

Variability of fertility indicators in Ayrshire firstcalf heifers under the influence of early lactation

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Abstract. The basic value for optimizing the reproduction of the herd in dairy cattle breeding is the ability of cows to procreate offspring - fertility. It is a complex feature, characterized by many indicators and due to a complex of factors. The goal of our work was to reveal and to study these indicators and factors. The studies were carried out on Ayrshire cows of the Megrega breeding farm (the Republic of Karelia). The average milk yield per cow is over 9,000 kg of milk per year. Fertility indicators were taken into account for 5 years according to the data of 3866 lactations. The following fertility indicators were analysed: the indifference period; the period of insemination; the service period; fertilization from the first insemination; conception index (number of inseminations per conception); early embryonic death. We have analysed the relationship of these indicators with age, the amount of milk yield in general for lactation and during the early lactation period. An increase in the level of milk yield of cows during the current lactation up to 10,000 kg of milk or more was accompanied by a decrease in fertilization after the first insemination from 78.1 to 33.6%, as well as a significant deterioration in other main indicators of reproduction. The study established the relationship between the level of productivity of first-calf heifers during the early lactation period and fertility indicators. The greatest influence on fertility indicators during the early lactation period and insemination was exerted by the level of milk yield in the 1st month of the first lactation. The worst reproductive abilities were shown by first-calf heifers with an average daily milk yield of 34 kg or more. The results obtained can be used in further research on the development of selection indices, selection according to which can provide a high genetic trend in milk yield while maintaining and developing the progressive fertility of dairy cows.

1 Introduction

Fertility is one of the most complex multifactorial indicators of cattle reproduction. The ability to procreate offspring is influenced by the genotype and a wide range of physiological and paratypic factors [1-3].

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The resulting effect of the interaction of the genotype and the occupational environment on the reproductive qualities of cows is difficult to predict. Such factors as housing and feeding conditions affect not only fertility, but also the character of the genetic relationship between reproductive function indicators and another, the most important economically useful trait - milk productivity of cows [4-5]. The heritability of indicators characterizing fertility is low [6]. All of this significantly complicates the choice of the selection strategy for fertility and reproductive efficiency in modern dairy herds [7-8].

The dominant role of genetic improvement of livestock in terms of milk productivity has led to a deterioration in the health of animals, a decrease in reproduction rates. This is confirmed by the established negative correlation ($r = - 0.2-0.7$) between the fertility and milkiness of cows [9].

Intensive milk production on its own does not always have a negative impact on health and fertility. There is evidence of the possibility of combining high milk productivity of cows (over 10,000 kg) with good fertility [10]. The antagonistic nature of the relationship between these features is in most cases associated with the subfertility syndrome, which is typical for highly productive cows during the early lactation period. The reason for this is the energy imbalance of the diet, when the energy of the fodder does not compensate for its costs for milk production. High metabolic loading during a period of negative energy balance leads to aggravation of the immune status of highly productive cows and to a decrease in their reproductive function. Due to the mobilization of adipose tissue, dairy cows have typical biochemical changes in blood serum, associated with an increase in the level of non-esterified fatty acids and a decrease in glucose concentration, which have a toxic effect on the egg, which leads to a decrease in its maturation and the ability of the embryo to develop [11-12]. The death of embryos in the early stages of development, the level of which under the influence of various factors can vary within 5-40% and above [13], is one of the reasons for the low fertility of cows.

Thus, the fertility of cows is a complex trait, the level of which is determined by a complex of many factors – physiological, hereditary, productive, food, disease resistance, as well as the relationship and mutual influence of various fertility indicators.

These relationships can be considered as associations of fertility indicators, the study of which is relevant from the standpoint of finding ways to increase the efficiency of the reproduction of a herd of dairy cows. However, this problem has not been studied enough. The results of individual studies available in the literature are contradictory, which requires further accumulation of knowledge in this area. The purpose of our research was to identify the relationship between fertility indicators, their dependence on the level of milk yield of the Ayrshire cows in the conditions of the European North of Russia.

2 Material and methods

The study was carried out in the herd of the breeding plant "Megrega" for breeding the Karelian type of Ayrshire cattle (the Republic of Karelia). The herd consists of 1530 cows. The average milk yield per forage-fed cow during the study period was 7625-8200 kg of milk.

The complex uses year-round loose and pastureless keeping of animals with automated feed distribution. The quality of livestock keeping and the level of animal feeding on the farm are characterized as high. One cow consumes 8000-8500 fodder units per year. The share of concentrated feed in terms of nutritional value in the structure of the annual diet is on average 57%. Milking of cows takes place in the De Laval milking parlour on a Europarallel machine for 32 heads.

The following fertility indicators were taken into account and studied in the work: the period from calving to the first insemination (days) – the indifference period (IP), the

period from the first to fruitful insemination (days) – the period of insemination (PI), the period from calving to fruitful insemination (days) – the service period (SP), fertility after the first insemination (%) – conception rate (CR), number of inseminations per conception (times) – conception index (CI), early embryonic death (%) – EED, milk yield for the first 305 days of lactation (kg) – MY.

Fertility indicators were taken into account in cows according to 3866 adjacent lactations in the period 2014-2019. The study used databases (the SELEKS program), "Journals of calving, insemination, cows drying off" and other zootechnical documents. To register early embryonic death, an indirect method was used by taking into account the extended intervals (25-35 days) between adjacent inseminations [14]. The frequency of EED was determined as the percentage of the number of extended intervals to the total number of cows examined.

To identify and characterize fertility indicators, we used the method of grouping and plotting of a graph.

Biometric data processing was carried out using the Excel program with the determination of the mean values (\bar{X}) and the mean error (m). The significance of differences between the compared mean values was assessed using Student's t-test and χ^2 test.

3 Results

The studied fertility indicators of cows were typical for the created zootechnical conditions (feeding level 8000-8500 fodder units, milk yield 7200-8200 kg of milk). The age of the animals did not have a significant effect on fertility parameters, which were almost the same from the first to the fifth lactation and older (Table 1). In older cows, there was a tendency towards an increase in the frequency of EED – from 9.6 to 12.5%.

Table 1. Indicators of productivity and fertility in cows different age.

Indicators	Age, lactation				
	1	2	3	4	5 and older
	$\bar{X} \pm m$	$\bar{X} \pm m$	$\bar{X} \pm m$	$\bar{X} \pm m$	$\bar{X} \pm m$
n	1310	1047	686	462	361
MY, kg	7236±29	8124±40	8238±54	8226±65	7908±69
IP, days	91.8±1.2	90.5±1.3	89.5±1.4	89.9±2.0	93.3±2.5
PI, days	42.9±1.7	41.2±1.8	41.5±2.3	38.5±2.7	40.2±2.9
SP, days	134.7±1.9	131.6±2.1	130.9±2.5	128.3±3.3	133.5±3.6
CI	1.91±0.03	1.90±0.04	1.84±0.04	1.82±0.05	1.84±0.05
CR, %	48.5	49.6	51.3	51.3	48.2
EED, %	10.6	9.6	10.4	11.0	12.5

Note. IP – the indifference period, PI – the period of insemination, SP – the service period, CR – conception rate (fertility after the first insemination), CI – conception index, EED – early embryonic death, MY – milk yield for the first 305 days of lactation.

The level of milk yield had a significant impact on the fertility of cows. With the growth of milk productivity in the current lactation, there is a deterioration in all indicators of reproduction (Figure 1). An increase in milk yield in cows from less than 5,000 kg to 10,000 kg of milk or more was accompanied by a lengthening of their IP by 38.4 days, PI by 50.5, and SP by 88.9 days ($P < 0.001$).

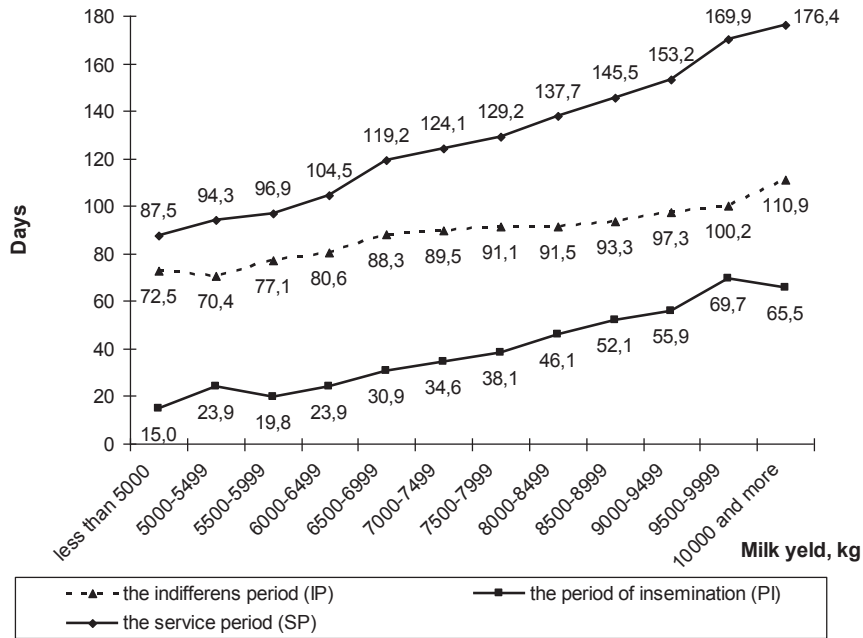


Fig. 1. Fertility indicators of cows depending on the amount of milk yield in the current lactation.

The increase in milk productivity was accompanied by a significant ($P < 0.001$) deterioration in fertility (decreased from 78.1 to 33.6%), conception index (increased from 1.25 to 2.27). The level of embryonic death increased from 3.1% to 13.3%. We studied the indicators of fertility of first-calf heifers with different levels of milk yield in the first 100 days of lactation (Table 2). We noted that the IP practically did not change and amounted to 86.4-94.5 days in cows of different groups. The first-calf heifers with a milk yield of 2500-2799 kg per 100 days of lactation were characterized by relatively better fertility indicators. An increase in the level of milk yield to 2800-3399 kg was accompanied by a lengthening of the PI by 10.7 days, the SP – by 2.6-8.7 days, an increase in the CI – by 0.25-0.26, a decrease in the CR by 10.7-11.0 %. The worst indicators of fertility were revealed in the group of first-calf heifers with a milk yield of 3400 kg or more - a significant lengthening of the PI by 25.4 days, the SP – by 23.5 days, an increase in CI by 0.49, and a decrease in CR by 14.5%. EED increased from 8.7 to 14.3%.

The level of milk yield of first-calf heifers is about 90% of the average for the herd. This testifies to the good quality of the reared young animals. According to the results of the first 100 days of lactation, most of the young cows introduced into the herd had a high level of milk production. During the period of early lactation, they provided from 40 to 50% of milk from the total milk yield (Table 2).

A negative correlation was established between the level of milk yield for the first 100 days of lactation and the fertility of first-calf heifers. With an increase in milk yield from 2500-2799 kg to 3400 kg or more, the efficiency of the first insemination decreased from 55.2 to 40.7% ($P < 0.05$), more inseminations were required for the beginning of pregnancy – 1.74 versus 2.23 ($P < 0.01$). Due to this, the duration of the PI and the SP increased by 25.4 and 23.5 days, respectively ($P < 0.01$; $P < 0.05$).

The level of milk yield did not affect the duration of the IP of first-calf heifers. We can assume that young animals with different degrees of early lactation need approximately the same time to complete the involutinal processes.

Table 2. Fertility indicators of first-calf heifers with different levels of early lactation.

Indicators	Milk yield gradations for the first 100 days of lactation, kg				
	less than 2500	2500-2799	2800-3099	3100-3399	3400 and more
n	232	368	410	209	91
Milk yield, kg	2299±12	2600±4	2940±4	3240±6	3590±20
IP, days	91.0±2.8	94.5±2.3	92.5±2.2	86.4±2.9	92.7±4.9
PI, days	40.0±3.7	35.2±2.9	45.9±3.1	45.9±4.2	60.6±7.3**
SP, days	131.1±4.3	129.7±3.4	138.4±3.5	132.3±5.0	153.2±8.7*
CI	1.81±0.07	1.74±0.06	2.00±0.06**	1.99±0.08*	2.23±0.15**
CR, %	52.6	55.2	44.2**	44.5*	40.7*
EED, %	10.8	8.7	12.9	7.7	14.3

Note. IP – the indifference period, PI – the period of insemination, SP – the service period, CR – conception rate (fertility after the first insemination), CI – conception index, EED – early embryonic death.

*, ** Differences with a gradation of 2500-2799 kg are statistically significant, respectively, at $P < 0.05$; $P < 0.01$.

The worst reproductive abilities were shown by first-calf heifers with an average daily milk yield of 34 kg or more in the 1st month of lactation (Figure 2). Compared with peers with milk yield of less than 25 kg during this period, their CI is more by 0.51 ($P < 0.05$). Between these groups, the greatest difference is also in terms of the PI and the SP – 30.7 days ($P < 0.01$) and 33.8 days, respectively ($P < 0.05$). These groups also differed in other indicators: CR is lower by 10.6%, EED is higher by 5.5%.

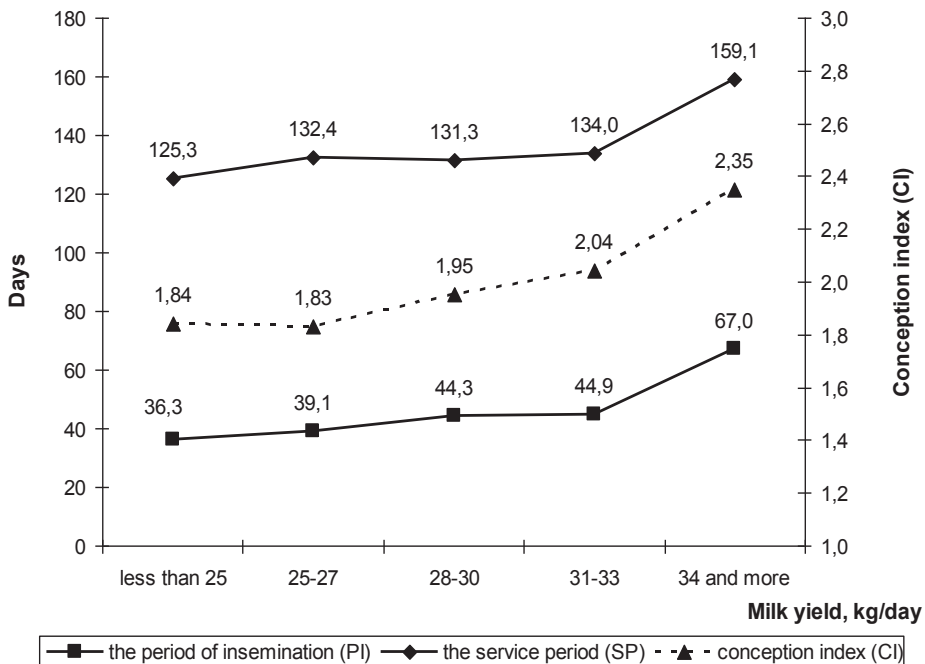


Fig. 2. Fertility indicators of first-calf heifers with different levels of daily milk yield in the 1st month of lactation.

Despite the fact that the first insemination after calving (IP) occurs on average in the 3rd month of lactation, productivity in the first months affects the reproductive qualities of animals. The level of milk yield in the 1st month of lactation had the greatest impact on fertility indicators during the period of early lactation and insemination. So, for example,

with an increase in the average daily milk yield from 27 kg or less to 34 kg or more, CI increases from 1.83-1.84 to 2.35. Less noticeable differences were observed in subsequent months of early lactation (Figure 3). It can be assumed that first-calf heifers that have reached the maximum daily milk yield for their age and conditions by the 2nd (and especially by the 3rd) month have time to adapt to physiological stress and react to a lesser extent with a deterioration in fertility.

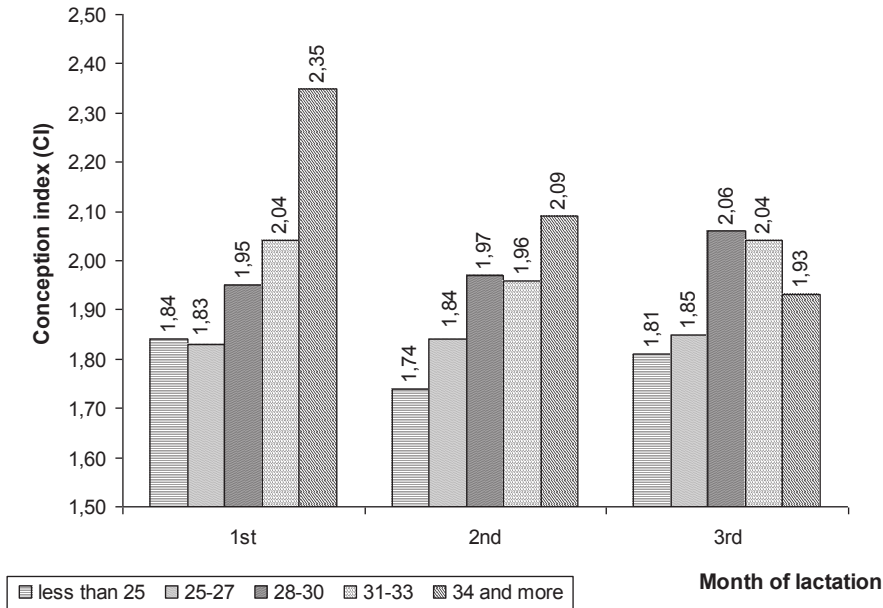


Fig. 3. Change of the conception index of first-calf heifers depending on the level of daily milk yield in the first months of lactation.

4 Discussion

In the course of the study, we noted a similar level of EED in cows of different ages - from 9.6 to 12.5%, although there was a tendency towards an increase in the frequency of EED among the oldest cows.

In previous studies [13], under the conditions of low energy supply in the diet, the frequency of embryonic death was significantly higher - 19.1–38.9%. We confirmed the conclusion of many researchers [14-16] about the decisive role of energy imbalance in the diet in reducing the fertility of cows, including the viability of embryos.

The deterioration of reproduction indicators with the growth of milk productivity in the current lactation indicates that during the simultaneous flow of lactation and reproductive cycles of cows, a clear and reliable inverse relationship is formed between the amount of milk yield and fertility indicators.

We noted a negative relationship between the fertility of first-calf heifers and the level of milk yield for the first 100 days of lactation. The worst reproductive abilities were shown by first-calf heifers with a total milk yield in this period of 3400 kg or more, which is consistent with the data of other researchers. At the same time, milk yield of more than 3600 kg per 100 days of lactation is considered a critical level of productivity of first-calf heifers [17].

5 Conclusion

Thus, the study of the correlation between the fertility indicators of cows and their relationship with the amount of milk yield made it possible to reveal new factors for selecting cows to combine high milk productivity with good fertility. The results obtained can be used in further research on the development of selection indices, the use of which in breeding can provide a high genetic trend in milk yield while maintaining and developing the progressive fertility of dairy cows.

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