

Milk producing ability and reproductive qualities of the daughters of stud bulls whose semen was obtained using different methods

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Abstract— In the course of this research, parameters of the efficiency of sexed semen use were studied, as well as peculiarities of growth and development of the offspring, parameters of milk producing ability and reproductive qualities of daughters of stud bulls whose semen was sorted by sex and was obtained using traditional method. As a result, it was established that during the insemination of heifers with semen sorted by sex, the output of calves decreased by 22.9% compared with the normal semen, but the percentage of heifers increased by 37.6%. At the same time, fertilization rate of studied animals was 58.7%, the number of semen doses – 1.7. The best fertility was in the bull Parrah 343313777, it amounted to 74.0%. When using normal semen, the total fertilization rate of heifers was 75.4%, with semen dose rate of 1.3. When studying milk producing ability of the offspring, it was shown that the first lactation of daughters of stud bulls, whose semen was obtained by traditional method, exceeded milk yield of daughters of stud bulls, whose semen was sorted by sex, by 546.4 kg, while fat mass fraction in milk here was lower by 0.14%. Realization of genetic potential for milk yields during 1 and 2 lactations was higher among the stud bulls of second group and amounted to 56.5-58.7%, genetic potential realization of the stud bulls of first group was 45.9-53.5%. Reproductive qualities of the daughters of stud bulls of the compared groups are practically at the same level. Duration of indifference- and service periods for the daughters of bulls, whose semen was sorted by sex, turned out to be slightly longer in comparison with the herdmates of the second group by 1.4 and 1.3 days on average.

Keywords— *stud bulls, first-calf cows, sexed semen, normal semen, milk producing ability, reproductive qualities.*

I. INTRODUCTION

Increasing of milk and dairy products production volume, as well as their quality parameters, is one of the vital tasks currently facing the agroindustrial complex of Russia [1, 2].

Dairy cattle industry includes labor-intensive processes one of which is cattle herd reproduction. Thus, the results of herd reproduction specialists activity will influence the level and quality parameters of the future milk producing ability of animals, the duration (and intensity of the process) of practical use of genetically valuable highly productive cows. In addition, the level of herd reproduction will determine the parameters of economic efficiency and production profitability [3, 4].

Regulation of sex ratio in animal husbandry is a topical problem that has been solved for a long time: world science has developed methods for planning the sex of offspring and getting animals of a certain sex. Using of modern developments in the issue of offspring sex ratio regulation in dairy cattle breeding is especially important [5, 6].

At present, there is an increasing need for agricultural producers to provide farms with valuable young cattle because the existing breeding base cannot fully provide it. There are a number of both already proven and completely new, unique in their own way methods to provide the required rate of animal reproduction. Today, the most effective method for this purpose is using of sexed semen. Thus, the current trend in the field of modern technologies for animal husbandry is the fertilization of heifers with sexed semen (with X-chromosome spermatozoa) [7, 8, 9].

Many countries in the world showed a high interest in practical ways of regulating the sex of offspring of different farm animals. In this regard, it is necessary to provide a high percentage of heifers during cattle reproduction process, and the technology of sexed semen obtaining makes it possible. Using of this technology will enable specialists to intentionally get individuals of a certain sex in larger quantities what will increase the breeding effect and economic efficiency of livestock industry [10, 11, 12].

The rate of genetic improvement of herds is directly dependent on selection intensity. Using of sexed semen is one of the innovative methods and is applied in many countries with developed animal husbandry [6, 13].

The use of semen sorted by sex allows reducing the shortage of heifers for herd replacement and using stud bulls more intensively. In this regard, there is a need to evaluate stud bulls whose semen is used for reproduction.

The goal of this research was to compare milk producing ability and reproductive qualities of daughters of stud bulls whose semen was obtained using different technologies.

II. PRACTICAL RELEVANCE, SUGGESTIONS AND RESULTS OF IMPLEMENTATION

Results are of practical interest for livestock farm breeders and can be used as recommendations for specialists working with sexed semen.

Practical relevance of the results also includes the possibility of increasing economic efficiency of dairy cattle breeding and reducing the shortage of replacement heifers through the rational use of sexed semen [14].

During using sexed semen, the yield of heifers was 84.8%; this is a good alternative under conditions of insufficient production space and food supply. According to economic parameters, profitability level including breeding sales was 59.8%.

III. RESEARCH METHODOLOGY

The studies were conducted from 2014 to 2018 in "Udmurtia" agricultural production cooperative (collective farm) of Vavozhsky region of the Udmurt Republic. In order to study the effectiveness of the use of sexed semen, a control and test group of heifers, 183 heads each, were formed using the principle of analogous groups. For insemination of test group heifers, sexed semen of the following stud bulls was used: Surprise 342544408, Parrah 343313777 and Yotan 831644. For insemination of control group heifers, semen obtained by traditional method of the following bulls was used: Patrick 51660096, Maradonna 466685 and Elsinore 1731.

The offspring was registered according to established procedure. The growth characteristics of heifers were studied by weight at birth, and then at the age of 3, 6, 9, 12, 15, 18 months and at the first calving.

To study milk producing ability and reproductive qualities, 2 groups of first-calf cows were formed: 1 group included daughters of stud bulls whose semen was sorted by sex, and 2 group included daughters of stud bulls whose semen was obtained using traditional method.

Genetic potential of stud bulls was calculated on the basis of the best lactation of female ancestors as a parental bull index (PBI).

The results of the study were processed using biometrics methods according to the method of N.A. Plokhinsky (1969) on a PC with Microsoft Excel.

IV. RESULTS

Making of technological herds with an increased genetic potential for milk production will be largely determined by the breeding qualities of the bulls used [9].

For obtaining normal and sexed semen, bulls with the following genetic potential were used: in terms of milk yield, 11945 ± 940.6 kg and 13714 ± 763.9 kg, respectively, the difference was 1769 kg ($P \geq 0.05$). Fat mass fraction in the female ancestors of bulls whose semen was obtained according to the traditional method was higher by 0.31% ($P \geq 0.05$). Parental index for protein mass fraction was equal in both groups.

Among the bulls with sexed semen, the bull Yotan 831644 showed the greatest PBI – 14,911 kg, the bull Surprise 34244408 had the best value for the mass fraction of fat in milk – 4.22%, and the bull Parrah 343313777 – for the mass fraction of protein – 3.52 % The highest PBI for milk yield among bulls whose semen was obtained according to the traditional method belonged to the bull Elsinore 1731 – 13,469 kg, and the highest mass fraction of fat and protein in

milk – to the bull Patrick 51660096 – 4.93 and 3.64%, respectively.

In the study of the reproductive qualities of stud bulls, it was found that in the case of using sexed semen fertility rate was 58.7% (at the rate of 1.7 semen doses). The best fertility was demonstrated by the bull Parrah 343313777, it amounted to 74.0%, with a minimal semen dose rate of 1.3. The bull Yotan 831644 showed the worst parameters. Fertilization with single insemination was 44.5% with the highest semen dose rate of 2.2. The results obtained align with data from the world practice of using sexed semen: the farm has achieved a similar value of successful insemination (in %).

In the case of fertilization of heifers with normal semen (semen obtained by traditional method), fertility rate was 75.4% (at the rate of 1.3 semen doses). Among individual bulls, Patrick 51660096 had the best fertility rate – 83.6% with a minimal semen dose rate of 1.2, and the worst value was in Elsinore bull 1731 – fertility rate was 67.2% (at the rate of 1.5 semen doses).

In general, during insemination with sexed semen, the yield of heifers was 84.8%. At the same time, the highest percentage of the output of heifers was registered in the bull Parrah 343313777 (the birth of twins from this bull was noted) – 90.6%.

When using traditional semen, there was no difference by sex, there were 50.6% of heifers. The highest yield of heifers was from the bull Patrick 51660096 – 54.0%.

Thus, during the fertilization of heifers with sexed semen, there was a decrease in calf yield rate (by 22.9%) compared to normal semen, but the heifer yield percentage was increased by 37.6%.

Parameters of growth and development of heifers obtained from stud bulls of different groups were also studied.

Heifers obtained from sexed semen were obviously smaller at birth than heifers from normal semen – by 1.4 kg ($P \leq 0.05$). Live weight gradually increased with growth, and at 3 months these heifers became larger than their herdmates by 1.34 kg ($P \geq 0.05$), at 6 months the difference was 2.1 kg ($P \geq 0.05$), at 10 months – 1.37 kg ($P \geq 0.05$). By the age of 12 months, live weight of heifers from sexed semen decreased slightly compared to heifers from normal semen – by 3.1 kg ($P \geq 0.05$).

Live weight index of heifers at first insemination is one of the most important factors affecting the subsequent milk producing ability.

The highest live weight at first successful insemination was in the daughters of the bull Parrah 343313777 – 419.38 ± 6.84 kg at the age of first successful insemination of 16.3 months. In daughters of other bulls, the age of first successful insemination was actually equal – 15.6-15.9 months.

The final stage of the evaluation of stud bulls is their assessment by the productivity level of their descendants. Table 1 shows the parameters of milk producing ability of the daughters of stud bulls analyzed.

TABLE I. MILK PRODUCING ACTIVITY OF THE DAUGHTERS OF STUD BULLS

Name and No. of the bull	1 lactation			2 lactation		
	Milk yield, kg	FWF, %	PWF, %	Milk yield, kg	FWF, %	PWF, %
Sexed semen						
Surprise 342544 408	6074.7±2 66.9	3.96±0 .08	3.21±0 .01	6606.2±2 01.9	4.25±0 .11	3.17±0 .03
Yotan 831644	6647.0±2 58.2	3.46±0 .06	3.21±0 .02	-	-	-
Parrah 343313 777	6552.5±2 14.4	3.72±0 .04	3.15±0 .03	7499.6±2 96.0	3.88±0 .10	3.12±0 .02
Average	6373.9±1 52.2	3.78±0 .05	3.18±0 .02	7142.2±2 09.3	4.03±0 .08	3.14±0 .02
Normal semen						
Maradonna 466685	6639.9±9 9.4	3.69±0 .03	3.16±0 .01	7279.7±1 81.6	4.14±0 .05	3.16±0 .01
Patrick 516600 96	6619.2±8 8.1	3.69±0 .03	3.22±0 .01	6809.7±1 85.0	4.36±0 .08	3.16±0 .02
Elsinore 1731	6820.7±1 12.3	3.73±0 .03	3.21±0 .01	7210.6±1 93.2	4.22±0 .06	3.15±0 .01
Average	6695.9±5 8.2	3.71±0 .02	3.19±0 .01	7135.5±1 09.7	4.23±0 .04	3.16±0 .01

Daughters of the bulls whose semen was sorted by sex showed the lowest milk yield during the first lactation - 6,373.9 kg; it was 322.0 kg ($P \leq 0.05$), or 5.1%, less than that of the daughters of stud bulls whose semen was obtained by traditional method. Among the bulls of the first group, the highest milk yield was in the daughters of the bull Yotan 39371484 - 6,647.0 kg of milk, but fat mass fraction in this milk was the lowest one - 3.46%, the difference was 0.5-0.26% ($P \leq 0.05$). The daughters of the bull Surprise 342544408 had the lowest milk production of 6,074.7 kg while fat mass fraction was the highest - 3.96%.

For the second group of bulls whose semen was obtained by traditional method, the greatest milk yield was obtained from the daughters of the bull Elsinore 1731 - 6,820.7 kg of milk; it was 3.0 and 2.7% higher than the herdmates in the group. Fat mass fraction in milk was also the largest among the daughters of the bull Elsinore 1731 - 3.73%; it was 0.04% higher than that of the daughters of the bull Maradonna 466685 and the daughters of Patrick 51660096.

Milk producing ability during second lactation was higher in the daughters of the first group of bulls - 7,083.7 kg, but the difference was only 145.7 kg ($P \geq 0.05$).

The greatest milk yield among the daughters of the bulls of first group belonged to the daughters of the bull Parrah 343313777 - 7,358.8 kg; it was the highest milk yield among all the daughters of the bulls of both groups. But fat mass fraction in milk was the lowest and amounted to 3.96%.

Among the daughters of stud bulls of the second group, the highest milk yield during the second lactation belonged to the daughters of the bull Maradonna 466685 - 7,089.6 kg and the daughters of the bull Elsinore 1731 - 7,061.9 kg, and the smallest milk yield of 6,639.8 kg was in the daughters of Patrick 51660096. But they showed the highest mass fraction of fat in milk - 4.64% - what was higher than in the

daughters of other bulls of both groups by 0.41-0.68%, while there was a significant difference with the daughters of the bull Parrah 343313777 ($P \leq 0, 05$).

The parameter of genetic potential realization for milk yield during the first lactation was higher by 10.6% in stud bulls whose semen was obtained by traditional method, it amounted to 56.5%. The highest genetic potential realization for milk yield was in the descendants of the bull Patrick 51660096 (64.7%) in the second group, and in the bull Parrah 343313777 (48.7%) among the bulls of the first group. Genetic potential realization shown in the highest milk yield during second lactation was also in the daughters of the bull Patrick 51660096 - 66.5%, the lowest value was in the bull Elsinore 1731 - 52.4%.

In terms of quality parameters, genetic potential realization was higher than in terms of milk yield in both groups. The highest genetic potential realization in terms of fat mass fraction was in the daughters of the bull Surprise 342544408 - 95.7%, among the bulls of second group in the bull Maradonna 466685 - 93.8%.

In order to increase production volume, the reproductive potential of cattle breeding stock should be used to the full extent. One of the important problems of herd reproduction is an impairment of the reproductive function of highly productive cows: this factor interferes with the process of increasing milk production and the profitability level of dairy cattle breeding in general.

Table 2 shows reproductive qualities of the daughters of evaluated stud bulls.

TABLE II. REPRODUCTIVE QUALITIES OF THE DAUGHTERS OF STUD BULLS

Name and No. of the bull	Insemination frequency to 1 lactation	Indifference period, days	Insemination frequency during 1 lactation	Service period, days	Calving interval, days
Sexed semen					
Surprise 3425444 08	1.17±0.12	54.7±4.43	2.00±0.35	110.6±1 9.2	383.1±1 9.9
Yotan 3937148 4	1.83±0.40	53.0±2.90	2.83±0.87	139.2±3 8.7	416.2±3 9.9
Parrah 3433137 77	1.52±0.23	62.8±4.47	2.38±0.33	123.5±1 7.8	403.7±1 7.6
Average	1.72±0.13	58.2±2.80	2.28±0.24	120.0±1 2.2	399.8±1 2.5
Normal semen					
Maradonna 466685	1.48±0.07	63.5±2.87	2.02±0.14	117.1±8. 53	394.1±8. 48
Patrick 5166009 6	1.52±0.08	51.3±1.27	2.39±0.17	118.9±7. 98	388.1±8. 22
Elsinore 1731	1.48±0.09	56.3±1.97	2.32±0.15	119.7±7. 78	392.6±7. 81
Average	1.49±0.05	56.8±1.23	2.26±0.09	118.7±4. 60	391.6±4. 70

Reproductive qualities of the daughters of stud bulls in compared groups are practically at the same level. Thus, the duration of indifference and service periods for daughters of bulls whose semen was sorted by sex turned out to be slightly longer compared with the herdmates in second group by 1.4 and 1.3 days on average.

However, the values differ within groups. The best reproductive qualities among the daughters of the bulls of first group were in the daughters of Surprise 342544408. Indifference and service periods for his daughters lasted for 54.7 and 110.6 days with insemination rate of 1.17 and 2.00, respectively. This is less than in the daughters of the other bulls in this group by 8.1-28.6 days.

Among the daughters of the bulls of second group whose semen was obtained using traditional method, the daughters of Maradonna 466685 and Patrick 51660096 were characterized by the best reproductive qualities. The duration of service period and calving interval was slightly less compared with the daughters of Elsinore 1731, established difference was not significant. The lower insemination rate during the first lactation was also observed in the daughters of Maradonna 466685 – 2.02, whereas in the daughters of the other bulls it was 2.32 and 2.39.

V. CONCLUSIONS

In the course of this study, it was found that during the fertilization of heifers with sexed semen, calf output rate decreased by 22.9% compared with normal semen, but at the same time the yield rate of heifers increased by 37.6% and amounted to 84.8%.

Fertility rate of animals was 58.7% (at a rate of 1.7 semen doses) when using sexed semen, while during fertilization of heifers with normal semen fertility rate of animals was higher: 75.4% (at a rate of 1.3 semen doses).

The growth rate of young stock obtained from the studied groups of stud bulls was at the same level during all periods what indicated herd uniformity. Heifers born from sexed semen were reliably smaller than these derived from normal semen, by 1.4 kg, however, in growth up to 6 months, they had more intensity.

First lactation milk yield of the daughters of stud bulls whose semen was obtained by traditional method exceeded milk yield of the daughters of stud bulls whose semen was sorted by sex by 546.4 kg, while fat mass fraction in milk was in this case lower by 0.14%. Mass fraction of protein in milk was 0.02% higher in daughters of bulls of the second group. In subsequent lactations, the daughters of bulls whose semen was sorted by sex had milk yield of 145.7 kg more.

In general, the method of semen obtaining did not affect milk producing ability and reproductive qualities of the daughters of stud bulls. The level of milk producing ability and reproductive functions largely depend on the individual characteristics and the genetic potential of animals.

REFERENCES

- [1] M. Dunin, "Effectiveness of insemination of heifers with sexed semen," *Dairy and Beef Cattle Breeding*, № 3, pp. 9-11, 2011.
- [2] A. Lyubimov, E. Martynova, G. Azimova, and Yu. Isupova, "Evaluation of genotype realization of stud bulls of different breeding," *Efficiency of adaptive technologies in plant growing and animal husbandry: materials of All-Russian Scientific and Practical Conference, Izhevsk, Federal State Budgetary Educational Institution of Higher Education Izhevsk State Agricultural Academy*, pp. 200-203, 2008.
- [3] V. Golovan, "Description of stud bulls whose semen was sorted by sex," *Collection of research papers of the North Caucasus Research Institute of Animal Husbandry, Krasnodar*, pp. 130-135, 2014.
- [4] A. Lyubimov, E. Martynova, and Yu. Isupova, "Evaluation of the genetic potential of the bulls of breeding enterprises of the Udmurt Republic," *Scientific support of the innovative development of animal husbandry: materials of International Scientific and Practical Conference, Izhevsk, Federal State Budgetary Educational Institution of Higher Education Izhevsk State Agricultural Academy*, pp. 90-93, 2010.
- [5] J. De Jarnette, R. Nebel, and C. Marshall, "Evaluating the success of sex-sorted semen in US dairy herds from on farm records," *Theriogenology*, vol. 71, pp. 49-58, 2009.
- [6] G. Seidel, "Application of Sex-selected Semen in Heifer Development and Breeding Programs Veterinary Clinics of North America," *Food Animal Practice*, vol. 29(3), pp. 619-625, 2013.
- [7] A. Donchenko, V. Soloshenko, and I. Klimenok, "The use of sexed semen in dairy cattle breeding," *Agrarian science for agricultural production of Siberia, Mongolia, Kazakhstan, Belarus and Bulgaria: Collection of scientific reports of XX International Scientific and Practical Conference (Novosibirsk, October 4-6, 2017)*, Novosibirsk, Siberian Federal Scientific Center of RAS, Novosibirsk State Agricultural University, pp. 149-150, 2017.
- [8] M. Kudrin, and K. Simakova, "Experience of working with sexed semen in the conditions of Udmurt Republic," *Efficiency of adaptive technologies in agriculture: materials of All-Russian Scientific and Practical Conference dedicated to the 50th anniversary of Michurin Agricultural and Industrial Complex of Vavozhsky Region of the Udmurt Republic, Izhevsk, Federal State Budgetary Educational Institution of Higher Education Izhevsk State Agricultural Academy*, pp. 177-181, 2016.
- [9] N. Nikitin, and N. Sinitsyna, "Peculiarities of sexed semen use," *Animal breeding technologies*, № 9, pp. 44, 2014.
- [10] A. Zorina, and E. Martynova, "Evaluation of the influence of the sexed semen of bulls on the survival and growth of their daughters," *Scientific and staff support of AIC for food import substitution: materials of All-Russian Scientific and Practical Conference, February 16-19, 2016, Izhevsk. In 3 volumes, Izhevsk, Federal State Budgetary Educational Institution of Higher Education Izhevsk State Agricultural Academy*, vol. 2, pp. 94-97, 2016.
- [11] V. Usenko, "Experience and prospects of using sexed semen for increase of the number of dairy cows in the Kuban region," *Scientific journal of Kuban State Agrarian University*, № 101 (07), pp. 57-61, 2014.
- [12] J. Carvalho, R. Sartori, G. Machado, and G. Mourão, "Dode M.A.N. Quality assessment of bovine cryopreserved sperm after sexing by flow cytometry and their use in in vitro embryo production," *Theriogenology*, vol. 74, pp. 1521-1530, 2010.
- [13] E. Cherkashin, and G. Yarmots, "Experience of using sexed semen in the farms of the Tyumen region," *Integration of science and practice for the development of agroindustrial complex: materials of All-Russian Scientific Conference, Tyumen, State Agricultural University of Northern Zauralye*, pp. 152-158, 2017.
- [14] D. Posunko, "Sexed semen: myths and reality," *Chief Animal Technologist*, № 8, pp. 12-14, 2010.