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INFLUENCE OF NON-GENETIC FACTORS ON THE REPRODUCTIVE TRAITS OF HOLSTEIN COWS

Iryna LIUTA,
Assistant of the Department
https://orcid.org/0000-0002-1672-2337
Mykolaiv National Agrarian University, Mykolaiv, Ukraine

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The study analyzes the influence of non-genetic factors on the reproductive qualities of Holstein cows. The material consisted of record data of cows (n = 644 heads) raised at LLC «Promin» (Mykolaiv region).

The study established a statistically significant effect of the year of conception on the age of first-calf heifers at conception (P<0.001). The highest age at conception was observed in 2014 – 914.8 days, while in 2020-2022 it was significantly lower – 766.0-775.3 days. Similarly, the year of conception significantly influenced the number of services (P<0.001): the maximum value was recorded in 2017 – 2.46, the minimum ones – in 2018 and 2021 – 1.59 and 1.59, respectively.

The month of conception had a statistically significant effect on the age of first-calf heifers at conception (P=0.010), as well as on the pregnancy duration (P=0.020). The lowest age at conception was observed in December, August, and October, and the maximum one was in February. The shortest pregnancy duration was recorded in cows calving in March and January, and the maximum one was in June, May, and September.

The number of services until conception significantly influenced the age of first-calf heifers at conception and the second calving (P<0.001), as well as the duration of the service period (P<0.001). At the same time, the pregnancy duration remained stable (275.0-277.0 days, P=0.935), and the dry period fluctuated within 55.0-62.4 days without significant influence (P=0.369).

The year and month of calving significantly influenced the duration of the dry period (P=0.034-0.009) and calving intervals (P<0.001-0.017).

Keywords: year and month of conception and calving, number of services, calving-to-conception interval, gestation lenght, calving age, dry period, calving interval.

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ВПЛИВ НЕГЕНЕТИЧНИХ ФАКТОРІВ НА ВІДТВОРЮВАЛЬНІ ЯКОСТІ КОРІВ ГОЛШТИНСЬКОЇ ПОРОДИ

Ірина ЛЮТА, асистентка кафедри
https://orcid.org/0000-0002-1672-2337
Миколаївський національний аграрний університет, Миколаїв, Україна

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У дослідженні проаналізовано вплив негенетичних факторів на відтворювальні якості корів голштинської породи. Матеріалом слугували облікові дані корів (n = 644 гол.), вирощених у СТОВ «Промінь» (Миколаївська область).

У ході дослідження встановлено статистично значущий вплив року запліднення на вік первісток при заплідненні (P < 0,001). Найвищий вік запліднення спостерігався у 2014 році – 914,8 днів, тоді як у 2020-2022 роках він був достовірно нижчим – 766,0-775,3 днів. Аналогічно, рік запліднення достовірно впливав на кількість осіменінь (P < 0,001): максимальне значення зафіксовано у 2017 році – 2,46, мінімальні – у 2018 та 2021 роках – 1,59 і 1,59 відповідно.

Місяць запліднення корів статистично значуще впливав на вік первісток при заплідненні (P = 0,010), а також на тривалість тільності (P = 0,020). Найменший вік запліднення спостерігався у грудні, серпні та жовтні, а максимальний – у лютому. Найменша тривалість тільності була зафіксована у корів з отеленням у березні та січні, а максимальна – у червні, травні та вересні.

Кількість осіменінь до настання запліднення істотно впливала на вік первісток при заплідненні та другому отеленні (P < 0,001), а також на тривалість сервіс-періоду (P < 0,001). Водночас тривалість тільності залишалася стабільною (275,0-277,0 днів, P = 0,935), а сухостійний період коливався у межах 55,0-62,4 днів без достовірного впливу (P = 0,369).

Рік та місяць отелення корів статистично достовірно впливали на тривалість сухостійного (P = 0,034-0,009) та міжотельного періодів (P < 0,001-0,017).

Ключові слова: рік та місяць запліднення і отелення, кількість осіменінь, сервіс-період, тривалість тільності, вік отелення, сухостійний період, міжотельний період.

Introduction. The overall productivity and adaptive efficiency of cattle largely depend on the level of their reproductive capacity under specific housing conditions. Reproduction is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs, especially in dairy and beef cattle systems (Nuraddis et al., 2011).

Productive and reproductive traits are key factors determining the profitability of dairy production. Therefore, studying reproductive indicators is necessary to assess the condition of animals and prevent economic losses on farms. In dairy cattle breeding, the main productive and reproductive traits that determine the profitability of milk production include the age at first calving, calving-to-conception interval, calving interval, dry period, lactation duration, milk yield, etc. (Lobago et al., 2007). These economically significant traits are influenced by both genetic and non-genetic factors (Abd-El Hamed et al., 2021; Abera et al., 2023; Polupan et al., 2019). The main non-genetic factors that can cause variation in these indicators include the calving season, parity, housing conditions, and production direction (Epaphras et al., 2004; Thakkar et al., 2021; Tahir et al., 2023).

Regulating calving by seasons for uniform milk production should primarily be carried out at dairy complexes and farms, ensuring full feeding for animals in all periods of the year. However, in recent years, there has been a lack of information regarding the efficiency of raising and successful insemination of heifers at an earlier age depending on the calving season of cows (Wondifraw et al., 2013).

The number of services per conception (NSC) is the number of inseminations (natural or artificial) required for successful conception. NSC is an indicator of cow reproduction efficiency and simultaneously reflects the level of farm management (Hunde et al., 2015).

The insemination period can determine the level of fertility: an extended open period can increase the frequency of pregnancy, providing cows sufficient time to recover after calving and return to estrus in an optimal physiological state (Didanna et al., 2025). Shortening the calving-to-conception interval helps reduce the generation interval and increase genetic progress per unit of time (Santschi et al., 2011).

Didanna et al. (2025) found that the NSC indicator significantly depended on the insemination period ($p<0.05$) and parity (pregnancy order number) ($p<0.01$). The researchers also established a statistically significant effect of the insemination period on NSC, which is consistent with the results of Jalata et al. (2023).

The calving-to-conception interval, lactation duration, dry period, level of milk productivity, and calving interval have important economic significance as indicators of breeding efficiency (Hadad et al., 2020).

The calving interval is an indicator of reproductive capacity, characterizing the period between two consecutive calvings, and depends on the duration of the calving-to-conception interval and the gestation lenght. The extension of the calving interval can lead to a decrease in the number of lactations during the entire productive life of cows, as well as to a reduction in the total number of replacement heifers in the herd, which, in turn, reduces the possibility of forming a sufficient replacement stock (Hunde et al., 2015).

The calving-to-conception interval (Days Open, DO) is a reliable indicator for assessing the reproductive efficiency of a dairy herd and achieving an optimal calving interval of 12-13 months. Under optimal conditions, cows should be fertilized within 85-110 days after calving. Fluctuations in DO values may be caused by differences in dairy cattle management systems (Didanna et al., 2025).

In this regard, to improve productive and reproductive traits in order to increase the economic efficiency of dairy cattle breeding, it is important to study the influence of non-genetic factors such as calving year, calving season, and parity (Wondifraw et al., 2013; Mikláš et al., 2021; Samia et al., 2022). These conclusions align with the results of authors (Tahir et al., 2023), who confirm the feasibility of considering the calving season, calving period, and parity in herd management programs for breeders, as they significantly affect the productivity and profitability of the farm.

In general, a significant number of studies have been conducted comparing productive and reproductive indicators in dairy cows (Eldawy et al., 2021; Ihsanullah et al., 2020), but work aimed at studying factors influencing economically important traits in dairy cattle remains insufficient. Therefore, the purpose of this study was to investigate the influence of various non-genetic factors on the reproductive indicators of Holstein

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cows.

Materials and research methods. For the study, primary record materials were used regarding Holstein cows kept at LLC «Promin» in the Mykolaiv region (n = 644 heads).

The farm operates a loose housing system for cows and replacement young stock. A distinctive feature is the use of the so-called «cold» housing technology, used from an early age and applied to the entire cattle population. Calves, a few hours after birth, are sent from the maternity ward to individual houses, where they are fed colostrum. The cow population is kept in specialized livestock premises equipped with circulation fans to ensure optimal microclimate parameters. Freshly separated solid manure fraction is used as bedding.

Feeding is based on farm-produced feed: corn silage, alfalfa haylage, hay, and straw. Premixes made at the farm's own feed mill are also introduced into the rations. For the high-productivity group of cows, the proportion of dry matter in the ration structure is 50.0%, and concentrated feed is 44.0%.

The realization of the high genetic potential of the Holstein breed at the farm is ensured by using improver bulls with high breeding value, evaluated by the quality of offspring. Specifically, sires representing leading genetic lines of the Holstein breed are used: Starbuck, Chief, Marshal, Bell, Elevation, and Valiant.

Reproductive capacity indicators included: age of first-calf heifers at conception; number of services required for one confirmed conception resulting in calving; age of cows at second calving; gestation lenght; duration of the first calving-to-conception interval; duration of the first dry period; calving interval duration.

Qualitative factors were considered as independent variables, including the year of conception/calving with corresponding graduations (2014-2022 and 2014-2023); month of conception/calving, represented by 12 levels (from January to December), and the number of services with 6 graduations.

For each trait, the arithmetic mean and the standard error of the mean ($\overline{X} \pm S_x$) were determined. Testing the null hypothesis regarding the absence of influence of individual factors on the studied quantitative indicators was performed using one-way analysis of variance (ANOVA) according to R. Fisher with fixed factors. The value of the Fisher-Snedecor criterion *(F)* and the corresponding level of statistical significance *(P)* were calculated.

Statistical processing of the results was carried out according to the methodological recommendations set out in the manual by S. Kramarenko and co-authors (Kramarenko et al., 2019), using the MS Excel spreadsheet processor and PAST software (Hammer, 2001), STATISTICA v.7.0 (StatSoft Inc.).

Research results. During the study, the variability of the age of first-calf heifers at conception and the number of services depending on the year of conception was examined (Table 1).

As a result of the study, a statistically significant influence of the year of conception on the age of primiparous heifers at conception was established ($P<0.001$). The highest values of this indicator were recorded in cows fertilized in 2014 – 914.8 ± 27.08 days, which significantly exceeded the corresponding indicators in animals inseminated in 2020-2022 (766.0-775.3 days).

Since 2018, a steady trend towards reducing the age of primiparous heifers at conception has been noted, which is likely associated with the improvement of housing and feeding conditions, as well as the implementation of more effective approaches to puberty management.

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Table 1

Variability of age indicators of primiparous heifers at conception and the number of services depending on the year of conception, $\overline{X} \pm Sx$

Year of conception	*n*	Age of primiparous heifers at conception, days	Number of services
2014	9	914.8±27.08	2.30±0.50
2015	17	870.2±22.69	2.00±0.26
2016	37	824.5±10.47	2.08±0.19
2017	26	833.7±13.85	2.46±0.28
2018	34	798.7±12.09	1.59±0.13
2019	46	809.2±11.04	2.20±0.22
2020	105	775.3±4.78	1.89±0.10
2021	223	768.7±3.48	1.59±0.06
2022	102	766.0±5.12	1.69±0.11
		F=(8; 590)= 19.7, P < 0.001	F=(8; 590)= 4.12, P< 0.001

Note: n – number of animals; $\overline{X} \pm Sx$ – evaluation of the arithmetic mean and its error; F – Fisher criterion evaluation; P – significance level.

Furthermore, a significant influence of the year of conception on the number of services required for conception was revealed (P<0.001). The maximum average value of this indicator was observed in cows fertilized in 2017 and amounted to 2.46 ± 0.28, which may indicate complications in fertilization processes during this period. At the same time, the minimum values are characteristic of animals inseminated in 2018 and 2021 – 1.59 ± 0.13 and 1.59 ± 0.06, respectively.

In general, a positive trend in improving reproductive indicators is observed over the years, in particular, a decrease in the age of primiparous heifers at conception and stabilization of the number of services, which indicates progress in the rearing system, selection work, and reproduction management at the farm.

Table 2 shows the results of the study on the influence of the month of conception on the age of primiparous heifers at conception and the number of services required for pregnancy. In the course of the study, a statistically significant influence of the month of conception on the age of primiparous heifers during conception was established (P=0.007). The lowest values of this indicator were recorded in animals fertilized in March – 754.1 ± 5.73 days, while the maximum age of primiparous heifers at conception was observed in animals whose insemination was carried out in May – 821.4 ± 14.89 days.

The influence of the month of conception on the number of services required for conception was not statistically significant (P=0.127). At the same time, it should be outlined that cows fertilized in March were characterized by the lowest average number of services to achieve pregnancy – 1.45 ± 0.105, while in animals fertilized in May, this indicator was the highest and amounted to 2.16 ± 0.270.

Overall, March proved to be the most favorable month for insemination, as of primiparous heifers of this period were characterized by the lowest age at conception and the minimum number of services required for pregnancy, indicating a high level of their reproductive readiness.

Table 2

Variability of age indicators of primiparous heifers at conception and the number of services depending on the month of conception, $\overline{X} \pm Sx$

Month of conception	*n*	Age of primiparous heifers at conception, days	Number of services
January	56	779.0±8.14	1,79±0,160
February	71	788.6±6.90	1,90±0,149
March	45	754.1±5.73	1,45±0,105
April	48	787.5±8.20	1,94±0,163
May	35	821.4±14.89	2,16±0,270
June	30	782.5±13.32	1,70±0,192
July	59	782.5±7.84	1,62±0,139
August	52	795.2±9.50	1,80±0,117
September	53	797.0±9.59	1,96±0,155
October	51	787.0±10.04	2,00±0,153
November	49	780.4±9.85	1,58±0,128
December	51	778.9±8.17	1,73±0,138
		F= (11; 588) = 2.39, P=0.007	F= (11; 588) = 1.50, P=0.127

Conversely, insemination in May and October was accompanied by a higher age of animals at conception and an increased number of services required to achieve pregnancy, which may reflect seasonal changes in housing conditions or a decrease in the intensity of sexual activity in cows.

Thus, the month of conception significantly affects the age of primiparous heifers at conception, but does not exert a statistically significant influence on the number of services. The most optimal reproductive indicators were noted in cows inseminated in the spring, specifically in March.

Table 3 shows the dynamics of reproductive indicators of cows depending on the year of calving.

Table 3

Variability of calving-to-conception interval, gestation lenght, and age of cows at second calving depending on the year of calving, $\overline{X} \pm Sx$, days

Year of calving	*n*	Calving-to-conception interval	Gestation lenght	Age of cow at second calving
2014	9	133.1±25.42	-	1165.7±27.68
2015	17	86.4±7.54	280.00±1.991	1226.4±21.01
2016	37	102.6±6.67	277.81±1.012	1123.8±18.58
2017	26	114.0±9.48	277.68±0.874	1104.4±11.71
2018	35	98.1±6.71	277.82±0.766	1118.0±12.23
2019	46	121.5±7.59	276.02±1.027	1068.4±10.12
2020	105	104.4±3.31	275.54±0.971	1082.5±12.25
2021	223	92.9±1.94	275.85±0.503	1048.4±4.31
2022	102	97.2±3.11	275.95±0.296	1042.8±3.11
2023	-	-	273.57±0.900	1057.9±16.39
		F = (8; 591) = 5,26, P< 0.001	F= (8; 591) = 2.04, P=0.039	F= (9; 591) = 22.25, P< 0.001

The statistically significant influence of the calving year on the duration of the calving-to-conception interval was established (P<0.001). Its minimum duration was noted in cows whose calving took place in 2021 and was 92.9 ± 1.94 days, which indicates effective recovery of reproductive function after the first calving. Conversely, the longest calving-to-conception interval was recorded in cows that calved for the second time in 2014 (133.1 ± 25.42 days) and in 2019 (121.5 ± 7.59 days), which is likely due to the specifics of animal housing or the presence of postpartum physiological complications.

During the analysis of the variability of gestation lenght depending on the calving year, statistically significant but moderate differences were revealed (P=0.039). The greatest gestation lenght was established in cows calving in 2015 – 280.0 ± 1.99 days, while the lowest values were recorded in animals calving in 2023 – 273.6 ± 0.90 days. In general, fluctuations in gestation lenght were within the physiological norm, indicating their predominantly statistical rather than practical nature.

The influence of the calving year on the age of cows at the second calving was statistically significant (P<0.001). The lowest age at the second calving was noted in cows calving in 2022 – 1042.8 ± 3.11 days, reflecting positive changes in the system of raising and reproduction of animals at the farm. At the same time, the highest age at second calving was established in animals calving in 2015 (1226.4 ± 21.01 days) and 2014 (1165.7 ± 27.68 days), which may indicate delays in development or insufficient efficiency in reproductive process management.

In general, the calving year had a significant influence on the duration of the calving-to-conception interval and age at second calving, as well as a partial influence on gestation lenght. The most favorable reproductive indicators for cows were observed in 2021-2022, which may be a consequence of improved housing conditions, feeding, and veterinary support. Consistent improvement of technologies and renewal of genetic material positively affect animal reproduction efficiency.

The statistically significant influence of the calving month of cows on the duration of the calving-to-conception interval was established (P=0.036) (Table 4). Minimum values of this indicator were recorded in animals calving in March (87.5 ± 3.16 days), November (91.4 ± 4.88 days), and July (93.1 ± 3.79 days), which may indicate more effective recovery of reproductive function after calving in the summer-autumn period. Nevertheless, the maximum duration of the calving-to-conception interval was observed in cows calving in May (110.2 ± 8.07 days), October (108.1 ± 5.64 days), and September (107.4 ± 5.22 days), which may be related to seasonal characteristics of housing conditions or the physiological state of animals during these periods.

The gestation lenght of cows also showed a statistically significant dependence on the calving month (P=0.020). Minimum values of this indicator were noted in animals calving in March (273.9 ± 1.33 days) and January (274.4 ± 0.95 days). Conversely, the maximum gestation lenght was observed in cows calving in June (277.4 ± 0.60 days), May (277.3 ± 0.55 days), and September (277.3 ± 0.86 days). The identified seasonal fluctuations are likely due to the influence of microclimatic conditions during the final trimester of gestation.

The age of cows at second calving was also subject to a statistically significant influence of the calving month (P=0.010). The lowest age at the second calving is characteristic of cows calving in December (1031.9 ± 6.15 days), August (1055.1 ± 10.49 days), and October (1057.3 ± 7.37 days). The highest values of this indicator were recorded in first-calf heifers calving in February (1102.5 ± 14.93 days).

Table 4

Variability of calving-to-conception interval duration indicators, gestation lenght, and age of cows at second calving depending on the month of calving, $\overline{X} \pm Sx$, days

Month of calving	*n*	Calving-to-conception interval	Gestation lenght	Age of cow at second calving
January	56	96.2±4.66	274.4±0.95	1065.1±9.16
February	71	103.3±5.12	276.6±0.72	1102.5±14.93
March	45	87.5±3.16	273.9±1.33	1062.1±12.95
April	48	106.9±5.18	276.7±0.70	1062.2±8.44
May	35	110.2±8.07	277.3±0.55	1068.4±9.02
June	30	97.1±8.33	277.4±0.60	1070.0±9.64
July	59	93.1±3.79	275.2±0.77	1070.6±10.83
August	53	101.4±4.02	276.7±0.94	1055.1±10.49
September	53	107.4±5.22	277.3±0.86	1063.4±9.86
October	51	108.1±5.64	276.0±0.54	1057.3±7.37
November	49	91.4±4.88	276.0±0.61	1062.1±6.64
December	51	97.5±5.07	275.2±0.61	1031.9±6.15
		F = (11; 589) = 1.91, P = 0.036	F= (11; 589) = 2.08, P=0.020	F= (11; 589) = 2.27, P=0.010

In general, the calving month of cows had a statistically significant influence on the duration of the calving-to-conception interval, gestation, and age at the second calving. Spring-summer calvings (March-June) proved to be the most favorable for the course of the next reproductive cycle, accompanied by a reduction in the calving-to-conception interval and a decrease in the age of cows at the second calving. These features should be taken into account when forming the insemination calendar under conditions of seasonal organization of reproduction at the farm.

Positive association between the number of services and the age of primiparous heifers at conception is clearly observed (P<0.001) (Table 5). With an increase in the number of services, a significant increase in the age of animals is observed: in cows fertilized after the first service, it averaged 757.3 days, while if 4-6 services were necessary, the age exceeded 859-901 days. The results obtained indicate a slowdown in the course of reproductive development of females under conditions of reduced fertility, which negatively affects the timeliness of the next reproductive cycle.

The number of services also has a statistically significant effect on the duration of the calving-to-conception interval of cows (P<0.001). Under the condition of gestation occurring after the first service, the average duration of the service period was 76.1 ± 0.50 days, while if six services were needed, this indicator increased to 228.0 ± 12.51 days. Thus, as the number of services increases, the period of restoration of reproductive function until the next conception is significantly extended, which negatively affects the efficiency of cow reproduction.

Therefore, the number of services did not have a statistically significant effect on gestation lenght (P=0.935), as the average values of this indicator fluctuated between 275.0-277.0 days without significant differences between groups.

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Table 5

Variability of age indicators of primiparous heifers at conception, duration of the calving-to-conception interval, gestation lenght, and age at second calving depending on the number of services, $\overline{X} \pm Sx$, days

Number of services	*n*	Age of primiparous heifers at conception	Calving-to-conception interval	Gestation lenght	Age at second calving
1	339	757.3±2.46	76.1±0.50	276.24±0.286	1033.4±2.50
2	127	801.8±5.99	106.1±1.42	275.89±0.497	1077.6±6.08
3	77	822.3±5.99	140.6±2.07	276.06±0.657	1098.2±6.20
4	32	859.5±9.32	175.4±4.63	276.14±0.863	1135.5±9.66
5	14	892.4±18.50	179.4±4.13	275.00±1.158	1167.4±18.07
6	6	901.7±19.14	228.0±12.51	277.29±2.485	1177.8±18.41
		F= (5; 589) = 59.3, P< 0.001	F = (5; 589) = 711.31, P< 0.001	F= (5; 589) = 0.26, P=0.935	F= (5; 589) = 56.82, P< 0.001

Similar to the age at conception for primiparous heifers, the age of cows at second calving significantly increased with an increase in the number of services (P<0.001): from 1033.4 ± 2.50 days in animals fertilized after one service to 1177.8 ± 18.41 days with six services. This indicates a delay in the course of the reproductive cycle and an extension of the calving interval under conditions of low female fertility.

In general, an increase in the number of services required for conception is accompanied by an increase in the age of animals at the time of the next conception and calving, as well as a significant extension of the calving-to-conception interval. The results obtained emphasize the importance of optimizing insemination conditions to minimize time losses in the reproductive cycle, while the gestation lenght remains stable and does not depend on the number of services.

Table 6 presents the results of assessing the influence of the calving year on the duration of the dry and calving intervals in cows.

Table 6

Variability of dry period duration indicators and calving interval in cows depending on the year of calving, $\overline{X} \pm Sx$, days

Year of calving	*n*	Dry period	Calving interval
2015	8	56.0±5.26	428.1±29.59
2016	26	59.6±2.24	365.8±6.61
2017	34	60.0±1.68	379.8±7.02
2018	34	57.8±1.22	390.7±8.94
2019	53	56.9±1.09	383.8±6.71
2020	41	58.1±1.97	394.7±7.61
2021	136	56.3±0.53	376.7±3.02
2022	294	56.2±0.32	369.1±1.82
2023	14	54.4±0.90	391.1±7.34
		F = (8; 631) = 2.09, P = 0.034	F = (8; 631) = 5.89, P< 0.001

The average duration of the dry period in cows varied depending on the calving year within 54.4-60.0 days. Statistical analysis results showed a significant influence of the calving year on the duration of the dry period (P=0.034), although the observed fluctuations were relatively minor. Maximum values of this indicator were noted in first-calf heifers calving in 2016 and 2017 – 59.6 ± 2.24 and 60.0 ± 1.68 days, respectively, while the minimum dry period duration was recorded in 2023 – 54.4 ± 0.90 days, which may reflect changes in the management system or animal housing conditions. Despite statistical significance, all values were within the physiologically justified standard (about 60 days).

The calving interval duration of cows proved to be more sensitive to interannual changes. In particular, in 2015, this indicator was 428.1 ± 29.6 days, while in 2022 it decreased to 369.1 ± 1.82 days, which is confirmed by a high level of statistical significance (P<0.001). The results obtained indicate a significant increase in the efficiency of reproductive management in recent years, in particular, by reducing the interval between calvings, which has important economic significance for dairy production.

In general, the calving year of cows affects both the duration of the dry period and the calving intervals. At the same time, while the dry period remained relatively stable within 54-60 days, the calving interval has undergone a significant reduction in recent years. This may indicate the improvement of management decisions in the field of cow reproduction and feeding, which contributes to the intensification of the production cycle.

Table 7 provides an assessment of the influence of the calving month of cows on the duration of their dry and calving intervals.

Table 7

Variability of dry period duration indicators and calving interval in cows depending on the month of calving, $\overline{X} \pm Sx$, days

Month of calving	*n*	Dry period	Calving interval
January	47	55.0±1.00	383.4±5.07
February	36	60.1±2.24	386.0±9.10
March	36	53.4±1.64	368.6±6.04
April	49	57.5±0.73	371.8±5.60
May	63	58.6±0.67	377.1±3.82
June	58	57.0±0.61	381.4±4.87
July	53	56.3±1.11	384.6±5.87
August	56	56.4±0.93	364.2±4.59
September	50	57.7±1.08	381.3±6.00
October	63	56.7±1.02	373.4±4.54
November	87	56.5±0.65	378.1±4.82
December	46	55.3±0.59	361.8±3.22
		$F = (11; 632) = 2.32$, $P = 0.009$	$F = (11; 632) = 212$, $P = 0.017$

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The average duration of the dry period in cows varied within 53.4-60.1 days, indicating minor but statistically significant differences depending on the calving month (P=0.009). Maximum dry period values were recorded in animals calving in February – 60.1 ± 2.24 days, which may be due to the specifics of feeding and housing organization in the winter-spring period. The minimum duration of the dry period was observed in cows calving in March – 53.4 ± 1.64 days. For most months, the indicators were within the recommended standard (55-60 days), demonstrating compliance with technological requirements at the farm.

The duration of the calving interval in cows was characterized by more pronounced variability – from 361.8 to 386.0 days, with a significant influence of the calving month (P=0.017). The shortest calving interval was noted in cows calving in December (361.8 ± 3.22 days) and August (364.2 ± 4.59 days), indicating effective restoration of their reproductive function. Conversely, the longest intervals between calvings were observed in animals calving in February (386.0 ± 9.10 days) and July (384.6 ± 5.87 days). The identified seasonal fluctuations may be caused by changes in housing conditions, feeding levels, or the influence of temperature stress, which affects the reproductive capacity of cows.

In general, the calving month of cows influences both the duration of the dry and calving intervals. Animals calving in December, August, and March were characterized by the most stable and physiologically optimal indicators. However, calving in February was accompanied by an extended recovery of reproductive function, which may indicate the feasibility of correcting housing and feeding conditions for animals in the winter period.

Table 8 shows the influence of the number of services until conception on the duration of the dry and calving intervals of cows. The duration of the dry period fluctuated within the range of 55.0-62.4 days; however, no statistically significant influence of the number of services on this indicator was found *(P = 0.369)*. This indicates that regardless of the reproductive efficiency of the animals, the duration of the period before calving remained relatively stable, which is a sign of compliance with the technological regulations of management.

Table 8

Variability of dry period duration indicators and calving interval in cows depending on the number of services, $\overline{X} \pm Sx$, days

Number of services	*n*	Dry period	Calving interval
1	355	56.8±0.37	352.2±0.58
2	141	56.4±0.57	381.9±1.53
3	85	56.6±1.06	416.5±2.22
4	36	56.6±0.98	451.5±5.17
5	14	55.0±1.12	454.4±4.11
6	7	62.4±4.78	504.2±12.91
		F = (5; 632) = 1.08, P = 0.369	F = (5; 632) = 584.49, P < 0.001

In contrast, the number of services significantly influenced the duration of the calving interval (P < 0.001). With a single service, the calving interval was the shortest –

352.2 ± 0.58 days, while with an increase in the number of services, it gradually lengthened, reaching 504.2 ± 12.91 days with six services. The obtained pattern indicates a significant prolongation of the reproductive cycle in the case of low insemination efficiency, which negatively affects the overall productivity of the herd.

Thus, although the duration of the dry period remains stable regardless of the number of services, an increase in the number of fertilization attempts leads to a substantial prolongation of the calving interval, which can be economically disadvantageous. This underscores the need to increase insemination efficiency by improving heat detection, semen quality, housing conditions, and the recovery of animals after calving.

Discussion. The statistically significant influence of the year of conception on the age of primiparous heifers at conception was established ($P < 0.001$): the highest values were noted in 2014 (914.8 days), while in 2020-2022 this indicator was significantly lower (766.0-775.3 days). Similarly, the year of conception significantly influenced the number of services per conception (NSC; $P < 0.001$): maximum values were recorded in 2017 (2.46), and minimum ones were in 2018 and 2021 (1.59).

The results obtained are consistent with the data of Hunde et al. (2015) and Asimwe and Kifaro (2007), who noted a significant impact of the year and other fixed factors on NSC. At the same time, individual studies (Gebeyehu et al., 2007; Hammoud et al., 2010; Tadesse et al., 2010) report the absence of significant seasonal influence.

The statistically significant influence of the month of conception on the age of primiparous heifers at conception was established ($P = 0.007$): minimum values were recorded in March (754.1 days), while maximum ones were in May (821.4 days). The influence of the month of conception on the number of services was statistically insignificant ($P = 0.127$), although there was a trend toward a lower NSC in March (1.45) and a higher one was in May (2.16). These results generally correlate with data of other researchers regarding NSC levels (Makgahlela et al., 2007; Tadesse et al., 2010; Abebe et al., 2021; Tahir et al., 2023). However, they do not confirm the conclusions of Hunde et al. (2015) regarding a significant influence of the breeding period on NSC, which may indicate differences in housing conditions and climatic factors.

The statistically significant influence of the calving year on the duration of the calving-to-conception interval (Days Open, DO) was established ($P < 0.001$): minimum values were noted in 2021 (92.9 days), while maximum ones were in 2014 (133.1 days) and 2019 (121.5 days), indicating a gradual improvement in the recovery of reproductive function in later years. These results align with literature data on the variability of the infertility period depending on housing conditions and calving time. For instance, the average DO value (186.9 days) reported by Didanna et al. (2025) is lower than that of Beneberu et al. (2021) (221.09 days), but higher compared to Jalata et al. (2023) (99.9 days). The significant influence of the calving season or period on DO established by several researchers (Getahun et al., 2019; Beneberu et al., 2021; Tahir et al., 2023; Didanna et al., 2025) confirms the role of external factors, while some studies (Jalata et al., 2023) do not find this factor significant, which may be due to breed and regional differences.

The influence of the calving month on the duration of the calving-to-conception interval was established ($P = 0.036$): the shortest values were noted in March, July, and November (87.5-93.1 days), while the longest ones were in May, September, and October (107.4-110.2 days), likely due to seasonal housing conditions and the physiological state of the animals. A statistically significant but moderate influence of the calving year on gestation lenght was also revealed ($P = 0.039$): fluctuations were within the physiological norm and were primarily statistical in nature. These results partially agree with

Kramarenko et al. (2025), who found no effect of the calving year but established differences between seasonal subgroups and a tendency for gestation to lengthen with increasing calving age.

The results confirm a statistically significant influence of the calving month on gestation lenght (P = 0.020): minimum values were noted in the winter-spring period, while maximum ones were in late spring-summer and autumn months. The fluctuations identified were seasonal and remained within the physiological norm. Similarly, the calving month significantly affected the age of cows at second calving (P = 0.010): the lowest values were observed in animals with winter-autumn calving (1031.9-1057.3 days), while the highest were for calving in February (1102.5 days). These results are consistent with Bhave et al. (2021), who also noted a significant impact of calving time on age-related reproduction indicators.

The statistically significant positive relationship was found between the number of services and the age of primiparous heifers at conception (P < 0.001): as NSC increased, the age of the animals significantly increased. An increase in the number of services was also accompanied by a substantial prolongation of the calving-to-conception interval, indicating a decrease in reproductive efficiency under conditions of low fertility. At the same time, the influence of NSC on gestation lenght was insignificant (P = 0.935).

The age of cows at second calving significantly increased with the number of services (P < 0.001), indicating a prolongation of the calving interval and a delay in the reproductive cycle.

The statistically significant influence of the calving year on the duration of the dry period was established (P = 0.034), though all values remained within the physiologically justified standard. Simultaneously, the calving year had a highly significant impact on the duration of the calving interval (P < 0.001): in later years, a significant reduction was observed, indicating an improvement in reproductive management efficiency and carrying important economic weight for dairy farming.

The statistically significant influence of the calving month on the duration of the dry period was established (P = 0.009): maximum values were noted for calving in February (60.1 days), and minimum ones were in March (53.4 days). However, for most months, the dry period duration remained within the recommended standard (55-60 days), indicating compliance with technological requirements on the farm and an absence of practically significant deviations.

According to research by Tahir et al. (2023) and Abera et al. (2023), the duration of the calving interval (CI) significantly depends on the calving year, while the influence of the season is ambiguous. The results of this study confirm the high sensitivity of CI to interannual changes (P < 0.001): during the study period, the indicator decreased from 428.1 days in 2015 to 369.1 days in 2022, indicating increased efficiency in reproductive management and a positive economic effect.

Nevertheless, data on seasonal influence remain contradictory: the lack of significance found in some studies (Abera et al., 2023; Habtamu et al., 2009; Jalata et al., 2023) does not align with the results of other scientists who found a significant effect of calving season on CI (Tadesse et al., 2010; Beneberu et al., 2021; Didanna et al., 2025). This study established a statistically significant influence of the calving month on CI (P = 0.017): the shortest intervals were noted for calving in winter-summer months (361.8-364.2 days), while the longest were in February and July (386.0-384.6 days).

The number of services until conception did not have a statistically significant effect on the dry period duration (P = 0.369), which remained relatively stable and within the technological standard. At the same time, a highly significant influence of NSC on the duration of the calving interval was established (P < 0.001): as the number of services increased, a substantial prolongation occurred, indicating a slowdown of the reproductive cycle and a decrease in reproductive efficiency under conditions of low fertility.

Conclusions. The year and month of conception and calving significantly influence the reproductive indicators of cows. With an increase in the number of services, the age of primiparous heifers at conception and calving, as well as the calving-to-conception interval, are prolonged, while the duration of pregnancy and the dry period remain stable.

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