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Development of lifetime productivity of cows depending on the live weight of heifers of different ages

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Abstract. One of the problems of modern dairy farming is the short period of productive use of cows. It is observed both in Ukraine and in most countries of the world with developed dairy cattle breeding. The consequence of a short period of productive use is a decrease in the lifetime productivity of cows. The purpose of this work was to investigate the possibility of influencing the duration of use and lifetime milk yield of cows by selecting heifers by live weight during their growing period. The study analysed the lifetime productivity of 1071 cows of the Ukrainian black-and-white dairy breed, starting from their rearing and up to retirement from the herd. Animals were divided into five groups by live weight at the age of 3, 6, 12 and 15 months using standard deviation (σ) from the mean. Within the groups, the number of calvings, productive life expectancy, lifetime estrus and estrus for higher lactation and the average period between calvings were determined. It was established that the hope for higher lactation is associated with the weight of heifers at the onset of puberty and sexual maturity. Animals, which at 6 months had a live weight of $+0.5-1.5 \sigma$ and at 12 months more than $+1.5 \sigma$ from the average in the herd, were characteristics of the highest milk yield. The group of traits of lifetime productivity (number of calvings, duration of productive use and lifetime milk yield) was positively influenced by the live weight of heifers at the age of 3, 6, 12 and 15 months, which exceeded the average for the herd by $0.5-1.5 \sigma$. Cows belonging to these groups exceeded other groups by 0.2-1.4 calving. During the period of use, these cows received 11-32% more milk than the average for the herd. The results of the research expand the understanding of the impact of heifer breeding on the development of lifetime productivity of cows and can be used for the selection of livestock and correction of plans for the cultivation of dairy cattle.

Keywords: dairy cattle breeding, milk yield, reproductive capacity, calving, duration of productive use

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Relevance

The duration of use of cows is only 3–4 years (De Vries and Marcondes, 2020; Siatka *et al.*, 2020), while it should recover the costs of their breeding and ensure profitable maintenance through milk production. It is implemented through the development of high productivity and long-term use of cows. It was identified that the vast majority of cows leave the herd before the 600th day of productive use (Macalovich *et al.*, 2018), which significantly limits the lifetime productivity of animals. In the breeds common in Ukraine (Ukrainian Red and Black-and-White dairy and Holstein), cows are used in herds for an average of 2.32–2.50 lactations, and their lifetime milk yield is 14940–18669 kg (Mazur *et al.*, 2018). The reduction of productive longevity of cows is gradually recorded (Milostiviy *et al.*, 2017), so the study of the factors that determine it remains relevant.

Analysis of Recent Studies and Publications

To increase the lifetime productivity of cows, the possibility of using selection methods for the duration of productive use is being explored. A close correlation was identified between the duration of cow use and lifetime milk yield and milk fat yield (Hdud *et al.*, 2018). Therewith, the influence of hereditary factors on the manifestation of lifetime productivity traits is insignificant (Milostiviy *et al.*, 2017), and the selection is complicated by a long evaluation period and the receipt of final results after the animal's retirement. Therefore, there is a necessity to apply other approaches to improve the lifetime productivity of cows. One such measure is considered to be the intensification of growing young stock, which reduces the cost of keeping heifers and increases the productivity of cows (Kruglyak, 2018). The fact

that the development of high lifetime productivity of cows is influenced by the conditions of their use, the origin and management of the dairy herd, and the features of growing heifers is indicated by other researchers (Schuster *et al.*, 2020). There is evidence of an increase in the lifetime productivity of cows when introduced into the herd at the age of 22–26 months (Sawa *et al.*, 2019). In particular, to extend life expectancy and improve other productivity traits, it is recommended to inseminate heifers aged 15–16 months with a live weight of at least 412 kg, provided that at 12 months it is 327–347 kg, or inseminate heifers at 17–18 months with a live weight of 426 kg, provided that at 12 months they weighed 316–344 kg (Levina *et al.*, 2019). In Simmental cows, the highest milk yields and milk fat were observed when their live weight at birth was 33–34 kg, at 6 months of age – 171–190, at 12 months – 291–300, and at 18 months – 401–415 kg (Fedorovych, 2017).

Features of changes in the live weight of heifers during the growing period are significant. It was established that in terms of milk yield, milk fat and protein yield, first-born animals have an advantage over animals with a slow decline in relative growth rate (Polupan & Siriak, 2019). In subsequent lactations, the advantages of such animals in terms of productivity have not been confirmed, but since the milk yield for the first lactation is a significant proportion of lifetime productivity, this pattern should be considered. In addition, it was established that the lifetime milk yield of cows decreases by 15–37% if short-term growth delays occur during heifer rearing (Klimkovetskyi *et al.*, 2020)

To improve milk yields during life, work is performed to establish benchmarks for heifer growth. They include such traits as optimal age and live weight, condition, and development of

body tissues during the stages of growing and beginning of productive use of animals. An important role is devoted to the development of the udder. There are still concerns that the development of the mammary gland is disturbed when the increase in live weight exceeds a specific threshold, which adversely affects milk yield. It has been demonstrated (Van Amburgh *et al.*, 2019) that mammary gland development during the prepubertal growth phase does not decrease due to high energy intake, the overall growth of the mammary parenchyma depended on the attainment of puberty, and the udder, like most reproductive organs, grows in proportion to body size and not in proportion to nutrient intake. Therewith, achieving reasonable targets for the live weight of heifers is essential. To increase milk production in terms of dry matter, it was confirmed (Martín *et al.*, 2020) the importance of heifers reaching the target live weight at 12 and 15 months of age, while a limited lag behind the target at 6 and 9 months of age had little effect on cow performance.

Thus, the literature data confirm the possibility of influencing the lifetime productivity of cows by targeted breeding of heifers. For this

purpose, it is advisable to justify the target indicators of their growth. It is advisable to determine the optimal criteria within individual breeds, and apply them in the conditions of the level of productivity of cows, on which the research was conducted.

The purpose of the research – determine the live weight of heifers of different ages, which is associated with the development of high lifetime productivity of cows.

Material and Methods of Research

The productivity of animals of the Ukrainian black-and-white dairy breed of Shevchenkivsky PAE of the Kyiv-Svyatoshinsky district of the Kyiv region was analysed. The results of the lifetime use of 1071 cows for the period from 1992 to 2014 were explored. The average productivity of cows was 4565 ± 46.2 kg for 305 days of lactation, life expectancy 5.9 ± 0.30 years, including productive use 3.1 ± 0.27 years.

The live weight at birth at the age of 3, 6, 12 and 15 months was explored in animals. According to these indicators using the standard deviation from the mean ($X \pm \sigma$), the animals were divided into 5 groups (Table 1).

Table 1. Criteria for dividing animals into groups by live weight of heifers

Group	Selection criteria	Range in live weight (kg) at age			
		3 months	6 months	12 months	15 months
1	$< X - 1,5\sigma$	≤ 57	≤ 93	≤ 165	≤ 203
2	$X - 0,5...1,5\sigma$	57-71	94-117	166-203	204-247
3	$X \pm 0,5\sigma$	72-86	118-142	204-242	248-292
4	$X + 0,5...1,5\sigma$	87-100	143-166	243-280	293-336
5	$> X + 1,5\sigma$	≥ 101	≥ 167	≥ 281	≥ 337

Within each of the groups, the results of lifetime use of cows were explored, in particular, the number of calvings, productive life expectancy, lifetime milk yield and milk yield for higher lactation and the average period between calvings.

The influence of the live weight of heifers on the lifetime productivity of cows was determined by graphical analysis. The significance of the difference between the groups was determined using Student's t-test ($p < 0.05, 0.01, 0.001$).

Research Results and their Discussion

The analysis demonstrated that there is a regularity between the growth of heifers and the number of calves obtained from cows. A greater number

of calvings during life was obtained from animals that had a higher than average live weight during the analysed age periods. Most calves were obtained from livestock assigned at the age of 3, 6, 12 and 15 months to the fourth group (Fig. 1).

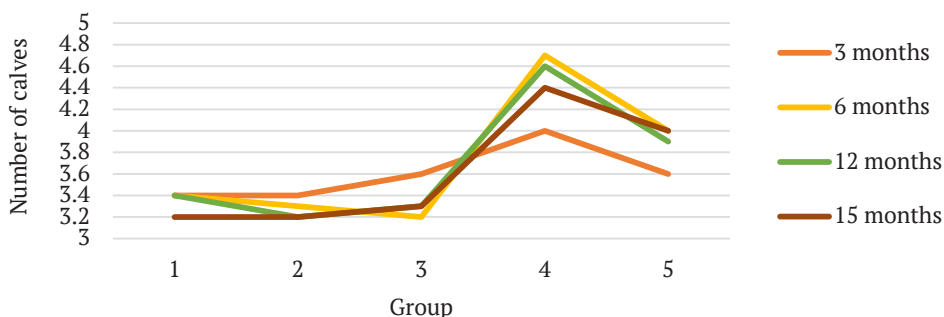


Figure 1. Effect of live weight of heifers of different ages on lifetime number of calvings

In particular, animals included in the fourth group by live weight at the age of 3 months exceeded others by 0.2-0.6 calving; at the age of 6 months by 0.4-1.5 ($p < 0.05 \dots p < 0.001$); at 12

months by 0.7-1.4 ($p < 0.05 \dots p < 0.001$) and at 15 months by 0.4-1.2 calving. A similar result was for the duration of productive use (Fig. 2) and lifetime milk yield (Fig. 3).

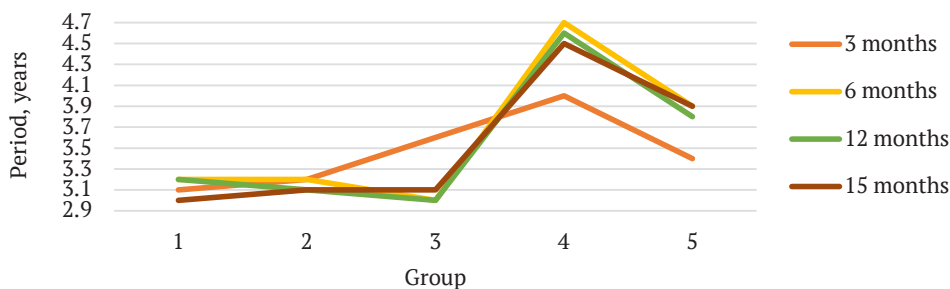


Figure 2. Influence of live weight of heifers of different ages on the duration of productive use of cows

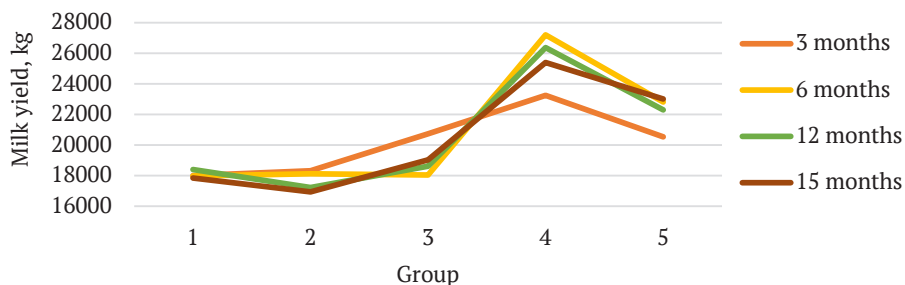


Figure 3. Effect of live weight of heifers of different ages on lifetime milk yield of cows

The graphs demonstrate that the low live weight of heifers, at the level of the herd average ($\pm 0.5 \sigma$) and below, reduces the duration of productive use of cows. But the lifetime productivity of cows decreased when heifers reached the highest live weight in all controlled age periods (indicators of the fifth group). Thus, it can be argued that the live weight of heifers that exceeds the average in the herd by 1.5σ is not desirable. The study identified the optimal parameters for the live weight of heifers, which allows for obtaining the highest lifetime productivity of cows. They correspond to the criteria of the fourth group at the age of 3, 6, 12 and 15 months. Animals assigned to this group not only outperformed cows of other groups, their productivity was higher than the average for the herd. The advantage in lifetime milk yield of animals of the fourth group by live weight at the age of 3 months was 11%. In terms of live weight at the age of 6 months, the difference with the herd average reached 32% ($p < 0.001$). Thus, in the populations of the Ukrainian black-

and-white dairy breed, to ensure maximum lifetime productivity, the live weight of heifers at the age of 3, 6, 12, and 15 months should be within the range of $+0.5...+1.5\sigma$ from the average herd. In the conditions of the investigated herd, the optimal for maximum lifetime productivity was live weight at the age of 3 months 87-100 kg, at the age of 6 months – 14-166, at 12 months – 243-280 and at 15 months – 293-336 kg.

One of the criteria for assessing the milk production of cows is the hope for higher lactation. Features of the development of this trait of cows, depending on the live weight of heifers, differ from the trends established by the duration of use and lifetime milk yield. A relationship was identified between milk yield for 305 days of higher lactation and the live weight of heifers at the age of 3 and 15 months (Fig. 4). Cow productivity was highest when the live weight of heifers of this age corresponded to the criteria of the third group. But no significant difference between the groups was established.

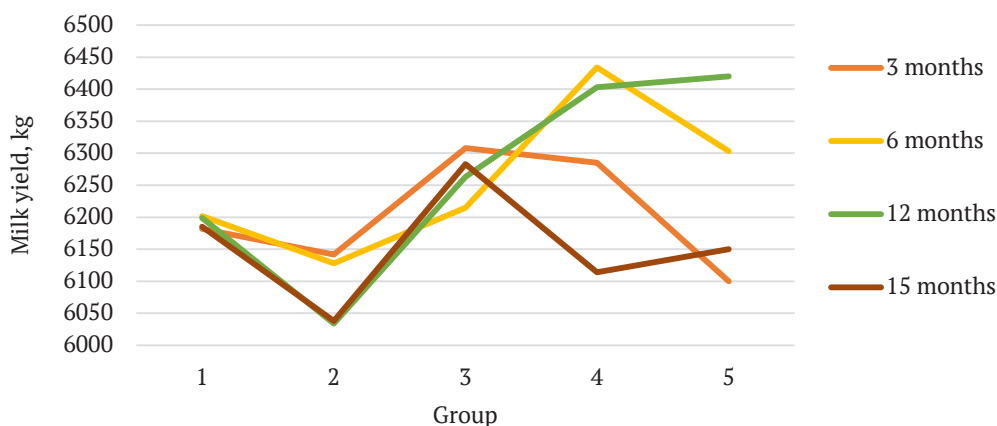


Figure 4. Influence of live weight of heifers of different ages on milk yield during 305 days of higher lactation

It was established that the increase in the live weight of heifers at the age of 6 and 12 months, which coincides with the onset of puberty and the onset of sexual maturity, has a positive effect on the increase in milk yield during higher lactation. Optimal at the age of 6 months to obtain the highest milk yield was live weight in the range of 143-166 kg (group 4), and at 12 months - more than 280 kg (group 5). Thus, for the development of high productivity, it is

of great importance to achieve sufficient development in live weight at the age of 12 months, which partially coincides with the conclusions (Martín *et al.*, 2020) made in the analysis of cow productivity in New Zealand.

Indicators of reproductive capacity, which in cows with two or more calvings were estimated by the duration of the period between calvings, depending on the live weight of heifers did not change significantly (Fig. 5).

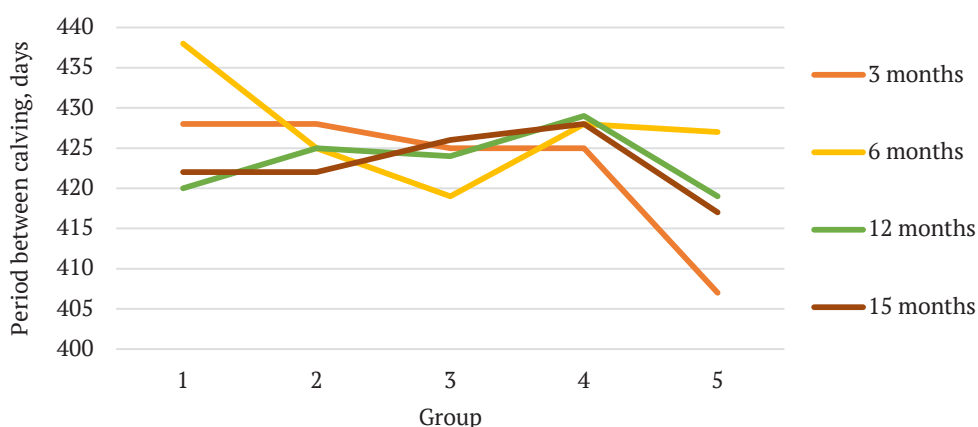


Figure 5. Effect of live weight of heifers of different ages on the average period between calving

There was a tendency to shorten the period between calving in animals of group 5 by live weight at the age of 3 months and prolongation in animals of the first group by live weight at 6 months. It may be evidence of the influence of growth rate or general level of nutrition of heifers of this age on the development of the ability of cows to reproduce effectively, but the statistical analysis did not confirm a significant difference between the individual groups.

Conclusions and Perspectives

By selecting heifers during the growing period, the lifetime productivity of cows can be

influenced. The longest life expectancy, productive use and lifetime milk yield are characterised by animals that at the age of 3, 6, 12 and 15 months have a live weight of $0.5 \dots 1.5 \sigma$ more than the average for the herd, thus, these parameters can be considered optimal.

The milk yield for 305 days of the highest lactation was higher in animals that at the age of 6 months had a live weight of $0.5 \dots 1.5 \sigma$ higher than the average for the herd, and at 12 months, reached its highest indicators. The influence of the live weight of heifers at the age of 3, 6, 12 and 15 months on the duration of the period between calving was not confirmed.

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Формування довічної продуктивності корів залежно від живої маси телиць різного віку

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Анотація. Однією з проблем сучасного молочного скотарства є короткий період продуктивного використання корів. Це спостерігають не лише в Україні, а і в більшості країнах світу з розвиненим молочним скотарством. Наслідком короткого періоду продуктивного використання стає зниження довічної продуктивності корів. Метою цієї роботи було вивчити можливість вплинути на тривалість використання і довічний надій корів шляхом добору телиць за живою масою в період їх вирощування. В дослідженні було проаналізовано довічну продуктивність 1071 корови української чорно-рябої молочної породи, починаючи з їх вирощування і до вибуття зі стада. Тварин за живою масою у віці 3, 6, 12 і 15 місяців розподілили на п'ять груп з використанням стандартизованого відхилення (σ) від середньої величини. В межах груп визначали кількість отелень, тривалість продуктивного життя, довічний надій і надій за вищу лактацію та середній період між отеленнями. Було встановлено, що надій за вищу лактацію пов'язаний із масою телиць у період початку статевого дозрівання і настання статевої зрілості. Тварини, які в 6 місяців мали живу масу $+0,5-1,5 \sigma$ і в 12 більше ніж $+1,5 \sigma$ від середньої в стаді, характеризувались найбільшим надоєм. На групу ознак довічної продуктивності (кількість отелень, тривалість продуктивного використання і довічний надій) позитивно вплинула жива маса телиць у віці 3, 6, 12 і 15 місяців, яка перевищувала середню по стаду на $0,5-1,5 \sigma$. Корови віднесені до цих груп переважали інші групи на $0,2-1,4$ отелення. За період використання, від цих корів отримали на 11-32 % молока більше, ніж в середньому по стаду. Результати досліджень розширюють розуміння впливу вирощування телиць на формування довічної продуктивності корів та можуть бути використані для добору поголів'я і корекції планів вирощування великої рогатої худоби молочних порід

Ключові слова: молочне скотарство, надій, відтворювальна здатність, отелення, тривалість продуктивного використання