Comparative study of the influence of type belonging on the productive and biological indicators of first-calf heifers

T F Lefler, I V Sidorenkova, A A Nagibina and A G Volkova
FSBEI HE Krasnoyarsk State Agrarian University, 90 Mira Ave., Krasnoyarsk, 660042, Russia

E-mail: leflertam@yandex.ru

Abstract. In modern economic conditions, the most profitable livestock industry is dairy farming. One of the main conditions ensuring an increase in milk production is the acceleration of the rate of breeding work aimed at creating herds whose animals meet modern requirements for the efficient use of feed, are characterized by a high level of early maturity and the maximum realization of their genetic potential. The comparative assessment of weight and linear characteristics of heifers of different genotypes presented in the work indicates the compliance of the indicators with the standards of breed types. All the animals had a pronounced dairy type. In terms of live weight, the Yenisei type heifers of red-motley breed during the period of fertile insemination were superior to the peers of the Krasnoyarsk type of black-motley breed by 2.2 and 2.1%. The insemination index in heifers of the first and third groups was significantly lower (by 0.26 and 0.31%) than in the compared animals. In the first lactation, the cows of the Krasnoyarsk type of black-motley breed from the third group were superior in milk yield to the cows from the fourth group by 285.2 kg of milk or by 4.9% (P> 0.99). The cows of the Yenisei type of red-motley breed of the first group were superior in milk yield to the cows from the second group by 126 kg of milk or by 2.5% (P> 0.95). The animals inseminated at the age of 16-17 months had the largest mass fraction of fat and protein in milk, regardless of breed.

1. Introduction
Growth intensity and its impact on future milk productivity are one of the most studied aspects of growing milk heifers and one of the most uncertain according to the results and conclusions [1]. Proper care, feeding, maintenance, and targeted rearing of young animals are separate links in a single process of herd reproduction and animal preservation [2].

Due to the intensification of dairy cattle breeding, both in the country and in the Krasnoyarsk Territory, a course was set for mass crossbreeding of local livestock breeds with specialized dairy breeds, one of which was Holstein [3]. Thus, red-motley and black-motley breeds were developed. In the process of breed development, scientists studied the exterior and body condition, milk and meat productivity as well as reproductive capacity [4-6]. However, many of these indicators concerned mainly crossbred animals, and the formed intra-breed types were ignored. In this regard, the need for a comprehensive comparative study of the economic and biological characteristics of heifers of the Yenisei type of red-motley breed and the Krasnoyarsk type of black-motley breed arose.

Agricultural producers have many questions regarding the effect of live weight and the age of mating on milk productivity and the subsequent reproductive function of cows. This area has been studied quite actively in our country and abroad. A lot of data have been accumulated on animals of various breeds.
which are contradictory in nature, and since the Yenisei type of red-motley breed and the Krasnoyarsk type of black-motley cattle are recently registered in the register of selection achievements, they exhibit huge interest in terms of studying the economic and biological features.

The purpose of the research is a comparative study of the influence of type belonging on the productive and biological indicators of first-calf heifers.

The research objectives are to study the weight and linear growth of animals, determine the insemination index and the level of milk productivity of first-calf heifers.

1.1. The development of the Yenisei type of red-motley breed
When breeding the Yenisei type, scientists and breeders were set the goal to increase gross milk yield, the mass fraction of fat and protein in milk, to consolidate hereditary qualities in combination with high live weight, good adaptability to the natural and climatic conditions of Siberia.

Work on breeding a new type was carried out from 2000 to 2009 inclusive. The breeding stock, with a pronounced dairy type and a low protein content in milk, was inseminated with red-motley and red-motley Swedish breed semen. Cows with a tendency towards the dairy-meat type were inseminated with the sperm from bulls of the Holstein breed. Offspring that meet the requirements of the desired type was bred in themselves. Thus, a new type of red-motley breed which was called the Yenisei was developed.

On the basis of the decision of the State Commission for Testing and Protection of Breeding Achievements in Dairy and Beef Cattle Breeding, the Ministry of Agriculture of the Russian Federation issued patent No. 4804 dated 06.22.2009 for the Yenisei type of red-motley breed, which was entered into the State Register of Breeding Achievements and approved for economic use.

When developing the Yenisei type, eight red-motley stud bulls were used with mother's productivity of 7,256 kg of milk, a mass fraction of fat of 4.21%, a mass fraction of protein of 3.10%; 26 stud bulls of the Holstein red-motley type (11,782 kg - 4.51% - 3.40%) and 17 stud bulls of the Swedish red-motley type (12363 kg - 4.56% - 3.60%) were used.

The young stock of the Yenisei type is characterized by an increased growth rate and early maturity.

The Yenisei type cows are characterized by a pronounced dairy type, good height, elongated body, strong back and lower back, well-developed and correctly set limbs, solid hooves, and a well-developed volumetric udder. Balanced constitution and strong body condition in the Yenisei type animals, in comparison with animals of the red-motley breed, indicates a higher resistance to feeding and maintenance conditions.

The milk productivity of the Yenisei type cows met the requirements of the target standards for the type. The morphological features of the udder have significantly improved in first-calf heifers of the new Yenisei type; it is well developed, bowl-shaped (98.8%) and round (1.2%) in shape. The milk and saphenous veins are pronounced, the milk mirror is large and clean. Additional nipples in the form of rudiments are very rare, nipples are cylindrical or conical, medium-length (4-8 cm). The ratio of milk in the front and rear quarters of the udder is almost equal. The udder subsidence in five measurements (udder circumference, udder length, udder width, depth of the front and rear quarters of the udder) is quite good and ranged from 12.0 to 18.0% in the Yenisei type first-calf heifers [4].

1.2. The development of the Yenisei type of black-motley breed
In 1978, the experts were tasked to achieve an increase in milk productivity in crossbred black-motley cows by at least 20% due to the existing genetic differences between Holstein and black-motley breeds, to improve the exterior, and to increase the technological properties of the udder.

Over a 30-year period (1978–2008), Siberian breeding farms using the method of reproductive crossbreeding developed the Krasnoyarsk type of black-motley cattle valuable in breeding and economic terms. The success of the work to create a new Krasnoyarsk type of black-motley cattle was the targeted use of bulls of various origin with a high assessment of breeding value.

The structure of the Krasnoyarsk type was formed by using the gene pool of the leading genealogical lines of the Holstein breed: V.B. Ideal 1013415, R. Sowering 198998, M. Chiftein 95679, R. Sitation
267150, P. Governor 882933 and S.T. Rokit 252803. Holstein stud bulls of German and Hungarian line breeding participated in the breeding of the Krasnoyarsk type in the third final stage.

A comparative analysis revealed that the young stock of a new type is characterized by an increased growth rate and early maturity. The first-calf heifers of the new Krasnoyarsk type were superior to their peers in terms of the majority of measurements.

The first-calf heifers of the Krasnoyarsk type had significantly improved morphological features of the udder. The udder of new-type cows is well developed, bowl-shaped (98.2%) and round (1.8%). Milk and saphenous veins are well defined, the milk mirror is large and clean, additional nipples are rare, the nipples are mostly cylindrical in shape, 4 to 7 cm long.

The cattle of the Krasnoyarsk type, in comparison with their peers, are characterized by more pronounced milk productivity.

By the decision of the State Commission for Testing and Protection of Breeding Achievements in Dairy and Beef Cattle Breeding, the Ministry of Agriculture of the Russian Federation issued a patent for breeding achievement No. 4365 dated December 8, 2008 [5] for a new Krasnoyarsk type of black-motley breed.

2. Materials and methods
A scientific and economic experiment was carried out at LLC Experimental Production Farm “Solyanskoye”, Rybinsk district of the Krasnoyarsk Territory from 2017 to 2019. In accordance with the purpose and specific tasks of this work, the object of the study was heifers of the Yenisei type of red-motley breed and Krasnoyarsk type of black-motley breed.

The materials for the analysis of research data were reports of the veterinary service, artificial insemination logs, acts of observation and control weighing of calves, acts of control milking, etc.

For the experiment, four groups of heifers of the preweaning period were formed at the age of 10 days, 15 heads each. In the first two groups, there were the Yenisei type heifers of the red-motley breed, in the third and fourth - the Krasnoyarsk type heifers of the black-motley breed. The animals of the first and third groups were inseminated at the age of 16–17 months, and the heifers of the second and fourth — at the age of 18–19 months. The groups were formed by the method of analogues. The experimental animals were in the same conditions of feeding, care, and maintenance. The diet was compiled according to the norms of the Russian National Research Institute of Livestock taking into account the live weight and physiological state of the experimental animals. The same workers served all the experimental animals.

Feeding and caring for young animals was carried out in accordance with the daily routine adopted at the farm. The housing of heifers from birth to calving was group and yard, after calving - group and tie-up. In the summer, all animals were grazed on one pasture. Growth control was carried out by individual weighing and taking measurements. Relative speed was calculated using the formula of S. Brody. Milk productivity was analyzed using the acts of cattle control milking; the content of the mass fraction of fat (MFF) and the mass fraction of protein (MFP) was evaluated monthly by examining audit samples of milk.

Biometric processing of the experiment results was carried out using a personal computer in the program "Microsoft Excel" with the calculation of arithmetic mean values and its errors (M ± m). The reliability criterion (P) was determined by the method of N.A. Plokhinsky (1969).

3. Results and discussions
The calves at birth had almost the same live weight (table 1). From birth to 12 months of age, significant differences in live weight were not detected. The largest live weight during the period of fertile insemination both at the age of 16–17 and 18–19 months was recorded in the Yenisei type heifers, that is, the first and second groups, which amounted to 389.3 and 404.0 kg, which is more than that of peers of the Krasnoyarsk type, by 8.4 and 8.6 kg, or by 2.2 and 2.1%, respectively (P> 0.95). It should also be noted that insemination at a later age (18–19 months) affected the live weight of animals, which turned
out to be maximum in the second and fourth groups relative to the first and third, in which animals were inseminated at the age of 16–17 months (P> 0.99).

**Table 1.** Age dynamics of live weight of the compared animals (M±m), kg.

| Indicator                  | Yenisei type, red-motley breed | Krasnoyarsk type, black-motley breed |
|----------------------------|---------------------------------|--------------------------------------|
| At birth                   | 29.1±0.40                       | 29.3±0.43                           |
| 3 months                   | 94.5±0.86                       | 94.7±0.82                           |
| 6 months                   | 161.6±1.35                      | 162.1±1.03                          |
| 9 months                   | 226.5±1.56                      | 227.1±1.73                          |
| 12 months                  | 290.1±1.92                      | 295.2±2.12                          |
| During fertile insemination| 389.3±3.06                      | 404.0±2.79**                        |

*Hereinafter, the reliability of the difference with respect to the same indicator of the compared groups is shown: *P>0.95; **P>0.99; ***P>0.999.

The highest absolute growth during the growing period (374.7 kg) was observed in the experimental animals of the second group, which were 8.8 kg heavier than their peers in the fourth group and 14.5 kg heavier than the first one. The smallest absolute growth during the growing period (350.9 kg) was observed in the heifers of the Krasnoyarsk type of black-motley breed. The lightness of these animals is explained by their belonging to the dairy type of constitution.

Until the age of 6 months, the calves grew more intensively. The maximum daily average growths, similarly to the absolute ones, were detected in the first and third groups (P> 0.999; P˃0.99). In general, the average daily growths during the growing period was in the range of 710.4–725.7 g, which correspond to an intensive level of growth and have a positive effect on the physiological status of the animals [9].

Objective conclusions about the growth rate of the compared animals can be made by determining the relative growth rate. The relative growth in all groups decreased with age (table 2). The largest drop occurred in the first six months of life. Up to 12 months of age, the young stock had approximately the same growth rate. A significant difference in the relative rate of increase in live weight is observed in the period from 12 months to fertile insemination.

**Table 2.** The relative growth rate of animals of different breed types (n=15), %.

| Relative period                  | Yenisei type, red-motley breed | Krasnoyarsk type, black-motley breed |
|----------------------------------|---------------------------------|--------------------------------------|
| 0-3 months                       | 105.8±12.32                    | 105.5±13.56                          |
| 3-6 months                       | 52.4±5.65                      | 52.6±6.17                            |
| 6-9 months                       | 33.4±3.16                      | 33.3±4.37                            |
| 9-12 months                      | 24.6±2.17                      | 22.6±2.19                            |
| From 12 months to fertile insemination | 29.2±1.19                    | 31.1±2.03                            |

The dynamics of live weight, both absolute and relative, does not give a complete picture of the development of external body parts of the animal organism. In this regard, in parallel with the weight characteristics of animals, their linear development was studied. The average values of body measurements of heifers of different breed types and their age-related changes at 12 months are shown in figure 1.
Figure 1. Measurements of experimental animals at 12 months, cm.

Figure 2. The body built indices of the experimental animals at the age of 12 months, %.

The linear measurement indicators of the body of the experimental animals had no significant differences and met the standards of breed types.
An increase in measurements with heifers of all groups occurred almost uniformly. A change in indicators during the process of raising animals indicates that the main measurements increase with age and the intensity of their increase decreases.

Based on the data obtained, the body built indices of heifers of different origin were calculated, which make it possible to judge both the degree of development of the organism as a whole and the basic proportions of development of individual external body parts of the animal (figure 2).

Body indices, as well as body measurements of compared heifers, indicate compliance with the standards of breed types. The differences between the groups are insignificant, with the exception of the pelvic thoracic index at the age of six months (P> 0.95). With age, the heifers of all groups have an increase in the indices of stretch, blockiness, and thoracic, and the index of long legs decreases. All this suggests that at LLC Experimental Production Farm “Solyanskoye” of the Rybinsk district, first-calf heifers with a pronounced milk-type constitution are introduced into the main herd.

In accordance with the scheme of scientific and economic experience, the heifers of the 1st, 3rd and 2nd, 4th groups were inseminated at the age of 16–17 and 18–19 months. Insemination was carried out artificially, by the rectal cervical method. The results are presented in table 3.

**Table 3. Heifers reproductive indicators.**

| Indicator                              | Yenisei type, red-motley breed | Krasnoyarsk type, black-motley breed |
|----------------------------------------|---------------------------------|-------------------------------------|
| Age of fertile insemination, months    | 16-17                           | 18-19                               |
|                                        | 18-19                           | 16-17                               |
|                                        | 18-19                           | 18-19                               |
| Insemination index                     | 1.09±0.06*                      | 1.35±0.08                           |
|                                        | 1.10±0.07*                      | 1.41±0.09                           |
| Inseminated, total heads               | 15                              | 15                                  |
|                                        | 15                              | 15                                  |
|                                        | 15                              | 15                                  |
| Live weight at the time of insemination, kg | 389.3±3.06                      | 404.0±2.79**                        |
|                                        | 380.9±2.85                      | 395.4±2.96**                        |

The analysis of the obtained data showed that the live weight of heifers inseminated at 18–19 months exceeded the live weight of animals from the 1st and 3rd groups by 14.7 and 14.5 kg, respectively (P> 0.99). Table 4 presents the indicators of milk productivity of experimental animals.

**Table 4. Milk productivity of first-calf heifers.**

| Indicator         | Yenisei type, red-motley breed | Krasnoyarsk type, black-motley breed |
|-------------------|---------------------------------|-------------------------------------|
| Milk yield in 305 days, kg | 5134.3±300.42                   | 5008.3±231.88                       |
| MFF, %            | 3.85±0.02***                    | 3.69±0.04                           |
| Milk fat, kg      | 213.4±12.04                     | 207.5±9.51                          |
| MFP, %            | 2.8±0.02**                      | 2.7±0.03                            |
| Milk protein, kg  | 158.0±10.41                     | 153.7±7.67                          |
| Milk ratio        | 1117±81.45                      | 1032±55.17                          |
| Milk flow rate, kg / min | 1.87±0.07                      | 1.79±0.16                           |

Different age and live weight during the first insemination had a certain impact on the results of fertilization of heifers of the experimental groups. All 60 animals involved in the experiment were
fertilized, but the insemination index in the animals of the 1st and 3rd groups was significantly lower by 0.26 and 0.31% than their analogues from the 2nd and 4th groups. It follows that overexposure of heifers and an increase in their live weight negatively affect the ability to be fertilized and the subsequent profitability of milk production.

As it can be seen from table 4, there is some intergroup difference in the amount of milk yield in the experimental animals. According to the first lactation, the cows of the Krasnoyarsk type of black-motley breed from the third group exceeded the yield of cows from the fourth group by 285.2 kg of milk or 4.9% in milk yield (P > 0.95; P > 0.99). If we consider cows of the Yenisei type of red-motley breed, then from the data of the table it can be seen that the animals of the first group exceeded by 126 kg of milk or 2.5% in milk yield of cows from the second group (P > 0.99). A study of the qualitative characteristics of milk productivity showed that the animals of both breeds inseminated at the age of 16-17 months had the largest mass fraction of fat and protein in milk compared with the experimental animals inseminated later. It should be noted that the amount of milk fat and protein is greater in the cows of the Krasnoyarsk type of the black-motley breed of the third and fourth groups than their counterparts from the first and second groups. The superiority was 30.1; 22.4 and 24.1; 15.3 (P > 0.95; P > 0.99) for the first lactation.

The maximum milk productivity of the black-motley cows of the third group had a positive effect on the milk ratio, which amounted to 1243 (P > 0.99). This suggests that black-motley cows are more consistent with the dairy production direction.

The highest milk flow rate per minute is observed in first-calf heifers of the first group – 1.87 kg / min, the lowest is in heifers of the second group - 1.79 kg / min.

4. Conclusion
A comparative assessment of the weight and linear characteristics of heifers of different genotypes indicates that the indicators meet the standards of breed types. All the animals have a pronounced dairy type. In live weight, the Yenisei type heifers of the red-motley breed during the period of fertile insemination exceeded the peers of the Krasnoyarsk type of the black-motley breed by 2.2 and 2.1%. The insemination index in heifers of the first and third groups was significantly lower (by 0.26 and 0.31%) than in the compared animals. The experimental animals inseminated at 16-17 months of age significantly exceeded the first-calf heifers inseminated at a later age, both in quantitative and qualitative indicators of milk productivity. Therefore, regardless of the breed, the mating of heifers should be carried out no later than 16–17 months of age, with a live weight of 380–390 kg. Since overexposure for two months negatively affects the productive-biological and economic indicators.

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