



Dairy Productivity of Holstein Cows of Different Genetic Lines in the Conditions of Kostanay Region of Kazakhstan

Gulzhan Kalenovna Mussayeva^{1*}, Alikhan Meldebekovich Meldebekov², Nurgul Alikhanovna Meldebekova², Gulshat Imanzhankyzy Shaykamal¹, Batyrkhan Azimkhanovich Buralkhiyev², Nurkuisa Mirzabekovich Rametov³ and Kanat Zhumanov⁴

¹JSC A. Baitursynov Kostanay Regional University, Ministry of Education and Science of the Republic of Kazakhstan, Baytursynov Street 47, 110000, Kostanay, Republic of Kazakhstan

²Kazakh National Agrarian Research University, Almaty, Republic of Kazakhstan

³K.I. Satpayev Kazakh National Research Technical University, Almaty, Republic of Kazakhstan

⁴LLP, Kazakh Scientific Research Institute of Animal Breeding and Forage Production, City of Almaty, Republic of Kazakhstan

ABSTRACT

This article presents a comparative characteristic of cows' dairy productivity in the context of three lines: Reflection Sovereign and Wis Burke Ideal and Osborndale Ivanhoe in the conditions of the breeding farm of Kostanay region. Studies on lactating cows have shown that cows of the Wis Burke Ideal line have an advantage in milk productivity. Furthermore, that the highest productivity was noted in cows of the Wis Burke Ideal line – 14793.02, which is 3894.44 and 3523.52 kg higher than in the peers of the Reflection Sovereign and Osborndale Ivanhoe lines. Since the research farm specializes in breeding Holstein breed it is necessary to adhere to the standard of the breed in all genetic, constitutional, exterior and productive parameters. To fully realize the genetic potential of the breed it is necessary: to select for artificial insemination bulls from the line whose offspring are most productive and physiologically more adapted to the climatic, technological and forage conditions of the farm. When selecting, special attention should be paid to the strength of the hoofed horn and the duration of commercial use. For the given purposes it is recommended to use such bulls of the Wis Burke Ideal line whose average milk productivity exceeds that of their coevals and the breed standard and simultaneously allows to keep productive longevity and reproductive ability. The results obtained in the course of research indicate the influence of such genotypic factor as 'lineage' on the productive longevity of Holstein cows. The most longevity and highly productive were the cows of line Wis Burke Ideal. The results obtained during the researches testify to the influence of such genotypical factor as "lineage" on the productive longevity of Holstein cows. The most long-lived and highly productive cows were those of the Wis Burke Ideal line. The prospects for breeding dairy cows also lie in the fact that they have practically shown high milk productivity at the end of three lactations.

INTRODUCTION


Dairy productivity is the primary indicator that characterizes the dairy breed of livestock. It is known

that the indicators of milk productivity (milk yield, fat, and protein content in milk) are determined by the genotype of the animal and the environmental conditions in which it is implemented (Misztal *et al.*, 2016). An important role, in this case, belongs to the rational and full-fledged feeding of dairy cattle, which contributes to the disclosure and realization of their productivity's genetically determined level. Among the factors of a balanced diet of dairy cows, a special place is occupied, along with organic and biologically active compounds, minerals, represented in feed products by macro-microelements, which are not always sufficient in livestock diets. Therefore, in the practice of dairy cattle breeding, it is customary to introduce top mineral dressing into the diets.

* Corresponding author: musaeva____1984@mail.ru
0030-9923/2022/0001-0001 \$ 9.00/0



Copyright 2022 by the authors. Licensee Zoological Society of Pakistan.

This article is an open access  article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Article Information

Received 18 August 2021

Revised 29 March 2022

Accepted 17 April 2022

Available online 27 July 2022

(early access)

Authors' Contribution

MGK conducted a critical review of the article, read and approved the final version of the manuscript and collected data on the Holstein breed's milk productivity, conducted data processing. SGI developed the design of the study, read and approved the final version of the manuscript. MAM and RNM collected data on the milk productivity of the Holstein breed, processed the data and reviewed publications on the topic of the article. ZK, BBA and MNA developed the concept and design of this study, participated in the writing of the article.

Key words

Holstein cows, Productivity, Milk, Longevity, Genetic lines

Many factors influence the milk content of cows. The leading role, in this case, is given to the genetic potential of cow productivity, which cannot be realized without the organization of their proper feeding and appropriate livestock maintenance.

According to [Nikiforova \(2008\)](#), the live weight of Holstein heifers at the age of 12 months should be 300-320 kg and at the age of 18 months 390-400 kg, which will allow to get from them for lactation up to 6000 kg of milk. Otherwise, their genetic capabilities are not realized ([Bekenev, 2019](#)).

In this period, at the beginning of lactation, cows cover the need for nutrients at the expense of body reserves, and in the second half of lactation cows need to replenish the stock of spent nutrients. Norms of feeding cows in lactation period recommended by Kazakh Research Institute of Livestock and Fodder Production LLP, which is a proof that its use contributes to obtaining high milk yields ([Ryadchikov, 2012](#)).

The decrease in the productive longevity of cows is a negative energy balance when the cow in the early lactation period continues to increase milk yield even after the exchange energy absorbed with the feed does not cover its costs for dairy products. As a result, a negative energy balance occurs in the early lactation period when the body's reserves cover the cow's energy deficit for a certain period. As a result, body weight, fatness, and metabolism are reduced, with all the negative consequences ([Sharvadze, 2020](#); [Cherepanov, 2020](#); [Butler and Smith, 1989](#)).

The aim of this study was to determine the effect of feeding conditions and genetic predisposition for high milk production by Holstein Friesian cows bred in Northern Kazakhstan during 6-7 lactation period.

MATERIALS AND METHODS

The study was carried out on 900 Holstein dairy cows breeding in Bek Plus LLP, Lesnoye village, Fedorovsky district, Kostanay region of Kazakhstan. The cattle were imported from Canada in 2013. The company specializes in milk production and breeding Holstein cattle for dairy production. The farm comprising of production facilities for keeping animals and Karusel milking complex with the accompanying Dairy Plan program is designed for 1200 broodstock. On the farm dairy herd includes 1129 cows from three different genealogical lines, Wis Burk Ideal, Reflection Sovereign, and Osborndale Ivanhoe, which were included in the present lactation studies.

During the study period, the cows were kept in the same conditions. The normalized feeding was carried out following the explicit norms of feeding, taking into account their cows' physiological state. The daily feeding

rations were made, taking into account our product feed's chemical composition feed using the premix "IN-R 18 PRO" at 200 g per head per day as part of the grain mixture.

In order to ensure the effective use of the nutrients of the feed ration, it is necessary to study the chemical composition of the feed, its nutritional value and the content of macro-microelements in them, which allows us to objectively compensate for the deficiency of a particular substance or mineral element in the diets of cows. To identify the potential of milk productivity of highly productive Holstein cows in the context of lines in the north of Kazakhstan, we studied the chemical composition and nutrient content at year-round cost content, analyzed the feeding rations of dairy herds, the indicators of dairy production of experimental animals in BEK Plus LLP of Kostanay region.

The study of cows' productive longevity was carried out using the data of primary zootechnical and breeding records in the farm. The necessary digital material for processing is obtained from the IAS program's database (Information and Analytical System) and Dairy Plan. The age of cows determined productive longevity in lactation.

Milk productivity was recorded by conducting control milk once a decade using additional measuring equipment of the Dairy Plan 21 milking complex. The following indicators were taken into account: milk yield for full lactation (kg), milk yield for 305 days of lactation (kg), the content of fat and protein in milk (%), the amount of fat and protein in milk yield (kg) and the duration of lactation (days).

The study of the qualitative composition of milk was carried out in the second month of lactation. The selection was done following GOST RK 52738-2007 "Milk and milk processing products. Terms and definitions", with proposed regulatory references. In the studied milk samples, the fat and protein content were determined on the Milkoscan FT-120 device.

Correlation coefficients between production parameters (milk yield per completed lactation, age of cows in lactations, 305 days of lactation.) were calculated using one-factor analysis of variance using Microsoft Excel Analysis Package.

The obtained results were processed by the method of variation statistics, according to [Papusza \(2011\)](#) and [Saitova and Dagova \(2015\)](#) using the standard statistical analysis package Microsoft Excel 2007 on a personal computer. The reliability of the obtained results was evaluated using the Student's criterion.

RESULTS AND DISCUSSION

In terms of the content of nutrients (coarse, juicy and

Table II. Dairy productivity of cows of lactation in a herd.

Lactation	Milk yield per completed lactation (kg)			Milk yield for 305 days of lactation (kg)			Fat (%)	Quantity of milk fat for 305 days (kg)	Protein (%)	Quantity of milk protein for 305 days (kg)			
	Mean±SEM	σ	Cv	Mean±SEM	σ	Cv					Mean±SEM	σ	Cv
1	345	12192.48±706.25	14422.06	7835.38±323.66	8226.36	3.17±0.02	0.46	259.76±7.83	67.81	3.21±0.01	0.28	242.90±6.54	56.65
2	244	12990.52±1471.05	17467.79	7521.55±134.47	2087.50	3.11±0.03	0.47	232.13±4.30	66.78	3.22±0.02	0.25	242.10±4.50	69.81
3	225	12507.96±1332.25	16586.38	8493.32±917.19	13727.17	3.18±0.03	0.44	268.59±28.29	423.40	3.21±0.02	0.30	272.54±29.57	442.58
4	103	9529.70±299.41	2117.13	7322.39±140.32	1410.01	3.08±0.05	0.48	225.25±5.76	57.90	3.21±0.03	0.29	234.97±4.86	48.86
5 >	5	10709.50±446.50	631.45	7688.75±296.51	593.01	3.01±0.24	0.48	231.37±21.42	42.83	3.16±0.08	0.16	242.13±7.52	15.05

Table III. Dairy productivity of cows, depending on the linear genetic affiliation.

Line	Milk yield per completed lactation (kg)			Milk yield for 305 days of lactation (kg)			Fat (%)	Quantity of milk fat (kg)	Protein (%)	Quantity of milk protein (kg)									
	Mean±SEM	σ	Cv	Mean±SEM	σ	Cv					Mean±SEM	σ	Cv	Mean±SEM	σ				
1	Reflection	11293.83±347.89	2359.52	23.22	7587.38±242.74	1716.42	22.47	3.35±0.05	0.40	11.77	255.27±9.55	67.56	26.21	3.13±0.04	0.28	9.47	236.51±7.58	53.56	22.44
	Wis burke	12189.08±1039.60	3748.35	30.75	7751.78±548.59	2052.63	25.81	3.44±0.08	0.31	8.63	268.29±20.59	77.05	28.12	3.29±0.09	0.33	9.30	254.74±18.90	70.73	26.82
	Osbornedale	11023.76±305.89	1825.25	19.22	7478.68±218.14	2018.32	21.67	3.45±0.05	0.38	9.78	259.27±6.55	69.56	27.28	3.33±0.04	0.38	6.47	245.51±7.58	53.56	26.44
2	Reflection	11442.28±430.06	3572.42	31.22	7513.01±197.47	2126.83	28.49	3.12±0.04	0.45	14.34	232.71±6.40	68.96	29.76	3.25±0.02	0.28	8.76	244.29±6.82	73.44	30.35
	Wis burke	12262.45±669.83	4236.40	34.55	7627.85±250.66	2020.92	26.77	3.06±0.06	0.50	16.21	229.69±7.46	60.21	26.23	3.19±0.03	0.21	6.46	243.46±8.01	64.62	26.82
	Osbornedale	11701.75±1172.09	2344.18	20.03	8951.46±621.11	2060.00	22.10	2.81±0.14	0.47	16.46	249.01±16.98	56.31	22.41	3.22±0.05	0.17	8.16	289.09±21.51	71.36	23.87
3	Reflection	10898.56±298.93	2640.098	24.20	7540.86±174.38	1845.45	24.44	3.15±0.04	0.43	13.68	236.73±5.87	62.18	26.21	3.24±0.03	0.30	9.17	243.48±5.66	59.96	24.57
	Wis burke	14793.02±3246.17	25765.67	173.09	10004.04±2268.89	21524.63	213.45	3.17±0.05	0.47	14.92	313.36±69.15	659.68	27.11	3.17±0.03	0.31	9.85	318.10±72.36	690.26	26.66
	Osbornedale	11269.50±152.37	4292.41	29.53	7695.23±510.44	1840.41	23.00	3.46±0.08	0.29	8.19	264.81±16.94	61.10	22.13	3.25±0.08	0.29	9.51	250.61±18.92	68.24	26.76
4	Reflection	9319.15±391.14	1749.21	18.30	7100.02±178.20	1168.53	16.31	3.07±0.07	0.46	14.76	217.05±6.54	42.91	19.53	3.18±0.04	0.26	8.38	225.21±6.03	39.54	17.35
	Wis burke	9504.73±486.34	2479.88	25.63	7433.21±228.54	1566.78	20.84	3.07±0.07	0.50	16.13	228.70±9.59	65.75	28.44	3.21±0.04	0.30	9.51	238.34±8.08	55.40	23.09
	Osbornedale	10979.00±103.00	145.66	13.41	7063.83±414.94	1016.39	23.66	3.37±0.19	0.51	17.60	244.48±16.27	43.04	35.50	3.34±0.12	0.31	9.51	239.31±14.59	35.73	19.54

All other things being equal, the dairy productivity of cows and their cow milk composition depends not only on their breed but also on their linear genetic affiliation.

When studying the milk productivity of cows in the context of the herd lines of the whole herd for 305 days of lactation, it was found that in general, this indicator ranges from 7100.02 kg in cows of the reflection sovereign line to 10004.04 kg in individuals of the wis burke ideal line.

Analysis of the fat content in the milk of cows of different lines showed that the higher fat content of milk was noted in the cows of the osbondale ivanhoe line (3.46%), the lower in the cows of the reflection sovereign line (3.12%).

Most of the characteristics used for breeding dairy cattle are interrelated, which is established based on correlation data.

The significance of correlation analysis lies in the fact that it allows for more reasonable selection while simultaneously improving animals for several characteristics. It is known that the dispersion of breeding pressure on many grounds dramatically slows down the process of improving animals.

For greater objectivity and obtaining reliable indicators of correlation coefficients, we conducted a sample of equal groups of cows with different lactation periods because the correlation coefficient calculated as a whole for the entire herd of cows does not give an objective picture since the number of cows for the first lactation in the studied herd is more than 60% of the total population. The cows formed into groups to calculate the correlation coefficient are presented in Table IV.

From the data in Table IV, on average, the correlation between milk yield for the entire lactation and the age

of cows in lactation on the farm was negative (-0.042). However, at the same time, the correlation coefficient between the milk yield of cows for 305 days of lactation and their age in lactation was positive and was equal to +0.011.

Studies have shown that the technological and economical feeding of dairy cattle in the north of Kazakhstan is silage-haylage. This feeding in winter allows normalizing the digestive process in the gastrointestinal tract of dairy cows and getting high milk yields of good quality.

Many scientists have revealed that the discrepancy between the high genetic potential of dairy productivity and the conditions necessary for its implementation in agricultural enterprises leads to premature retirement of animals from the herd (Sasaki *et al.*, 2017; Rojas *et al.*, 2016; Weller and Wezra, 2015; Strapakova *et al.*, 2014; De Vries, 2013; Rushen and Passillé, 2013).

High rates of forced culling on dairy farms due to the animal's disease or reproductive problems occur for low animal resistance and reduce the profitability of the dairy farm. Therefore, eliminating the main causes of forced culling will improve animal health and increase farm income. According to Martens (2013) and many cows leave the herd after 2-3 calves, without reaching the maximum productive capacity.

Bergk *et al.* (2011) report a cull rate of 10.7% during the first 300 days of lactation and 20.9% on the 450-th day after the first calving. Similar results were obtained by Authors, who analyzed the reasons for culling 25% of cows during the first lactation in Baden-Württemberg. Infertility is the most common cause (20.9%), followed by mastitis (14,3%) and lameness (11%).

Table IV. Correlation dependence of cows' dairy productivity indicators in the context of lines and in general for the herd of BEK Plus LLP.

Indicators	Experienced groups			Equivalent groups of cows of different lactation types	In the whole herd
	Wis burke ideal	Reflection sovereign	Osbondale ivanhoe		
Milk yield for completed lactation the age of cows in lactation (kg)	0.129	0.049	0.216	-0.291	-0.042
Milk yield for 305 days of lactation the age of cows in lactation (kg)	0.005	0.001	0.003	0.033	0.011
Milk yield for 305 days of lactation-fat (%)	0.128	-0.156	0.254	0.149	-0.031
Milk yield for 305 days of lactation-protein (%)	0.259	0.241	0.001	0.043	-0.002
Milk yield for 305 days of lactation-service period (kg)	0.025	-0.425	0.041	-	-
Milk yield for frozen lactation – service period (kg)	-0.132	-0,142	0.124	-	-
Age of cows in lactation – fat (%)	0.012	0.231	0.111	-0.131	-0.116
Age of cows in lactation-protein (%)	0.122	0.002	0.007	-0.020	0.004

German scientists (Punsmann and Ditzl, 2017) studied productive life and longevity in dairy cows the heritability of longevity traits and their genetic correlations with milk productivity and functional traits on the German example black-and-white cattle breed. These scientists concluded that productive life duration is genetically positively correlated with milk productivity.

The works of, and others are devoted to the productive longevity of cows of dairy herds in Russia (Dedov and Sivkin, 2004; Dunin, 1995; Bekenev, 2019).

According to Kopytets and Voloshyn (2021) in the farms of Ukraine, the average duration of productive use of black-and-white cows more than 3.5 lactations. The author claims that if the duration of cows' use is less, then the mother cows will begin to drop out of the herd before their daughters give offspring. In this situation, the herd will cease to exist as an integrated biological system, and its disintegration will occur.

In dairy farming, some lines are characterised by abundant milking capacity, others by fat and protein dairy capacity, others by resistance to leukaemia, etc. In line breeding, valuable breeders play a decisive role and have an impact on the progress of the breed, so the line breeding system is an opportunity for the wide use of the ancestor and his descendants in the breed (Alentayev *et al.*, 2018; Misztal *et al.*, 2016).

Line breeding as a method of breeding involves a set of zootechnical measures aimed at improving, consolidating and further improving the valuable qualities of animals (Ansimova and Katmakov, 2020; Brascamp, 1978).

Line breeding means creating a highly productive and hereditary stable group of animals by using a targeted breeding process, conducting a certain system of animal selection and pairing to an outstanding producer and keeping its most valuable offspring obtained in a number of generations under conditions that promote the development of valuable traits and properties of animals for a given line (Bastin *et al.*, 2011; Chupsheva *et al.*, 2020; Schennink *et al.*, 2008; Kudinov *et al.*, 2021; Lopez-Villalobos *et al.*, 2020; Wiener and Wilkinson, 2011).

The above is especially valuable for Kazakhstan, which does not have its breeding base of producers. The main task of dairy cattle breeding is to produce highly productive animals that produce milk with high protein content and good technological properties. Most of these indicators are polygenic and are determined by many genes when interacting with environmental conditions. The effectiveness of breeding work is determined by selecting genotypes to specific environmental conditions, the carriers of which in such conditions differ in the desired productivity. An increase in breeding work efficiency can be achieved by identifying genotypes for carriers of which

the existing conditions allow developing a set of desirable productivity traits.

According to the literature, genetic factors determine 20% of the productive performance of an animal. This is why the selection of bull producers is important in improving the breeding qualities of dairy cows. The analysis of existing data shows that the average duration of bull progeny use in a herd is 10-12 years. In the first 6 years, the number of bull progeny in the herd is rather high and this determines the productive performance of the herd.

CONCLUSIONS

Highly productive cows of Holstein breeds were identified in milk productivity (milk yield for 305 days of lactation, milk yield for complete lactation). Analyzing the age composition of black-and-white cows, cows occupy a significant share for the first lactation, so in both farms, first-calf cows make up 54% of the total livestock. The share of cows on the 3rd and older lactation is at the level of 22-25%. Analyzing the Holstein breed of Bek Plus LLP, the number of cows for the first lactation is 37.6% of the total number (922 heads). The smallest number of cows by age are attributed to 4-5 calving; their percentage is 11.6.

There is a positive correlation between milk yield indicators for 305 days of lactation the age of cows in lactation, milk yield for lactation, and the service period, which is quite natural. With the positive correlation between the age in the lactation of the mother and daughter, it is possible to predict an increase in the productivity of offspring in the older lactation, which will guarantee success, provided that the technology of keeping and feeding cows is observed. The data analysis showed that the repeatability coefficients in cows for milk yield for 305 days are the highest in the Bek Plus LLP animals and are in the range from $r = 0.60$ to $r = 0.87$. From lactation to lactation, the repeatability coefficients increase and reach $r = 0.87$ between the third and fourth lactation. It indicates that the connection is growing and becoming more stable.

The results obtained in the research course indicate the influence of such a genotypic factor as "linear genetic affiliation" on Holstein cows' productive longevity. The most long-lived and highly productive cows were the Wis Burke Ideal line.

According to the last completed lactation data, the highest productivity was noted in the Wis Burke Ideal line cows - 14793.02 which is 3894.44 and 3523.52 kg higher than in the peers of the reflection sovereign and osbondale ivanhoe line.

The prospects for breeding dairy cows are also that they practically showed a high level of milk productivity at the end of three lactation periods.

ACKNOWLEDGMENTS

The work was carried out within the framework of the project of grant financing of the Ministry of Education and Science of the Republic of Kazakhstan for 2018-2020 “Development and implementation of a comprehensive program for improving the productive longevity of high-yielding cows of domestic selection” (State registration No. 0118RK00398).

Supplementary materials

The following are available online at <http://www.kazpatent.kz>, e-mail: kazpatent@kazpatent.kz No. 5284, 8-32/06-1 of 13.08.2020. On No. 2019/0980.2 dated 08.11.2019.

Funding

The work has been performed within the framework of the grant financing project of the Ministry of Education and Science of the Republic of Kazakhstan for 2018–2020 “Development and implementation of a comprehensive program to improve productive longevity of high yielding cows of local selection” (state registration number 0118RK00398) and were carried out in the dairy farm of Bek Plus limited liability partnership, Lesnoye village, Fedorovsky district, Kostanay region, Republic of Kazakhstan.

Institutional review board statement

The study was conducted in accordance with the rules of the Bioethics Committee. Extract from the Minutes No. 6 of the meeting of the local Ethics Commission of the RSE “National Center for Biotechnology” of the RK Ministry of Education and Science, Astana, September 25, 2017. The status of the animals.

Data availability statement

On results of the conducted researches the application “On useful model”, on complex use in rations of dairy cows of Holstein breed of forage additives which has received a positive estimation has been submitted to Kaz patent RK. <http://www.kazpatent.kz>, e-mail: kazpatent@kazpatent.kz No. № 5284, 8-32/06-1 of 13.08.2020. On No. 2019/0980.2 dated 08.11.2019.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

- Alentayev, A.S., Baimukanov, D.A., Smailov, S.D., Semenov, V.G., Abdrakhmanov, K.T., Begaliyev, D.A., and Omarov M.M., 2018. Efficiency of breeding of the Alatau breed of Brown Cattle in the “ADAL” Agro-Industrial Company JSC. *Bull. Nat. Acad. Sci. Repub. Kazakh.*, **5**: 12-29. <https://doi.org/10.32014/2018.2518-1467.2>
- Ansimova, E., and Katmakov, P., 2020. The genotypic composition of the herd of black-motley breed and phenotypic characteristic in connection with Holsteinization. *Agrar. Bull.*, **193**: 37-43. <https://doi.org/10.32417/1997-4868-2020-193-2-37-43>
- Bach, A., Calsamiglia, S., and Stern, M.D., 2005. Nitrogen metabolism in rumen. *J. Dairy Sci.*, **88**: E9-E21. [https://doi.org/10.3168/jds.S0022-0302\(05\)73133-7](https://doi.org/10.3168/jds.S0022-0302(05)73133-7)
- Bastin, C., Gengler, N., and Soyeurt, H., 2011. Phenotypic and genetic variability of production traits and milk fatty acid contents across days in milk for Walloon Holstein first-parity cows. *J. Dairy Sci.*, **94**: 4152-4163. <https://doi.org/10.3168/jds.2010-4108>
- Bekenev, V.A., 2019. Productive longevity of animals, methods of its prediction and extension. *Agric. Biol.*, **54**: 655-666. <https://doi.org/10.15389/agrobiology.2019.4.655eng>
- Bergk, N., Swalve, H.H., and Wensch-Dorendorf, M., 2011. Relationship between maternal traits of the dam and growth of dairy replacement heifers. *EAAP Book Abstract 62nd Annu. Meet. Eur. Fed. Anim. Sci. Stavanger*, **17**: 201. https://meetings.eaap.org/wp-content/uploads/2022/01/2011_Stavanger_Book_of_Abstracts.pdf
- Brascamp, E.W., 1978. *Methods on economic optimization of animal breeding plans*. University of Helsinki. Research Institute for Animal Husbandry Schoonoord. Rapport B-134. p. 1-117. https://moskit.uwm.edu.pl/wwwmail/?_task=mail&_frame=1&_mbox=INBOX&_uid=99951&_part=2&_action=get&_extwin=1
- Butler, W.R., and Smith, R., 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. *J. Dairy Sci.*, **72**: 767-783. [https://doi.org/10.3168/jds.S0022-0302\(89\)79169-4](https://doi.org/10.3168/jds.S0022-0302(89)79169-4)
- Cherepanov, G.G., 2020. New approaches in the study of viability of high yielding cows: Concepts, models, data, analysis. *Probl. Boil. Prod. Anim.*, **2**: 5-42.
- Chupsheva, N.Y., Karamayev, S.V., and Karamayeva, A.S., 2020. Productive longevity of cows with different stress resistance. *Bull. Samara State Agric. Acad.*, **5**: 39-45. <https://bulletin.ssaa.ru/1997-3225/article/view/50933>, <https://doi.org/10.12737/38767>

- De Vries, A., 2013. *Cow longevity economics. The economic benefits of keeping a cow in a herd. In proceedings of the cow longevity conference.* Tumba, Sweden. 28-29 August 2013. pp. 22-52.
- Dedov, M.D., and Sivkin, N.V., 2004. Features of cows with high lifetime productivity [In Russian]. *Biotechnology*, **10**: 2-4. <https://naukarus.com/osobennosti-korov-s-vysokoy-pozhizne-nyoy-produktivnostyu>
- Dunin, I., 1995. Improving the productive longevity of cows [In Russian]. *Zootehnika*, **6**: 21-22.
- Kopytets, N., and Voloshyn, V., 2021. Organizational and economic aspects of functioning of the field of cattle breeding in Ukraine. *E3S-Web Conf. EFSC2021*, **282**: 1-8. <https://doi.org/10.1051/e3sconf/202128207015>
- Kudinov, A.A., Mäntysaari, A.A., Pitkänen, T.J., Saksa, E.I., Aamand, G.P., Uimari, P.U., and Strandén, I., 2021. Single-step genomic evaluation of Russian dairy cattle using internal and external information. *J. Anim. Breed. Gen.*, **00**: 1-12.
- Lopez-Villalobos, N., Wiles P.G., and Garrick, J., 2020. Sire selection and genetic improvement of dairy cattle assuming pure market competition. *J. Dairy Sci.*, **103**: 4532-4544. <https://doi.org/10.3168/jds.2019-17582>
- Martens, H., 2013. *Longevity of high producing dairy cows: A case study.* Lohman Information. January. <https://lohmann-breeders.com/lohmanninfo/longevity-of-high-producing-dairy-cows-a-case-study/>
- Misztal, I., Pocrnic, I., Lourenco, D., and Masuda, Y., 2016. 0291 APY inverse of genomic relationship matrix-theory, analyses and questions. *J. Anim. Sci.*, **94**: 138. <https://doi.org/10.2527/jam2016-0291>
- Nikiforova, L.N., 2008. *Milk yield of cows of different lines.* Manuscript Bransk State Agricultural University. Bransk. pp. 1-4. [In Russian] https://moskit.uwm.edu.pl/wwwmail/?_task=mail&_frame=1&_mbox=Trash&_uid=38703&_part=2&_action=get&_extwin=1
- Papusza, W.N., 2011. *Guidelines for laboratory and practical classes in biometrics.* Publishing House of the Baitursynov State University in Kostanay. pp. 1-76. [In Russian]. https://moskit.uwm.edu.pl/wwwmail/?_task=mail&_frame=1&_mbox=INBOX&_uid=99960&_part=2&_action=get&_extwin=1
- Punsmann, T., and Distl, O., 2017. Length of productive life and longevity in dairy cows: Heritability of traits for longevity and their genetic correlations with milk performance and functional traits. *Zuchtungskunde*, **89**: 125-139. <https://www.cabdirect.org/cabdirect/abstract/20173141076>
- Rojas, J.R.A., Lopez, F.J.R., Murillo, V.E.V., and Montaldo, H.H., 2016. Genetic analysis of productive life in Holstein cattle in Mexico. *Rev. Mex. Ciencias Pecuarias*, **7**: 14-27. <https://issuu.com/revistamexicanadecienciaspecuarias/docs/volumen-final-1>, <https://doi.org/10.22319/rmcp.v7i1.4146>
- Rushen, J., and Passillé, A.M., 2013. *The importance of improving cow longevity.* In: Proceedings of the cow longevity conference. Tumba, Sweden. 28-29 August 2013. pp. 3-21.
- Ryadchikov, V.G., 2012. *Nutritional basics and feeding animals on farms.* Educational and Practical Guide Kuban State Agrarian University, Krasnodar. pp. 1-332. [In Russian].
- Saitova, F.N., and Dagova M.M., 2015. *Mathematical methods in Biology. Methodical instructions for practical training of graduate students.* Veterinary and animal husbandry. North Caucasian State Humanitarian and Technological Academy, Cherkessk. pp. 1-16. [In Russian]. https://nrsa.ru/upload/images/news/doc_2019-03-15%2010_32_11.pdf
- Sasaki, O., Aihara, M. Nishiura, A. and Takeda, H., 2017. Genetic correlations between cumulative survival rate, milk income, and a somatic lot during lactation in Holstein cattle in Japan using a random regression model. *J. Dairy Sci.*, **100**: 7882-7294. <https://doi.org/10.3168/jds.2016-12311>
- Schennink, A., Heck, J.M., Bovenhuis, H., Visker, M.H.P.W., van Valenberg, H.J.F., and van Arendonk J.A.M., 2008. Milk fatty acid unsaturation: Genetic parameters and effects of stearoyl-CoA desaturase (SCD1) and Acyl CoA: diacylglycerol acyltransferase 1 (DGAT1). *J. Dairy Sci.*, **91**: 2135-2143. <https://doi.org/10.3168/jds.2007-0825>
- Sharvadze, R., Gaidukova, E., Krasnoshchekova, T., Babukhadiya, K., and Burmaga, A., 2020. Influence of biologically active compounds on milk production and metabolism of lactating cows. *E3S-Web. Conf. EBWFF*, **203**: 1-13. <https://doi.org/10.1051/e3sconf/202020301005>
- Strapakova, E., Strapak, P., and Candrak, J., 2014. Estimation of breeding values for functional productive life in the Slovak Holstein population. *Czech J. Anim. Sci.*, **59**: 54-60. <https://www.agriculturejournals.cz/publicFiles/113324.pdf>, <https://doi.org/10.17221/7229-CJAS>
- Weller, J.I., and Ezra, E., 2015. Environmental and

genetic factors affecting the survival of the Israeli Holstein cow. *J. Dairy Sci.*, **98**: 676-668. <https://www.sciencedirect.com/science/article/pii/S0022030214007346>, <https://doi.org/10.3168/jds.2014-8650>

Wiener, P. and Wilkinson, S., 2011. Deciphering the genetic basis of animal domestication. *Proc. R. Soc. B Biol. Sci.*, **278**: 3161-3170. <https://doi.org/10.1098/rspb.2011.1376>

Online First Article