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PHENOTYPIC RELATIONSHIPS AMONG SOMATIC CELL COUNT, MILK UREA CONTENT, TEST-DAY MILK YIELD AND PROTEIN PERCENT IN DAIRY CATTLE

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ABSTRACT

A total number of 33,881 individual test-day milk records involving 15,565 dairy cows for a 12-month period between January and December 2001 enrolled in Database Computer Center belonging to Czech Moravian Breeders´ Corporation, Inc., Hiradistko, The Czech Republic were used to study the phenotypic relationships among test-day milk yield (TDM), milk protein percentage (PP), protein yield (PY), somatic cell count (SCC) and milk urea content (MU) and to generate prediction regression equations to predict both SCC and MU using different independent variables in dairy cattle reared in Czech Republic using individual test-day records. Phenotypic correlations and regression coefficients were estimated using Statistical Analysis System (SAS, 2004). The overall mean (±SD) of TDM was 22.6 ± 8.50 kg, that of PP was 3.38 ± 0.36%, that of PY was 0.75 ± 0.26, that of SCC was 404 ± 750 thousand cell/ml, that of somatic cell score was 3.76 ± 1.85, that of somatic cell count transformated was 3.74 ± 1.84 and that of MU was 31.7 ± 9.99 mg/dl. Significant (P<0.001) negative correlation coefficients between TDM and each of PP (-0.42), SCC (-0.13) and SCS (-0.22), between PY and each of SCC (-0.12) and SCS (-.018) and between MU and both SCC (-0.08) and SCS (-0.09) were found. Meanwhile, there were high significant (P<0.001) and positive correlation coefficients between TDM and each of PY (0.96) and MU (0.24). Prediction regression equations were generated to predict both SCC and MU using different independent variables. The significant negative correlations suggest that a lower test-day milk yield is phenotypically associated with higher somatic cell counts. It is recommended that because of association of somatic cell counts and milk yield, it may be important to consider effects of environment on somatic cell counts.

Keywords: correlation, dairy cattle, milk traits, milk urea nitrogen, regression equations

INTRODUCTION

The somatic cell counts can serve as an indication of possible udder problems specially mastitis while the milk urea content can be an indication of the nutritional status of the herd. Somatic cell counts are widely used in milk recording programs in North America and Europe to indicate milk quality and health status of the cow's udder. On the other hand, protein content of milk also has received much attention from producers of milk and processors of dairy products. Increased recognition of the value of protein in milk has led processors to pay a premium for milk exceeding minimum protein percentages. To take advantage of such pricing schemes, producers have considered protein performance for culling decisions and breeding plans (Wiggans 1986). The interpretation of these traits and parameters assists the breeders in effectively selecting cows and also in making important management decisions with regard to the health status and nutrition of his herd. On the other hand, Jones *et al.* (1984) detected negative relationships of daily milk yields and somatic cell counts. Eicher *et al.* (1999) reported insignificant association of somatic cell counts on milk urea nitrogen. Godden *et al.* (2001) also reported a slightly negative relationship between milk urea nitrogen and linear score.

This study raises important issue about predicting one trait relatively difficult to measure (e.g. somatic cell count and milk urea nitrogen) from other traits relatively easy to record (e.g. milk yield and protein percentage). The objectives of the present study were: 1) to estimate the phenotypic correlations among test-day milk yield, milk protein percentage, protein yield, somatic cell count and milk urea content, in dairy cattle in Czech Republic and 2) to generate prediction regression equations to predict both somatic cell counts and milk urea content using different independent variables using individual test-day milk records.

MATERIALS AND METHODS

Data

A total of 33,881 individual monthly cow test-day records involving 15,565 dairy cows including cow' number, date of test, calving date, test-day milk yield (TDM, kg), somatic cell count (SCC, 1000 cells/ml), milk urea concentration (MU, mg/dl) and percentage of milk protein (PP, %) from January to December 2001 was used in the statistical analyses. The data were enrolled in Database Computer Center belonging to Czech Moravian Breeders´ Corporation, Inc., (Czech Member of International Committee for Animal Recording, ICAR), Hiradistko, Czech Republic. Apparently, the majority of the cows belong to either Holstein or Czech Spotted breed and very small number of cows was Jersey. The cows were in different parities, but no distinction was made for breed or parity in the data set used in the study. Methods used for milk recording were A4 and AT (ICAR norms). From 3788 herds, 98.2 and 1.8% herds were recorded using A4 and AT methods, respectively. Generally, the total mixed ration feeding was the most common management practices on the farms located at the Czech part of CZ. The managerial and nutritional practices were nearly similar across farms. To convert MU (milk urea content) to MUN (Milk urea nitrogen), the following conversion formula can be used (after Kureoja and Kaart 2004): Milk urea content (MU, mg/dl) × 0.467 = Milk urea nitrogen (MUN, mg/dl) or the formula (after Godden *et al.* ., 2001b): Milk urea content (MU, mmol/L) × 2.8 = Milk urea nitrogen (MUN, mg/dl).

Laboratory procedures

Individual test-day milk samples were analyzed in the Milk Testing Laboratory of Buštehrad. Somatic cell count was estimated using Bentley Instruments (Somacount 3000, the instrument utilize a laser based flow cytometry). Protein percentage was estimated also using Bentley Instruments (Bentley 2000, infrared transmission photometer). The direct specific enzymatic method UREAKVANT (made by Agrosluzby Morava a Slezko) was used for the routine determination of the MU

Statistical analyses

Variables were test-day milk yield, protein percentage, protein yield, somatic cell count and milk urea content. Moreover, to evaluate somatic cell count, three methods of evaluating were used: the first was the actual somatic cell count (measured by 1000 cell/ml milk). The second method was linear somatic cell count score defined by Shook (1982). A score of 0.0 to 9.0 was assigned to each sample day according to somatic cell counts level and each integer increase in linear score is associated with a doubling of the actual somatic cell counts (Shook 1982). The third method was somatic cell count transformed, where somatic cell counts had been transformed to somatic cell count transformed with the base 2 log scale used by Dabdoub and Shook (1984) using the international formula: [SCT = log2 (SCC / 100,000) + 3]. Data analysis was performed using the Statistical Analysis System (SAS/STAT 9.1 User's Guide, 2004). The statistical analyses were conducted using PROC FREQ, PROC MEANS, PROC CORR and PROC REG.

RESULTS AND DISCUSSION

Descriptive statistics

Summary of the descriptive statistics of test-day records used in this study is shown in Table 1.

Table 1: Unadjusted means, standard deviation (SD), minimum and maximum of studied traits

Trait	No.	Mean	SD	Min.	Max.
Test-day milk yield, kg	31848	22.6	8.50	3	59.8
Protein percentage, %	31517	3.38	0.36	2.03	4.98
Protein yield, kg	31502	0.75	0.26	0.07	1.91
Somatic cell count, 1000 cell/ml	22857	404	750	1	6992
Somatic cell score	22857	3.76	1.85	0	9
Somatic cell count tranformated	22857	3.74	1.84	-3.64	9.13
Milk urea content, mg/dl	30788	31.7	9.99	10	60

The unadjusted mean of test-day milk yield of 31848 records (±SD) was 22.6 ± 8.50 kg with protein percentage 3.38 ± 0.36%. The high SD of test-day milk yield is expected where the animals used in the study belong to different herds, are in different lactation and from different locations. According to results of Czech-Moravia Breeders Association (CMBA), Prague, Hanuš *et al.* (2002) reported that the overall mean of protein percentage of the dairy cows (all breeds and all lactations) of the individual milk samples during standard lactations in the Czech milk recording in 2002 was 3.35 ± 0.30% which is in agreement with the result of the present study. Johnson and Young (2003) in USA found that milk yield in Holstein and jersey cows were 33.8±10.73 and 22.4 ± 7.2 kg, respectively with PP 3.19 ± 0.37 and 3.70 ± 0.45%, respectively.

The unadjusted mean of SCC for 22857 records in the present study was 404±750 thousand cell/ml which was also near from the value of Hanuš *et al.* (2002) (400±300 thousand cell/ml). El-Awady and Oudah (2009) found that the overall mean of SCC across lactations in Friesian cattle in Egypt was 453±218 thousand cell/ml. The overall mean (±SD) of somatic cell score was 3.76 ± 1.85, and that of somatic cell count transformated was 3.74 ± 1.84. The unadjusted mean of milk urea content was 31.7±9.99 mg/dl. The results of Czech-Moravia Breeders Association (CMBA), Prague regarding milk urea content for all Czech republic reported by Hanuš *et al.* (2002) was 36 ± 19 mg/dl. The very high standard deviation of somatic cell counts in this study (750,000 cell/ml) reflects very high variability between herds. Johnson and Young (2003) found that somatic cell counts in Holstein and jersey cows were 270±741 and 336±909 thousand cell/ml milk, respectively and the corresponding values for linear score were 2.57 ± 2.11 and 2.88 ± 2.11 for the two breeds, respectively.

The overall mean of milk urea content in the present study was 31.7 ± 9.99 mg/dl (this amount equal 14.8 mg/dl milk urea nitrogen) which was nearly similar to those reported by Johnson and Young (2003) for Holstein and Jersey cows (15.5 ± 3.73 and 14.1 ± 3.20 mg/dl milk urea nitrogen, respectively).

Phenotypic correlation coefficients among traits

Pearson correlation coefficients among test-day milk yield, milk protein percentage, protein yield, somatic cell counts, somatic cell score and milk urea content are presented in Table 2.

Table 2: Pearson correlation coefficients (below diagonal) and number of observations (above diagonal) among different traits*

Trait	TDM	PP	PY	SCC	SCS	MU
TDM		31502	31502	22835	22835	30776
PP	- 0.42		31502	22816	22816	30741
PY	0.96	- 0.17		22802	22802	30729
SCC	- 0.13	0.11	- 0.12		22857	22266
SCS	- 0.22	0.19	- 0.18	0.740		22266
MU	0.24	- 0.004	0.26	- 0.08	-0.09	

***TDM=test-day milk yield, PP=protein percentage, PY=protein yield, SCC=somatic cell count, SCS=somatic cell score, MU=milk urea content. All correlation values were significant at P<0.001, except between milk protein percentage and milk urea content was not significant.**

There were significant negative correlation coefficients between test-day milk yield and each of milk protein percentage (-0.42), somatic cell count (-0.13) and somatic cell score (-0.22), between protein yield and each of somatic cell count (-0.12) and somatic cell score (-.018) and between milk urea content and both somatic cell counts (-0.08) and somatic cell score (-0.09). These significant negative correlations suggest that a lower test-day milk yield is phenotypically associated with higher somatic cell counts. Moreover, there were significant positive correlation coefficients between test-day milk yield and both protein yield (0.96) and milk urea content (0.24), between milk protein percentage and both somatic cell counts (0.11) and somatic cell score (0.19) and between milk urea content and protein yield (0.26) (Table 2).

Comparing the present results with the other investigators, Kiiman and Kaart (2004) working on Estonian Red cattle fount that phenotypic correlation coefficient between log somatic cell counts and both milk protein percentage and protein yield in the first lactation were 0.195 and -0.334. Kureoja and Kaart (2004) found that the phenotypic correlation coefficients between milk urea content and milk yield, protein yield and protein percent were 0.20, 0.16, -0.14, respectively using Estonian Red cattle. They found also that the corresponding values using Estonian Holstein cattle were 0.19, 0.14, -0.06, respectively. Johnson and Young (2003) concluded that milk urea N concentrations were positively associated with milk yield and negatively associated with milk protein. They added that milk urea N concentration appeared to have an inverse association with somatic cell counts. They suggest that milk urea N concentrations should be evaluated in association with breed, days in milk, milk yield, and protein percentage when determining the efficiency of N utilization. The present results are in close agreement with those of Johnson and Young (2003). Negative phenotypic correlation coefficient between SCC and milk and protein yields were found by El-Awady and Oudah (2009) who working with Friesian cattle in Egypt and found that the phenotypic correlations between SCC and each of 305-day milk yield and protein yield were -0.39 and -0.51, respectively.

Prediction regression equations

To predict both somatic cell counts and/or milk urea content using test-day milk recording, three prediction regression equations were generated according to which independent variables are available (Table 3).

Table 3: Estimates of intercept and partial regression coefficient (±SE) for somatic cell counts and milk urea content predictions using different independent variables

Dependent variable	Intercept (±SE)	Partial regression coefficient (± SE) of		
		1st independent variable	2nd independent variable	3rd independent variable
SCC (1000/ml)	673±14.0	-12.1±0.59 TDM		
	771±18.8	-11.0±0.63 TDM	-3.80 ± 0.51 MU	
	146±58.4	-7.65±0.69 TDM	-4.42 ± 0.51 MU	168 ± 15.0 PP
MU (mg/dl)	25.4 ± 0.16	0.282±0.007 TDM		
	24.6 ± 0.19	0.329±0.008 TDM	-0.00066±0.00009 SCC	
	9.93 ± 0.77	0.397± 0.009 TDM	-0.00077±0.00009 SCC	3.91 ± 0.20 PP

***TDM=test-day milk yield, PP=protein percentage, SCC=somatic cell count, MU=milk urea content. Analyses of variance of all regression models were significant at P<0.001. R^2= for SCC and MU prediction equations were 0.04 and 0.18, respectively.**

For predicting somatic cell counts using test-day milk yield, milk urea content and/or milk protein percentage and for predicting milk urea content using test-day milk yield, somatic cell counts and/or milk protein percentage. These prediction regression equations could be applied in the regions where somatic cell counts and/or milk urea content estimation is expensive or need time for analyses. Using this tool also give quick chick about udder health waiting for the results of laboratory analyses.

CONCLUSIONS

These results indicate that milk urea content contents were positively associated with test-day milk yield and negatively associated with milk protein percentage and somatic cell counts measures. Somatic cell count measures appeared to have an inverse association with test-day milk yield and milk urea content. The significant negative correlations suggest that a lower test-day milk yield is phenotypically associated with higher somatic cell counts. It is recommended that because of association of somatic cell counts and milk yield, it may be important to consider effects of environment on somatic cell counts.

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REFERENCES

Dabdoub, S. M. and Shook, G. E. (1984). Phenotypic relations among milk yield, somatic cell count and clinical mastitis. J. Dairy Sci., 67(Supplement. 1):163–164.

Eicher, R.; Bouchard, E. and Bigras-Poulin, M. (1999). Factors affecting milk urea nitrogen and protein concentrations in Quebec dairy cows. Preventive Veterinary Medicine, 39:53–63.

El-Awady, H.G. and Oudah, E.Z.M. (2009). Genetic and economic analysis for the relationship between udder health and milk production traits in Friesian cows. J. Agric. Sci., Mansoura Univ., 34 (8): 8667 - 8685**.**

Godden, S. M.; Lissemore, K. D.; Kelton, D. F.; Leslie, K. E.; Walton, J. S. and Lumsden, J. H. (2001). Factors associated with milk urea concentrations in Ontario dairy cows. J. Dairy Sci., 84:107–114.

Hanuš, O.; Pytloun, J.; RíhaJ, Hering P.; Matouš, E. and Genèurová, V. (2002). First meeting of ICAR Reference Laboratory Network (Interlaken, 27 May 2002)–Report http://www.icar.org/Documents/milk_laboratories_leray/NWmeeting-1.pdf

Johnson, R. G. and Young, A. J. (2003). The Association Between Milk Urea Nitrogen and DHI Production Variables in Western Commercial Dairy Herds. J. Dairy Sci., 86:3008–3015.

Jones, G. M.; Pearson, R. E.; Clabaugh, G. A. and Heald, C. W. (1984). Relationships between somatic cell counts and milk production. J. Dairy Sci., 67:1823-1831.

Kiiman, H. and Kaart, T. (2004) In: Proceedings of the 10th Animal Breeding in Baltics Conference. 13-14 May, Institute of Animal Science, Estonian Agricultural University, Tartu, Estonia 2004. PP: 36-39 http://www.eau.ee/~lki/babc/X/

Kureoja, A. and Kaart, T. (2004). Genetic and environmental influences on urea concentration in dairy cows, milk. In: Proceedings of the 10th Animal Breeding in Baltics Conference. 13-14 May, Institute of Animal Science, Estonian Agricultural University, Tartu, Estonia, PP: 42-47 http://www.eau.ee/~lki/babc/X/

SAS (2004). SAS Institute Inc. 2004. SAS/SAT© 9.1 user's guide Cary. NC: SAS Institute Inc.

Shook, G. E. (1982). Relationship between lactation measures of somatic cell concentration and milk yield. J. Dairy Sci., 65: 419-425.

Wiggans, G. R. (1986). Projection of Protein Yield to 305 Days. J. Dairy Sci., 69: 2908–2914.

العلاقة المظهرية بين عدد الخلايا الجسدية، محتوى اللبن من اليوريا، محصول لبن يوم الاختبار، نسبة البروتين فى ماشية اللبن

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استخدم فى هذه الدراسة ٣٣٨٨١ سجل إنتاج لبن يوم الاختبار لمدة ١٢ شهر (من يناير وحتى ديسمبر ٢٠٠١)، تمثل ١٥٥٦٥ بقرة مسجلة بمركز قواعد البيانات التابع لجمعية مربى الماشية التشيكية (Czech Moravian Breeders´ Corporation, Inc.) وذلك لتقدير معاملات الارتباط بين كل من عدد الخلايا الجسدية، محتوى اللبن من اليوريا، محصول لبن يوم الاختبار، نسبة البروتين ومحصول البروتين إضافة إلى تكوين معادلات للتنبؤ بكل من عدد الخلايا الجسدية ومحتوى اللبن من اليوريا باستخدام صفات أخرى وذلك فى ماشية اللبن المرباة فى الجزء التشيكى من جمهورية التشيك. تم استخدام برنامج التحليل الاحصائى "ساس" لتقدير معاملات الارتباط والانحدار بين الصفات المختلفة. بلغ متوسط محصول لبن يوم الاختبار، نسبة بروتين اللبن، محصول البروتين، عدد الخلايا الجسدية و محتوى اللبن من اليوريا ٢٢,٦ كجم، ٣,٣٨%، ٠,٧٥ كجم، ٤٠٤ ألف خلية/مل لبن، ٣١,٧ مل/دل، على التوالى. وجد معامل ارتباط مظهرى معنوى (على مستوى ٠,٠٠١) وسالب بين محصول لبن يوم الاختبار وكل من نسبة البروتين (-٠,٤٢) وعدد الخلايا الجسدية (-٠,١٣)، بين محصول البروتين وعدد الخلايا الجسدية (-٠,١٢) وبين محتوى اللبن من اليوريا وعدد الخلايا الجسدية (-٠,٠٨). بينما كان هناك معامل ارتباط موجب ومعنوى (على مستوى ٠,٠٠١) بين محصول لبن يوم الاختبار وكل من محصول البروتين (٠,٩٦) ومحتوى اللبن من اليوريا (٠,٢٤). تم تكوين معادلات للتنبؤ بكل من عدد الخلايا الجسدية ومحتوى اللبن من اليوريا باستخدام محصول لبن يوم الاختبار و/أو نسبة البروتين فى اللبن, يشير معامل الارتباط السالب بين الصفات إلى أن هناك علاقة مظهرية بين انخفاض محصول لبن يوم الاختبار مع ارتفاع عدد الخلايا الجسدية باللعينة. يستنتج من هذه الدراسة أنه نظرا لوجود علاقة سالبة بين محصول لبن يوم الاختبار وعدد الخلايا الجسدية فانه يجب الأخذ فى الاعتبار تأثير العوامل البيئية على عدد الخلايا الجسدية.