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Relationship between main reproductive parameters and productivity traits in dairy cows

[*Relação entre os principais parâmetros reprodutivos e características de produtividade em vacas leiteiras*]

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ABSTRACT

The objective of this study was to determine relationship between Lithuanian dairy cow breed productive and reproductive traits. The study was carried out with 586 fully completed lactation cows: 184 Lithuanian Holstein (H), 320 Lithuanian Black and White (LBW) and 82 Lithuanian Red (LR) cows (291 cows in I, 149 in II and 146 in III and older lactations). Cow productivity and reproduction traits were calculated. H cows in I lactation had a lower insemination index compared to the LR, shorter calving interval (P≤0.05) and service period (P≤0.05) than LBW cows. LBW cows produced 1440.46kg more milk (P≤0.05) with less milk fat and protein content (accordingly 0.28 and 0.22 percent) (P≤0.05) compared with the LRd. The service period of LBW older lactation cows was 21.38 days longer and the insemination index was 0.68 times higher compared to the I lactation cows (P<0.05). LR cows of III and older lactations produced 3742kg more milk (P≤0.05) compared with the I lactation. All cows from 131 and more service period days produced 1420kg more milk with 0.51 percent less fat (P≤0.05) and 0.1 percent less protein than cows with the service period from 91 till 110 days (P≤0.05).

Key words: cow, breed, reproduction, production

RESUMO

O objetivo deste estudo era determinar a relação entre características produtivas e reprodutivas de vacas leiteiras lituanas. O estudo foi realizado com 586 vacas em lactação totalmente completas: 184 vacas Holstein (H) lituanas, 320 vacas Preto e Branco (LBW) lituanas e 82 vacas Vermelhas (LR) lituanas (291 vacas da raça I, 149 da raça II e 146 da raça III e lactações mais velhas). Foram calculadas a produtividade e as características de reprodução das vacas. As vacas da vaca H da vaca em lactação I tinham um índice de inseminação menor em comparação com a LR, intervalo de parição mais curto (P≤0,05) e período de serviço (P≤0,05) do que as vacas LBW. As vacas LBW produziram 1440,46 kg a mais de leite (P≤0,05) com menos gordura láctea e teor de proteína (consequentemente 0,28 e 0,22 por cento) (P≤0,05) em comparação com a LRd. O período de serviço das vacas de lactação LBW mais velhas foi 21,38 dias mais longo e o índice de inseminação foi 0,68 vezes maior em

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comparação com as vacas de lactação I (P<0,05). As vacas LR de lactação III e mais velhas produziram 3742 kg mais leite (P≤0,05) em comparação com a I lactação. Todas as vacas de 131 e mais dias de serviço produziram 1420kg mais leite com 0,51% menos gordura (P≤0,05) e 0,1% menos proteína que as vacas com o período de serviço de 91 a 110 dias (P≤0,05).

Palavras-chave: vaca, raça, reprodução, produção

INTRODUCTION

Reproduction is an important factor in determining the efficiency of animal production. Poor reproductive performance leads to economic losses due to reduced production, a prolonged calving interval, and additional costs for improving lactation persistency and reproductive traits (Strapáková *et al*., 2016; Kumar *et al*., 2017; Niozas *et al*., 2019). Dairy cow reproduction is affected by the different aspects of management including differences within and between breeds in production, nutrition and breeding become significant. The reproductive efficiency of a breeding cow is determined by factors like age at first calving, calving interval, and number of services per conception (Bujko *et al*., 2013; Dochi *et al*., 2010; Nuraddis and Ahmed, 2017). Shortening the calving interval reduces the average days in milk of the herd (Ribeiro *et al*., 2012). The increased number of services per conception often indicates the problems with cow reproductive system, which has a negative impact on farms profitability (Honarvar *et al*., 2010).

The productive life of a dairy cow is an indicator of her utility and is influenced by her age at first calving, calving intervals, length of each lactation, and milk yield and quality (Nuraddis and Ahmed, 2017). As environmental conditions, keeping and feeding systems change, reproductive parameters and milk composition and other productivity traits of milking cows change as well (Šernienė *et al*., 2015). Milk protein concentration has been positively associated with reproductive performance in dairy cows in both seasonally calving (Patton *et al*., 2007). Higher milk protein concentration has been associated with shorter calving to first service intervals higher submission and conception rates (Miettinen and Setala, 1993, Buckley *et al*., 2003). It was found mastitis leads to decreased pregnancy rates, higher number of services per conception, and decreased conception rate (Hertl *et al*., 2010) in dairy cattle. The most important aims in cattle breeding are to obtain a calf in a year and high milk yield from cows. Profitable breeding could be achieved by keeping lactation duration, dry and service periods between optimal limits (Kocak *et al*., 2007; Cilek and Tekin, 2005). The objective of this study was to determine the relationship between Lithuanian dairy cows breeds productive and reproductive traits.

MATERIALS AND METHODS

The study was carried out with 586 fully completed lactation cows (184 Lithuanian Holstein (H), 320 Lithuanian Black and White (LBW) and 82 Lithuanian Red (LR). From all analyzed cows 291 of them were first lactation, 149 cows in the second and 146 cows in the third and older lactation). The experiment was conducted from June 2018 to February 2020. Cows calved from June 2018 to January 2019 were used in the study. All cows on the farm were housed and fed equally. Cows were kept throughout the year in a cold type loose-housing farm. Cows were milked twice a day at the side by side 2 x 14 milking parlor.

Data for the analysis were obtained from the Dairy Farm, the Agricultural Information and Rural Business Center and the Cow herd management program. Fat and protein content in milk was determined by the Lactoscope 550 and number of somatic cells was determined by the device Somascop MK2 (Delta Instruments, Netherlands).

For each evaluated trait cow productivity indicators were calculated: milk yield per lactation (kg), milk fat and protein content (percent), somatic cell count in milk (thousand/ml) and reproduction parameters – service period (days), insemination index (times) - averages (X) and mean errors (mx). The statistical analysis of the research data was performed using the data collection and the analysis program package SPSS 22.0 (Statistical Package for Social Science 22 for Windows).

Statistical analysis of data was performed by dispersive analysis method (ANOVA) using statistical packet SPSS 20. Statistical reliability (p) of differences between averages was assessed by LSD Fisher criterion. Differences were considered reliable when P≤0.05.

RESULTS

The distribution of reproductive parameters of H, LBW and LR cows breed is shown in Table 1. LR cows were inseminated 0.53 times more than H breed cows, and 0.21 times less than cows of LBW breed (P<0.05) respectively. The longest calving interval and service period for LBW cows were on average 13.09 days longer compared with H breed cows (P<0.05). The minimum number of days before the first insemination was an average 2.48 days shorter in comparison with the H breed cows was obtained for LR cows.

The influence of cows' breed and lactation number on reproductive performance of cows' is shown in Table 3. Lithuanian red cows of the second lactation had the longest service period. It was on average 19.59 and 26.13 days longer than that of LBW and H breed cows respectively. Lithuanian red cows of the first lactation had the shortest service period, i.e., 35.23 shorter compared with the second lactation cows and 13.21 days shorter compared to LBW breeding cows (P≤0.05). Service period of first lactation H breed cows was 3.28 days shorter compared with the second lactation cows. Insemination index (services/conception) of H cows was 1.89, LBW and LR breed 2.25 and 2.12 respectively.

Table 1. Reproductive performance of cows by breed

Breed	Lactation	n	Service period, days	Insemination index, times	Days up to max yield
H	I	78	106.47±6.34	1.71±0.18^{a}	98.16±7.30^{a}
	II	67	109.75±7.69	1.91±0.19^{b}	54.69±5.31^{b}
	III and older	47	107.23±7.26	2.05±0.22^{b}	58.50±6.35^{b}
LBW	I	164	113.86±5.70^{a}	1.95±0.13^{a}	93.98±4.82^{a}
	II	64	116.29±8.26^{a}	2.16±0.19^{b}	69.52±7.87^{b}
	III and older	99	135.24±6.20^{b}	2.63±0.19^{c}	61.45±4.18^{c}
LR	I	49	100.65±6.92^{a}	1.87±0.21	84.52±8.68^{a}
	II	18	135.88±17.93^{b}	2.5±0.63	51.38±5.15^{b}

a, b - means in the column with different superscripts differed significantly (P≤0.05) The distribution of productivity indicators of different cow breeds is presented in Table 2. LBW cows produced an average 1440.46kg (14.85%) more milk than LR cows (P≤0.05). In the milk of H breed cows were found 0.29 % more fat and 0.11% higher protein content compared to LBW cows (P≤0.05). LR cows produced the most protein-enriched milk. Milk with the lowest somatic cells count was found in LBW breed cows.

Table 2. Productivity parameters of cows by breed

Breed	Milk yield, kg	Fat, %	Protein, %	SCC, thousand/ml
H	9133.22±189.44^{a}	4.64±0.10^{a}	3.60±0.04^{a}	337.84±79.47
LBW	9698.19±156.43^{b}	4.35±0.07^{b}	3.49±0.03^{b}	325.28±68.03
LR	8257.73±335.94^{c}	4.63±0.15	3.71±0.07^{a}	415.27±132.38

a, b, c - means in the column with different superscripts differed significantly (P≤0.05)

Table 3. Influence of breed and lactation on reproductive performance of cows

Breed	Lactation	n	Service period, days	Insemination index, times	Days up to max yield
H	I	78	106.47±6.34	1.71±0.18 ^{a}	98.16±7.30 ^{a}
	II	67	109.75±7.69	1.91±0.19 ^{b}	54.69±5.31 ^{b}
	III and older	47	107.23±7.26	2.05±0.22 ^{b}	58.50±6.35 ^{b}
LBW	I	164	113.86±5.70 ^{a}	1.95±0.13 ^{a}	93.98±4.82 ^{a}
	II	64	116.29±8.26 ^{a}	2.16±0.19 ^{b}	69.52±7.87 ^{b}
	III and older	99	135.24±6.20 ^{b}	2.63±0.19 ^{c}	61.45±4.18 ^{c}
LR	I	49	100.65±6.92 ^{a}	1.87±0.21	84.52±8.68 ^{a}
	II	18	135.88±17.93 ^{b}	2.5±0.63	51.38±5.15 ^{b}

a, b, c - means in the column with different superscripts differed significantly between breeds (P≤0.05)

The highest insemination index was found for LR and H breed cows of III and older lactations except second lactation cows of LBW breed.

The data presented in Table 3 shows that LBW cows of the third and older lactation were inseminated mostly - 0.68 times more than first lactation cows (P≤0.05) and on average 0.47 times more compared with the second lactation cows (P≤0.05). The lowest insemination index between three analyzed breeds was established for the first lactation H breed cows. These cows were inseminated 0.24 times less than first lactation LBW cows and accordingly 0.34 times less than third lactation H cows (P≤0.05). Most days to the highest (max) milk yield had all first lactation cows. It was 4.18 days less for LBW cows compared with H, but 9.46 days more compared with LR cows. The minimum number of days to peak milk yield was found in LBW second lactation cows (P≤0.05). The relationship between the service period, breed and the main reproductive parameters of cows is presented in Table 4. LBW cows needed about 8.1 days more to produce the largest milk yield than H cows, but 6.4 days less compared with LR cows during the 91-110 service days. LBW cows to reach peak productivity lasted longer compared to other breeds at all other stages of the service period. At the service period between 111-130 days from LR cows were milked 13.52 kg milk less than that from Lithuanian Holstein cows (P≤0.05).

Effect of the insemination index on cow productivity traits is presented in Table 5. H and LR breed cows which were inseminated on average three times produced the highest milk yield. Milk yield from four times inseminated LBW cows was 1421kg higher compare with triple insemination and 1989 kg milk more compare with one time insemination (P≤0.05). The largest differences in the milk composition between all breeds were established with triple cow insemination. Holstein cows produced milk with 0.66 % more fat and LR cow's milk with 0.48 % more protein compared to LBW breed (P≤0.05). Effect of the service period on milk content, fat and protein content is presented in Fig. 1. With a service period of up to 90 days, the amount of cow's milk gradually increased. A slight decrease in productivity was found between 91 and 110 days. Were milked 193 kg milk less when the duration of the service period was from 71 to 90 days but 438 kg milk more when service period lasted up to 70 days. With a service period of 91 days or more, the productivity of cows has steadily increased. Most of the milk from cows were milked when the service period lasted 131 days or more. Our results showed an average of 0.51 percent fat (P≤0.05) and 0.1 percent protein was obtained during this period by following the service period up to 91-110 days.

Table 4. Influence of service period and breed on selected performance indicators of cows

Service period, days	Breed	N	Insemination index, times	Days to max milk yield	Maximum daily yield, kg
up to 70	H	44	1.00±0.00	82.23±9.24	43.44±1.54
	LBW	46	1.04±0.04	84.65±9.38	42.11±1.73
	LR	12	1.00±0.00	71.17±15.05	38.98±3.15
71 - 90	H	36	1.22±0.10	71.83±9.63	41.38±1.27
	LBW	66	1.42±0.09	82.03±8.10	44.81±1.38
	LR	18	1.44±0.18	78.11±10.97	41.26±2.72
91 - 110	H	24	1.58±0.19	69±13.48	45.15±1.55 a
	LBW	40	1.75±0.18	77.10±8.55	40.72±1.34 b
	LR	24	1.92±0.19	83.50±13.81	39.61±1.7 b
111 - 130	H	12	2.17±0.40	54.83±13.93	47.25±2.05 b
	LBW	48	2.08±0.15	82.46±8.27	44.41±1.52 b
	LR	6	2.00±0.00	60.00±3.00	33.73±2.09 a
131 and more	H	68	2.79±0.19	73.76±7.26	43.73±0.92
	LBW	120	3.27±0.15	75.15±5.31	46.18±0.92
	LR	22	3.18±0.44	59.55±7.60	42.19±1.99

a, b - means differed significantly between service periods (P≤0.05)

Table 5. Influence of insemination index on the cow productivity indicators

Insemination index, times	Breed	n	Milk yield, kg	Fat content, %	Protein content, %
1	H	92	8610.89±249.04 A	4.85±0.13 A	3.67±0.05 a; A
	LBW	114	9073.25±224.3 b; A	4.51±0.12	3.51±0.04 b
	LR	30	7844.4±560.63 a	4.43±0.25	3.51±0.07 A
2	H	48	9031.67±314.17 A	4.32±0.2 B	3.44±0.09 b; B
	LBW	98	9762.47±245.31 a; B	4.41±0.13	3.52±0.06 b
	LR	34	8103.29±486.83 b	4.88±0.25	3.86±0.1 a; B
3	H	28	10854.64±445.18 B	4.72±0.23 a	3.69±0.11 b
	LBW	58	9641.55±440.31	4.06±0.14 b	3.4±0.06 a
	LR	10	9940.4±1278.18	4.52±0.47	3.88±0.44 b
4 and older	H	16	9428.75±688.32 b	4.23±0.27	3.52±0.16
	LBW	50	11062.8±395.58 a; B	4.2±0.13	3.51±0.08
	LR	8	8360.75±630.43 b	4.45±0.3	3.63±0.19

a, b – mean values according to the insemination index differ statistically significantly between breeds (P ≤ 0.05).
A, B - mean values according to the insemination index in the same breed differed significantly (P≤0.05).

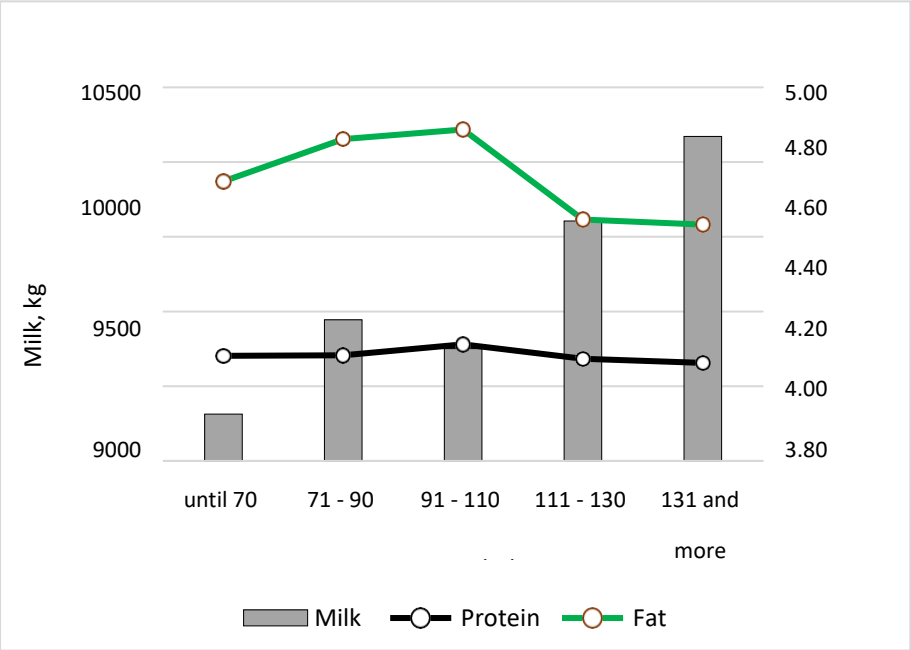

Figure1. Influence of service period on cow productivity indicators by days

DISCUSSION

The reproductive performance of dairy cows is the most important factor that is a prerequisite for sustainable dairy production system and influences the productivity (Nuraddis and Ahmed, 2017). Recent advances in genomic selection have accelerated the rate of genetic improvement in some cattle breeds (Spelman *et al*., 2013). Coffey *et al*. (2016) have described calving interval for Holstein cows 382 days while our results showed calving interval about 391 days for H cows. Results of other study (Ansari-Lari *et al*., 2010) showed that mean (±SD) days calving interval, and days to first service for study Holstein herds were 403 (±86), and 67 (±38) days, respectively. Conception rates at the first service and the overall service-conception rate were 41.6% and 41%, respectively. Cielava *et al*. (2017) found that the insemination index, calving interval and Based on the results of our study breed and lactation number had a significant impact on cow reproduction performance and productivity. Lithuanian red breed second lactation cows had the longest service period and cows of the first lactation had the shortest service period compared with two other breeds ($P<0.05$). Meanwhile insemination index for the first lactation H breed was the lowest (1.89 services/conception). Coffey *et al*. (2016) analyzed milk production and fertility performance for Holstein, and other breed cows and there was no consistent breed effect on the reproductive traits investigated. Cielava *et al*. (2017) also found that the insemination index of Holstein cows increased in subsequent lactations. Bekenov *et al*. (2019) analyzed age of cows at the time of fruitful insemination averaged 23.6 months for cows of the first calving, 40.1 months for cows of the second calving, and 62.7 months for cows of the third and more calvings. The insemination indexes ranged from 2.3 to 2.4. It was established that the variability of the insemination index is directly dependent on the level of cow productivity, while the variability of this indicator in terms of lactation numbers has not been established (Bekenov *et al*., 2019). Patton *et al*. (2007) have described no milk yield at insemination, or peak milk yield were significantly associated with reproductive performance. Haile-Mariam *et al*. (2003) estimated the strongest genetic correlation between a 305-day milk yield in the first lactation and the calving interval. This indicates that a longer calving interval is associated with a

higher milk yield in the first lactation (0.51±0.11).

The results showed the prolonged service period of cows leads to an increase in the number of artificial inseminations. With a service period of up to 70 days it took only one insemination on average to fertilize all analyzed breed cows. As the length of the service period increases, the insemination index increases as well. LBW cows needed an average of 8.1 days more to produce the biggest milk yield than H cows, but 6.4 days less compared with LR cows during the 91-110 service days. At the service period from 111 to 130 days LR cows produced 13.52 kg milk less than H breed cows ($P \leq 0.05$). Slightly longer interval form calving to first insemination, higher number of services per conception and especially significantly ($P<0.05$) longer days open period for 38 days were detected in cows yielded more than 9500 kg through 305 days than cows with low milk productivity (Němečková *et al*., 2015).

After analysis of milk composition between all three breeds has been determined the fattest milk produced H breed cows and the biggest protein content was found in LR cow's milk. Morton *et al*. (2016) didn't determine the relationship between milk yield, and the results indicate that mechanisms causing the associations between milk protein concentration and reproductive performance may be linked to milk yield.

We analyzed the effect of the service period on milk content, fat, and protein content. The results showed that except for the 91-110 day period, the proportionally prolonging service period resulted in increased cow productivity. The biggest milk yield was produced when the service period lasted 131 days or more. Then the cows produced on average of 10171 kg or 1858 kg milk more than cows with a service period up to 70 days ($P \leq 0.05$).

Although the longest service period, i.e. 131 and more days was the maximum amount of milk from cows, it had the lowest percentage of fat and protein. Toghiani (2012) found genetic correlations between production traits were form −0.505 for milk yield and protein percentage to 0.81 between milk yield with fat yield but most genetic correlations between reproductive performances were found close to zero.

CONCLUSIONS

The results of the studies show an evident influence of cow reproduction rates on productivity traits. The most productive are cows with a service period of more than 150 days. Increased service period determines increased cow milk yield, but other productivity indicators (milk fat, protein content) decreases. This is confirmed by the results of this study - the highest milk yield with the lowest percentage of fat and protein was obtained from cows with the longest service period (131 and more days). With a service period of 131 days or more, 1420 kg more milk was produced from cows compared with service period of 91-110 days ($P<0.05$), but fat and protein content in this milk was respectively 0.51 ($P<0.05$) and 0.1 percent lower. As the cow's service period grows, the number of insemination times needed to produce one calf increases. The tendency of this reproduction trade of change is also observed in the results of the research. Holstein and LR cows with the service period of up to 70 days were inseminated about 1.00 times, and LBW - 1.04 times. Cows with a service period of 131 days or more were mostly inseminated.

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