Regulatory Mechanisms in Biosystems

ISSN 2519-8521 (Print)
ISSN 2520-2588 (Online)
Regul. Mech. Biosyst.

Productive and reproductive capacities of first-calf cows Ayrshire depending on age and body weight at first fertilization

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Article info
Received 07.12.2025
Received in revised form 08.01.2026
Accepted 03.02.2026

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Admin, O. Y., Admina, N. G., Paliy, A. P., Pavlichenko, O. V., Stepanenko, A. V., Stryzhyus, V. V., Grebenyk, N. P., & Musiienko, Y. V. (2026). Productive and reproductive capacities of first-calf Ayrshire cows depending on age and body weight at first fertilization. Regulatory Mechanisms in Biosystems, 17(1), e26015. doi:10.15421/0226015

The efficiency of dairy farming hinges on properly organized livestock reproduction. Farms use several indicators to assess herd reproduction, one of which is the age and live weight of heifers at their first fertilization. In this study, data from the zootechnical records of first-calf Ayrshire cows at the "Myrne" State Enterprise in the Poltava region of Ukraine were analyzed. The animals were divided into groups according to their age at insemination (under 14 months, 14 to 16 months, or over 16 months) and their live weight at insemination (under 370 kg, 370 to 400 kg, or over 400 kg). The analysis revealed that the first service period (days open) was 95 days shorter for animals inseminated before 14 months of age compared to those inseminated at 16 months of age or older. First-calf heifers that were inseminated at an earlier age had a significantly lower milk yield per lactation compared to animals in other groups, by 1,326–1,463 kg. The duration of lactation explains this difference. Animals inseminated at up to 14 months of age with a live weight exceeding 400 kg had the shortest lactation and service periods. The lowest milk yield for the first lactation and the first 305 days of lactation was observed in animals inseminated at up to 14 months of age and weighing 370–400 kg. The longest first service period was characteristic of late-inseminated heifers with a high live weight. Heifers inseminated at an age younger than 14 months had the highest average daily gain from birth to 15 months. For heifers with a live weight of up to 370 kg, it was 800 g; for heifers with a live weight of 370-400 kg, it was 835 g; and for heifers with a live weight of more than 400 kg, it was 913 g. Intensive rearing of replacement heifers contributes to faster herd reproduction and increases the profitability of dairy farming. Further research should determine the economic lifespan of cows based on the age of first insemination and first calving.

Keywords: heifers; Ayrshire cows; age at first fertilization; body weight; lactation; longevity; productivity; reproduction.

Introduction

Raising replacement heifers is a crucial task for dairy farms, as it provides the herd with future income-generating units. However, the heifer rearing period is financially unproductive and requires substantial investment for most dairy farms (Hawkins et al., 2020; Masello et al., 2021). The primary objective of a dairy herd replacement program is to raise heifers to the desired size and body weight at the lowest possible cost, enabling them to achieve maximum genetic milk productivity throughout their lives (Zipp & Knierim, 2020; Freetly et al., 2021; Aseged et al., 2023).

Reproduction of heifers is an important factor in dairy farming (Hindman et al., 2022; Dias et al., 2023). Good reproductive performance improves not only milk production, but also genetic progress (Hancock et al., 2021; Paliy et al., 2021). To realize the full genetic potential of dairy cattle, the optimal ages of first fertilization and first calving must be ensured. Early fertilization of heifers can shorten the rearing period and reduce associated costs. This allows the heifers to start their productive lives and reach the break-even point faster. However, too early fertilization can compromise their future productivity. Conversely, delaying fertilization increases the age at first calving, which delays the return on investment and increases the costs of raising heifers without additional benefits (Serrenho, 2024). Determining the ideal time for the first fertilization of heifers requires balancing reproductive biology, growth, productivity, and economic considerations. The general recommendation for the optimal timing of first fertilization is based on live body weight. Specifically, heifers should reach 55–60% of their live weight before first fertilization and 82–85% after calving to optimize milk production during the first lactation (Van Amburgh et al., 2021). Using age to determine suitability for first fertilization can lead to an underestimation of body muscle mass and delayed fertilization (Duplessis et al., 2015). Heifers that required more than one fertilization to conceive were more likely to be culled before their first calving and had a higher risk of being culled within 50 days after their first calving (Fodor et al., 2019). A Spanish study found that heifers requiring at least five fertilizations to conceive were 52% less likely to complete their first lactation than those conceiving during the first fertilization (Bach, 2011). Another commonly used parameter to evaluate the effectiveness of reproduction programs in dairy herds is age at first calving (AFC). This is because AFC influences the functional longevity and reproductive performance of dairy cows (Cooke et al., 2013; Castillo-Badilla et al., 2019; Hawkins et al., 2020). Results regarding the optimal age at first calving in terms of production and lifetime income are consistent: 22 to 25 months is generally considered optimal (Heinrichs et al., 2017). Other studies have found that maximum milk yield during the first lactation is achieved with an AFC between 24 and 25 months (Wathes et al., 2008). In intensive milk production systems, breeding programs usually aim to have animals calve for the first time before 24 months of age (LeCozler et al., 2008; Do et al., 2013; Sawa et al., 2018). However, other studies have shown that the greatest profitability was achieved with an AFC between 24 and 26 months (Krpalkova et al., 2014). A Belgian study found that calving age below 22 months reduced milk production during the first lactation by 11%, compared to calving ages between 22 and 26 months (Froidmont et al., 2013). Cows with an AFC of ≤ 24 months consistently demonstrated better lifetime

longevity, lifetime milk production, and milk production per day of life. This trend was consistent across all three tested breed groups (Vargas-Leitón et al., 2023). Heifers with early AFC and low body weight (under 23.0 months and under 578 kg) had a higher incidence of calving difficulties and more stillbirths than older, heavier heifers (between 23.0 and 24.6 months old and between 579 and 613 kg). Additionally, the former had lower fertility rates and longer service periods (days open) than the latter. The frequency of difficult calving and the incidence of stillbirths were significantly associated with heifers' live weight, rather than their weight after calving. Specifically, heifers with low body weight experienced a higher frequency of calving problems compared to those with moderate body weight. However, an increase in calving difficulties did not affect subsequent reproductive performance. Young heifers had the highest average milk yield, significantly higher than heifers in the middle and older age groups (Kusaka et al., 2022). However, milking methods and the condition of the equipment should be considered (Paliy et al., 2020).

Body weight at first calving is another trait that is widely evaluated in heifer rearing. Studies have shown that, among heifers kept under the same conditions, those that were heavier at first calving produced slightly more milk during their first lactation than lighter heifers did. Heavier heifers also lost more weight during the first month of lactation and were at a higher risk of being culled earlier in life (Han et al., 2021). Intensive growth in heifers can negatively impact milk production. Retrospective studies have reported these adverse effects (Ettema & Santos, 2004; Berry & Cromie, 2009). An economic analysis showed that larger, well-grown heifers were more profitable due to their greater productive potential. Researchers have established that live body weight at pairing is associated with subsequent calving dates, subsequent live weights of cows, and milk fat and protein yields (Archbold et al., 2012). Previous studies have found a positive relationship between live body weight before calving and milk production during the first lactation period (McNaughton & Lopdell, 2013; Eetvelde et al., 2017). These results confirm that higher productivity during the first and second lactations can be achieved by raising heifers to a higher body weight. New Zealand scientists have identified the potential to increase milk production during the first lactation by increasing heifer's body weight. They also suggest that balanced feeding of lighter heifers before calving could be a more effective strategy for achieving greater body weight (Handcock et al., 2019; Martin et al., 2020). Other studies have demonstrated a positive relationship between replacement heifer live weight and reproduction as well as resistance to negative factors (Handcock et al., 2020). Our studies on Black-and-White dairy cows confirmed that the animals with the highest live weight gain were significantly younger at insemination, had the highest live weight during their first lactation, and were more productive. However, they experienced some reproductive issues, such as a slightly longer service period. Therefore, the early maturity of replacement heifers contributes to intensive herd reproduction and increases the profitability of dairy farming (Admin et al., 2024, 2025).

The current population of Ayrshire cattle in Ukraine is divided into two breeding herds that differ significantly in productivity and genealogical structure. Characteristic features of Ayrshire cattle include high milk quality (fat and protein content), adaptability to difficult conditions, cost-effective feeding (low feed costs per unit of production, particularly for concentrates at 0.95 and 0.25 feed units per liter of milk, respectively), and strong calf health. However, it has been established that, compared to traditional technology, progressive milk production technology increases milk productivity in cows while decreasing their reproductive capacity. This is evidenced by a 20-head decrease in calf yield per 100 cows (Voitenko et al., 2021).

Thus, a literature review indicates that there is no consensus on how the age and live weight of heifers at first fertilization influence subsequent cow productivity and survival in the herd. Therefore, this study aimed to determine how age and live weight at first fertilization affect the productive and reproductive abilities and longevity of Ayrshire heifers.

Materials and methods

The research was conducted at the "Myrne" State Enterprise of the Institute of Food Resources of the National Academy of Agrarian Sciences of Ukraine in Poltava Region. The farm has the status of a breeding reproducer for the Ayrshire breed. Cattle at the State Enterprise "Myrne" are kept in livestock premises using various systems. Calves are raised at an early age in individual pens, then in groups without tethering, with automatic feeding. Older calves and heifers are also kept free-range. Newly calved cows are kept tethered. Subsequently, cows are kept free-range and divided into groups depending on their productivity and stage of lactation. The free-range system is used on both deep and long-term straw bedding. Depending on the housing technology, ADM-100 (milk pipeline) and EuroClass 1200 "Yalynka" milking machines are used for milking cows on the farm.

The calculations were based on data from the farm's zootechnical and breeding records. The results were analyzed using a set of generally accepted methods: a systematic review (introduction and discussion), generalization (interpretation of results), and a zootechnical assessment (evaluation of productivity and reproduction). Heifers were weighed monthly using animal scales. Milk productivity was determined based on the results of monthly control milking of cows. Artificial insemination technicians recorded the dates of fertilization. A veterinarian determined the results of fertilization and the duration of gestation using ultrasound one month after the last fertilization. Cows were induced to calve 60 days before the planned calving date using special preparations (simultaneous induction technology). According to the primary records of cattle, the live weight of animals was calculated for their exact age in months only if the primary data was available within a range of ± 30 days. The change in live weight was considered linear in the calculation. Milk yield was calculated as the sum of monthly milk yields. Monthly milk yield was determined by multiplying the daily milk yield by the number of milking days in the month.

During the dispersion analysis, the data from all first-calf animals were divided into groups. Based on age at fertilization, animals fertilized before 14 months of age were assigned to group I; those fertilized between 14 and 16 months were assigned to group II; and those fertilized after 16 months were assigned to group III. The boundaries of the groups corresponded approximately to ± 0.7 σ. Based on live weight at fertilization, animals weighing up to 370 kg were assigned to group I, animals weighing 370–400 kg were assigned to group II, and animals weighing more than 400 kg were assigned to group III. Only animals with a lactation period of more than 200 days were selected to determine productive indicators for lactation.

The mean (x) and standard deviation (SD) were calculated based on the data. To determine the probability of differences between groups, a one-way analysis of variance was performed. The strength of the influence of factors (η^2) was calculated as the ratio of intergroup variance to total variance, expressed as a percentage. The probability of differences (P) between individual groups was determined using Tukey's a posteriori criterion, and Pearson's criterion (χ^2) was used to compare the probability of survival of first-calf heifers up to 100 days of lactation and the probability of their fertilization after the first calving up to 100 and 200 days of lactation. All calculations were performed using the SPSS-20.0 computer program.

Results

It is important to note that first-calf heifers that calved at an earlier age had better reproductive functions (Table 1). Thus, the service period was 95 days shorter for them compared to the third group. Consequently, the average lactation period for first-calf heifers of different ages at fertilization differed by 102 days. These differences were statistically significant ($P < 0.05$). The most important productivity indicator is milk yield. First-calf heifers that were fertilized at an earlier age had a significantly lower milk yield per lactation than animals in other groups, by 1,326-1,463 kg of milk. The duration of lactation explains this difference. However, differences in milk yield over 305 days of lactation were not significant.

The studies noted different growth rates of the experimental heifers (Table 2). As shown in the table, there were no significant differences in the live weight of animals in the experimental groups at 3 and 6 months of age. By 9 months, however, the live weight of heifers in groups 1 and 3 had already begun to differ significantly. Subsequently, at 12 and 15 months, the live weight of animals in group 1 was 37–60 kg and 33–56 kg higher, respectively, than that of animals in groups 2 and 3. These differences were statistically significant.

Important indicators in cattle breeding are the longevity and fertility of heifers (Table 3).

Table 1

Productive and reproductive qualities of first-calfs depending on age at first fertilization (x ± SD)

Age at first fertilization, months	First lactation				
	n	days	milk yield, kg	milk yield for 305 days, kg	days open
< 14	28	347 ± 93[a]	8033 ± 2203[a]	7016 ± 920[a]	128 ± 98[a]
14–16	40	412 ± 102[ab]	9359 ± 2124[b]	7324 ± 582[a]	196 ± 103[ab]
> 16	26	449 ± 166[b]	9496 ± 2081[b]	7295 ± 547[a]	233 ± 167[b]

Notes: means in each column followed by different letters are significantly different from one another on the results of comparison using the Tukey test ($P < 0.05$).

Table 2

Average growth rates of heifers that had different ages at first fertilization (x ± SD, kg)

Age at first fertilization, months	Body weight at age, months					
	n	3	6	9	12	15
< 14	28	100.0 ± 9.1[a]	164.1 ± 27.0[a]	238.7 ± 29.9[b]	329.7 ± 29.7[c]	405.3 ± 20.7[c]
14–16	40	98.4 ± 8.3[a]	164.8 ± 18.9[a]	226.7 ± 22.0[ab]	292.6 ± 29.5[b]	372.3 ± 32.4[b]
> 16	26	96.0 ± 7.3[a]	153.0 ± 16.2[a]	218.7 ± 25.5[a]	270.4 ± 33.8[a]	348.9 ± 47.4[a]

Note: as in Table 1.

Table 3

Reproductive qualities and longevity of first-calfs depending on age at first fertilization (%)

Age at first fertilization, months	Heifers calved, heads	Longevity of first calving cows up to 100 days of lactation, %	The probability of fertilization during the first	
			100 days of lactation	200 days of lactation
< 14	190	93.1	24.7	38.4
14–16	225	90.6	25.3	47.6
> 16	224	86.7	20.5	44.6
Total	639	90.1	23.5	43.8
The value of the χ^2 criterion		3.720	1.678	3.587
Probability (P)		0.156	0.432	0.166

Thus, the longevity of first-calf heifers in the first 100 days of lactation was slightly higher in animals that were fertilized before 14 months of age. During the same period, animals fertilized before 16 months of age were more likely to become pregnant. However, these differences were not statistically significant. There were no significant differences in the percentage of first-calf heifers inseminated 200 days after calving.

The study examined the productive and reproductive qualities of animals depending on their weight at first fertilization (Table 4). According to Tukey's a posteriori criterion, no significant differences were found in the duration of lactation, milk yield of first-calf heifers, and the duration of the first service period. All subsets, regardless of weight at first fertilization, were homogeneous.

The dynamics of changes in the live weight of heifers that were fertilized with different live weights were considered (Table 5). As shown in the table, at 3, 6, and 9 months of age, there were no significant differences in the live weight of animals in the experimental groups. At 12 months, the weight of heifers in group 1 already differed significantly from groups 2 and 3. Subsequently, at 15 months, the advantage of animals in the first group in terms of live weight increased. The differences between all groups were significant.

Table 4

Productive and reproductive qualities of first-calfs depending on body weight at first fertilization (x ± SD)

Body weight at first fertilization, kg	First lactation				
	n	days	milk yield, kg	milk yield for 305 days, kg	days open
< 370	42	410 ± 105[a]	9384 ± 2249[a]	7375 ± 714[a]	194 ± 103[a]
370–400	33	377 ± 99[a]	8499 ± 2061[a]	7055 ± 756[a]	158 ± 101[a]
> 400	19	437 ± 197[a]	9085 ± 2292[a]	7194 ± 439[a]	224 ± 199[a]

Note: as in Table 1.

Table 5

Average growth rates of heifers that had different body weights at first fertilization (X ± SD), kg

Body weight at first fertilization, kg	Body weight at age, months					
	n	3	6	9	12	15
< 370	42	100.0 ± 8.7[a]	162.0 ± 20.3[a]	223.9 ± 25.6[a]	286.4 ± 35.0[a]	355.4 ± 35.1[a]
370–400	33	96.5 ± 7.3[a]	158.2 ± 23.0[a]	227.5 ± 27.7[a]	302.0 ± 42.5[b]	381.2 ± 40.8[b]
> 400	19	96.7 ± 8.9[a]	165.6 ± 20.8[a]	238.3 ± 23.9[a]	313.4 ± 29.8[b]	410.9 ± 19.4[c]

Note: as in Table 1.

Thus, the survival rate of first-calf heifers in the first 100 days of lactation was slightly higher in animals that were fertilized with a live weight of up to 370 kg (Table 6).

The analysis of the results showed that the differences in the survival of first-calf heifers were not significant. During the 100- and 200-day lactation periods, there was a higher probability of second fertilization of animals that were first fertilized with a higher live weight, but these differences were also not statistically significant.

The next stage of the study was to determine the combined effect of the above factors on the productive and reproductive abilities of first-calf heifers (Table 7). For this purpose, a two-factor analysis of variance was performed. As shown in the table, animals fertilized at

the age of up to 14 months with a live weight of over 370 kg had the shortest lactation and service periods. The best milk yield for 305 days of lactation was observed in first-calf heifers inseminated at the age of up to 14 months with a live weight of over 400 kg. The longest first service period was observed in late-fertilized heifers. However, no significant combined effect of age and live weight at the first fertilization was found. No significant differences were found using Tukey's a posteriori criterion in terms of lactation duration, first-calf heifer milk yield, and first service period duration. All subsets, regardless of age and weight at the first fertilization, were homogeneous.

Table 6

Reproductive qualities and longevity of first-calfs depending on body weight at first fertilization, %

Body weight at first fertilization, kg	Heifers calved, heads (n)	Longevity of first calving cows up to 100 days of lactation, %	The probability of fertilization during the first	
			100 days of lactation	200 days of lactation
< 370	173	93.1	16.8	34.1
370–400	181	90.6	28.7	45.9
> 400	181	86.7	27.1	49.7
Total	535	90.1	24.3	43.4
The value of the χ^2 criterion		4.044	8.029	9.479
Probability (P)		0.132	0.18	0.09

Table 7

Productive and reproductive qualities of first-calfs depending on age and body weight at first fertilization (x ± SD)

First fertilization		First lactation				
age, months	body weight, kg	n	days	milk yield, kg	milk yield for 305 days, kg	days open
< 14	< 370	32	377 ± 105[a]	8398 ± 1919[a]	7146 ± 795[a]	157 ± 114[a]
	370–400	29	348 ± 93[a]	7820 ± 2110[a]	6811 ± 855[a]	121 ± 89[a]
	> 400	3	340 ± 64[a]	8106 ± 660[a]	7604 ± 203[a]	122 ± 68[a]
14-16	< 370	37	437 ± 129[a]	9707 ± 2656[a]	7263 ± 757[a]	213 ± 125[a]
	370–400	30	373 ± 108[a]	8099 ± 1822[a]	6988 ± 691[a]	139 ± 96[a]
	> 400	23	350 ± 70[a]	8047 ± 1328[a]	7182 ± 622[a]	131 ± 75[a]
> 16	< 370	8	453 ± 106[a]	9804 ± 1955[a]	7407 ± 630[a]	205 ± 108[a]
	370–400	16	396 ± 83[a]	8660 ± 1670[a]	7031 ± 612[a]	180 ± 79[a]
	> 400	54	369 ± 133[a]	8044 ± 1993[a]	6990 ± 766[a]	150 ± 126[a]

Note: as in Table 1.

In terms of average growth rates, the combined effect of the initial fertilization parameters was 18.9%, which was significant for the live weight of heifers at 15 months of age (Table 8).

Significant differences in weight were found using the Tukey *a posteriori* criterion from 6 months of age onwards. The difference in weight between groups increased with the age of the animals. Heifers that were fertilized at less than 14 months of age had the highest growth rate. For animals with a live weight of up to 370 kg, the average daily gain was 800 g; for animals with a live weight of 370–400 kg, it was 835 g; and for animals with a live weight of more than 400 kg, it was 913 g.

Table 8

Average growth rates of heifers that had different ages and body weights at first fertilization (x ± SD, kg)

First fertilization		Body weight at age, months					
age, months	age, months	n	3	6	9	12	15
< 14	< 370	81	97.3 ± 7.7[a]	160.1 ± 17.6[abc]	225.9 ± 21.1[bc]	319.8 ± 24.4[cd]	392.1 ± 14.6[c]
	370–400	55	96.9 ± 8.0[a]	163.2 ± 20.7[bc]	237.5 ± 22.8[cd]	341.9 ± 25.1[d]	414.3 ± 15.6[d]
	> 400	4	95.4 ± 5.1[a]	171.8 ± 35.0[c]	256.0 ± 20.2[d]	380.0 ± 26.1[e]	456.3 ± 9.8[e]
14–16	< 370	47	96.4 ± 7.4[a]	159.0 ± 17.4[abc]	215.0 ± 20.5[ab]	280.3 ± 23.6[b]	352.1 ± 19.6[b]
	370–400	80	95.3 ± 7.4[a]	156.6 ± 16.6[abc]	220.4 ± 19.8[abc]	300.5 ± 21.1[bc]	388.2 ± 16.5[c]
	> 400	42	95.6 ± 9.1[a]	160.4 ± 19.6[abc]	233.7 ± 22.4[bc]	322.4 ± 36.3[cd]	418.7 ± 19.8[d]
> 16	< 370	12	97.0 ± 7.2[a]	150.6 ± 14.9[ab]	213.8 ± 26.1[ab]	258.6 ± 20.9[a]	316.2 ± 26.9[a]
	370–400	32	92.3 ± 7.4[a]	142.8 ± 16.0[a]	203.0 ± 30.4[a]	257.2 ± 23.1[a]	340.6 ± 24.6[b]
	> 400	110	94.9 ± 8.0[a]	151.1 ± 18.8[ab]	215.0 ± 27.2[ab]	296.1 ± 35.3[b]	383.1 ± 31.9[c]

Note: as in Table 1.

Discussion

The economic efficiency of dairy farming hinges on properly raising replacement heifers to reach their optimal live weight, at which point they can successfully realize their biological potential for high milk yield. In global cattle farming, the most economically viable model is generally accepted to be fertilizing heifers for the first time at 15 to 18 months of age and calving them for the first time at 24.5 to 27.5 months of age (Stankov, 2020). Reducing the age of first fertilization decreases the cost of raising dairy heifers and increases the economic efficiency of milk production (Silva et al., 2015; Chebel & Cunha, 2020). However, low reproduction rates slow down herd renewal, reducing the possibility of selection based on key breeding traits (Tippenhauer et al., 2023). On commercial dairy farms, infertility is one of the primary reasons cows are culled, along with health issues and low milk production (Dallago et al., 2021; Lopez-Gatius, 2022).

Therefore, when using intensive technology to raise replacement heifers, it is important to consider their physiological characteristics. Our research has shown that there were no significant differences in live weight between the experimental groups at 3 and 6 months of age. However, at nine months, the live weight of the heifers in groups one and three differed significantly. Subsequently, the live weight of the animals in group 1 increased by 37-60 kg and 33-56 kg at 12 and 15 months, respectively. These results confirm that higher productivity in the first and second lactations can be achieved by raising heifers to a higher body weight. Previous studies have found a positive relationship between live body weight before calving and milk production during the first lactation (Eetvelde et al., 2017). New Zealand scientists have identified the potential to increase first-lactation milk production by increasing heifer body weight, as well as the greater milk production potential of balanced feeding of lighter heifers to achieve greater body weight before calving (Hancock et al., 2019; Martin et al., 2020). Economic analyses in other studies also confirmed that larger, well-grown heifers were more profitable due to their greater productive potential (Busanello et al., 2022). Heifers with growth retardation at any time during their first year were characterized by an older age at first calving, a lower live weight during their first year of life, and a lower milk production during their first lacta-

tion and lifetime (Polupan et al., 2023; Polupan & Pryima, 2024). However, other studies have shown that accelerated heifer rearing does not always affect lifetime milk production (Krpálková et al., 2014; Salte et al., 2020). In our studies, first-calf heifers tended to produce more milk with increased live weight gain at fertilization.

Previous studies have found a positive relationship between live body weight before calving and milk production during the first lactation period (McNaughton et al., 2013; Eetvelde et al., 2017).

Our research established the shortest lactation and service periods for animals fertilized at up to 14 months of age with a live weight exceeding 400 kg. These animals also had the highest milk yield for 305 days of lactation. Heifers of the Ayrshire breed that were fertilized before reaching 14 months of age experienced a first service period that was 95 days shorter than that of animals that were fertilized after reaching 16 months of age. Other studies have demonstrated the economic feasibility of inseminating heifers between 14 and 18 months of age and well-developed heifers between 12 and 13 months. This has a positive effect on the reproductive capacity and milk productivity of cows (Sharapa et al., 2022). Previous studies have found that heavier heifers at 6, 12, and 15 months were more likely to remain in the herd for their first, second, and third calving. They also calved earlier for their first calving compared to lighter heifers, regardless of breed group (Hancock et al., 2020). The longest first service period was characteristic of late-fertilized heifers with high live weights ($P > 0.05$).

Daily live weight gain is the decisive factor for effectively breeding productive dairy heifers (Chester-Jones et al., 2017), and it significantly affects milk yield. Our research confirmed that heifers fertilized at less than 14 months of age had the highest growth rate. Animals with a live weight of up to 370 kg had an average daily gain of 800 g; those with a live weight between 370 and 400 kg had an average daily gain of 835 g; and those with a live weight greater than 400 kg had an average daily gain of 913 g.

Thus, rearing replacement heifers and understanding the relationship between animal growth, development, and subsequent production characteristics lays the foundation for improving overall farm management strategies.

Conclusion

Timely breeding and calving of replacement heifers is crucial for future milk production. Our research has shown that there were no significant differences in live weight at three and six months of age between the experimental groups when raising heifers. However, at nine months, the live weight of heifers in groups one and three differed significantly. Subsequently, the live weight of the first group increased by 37–60 kg and 33–56 kg at 12 and 15 months, respectively. The first-service period was 95 days shorter for first-calf Ayrshire heifers that were fertilized before 14 months of age compared to those fertilized after 16 months. Animals that were fertilized before 14 months of age and had a live weight of over 400 kg had the shortest lactation and service periods. These animals also produced the most milk over the course of 305 days of lactation. Therefore, when raising replacement heifers, it is crucial to consider their growth and development to maximize reproductive capacity and genetic productivity.

The authors have no conflicts of interest regarding the authorship and publication of this paper.

References

Admin, O., Admina, N., Paliy, A., Petrov, R., Nagorna, L., & Kovalenko, L. (2024). Influence of growth intensity of black and white dairy cattle on their reproduction and productivity under free housing. Regulatory Mechanisms in Biosystems, 15(3), 469–476.

Admin, O., Admina, N., Paliy, A., Risovani, V., Pavlichenko, O., Panasenko, O,. Fotina, H., & Kovalenko, L. (2025). Dependence of milk productivity and reproductive capacity of cows on their growth intensity under different conditionsof maintenance. Regulatory Mechanisms in Biosystems, 16(3), e25098.

Archbold, H., Shalloo, L., Kennedy, E., Pierce, K. M., & Buckley, F. (2012). Influence of age. body weight and body condition score before mating start date on the pubertal rate of maiden Holstein-Friesian heifers and implications for subsequent cow performance and profitability. Animal, 6, 1143–1151.

Aseged, T., Getachew, T., Banerjee, S., Belayhun, T., Melak, A., Engdawork, A., Kefyalew, E., Assefa, A., & Hailu, A. (2023). Production systems and breeding practices of Begaria cattle breed as input for a community-based breeding program. Heliyon, 9, 21963.

Bach, A. (2011). Associations between several aspects of heifer development and dairy cow survivability to second lactation. Journal of Dairy Science, 94(2), 1052–1057.

Berry, D., & Cromie, A. (2009). Associations between age at first calving and subsequent performance in Irish spring calving Holstein-Friesian dairy cows. Livestock Science, 123, 44–54.

Busanello, M., Sousa, D. G., Poczynek, M., de Almeida, R.. Bittar, C. M. M., Mendonça, F. A C., & Lanna, D. P. D. (2022). Body growth of replacement dairy heifers from 3 distinct genetic groups from commercial Brazilian dairy herds. Journal of Dairy Science, 105, 3222–3233.

Castillo-Badilla, G., Vargas-Leitón, B., Hueckmann-Voss, F., & Romero-Zúñiga, J. (2019). Factores que afectan la producción en primera lactancia de vacas lecheras de Costa Rica. Agronomía Mesoamericana, 30(1), 209–227.

Chebel, R. C., & Cunha, T. (2020). Optimization of timing of insemination of dairy heifers inseminated with sex-sorted semen. Journal of Dairy Science, 103(6), 5591–5603.

Chester-Jones, H., Heins, B. J., Ziegler, D., Schimek, D., Schuling, S., Ziegler, B., de Ondarza, M. B., Sniffen, C. J., & Broadwate, N. (2017). Relationships between early-life growth, intake, and birth season with first-lactation performance of Holstein dairy cows. Journal of Dairy Science, 100, 3697–3704.

Cooke, J., Cheng, Z., Bourne, N., & Wathes, D. (2013). Association between growth rates, age at first calving and subsequent fertility, milk production and survival in Holstein-Friesian heifers. Open Journal of Animal Sciences, 3, 1–12.

Dallago, G. M., Wade, K. M., Cue, R. I., McClure, J. T., Lacroix, R., Pellerin, D., & Vasseur, E. (2021). Keeping dairy cows for longer: A critical literature review on dairy cow longevity in high milk-producing countries. Animals, 11(3), 808.

Dias, H. R. S., Camargo, A. J. D. R., Oliveira, G. F., Mourão, A. M., Saraiva, N. Z., Camargo, L. S. A., Müller, M. D., Martins, C. E., Nogueira, L. A. G., Brandão, F. Z., & Oliveira, C. S. (2023). Reproductive development of dairy heifers in an integrated livestock-forest system during the summer. Animal Reproduction, 20(3), e20230100.

Do, C., Wasana, N., Cho, K., Choi, Y., Choi, T., Park, B., & Lee, D. (2013). The effect of age at first calving and calving interval on productive life and lifetime profit in Korean Holsteins. Asian-Australasian Journal of Animal Sciences, 26, 1511–1517.

Duplessis, M., Cue, R. I., Santschi, D. E., Lefebvre, D. M., & Lacroix, R. (2015). Weight, height, and relative-reliability indicators as a management tool for reducing age at first breeding and calving of dairy heifers. Journal of Dairy Science, 98(3), 2063–2073.

Eetvelde, M., Kamal, M. M., Vandaele. L., & Opsomer, G. (2017). Season of birth is associated with first-lactation milk yield in Holstein Friesian cattle. Animal, 11, 2252–2259.

Ettema, J., & Santos, J. (2004). Impact of age at calving on lactation, reproduction, health, and income in first-parity Holsteins on commercial farms. Journal of Dairy Science, 87, 2730–2742.

Fodor, I., Lang, Z., & Ózsvári, L. (2019). Relationship of dairy heifer reproduction with survival to first calving, milk yield and culling risk in the first lactation. Asian-Australasian Journal of Animal Sciences, 33(8), 1360–1368.

Freetly, H. C., Cushman, R. A., & Bennett, G. L. (2021). Production performance of cows raised with different postweaning growth patterns. Translational Animal Science, 5(3), txab031.

Froidmont, E., Mayeres, P., Picron, P., Turlot, A., Planchon, V., & Stilmant, D. (2013). Association between age at first calving, year and season of first calving and milk production in Holstein cows. Animal, 7(4), 665–672.

Han, L., Heinrichs, A. J., De Vries, A., & Dechow, C. D. (2021). Relationship of body weight at first calving with milk yield and herd life. Journal of Dairy Science, 104(1), 397–404.

Handcock, R. C., Lopez-Villalobos, N., Back, P. J., Hickson, R. E., & McNaughton, L. R. (2021). Growth, milk production, reproductive performance, and stayability of dairy heifers born from 2-year-old or mixed-age dams. Journal of Dairy Science, 104(11), 11738–11746.

Handcock, R. C., Lopez-Villalobos, N., McNaughton, L. R., Back, P. J., Edwards, G. R., & Hickson, R. E. (2019). Positive relationships between body weight of dairy heifers and their first-lactation and accumulated three-parity lactation production. Journal of Dairy Science, 102, 4577–4589.

Handcock, R. C., Lopez-Villalobos, N., McNaughton, L. R., Back, P. J., Edwards, G. R., & Hickson, R. E. (2020). Body weight of dairy heifers is

positively associated with reproduction and stayability. Journal of Dairy Science, 103, 4466–4474.
Hawkins, A., Burdine, K. H., Amaral-Phillips, D. M., & Costa, J. H. C. (2020). Effects of housing system on dairy heifer replacement cost from birth to calving: evaluating costs of confinement, dry-lot, and pasture-based systems and their impact on total rearing investment. Frontiers in Veterinary Science, 7, 625.
Heinrichs, A. J., Zanton, G. I., Lascano, G. J., & Jones, C. M. (2017). A 100-year review: A century of dairy heifer research. Journal of Dairy Science, 100(12), 10173–10188.
Hindman, M. S., Huedepohl, B., Dewell, G. A., Brick, T. A., Silva, G. S., & Engelken, T. J. (2022). Physical traits and reproductive measurements associated with early conception in beef replacement heifers. Animals, 12(15), 1910.
Krpálková, L., Cabrera, V., Kvapilík, J., Burdych, J., & Crump, P. (2014). Associations between age at first calving, rearing average daily weight gain, herd milk yield and herd dairy production, reproduction, and profitability. Journal of Dairy Science, 97, 6573–6582.
Kusaka, H., Yamazaki, T., & Sakaguchi, M. (2022). Association of the age and bodyweight at first calving with the reproductive and productive performance in one herd of Holstein dairy heifers in Japan. Veterinary Record Open, 9(1), 44.
Le-Cozler, Y., Lollivier, V., Lacasse, P., & Disenhaus, C. (2008). Rearing strategy and optimizing first-calving targets in dairy heifers: A review. Animals, 2, 1393–1404.
López-Gatius, F. (2022). Revisiting the timing of insemination at spontaneous estrus in dairy cattle. Animals, 12(24), 3565.
Martin, N. P., Hickson, R. E., Clifford, de R. P., Tulley, W., Lopez-Villalobos, N., & Back, P. J. (2020). Production benefits from meeting liveweight targets in dairy heifers. New Zealand Journal of Agricultural Research, 63, 220–232.
Masello, M., Perez, M. M., Granados, G. E., Stangaferro, M. L., Ceglowski, B., Thomas, M. J., & Giordano, J. O. (2021). Effect of reproductive management programs for first service on replacement dairy heifer economics. Journal of Dairy Science, 104(1), 471–485.
McNaughton, L. R., & Lopdell, T. (2013). Effect of heifer live weight on calving pattern and milk production. Proceedings of the New Zealand Society of Animal Production, 73, 103–107.
Paliy, A., Aliiev, E., Nanka, A., Bogomolov, O., Bredixin, V., Paliy, A., Shkromada, O., Musiienko, Y., Stockiy, A., & Grebenik, N. (2021). Identifying changes in the technical parameters of milking rubber under industrial conditions to elucidate their effect on the milking process. Eastern-European Journal of Enterprise Technologies, 3(1), 21–29.
Paliy, A., Naumenko, A., Paliy, A., Zolotaryova, S., Zolotarev, A., Tarasenko, L., Nechyporenko, O., Ulko, L., Kalashnyk, O., & Musiienko, Y. (2020). Identifying changes in the milking rubber of milking machines during testing and under industrial conditions. Eastern-European Journal of Enterprise Technologies, 107, 127–137.
Polupan, Y. P., & Pryima, S. V. (2024). The influence of growth retardation of heifers to yearling age on the milk productivity of cows. Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies. Series: Agricultural Sciences, 26(101), 67–74.
Polupan, Y., Stavetska, R., Melnyk, Y., & Siryak, V. (2023). Influence of growth retardation of heifers on the development, production, duration and efficiency of productive lifespan of dairy cows. Veterinarija ir Zootechnika, 81(2), 36–43.
Salte, R., Storli, K. S., Wærp, H. K. L., Sommerseth, J. K., Prestløkken, E., & Klemetsdal, G. (2020). Designing a replacement heifer rearing strategy: Effects of growth profile on performance of Norwegian Red heifers and cows. Journal of Dairy Science, 103, 10835–10849.
Sawa, A., Siatka, K., & Krężel-Czopek, S. (2018). Effect of age at first calving on first lactation milk yield, lifetime milk production, and longevity of cows. Annals of Animal Science, 19, 189–200.
Serrenho, R. C. (2024). Challenging the norm: What is the perfect time to start inseminating dairy heifers? American Association of Bovine Practitioners Conference Proceedings, 57(2), 74–78.
Sharapa, H. S., Boiko, O. V., & Demchuk, S. Y. (2022). Reproductive ability and productivity of cows for three lactations, depending on the age of conception of heifers. Animal Breeding and Genetics, 63, 185–190.
Silva, T. V., Lima, F., Thatcher, W., & Santos, J. (2015). Synchronized ovulation for first insemination improves reproductive performance and reduces cost per pregnancy in dairy heifers. Journal of Dairy Science, 98(11), 7810–7822.
Stankov, K. (2020). Influence of the age of first insemination and first calving in Holstein-Friesian heifers on farm economic efficiency. Agricultural Science and Technology, 12(4), 379–383.
Tippenhauer, C. M., Plenio, J. L., Madureira, A., Heuwieser, W., & Borchardt, S. (2023). Timing of artificial insemination using sexed or conventional semen based on automated activity monitoring of estrus in Holstein heifers. Animals, 13(19), 2994.
Van Amburgh, M. E., Soberon, F., Meyer, M. J., & Molano, R. A. (2021). Integrating concepts mammary development, growth and nutrient requirements to describe productivity outcomes in dairy heifers. WCDS Advances in Dairy Technology, 33, 53–63.
Vargas-Leitón, B., Romero-Zúñiga, J., Castillo-Badilla, G., & Saborío-Montero, A. (2023). Optimal age at first calving in pasture-based dairy systems. Dairy, 4(4), 581–593.
Voitenko, S. L., Hladii, M. V., Porkhun, M. H., Sydorenko, O. V., & Tsybenko, V. H. (2021). Ayrshire breed in the conditions of Ukraine. Animal Breeding and Genetics, 62, 21–30.
Wathes, D. C., Brickell, J. S., Bourne, N. E., Swali, A., & Cheng, Z. (2008). Factors influencing heifer survival and fertility on commercial dairy farms. Animal, 2(8), 1135–1143.
Zipp, K., & Knierim, U. (2020). Physical development, ease of integration into the dairy herd and performance of primiparous dairy cows reared with full whole-day, half-day or no mother-contact as calves. The Journal of Dairy Research, 87, 154–156.