Assessment of the effect of inbreeding on the productive longevity of dairy cattle

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Abstract. When breeding dairy cattle, both heterogeneous and homogeneous selection is used. Assessment of the influence of the degree of inbreeding on the productive quality and duration of the productive longevity of cows. It was found that despite a slight increase in milk yield in inbred animals (by 93 - 378 kg depending on the degree of inbreeding and by 73 kg on average for the group of inbred animals), a decrease in the qualitative indicators of milk, the mass fraction of fat and the mass fraction of protein and a significant increase in live weight of cows (P≤0.05) obtained using inbreeding. There is a superiority of herd cows over the requirements of the standard for black and white breed by 2500 - 2947 kg in groups (on average by 2624 kg) in milk yield and by 0.31% in the mass fraction of fat in milk; for Holstein breed these results are slightly lower and amount to 1500 - 1924 kg (an average of 1624 kg) for milk yield. The greatest amount of milk and nutrients was obtained from inbred cows with moderate levels of inbreeding and outbred animals, due to an increase in the duration of productive use. With the age of the cows, their milk production practically does not change, remaining at a fairly high level. The use of closely related crossbreeding with a simultaneous increase in the blood level in the Holstein breed leads to a slight increase in milk yield and the duration of productive longevity by 0.2 - 0.4 lactation. In lifetime productivity, inbred cows with a moderate degree of inbreeding remain superior. Outbred animals are at second place.

1. Introduction

An uninterrupted supply of high-quality products, including milk, is the main need to ensure the health of the nation and food security of the country. Increasing the production of high-quality livestock products for milk and dairy products is one of the most important tasks in the development of livestock production around the world, which is becoming increasingly important both with the growth of the population of our planet and the satisfaction of humanity’s need for food. So, great economic importance is attached to the development of this industry [1-7]. Increasing the productivity of cows is connected with improving the quality of milk, which has a significant impact on the quality of finished dairy products [8-18]. All over the world, dairy cattle are used for milk production, including black-motley, Holstein, Dutch, which differ in economically useful qualities depending on the climatic and ecological-feed conditions of the breeding zone, and the gene pool of pedigree resources [19-20]. However, since these are related breeds, both heterogeneous and homogeneous selection is used in herds of dairy cattle. As a result, in the Sverdlovsk Region, in herds of Holstein black-and-white cattle of the Ural type, up to 98% of cows were obtained by remote or moderate inbreeding [21-23]. Assessment of the effect of the
degree of inbreeding on the productive longevity of cows is relevant and of practical importance, especially in conditions of increased blood pressure in the Holstein breed.

The purpose of the work was to assess the effect of the degree of inbreeding on the productive quality and duration of the productive use of cows.

2. Materials and method
The study included all the cows that finished lactation from the breeding farm for breeding black-and-white cattle in the Sverdlovsk region.

They were divided into 4 groups depending on the level of inbreeding, group 1 - obtained as a result of unrelated mating, group 2 - remote inbreeding, group 3 - moderate inbreeding, group 4 - close inbreeding. We used data from zootechnical and breeding records of the Selex program.

We calculated the milk coefficient, the amount of milk fat and milk protein for lactation and for the period of use, milk yield for the entire productive period.

The average age of the first effective insemination of heifers in this herd is 14-15 months.

3. Results
The agricultural enterprise is engaged in the cultivation of highly productive, holsteinized black-motley cattle of the Ural type, obtained both through outbreeding and inbreeding. Indicators of milk productivity are presented in table 1.

| Inbreeding rate | Milk yield, kg | Mass fraction of fat, % | Mass fraction of protein, % | The amount of milk Fat, kg | The amount of milk protein, kg | Live weight, kg | Milk ratio, kg |
|-----------------|----------------|-------------------------|----------------------------|---------------------------|------------------------------|----------------|--------------|
| Outbred         | 6551 ±157.3    | 3.92 ±0.004             | 3.07 ±0.002                | 257 ±3.1                  | 201 ±3.1                     | 536 ±11.6       | 1222 ±13.6   |
| Remote          | 6644 ±172.4    | 3.91 ±0.004             | 3.05 ±0.002                | 260 ±6.9                  | 203 ±3.4                     | 561 ±10.6       | 1184 ±14.8   |
| Moderate        | 6500 ±167.4    | 3.91 ±0.004             | 3.05 ±0.003                | 254 ±6.7                  | 198 ±5.0                     | 555 ±14.7       | 1171 ±11.3   |
| Close           | 6947 ±0.0      | 4.43 ±0.004             | 3.16 ±0.002                | 308 ±0.0                  | 217 ±0.0                     | 530 ±0.0        | 1311 ±0.0    |
| Inbred average  | 6629 ±186.7    | 3.91 ±0.003             | 3.05 ±0.02                 | 259 ±5.6                  | 202 ±3.7                     | 561 ±13.7       | 1182 ±13.6   |
| Herd average    | 6624 ±197.8    | 3.91 ±0.02              | 3.05 ±0.002                | 259 ±3.9                  | 202 ±3.9                     | 558 ±9.6        | 1187 ±20.6   |
| Black-motley    | 4000           | 3.6 ±0.02               | 3.2 ±0.002                 | 144                       | 128                          | -              | -            |
| breed standard  |                |                         |                            |                           |                             |                |              |
| Holstein        | 5000           | 3.6 ±0.02               | 3.2 ±0.002                 | 180                       | 160                          | -              | -            |
| Standard        |                |                         |                            |                           |                             |                |              |

Assessing the results of the use of inbreeding in a herd of highly productive dairy cattle, one can state: firstly, despite a slight increase in milk yield in inbred animals (by 93 - 378 kg depending on the degree of inbreeding and by 73 kg on average in the group of inbred animals), there is a decrease in the quality milk indicators, exactly the mass fraction of fat and the mass fraction of protein. Secondly, a significant increase in live weight in cows (P≤0.05) obtained using inbreeding was established, which to some extent led to a decrease in milk ratio. It should be noted that the use of close inbreeding allowed to increase the productive qualities of the cow while improving the quality of milk. However, there is
only one animal in the herd and this cannot serve as an indicator that allows us to draw conclusions about the further use of close inbreeding, but indicates the correct selection of pairs in this herd.

The high level of pedigree work in the herd can be judged primarily by the uniformity of the herd, since only a positive trend was revealed in increasing milk production in inbred animals, relatively outbred. In addition, the homogeneity is confirmed by the calculated coefficients of milk yield, according to which all animals by constitutional type can be considered to the milk direction of productivity and a comparison of the productivity indicators of these animals with the breed standard. According to these data, the superiority of herd cows over the requirements of the standard for black-motley breed is 2500-2947 kg in groups (on average 2624 kg) in milk yield and 0.31% in the mass fraction of fat in milk. Compared with the standard for Holstein breed, these results are slightly lower, but also significant and amount to 1500-1924 kg (an average of 1624 kg) for milk yield and a similar difference in the mass fraction of fat. The results of a comparative assessment of the protein content in milk showed that the mass fraction of protein in the milk of herd cows is 0.15-0.17% lower than the standards for black-motley and Holstein breeds. This did not affect the yield of milk fat and milk protein and they were higher than the requirements of the standards by 115 - 79 kg (milk fat) and 74-42 kg (milk protein), respectively, by breed.

The indicators of lifelong productivity of cows, depending on the degree of inbreeding are also of great interest (figure 1).

The greatest amount of milk and nutrients was obtained from inbred cows with moderate levels of inbreeding and outbred animals, due to an increase in the duration of productive use. However, it should be noted that life-long milk yield and yield of nutrients on average for inbred animals without taking into account the productivity of outbred cows is lower than the average for the herd, which is also due primarily to a decrease in productive longevity.

Since the milk productivity of cows is the main breeding characteristic in the selection of animals for further breeding, and thorough-bredness in the Holstein breed only increases, we evaluated the effect of inbreeding on the productive qualities of Holstein black and white cattle with a thorough-bredness percentage of Holstein breed of 97% or more on average for period of productive use.

![Figure 1. Lifetime productivity of cows with varying degrees of inbreeding.](image-url)

The highest rates of average milk yield per lactation were found in cows obtained as a result of outbred selection. 6878 ± 123.9 kg of milk was obtained from them, which is 411 - 428 kg or 6.1 - 6.4% more milk than in other groups, therefore a higher yield of milk fat and milk protein. However, in this group of animals the lowest indicators of productive longevity are observed, which amounted to only 2.0 lactation. The studies revealed a significant difference between the groups at P≤0.05 - P≤0.01 for
the duration of the productive longevity of cows. Cows with a moderate degree of inbreeding of 2.6 ± 0.6 lactation are used for a longer time in the conditions of the breeding reproducer. The use of distant inbreeding reduces the average age of cows in lactations by 0.2 lactations. A positive tendency was revealed for a slight increase in the duration of productive longevity with an increase in the degree of related mating. Inbred cows with varying degrees of inbreeding for milk yield per lactation, mass fraction of fat and mass fraction of protein, as well as the amount of milk fat and milk protein obtained with milk did not differ. This indicates a high level of breeding in the herd and the suitability of animals for the industrial production of milk. To some extent, the genetic potential of cow productivity can be judged by the results of highest lactation. These data are presented in table 2.

Table 2. Productive qualities of cows (with a blood rate of over 97 percent for Holstein breed of highest lactation).

| Inbreeding rate | Highest Lactation Number | Milk yield, kg | Mass fraction of fat, % | Mass fraction of protein, % | The amount of milk fat, kg | The amount of milk protein, kg |
|-----------------|--------------------------|----------------|------------------------|--------------------------|--------------------------|--------------------------|
| Outbred         | 1.3±0.3                  | 6968±156.7     | 3.96±0.004            | 3.07±0.003              | 276±6.3                  | 214±4.7                  |
| Remote          | 1.7±0.2                  | 6971±287.6     | 3.97±0.003            | 3.05±0.002              | 277±8.6                  | 213±5.8                  |
| Moderate        | 1.9±0.2                  | 6994±186.2     | 3.95±0.005            | 3.03±0.003              | 276±5.9                  | 212±5.6                  |
| Total           | 1.7±0.2                  | 6973±179.9     | 3.97±0.004            | 3.05±0.002              | 277±6.1                  | 213±5.7                  |

The data presented in table 2 confirm the above conclusions that the farm has a high level of pedigree work. All animals in terms of productivity for the highest lactation are of the same type. According to the method of breeding and selection, differences in milk yield and qualitative indicators of milk are insignificant and amount to only 3-26 kg of milk, 0.02% by mass fraction of fat and as much as 0.04% in protein (P≤0.05 - P≤0.01 in favor of outbred cows). However, this did not affect the yield of milk fat and milk protein with cow's milk. It should be noted that a large number of animals had the highest productivity indicators for the first lactation, which can most likely be explained not by a change in the general biological regularity, but by a decrease in the duration of the productive longevity of cows due to their intensive use, starting from the breeding of remount young animals.

Despite the higher yields for inbred cows obtained by the method of remote inbreeding, more milk during the period of use was obtained from animals with a moderate degree of inbreeding. Cows of outbred origin were in second place. This is explained by the longer duration of the productive use of these animals (figure 2).

Figure 2. Lifetime cow productivity (blood rate over 97%).
We evaluated these animals according to the dynamics of milk productivity depending on age (figure 3).

It has been established that with the age of cows, their milk productivity remains unchanged, remaining at a fairly high level.

![Figure 3. Dynamics of milk production of cows by lactation.](image)

4. Discussion
The use of inbreeding in the breeding of Holstein black-motley cattle of the Ural type leads to an increase in milk yield per lactation ($P \geq 0.05$) with a decrease in the qualitative indicators of the mass fraction of fat and the mass fraction of protein in milk. Inbred cows with varying degrees of inbreeding for milk yield per lactation, mass fraction of fat and mass fraction of protein, as well as the amount of milk fat and milk protein obtained with milk had practically the same indicators. Similar studies have been conducted by V. S. Mymrin, O. G. Loretts [7], I. V. Tkachenko, V. F. Gridin, S. L. Gridina [10], S. L. Gridina, V. F. Gridin, O. I. Leshonok [8].

5. Conclusion
The use of closely related crossbreeding with a simultaneous increase in thorough-bredness level in the Holstein breed leads to an increase in milk yield and duration of productive longevity by 0.2-0.4 lactation. In lifetime productivity, inbred cows with a moderate degree of inbreeding remain superior. Outbred animals came in second place.

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References
[1] Belookov A, Belookova O, Zhuravel V, Gritsenko S and Ponomarev E 2019 Using of EM-technology (effective microorganism) for increasing the productivity of calves. International Journal of Engineering and Advanced Technology 8(4) 1058
[2] Khaziakhmetov F, Khabirov A, Rebezov M, Basharov A, Ziangulov I and Okuskhanova E 2018
Influence of probiotics "Stimix Zoostim" on the microflora of faeces, hematological indicators and intensitivity of growth of calves of the dairy period International Journal of Veterinary Science 7(4) 178

[3] Gorelik O, Derkho M, Gorelik A, Fedoseeva N and Kiselev L 2020 Studying the biochemical composition of the blood of cows fed with immune corrector biopreparation. AIP Conference Proceedings 2207 020012 DOI: 10.1063/5.0000317

[4] Khaziakhmetov F, Khabirov A, Avzalov R et al. 2018 Effect Of Probiotics On Calves, Weaned Pigs And Lamb Growth Research journal of pharmaceutical biological and chemical sciences 9(3) 866-70

[5] Gorelik O, Harlap S, Gorelik A, Dolmatova I, Zalilov R, Dogareva N, Fedoseeva N, Delian A and Ermolaev V 2019 The state of nonspecific resistance of calves during the preweaning period International Journal of Pharmaceutical Research DOI: 10.31838/ijpr/2019.11.01.133

[6] Gorelik O, Rebezov M, Gorelik A, Harlap S and Novikova N 2019 Effect of bio-preparation on physiological status of dry cows International Journal of Innovative Technology and Exploring Engineering 8(7) 559-62

[7] Gorelik O, Shatskikh Y, Rebezov M and Okuskhanova E 2017 Study of chemical and mineral composition of new sour milk bio-product with sapropel powder Annual Research and Review in Biology 18(4) DOI: 10.9734/ARRB/2017/36937

[8] Smolnikova F, Moldabayeva Z, Klychkova M, Gorelik O, Khaybrakhmanov R, Mironova I, Kalimullin A and Latypova G 2019 Sour milk production technology and its nutritive value International Journal of Innovative Technology and Exploring Engineering 8(7) 670-2

[9] Serikova A, Smolnikova F, Rebezov M and Tumbasova Ye 2018 Development Of Technology Of Fermented Milk Drink With Immune Stimulating Properties Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS) 9(4) 495-500

[10] Kuramshina N, Rebezov M, Kuramshin E and Okuskhanova E 2019 Heavy metals content in meat and milk of Orenburg region of Russia International Journal of Pharmaceutical Research 11(1) 1301-5

[11] Chernopolskaya N, Gavrilova N and Karapetyan I 2019 Biotechnology of specialized fermented product for elderly nutrition International Journal of Pharmaceutical Research 11(1) 545-50

[12] Smolnikova F, Toleubekova S, Temerbayeva M and Penkova I 2018 Nutritive Value Of Curd Product Enriched With Wheat Germ Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS) 9(3) 1003-8

[13] Chernopolskaya N, Gavrilova N and Voskanyan O 2019 Biotechnology of specialized product for sports nutrition International Journal of Engineering and Advanced Technology 8(4) 40-5 DOI: 10.35940/ijrte.B3158.078219

[14] Temerbayeva M, Rebezov M, Okuskhanova E and et al. 2018 Technology of Sour Milk Product For Elderly Nutrition Research journal of pharmaceutical biological and chemical sciences 9(1) 291-5

[15] Gavrilova N, Chernopolskaya N, Molyboga E and Ponomareva L 2019 Biotechnology application in production of specialized dairy products using probiotic cultures immobilization. International Journal of Innovative Technology and Exploring Engineering 8(6) 642-8

[16] Gavrilova N, Chernopolskaya N, Schetinina E, Suyazova I, Safronov S, Ivanova V and Sultanova E 2020 Development of specialized food products for nutrition of sportsmen Journal of Critical Reviews 7(4) 233

[17] Temerbayeva M, Rebezov M, Okuskhanova E and Yessimbekov Zh 2018 Development of Yoghurt from Combination of Goat and Cow Milk Annual Research & Review in Biology 23(6) 1-7 DOI: 10.9734/arrb/2018/38800

[18] Gavrilova N, Chernopolskaya N, Rebezov M and Derkho M 2019 Advanced biotechnology of specialized fermented milk products International Journal of Recent Technology and Engineering 8(2) 2718-22 DOI: 10.35940/ijrte.B3158.078219

[19] Skvortsov E, Bykova O, Mymrin V, Skvortsova E, Neverova O, Nabokov V and Kosilov V 2018
Determination of the applicability of robotics in animal husbandry *The Turkish Online Journal of Design Art and Communication* **8** 291-9

[20] Mymrin V and Loretts O 2019 Contemporary trends in the formation of economically-beneficial qualities in productive animals *Digital agriculture - development strategy Proceedingsof the International Scientific and Practical Conference (ISPC 2019)* Advances in Intelligent Systems Research 511-4

[21] Tkachenko I, Gridin V and Gridina S 2016 Results of researches federal state scientific institution “Ural research institute for agri-culture” on identification of interrelation efficiency cows of the ural type with the immune status 85-90

[22] Gridina S, Gridin V and Leshonok O 2018 Characterization of high-producing cows by their immunogenetic status *Advances in Engineering Research* **3** 253-6

[23] Chechenikhina O, Loretts O, Bykova O, Shatskikh E, Gridin V and Topuriya L 2018 Productive qualities of cattle in dependence on genetic and paratypic factors *International Journal of Advanced Biotechnology and Research* **9(1)** 587-93