



Dependence of milk productivity and reproductive capacity of cows on their growth intensity under different conditions of maintenance

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The growth rate of replacement heifers significantly impacts their reproductive capacity and subsequent milk production. Therefore, breeding methods should be evidence-based to maximize the productivity of animals throughout their lives. To study this issue, we analyzed the zootechnical records of dairy cattle breeding enterprises in the Kharkiv and Poltava regions of Ukraine. We found that production technology on a particular farm most influenced heifer growth intensity. The influence of the "farm" factor on heifers' live weight at 3 months of age was 6.4%; at 6 months, 3.8%; at 9 months, 6.1%; at 12 months, 7.0%; and at 15 months, 13.2%. The youngest age at first insemination was observed in heifers from the Kutuzivka and Stepne farms due to their accelerated growth. Heifers from the "Gontarivka" and "Agroprogress" farms were inseminated later (after 3 months). Except for the SE RF "Named after Decabrysty", all farms showed a tendency to reduce the service period duration with an increase in lactations. This indicates similar selection methods on these farms. The results of the study showed that animals with the greatest live weight gain were significantly younger at first insemination. The milk yield of first-born heifers positively correlated with live weight at 15 months of age. The early maturity of replacement heifers contributes to the intensive reproduction of the herd and increases the profitability of dairy farming. Further research should determine the effect of growth intensity on cow fertility and calf survival.

Keywords: heifers; cows; body weight; lactation; productivity; reproduction.

Introduction

The primary objective of agricultural production is to supply the population with high-quality products (Geletu et al., 2021; Rueda-García et al., 2024). Dairy farming is the primary agricultural sector in many leading countries (Paliy et al., 2020; Ventura et al., 2021; Kuipers et al., 2024). Replacement heifers are essential for the future productivity and profitability of dairy herds (Eastham et al., 2018; Overton & Dhuyvetter, 2020). Rearing replacement heifers accounts for approximately 15–20% of total farm investments, making it the second largest cost on a dairy farm (Sommerseh et al., 2024). Daily weight gain is a decisive factor in the effective breeding of productive dairy heifers and significantly affects milk yield during the first lactation (Chester-Jones et al., 2017). Furthermore, an increase of every 0.1 kg is associated with an increase in milk yield of 85–113 kg during the first lactation (Soberon et al., 2012). While this finding has not always been replicated in similar studies (Davis Rincker et al., 2011; Kiezebrink et al., 2015), it has been concluded that increasing daily pre-weaning live weight gain above 0.5 kg/day can improve the efficiency of the first lactation (Gelsing et al., 2016). Ukrainian researchers also found that, at 12–15 months of age, animals with a growth rate similar to that of the average herd, with deviations within ± 0.5 standard deviation, had a long productive period (Klimkovetskyi, 2020). Other studies have demonstrated that achieving higher live weight gains before sexual maturity results in lower ages at first calving and positively affects milk yield during the first lactation. Additionally, there is a negative relationship between the frequency of inseminating heifers before first calving and achieving higher live weight gains before sexual maturity (Vacek et al., 2015). Heifers with growth retardation at any time during the first year were

characterized by an older age at first calving (4.7–7.9%, depending on when growth retardation occurred), a lower live weight during the first year of life (4.1–24.4%), and lower milk productivity during the first lactation (lower milk yield by 6.1–13.2%, lower milk fat yield by 7.4–13.1%, and lower milk protein yield by 8.7–17.3%) and lifetime milk productivity (lifetime milk yield by 12.1–25.9%, milk fat + milk protein by 13.1–26.3%) (Polupan et al., 2024). However, other studies indicate that accelerated heifer rearing does not always affect lifetime milk production (Krpalkova et al., 2014; Salte et al., 2020).

The body weight of a mature cow is an important factor associated with dairy heifer growth (Zimmermann et al., 2021; Busanello et al., 2022). Economic analyses have shown that larger, well-bred heifers are more profitable due to their greater productive potential (Snelling et al., 2019). Body weight at mating is associated with the subsequent calving date, the subsequent live weight of the cow, and the milk fat and protein yield (Archbold et al., 2012). Previous studies have found a positive relationship between pre-calving body weight and milk production during the first lactation (McNaughton & Lopdell, 2013; Eitelde et al., 2017). These results support the conclusion 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 raising heifer body weight. They also suggest that balanced feeding of lighter heifers before calving could lead to greater milk production (Handcock et al., 2019; Martin et al., 2020). Other studies have shown a positive relationship between the live weight of replacement heifers and their reproduction and resistance to negative factors (Handcock et al., 2020).

The age at first calving is also an important determinant of herd productivity, with optimal future cow productivity. In herds with ma-

nagement that ensures adequate body size and body condition assessment at both insemination and calving, a first calving age of less than 23 months is recommended for best subsequent productivity and reproduction (Krpálková et al., 2014). Other studies indicate that animals that first calved between 22 and 26 months of age had more lactations and productive days in their lifetime. They also had higher milk production in the first and second lactations and throughout their lives (Froidmont et al., 2013). Norwegian scientists also recommend planning the age of first calving at 22 months (Salte et al., 2020). Comparing the connection between the age of first calving and productivity and fertility traits, other scientists have found that lowering the age of first calving correlated with higher fertility and greater milk yield (Hutchison et al., 2017). In addition, the survival rate of herds calving at a younger age increased because the cow continued to have good fertility (Wathes et al., 2014). Poor growth, health, and nutrition during the growing period often lead to an increase in the age at first calving, primarily due to their negative impact on heifer fertility (Wathes et al., 2008). Conversely, calving too early has been linked to an increased risk of dystocia, as well as reduced milk yield, quality, and reproductive performance. A higher age at first calving is associated with a higher percentage of milk fat and a lower percentage of milk protein (Ghavi Hossein-Zadeh, 2011).

Thus, analysis of the literature shows that there is no consensus on whether the reproductive capacity and productivity of cows depend on their growth rate. The purpose of this study was therefore to determine and compare this dependence under different milk production technologies.

Materials and methods

The work was carried out on the basis of dairy cattle breeding enterprises: private enterprise (PE) "Agroprogress", state enterprise research farm (SE RF) "Kutuzivka" and "Gontarivka" in Kharkiv region, as well as SE RF "Named after Decabrysty" and "Stepne" in Poltava region of Ukraine. At the SE RF "Kutuzivka" dairy complex, the animals are kept on free-range, long-lasting straw bedding. The cows are

milked in a hall using a Yalynka milking machine. At the SE RF "Named after Decabrysty" farm, both free-range and stall housing are used. The other farms use stall housing. The milk yield per cow during the review period was over 6,000 kg.

The calculations used data from the farms' zootechnical and breeding records. The live weight of heifers was converted to the exact age in months. The results were analyzed using a set of generally accepted methods: systematic review (introduction and discussion), generalization (interpretation of results), and zootechnical (assessment of productivity, reproduction).

The mean and standard error of the mean ($x \pm SE$) were calculated for the data obtained. A one-factor analysis of variance was performed to determine the probability of differences between the groups. The strength of influence of the factors was calculated as the ratio of the intergroup variance to the total variance, expressed as a percentage. The probability of differences between individual groups was determined by the a posteriori Tukey test. Correlation and regression coefficients (r_{xy}) were calculated to establish dependencies. The regression analysis used the stepwise inclusion method, which provides for F-inclusion only of variables with a probability level ≤ 0.05 and F-exclusion ≥ 0.1 . We also used the squared values of the variables to determine possible nonlinearities in the relationships.

Results

The growth dynamics of heifers in different farms had its own characteristics. Thus, the differences between the maximum and minimum average live weight at 3 months of age were 10.0 kg, at 6 months of age – 16.8 kg, at 9 months of age – 28.6 kg, at 12 months of age – 31.4 kg, and at 15 months of age – 61.2 kg. It is important to note that the lowest average live weight, starting from 6 months of age, was in heifers of PE "Agroprogress". At 15 months of age, heifers of SE RF "Kutuzivka" and SE RF "Stepne" prevailed in body weight, although at 3 months of age these animals had the lowest weight (Table 1).

Table 1
Growth intensity of heifers

Farm	Live weight (kg) at the age of, months									
	3		6		9		12		15	
	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$
PE "Agroprogress"	1793	88.9 \pm 0.3 ^c	1610	139.8 \pm 0.6 ^a	1585	190.5 \pm 0.7 ^a	1506	249.5 \pm 0.8 ^a	1576	306.2 \pm 1.0 ^a
SE RF "Named after Decabrysty"	1291	89.5 \pm 0.3 ^c	1217	150.5 \pm 0.7 ^b	1251	210.2 \pm 0.9 ^b	1158	276.6 \pm 1.2 ^b	1009	344.1 \pm 1.3 ^b
SE RF "Gontarivka"	1111	90.7 \pm 0.4 ^d	1121	156.6 \pm 0.6 ^c	1109	217.9 \pm 0.9 ^d	1173	279.8 \pm 1.0 ^b	1027	341.2 \pm 1.3 ^b
SE RF "Kutuzivka"	4950	84.8 \pm 0.1 ^b	4755	151.6 \pm 0.4 ^b	4705	213.4 \pm 0.6 ^c	4634	284.6 \pm 0.8 ^c	4460	363.1 \pm 1.0 ^c
SE RF "Stepne"	1461	80.7 \pm 0.3 ^a	1409	151.5 \pm 0.5 ^b	1464	219.1 \pm 0.7 ^d	1448	290.9 \pm 0.9 ^d	1445	367.4 \pm 1.1 ^c

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

The share of the influence of the factor "farm" on the live weight of heifers at 3 months of age was 6.4%, at 6 months – 3.8%, at 9 months – 6.1%, at 12 months – 7.0%, and at 15 months – 13.2%.

The lowest age of first insemination was observed in heifers of SE RF "Kutuzivka" and SE RF "Stepne" due to the higher intensity of their rearing. The heifers of SE RF "Gontarivka" and PE "Agropro-

gress" were inseminated later (more than 3 months). As for the service period, the shortest duration for all lactations was inherent in the SE RF "Kutuzivka" cows. On all farms, except for SE RF "Named after Decabrysty", there was a tendency to decrease the duration of the service period with an increase in the lactation number. This indicates the same selection methods on these farms (Table 2).

Table 2
Reproductive capacity of animals

Farm	Age of first insemination, days		Service period duration, days							
			first		second		third		fourth	
	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$	n	$x \pm SE$
PE "Agroprogress"	1634	590.7 \pm 3.0 ^c	1201	161.0 \pm 2.9 ^{ab}	793	154.6 \pm 3.3 ^a	455	150.6 \pm 4.0 ^c	199	142.3 \pm 5.5 ^a
SE RF "Named after Decabrysty"	1625	543.9 \pm 3.0 ^b	1280	210.0 \pm 3.4 ^c	850	181.1 \pm 3.6 ^b	460	172.2 \pm 4.6 ^d	192	193.4 \pm 8.1 ^b
SE RF "Gontarivka"	1687	596.9 \pm 2.7 ^c	1203	168.2 \pm 3.2 ^b	702	146.9 \pm 3.5 ^a	365	141.5 \pm 4.4 ^{ab}	169	151.2 \pm 7.9 ^a
SE RF "Kutuzivka"	3906	506.6 \pm 1.4 ^a	2299	151.1 \pm 2.2 ^a	1235	147.2 \pm 2.7 ^a	576	129.9 \pm 3.5 ^a	214	129.9 \pm 4.9 ^a
SE RF "Stepne"	1439	507.8 \pm 2.2 ^a	973	168.5 \pm 3.5 ^b	665	155.5 \pm 4.0 ^a	414	141.7 \pm 4.4 ^{ab}	229	131.8 \pm 5.8 ^a

Notes: as in Table 1.

The most significant factor influencing the age of first insemination of heifers was production technology on the farm, accounting for 12.6% of the variation. Differences in the duration of the service peri-

od were attributable to this factor, ranging from 3.4% to 6.1%. There were significant differences in cow milk yields over 305 days of lactation and in fat content in milk across different farms. The milk yield

exhibited a variation of 8.3% to 14.2%, depending on the production conditions, and the percentage of fat in milk demonstrated a range of 28.7% to 43.7%, varying according to the age of the cows. Differences between the maximum and minimum average milk yield in the

first lactation were 1424 kg, in the second – 1629 kg, and in the third – 1921 kg, and in the percentage of fat – 0.51%, 0.43%, and 0.44%, respectively (Table 3).

Table 3
Milk productivity of cows

Farm	Lactation								
	first		second				third		
	n	milk yield for	fat content,%	n	milk yield for	fat content,%	n	milk yield for	fat content,%
		305 days, kg	x ± SE		305 days, kg	x ± SE		305 days, kg	x ± SE
PE "Agroprogress"	1179	6460 ± 35 ^b	3.56 ± 0.01 ^b	758	7009 ± 53 ^b	3.59 ± 0.01 ^a	438	7160 ± 70 ^c	3.65 ± 0.01 ^a
SE RF "Named after Decabrysty"	1247	6623 ± 51 ^c	3.95 ± 0.01 ^c	749	7314 ± 30 ^c	3.95 ± 0.01 ^c	423	7483 ± 43 ^d	3.95 ± 0.01 ^c
SE RF "Gontarivka"	1344	5668 ± 28 ^a	4.01 ± 0.01 ^d	816	6168 ± 4 ^a	4.02 ± 0.01 ^d	435	6252 ± 64 ^a	4.03 ± 0.02 ^d
SE RF "Kutuzivka"	2496	6479 ± 31 ^b	3.69 ± 0.01 ^c	1390	7048 ± 52 ^b	3.71 ± 0.01 ^b	637	6712 ± 84 ^b	3.72 ± 0.01 ^b
SE RF "Stepne"	1049	7092 ± 31 ^d	3.50 ± 0.01 ^a	715	7797 ± 50 ^d	3.59 ± 0.01 ^a	442	8173 ± 72 ^c	3.61 ± 0.01 ^a

Notes: as in Table 1.

Changes in cow milk yield over 305 days of lactation due to their age in different farms had their characteristics. Thus, the milk yield of PE "Agroprogress" cows in the second lactation was 108.5%, and in the third lactation, 110.8% compared to the first lactation. In the animals of SE RF "Named after Decabrysty", milk production increased by 10.4% and 13.0%, SE RF "Gontarivka" – by 8.8% and 10.3%, SE RF "Kutuzivka" – by 8.7% and 3.6%, and SE RF "Stepne" – by 9.9% and 15.2%, respectively. As for the age-related changes in fat content in cow milk, on all farms, except for SE RF "Named after Decabrysty", it slightly increased.

Thus, the farms had differences in the technology of keeping and feeding animals, as well as in the methods of breeding work with the herd, which led to some differences, namely in the growth of repair heifers and the age of their first insemination, reproduction, and productivity indicators. Next, the correlations between the live weight of heifers at different ages and the indicators of their subsequent reproduction were considered (Tables 4–8). The age of first insemination of heifers had a weak negative relationship with their live weight at three months. The values of the correlation coefficient were significant for all farms. The highest value was obtained from SE RF "Gontarivka", and the lowest from PE "Agroprogress". The first service period had a very low positive correlation in PE "Agroprogress" and a weak negative correlation in SE RF "Gontarivka". The values of the correlation coefficients of heifer weight at three months with service periods in other calculations were unreliable.

The strength of the relationship between the age of first insemination and live weight of heifers determined at an older age increased with age. Thus, the values of the correlation coefficients determined

for heifers of PE "Agroprogress" at 6 months of age differed by 0.109, at 9 months by 0.187, at 12 months by 0.287, and at 15 months by 0.385 relative to 3 months of age. For SE RF "Named after Decabrysty" animals, the differences were: 0.100, 0.204, 0.229, and 0.276, SE RF "Kutuzivka" – 0.225, 0.293, 0.374, and 0.403, SE RF "Stepne" – 0.104, 0.218, 0.234, and 0.264, respectively. Only SE RF "Gontarivka" did not show the above-mentioned increase in the strength of connection.

We found weak probable correlations between live weight at 12 months and the duration of the first service period in animals of SE RF "Kutuzivka" and SE RF "Stepne" and the fourth service period in the latter farm. Also, a weak relationship was observed between live weight at 15 months and the duration of the first service period in animals of SE RF "Kutuzivka". In other cases, the service period did not depend on the weight of the animals during rearing.

According to the data of the experimental farms, a significant positive correlation between the age of first insemination of heifers and the duration of the first service period was found. However, the strength of the correlation is very low. The duration of other service periods did not depend on the age of first insemination (Table 9). It should be noted that the established dependencies indicate an increase in the first service period in cows that calved at an older age.

The correlation coefficients between the live weight of heifers at 3 months of age and their subsequent milk yield during the first three lactations differed both in the direction of the relationship and its strength. Thus, significant positive correlations of body weight with milk yield during the first lactation were found on all farms.

Table 4
Correlations of live weight of heifers at 3 months of age with their reproductive functions

Farm	Age of first insemination, days		Duration of the service period, days							
	n	r _{xy}	first		second		third		forth	
			n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1325	-0.106**	950	+0.077*	624	+0.014	366	-0.025	150	-0.034
SE RF "Named after Decabrysty"	1030	-0.228**	804	+0.016	511	+0.015	260	-0.106	113	-0.143
SE RF "Gontarivka"	1226	-0.303**	825	-0.073*	549	-0.044	331	-0.064	184	-0.067
SE RF "Kutuzivka"	382	-0.295**	2251	-0.033	1211	+0.002	568	+0.025	210	+0.027
SE RF "Stepne"	976	-0.147**	710	+0.017	398	+0.001	195	+0.033	79	-0.088

Notes: * – P < 0.05; ** – P < 0.01.

Table 5
Correlations of live weight of heifers at 6 months of age with their reproductive functions

Farm	Age of first insemination, days		Duration of the service period, days							
	n	r _{xy}	first		second		third		fourth	
			n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1212	-0.215**	884	+0.002	584	+0.019	346	+0.025	138	-0.087
SE RF "Named after Decabrysty"	1031	-0.328**	804	-0.005	515	+0.076	257	-0.082	112	+0.146
SE RF "Gontarivka"	1207	-0.480**	823	+0.048	546	-0.013	336	+0.008	186	+0.065
SE RF "Kutuzivka"	3831	-0.520**	2255	-0.030	1210	-0.032	566	+0.063	210	-0.033
SE RF "Stepne"	1001	-0.251**	730	+0.007	409	-0.085	192	-0.092	75	+0.087

Notes: as in Table 4.

Table 6
Correlations of live weight of heifers at 9 months of age with their reproductive functions

Farm	Age of first insemination, days		Duration of the service period, days							
			first		second		third		fourth	
	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1232	-0.293**	897	+0.018	579	-0.004	338	-0.016	147	-0.120
SE RF "Named after Decabrysty"	1110	-0.432**	864	+0.004	561	-0.012	289	-0.095	114	+0.072
SE RF "Gontarivka"	1259	-0.425**	860	-0.015	577	+0.005	348	-0.020	190	+0.017
SE RF "Kutuzivka"	3877	-0.588**	2280	-0.035	1221	-0.022	571	+0.060	211	+0.014
SE RF "Stepne"	987	-0.365**	713	-0.030	404	-0.038	190	-0.053	76	+0.203

Notes: as in Table 4.

Table 7
Correlations of live weight of heifers at 12 months of age with their reproductive functions

Farm	Age of first insemination, days		Duration of the service period, days							
			first		second		third		fourth	
	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1180	-0.393**	854	+0.005	551	+0.004	321	+0.019	140	-0.099
SE RF "Named after Decabrysty"	1042	-0.457**	818	+0.016	540	+0.010	276	-0.122*	110	-0.020
SE RF "Gontarivka"	1255	-0.480**	850	-0.011	573	-0.051	339	+0.017	190	+0.050
SE RF "Kutuzivka"	3885	-0.659**	2285	-0.041*	1225	-0.007	569	+0.062	211	+0.044
SE RF "Stepne"	1034	-0.381**	745	-0.083*	418	-0.018	204	-0.032	91	0.257*

Notes: as in Table 4.

Table 8
Correlations of live weight of heifers at 15 months of age with their reproductive functions

Farm	Age of first insemination, days		Duration of the service period, days							
			first		second		third		fourth	
	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1244	-0.491**	903	+0.047	582	+0.005	334	+0.000	139	+0.056
SE RF "Named after Decabrysty"	931	-0.504**	738	-0.011	503	-0.010	258	-0.102	91	+0.007
SE RF "Gontarivka"	1253	-0.480**	856	-0.048	576	-0.013	351	+0.008	193	+0.065
SE RF "Kutuzivka"	3829	-0.698**	2256	-0.057**	1214	-0.010	569	+0.045	211	-0.009
SE RF "Stepne"	896	-0.411**	656	-0.055	360	-0.045	162	+0.072	65	+0.152

Notes: as in Table 4.

Table 9
Correlations of the age of first insemination of heifers with their subsequent reproductive functions

Farm	Duration of the service period, days							
	first		second		third		fourth	
	n	r _{xy}	n	r _{xy}	n	r _{xy}	n	r _{xy}
PE "Agroprogress"	1189	-0.048	783	+0.032	450	-0.010	198	+0.035
SE RF "Named after Decabrysty"	1276	+0.080**	847	+0.052	457	+0.054	191	+0.034
SE RF "Gontarivka"	1246	+0.068*	971	-0.039	662	+0.010	246	+0.007
SE RF "Kutuzivka"	2298	+0.078**	1235	-0.002	576	+0.042	214	+0.049
SE RF "Stepne"	1203	+0.062*	701	+0.031	365	+0.074	169	-0.027

Notes: as in Table 4.

The highest value of the coefficient was found in SE RF "Named after Decabrysty", and the lowest in SE RF "Stepne". The weight of heifers at 3 months had a lower effect on milk yield at 305 days of the second and third lactations. As for the fat content in milk, it was associated with weight in different ways in different farms (Table 10).

The values of the correlation coefficients calculated between the weight of heifers at 6, 9, 12 and 15 months and the indicators of their subsequent milk productivity were in some cases similar to the previous ones, but differed in terms of the probability and direction of the relationship in the farms (Tables 11–15).

The weight of SE RF "Stepne" heifers at 6, 9, 12, and 15 months had no significant correlation with milk yield for 305 days of lactation and the percentage of fat in milk for the first, second, and third lactations. In PE "Agroprogress", the weight of heifers at the ages of 6 and 9 months had no significant correlation with milk yield for 305 days of lactation, regardless of the lactation number. Starting from the age of 12 months, a positive correlation was found between live weight and milk yield for the first and second lactations. As for the fat percentage in the milk of cows of this farm, it had a negative correlation with the weight during rearing in most cases. It is important to note that all significant correlations in all farms between the weight of cows during rearing and their milk yield in the first lactation were positive. As mentioned above, the age of first insemination had a negative correlation with live weight during the period of animal

rearing. At the same time, the live weight of animals is positively related to the milk yield during the first lactation. Negative correlation coefficients between the age of first insemination and milk yield for the first lactation were found in PE "Agroprogress" and SE RF "Kutuzivka", and positive correlation coefficients were found in SE RF "Stepne" (Table 15).

The results of calculations of regression equations that can be used to determine the age of first insemination of heifers indicate that it depends on the weight of heifers at 15 months of age on all farms, as well as on the weight of animals at 9 months of age in SE RF "Named after Decabrysty" and "Gontarivka" (Table 16). The regression coefficients for the predictors that were included in the equations by the stepwise method were almost all negative (except for the square of the weight at 15 months in the SE RF "Kutuzivka"). This indicates a decrease in the age of first insemination with an increase in their weight at 9 and 15 months of age.

It should be noted that the equations calculated for the animals at the SE RF "Kutuzivka" farm most accurately describe the relationship between the age at first insemination of heifers and their weight. The coefficients of determination reflecting the correspondence between the empirical and theoretical data for the equations derived from the data of PE "Agroprogress" and SE RF "Gontarivka" were almost three times lower.

Table 10

Correlations of live weight of heifers at 3 months of age with their subsequent milk production

Farm	Lactation								
	first			second			third		
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	929	+0.093**	-0.046	608	+0.039	+0.057	354	-0.036	+0.172**
SE RF "Named after Decabrysty"	775	+0.203**	+0.346**	438	+0.101*	+0.226**	235	-0.027	+0.062
SE RF "Gontarivka"	888	+0.096**	+0.260**	587	+0.092*	+0.010	355	+0.164**	+0.049
SE RF "Kutuzivka"	2440	+0.135**	-0.016	1359	+0.020	-0.055*	627	-0.099*	-0.052
SE RF "Stepne"	783	+0.084*	-0.016	467	+0.094*	-0.069	245	-0.041	-0.140*

Notes: as in Table 4.

Table 11

Correlations of live weight of heifers at 6 months of age with their subsequent milk productivity

Farm	Lactation								
	first			second			third		
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	862	+0.040	-0.123**	562	+0.018	+0.005	327	+0.023	+0.167**
SE RF "Named after Decabrysty"	773	+0.158**	+0.238**	438	+0.091	+0.238**	233	+0.157*	+0.026
SE RF "Gontarivka"	884	+0.095**	+0.310**	584	+0.167**	+0.072	354	+0.109*	+0.02
SE RF "Kutuzivka"	2447	+0.114**	-0.046*	1364	-0.099**	-0.150**	623	-0.141**	-0.072
SE RF "Stepne"	800	-0.017	-0.058	483	-0.031	-0.066	245	-0.079	+0.030

Notes: as in Table 4.

Table 12

Correlations of live weight of heifers at 9 months of age with their subsequent milk productivity

Farm	Lactation								
	first			second			third		
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	872	+0.064	-0.176**	563	+0.008	-0.133**	325	-0.048	+0.072
SE RF "Named after Decabrysty"	832	+0.165**	+0.213**	483	+0.125**	+0.258**	265	+0.103	+0.045
SE RF "Gontarivka"	919	+0.070*	+0.276**	615	+0.064	+0.105**	378	+0.083	-0.010
SE RF "Kutuzivka"	2475	+0.133**	-0.029	1376	-0.091**	-0.154**	632	-0.153**	-0.096*
SE RF "Stepne"	781	-0.052	-0.009	465	-0.032	-0.023	242	+0.000	-0.033

Notes: as in Table 4.

Table 13

Correlations of live weight of heifers at 12 months of age with their subsequent milk productivity

Farm	Lactation								
	first			second			third		
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	835	+0.085*	-0.094**	538	+0.106*	-0.132**	306	-0.073	+0.032
SE RF "Named after Decabrysty"	792	+0.138**	+0.184**	466	+0.114*	+0.188**	256	+0.091	-0.009
SE RF "Gontarivka"	910	+0.057	+0.326**	611	+0.126**	+0.134**	362	+0.129*	+0.003
SE RF "Kutuzivka"	2482	+0.190**	+0.005	1379	-0.036	-0.154**	632	-0.149**	-0.173**
SE RF "Stepne"	816	-0.028	-0.080	492	-0.042	+0.013	260	-0.067	+0.017

Notes: as in Table 4.

Table 14

Correlations of live weight of heifers at 15 months of age with their subsequent milk productivity

Farm	Lactation								
	first			second			third		
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	884	+0.210**	-0.032	570	+0.144**	-0.024	320	+0.036	+0.048
SE RF "Named after Decabrysty"	720	+0.101**	+0.172**	439	+0.115*	+0.154**	237	+0.101	-0.030
SE RF "Gontarivka"	916	+0.095**	+0.310**	614	+0.167**	+0.072	378	+0.109*	+0.016
SE RF "Kutuzivka"	2446	+0.249**	+0.056**	1366	+0.036	-0.116**	630	-0.109**	-0.175**
SE RF "Stepne"	704	+0.022	-0.068	423	-0.017	-0.036	211	+0.038	-0.117

Notes: as in Table 4.

The calculations for the theoretical age of first insemination of heifers, depending on their weight at 15 months (Fig. 1), indicate that a similar pattern of decreasing age of first insemination with increasing weight at 15 months was observed on all farms.

Differences in the reduction of the age of first insemination of heifers with an increase in their live weight from 360 kg to 460 kg on different farms were different. Thus, on PE "Agroprogress" the difference was 134 days (from 506 to 372 days), in SE RF "Named after

Decabrysty" – only 50 days (from 553 to 403 days), in SE RF "Gontarivka" – 92 days (from 577 to 485 days), SE RF "Kutuzivka" – 742 days (from 505 to 432 days) and in SE RF "Stepne" – 123 days (from 526 to 403 days).

The method of stepwise inclusion of regression analysis showed that the duration of the first service period depended only on the age of their first insemination, and only in SE RF "Kutuzivka" and SE RF "Stepne". Live weight during rearing as a predictor was not included

in the equations (Table 17). It should be noted that the coefficient of determination for these regression equations was very low. The established trend in these farms indicates that the first-born heifers that calved at an earlier age had a shorter service period.

The results of the regression analysis for determining milk yield for 305 days of lactation of first-born cows differed significantly between farms (Table 18).

Table 15

Correlations between the age of insemination of heifers and their subsequent milk productivity

Farm	Lactation								
	first		second		third				
	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %	n	milk yield for 305 days, kg	fat content, %
PE "Agroprogress"	1166	-0.155**	-0.104**	748	-0.131**	-0.038	432	-0.113*	-0.051
SE RF "Named after Decabrysty"	1243	+0.009	-0.074*	746	+0.078*	-0.003	420	-0.005	+0.107*
SE RF "Gontarivka"	1046	+0.049	-0.202**	712	-0.013	+0.031	439	-0.083	+0.055
SE RF "Kutuzivka"	2495	-0.235**	-0.052**	1390	-0.094**	+0.047	637	+0.021	+0.070
SE RF "Stepne"	1344	+0.082**	+0.006	815	+0.053	-0.055	435	+0.045	-0.122*

Notes: as in Table 4.

Table 16

Constants and regression coefficients for calculating the age of first insemination

Farm	Constants	Regression coefficients				Determination coefficient (R^2)
		weight 15 months (x_1)	x_1^2	weight 9 months (x_2)	x_2^2	
PE "Agroprogress"	988.2 ± 37.7	-1.34 ± 0.12	0	0	0	0.179
SE RF "Named after Decabrysty"	845.9 ± 26.2	-0.50 ± 0.14	0	-0.77 ± 0.17	0	0.254
SE RF "Gontarivka"	960.5 ± 32.8	-0.92 ± 0.13	0	0	-0.0011 ± 0.0004	0.178
SE RF "Kutuzivka"	1201.7 ± 23.0	-2.87 ± 0.12	0.0026 ± 0.0002	0	0	0.521
SE RF "Stepne"	720.2 ± 11.6	0	-0.0015 ± 0.0001	0	0	0.254

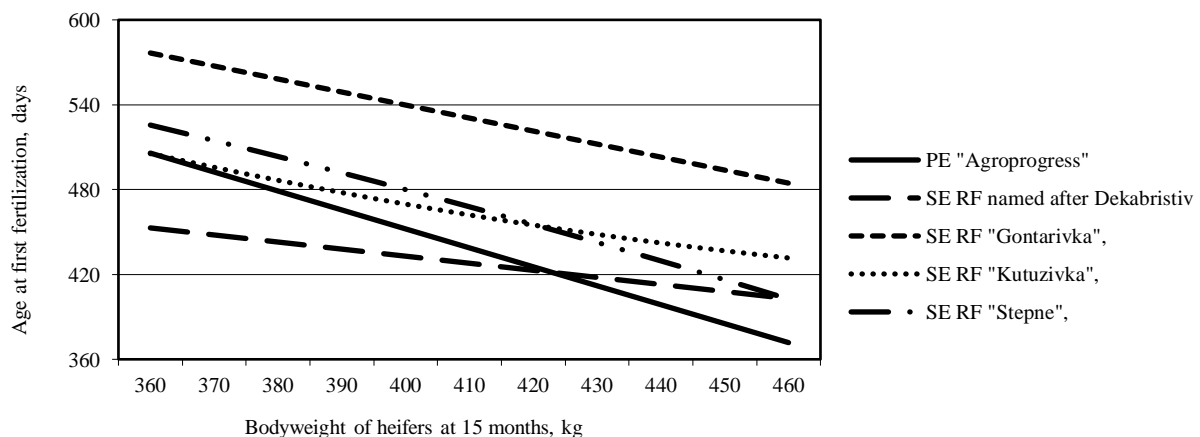


Fig. 1. Dependence of the age of first insemination of heifers on their live weight at 15 months of age (weight at 9 months in the calculations corresponded to the average live weight on the farm)

Table 17

Constants and regression coefficients for calculating the first service period

Farm	Constants	Regression coefficients			Determination coefficient (R^2)
		age of first insemination (x_1)	x_1^2	x_2^2	
SE RF "Kutuzivka"	93.3 ± 15.3	0.11 ± 0.03	0	0	0.007
SE RF "Stepne"	141.0 ± 15.4	0	0.00011 ± 0.00006	0	0.007

Table 18

Constants and regression coefficients for calculating milk yield for 305 days of first lactation

Farm	Constants	Regression coefficients						Determination coefficient (R^2)
		weight 15 months (x_1)	x_1^2	weight 9 months (x_2)	weight 3 months (x_3)	x_3^2	Age of first insemination (x_4)	
PE "Agroprogress"	4829 ± 559	5.8 ± 1.7	0	0	0	0	0	0.026
SE RF "Named after Decabrysty"	2060 ± 684	0	0	0	47.39 ± 7.49	0	0	0.081
SE RF "Gontarivka"	4638 ± 265	0	0	0	0	0.049 ± 0.017	1.09 ± 0.35	0.027
SE RF "Kutuzivka"	7624 ± 433	0	0.0131 ± 0.0015	-10.96 ± 1.59	0.088 ± 0.023	0	-2.32 ± 0.54	0.090
SE RF "Stepne"	2740 ± 656	8.4 ± 1.2	0	0	0	0	2.74 ± 0.61	0.077

Thus, for the milk yield of the first-born PE "Agroprogress", the only predictor was the weight at the age of 15 months. The amount of milk for 305 days of the first lactation of SE RF "Named after Decabrysty" animals depended only on their live weight at 3 months of age. To calculate the milk yield of the first-born heifers of SE RF "Gontarivka", the following predictors were included: live weight of heifers at 3 months of age and age of their first insemination. On SE RF "Kutuzivka", the predictors include live weight at 9 months, and for SE RF "Stepne" – live weight of heifers at 15 months and age of their first insemination.

Discussion

The main goal of the dairy herd improvement programme is to raise heifers that are of the desired size and live weight at minimal cost, to maximise their genetic milk productivity throughout their lives (Hawkins et al., 2020; Paliy et al., 2021; Aliiev et al., 2022). Our research has shown that heifers on different farms grow at different rates. The differences in average live weight at various ages were as follows: 3 months – 10.0 kg; 6 months – 16.8 kg; 9 months – 28.6 kg; 12 months – 31.4 kg; 15 months – 61.2 kg. Notably, the lowest average live weight from 6 months of age was observed in heifers from PE "Agroprogress". By 15 months of age, the heifers from SE RF "Kutuzivka" and SE RF "Stepne" had the highest body weight, despite having the lowest weight at 3 months of age.

Improving the growth rate of heifers can increase lifetime milk yield per cow, thereby enhancing the environmental and economic efficiency of dairy farming (Hayes et al., 2021). In order to maximise lifetime productivity, it is crucial that heifers remain healthy, reach their target growth rates, and receive proper care until their first calving (McCarthy et al., 2021; Plomaritou et al., 2025). Poorly reared heifers are less likely to become pregnant, calve later, and are culled earlier. Studies by Italian scientists have shown that calves that are heavier at birth and at weaning calve earlier than those with a low live weight (Costa et al., 2021). We obtained similar results. There is a negative correlation and regression coefficient between the age of first insemination and live weight during the growing period.

Other studies have found a positive relationship between pre-calving body weight and milk production during the first lactation (McNaughton et al., 2013; Eitelde et al., 2017). This suggests that higher productivity in the first and second lactations can be achieved by raising heifers to a higher body weight. New Zealand scientists have also identified the potential to increase milk production during the first lactation by increasing heifer body weight (Hancock et al., 2019; Martin et al., 2020). The results of our correlation analysis coincide with the above in most cases. However, on some farms, these relationships were not established or were the opposite.

Regarding the relationship between service period length and live weight, we found positive and negative correlations. The age at first insemination was also significantly correlated with live weight. However, other studies (Hancock et al., 2020) report only a positive relationship between live weight and reproduction.

Our research confirms that the age at first calving is also an important determinant of productivity in herds with optimal future milk production. These results corroborate those obtained in studies by other scientists (Krpálková et al., 2014; Hutchison et al., 2017; Salte et al., 2020) but contradict data from Ghavi Hossein-Zadeh (2011).

Further research is needed to determine the effect of growth intensity on cow fertility and calf survival.

Conclusion

In the process of rearing replacement heifers, it is necessary to take into account the peculiarities of their growth and development to realize their genetically programmed productivity. Our research has confirmed that animals with the highest live weight gain were significantly younger at first insemination, regardless of the production technology used on the farm. The duration of the first service period depended on the age at first insemination on two of the farms; on the other three, the duration of the service period did not depend on rearing intensity.

First-born heifers' milk production had a positive correlation with live weight, though not on all farms. Increasing the intensity of rearing replacement heifers increases the profitability of dairy farming; however, it is necessary to consider the genetic potential of the animals and the particular farm's production characteristics.

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