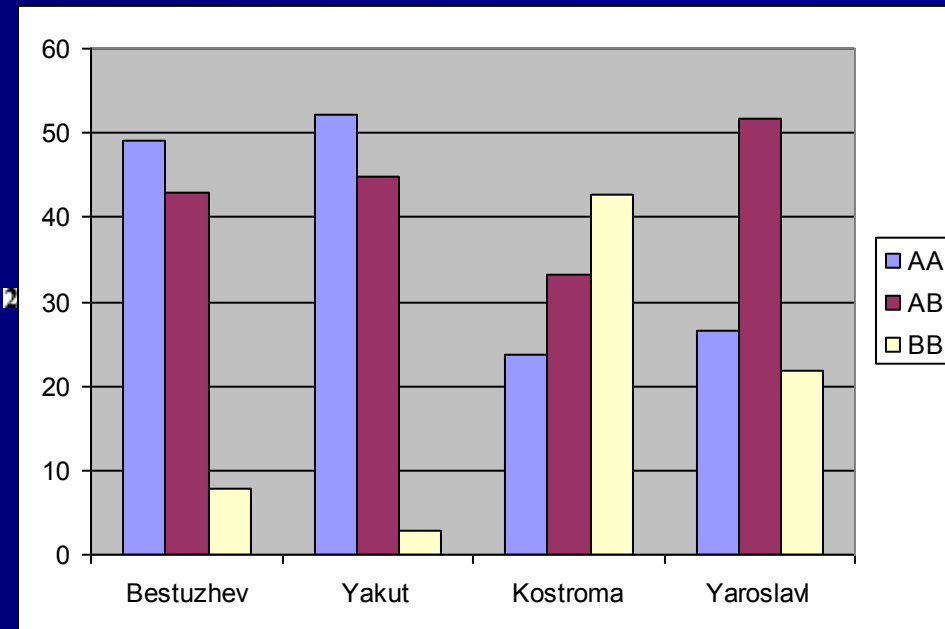


# The genetic polymorphism of four native Russian cattle breeds with respect to the kappa casein gene.

Allele frequencies of *CSN3* in four Russian cattle breeds



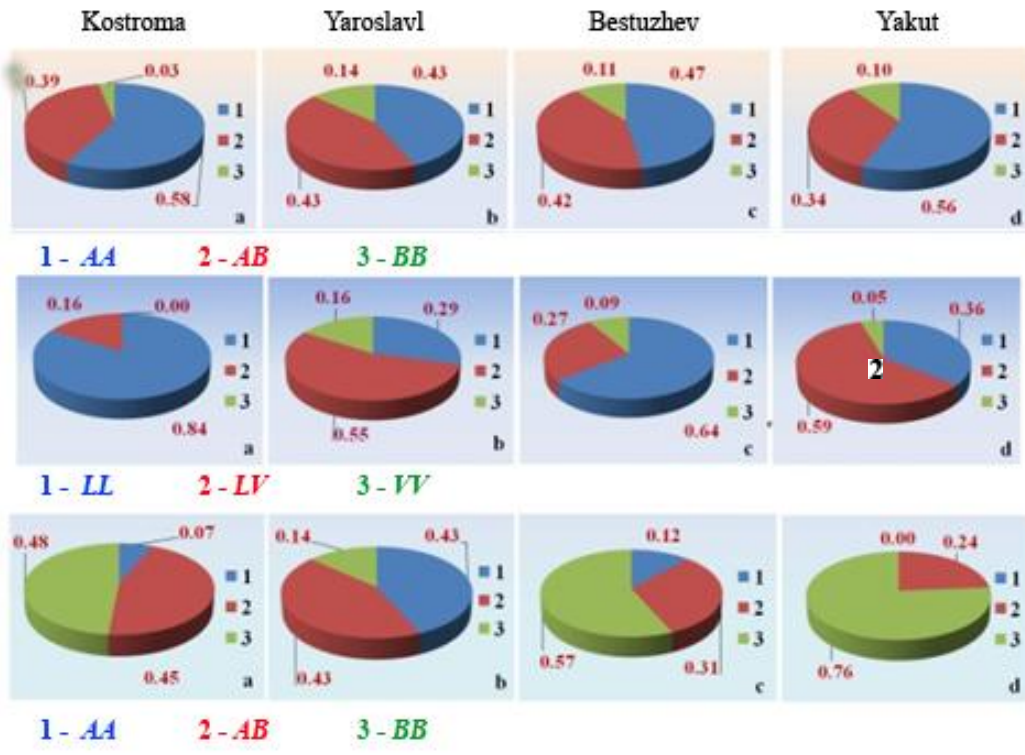
Genotype frequencies of *CSN3* in four Russian cattle breeds



**A high content of economically important allele (B-allele) of *CSN3* was shown in Kostroma and Yaroslavl cattle breeds.**

# The genetic polymorphism of four native Russian cattle breeds with respect to the prolactin, growth hormone, and transcription factor Pit1 genes.

Distribution of genotype frequencies for genes *bPRL*, *bGH*, *bPit1* in four Russian cattle breeds



A high content of economically important alleles of *bPRL* and *bGH* was shown in Kostroma and Yaroslavl cattle breeds.

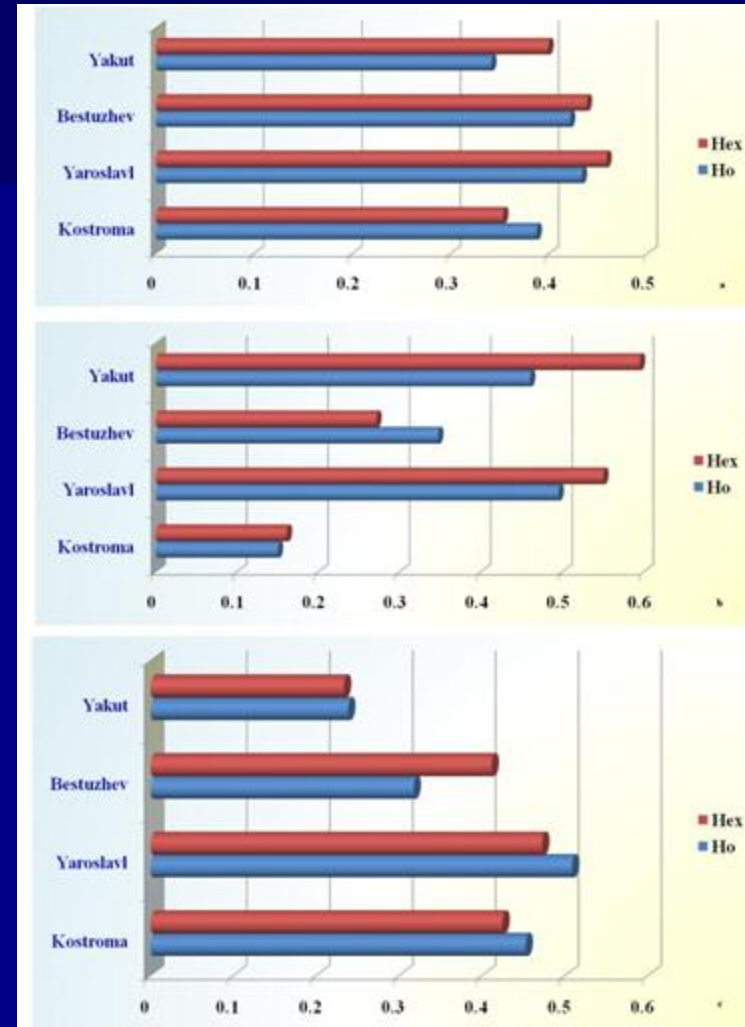
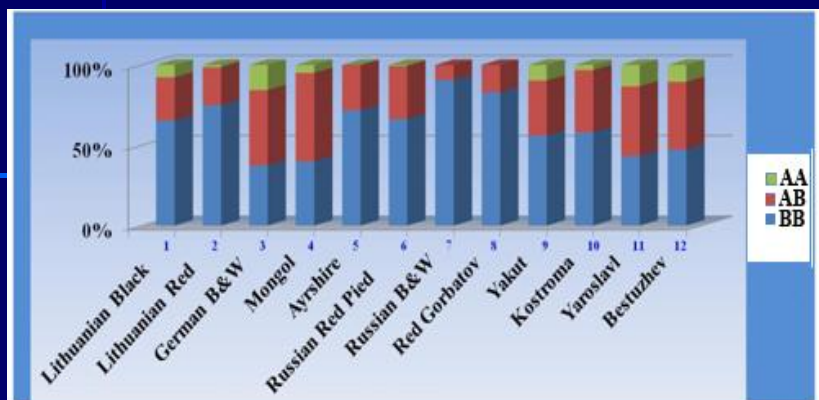


Fig. 2 The observed and expected heterozygosities for the analyzed markers of genes (a) *bPRL*, (b) *bGH*, and (c) *bPit1* in four Russian breeds of cattle.

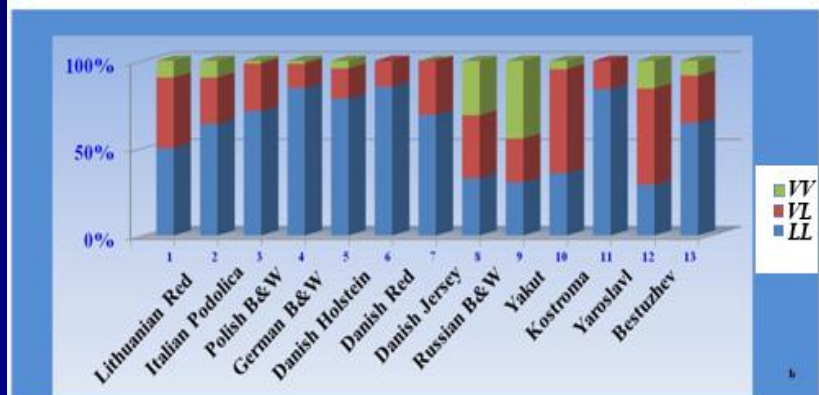
The G2 test **did not** show **significant differences** between the **breeds studied in the genotype frequencies for the *bPRL* gene** ( $G2 = 8.084$ ,  $v = 6$ ,  $p = 0.232$ ). However, the breeds differed in the **genotype frequencies for genes *bGH* and *bPit1*** ( $G2 = 69.124$ ,  $v = 6$ ,  $p \ll 0.001$  and  $G2 = 26.800$ ,  $v = 6$ ,  $p \ll 0.001$ , respectively). **Pairwise comparison of the breeds with respect to the frequencies of *bGH* genotypes demonstrated significant differences of almost all breeds from one another**, except for the pair Yaroslavl–Yakut breeds (Kostroma–Yaroslavl,  $G2 = 55.892$ ,  $df = 2$ ,  $p \ll 0.001$ ; Kostroma–Bestuzhev,  $G2 = 9.846$ ,  $df = 2$ ,  $p = 0.007$ ; Kostroma–Yakut,  $G2 = 23.825$ ,  $df = 2$ ,  $p \ll 0.001$ ; Yaroslavl–Bestuzhev,  $G2 = 19.988$ ,  $df = 2$ ,  $p \ll 0.001$ ; Bestuzhev–Yakut,  $G2 = 10.295$ ,  $df = 2$ ,  $p = 0.006$ ). A similar comparison with respect to the *bPit1* gene showed that **Yakut cattle significantly differed from all other breeds** (Yakut–Kostroma,  $G2 = 9.883$ ,  $df = 2$ ,  $p = 0.007$ ; Yakut–Yaroslavl,  $G2 = 22.431$ ,  $df = 2$ ,  $p \ll 0.001$ ; Yakut–Bestuzhev,  $G2 = 8.983$ ,  $df = 2$ ,  $p = 0.011$ ) and Yaroslavl cattle differed from all other breeds except Kostroma (Yaroslavl–Bestuzhev,  $G2 = 6.593$ ,  $df = 2$ ,  $p = 0.037$ ; Yaroslavl–Yakut, see above).

# Comparison of the frequency distributions of the *bGH*, *bPRL*, and *bPitI* genotypes in Russian and European breeds (own and literature data)

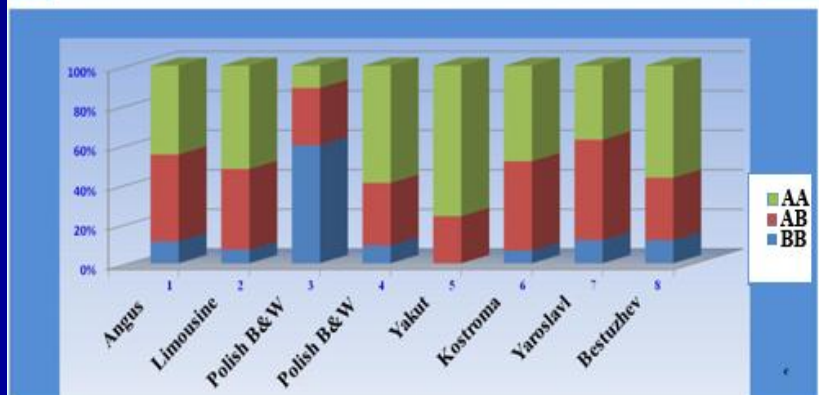
A



B



C



The genetic variation of the *AluI* marker of the *bGH* gene (B) in the studied Russian breeds is somewhat higher than in a number of European breeds.

The Russian and European breeds do not differ from each other in the degree of genetic variation of the *RsaI-bPRL* (A) and *HinfI-bPitI* (C) markers ( $\chi^2 = 1.57$ ,  $df = 1$ ,  $p = 0.211$  and  $\chi^2 = 0.13$ ,  $df = 1$ ,  $p = 0.718$ , respectively).



**The objectives of this work were to study not only the allelic polymorphisms of the *Pit1*, *bGH* and *bPRL* genes but the associations between polymorphic variants of the genes and milk productivity parameters**

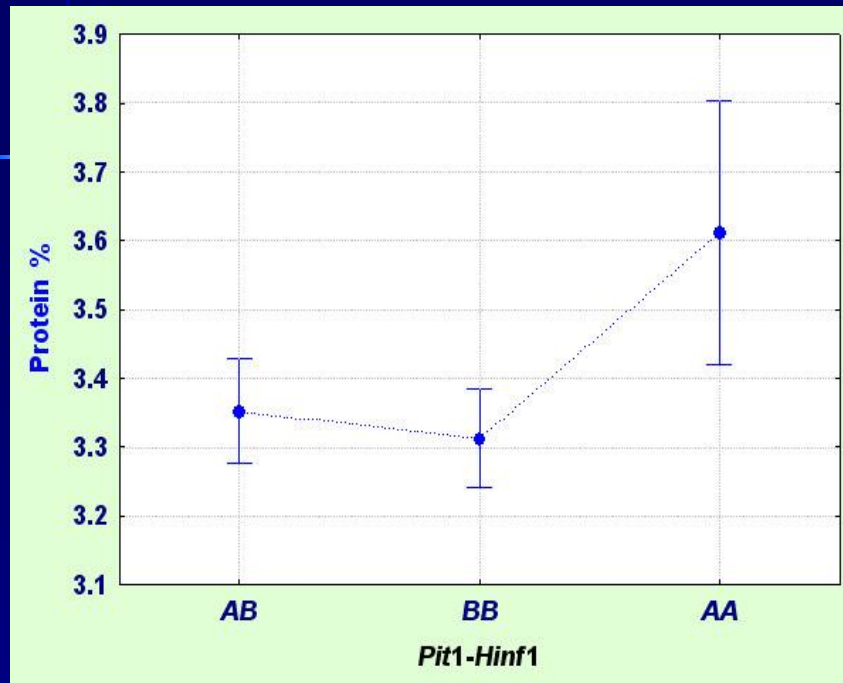


Fig. 1

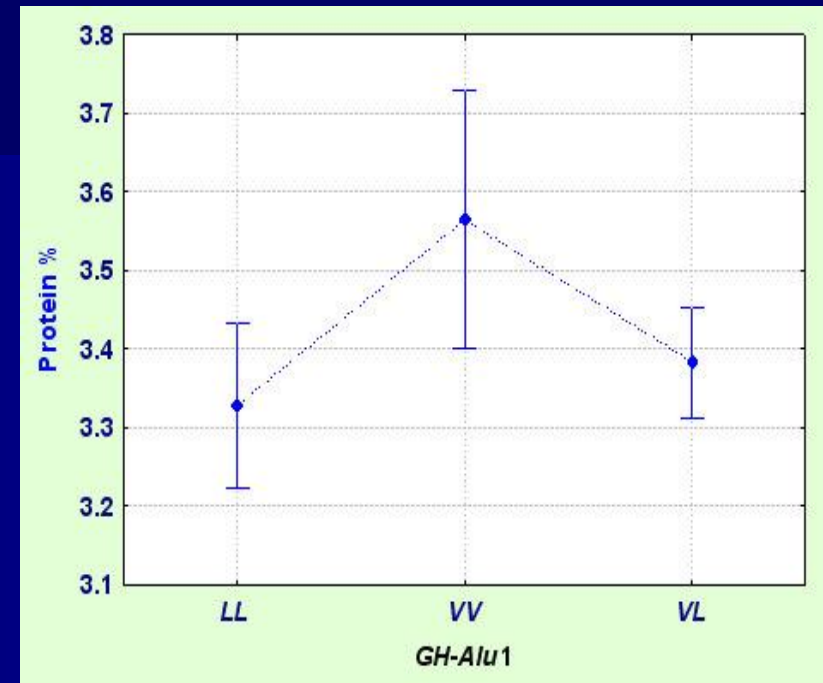
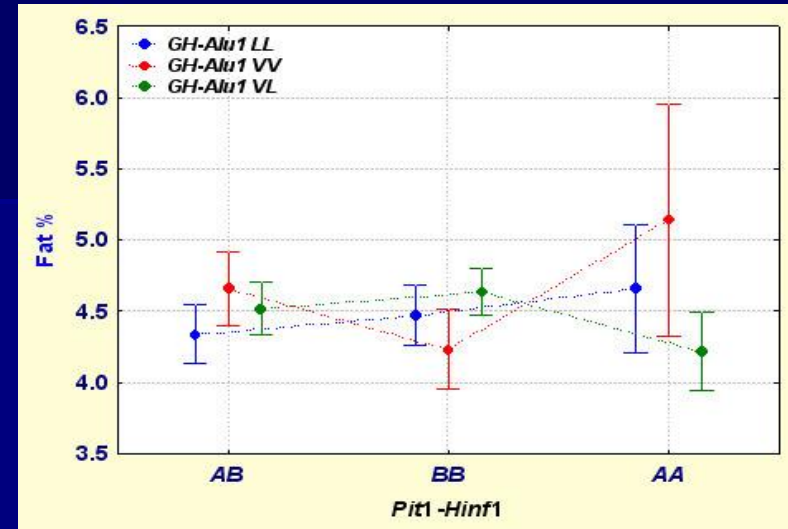
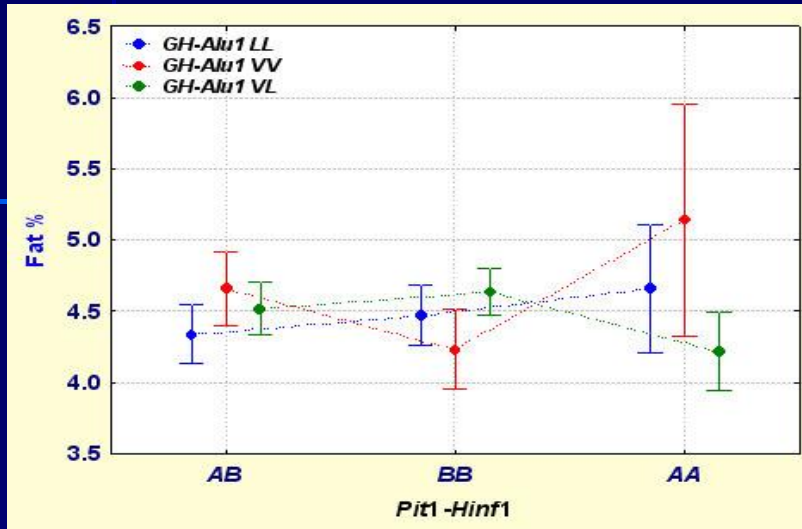


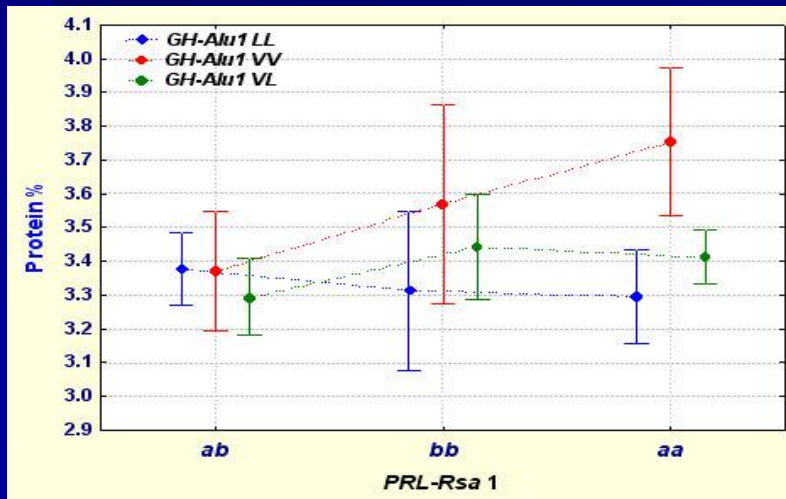
Fig. 2

Figures 1 and 2 graphically show the isolated effects of the genes studied. The abscissa shows the genotypes for the *Pit1/Hinf1* (Fig. 1) or *bGH* (Fig. 2) gene; the ordinate shows the mean protein or fat content of milk during lactation III. Vertical bars are the 95% confidence intervals. This parameter of animals with the **AA genotype of the *bPit1* gene** (mean,  $3.44 \pm 0.055\%$ ; max, 3.82%) and **the VV genotype of the *bGH* gene** (mean,  $3.39 \pm 0.061\%$ ; max, 3.82%) was significantly higher than that of animals with the other two genotypes.

Cumulative effect of the *Pit1*, *bGH* and *bPRL* coupled genotypes on the milk fat (P=0.041) and protein (P=0.024) content was clearly demonstrated.



The abscissa shows the genotypes; the ordinate shows the mean fat content (on the left) or protein content (on the right) of milk during lactation III. Vertical bars are the 95% confidence intervals.



**Cumulative effect of the coupled genotypes of the genes studied on milk production traits is more significant than effects of the single genes.**

**The combined genotypes were significantly differed from each other on their effect on fat ( $p < 0.01$ ) and protein ( $P < 0.05$ ) contents were determined.**

Significant cumulative effect of the *bGH* и *bPRL* coupled genotypes on the milk fat ( $P = 0.041$ ) and protein ( $P = 0.024$ ) content was revealed using two-way ANOVA.

	Fat content (%)		Protein content(%)	
	High	Low	High	Low
<b>Genotype</b> <b>Mean content</b> <b>± s.e.</b> <b>P</b>			<b>aaVV (1*)</b> 3,42 ± 0,08 (%) $P_{1*(4*,5*,6*)} = 0,017$	<b>aaLL (4*)</b> 3,22 ± 0,06(%)
<b>Genotype</b> <b>Mean content</b> <b>± s.e.</b> <b>P</b>	<b>abVV (1)</b> 4,72 ± 0,13 (%) $P_{1(3,4)} = 0,008$	<b>abLL (3)</b> 4,29 ± 0,09 (%)	<b>abLL (2*)</b> 3,39 ± 0,05 (%) $P_{1*(4*,5*,6*)} = 0,008$	<b>abVV (5*)</b> 3,22 ± 0,08(%)
<b>Genotype</b> <b>Mean content</b> <b>± s.e.</b>	<b>bbVL (2)</b> 4,72 ± 0,13 (%) $P_{2(3,4)} = 0,009$	<b>bbVV (4)</b> 4,26 ± 0,18 (%)	<b>bbLL (3*)</b> 3,47 ± 0,10 (%) $P_{1*(4*,5*)} = 0,020$	<b>bbVV (6*)</b> 3,22 ± 0,08(%)

**Thus it is possible to select the animals with the *bGH* and *bPRL* coupled genotypes determined desirable properties of milk.**

# CONCLUSIONS

- A genetic diversity of the studied Russian native cattle breeds on genes associated with milk production is high and comparable to that at the European cattle breeds.
- Associations of genotypes on the *bPRL*, *bGH* and *PitI* genes with the content of fat and protein in milk are revealed.
- Cumulative effect of the *PitI*, *bGH* and *bPRL* coupled genotypes on the milk fat ( $P=0.041$ ) and protein ( $P=0.024$ ) content is more significant than effects of the genotypes of the single genes.
- Genotypes on *bPRL* and *bGH* genes, associated with high or low content of protein and fat in milk are described.
- Russian native cattle breeds - Kostroma and Yaroslavl – have shown the high frequencies of economically valuable alleles and genotypes on the genes associated with good quality of milk. Thus these Russian native cattle breeds could be of interest for world selection practice as carriers of these economically valuable alleles and genotypes.





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Thanks  
for your attention

