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REPRODUCTIVE QUALITIES OF DAIRY COWS AT DIFFERENT AGE AND LEVELS OF MILK YIELD

Vera GRANACI, Valentin FOCSHA, Alexandra KONSTANDOGLO, Vasily CURULIUC, Valentina CIUBATCO

Scientific-Practical Institute of Biotechnologies in Animal Husbandry and Veterinary Medicine, 15 Shcolara Str., v. Maximovca, District Anenii Noi, Republic of Moldova

Corresponding author email: granaci@yahoo.com

Abstract

The study results of the reproductive ability of cows depending of their age and milk productivity are presented. The studies were conducted in the Republic of Moldova on cows of the Holstein breed. The optimal parameters for the duration of the SP and CI were detected in cows with milk productivity less than 6000 kg of milk, at which the animals were characterized by the maximum indicators of calves yield and CCR. In cows with a milk yield of 9001 kg or more, a significant increase in the duration of SP (+109.8 days) and the CI (+90.3 days) was observed, the CCR decreased by 0.22, and the yield of calves/100cows per years by 21.7 heads. On average, each increase in milk yield by 1000 kg increases the duration of the SP by 27.6 days, the CI by 20.9 days. The share of the impact (η^2_x) of level of milk yield on the duration of SP was 18.0% ($p<0.001$), on the duration of the CI 15.6% ($p<0.001$), on the CCR 25.6% ($p<0.001$), the yield of calves 35.6 % ($p<0.001$). In order to increase the economic profit, we recommend livestock holdings to monitor the duration of SP.

Key words*: correlation, dispersion analysis, Holstein breed cows, level of milk productivity, reproductive capacity.*

INTRODUCTION

Cattle reproduction is one of the most laborious processes in breeding and exploitation of dairy cattle. The productivity of milk in cows, the efficiency of selection and reproduction work, the duration and intensity of the use of animals with highly productive genetic value depend on the level of reproduction of the herd.

In the modern conditions of market relations, the primary task in the field of dairy cattle breeding is the breeding of economically profitable animals. The female stock must have a high productivity potential but also a high level of reproductive performance in order to obtain as many young breeding animals as possible. In recent years, in the dairy cattle breeding, along with the increase in the genetic potential of milk productivity, a tendency to decrease the reproduction function of cows has been observed (Gabor, 2008; Popescu, 2014; Firsova et al., 2017; Aminova et al., 2019; Vasil'eva, 2019). Which leads to a reduction in the period of their exploitation period, a decrease in the level of productivity, and, consequently, the profitability of the branch as a whole (Dunin et al., 2019).

The state of the reproductive function of cows depends on many factors: heredity, artificial insemination technology, conditions of maintenance, feeding, exploitation, physiological state of the animal, etc. (Tanana & Peshko, 2011; Agalakova & Tyapughin, 2013; Berezkina et al., 2019; Meshcherov et al., 2019). According to a number of scientific studies increase in the level of milk productivity leads to decrease in the fertility of animals, as a result the length of the service period increases but the coefficient of reproductive capacity and the yield of calves per 100 cows per year decreases (Saksa & Barsukova, 2007; Gromova et al., 2016; Revina & Astashenkova 2018). Marusich, (2017) believes that the cause of the antagonism between productivity and reproductive function is primarily unilateral selection aimed at obtaining high yields, but not taking into account factors affecting health and reproductive function. Therefore, parallel to an increase in milk productivity, a primordial feature, from an economic point of view, another equally important task is taking shape, such as improving the reproductive abilities of the cows (Golikova & Fedoseeva, 2016).

Researchers and practitioners in many countries report the influence of milk yield on the reproductive function of cows and the antagonistic relationship between the milk productivity level of cows and their fertility (Sangsritavong, et al. 2002; Wiltbank et al. 2006; Kononov, 2013).

But there are also contradictory data (Bolgov & Karamonova, 2003; Sudarev, 2008) which did not motivate the researchers to reach a consensus.

The purpose of the research - the study of reproductive indices in Holstein cows according to age and the level of milk productivity, and the interrelationships between breeding indicators and milk productivity indices.

MATERIALS AND METHODS

In the research was the population of Holstein breed cows from the SRL "Holstein" livestock farm, Roshkani village, Anenii Noi District. The material for the research was the data of zootechnical accounting (card form T-2) and the information database of the farms. The processing included data on milk productivity and reproductive performances of Holstein breed cows. Milk productivity was estimated by milk yield for 305 days of lactation and for full lactation, taking into account milking days. The reproductive indices was studied by the duration of the service period (SP) and calving interval (CI), the coefficient of reproductive capacity (CCR), and the number of calves obtained per 100 cows/year (birth rate – BC).

The coefficient of reproductive capacity (CCR) of the female population was calculated according to Èisner et al. (1978).

The birth rate was calculated according to the relationship (Marusich, 2017):

$$BR = \frac{365 - SP}{285} * (100 - C) \dots\dots\dots\dots\dots (1),$$

where: BR - birth rate (%).

365 - the number of days in a year.

SP - duration of the service period.

285 - the average length of gestation.

C - correction coefficient, taking into account abortions, stillborn calves, etc. (about 2-5%).

For establish the impact of milk productivity on indices of the reproductive function of cows, they were divided into five groups depending on the level of milk yield for 305 days and for the full lactation with a class interval of 1000 kg; ≤ 6000 kg or less; 6001-7000 kg; 7001-8000 kg; 8001-9000 kg; ≥ 9001 kg and more.

The studies were carried out by comparing groups of animals in terms of reproductive abilities at different levels of productivity. Correlation and regression analyzes were used to search for and obtain objective results reflecting the relationship between milk yield and reproductive traits that meet the objectives of dairy cattle selection and breeding activity.

The influence of the milk productivity on the reproductive indices was determined by one-factor variance analysis. The reliability of the difference between the mean values of the signs was determined by Student's td-test.

Statistical processing and biometric analysis of the obtained data were carried out according to the generally accepted methods of variation statistics (Grosu, 2005) using the MS Excel-2007 analysis software package.

RESULTS AND DISCUSSIONS

Reproductive capacity is an important component of dairy cattle breeding technology. Sudarev et al. (2015) claim that annual calving contributes to profitable milk production, and regular obtaining of calves in sufficient numbers makes it possible to carry out selection and breeding work at a high level and serves as a basis for extensive reproduction of the herd and, consequently, increases the branch's profitability. In Table 1 are presented the characteristics of cows according to the level of milk and the characteristics of the reproductive capacity of cows in the dynamics of lactations. The analysis of the obtained data showed that with age, milk yield increases in cows, while the duration of the service and calving interval increases. The shortest service period for first-calf heifers was 157.6 days.

Table 1. Milk productivity and reproductive qualities of Holstein cows in the dynamic of lactations, $X \pm Sx$

Indicators	Lactation				
	I	II	III	IV	V
Number of heads	394	165	78	105	64
Milk yield for 305 days, kg	6649.0±70.6***	7718.5±123.7***	7807.4±148.5***	8173.8±119.8***	8082.3±51.8**
Number of milking days	369.6±6.5	356.8±6.5	332.0±10.3**	354.0±7.3	404.9±5.0
Milk yield for full lactation, kg	7028.3±96.4	8355.3±171.8	8910.5±277.9	9326.4±256.4	9162.0±202.5
Service period, days	157.6±5.8	161.1±6.5**	169.8±10.5***	186.9±7.1***	199.8±4.8***
Calvings interval, days	404.5±4.7	424.2±5.5	460.2±10.1	422.5±6.7	431.7±5.0
Reproductive capacity coefficient (CCR)	0.90±0.01	0.88 ±0.01***	0.81±0.02***	0.89±0.01***	0.84±0.01***

**P<0.01. ***P<0.001.

With an increase in milk yield for 305 days of second lactation by 1069.5 kg (16.1%), the duration of the service period increased by 3.5 days (2.2 %). The length of the calving interval was the most optimal in first-calving heifers (404.5 days), but with the increase in milk production for normal lactation (305 days), it increased by 19.7 days (4.9%).

The coefficient for first lactation was 60.2%, while for the calving interval was 16.5%. With the advancing age of the cows, the variability of these indices decreases, reaching in cows in the V-th lactation 32.2% and 10.45%, respectively. The influence (η^2_x) of milk production on the variability of the duration of the service period and the calving interval was at the level of 51.1%) and (28.4%) ($p<0.01$).

The further increase in milk productivity during normal but also full lactation can be seen up to the fourth lactation, after which it decreases in cows in the fifth lactation for a statistically significant difference compared to animals from II-th and I-st lactation. At the same time, the duration of the service period is on the rise, in the dynamics of lactations, and reaches its maximum value in animals in the fifth lactation.

The coefficient of reproductive ability characterizes the fertility of the breeding stock of cattle, depends on the duration of the calving interval, and at the optimal level of fertility of cows is equal to one (Titova & Zabiyakin, 2020). In the case analyzed by us, this indicator reached the highest value in animals of the first lactation, while the minimum indicator was registered in the group of cows in the III lactation with a statistically significant difference.

Between lactation for 305 days, full lactation and duration of service and calving period, the presence of positive statistically significant correlation ($p<0.001$) are established (Table 2).

Table 2. Relationship between the breeding indices and milk yield of Holstein breed cows in lactations dynamic

Indicators	Correlation coefficient, r				
	I lactation	II lactation	III lactation	IV lactation	V lactation
Service period					
Milk yield/305 days of lactation, kg	0.38±0.06***	0.09±0.08	0.69±0.06***	0.64±0.06***	0.69±0.07***
Overall fat/305 days of lactation, kg	0.37±0.06***	0.08±0.08	0.66±0.06***	0.65±0.06***	0.69±0.07***
Milk yield/full lactation, kg	0.24±0.07***	0.08±0.08	0.54±0.08***	0.42±0.08***	0.50±0.09***
Overall fat/full lactation, kg	0.28±0.07 **	- 0.03±0.08	0.55±0.08 ***	0.41±0.08***	0.30±0.12**
Calvings interval					
Milk yield/305 days of lactation, kg	0.38±0.06***	0.10±0.08	0.69±0.06***	0.64±0.06***	0.62±0.08***
Overall fat/305 days of lactation, kg	0.37±0.06***	0.09±0.08	0.67±0.06***	0.65±0.06***	0.62±0.08***
Milk yield/full lactation, kg	0.13±0.07	- 0.13±0.08	0.51±0.08***	0.27±0.09**	0.46±0.08***
Overall fat/full lactation, kg	0.19±0.07**	- 0.08±0.08	0.52±0.08***	0.28±0.09**	0.28±0.1**
Reproductive capacity coefficient					
Milk yield/305 days of lactation, kg	- 0.37±0.06***	- 0.04±0.08	- 0.66±0.06	- 0.58±0.06***	0.69±0.07***
Overall fat/305 days of lactation, kg	- 0.36±0.06***	- 0.03±0.08	- 0.64±0.07***	- 0.58±0.06***	0.49±0.08***
Milk yield/full lactation, kg	- 0.16±0.07*	0.19±0.08 *	- 0.52±0.08***	- 0.30±0.09**	- 0.40±0.11**
Overall fat/full lactation, kg	- 0.23±0.07**	0.09±0.08	- 0.53±0.08***	- 0.31±0.09***	- 0.24±0.12*

*p<0.05; **p<0.01; ***p<0.001.

Similar results were also highlighted regarding the interrelationships between overall fat on normal and total lactation ($p<0.0$; $p<0.001$). Regarding lactation and overall fat for 305 days, full lactation yield and coefficient of reproductive ability of cows was established the presence of negative statistically significant correlation ($p<0.05$; $p<0.0$; $p<0.001$).

The data, presented in Table 3, characterized the changes in the signs of reproductive ability of first heifers depending on the level of milk for 305 days of the first lactation.

Table 3. Reproductive qualities of first lactation Holstein cows depending on the level of milk production (X ± Sx)

Group	Graduation by milk yield, kg	n	I-st lactation					
			Milk yield for 305 days, kg	Service period, days	Milk yield for the full lactation, kg	Calving interval, days	Birth coefficient, %	CCR
1	≤ 6000	26	5467.4±151.3	87.8±20.0	5644.1±277.8	354.3±15.5	98.4±7.5	1.03±0.04
2	6001-7000	56	6614.5±45.2	124.5±14.1	7104.5±141.1	388.8±11.0	93.2±4.6	0.96±0.02
3	7001-8000	114	7502.0±39.4	136.2±9.7***	8616.5±225.2	412.6±8.7***	84.1±2.4	0.87±0.02***
4	8001-9000	110	8408.8±33.1	180.8±9.7***	10210.0±224.1	428.1±8.0***	77.9±3.0	0.81±0.02***
5	≥ 9001	75	9566.3±75.2	197.6±13.1***	11841.9±36.6	444.6±9.9***	76.7±4.4	0.79±0.02***
Average		391	7918.4±66.3	158.0±5.9***	9078.4±163.4	416.7±4.9***	75.3±1.9	0.89±0.01***

***p<0.001.

The optimal duration of the service period was characterized by cows of the first group - 87.8 days, with a productivity below 6000 kg of milk. As the milk yield increased, the duration of the service period in cows of groups II, in relation to the first, increased by 36.7 days (+41.8%) ($p<0.001$). In highly productive first-calf heifers with a milk yield of more than 9001 kg, the service period was the longest and amounted to 197.6 days (+109.8 days, or 125.1%) ($p<0.001$) and the calving interval to 444.6 days (+90.3 days or +25.5%).

A similar trend was also observed during the calving interval. The calving interval within the biological cycle (354.3 days) was observed in low productivity first-calf heifers with a milk yield of less than 6000 kg of milk. In cows with more than 6000 kg of milk, the duration of the calving interval was more than 400 days, which exceeded the economically justified length of the calving interval (365 days) by 34.5-90.3 days (8.9-25.5%).

According to the regression coefficients, on average, each increase in milk yield by 1000 kg increases the duration of the service period by 27.6 days, the calving interval by 20.9 days, which worsens such an important indicator as "calves yield".

The highest coefficient of reproductive ability was noted in first-calf heifers with milk yield below 6000 kg - 1.03. When the milk yield increased to 8000 kg of milk, the coefficient of reproductive capacity reliably decreased by 0.07-0.16 (7.3-15.5%) ($p<0.01$). When increasing milk yield to 9000 kg of milk, the coefficient of reproductive capacity reliably decreased by 0.22 (21.4%) ($p<0.001$). In first-calf heifers with a milk yield of more than 9000 kg, the reproductive ability coefficient was the lowest - 0.79, which is 0.22 (23.3%) less compared to low-producing animals ($p<0.001$). The least calves were obtained from highly productive cows - 76.7 heads per 100 cows per years, which is less with 21.7 heads (-22.1%) compared to the first group

It is believed that the period from calving a cows to its subsequent fertilization (service period), compared with the interval between calving more accurately reveals the physiological possibilities of the reproductive ability of cows, because "the duration of lactation depends on the service period, the duration of the dry period and interval between calving, the regularity of calving and the calves yield per 100 cows, and as a result, the level of milk production and the efficiency of their use". In this regard, the influence of the duration of the service period on the indicators of milk productivity and the reproductive ability of cows was studied (Table 4). The distribution of cows after finishing the first lactation according of the service period shows that 25.5% of the studied livestock had a biologically justified and economically profitable service period (31-90 days).

Table 4. Productivity indicators depending on the length of the service period ($X \pm S_x$)

Group	Graduation by service period, days	n	Service-period, days	Milk yield/305 days of lactation, kg	Milking days	Milk yield for the full lactation, days	Calving interval, days	CCR
1	< 30	13	27.4±1.95	7178.0±550.10	297.5±16.70	7695.8±761.21	315.2±2.00	1.16±0.01
2	30 - 60	40	46.3±1.41	7278.8±215.23	317.4±16.33	7956.4±408.78	334.4±1.70	1.09±0.01
3	61 - 90	56	74.8±1.07	8033.0±207.20	332.6±9.10	8707.2±315.45	361.8±1.69	1.01±0.004
4	91-120	41	105.9±0.85	7876.3±224.70	344.1±7.01	8702.0±136.04	388.8±1.51	0.94±0.01
5	121-150	60	136.0±0.76	7294.1±92.54	352.35±3.97	7936.6±141.35	418.4±1.19	0.88±0.004
6	150-180	53	164.0±0.78	7769.9±114.71	377.4±4.71	8892.7±192.22	448.4±1.35	0.82±0.004
7	181-210	29	192.9±1.10	8080.5±135.06	406.1±9.61	9819.7±269.49	468.5±3.18	0.78±0.006
8	211-240	20	222.0±1.53	8464.6±283.57	411.9±13.60	10421.4±467.68	504.6±2.11	0.72±0.003
9	241-270	22	253.0±1.74	8593.3±233.45	430.2±17.50	11090.5±676.43	520.3±12.48	0.71±0.02
10	271-300	19	283.6±2.18	8777.5±243.96	489.2±8.14	10358.8±273.3	561.7±2.36	0.65±0.004
11	> 300	27	363.4±6.65	8828.1±165.60	575.8±15.60.	12964.3±515.5	637.8±14.52	0.57±0.012
Average		380	157.6±3.26	7868.3±54.58	364.9±3.53	8795.3±99.95	422.4±2.76	0.89±0.005

In cows of all these groups, with relatively low milk productivity, compared with the average value for the sample, the reproduction rates were high - the coefficient of reproductive capacity from 1.01 to 1.16 (+0.07 ... + 0.15), birth rate - from 96.8 to 112.1 (+6.2%…+15.8%). More than half of the analyzed cows (71.3%) had a service period longer than 91 days, of these, 32.5% were animals with a service period of more than 121 days, showed higher milk productivity - 8258.3 kg of milk for 305 days of lactation and 10212 kg of milk for full lactation (+390.0 kg and +1416.7 kg of milk to the average value for the sample), but low indicators whether in terms of reproducibility. Their reproductive ability coefficient decreased by 0.16 and the yield of calves by 12.5 calves.

Results (Figure 1) regarding the yield of calves state that the increase in the duration of the service period significantly decreases the birth coefficient, with a very high negative correlation persisting (r = -99.9), which confirms that an among the main conditions for accelerating the reproduction rate of the livestock in the household and for increasing the economic efficiency of the branch is that the cows to bee inseminated fertile in the first 2-3 months after calving.

Agalakova & Netecha (2011) related that both a shortened to 30 days and extended service period of more than 90 days negatively affect the productivity and reproductive functions of animals.

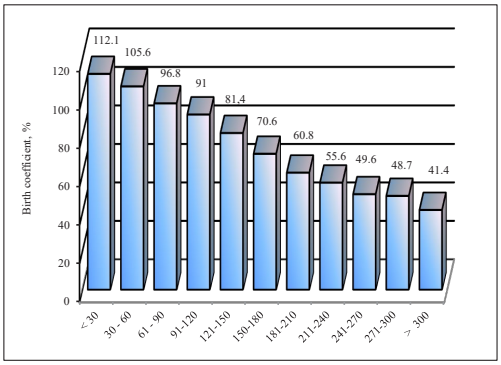

Figure 1. Birth coefficient dynamics depending of the duration of service-period

Table 5 presents the results of the regression analysis between the duration of the service period, milk productivity and the functional activity of the reproductive system in the analyzed cow population.

Table 5. Regression coefficient between service period, milk productivity and the main reproductive indicators of Holstein breed cows' population

Indices		R
Milk productivity for 305 days, kg	Service period, days	97
Milk productivity for full lactation, kg	Service period, days	4.5
Duration of lactation, days	Service period, days	0.53
Calving interval, days	Service period, days	0.75
Coeficient of reproductive capacity	Service period, days	- 0.002
Birth coefficient of, %	Service period, days	- 0.27

Thus, when increasing the length of the service period, milk yield for 305 days of lactation increases by 9.7 kg/day ($p<0.01$), milk yield for

full lactation - by 4.5 kg/day ($p<0.01$), the duration of the lactation increases by 0.53 days/day ($p<0.01$), the calving interval by 0.75 days/day ($p<0.01$). Because of this, the reproduction coefficient decreases by 0.02 ($p<0.001$) and the birth coefficient decreases by 0.27 ($p<0.01$). From these data, it is obvious that increasing the length of the service period and prolonging lactation contribute to increasing the amount of milk per lactation. Similar results were obtained by Popescu (2014). But, according to the obtained data (Table 4), the increase of these two indices (SP, CI) is not profitable, because at the same time it leads to the slowing down of the reproduction rate of the herd, due to the loss of calves, as a whole on the herd.

Dispersion analysis detected the influence of the factor (η^2x - the level of milk productivity) on the duration of the service period was 18.0% ($p<0.001$), on the duration of the calving interval - 15.6% ($p<0.001$), on the reproductive capacity coefficient - 25.6% ($p<0.001$) and on the yield of calves - 35.6% ($p<0.001$).

CONCLUSIONS

With the age of cows, milk increases, but simultaneously, rises the duration of the service-period and the calving interval. The increase of the milk productivity is accompanied by the decrease in the reproductive capacity of cows.

The optimal parameters for the duration of the service period and the calving interval were distinguished by cows that have finished their first lactation, with low milk productivity (yield less than 6000 kg of milk), at which the animals were characterized by the maximum indicators of the birth coefficient and reproductive capacity coefficient.

In cows with a milk yield of at least 9001 kg, a significant increase in the length of the service period (+109.8 days) and the calving interval (+90.3 days) was established, but the reproductive capacity coefficient decreased by 0.22 and the number of calves per 100 cows/year by 21.7 heads.

Increasing of the service period moderately influences milk productivity, but significantly some reproductive indicators of the herd - the duration of the calving interval increases, in the same situation, the coefficient of reproductive capacity and the birth coefficient decreases.

The influence of the level of milk productivity (η^2x) on the duration of the service period was 18.0% ($p<0.001$), on the duration of the calving interval 15.6% ($p<0.001$), on the reproductive capacity coefficient 25.6% ($p<0.001$), on the birth coefficient 35.6% ($p<0.001$).

We recommend livestock holdings to monitor the duration of the service period, as extending of this period is economically unprofitable for specialized dairy cattle farms.

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