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Productivity of Holstein cows with early insemination of heifers

Inna Kepkalo*
PhD in Agricultural Sciences, Senior Lecturer
National University of Life and Environmental Science of Ukraine
"Nizhyn Agrotechnical Institute"
16600, 10 Taras Shevchenko Str., Nizhyn, Ukraine
https://orcid.org/0000-0003-3098-8200

Mykhailo Kuzmenko
PhD in Agricultural Sciences
National University of Life and Environmental Science of Ukraine
"Nizhyn Agrotechnical Institute"
16600, 10 Taras Shevchenko Str., Nizhyn, Ukraine
https://orcid.org/0009-0000-9406-757X

Maryna Khomenko
PhD in Agricultural Sciences
National University of Life and Environmental Science of Ukraine
03041, 19 Horikhuvatskyi Shliakh Str., Kyiv, Ukraine
https://orcid.org/0000-0001-7023-3676

Mykola Seba
PhD in Agricultural Sciences, Assistant Professor
National University of Life and Environmental Science of Ukraine
03041, 19 Horikhuvatskyi Shliakh Str., Kyiv, Ukraine
https://orcid.org/0000-0001-9696-934X

Abstract. The age at first insemination is a critical factor influencing the duration of the non productive period, subsequent milk yield, and reproductive performance of cows. Accordingly, the study aimed to determine the impact of early insemination age on cows' milk productivity

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*Corresponding author

and reproductive capacity. The research was conducted using Holstein cows and carried out at Rozhnivka-Agro LLC, located in the Ichnia District of Chernihiv Region. The findings revealed that the live weight of the experimental animals at first calving showed no significant deviations, remaining within a 3.3% range. During the first lactation, the shortest service period was observed in animals inseminated at 13 months of age, with differences of 4.5 (Group I ↓) and 3.9 days (Group III ↓). The highest insemination index, reaching 3.1, was recorded across all experimental groups during the third lactation. The highest insemination index of 3.1 across all experimental groups was observed during the third lactation. Milk productivity was analysed daily by lactation months, considering milk fat and protein yields. The results indicated no significant differences in milk yield during the first lactation across all groups. However, during the second lactation, a general upward trend in milk yield was noted in all groups. Notably, cows inseminated at 13 months of age exhibited 4% and 1% higher milk productivity compared to Groups I and III, respectively. The peak milk yield across all groups occurred during the third lactation. The lowest milk yield was recorded in cows inseminated early (at 12 months), with differences of 7.8% (Group II ↑) and 6.9% (Group III ↑). Regarding lactation-specific fat content, Group II (13 months) demonstrated higher fat content during the third lactation by 0.23%, 0.13%, and 0.05% compared to the first, second, and fourth lactations, respectively. No significant differences were observed in milk protein content, which ranged between 3.20% and 3.23%. Thus, reducing the age of first insemination can enhance the economic utilisation of animals without compromising their reproductive performance or adversely affecting subsequent milk productivity

Keywords: gestation; milk yield; live weight; service period; insemination index

Introduction

The productive lifespan of cows is significantly shorter than their natural lifespan, averaging approximately 3-4 years in high-yielding dairy cows. Common reasons for culling include reduced milk production, injuries, low reproductive performance, and complications following calving. The productive life of an animal serves as an indicator of milk production efficiency and is measured by the number of lactations. The findings of V. Valchev *et al*. (2020) demonstrated that cows with later calving ages (30 months or more) faced a higher risk of culling at an early age, particularly during their first lactation. According to their compelling conclusions, reducing this risk would lead to improved outcomes in extending the productive lifespan of cows.

High reproductive performance plays a crucial role in the profitability of dairy farming. Reduced fertility and reproductive disorders are associated with decreased milk production (Talukder *et al*., 2022). According to P. Tamboli *et al*. (2022), the highest-yielding cows also exhibit the highest rates of infertility, which is often a primary reason for culling animals from the herd. The age at first calving is a critical factor for obtaining replacement heifers. This parameter significantly influences the subsequent reproductive performance and milk productivity of cows. Proper management of this factor can result in high animal productivity and substantial profitability for the farm.

Opinions among researchers regarding the optimal age for first calving vary, though it is generally considered to be around 24 months. According to M.C. McCarthy *et al.* (2022), achieving this target helps reduce the non-productive period, facilitates earlier returns on investment, and lowers rearing costs for replacement heifers. Farmers incur losses exceeding USD

100 per month for feed and maintenance for each animal if the first insemination is delayed. The age at first calving is directly influenced by the age at first successful insemination, as the gestation period is relatively fixed at an average of 285 days and is challenging to alter (Steele *et al*., 2021). H. Atashi *et al*. (2021) and P. Tamboli *et al.* (2022) argue that earlier calving accelerates genetic progress and reduces the generation interval. Consistent growth plays a crucial role in preparing heifers for insemination and future lactation. O. Dorobāţ *et al.* (2019) demonstrated a link between increased live weight and earlier sexual maturity. To ensure calving occurs without complications, heifers must meet specific live weight and growth criteria before their first insemination. Consequently, the age at first insemination depends on the growth rate, as sexual maturity cannot be achieved until the animal reaches the required weight. Research by B. Vargas-Leitón *et al*. (2023) indicates that earlier calving may negatively impact subsequent fertility. Therefore, replacement heifers must rapidly attain adequate body weight before their first calving. The adoption of intensive heifer-rearing technologies has enabled earlier insemination, allowing for both milk production and offspring at a younger age.

Early calving is generally associated with risks such as complications during and after calving, as well as reduced reproductive performance and milk productivity in cows. The most common issue during calving is the disproportion between the foetus and the dam, typically caused by an excessively large calf and/or a small pelvic size. However, A. Kraevskiy *et al*. (2020) found that animals inseminated at 20 months had the highest incidence of calving complications (50%), whereas heifers inseminated at 14-17 months experienced nearly half that rate (25.8%). Similarly, H. Kusaka *et al*. (2022) reported that early calving did not have adverse effects but instead resulted in improved reproductive performance. They observed that the frequency of difficult calvings and stillbirths was more closely linked to the weight of the heifer rather than the age at first calving. Their further studies indicated that calving at an earlier age enhanced both productivity and survival rates, while later calving negatively impacted these parameters (Kusaka *et al*., 2023). Research by S.G. Pishchan (2022) on Brown Swiss cows supports the conclusion that calving at 22.7 months results in a 7.33% higher milk yield compared to animals that calved at 25.5 months. Conversely, M.P. Turiello *et al*. (2020) argue that delaying the age of calving can lead to increased milk yields, though this approach also raises costs due to the extended heifer-rearing period. According to P. Tamboli *et al*. (2022), reducing the age of first calving could lower costs, reduce the production cost per unit, and improve the profitability of dairy enterprises.

Consequently, this study aimed to determine the relationship between the early insemination of Holstein heifers and their subsequent milk productivity and reproductive performance.

Materials and Methods

The study utilised Holstein cows as the research material. It was conducted at the Rozhnivka-Agro LLC in the Ichnia District of Chernihiv Region. Animal groups were formed based on age, live weight, lineage, and the order of oestrus onset. The live weight of the animals at the time of insemination ranged from 380 to 430 kg. Depending on the age at first successful insemination, the cows were divided into three groups: Group I (12 months), Group II (13 months), and Group III (14 months). Each Group comprised 15 animals. During the study period (2019-2023), culling occurred. By the beginning of the third lactation, Group I had 13 animals, Group II had 14, and Group III had 14. By the start of the fourth lactation, the numbers were as follows: Group I – 10 animals; Group II – 10 animals; Group III – 11 animals. All animals were housed and fed under similar conditions. They were kept free-stall in barns,

with an implemented uniform feeding system, which was sufficient to achieve a milk yield of 10,000-11,000 kg. A twice-daily milking schedule was implemented on the farm. Milk yield, along with fat and protein content, was measured monthly during control milking sessions. Fat and protein content in the milk were determined using the Ecomilk device. Reproductive performance indicators included the service period, calving interval, age at first calving, insemination index, and reproduction coefficient. Reproductive performance was assessed during the first, second, and third lactations, while milk productivity was evaluated from the first to the fourth lactation. The fifth lactation was excluded from the analysis as most animals had been culled from the study groups by that time.

The data were obtained from the livestock and breeding records, as well as from the Orsek herd management system. Heifers and cows were artificially inseminated using the recto-vaginal method with semen from a Holstein sire breed bull. Insemination occurred after the onset of oestrus, which was determined visually. Pregnancy was confirmed one month later via ultrasound. The live weight of the newborn calves was recorded by weighing them immediately after birth. Heifers were weighed before insemination and calving. The age at first calving was calculated by subtracting the cow's birth date from the date of her first calving. The calving interval was defined as the time between the first and second calving dates. The service period was calculated as the interval from calving to successful insemination.

The reproductive performance coefficient (RPC) was calculated using the formula:

$$RPC = \frac{365}{CI}, \quad (1)$$

where 365 is the number of days in a year; CI is the calving interval between two consecutive calvings.

The insemination index was defined as the number of inseminations per successful pregnancy.

The fertility index (*FI*) of the cows was calculated using the formula by J. Dokhi:

$$FI = 100 - (C + 2CI), \quad (2)$$

where *C* is the age of the cow at her first calving.

For statistical analysis, MS Excel software was used.

The study adhered to the guidelines for animal welfare as outlined in the European Convention on the Protection of Vertebrate Animals Used for Research and Other Scientific Purposes (1986).

Results and Discussion

A decline in reproductive performance in livestock farming is one of the major challenges. In this regard, current research focused on determining the relationship between the age at first insemination and subsequent reproductive performance (Table 1). The data obtained revealed that the duration of gestation across all groups during the three lactations was between 276-279 days, which is within the physiological norm. Analysis of the service period indicated that the lowest value of 92.7 days was recorded in the Group inseminated at 13 months, which was 9.1 and 11.1 days lower compared to the groups inseminated at 12 and 14 months, respectively. Notably, Group II also had the highest reproductive performance coefficient, at 0.99, while in the I and III groups, this value was slightly lower at 0.97 and 0.96, respectively. With an optimal calving interval of 365 days, all experimental groups showed an increase in this indicator: Group I increased by 14.6 days, Group II by 3.79 days, and Group III by 17.2 days. Comparison between groups showed that the interval was longest in animals inseminated at 14 months (Group III), with a difference of 2.6 days compared to Group I and 13.41 days compared to Group II. There were no significant differences in the insemination index between Groups I and III, with the lowest index observed in Group II (2.0).

Table 1. *Reproductive performance indicators of the experimental groups*

Group	Gestation	Service period	Insemination index	Calving interval	Reproductive coefficient
First lactation					
12 months	277.8 ± 1.33	101.8 ± 4.84	2.8 ± 0.34	379.6 ± 3.90	0.97 ± 0.01
13 months	276.09 ± 1.03	92.7 ± 4.20	2.0 ± 0.28	368.79 ± 4.20	0.99 ± 0.01
14 months	278.4 ± 0.80	103.8 ± 5.7	2.8 ± 0.40	382.20 ± 6.2	0.96 ± 0.01
Second lactation					
12 months	278.8 ± 0.90	108.9 ± 7.22	2.9 ± 0.40	387.7 ± 7.55	0.95 ± 0.02
13 months	277.9 ± 1.36	104.4 ± 6.76	2.7 ± 0.30	382.30 ± 7.46	0.96 ± 0.02
14 months	279.4 ± 1.10	108.3 ± 7.9	2.9 ± 0.40	387.7 ± 8.00	0.95 ± 0.01
Third lactation					
12 months	277.2 ± 0.79	106.8 ± 5.68	3.1 ± 0.30	384 ± 5.97	0.95 ± 0.01
13 months	276.4 ± 0.70	108.7 ± 10.80	3.1 ± 0.40	385.1 ± 10.60	0.96 ± 0.01
14 months	278.1 ± 0.78	107.8 ± 11.37	3.1 ± 0.43	386.8 ± 11.48	0.96 ± 0.01

Source: developed by the authors

During the second lactation period, the service period in Group II was 4.5 and 3.9 days shorter compared to Groups I and III, respectively. It is also worth noting that in this group, the insemination index was 6.9% lower. The calving interval in animals of Groups I and III was the same, at 387.7 days, which is 22.7 days longer than the optimal interval and 5.4 days longer than in Group II. Analysis of the key reproductive performance indicators in cows during the third lactation shows that there were no significant differences in the service period. The difference between Group I and Group II was 1.9 days, between Group II and Group III it was 0.9 days, and between Group I and Group III it was 1 day. The calving interval in Group II was 1.1 days longer than in Group I, while Group III had a calving interval that was 2.8 days longer than Group I and 1.8 days longer than Group II.

Another important indicator that characterises the reproductive performance of animals is the reproductive coefficient. The highest value of this indicator was observed in Group II during the first lactation (0.98), with a tendency for it to decrease in Groups I and III (0.96). When analysing the data for Group II across different lactations, it is evident that the service period was shorter during the first lactation, at 97.7 days, which is 6.4 and 11 days shorter compared to the first and third lactations, respectively. In Groups I and III, there was a tendency for the service period to increase during the second lactation. In Group I, it was longer by 7.1 days, and in Group III, it was longer by 4.5 days compared to the first lactation. In the third lactation, these groups showed a slight reduction in the service period, by 1-2 days.

The analysis of the dynamics of the insemination index shows that in all three groups, this indicator increases up to the third lactation, reaching 3.1. The dynamics of the calving interval across lactations mirrored the dynamics of the service period. To prevent dystocia, which could negatively affect subsequent reproductive performance and milk production in heifers, it is essential to monitor the heifers' body weight prior to the first insemination. According to the research by L. Han *et al*. (2021), heifers with higher body weight at first calving had higher milk production during the first lactation compared to lighter heifers. It is necessary for animals to meet the recommended body weight norm of 550-625 kg for Holstein heifers at first calving. In the study, animals inseminated at 12.12 months had an average body weight of 403.5 kg, which was only 3.3 and 7.5 kg lower than those inseminated at 13.1 and 14.2 months, respectively. A slight difference in body weight was also observed at first calving, with the difference between Groups II and III

being 2 kg, while exceeding Group I's weight by 18.3 and 20.3 kg, respectively. The difference in the birth weight of the calves was minimal, only 1 kg (Table 2).

Table 2. *Live weight and age at first calving*

Group	Age at first insemination, month	Live weight at first insemination	Age at first calving	Live weight at first calving	Calf birth weight	Fertility index
Group I	12.12 ± 0.01	403.5 ± 4.20	21.04 ± 0.15	592.7 ± 10.6	40.1 ± 0.8	52.94 ± 0.32
Group II	13.1 ± 0.03	406.8 ± 3.20	22.14 ± 0.03	611 ± 11.1	41 ± 1.1	53.60 ± 0.03
Group III	14.2 ± 0.01	411 ± 4.50	23.26 ± 0.01	613 ± 12.0	41.1 ± 0.6	51.57 ± 0.4

Source: developed by the authors

The fertility index was calculated using the Dokhi formula. Cows in Group II exhibited a higher fertility index (53.60) compared to animals inseminated at earlier (12 months) or later ages (14 months), with differences of 1.2% and 3.8%, respectively. A crucial aspect of this study was to analyse the milk yield of cows concerning the age at insemination. One of the primary indicators of milk yield is the average daily milk production, which allows for an analysis of the lactation curve.

Table 3 shows that the lowest average daily milk yields were observed in the first and tenth months of lactation in Group I – 35.1 and 24.1 kg, respectively; in Group II – 27 kg and 22.6 kg; and Group III – 34 and 24.8 kg. Notably, Group II had the lowest values. Furthermore, in this group, a sharp increase in milk yield of 11.4 kg was observed in the second month of lactation, marking the peak of lactation. From the third month onwards, yields levelled off, with a difference of only 2.2 kg between the third and seventh months. However, a steep decline of 10.8 kg began in the eighth month. In the other two groups, there was a gradual increase in milk yield, with peaks (38.4 and 41.4 kg) observed in the third month of lactation. From the third month onwards, there was a gradual decline, with a difference of 14.3 kg and 16.6 kg between the third and tenth months, respectively. The average daily milk yield over 305 days of lactation was the same for all three groups and amounted to 33.3 kg.

Table 3. *Average daily milk yield over 10 months of lactation*

Group	Months of lactation									
	1	2	3	4	5	6	7	8	9	10
First lactation										
Group I	35.1±1.52	37.6±2.43	38.4±1.54	37.9±0.97	36±0.93	33.4±1.45	31.2±1.60	30.1±2.26	29.2±2.39	24.1±2.57
Group II	27±1.08	38.4±1.68	37.3±1.10	37.40.70	37.4±0.82	36.6±0.70	35.1±0.93	33.4±1.44	27.7±1.38	22.6±1.16
Group III	34±1.79	37.1±1.87	41.4±1.62	38.8±1.44	34.4±1.30	33.9±1.23	31.2±0.95	29.1±1.08	27.4±1.27	24.8±1.21
Second lactation										
Group I	29.5±1.56	38.4±1.59	45.1±1.25	43.9±1.46	43.3±1.58	37.9±1.59	31.3±1.48	28.9±1.90	24.2±1.19	19.1±0.71
Group II	39.7±2.00	44.6±2.00	43.3±1.44	41.4±1.33	39.7±1.16	35.9±1.35	30.7±1.09	26.1±0.88	26.2±1.30	21.3±0.99
Group III	30.9±1.8	36.1±1.1	45.9±1.2	43.2±1.6	40.1±1.7	38.4±1.8	35.9±1.6	33.6±1.5	28.1±1.9	23.4±2.4
Third lactation										
Group I	36.3±1.36	46.9±1.59	42.6±1.53	42.9±1.21	41.7±1.06	37.3±1.03	34.3±0.91	31.2±0.98	26.8±0.92	20.3±1.05
Group II	40.4±0.82	49.7±0.86	47.2±0.86	46.3±0.71	43.9±0.83	41.2±0.91	37.9±1.04	32.5±1.35	29.1±1.26	22.5±1.22
Group III	38.5±1.68	45.5±1.29	46.5±1.02	43.41.02	43.2±1.10	41.6±1.38	38.4±1.82	34.3±1.6	30.4±1.78	25.1±1.45
Fourth lactation										
Group I	34.5±1.6	42.7±1.2	46.3±1.3	41.8±1.46	37.1±1.75	33.9±1.54	34.5±1.31	32.2±1.48	31±1.45	26.6±1.44
Group II	40.4±2.13	49.7±1.46	47.2±1.82	46.3±1.62	43.9±1.81	41.2±2.41	37.9±2.96	32.5±3.78	29.1±3.56	22.5±3.99

Table 3. Continued

Group	Months of lactation									
	1	2	3	4	5	6	7	8	9	10
Fourth lactation										
Group III	39.4±2.46	45.5±2.55	43.4±1.67	42.5±1.88	38.2±1.73	38.8±1.7	36.9±1.34	34.9±1.37	32.7±1.42	25.5±2.52

Source: developed by the authors

The dynamics of milk yield during the second lactation show that the highest yield in the first month was in Group II, at 39.7 kg, which was 10.2 and 8.8 kg higher than Groups I and III, respectively. In the animals of this group, peak lactation was observed in the second month (44.6 kg), and from the third month onwards, yields began to decline, with a difference of 23.3 kg between the second and tenth months. In Groups I and III, peak lactation occurred in the third month, with a difference of 16.4 kg and 15 kg between the first and third months, respectively. When analysing the lactation curves of all three groups, it can be observed that Groups II and III had more regular curves with a gradual decline in milk yield. In Group I, the curve was more irregular, with a sharp decrease of 5.4 kg in the sixth month.

The changes in milk yield during the third lactation indicate a greater uniformity of milk production compared to previous lactations. In Group II, peak production occurred in the second month (49.7 kg), followed by a gradual decline until the tenth month. The lactation curve of this Group corresponds to Type I (strong, persistent lactation with high yields). In Group I, milk yields were less uniform, with the peak lactation (45.5 kg) also occurring in the second month, but a gradual decline was observed starting from the fifth month. The dynamics of Group III show that maximum production occurred in the third month.

The characteristics of the fourth lactation indicate that the highest milk yields were observed in Groups II and III (46.8 and 46.3 kg, respectively). Animals in Group I exhibited their peak milk production in the second month of lactation (45.5 kg). The average daily milk yield of Group II was higher than that of Groups I and III from the first to the seventh month, and from the seventh month onwards, yields declined sharply. The dynamics of milk production in Group II indicate a sharp decrease starting from the third month, followed by a levelling off from the sixth month.

An analysis of the milk yield of the experimental animals over a 305-day lactation period indicates that, in the first lactation, the difference in milk yield among all three groups was within 1%. Milk production in the second lactation was highest in the experimental Group II, although the difference between this Group and Group III was less than 1%. In Group I, the milk yield over a 305-day lactation period was 4% lower compared to Groups II and III. Figure 1 shows that the dynamics of milk production in the experimental groups remained similar until the third lactation. In Group I, the milk yield was 7.8% and 6.9% lower compared to Groups II and III, respectively. An analysis of the fourth lactation reveals a decrease in milk yield in Groups II and III, while in Group I, a slight increase was observed compared to the previous lactation. The difference between the groups was 4.7% (between Groups I and II) and 4.5% (between Groups III and I).

An important aspect of dairy cow productivity is the fat and protein content of milk. Analysis of protein content shows that there were no significant changes in the experimental animals from the first to the fourth lactation. In all groups, the protein content of milk was within the range of 3.20-3.23% (Table 4). The dynamics of fat content in milk indicate a trend towards increased fat content with each subsequent lactation in every group. In Group I,

the highest content was observed in the fourth lactation, which was 0.17%, 0.15%, and 0.02% higher compared to the first, second, and third lactations, respectively. In Group II, the highest fat content was during the third lactation and exceeded the first, second, and fourth lactations by 0.23%, 0.13%, and 0.05%, respectively. In Group III, as in Group II, the maximum content was during the third lactation, with differences between lactations of 0.13% (first lactation), 0.14% (second lactation), and 0.07% (fourth lactation). A comparative analysis between the groups shows that the highest fat content was in Group II.

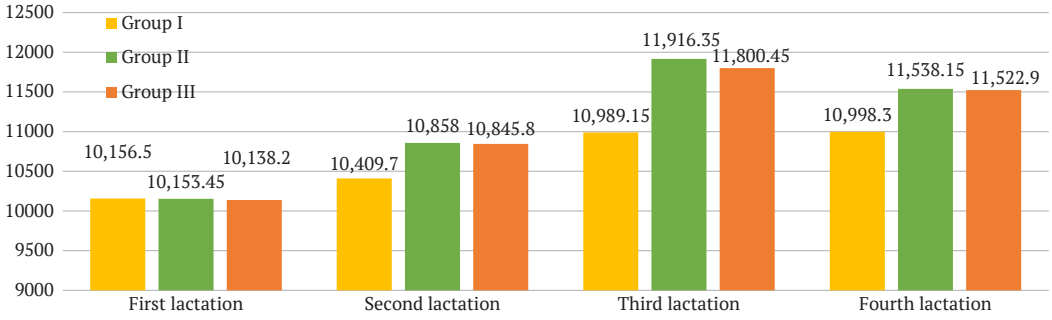

Figure 1. Milk productivity over 305 days of lactation

Source: developed by the authors

Table 4. *Protein and fat content in the milk of experimental animals across lactation*

Lactation	Group I		Group II		Group III	
	Fat content in milk	Protein content in milk	Fat content in milk	Protein content in milk	Fat content in milk	Protein content in milk
First lactation	3.69 ± 0.07	3.22 ± 0.01	3.68 ± 0.1	3.20 ± 0.01	3.75 ± 0.12	3.21 ± 0.01
Second lactation	3.71 ± 0.1	3.21 ± 0.02	3.78 ± 0.12	3.22 ± 0.02	3.74 ± 0.08	3.20 ± 0.01
Third lactation	3.84 ± 0.2	3.21 ± 0.01	3.91 ± 0.4	3.22 ± 0.01	3.88 ± 0.14	3.21 ± 0.02
Fourth lactation	3.86 ± 0.1	3.20 ± 0.01	3.86 ± 0.09	3.23 ± 0.02	3.81 ± 0.08	3.22 ± 0.01

Source: developed by the authors

When analysing the correlation between milk productivity and reproductive performance, it is important to note that there is a strong connection between these indicators. In this study, the relationship between milk productivity over 305 days of lactation and the indicators of reproductive performance, namely service period and reproductive coefficient were examined (Table 5).

Table 5. *Correlation between milk yield and reproductive performance indicators*

Group	Milk yield over 305 days of lactation/service period			Milk yield over 305 days of lactation/reproductive coefficient		
	First lactation	Second lactation	Third lactation	First lactation	Second lactation	Third lactation
Group I	+0.126	+0.031	-0.004	+0.137	+0.002	-0.087
Group II	+0.029	+0.643	-0.257	+0.520	-0.295	+0.135
Group III	-0.070	+0.306	-0.097	-0.450	-0.691	+0.256

Source: developed by the authors

In all three groups, during the first lactation, there was a negligible correlation between the service period and milk yield. In the second lactation, there was a moderate positive correlation in the Group of animals inseminated at 13 months and a low correlation in the other two groups. In the third lactation, a low negative correlation was observed between the indicators in all groups. Analysis of the relationship between milk yield over 305 days of lactation and calving interval showed that in Group I, it was insignificant and fluctuated between r = +0.137 and +0.087 depending on the lactation. In Group II, the correlation was moderately positive in the first lactation, while in the second lactation, it was low and negative. In Group III, the correlation coefficient was negative in both the first and second lactations and was at a moderate level.

Numerous researchers investigating the impact of age at first insemination on milk yield have noted a strong correlation between these two factors, including J. Pytlewski & I.R. Antkowiak (2021) and K.A. Copas Medina *et al*. (2022). However, there is limited literature reporting the negative impact of age at first insemination on animal fertility. This study found that animals inseminated at 13 months had a shorter service period of 11.1 days compared to those inseminated at 14 months, and this difference was statistically significant. Additionally, it is worth noting that in animals of this group, from the first to the fourth lactation, there was no increase in reproductive problems, as was the case in animals inseminated at 14 months. S.G. Pishchan (2022) also reported that, according to their research, heifers had satisfactory reproductive performance regardless of age at first insemination. G.S. Sharapa *et al*. (2021) determined that the highest fertility was observed in animals inseminated at 12-14 months, while older animals had a lower conception rate. In younger animals (12-14 months), the average service period was 102 days, while in older animals (15+ months) it was 121-136 days.

The insemination rate did not show significant variations across the groups, indicating the absence of a negative impact of early insemination on subsequent fertility. These findings are supported by recent studies conducted on Holstein cows. N.T. Eastham *et al.* (2018) reported that animals that calved at an earlier age (22 months) had better survival rates and milk production. Additionally, calving at this age did not negatively affect the reproductive performance of the animals.

Since mammary gland development occurs before the first calving, it is crucial to maintain adequate heifer growth. However, research by L. Han *et al.* (2021), H. Kusaka *et al.* (2022), and A.V. Demchuk & L.P. Ponko (2022) suggests a negative impact of excessive weight gain on mammary gland development, leading to excessive fat deposition in the animals. In this study, heifers selected for insemination had sufficient live weight. The average live weight in Group I was 403.5 kg, which was significantly lower by 2.7% and 5.3% compared to animals inseminated at 13 and 14 months, respectively. It should also be noted that at first calving, the animals also did not have a significant difference in weight; the live weight in the experimental groups was within the range of 592.7-613 kg.

The impact of age at first calving on milk yield has been extensively studied by researchers both in Ukraine and abroad, and despite this, it remains a relevant topic. This is because this indicator is a significant factor influencing a cow's lifetime milk production. By reducing the age at first calving, it is possible to decrease maintenance costs and increase the productive life of the animals (Karlova *et al.*, 2018).

A.L. Shulyar (2019) notes that insemination at too young an age can lead to health problems in animals, complications during pregnancy and calving, and consequently, low productivity and culling rates. According to her research, the optimal age for first insemination should be 16-18 months, and the corresponding

age at first calving should be 25-27 months. Heifers inseminated before 16 months had lower milk yields. Research by British scientists N.T. Eastham *et al*. (2018) indicates that cows that calved before 22 months had lower milk yields throughout their productive life compar ed to those that calved at 22 months or later. However, H. Kusaka *et al*. (2023) reported that, regardless of the age at first calving, there was no significant difference in milk yield during the first lactation, but in subsequent lactations, the milk yields of these animals decreased. Meanwhile, K.A. Copas Medina *et al*. (2022) believe that milk yield also depends on the live weight of the animals at first insemination and calving. If the live weight is low, then the milk yield in the first lactation is also lower, but it levels out in subsequent lactations.

Some of the current findings align with previous research, as there were no significant differences in 305-day milk yields during the first lactation across all three groups. However, the Group of animals that calved at 21 months had the lowest milk yields in the subsequent three lactations, while cows that calved at 22 months, conversely, had the highest yields. The difference between these groups was 4% in the second lactation, 7.8% in the third, and 4.7% in the fourth. Thus, age at first insemination had a greater impact on milk yield than live weight, as the youngest animals had a lower live w eight but their milk yield did not increase significantly with age. The research of S.G. Pishchan (2022) also shows that heifers inseminated at 13.4 months had milk yields 6.83% and 5.90% higher compared to those inseminated at 16.3 and 18.9 months, respectively. He also noted that animals with early insemination had a significant advantage in terms of milk fat and protein content. S.S. Kramarenko (2024) confirms that the highest content of these components in milk was observed in cows that were inseminated at a young age (13-15 months). The results of this study suggest that the age at first insemination did not have a significant impact on milk fat content, as there was no significant difference between Groups I, II, and III. However, it should be noted that the highest value for this indicator (3.91) was in Group II during the third lactation.

Therefore, research into the impact of age at first insemination on animal productivity remains relevant, as there is a divergence of opinions among different authors regarding the optimal age for this parameter. According to the results of the conducted study, the optimal age for first insemination is 13 months, as cows in this Group exhibited the highest milk productivity.

Conclusions

In summary, based on the research findings, it can be concluded that insemination at 13-14 months does not have a negative impact on the reproductive capacity and productivity of animals. On the contrary, it increases the productive lifespan of the animals. However, it should be noted that the study had a small sample size. Analysis of reproductive performance indicators showed that Group I had the shortest service period during the first lactation, with differences of 9.1 and 11.1 days compared to Groups I and III, respectively. This Group also had the highest conception rate at 53.6% (Group I ↓ – 1.2%, Group III ↓ – 3.8%). The insemination index tended to increase with each lactation, with the highest value across all groups, regardless of insemination age, observed in the third lactation at 3.1. There were no significant differences in milk yield between the experimental groups during the first lactation. However, starting from the second lactation, cows with earlier insemination (at 12 months) had lower milk production. The highest milk yield in all groups was observed during the third lactation. In Group II, the 305-day milk yield was 11,916.35 kg, which was 7.8% and 1% higher compared to Groups I and III, respectively. Peak lactation, regardless of the age at first insemination, occurred in the second or third month of lactation. Groups II and III exhibited the most

stable lactation curves, corresponding to Type I (strong, persistent lactation with high yields). The dynamics of fat content in milk showed an increase up to the fourth lactation. Groups II and III had the highest fat content in the third lactation, at 3.91% and 3.88%, respectively. In Group I, the highest fat content was observed in the fourth lactation (3.86%). Throughout the experimental period, the number of animals in the groups changed due to culling. At the end of the fourth lactation, there were 7 animals in Group I, 7 in Group II, and 8 in Group III. The highest number of culled animals was observed during the fourth lactation. Future research will be conducted on other dairy breeds common in Ukraine. Additionally, the impact of age at first insemination on productive lifespan and the profitability of milk production will be assessed.

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Conflict of Interest

None.

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Продуктивність корів голштинської породи за умов раннього осіменіння телиць

Інна Кепкало

Кандидат сільськогосподарських наук, старший викладач
Відокремлений підрозділ Національного університету біоресурсів і природокористування України «Ніжинський агротехнічний інститут»
16600, вул. Тараса Шевченка, 10, м. Ніжин, Україна
https://orcid.org/0000-0003-3098-8200

Михайло Кузьменко

Кандидат сільськогосподарських наук, старший викладач
Відокремлений підрозділ Національного університету біоресурсів і природокористування України «Ніжинський агротехнічний інститут»
16600, вул. Тараса Шевченка, 10, м. Ніжин, Україна
https://orcid.org/0009-0000-9406-757X

Марина Хоменко

Кандидат сільськогосподарських наук, асистент
Національний університет біоресурсів і природокористування України
03041, вул. Горіхуватський шлях, 19, м. Київ, Україна
https://orcid.org/0000-0001-7023-3676

Микола Себа

Кандидат сільськогосподарських наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Горіхуватський шлях, 19, м. Київ, Україна
https://orcid.org/0000-0001-9696-934X

Анотація. Вік першого осіменіння є важливим фактором, від якого залежить тривалість непродуктивного періоду, подальша молочна продуктивність та плодючість тварин. У зв'язку з цим метою статті було встановити вплив раннього віку осіменіння на молочну продуктивність та відтворну здатність корів. Для проведення дослідження використовували корів голштинської породи. Дослідження було здійснене на базі ТОВ «Рожнівка-Агро» в Ічнянському районі Чернігівської області. За результатами дослідження було встановлено, що жива маса піддослідних тварин при першому отеленні не мала значних відхилень і була в межах 3,3 %. У першу лактацію найкоротший сервіс-період був у тварин яких осіменяли в 13 місяців, різниця була 4,5 (група I ↓) та 3,9 днів (група III ↓). Найвищий індекс осіменіння 3,1 у всіх дослідних групах був у період третьої лактації. Молочну продуктивність досліджували за добу по місяцях лактації та виходу молочного жиру і білка. За отриманими результатами було встановлено, що в першу лактацію у всіх групах надої не мали значної різниці, у другій лактації спостерігається тенденція до їх зростання у всіх групах. Проте варто відзначити, що у тварин, яких осіменяли у 13 місяців, молочна продуктивність була вища на 4 % та 1 % порівняно з I та III групою. Пік в усіх дослідних групах спостерігався на третю лактацію. Найнижчий надій був у корів, які мали раннє осіменіння (12 місяців), різниця становила 7,8 (група II ↑) та 6,9 % (група III ↑). В розрізі лактацій вміст жиру у II групі (13 місяців) був вищим у період третьої лактації на 0,23; 0,13; 0,05 % порівняно з першою, другою та четвертою. Значних відмінностей у вмісті білка в молоці не спостерігалось – він був у межах 3,20-3,23 %. Таким чином, зменшуючи вік першого осіменіння, можна досягти вищого економічного використання тварин без зниження їхньої відтворної здатності та негативного впливу на подальшу молочну продуктивність

Ключові слова: тільність; надій; жива маса; сервіс-період; індекс осіменіння