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ANALYSIS OF THE RELATIONSHIP BETWEEN FIRST THREE LACTATIONS OF HOLSTEIN COWS

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ABSTRACT

The objective of this study was to evaluate relationship between milk yield in the first three lactations regarding levels of milk yield in the first lactation and levels of age at the first calving. Prediction of milk yield in later lactation based on milk yield in the earlier one was also carried out. The data used in this study were 5743 lactation yields collected from 1995 to 2003. All cows finished the first three lactations. Mean value of milk yield in the first lactation was 5283.5 kg, 6033.5 kg in the second and 6338.4 kg the third one. The milk yield estimation coefficients between the first and second lactation was 1.164, between the first and third was 1.231, and 1.079 between the second and third. The levels of milk yield in the first lactation highly significant influenced the value of estimation coefficient between first three lactations, while the age at first calving influenced less significantly. Determination coefficient (R^2) values for models used in prediction ranged from 0.348 to 0.396.

Key-words: Holstein breed, lactation, milk yield, estimation coefficients, statistical models

INTRODUCTION

Selection decisions can be based on the milk yield in the first lactation because of the relatively high repeatability among the milk yield between the subsequent lactations (Freeman, 1960). The relationship between the milk yield in the first three lactations vary depending on the genotype and environmental influences (Barker and Robertson, 1966).
Significant effect of the level of the milk yield in the first lactation on the milk production in the subsequent lactations was reported by Chladek and Kučera (1999; 2002), as well as by Sawa (2001). The same authors notified significant effect of the genotype at higher levels of the milk yield in the first lactation. Thomas (1988), deduced that the comparison between the first and second lactation must be based on mature-equivalent milk yield because of significant effect of age at calving on milk production in dairy cows.
The objective of this study was to evaluate relationships between the milk yield in the first three lactations, taking into account the levels of the milk yield in the first lactation and the levels of the age at the first calving in breeding conditions of Holstein cows in Croatia. The prediction of the milk yield in the later lactation based on the milk yield in the earlier one has also been conducted using calculated estimation coefficients.

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MATERIAL AND METHODS

The material for the study was provided by the Croatian Livestock Centre. The data used in this paper include 5743 standard lactation yields collected from 1995 to 2003 on family farms and enterprises in Croatia. All cows finished the first three lactations. They were divided into four levels by the milk yield in the first lactation, M_1 (≤ 4000 kg), M_2 (> 4000 kg and ≤ 5000 kg), M_3 (> 5000 kg; ≤ 6000 kg) and M_4 (> 6000 kg). In addition, the cows were divided into three levels depending of the age of the first calving, A_1 (≤ 24 months), A_2 (> 24 months and ≤ 27 months) and A_3 (> 27 months).

The relationship between lactations was expressed by individual estimation coefficients (between the first and second, the first and third, and between the second and third lactation). Individual estimation coefficients were calculated as a ratio of the milk yield in the later lactation and the milk yield in the earlier one. Estimation coefficients by levels were calculated as simple mean values of individual estimation coefficients by each level. Furthermore, mean values of calculated estimation coefficients between the first and second, the first and third, and between the second and third lactation were used for the correction of the milk yield in the earlier lactation. Furthermore, the corrected milk yield was used to predict the milk yield in the later lactation.

Five different statistical models were used for the prediction of the milk yield in the later lactation based on the milk yield in the earlier one. The models differed in the number of the effects (Table 1). Models were compared on the basis of the determination coefficient (R^2) and the degrees of freedom.

The SAS/STAT package was used (SAS Institute Inc., 2000) for statistical analysis.

Table 1. Selected statistical models for estimation of milk yield in later lactation from milk yield in earlier lactation

Tablica 1. Odabrani statistički modeli za procjenu količine mlijeka u kasnijoj laktaciji na osnovu količine mlijeka u ranijoj laktaciji

Model	df	**Factors included in the model** – *Čimbenici uključeni u model*			
		m_c	A	M	a*m
A	2	YES	NO	NO	NO
B	4	YES	YES	NO	NO
C	5	YES	NO	YES	NO
D	7	YES	YES	YES	NO
E	13	YES	YES	YES	YES

df – degree of freedom, m_c – corrected milk yield in earlier lactation, a – age at first calving in months, m – milk yield in the first lactation, a*m – interaction between a and m

*df – stupanj slobode, m_c – korigirana količina mlijeka u prethodnoj laktaciji, a – dob pri prvom teljenju u mjesecima, m – količina mlijeka u prvoj laktaciji, a*m – interakcija između a i m*

RESULTS AND DISCUSSION

The basic statistical parameters for the milk yield in the first three lactations were presented in Table 2. The mean value of the milk yield in the first lactation was 5283.5 kg, 6033.5 kg in the second, and 6338.4 kg in the third. The standard deviation of the milk yield ranged from 1226.5 kg in the first lactation to 1660.3 kg in the third lactation, and together with the coefficient of variation, showed high variability in the milk production of Holstein cows in Croatia.

Table 2. Basic statistical parameters for milk yield in the first three lactations
Tablica 2. Osnovni statistički parametri za količinu mlijeka u prve tri laktacije

Milk yield (kg) – *količina mlijeka (kg)*	**N**	**Mean**	**SD**	**CV**
First lactation – Prva laktacija	5473	5283.5	1226.5	23.21
Second lactation – Druga laktacija	5473	6033.5	1560.3	25.86
Third lactation – Treća laktacija	5473	6338.4	1660.3	26.19

N – number of data; *N – broj podataka*

The milk yield estimation coefficients between the first and second lactation were 1.164, 1.231 between the first and third, and 1.079 between the second and third (Table 3).

Table 3. Estimation coefficients between the first three lactations related to the milk yield in first lactation
Tablica 3. Koeficijenti procjene količine mlijeka između prve tri laktacije ovisno o količini mlijeka u prvoj laktaciji

Milk yield in the first lactation (kg) *Količina mlijeka u prvoj laktaciji (kg)*	Levels *Razine*	N	Estimation coefficients between lactations *Koeficijenti procjene između laktacija*		
			Second and first *Druge i prve*	Third and first *Treće i prve*	Third and second *Treće i druge*
≤ 4000	M_1	782	1.366^A	1.506^A	1.130^A
> 4000; ≤ 5000	M_2	1623	1.189^B	1.275^B	1.094^B
> 5000; ≤ 6000	M_3	1650	1.134^C	1.185^C	1.069^C
> 6000	M_4	1418	1.060^D	1.082^D	1.044^C
Total		5473	1.164	1.231	1.079

The values in the same column marked with different letters (A – D) vary highly significant (P<0.01); N – number of data
Vrijednosti u istim kolonama označene različitim slovima (A-D) razlikuju se značajno (P<0,01); N - broj podataka

The levels of the milk yield in the first lactation significantly influenced the value of estimation coefficient between the first three lactations. Similar results were reported by Chladek and Kučera (2002). Estimation coefficients which quantify relationships between the milk yield in the first and second lactation (1.366, 1.189, 1.134 and 1.060) were highly significant different in all levels of the milk yield (M_1, M_2, M_3 and M_4). With the increase of the milk yield in the first lactation, the value of estimation coefficient decreased, which means that the differences between the milk yield in the second lactation and in the first one decreased by 36.6%, 18.9%, 13.4% and 6.0%, with respect to the level of the milk yield. Similarly, the estimation coefficients between the first and second (1.506, 1.275, 1.185 and 1.082), and between the second and third lactation (1.130, 1.094, 1.069 and 1.044) on all the levels of the milk yield were significantly different (P<0.01). Differences in the milk yield between the first and the second, the first and third, and the second and third decrease with the increase of milk yield in the first lactation. The most intensive increase in the milk yield in the subsequent lactations was observed for the first lactation cows with the lowest level of the milk yield (M_1). The difference between the first and second, the first and third, and the second and third were 36.6%, 50.6% and 13.0%. These results were comparable to the results of Sawa (2001).

Table 4. Estimation coefficients between the first three lactations related to the age at first calving
Tablica 4. Koeficijenti procjene količine mlijeka između prve tri laktacije ovisno o starosti pri prvom teljenju

Age at first calving (months) *Dob pri prvom teljenju (mjeseci)*	Levels *Razine*	N	Estimation coefficients between lactations *Koeficijenti procjene između laktacija*		
			Second and first *Druge i prve*	Third and first *Treće i prve*	Third and second *Treće i druge*
≤ 24	A_1	1760	1.192^A	1.267^A	1.084^A
> 24; ≤ 27	A_2	2074	1.169^A	1.239^A	1.086^A

> 27	A_3	1639	1.129^{B}	1.182^{B}	1.065^{A}
Total - *Ukupno*		5473	1.164	1.231	1.079

The values in the same column marked with different letters (A, B) vary highly significant (P<0.01);
N – number of data
Vrijednosti u istim kolonama označene različitim slovima (A, B) razlikuju se visoko signifikantno (P<0,01);
N - broj podataka

The effect of age at the first calving on the estimation coefficient between the first three lactations was shown in Table 4. It was evident that the value of estimation coefficients decreases with the increase of age at the first calving. This means that the differences between the milk yield in the successive lactations decrease in the older first lactation cows. There was a significant difference in the estimation coefficients between the first and second (1.192, 1.169 and 1,129), and the first and third (1.267, 1.239 and 1.182) lactation of the cows older than 27 months (P<0.01). The effect of age at the first calving on the estimation coefficient between the second and third lactation was not significant (P>0.05). The differences among milk yield in later lactation in relation to the earlier one were the highest in the first lactation cows younger than 24 months. A significant effect of age at the first calving on the milk yield in the subsequent lactation was reported by Sawa (2001).
The effect of the estimation coefficient between the milk yield in the first and second lactation on the estimation coefficient between the first and third lactation, and between the second and third is given in Table 5. The estimation coefficients quantifying relationships between the milk yield in the first and third lactation (1.000, 1.082, 1.147, 1.221, 1.267, 1.344, 1.428 and 1.616) were significantly different at almost all the levels of the estimation coefficient between the milk yield in the first and the second lactation (P<0.01). The estimation coefficients between the first and third lactation significantly increased with the increase of the estimation coefficients between the first and the second lactation. It means that the increase of the milk yield in the second lactation in relationship to the first one, leads to the increase of the milk yield in the third lactation in relation to the first one. The estimation coefficients between the second and third lactation (1.276, 1.135, 1.093, 1.062, 1.016, 0.999, 0.987 and 0.951) significantly decreased at almost all the levels (P<0.01) with the increase of the value of estimation coefficients between the first and the second lactation. Tendency of increasing the values of estimation coefficients between the first and third, and decreasing the values of estimation coefficients between the second and third one for Holstein breed was also reported by Chladek and Kučera (2002).

Table 5. Estimation coefficients between the third and first or third and second lactation in relations to estimation coefficient between the second and first lactation
Tablica 5. Utjecaj koeficijenata procjene količine mlijeka između prve i druge laktacije na vrijednost koeficijenta procjene između prve i treće te druge i treće laktacije

Estimation coefficient between the second and first lactations *Koeficijenti procjene između druge i prve laktacije*	Levels *Razine*	N	Estimation coefficient between lactations *Koeficijenti procjene između laktacija*	
			Third and first *Treće i prve*	Third and second *Treće i druge*
≤ 0.9	K_1	766	1.000^{A}	1.276^{A}
> 0.9; ≤ 1.0	K_2	715	1.082^{B}	1.135^{B}
> 1.0; ≤ 1.1	K_3	947	1.147^{C}	1.093^{C}
> 1.1; ≤ 1.2	K_4	870	1.221^{D}	1.062^{D}
> 1.2; ≤ 1.3	K_5	730	1.267^{D}	1.016^{E}
> 1.3; ≤ 1.4	K_6	544	1.344^{E}	0.999^{EF}
> 1.4; ≤ 1.5	K_7	354	1.428^{F}	0.987^{F}
> 1.5	K_8	547	1.616^{G}	0.951^{G}
Total		5473	1.231	1.079

The values in the same column marked with different letters (A – G) vary highly significant (P<0.01);
N – number of data
Vrijednosti u istim kolonama označene različitim slovima (A – G) razlikuju se visoko značajno (P<0,01);
N - broj podataka

The determination coefficient (R^2) values for models used to predict the milk yield in the second lactation based on the milk yield in the first one range from 0.348 in model A, which includes only the corrected milk yield in the first lactation as a linear regression to 0.354 in model E, that includes effects due to the corrected milk yield in the first lactation, the age at the first calving, the milk yield in the first lactation, as well as the interaction between the age at the first calving, and the milk yield in the first lactation (Table 6).
Determination coefficient (R^2) values of the prediction of the milk yield in the third lactation based on the milk yield in the first one range from 0.234 in model A to 0.242 in model E, while in prediction of milk yield in the third lactation from milk yield in the second one determination coefficient (R^2) values range from 0.375 in model A to 0.396 in model E.

Table 6. F–value and determination coefficient (R^2) for models used to predict milk yield in later lactation from milk yield in earlier lactation
Tablica 6. F – vrijednost i koeficijent determinacije (R^2) modela za procjenu količine mlijeka u kasnijoj na osnovu količine mlijeka u ranijoj laktaciji

Model	df	Second from first Druge iz prve		Third from first Treće iz prve		Third from second Treće iz druge	
		F value	R^2	F value	R^2	F value	R^2
A	2	2918.14**	0.348	1673.67**	0.234	3283.62**	0.375
B	4	985.06**	0.351	573.96**	0.239	1312.61**	0.376
C	5	734.99**	0.350	420.42**	0.235	884.45**	0.393
D	7	496.21**	0.353	288.31**	0.240	594.11**	0.395
E	13	249.43**	0.354	145.10**	0.242	297.65**	0.396

df – degree of freedom; df – *stupanj slobode*

These results show that the amount of the explained variance is higher for the more complex models (E) than for the simpliest (A) ones by 0.6% for the prediction of the milk yield in the second lactation based on the milk yield in the first one, 0.8 % for the prediction of the milk yield in the third lactation based on the milk yield in the first one, and 2.1% for the prediction of the milk yield in the third lactation based on the milk yield in the second one.
The levels of milk yield in the first lactation highly significant influenced the value of estimation coefficient between the first three lactations, while the age at first calving influenced less significantly. Differences between the models according to the determination coefficient are minor. Therefore, we recommend the use of model A in practice.

CONCLUSION

Based on the study the following conclusion can be drawn:
- levels of the milk yield in the first lactation significantly influenced the values of estimation coefficient between the first three lactations. Differences in the milk yield between the first and second, the first and third, and the second and third decrease with the increase of milk yield in the first lactation.
- effect of age at the first calving significantly influenced the values of estimation coefficients between the first and second, the first and third lactation of the cows older than 27 months (P<0.01), while the same effect on the estimation coefficient between the second and third lactation was not significant (P>0.05). Differences among milk yield in later lactation in relation to the earlier one were the highest in the first lactation cows younger than 24 months.

- values of estimation coefficients between the first and third lactation significantly increased with increasing estimation coefficients between the first and second lactation while the values of estimation coefficients between the second and third one significantly decreased.
- the amount of the explained variance is higher for the more complex models (E) than for the simpliest (A) ones, but the differences between the models according to the determination coefficient are minor. Therefore, we recommend the use of model A in practice.

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ANALIZA ODNOSA IZMEĐU PRVE TRI LAKTACIJE U HOLSTEIN KRAVA

SAŽETAK

Cilj istraživanja bio je utvrditi odnos između količine mlijeka u prve tri laktacije krava Holstein pasmine, uz uvažavanje razine mliječnosti u prvoj laktaciji i dobi pri prvom teljenju te procijeniti količinu mlijeka u kasnijim na temelju količine mlijeka u ranijim laktacijama. Korišteni su podaci o količini mlijeka 5743 krava, koje su u razdoblju od 1995. – 2003. završile prve tri laktacije. Prosječna količina mlijeka u prvoj standardnoj laktaciji bila je 5283,5 kg, u drugoj 6033,5 kg te 6338,4 kg u trećoj laktaciji. Prosječna vrijednost koeficijenata procjene između prve i druge laktacije bila je 1,164, prve i treće 1,231 te druge i treće 1,079. Utvrđene su statistički visoko signifikantne razlike između koeficijenata procjene pri uvažavanju razine mliječnosti u prvoj laktaciji, dok je utjecaj dobi pri prvom teljenju bio manje signifikantan. Vrijednosti koeficijenata determinacije (R^2) modela za procjenu količine mlijeka u kasnijoj laktaciji na osnovu ranije kretali su se od 0,348 do 0,396.

Ključne riječi: Holstein pasmina, laktacija, količina mlijeka, koeficijenti procjene, statistički modeli

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