# DYNAMICS OF DAIRY COW MILKING PERFORMANCE AND PRODUCTIVITY BEFORE AND AFTER INSEMINATION

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**Abstract.** The scientific research work was carried out at the Lithuanian dairy farm from April to October, 2012. The results did not show a significant decrease of milk yield, but on the day of insemination dairy cows milk yield was 6.59 % (P>0.05) less than on a day before insemination (P>0.05). Before and on insemination day, the milk production decreased in all studied breeds of dairy cows, with the exception of Lithuanian Black and White. Cows' milking time in the morning was 4.96 % (P>0.05) shorter than a day before insemination. On the insemination day, milking time in the evening was 12.18 % (P<0.05) shorter than three days before insemination. The milking speed in the morning declined one day prior to insemination and was 4.94 % (P>0.05) less on the day of insemination; milking speed further decreased by 9 % (P>0.05) on the 1st day after insemination. The milking speed in the evening dropped by 3.92 % (P>0.05) 3 days before insemination of cows, and decreased by 8.67 % (P>0.05) until the 3rd day after insemination. The high milk flow increased significantly two days before insemination, on the insemination day and the day after insemination (P<0.05). The study has indicated the relationship between the assessed values of milkability traits, which may help in observing the hazy cow ooestrus. However, further investigation of the relationship between these indicators is necessary.

**Keywords:** milk yield, milking time, milking speed.

## Introduction

The cow milk production and reproduction are the most significant traits of dairy cattle for the most farmers in the world (Klaas et al., 2005). It has been observed that improving the productivity of cows', the reproductive traits of cows' are weakened (Hogeveen, 2005). Weak signs of oestrus and a longer recovery period after calving (Simersky et al. 2007) define impaired reproductive function. A study by V. Žilaitis (2009) indicated a tendency that increased cows' milk production is associated with the deteriorating cows' reproductive traits. The effect of production on cows' health is indirect. The reduction in productivity provides the conditions for the activation of the reproductive system. Mild signs of ooestrus are typical for modern breeds of cows. Between 10 and 40 percent of cows, do not show signs of ooestrus at all. It is believed that this observation is the consequence of wrong selection and high productivity. Anooestrus after calving is a major reason for the prolonged period from calving to insemination (servis period; Žilaitis, 2009). This period characterizes cow's reproductive physiology, and is associated with all the physiological parameters of the cow (Van Knegsel et al., 2005). Servis period is also an important indicator of herd health (Sheldon et al., 2009). Cow's oestrous cycle is divided into oestrus (day 0), metooestrus (days 1-4), diooestrus (days 5-18) periods which correspond to the luteal phase, and prooestrus period (days18–20) (Žilaitis, 2009). Prooestrus is the period during which the female sex organs become ready for mating and conception. During this period, the first signs of sexual arousal are already seen (Zootechniko žinynas, 2007). Prooestrus phase lasts for 2-3 days, during which the corpus luteum regresses and ovulatory follicle reaches the last stage of growth. The concentration of progesterone decreases, luteinizing hormones and estrogens act on each other via a positive feedback loop. The cow becomes restless, eats less, but the external signs are visible just a few hours before oestrus. (Zootechniko žinynas, 2007). The major cytological and morphological changes occur during the time of oestrus (Žilaitis, 2009). Oestrus is the most important stage of the sexual cycle, during which the entire activity of the female body is directed towards one goal - to mate and get inseminated. During oestrus the overall arousal of the cow and agitation are observed, metabolism is activated. (Zootechniko žinynas, 2007). Due to the proliferation of the cells the epithelium of the vaginal front is thickened, hypertrophy of uterine secretory cells takes place. The uterus and endometrium are filled with edema fluid, and the uterine muscle layer contracts. In such state the uterus is one day before and after oestrus. After oestrus, leukocyte invasion is activated. This lasts for 2–5 days at most. After oestrus the mucus becomes clear and drains easily. (Žilaitis, 2009). The duration of oestrus cycle of the cow is determined by its breed, age, time of the year, time of day and health. It has been noticed that dairy cows of modern breeds undergo longer oestrus, while the behavioural changes are mild (Žilaitis, 2009). At the beginning of oestrus milk production decreases, and the reason usually is that cows do not release milk (Zootechniko žinynas, 2007). The importance of milking properties is increasing in the modern dairy farms. Due to their significant economic effect on the farm, these features are being included in breeding programs (Mijic et al., 2003; Santus et al., 2005). Milkability traits test is a good tool for the additional monitoring and evaluation of the milk production, milking efficiency and economic aspects, as

well as for synchronization and development of milking equipment (Tancin et al., 2007; Strapák et al., 2009; Strapák et al., 2011). It was found that the stage of lactation has a significant impact on the total milk production, milk secretion rate and the main milk secretion phase (Antalík and Strapák, 2011; Strapák et al., 2011). During the first term of lactation, the cows are milked longer than during the second one (Pelt, 2008). The results obtained during the investigation of the morning and evening milking, show differences in milkability traits, milk yield and milk composition, provide additional data, which allows the selection of the most suitable intervals between milking (Chladek et al., 2011). The research on milkability traits, productivity, reproductive performance and the relationship between these parameters of dairy cows is very important, because all of these features and their proper combination is the basis for economic growth of the dairy farm and its efficient development.

The aim of the work was to assess the dynamics of the productivity and milkability traits of dairy cows during the period of oestrus and insemination day.

**Materials and methods**

The scientific research work was carried out at a Lithuanian dairy farm from April to October, 2012. The research involved 149 dairy cows that were successfully inseminated during this period. Cows were grouped by breed. Milk production and milkability traits of the 21 Lithuanian Black and White, 28 Holstein, 6 German Black and White, 80 Lithuanian Red and 9 Ayrshire cows were evaluated. During the study, the following parameters were assessed - daily milk yield (kg), milk yield, milking time (kg), milking speed (kg/min.) and high milk flow (kg/min.). The parameters determined every day from $5^{th}$ days before the successful insemination of the cows, on the day of insemination, and 5 days after insemination of cows. The milkability traits and productivity of the cows were studied every day during the morning and evening milkings using electronic milk-meters (DeLaval) installed in the cow-milking parlour. The obtained data on milkability traits was processed using DeLaval Apro Windows program.

The statistical analysis was performed using analysis of variance (ANOVA) using the statistical package R 2.15.2. (http://www.rproject.org/). All records necessary for the study were selected and included into the designed database. When analysing the data, averages ($\bar{x}$) and their errors ($m_x$), and reliability (P) were calculated for each measured parameter.

The significance of the difference between the arithmetic averages of average parameters was determined by calculating the reliability criteria $t_d$ between different groups of parameters. Reliability criteria $t_d$ was compared to a standard t-value of the Student's table. After grouping the studied parameters, the reliability of the difference between the arithmetic averages was determined between the respective groups of parameters. The results were considered reliable when significance P was <0.05, and unreliable when P>0.05.

**Results**

Evaluation of the average productivity of cows per day, and during morning and evening milkings (see Fig. 1) showed no significant difference in the amount of milk five days before and after insemination. From day $3^{rd}$ before insemination, slight non-significant increase of milk production (1.71 kg) was observed. On the day of insemination, slightly less milk 1.51 kg (P>0.05) was produced than on the day before insemination. Until the second day after insemination the amount of milk decreased slightly (0.83 kg), while on day $3^{rd}$ after insemination started to rise again (P>0.05).

A similar trend of milk yield was observed during the morning and evening milking (P>0.05). There was slightly, but non-significantly more milk produced during morning milking (0.26 to 1.07 kg) than during the evening milking (P>0.05).

The evaluation of milk yield of different breeds dairy cows during the day of the investigation period (see Fig. 2) showed that milk yield of Holstein cows decreased slightly 4 days before insemination and increased 3 days before insemination. On the day of insemination a slight decrease of milk yield was observed (P>0.05). The highest milk yield was on the $2^{nd}$ day after insemination; it was 9.8% (2.16 kg) higher than at the start of the study period (P>0.05) and 1.85% (0.44 kg) more than at the end of the study (P>0.05).

The milk yield of Lithuanian Black and White, Lithuanian Red and Ayrshire cows decreased on days 2–3 before insemination and increased on the day before insemination, during insemination day and day one after insemination, after which a decrease of milk yield was observed again. The productivity of Lithuanian Black and White cows started to decline three days before insemination and decreased by 28.5% (6.76 kg) (P>0.05) as compared with day 4 before insemination. One day before and after insemination and on the insemination day, the milk yield of these cows rose and was 25.3% (5.87 kg) higher as compared to that on day 2 before insemination (P>0.05). Later, the productivity declined, but in the case Lithuanian Red and Ayrshire cow breeds, this trend was not significant. The milk yield of German Black and White cows increased on the day before insemination. On the insemination day and one day after insemination, the production decreased and was 29.32% (6.46 kg) less than on the day before insemination (P>0.05). On the second day after insemination, milk yield increased by 32.3% (5.03 kg). From day 4 after insemination, decrease of milk yield was observed.

Evaluation of the milking duration (see Fig. 3) showed that the milking time in the morning of the day before insemination and on insemination day was shorter by 4.96% (0.28 min), and on the $1^{st}$ day after insemination reduced further by 1.68% (0.09 min.) (P>0.05), and was lowest during study period.

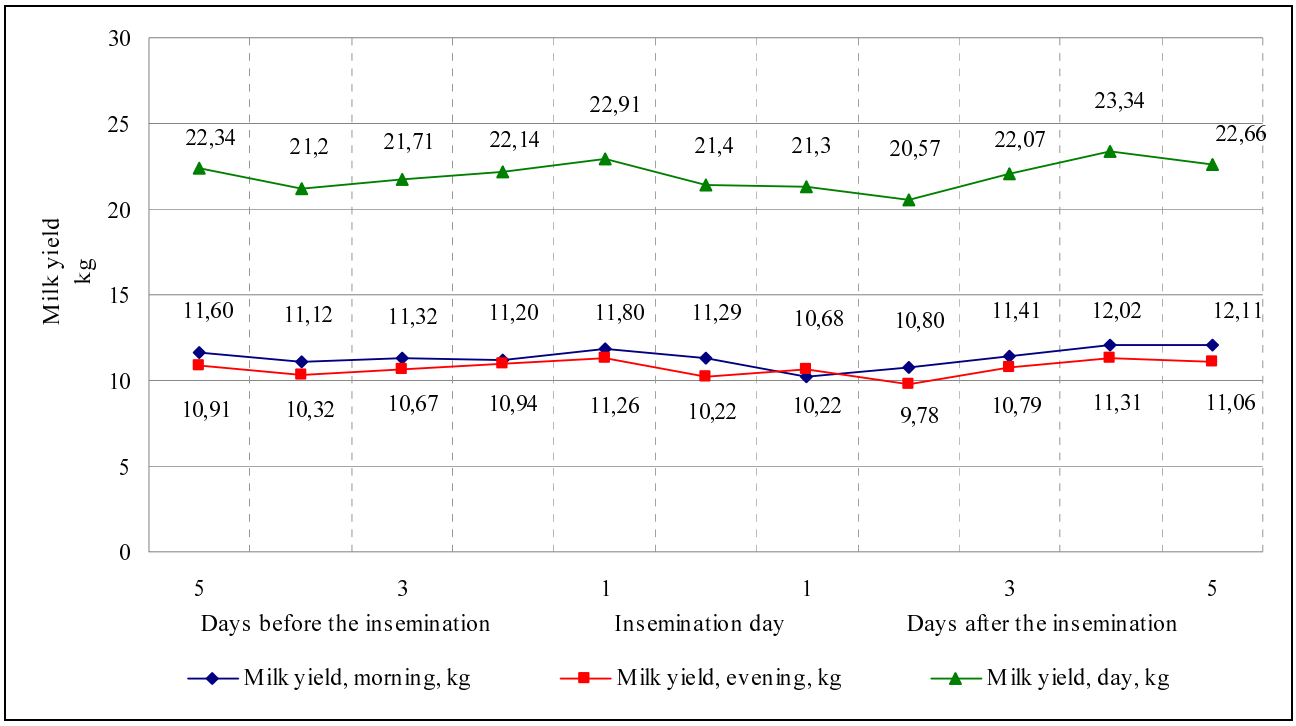


Fig. 1. **Changes of milk yield before and after insemination**

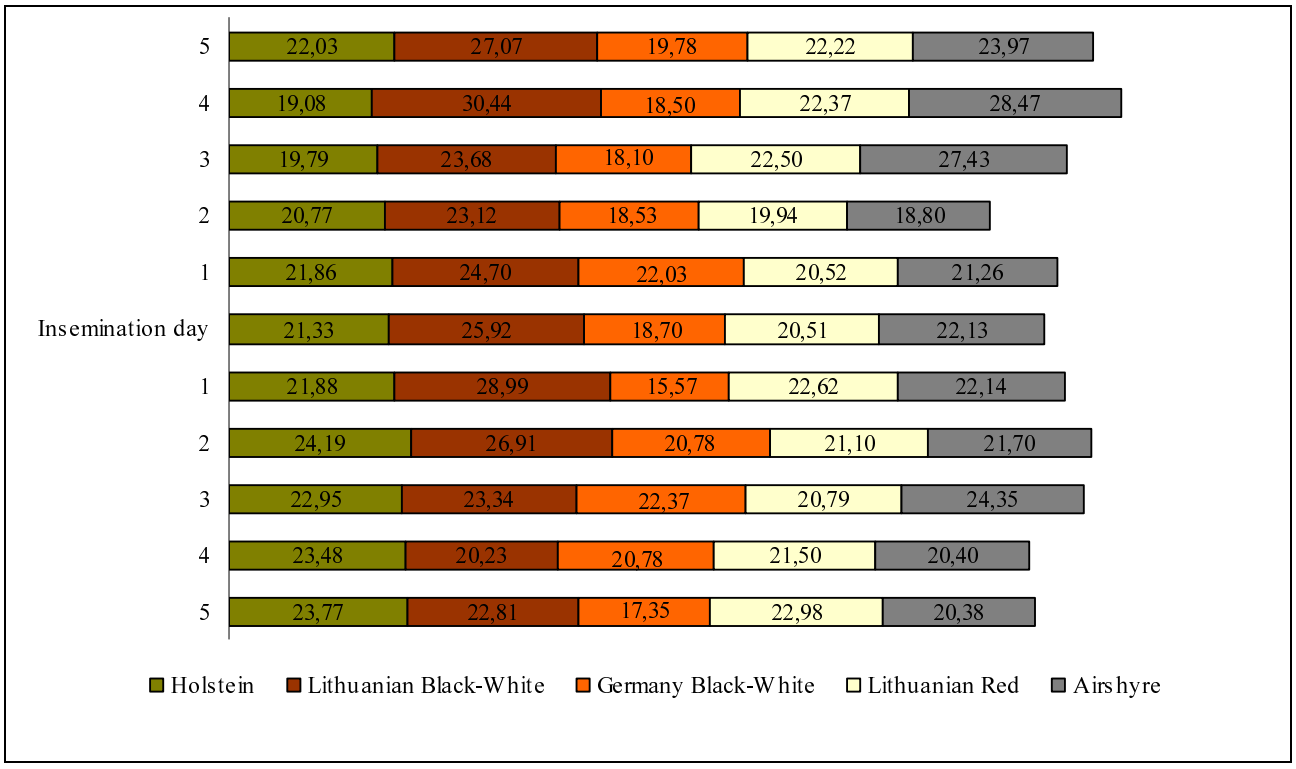


Fig. 2. **The variation of milk yield (kg) of different cow breeds before and after insemination**

From the second day after insemination, the milking time in the morning increased, and on day 4 after insemination was 17.88% (0.91 min.) longer than on the first day after insemination ($P<0.05$). From the 5$^{th}$ day, the milking time was similar to that at the start of the study period.

Three days before insemination, the milking time in the evening decreased, and on the day of insemination was 18.12% (0.71 min) ($P<0.05$) shorter. It shortened further by 0.59 % (0.03 min.) ($P<0.05$) on the 1$^{st}$ day after insemination and was lowest during study period. On the 2$^{nd}$ day after insemination, the milking time in the evening

increased and on the 3rd day after insemination was 14.31% (0.85 min.) longer than on the 1st day after insemination (P>0.05). From the 4th day, the milking time in the evening was similar to that at the start of the study period.

The evaluation of milking time of the different breeds during the study period (see Fig. 4) showed that the shortest milking was of Holstein, Lithuanian Red and German Black and White breeds, while the longest milking was of Lithuanian Black and White and Ayrshire cows.

The milking time of Holstein and Lithuanian Black and White cows' decreased on the insemination day, while in the case of Ayrshire cows, this indicator decreased one day prior to insemination. Meanwhile, in the case of German Black and White and Lithuanian Red cows, the milking time increased before insemination (on days 1 and 2 respectively).

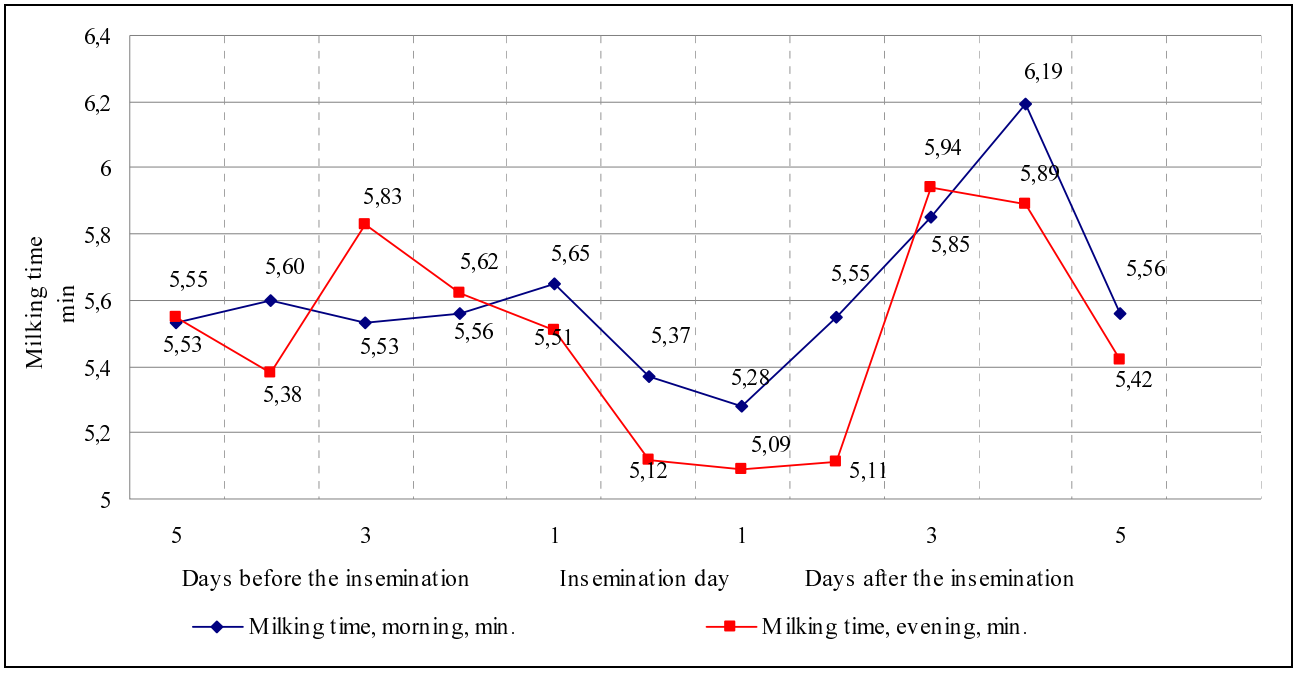


Fig. 3. **The variation of milking time before and after insemination**

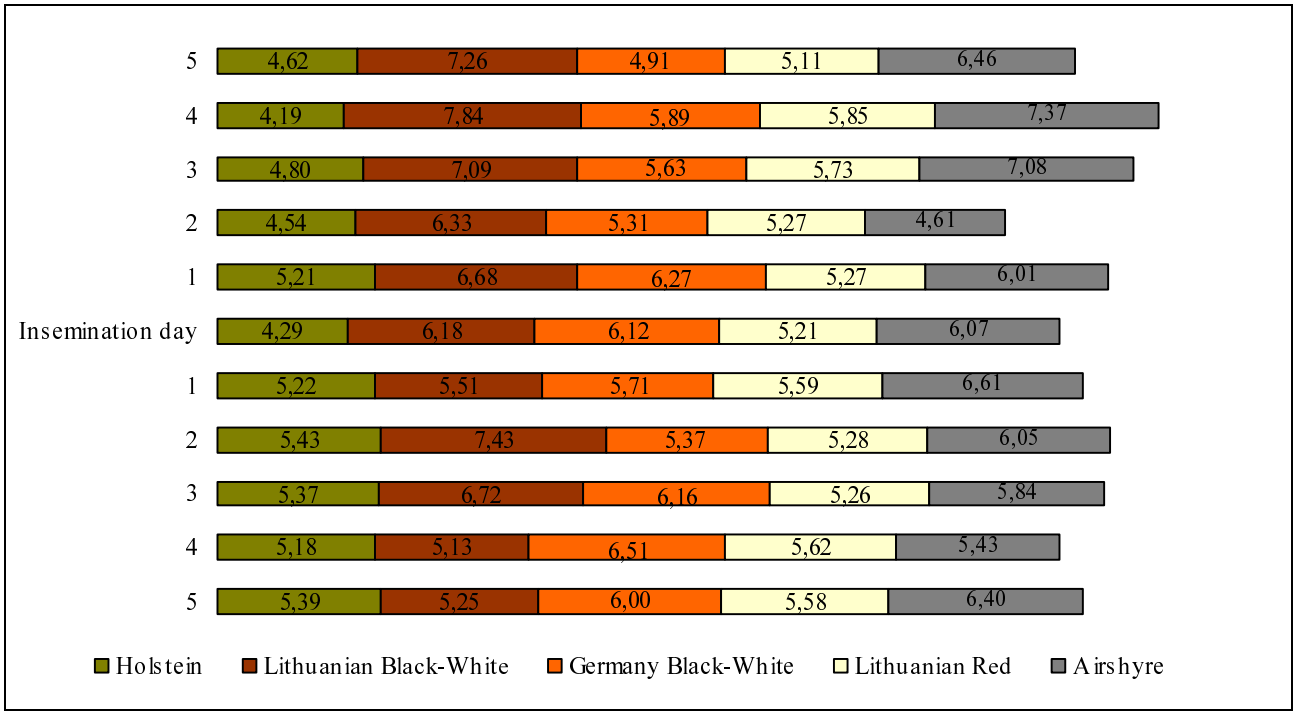


Fig. 4. **Variation of milking time** (min.) **of different cow breeds before and after insemination**

On the insemination day, the milking time of the Holstein, Lithuanian Black and White and Ayrshire cows was shorter by 14.7% (0.33 min.), 14.87% (1.08 min.), and 6.04% (0.39 min.) respectively, whereas the milking time of German Black and White and Lithuanian Red cows was longer by 24.64% (1.21 min.), and 7.2% (0.37 min.), respectively, as compared to the milking time at the start of study period (P>0.05). At the end of study period, the milking time for all cow breeds, with the exception of Lithuanian Black and White cows, increased and was similar or higher than the milking time at the start of the study (P>0.05).

Statistical analysis of milking speed data showed (see Fig. 5) that the milking speed of both, morning and evening milking, increased 2–3 days before insemination. On day 2 before the insemination the milking speed was highest and increased by 11.6% (0.23kg/min) as compared to the 4 days before insemination (P>0.05). One day prior to insemination, the milking speed declined by 4.94% (0.08 kg/min; P>0.05) and further decreased by 9% (0.18 kg/min; P>0.05) on the 1st day after insemination, when it was the lowest. From the 2nd day after insemination the milking speed started to increase and on the 5th day after insemination was 10.34% (0.21 kg/min) higher than on the 1st day after insemination (P>0.05).

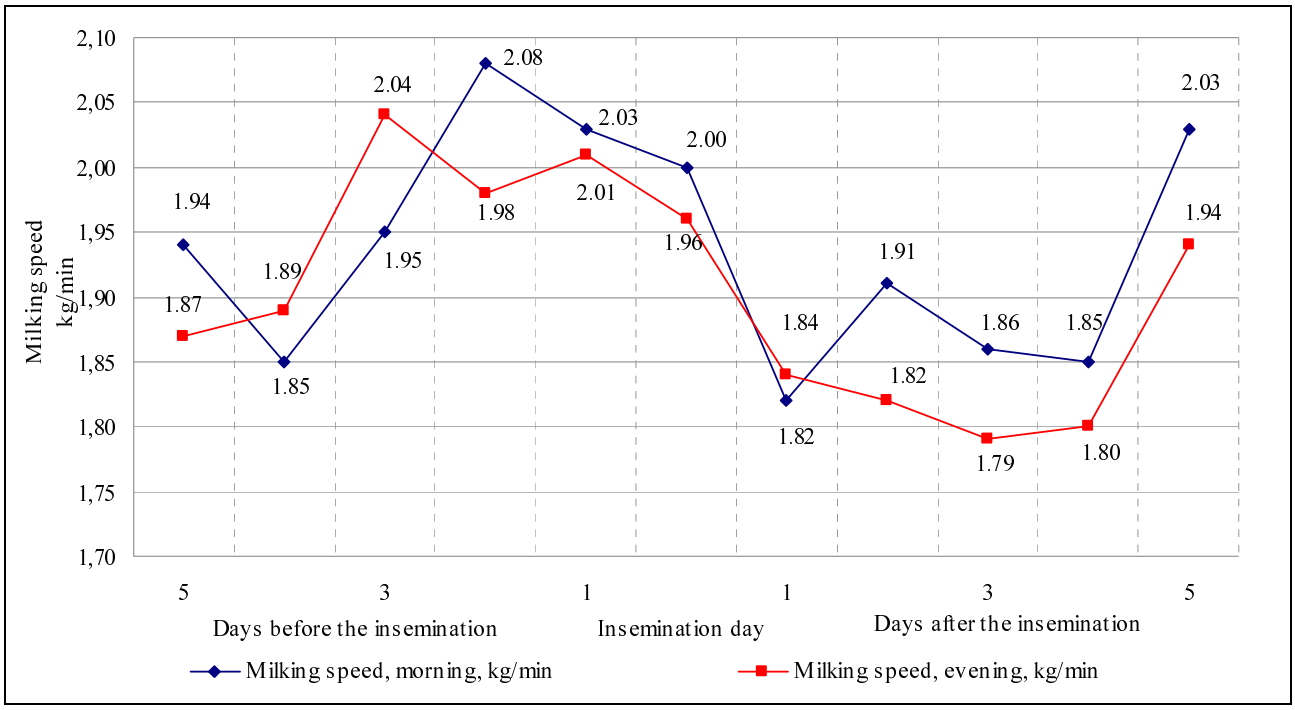


Fig. 5. **Variation of milking speed before and after insemination**

Similar changes of milking speed were observed in the evening milking. Three days before insemination, the milking speed in the evening was the highest and increased by 31.9% (0.19 kg/min; P>0.05) as compared to the milking speed 4 days before insemination. On the insemination day, the milking speed in the evening was slower by 3.92% (0.08 kg/min; P>0.05) as compared with that of three days before insemination. The evening milking speed further decreased by 8.67% (0.17 kg/min; P>0.05) until the 3rd day after insemination, when it was lowest. On the 4th day after insemination, the milking speed started to increase and on the 5th day after insemination it was 7.73% higher (0.15 kg/min.) than on the 3rd day after insemination (P>0.05).

The evaluation of milking dynamics of different cow breeds during the study period (see Fig. 6.) showed that the highest and lowest milking speeds were of Holstein and Ayrshire breeds, respectively.

The milking speed of Holstein cows increased on the day of insemination and was highest throughout the study period. On the 1st day after insemination, the milking speed was lower by 17.2% (0.43 kg/min) than on the insemination day (P<0.05). The lowest milking speed was observed 3 days before insemination, and was 23.2% (0.58 kg/min) lower than on the insemination day (P>0.05).

The variation of milking speed of other breeds was negligible. In the case of Lithuanian Black and White cows the milking speed on the insemination day was 15% (0.27 kg/min) higher than lowest value 3 days before insemination (P>0.05). The high milking speed of this breed was at the 1st day after insemination, and was 17.39% (0.36 kg/min) higher than on the day of insemination (P<0.05), and 35% (0.63 kg/min) higher than 3 days before insemination (P>0.05).

Statistical analysis of the high milk flow showed (see Fig. 7) that on 4 days before insemination the high milk flow in morning decreased and was 5.06% (0.16 kg/min; P>0.05) less than on 5 days prior to insemination. Two days before insemination, the high milk flow in the morning was highest and was 9.91% (0.33 kg/min; P>0.05) higher as compared to 4 days prior to

insemination. A day prior to insemination, the high milk flow in the morning decreased and was 3.90% (0.13 kg/min; P>0.05) lower than on two days prior to insemination. On the insemination day, the high milk flow increased by 1.56% (0.05 kg/min; P>0.05). Starting on the 1st day after insemination, the high milk flow was decreasing and on the 4th day after insemination was 8.31% (0.27 kg/min) lower than on the insemination day (P>0.05). On the 5th day after insemination, the high milk flow of cows increased again.

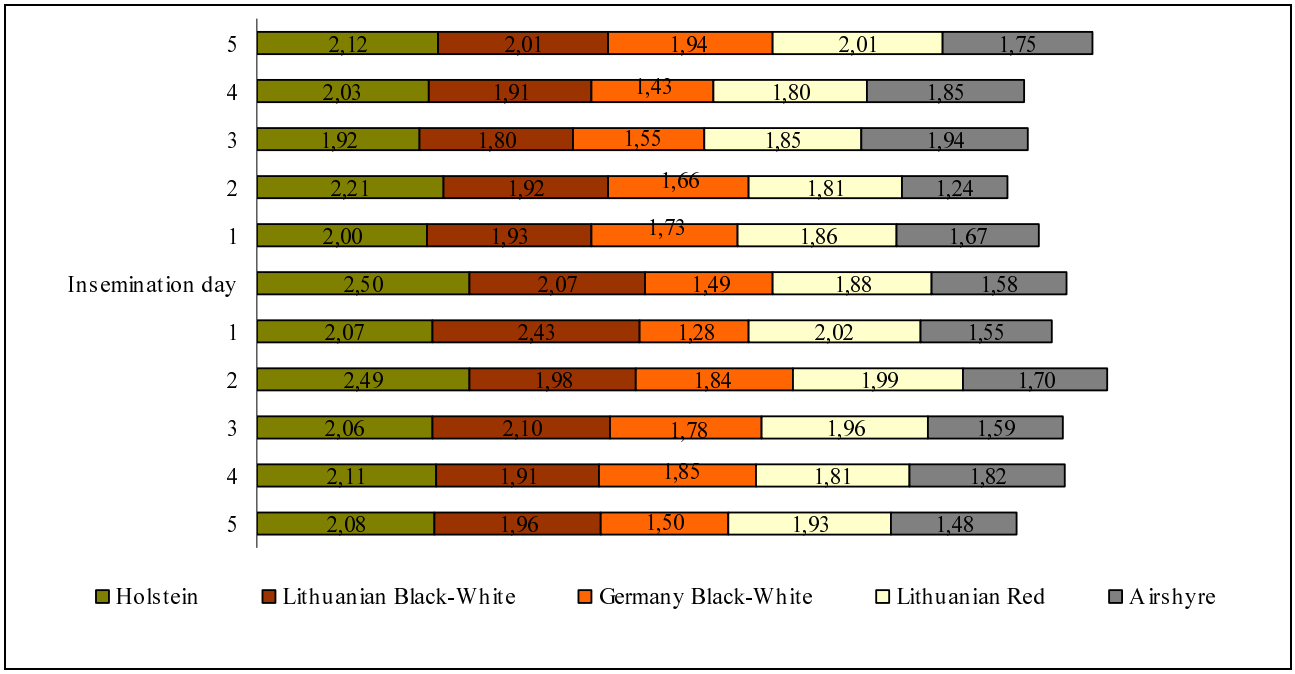


Fig. 6. **The milking speed** (kg/min.) **variation of different cow breeds before and after insemination**

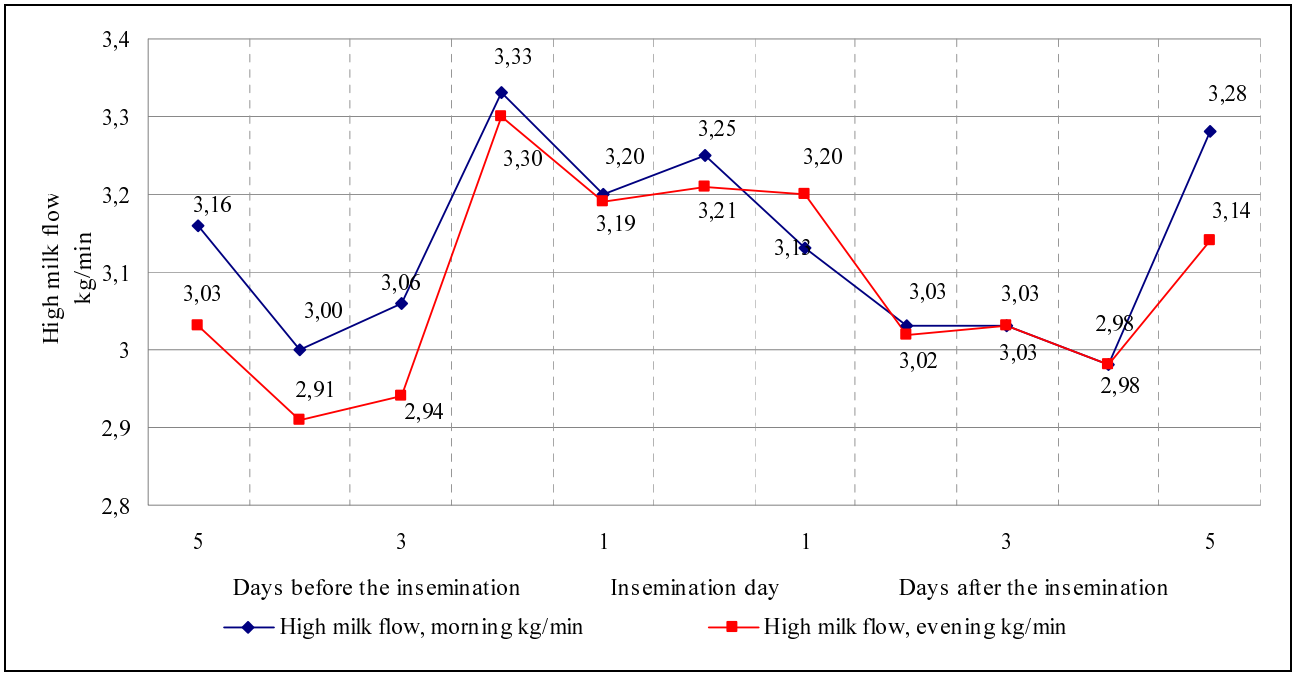


Fig. 7. **Changes of the highest milk flow before and after insemination**

Similar variation of the high milk flow was observed in the evening milking. Two days before insemination, the high milk flow in the evening was the highest and was 11.82% (0.39 kg/min; P<0.025) higher as compared 4 days prior to insemination and 3.33% (0.11 kg/min; P>0.05) higher than one day prior to insemination. On the insemination day, the high milk flow in the evening milking was only slightly higher (0.02 kg/min, i.e., 0.62%; P> 0.05). The high milk flow in the evening decreased by 17.7% (0.23 kg/min; P>0.05) on the 4th day

after insemination and was lowest, after which the high milk flow started to increase, and on the 5th day after insemination was 4.78% (0.15 kg/min) higher than on the previous day (P>0.05).

The results of the high milk flow dynamics during the study period among different cow breeds (see Fig. 8) show that the high milk flow of Holstein cows was highest three days prior to insemination, and was 15.6 % (0.4 kg/min) higher than at the start of the study period (P>0.05).

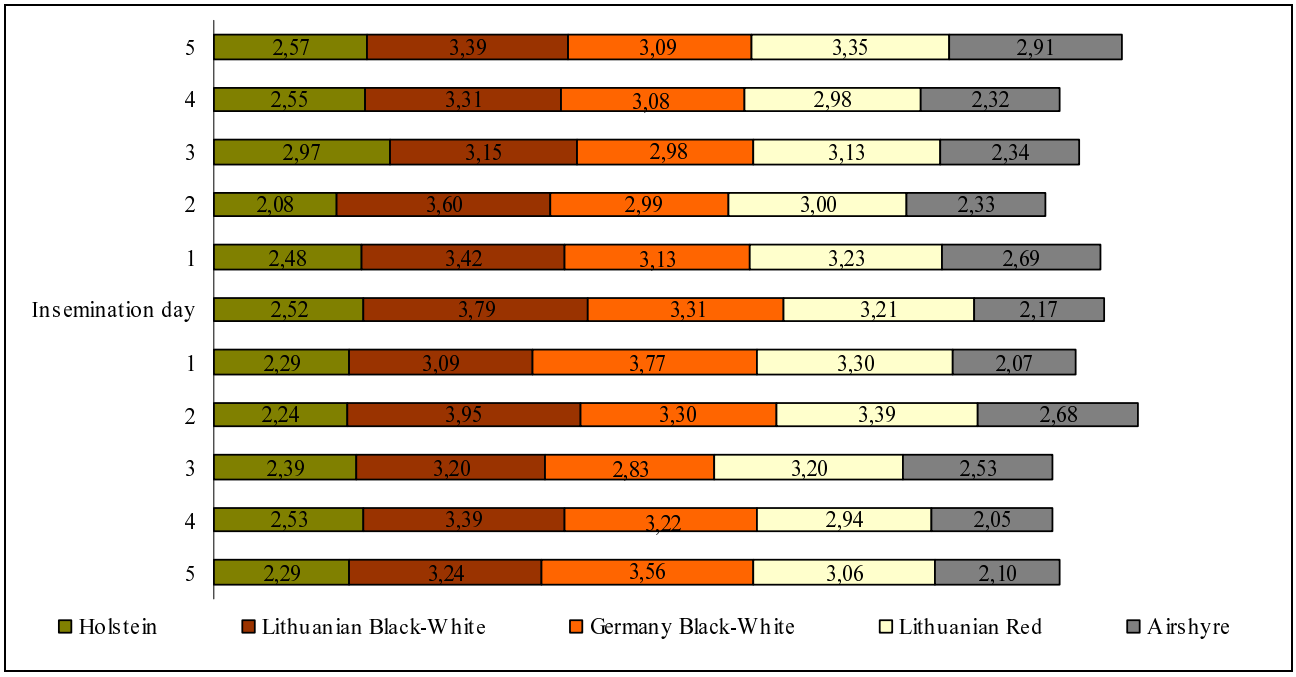


Fig. 8. **Different breeds of cows in highest milk flow** (kg/min.) **changes before and after insemination**

Two days prior to insemination, a clear decrease (by 29.96% (0.89 kg/min)) of the high milk flow was observed (P>0.05). On the insemination day, the high milk flow was similar to that of the start of study period, while on the 1st day after insemination, the high milk flow decreased.

The highest milk flow of Lithuanian Black and White cows on the insemination day was 11.8% (0.4 kg/min) higher than at the start of the study period and on the 4th day after insemination (P>0.05). A smaller increase of this parameter was observed in German Black and White cows - the high milk flow on the insemination day was 11.7% (0.22 kg/min) higher than at the start of the study period (P>0:05) and 7.02% (0.25 kg/min) lower than at the end of the study period (P>0.05). On the 1st day after insemination, the high milk flow increased significantly (by 13.89% (0.46 kg/min)), and was highest during the entire study period. In the case of Lithuanian Red and Ayrshire cows, the high milk flow decreased on the insemination day, and two days after insemination it was similar to that at the start of the study period.

**Discussion**

Due to the reproductive disorders or delayed insemination of cows, farmers suffer significant losses. Lithuanian dairy farms are becoming larger; the milk yield tends to increase, while at the same time the number of reproductive problems increases. Genetic improvement of dairy cow herds in order to increase milk production reduces their fertility. Naturally, not all dairy cows of modern breeds become fertilized within three months after calving. The causes of in fertilization are high productivity and impaired energy turnover (Žilaitis, 2009). The oestrous cycle of the cow is a complex neurohumoral process during which physiological and morphological changes in sex organs and in the whole organism of the cow occur (Masiulis et al, 2003), which in turn have an effect on the productivity of cows. At the beginning of oestrus, the production of milk decreases, and the reason for this usually is that the cow does not release milk (Zootechniko žinynas, 2007).

Tancin and co-authors (2006) found that 3.5 kg more milk was obtained during the morning milking as compared to the evening milking. Chladek and colleagues (2011) investigated the milk yield of the morning and evening milkings and found that approximately 3.6 kg more milk was obtained during the morning milking. Sarb et al., (2007), Jovanovac and co-authors (2008), as well as Adebosin et al. (2010) also found that higher productivity is during the morning milking. The study of Tancin and co-authors (2006) also showed that the milking speed of the morning milking was 0.07 kg/min higher than that of the evening milking. In addition, the differences in milk flow and milking time between the morning and evening milking were related to the milk yield (Tancin et al., 2003). The higher milk yields lead to the increase of the average duration of milking, but also increases the average milking speed and the high milk flow. A study by R. Japertiene (2007) showed that the most productive cows' had the longest milking time, and that the higher

milking speed is associated with the higher milk yield.

It has been observed that hat oestrus of modern dairy cow breeds is becomig longer, and that behavioral changes during the heat are mild (Žilaitis, 2009). The duration of cows' oestrus, productivity and milking properties are affected by their breed, age, time of the year, time of day and health (Žilaitis, 2009).

According to the data of German scientists (Gade et al., 2005), the average milking time of Holstein cows was 5.7 min, the maximum milk flow 3.8 kg/min, milking speed was 2.5 kg/min. Mijic and colleagues (2003) found that the milk yield ranged from 1.61 to 3.60 kg/min in 67% cows of Holstein breed. The study of Strapák et al. (2011) showed that the average total milk yield per milking of Holstein cows was 11.98 ± 3.41kg, the average milk flow 2.52 ± 0.75 kg/min, and the high milk flow 3.94 ± 1.30 kg/min. S. Walsh and co-authors (2007) found that the milking speed of Holstein cows was 1.52 kg/min, high milk flow 3.67 kg/min. V. Juozaitienė and R. Japertienė (2010) found that the average milking speed of Black and White cows was 1.69 ± 0.01 kg/min, while the average high milk flow was 3.12 ± 0.01 kg/min.

Many authors have found that cows' oestrus is a complex neurohumoral process during which physiological and morphological changes occur in the cows' body (Masiulis et al., 2003), which can be observed in animal behaviour change, the body's excitement and productivity losses. Most other authors have analysed the interrelationship between cows' oestrus and productivity, but very few studies examined how physiological changes of oestrus affect milkability traits, although many authors associate the decreased amount of milk during this physiological period with the reduced milk release. More often in the papers of other authors the changes of milkability traits are analysed during the course of lactation, and not during certain physiological periods.

Scientists have estimated that not only cow productivity dcreases during the heat but also the change in milk composition and quality occurs (Jukna, 1998). Stankūnienė et al., (2008) determined that heat reduces the yield. Milk yield and composition during this period depends on oestrus activity and individual cows' performance. Gumauskas and co-authors (2012) have determined the decline in cow productivity during oestrus. However, other researchers argue that reproduction indicators do not depend on milk production (Patton et al. 2007). It is believed that the optimal insemination time is after the 60$^{th}$ day of lactation, because cows impregnate more successfully at that time (Inchaisri et al., 2010). S. König (2008) has found that there is a significant negative statistical relationship between milk production and successful impregnation, so it is recommended to inseminate the cow during the productivity decline phase, which is the 60$^{th}$–90$^{th}$ days of lactation. Considering the Holstein cows lactation, the average high milk flow was achieved at the beginning of lactation (up to 100 days in milk), the high milk flow was determined in the second lactation of dairy cows. R. Japertiene (2007) conducted a test to determine the milking speed in Black and White cows, which was 1.691 (± 0.614) kg/min. (P <0.001), while in the Red and White cows 1.634 (± 0.018) kg/min. P<0.001). Cow milking duration kept increasing until the 60$^{th}$ day of lactation (P<0.001), after that day there was a prominent decrease in milking time. Considerable increase in milking speed in Black and White cows (from 1.468 to 1.791 kg/min., P<0.001) was determined until the 60$^{th}$ day of lactation and not so prominent from the 120$^{th}$ to the 180$^{th}$ days of lactation (from 1.749 to 1.860kg/min., P<0.001).

**Conclusions**

The results have not shown any significant decrease in milk yield of cows, but on the day of insemination milk yield was smaller by 6.59% (P>0.05) than on the day before the insemination, and only from the 3$^{rd}$ day after insemination milk yield began to increase (P>0.05). Milk yield decreased slightly before and on the insemination day in all breeds of cows, except for Lithuanian Black and White, where the milk yield fell on the day before insemination, and increased on the insemination day and the day after.

The milking time in the morning shortened on the day before insemination, and on the insemination day it was 4.96% (P>0.05) shorter; the milking time in the evening was decreasing three days before insemination, and on the insemination day it was 12.18% (P<0.05) shorter. One day before insemination, the milking speed decreased and on the insemination day it declined by 4.94% (P>0.05); on the 1$^{st}$ day after insemination it decreased yet by 9% (P>0.05). Three days before insemination, the evening milking speed dropped by 3.92% (P>0.05) and until the 3$^{rd}$ day after insemination decreased by further 8.67% (P>0.05). A significant increase in high milk flow two days before insemination, on the insemination day and after that has been established (P<0.05).

During the study period, the most notable changes in the milking characteristics have been observed in Holstein, Lithuanian Black and White, German Black and White cows. Less pronounced changes have been noticed in the Lithuanian Red and Ayrshire cows.

Many authors have determined the impact of oestrus on the overall physiological state and productivity, the decrease of which has been explained as reduced milk yield. However, there are no studies on the impact of oestrus on cows milking characteristics. Our studies have shown the interrelationship between these indicators, which can help to notice inconspicuous cow oestrus, but it requires more research on the interrelation between these indicators.

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