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PRODUCTION TRAITS OF ROMANIAN SIMMENTAL COWS AT FIRST LACTATION

E. NISTOR[1], V. A. BAMPIDIS[2]*, M. PENTEA[3]

[1]Department of Animal Science, Faculty of Animal Science and Biotechnologies, Banat's University of Agricultural Sciences and Veterinary Medicine, Timişoara, Romania
[2]Department of Animal Science, Faculty of Agricultural Technology, Food Technology and Nutrition, Alexander Technological Educational Institute of Thessaloniki, Thessaloniki, Greece
[3]Department of Preclinical Disciplines, Faculty of Veterinary Medicine, Banat's University of Agricultural Sciences and Veterinary Medicine, Timişoara, Romania

ABSTRACT

Ninety-nine first lactation cows of the Romanian Simmental breed were used in a 305-day lactation period to study the production traits of the breed and its potential for genetic improvement. The phenotypic parameters studied were milk, fat and protein yield, as well as fat and protein percentage; variance components were calculated. The milk yield in the dairy cow population was 4053 ± 1391.8 kg, whilst the fat and protein yield were 157.6 ± 55.3 kg and 131.6 ± 46.3 kg, respectively. Phenotypic correlation between milk yield and milk fat yield was high ($r = 0.9973$) and between milk yield and milk protein yield was relatively low ($r = 0.1403$). In addition, correlations obtained between milk yield, and milk fat and protein percentages were low ($r = 0.0519$ and $r = 0.0022$, respectively), whilst the correlation between milk fat yield and milk protein yield was weak ($r = 0.1414$), and between milk fat percentage and milk protein percentage was moderate ($r = 0.5139$). The strong phenotypic correlation between the milk yield and milk fat yield indicates that the population of dairy cows can be improved by selection using the independent level of selection.

Key words: first lactation; milk yield; protein-fat correlations; Romanian Simmental cows

INTRODUCTION

Milk is a mixture of fat, protein, lactose, vitamins and minerals, either dissolved or suspended in water. This connection was already studied at phenotypic and genetic level. The usual description of milk secretion refers to the occurrence of changes in milk contents during lactation, being the decrease of milk yield accompanied by the increase in fat and protein contents (Kolb, 1987).

A dairy farmer wants to run fewer cows yielding more milk, which means that a higher profit can be obtained with less costs. Fewer cows with a great milk yield means less pollution for the environment, less forages for nourishment, less shelters for animals. All these arguments are of economic importance all over the world. Research has shown clearly that selecting for milk yield only also increases the total fat and protein yield (Linn *et al.*, 1999).

Replacement heifer management is very important in dairy herds. The future producing ability of a heifer is unknown and performance at first lactation is often different from what is expected on the basis of the pedigree index alone. Thus, the selection of replacement heifers could be improved by the use of physiological markers of milk production and quality

***Correspondence:** E-mail: bampidis@ap.teithe.gr
Vasileios A. Bampidis, Department of Animal Science, Faculty of Agricultural Technology, Food Technology and Nutrition, Alexander Technological Educational Institute of Thessaloniki, 57400 Thessaloniki, Greece
Tel.: +30 231 0013313 Fax: +30 231 0791169

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(Sabbioni *et al*., 2007). The value of milk is based on its composition. This is not only true from the producer side, but the consumer side as well. Consumers are looking for milk that is nutritious, has good flavour and is low in fat. Protein is a component that can contribute to flavour and nutrition without increasing the fat or calorie content of milk (Dechow *et al*., 2007). Milk, fat and protein yields are the main economic traits for selection in dairy cows. Estimates of phenotypic parameters are required for prediction of breeding values. Phenotypic correlations show relationships between phenotype traits. These parameters are important especially in multi-trait selection and improvement programs because they are used in the calculation of selection responses (DeLorenzo and Wiggans, 1986). Selection programme is necessary to increase the total amount of milk while maintaining contents of fat and protein (Hardie *et al*., 1978).

The Romanian Simmental breed, also known as Romanian Spotted cattle breed, has been formed as the result of a long crossing between the Romanian Grey cattle native breed cows with Simmental bulls (Sas and Sas, 1996). The breed is characterized by a high variability due to the variability of the maternal breed (Romanian Grey cattle with five zonal types); the polymorphism of the Simmental breed that is due to morphological type differences from origin countries and the changing, in time, of the objects in differentiated improvement of Simmental cattle's main productive abilities.

Although Romanian Simmental is a multipurpose breed, at present it is the main supplier of beef meat in Romania, with the meat productive type surpassing in importance the milk productive type. Therefore, genetic selection is necessary in order to improve milk production type cattle of this breed. The genetic potential of the Romanian Simmental breed is estimated to be 5000 kg milk per lactation period with 3.90 % fat and 3.30 % protein, or otherwise 195 kg fat and 165 kg protein per lactation period (Sas and Sas, 1996).

Thus, the objective of this study was to determine milk yield, milk fat and protein yield, as well as milk fat and protein percentage, and to evaluate relations among the studied parameters for a first lactation dairy herd of the Romanian Simmental breed, in order to improve selection for milk yields.

MATERIAL AND METHODS

Data Collection

The study was conducted in a dairy farm located at Timiş County in the west of Romania, from February 2010 to April 2012. Ninety-nine first lactation Romanian Simmental cows were selected from 1275 dairy cows of the herd to participate in the study immediately after first calving. Cows were housed and treated in accordance with the applicable recommendations of the European Council (EEC, 1986), and the Animal Care and Use Protocol for Banat's University of Agricultural Sciences and Veterinary Medicine, Timişoara, Romania. From April to October, during the day, cows were allowed to graze on the surroundings of the farm, from 10:00 h and flocked back at 17:00 h. The rest of the year, animals were not allowed to graze. In addition, during the whole year, cows were fed a total mixed ration (TMR) (alfalfa hay 0.30, corn silage 0.40, corn grain 0.18, wheat bran 0.10, and vitamin and mineral premix 0.02, dry matter – DM basis) and water ad libitum in elongated troughs and drinkers, respectively, in the courtyard of the farm, to meet their nutrient requirements as given by NRC (2001). Cows were machine milked twice a day, for a completed lactation of at least 305 days, with a "Bradulet" type milking machine (Banat Nova Puls, Timişoara, Romania). The milking machine was equipped with a computerized management system (Banat Afimilk, Timişoara, Romania) that provides daily data report on milking efficiency, reproduction and fertility, medication and treatment procedures etc. Thus, milk yield was recorded daily at a morning and afternoon milking. During milk yield recording, milk samples were collected from each cow (after cleaning and disinfecting the teats) and kept refrigerated at 4 °C until chemical analysis within a day at the Central Laboratory of the Milk Control Association (Timişoara, Romania). Milk samples were analyzed for fat and protein with IR spectroscopy (MilkoScan^{TM}Minor4; TESCO, Denmark) according to the method 972.16 of AOAC (1990).

Statistical Analysis

Arithmetic mean (X), standard deviation (SD), range of variation and variability were computed for milk yield, milk fat and protein yield, as well as milk fat and protein percentage. An individual cow was used as the experimental unit. All dairy cows were kept in the same farm in a free nutrition system. Therefore, the quantity of food consumed was different from one cow to another.

Analyses were conducted by means of the restricted maximum likelihood (REML) procedures using the programme StatSoft (2007) for the variables milk, fat and protein yield and fat and protein percentages. The basic model (Hallowell *et al.*, 1998) fitted was as follows:

$$y = Xa + Zb + e$$

where: y, a vector of observations on first lactation milk, fat and protein yield, fat and protein percentage; X and Z, known incidence matrices relating observations to effects; a, a vector of fixed effects consisting of month of calving, herd and times milked depending on which were significant; b, a vector of continual effects, age and calving interval with the effects of sire randomised; and e, a vector of unknown residual effects.

To evaluate relations among the studied parameters, the slope (b) of the regression coefficient was calculated using the following model (Tibshirani, 1996):

Regression Equation (y) = a + bx

Slope (b) = (NΣXY - (ΣX)(ΣY)) / (NΣX2 - $(\Sigma X)^2$)

Intercept (a) = [ΣY - b(ΣX)] / N

where: x and y, the variables; b, the slope of the regression line; a, the intercept point of the regression line and the y axis; N, the number of values or elements; X, the First Score, Y, the Second Score; ΣXY, the Sum of the product of First and Second Scores; ΣX, the Sum of First Scores; ΣY, the Sum of Second Scores; and ΣX^2, the Sum of square First Scores.

The coefficient of variation (CV %) was calculated as follows: CV % = (SD/ $\bar{x}$) ×100, to describe the variation of the traits (Hendricks and Robey, 1936).

RESULTS AND DISCUSSION

Data for the milk, fat and protein yields, as well as milk fat and protein percentage, at first lactation of Romanian Simmental cows are presented in Table 1. For each parameter examined, the mean value and the variation components were estimated. The linear regression relationship and correlations among milk traits are presented in Figures 1, 2, 3, 4, 5 and 6. Results suggested that as much as the milk yield increases, the fat yield will also increase. Furthermore, when milk fat percentage increases, the milk protein percentage will increase in the same extent. The other low values of correlation between the other milk traits indicate that the relationship between the predictor and response variable is very low linearly.

Milk recording provides cattle breeders with information on milk yield and milk composition for each dairy cow in the herd. The results help breeders in herd management and represent the basic source of information for the prediction of breeding value. Several variables (days in milk, milk fat and protein percentage, season) related to milk yield are collected as the parameters of the forecasting model. Fat and protein percentage are the most important components that dictate the purchase price of milk.

Milk yield for the first lactation of our Romanian Simmental cows (4053 kg) was lower than milk yield reported by Janžekovic *et al*. (2004) for first lactation of Slovenian Simmental cows (4870 kg), by Petrović *et al.* (2009) for first lactation of Serbian Simmental cows (4868 kg), and by Wolfová *et al.* (2007) and Jílek *et al.* (2008) in three herds of Czech Fleckvieh cows (5700 kg, 7651 kg and 6003 kg, respectively).

The high coefficient of variation for milk yield of 34.3 % in our Romanian Simmental cows denotes a very heterogenic population. As the data show, the herd had a very good phenotypic performance for this character, but only cows with a yield over 4000 kg/lactation were recommended to be retained for selection. Variation is a natural part of the biological process of making milk components. Age, illness,

Table 1: Mean and variability factors for milk yield and composition of first lactation Romanian Simmental cows[a]

	Mean $\bar{x}$	Standard deviation ± s	Coefficient of variation CV %	Min	Max	Standard Error ± $s\bar{x}$
Yield (kg)						
Milk	4053.0	1391.8	34.3	1055.6	7432.5	139.9
Fat	157.6	55.3	35.1	41.3	289.0	5.6
Protein	131.6	46.3	35.2	34.6	234.7	4.6
Milk percentage (%)						
Fat	3.820	0.378	9.890	2.800	4.700	0.038
Protein	3.120	0.358	11.470	2.000	4.500	0.036

[a]n = 99

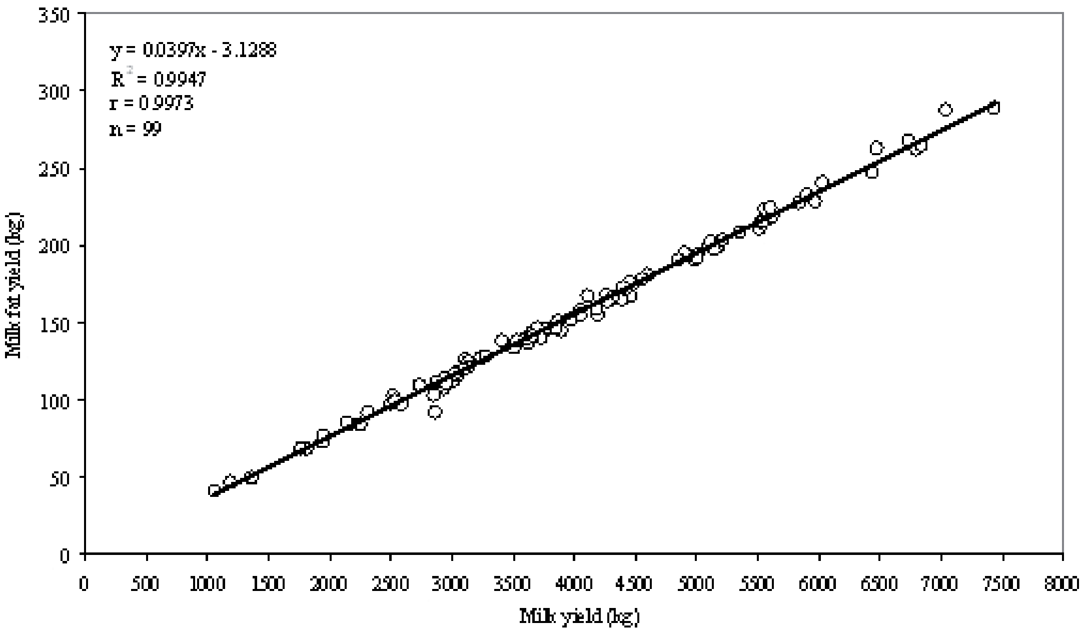

Fig. 1: The linear regression relationship between milk yield (kg) and milk fat yield (kg)

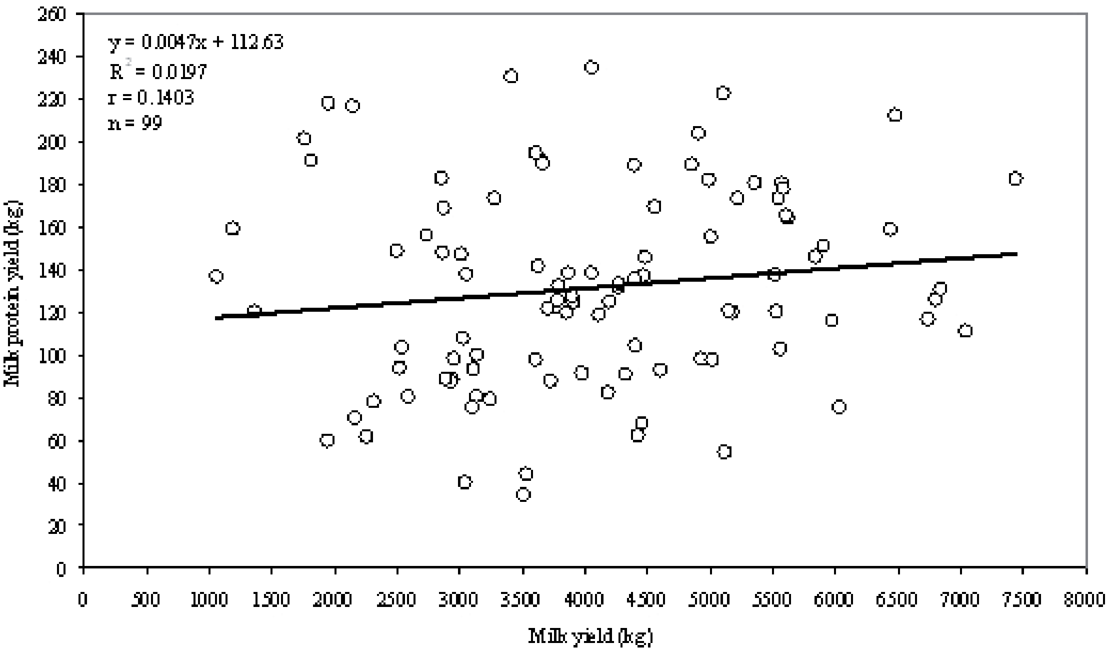

Fig. 2: The linear regression relationship between milk yield (kg) and milk protein yield (kg)

injury, feed, reproductive processes, climate, milking procedures and equipment, sampling techniques, sample shipment and lab procedures are possible sources of variability in component test results (Ježková and Dřevo, 2002). Some of these factors operate in a rather random fashion, in some cases increasing and in others decreasing component test results. Some of the factors may be systematic in nature, introducing bias into milk component test results (Gilmore and Gaunt, 1963). Furthermore, fat tests may respond quite differently from protein tests under the influence of some factors (Lee and Wardrop, 1984).

In our study, Romanian Simmental cows, in 305 days of lactation, yielded more milk fat (157.6 kg) than the Slovenian Simmental cows (133.5 kg milk fat; Logar *et al*., 2007), but less than the Czech Fleckvieh cows (275.7 kg milk fat, Bouška *et al*., 2008; and 255 kg milk fat, Čermák *et al.*, 2008). In addition, milk protein yield in this study (131.6 kg) was higher than that reported by Logar *et al.* (2007) in Slovenian Simmental cows (106.9 kg milk protein), but lower than milk protein yield found by Bouška *et al*. (2008) and Čermák *et al.* (2008) in Czech Fleckvieh (223.4 kg and 198 kg milk protein, respectively). For milk fat and protein yields, the coefficient of variation indicates a high heterogeneity in the cows' population.

In first lactation Romanian Simmental cows, milk fat and protein percentage was 3.82 % and 3.12 % respectively. Fat and protein percentage of cow milk used in this study was similar to the respective parameters in milk obtained from Simmental cows (Chládek and Kučera, 2002; Hanuš *et al.*, 2007; Krupová *et al.*, 2009). Petrović *et al.* (2009) found similar results for milk fat percentage (3.76 %) in first lactation Serbian Simmental cows. In contrast, Janžekovic *et al.* (2004) found higher milk fat (4.28 %) and milk protein percentage (3.43 %) in first lactation Slovenian Simmental cows than in our cows. Krupa *et al*. (2005) also found higher milk fat (4.10 %) and milk protein (3.35 %) percentage in Slovakian Pied cattle. Moreover, in three herds of Czech Fleckvieh cows, Wolfová *et al.* (2007) and Jílek *et al.* (2008) found milk fat percentage of 4.05 %, 4.28 % and 3.86 %, respectively, and milk protein percentage of 3.42 %, 3.45 % and 3.24 %, respectively. Low milk protein levels are frequently due to the low ration protein and/or energy level (Wolfová *et al*., 2007).

In our study, the milk fat and protein yields were highly variable with a coefficient of variation over 30 %. This suggests a very heterogenic dairy cows' population but, at the same time, there is the possibility of improving daily production by genetic means. Moreover, the milk fat and protein percentage had a coefficient of variation of 9.89 % and 11.47 %, respectively. Syrstad (1977) calculated standard deviations for cows and reported 0.364 and 0.078 percentage units for cow milk fat and protein percentage, respectively, whilst the respective standard deviations in our study were of 0.378 (for fat) and 0.358 (for protein) percentage units.

The potential fat percentage of milk from an individual cow is determined genetically, as are protein and lactose levels. Thus, selective breeding can be used to upgrade milk quality. Heredity also determines the potential milk production of the animal (Dematawewa and Berger, 1998). However, environment and various physiological factors greatly influence the amount and composition of milk that is actually produced. Fat percentage is the most variable component of milk and, besides the factors listed above, also depends on completeness of milking, sampling procedure and milking interval (Hargrove *et al.*, 1981). In our study, cows were milked at 12-hour intervals and the variation in fat percentage between milkings was negligible, but this is not practicable on most farms (Klopčič *et al*., 2003). Also, the first milk drawn from the udder is low in fat, whilst the last milk (or strippings) is always quite high in fat. Thus, it is essential to mix thoroughly all the milk removed, before taking a sample for analysis. The fat left in the udder at the end of a milking is usually picked up during subsequent milkings, so there is no net loss of fat.

Milk proteins represent one of the greatest contributions of milk to human nutrition. Protein does not vary to the same extent as fat percentage and the energy supply has the strongest impact on the protein percentage (Meinert *et al*., 1989). Longer milking intervals do not change protein percentage as much as fat percentage (Filistowicz *et al*., 1993). Milk protein has economic value because higher protein leads to higher cheese yields. Consequently, milk protein percentage of milk is emphasized (Grant, 2007). This parameter represents a decisive criterion in dairy selection. Results obtained can be also used for choosing the dams as mother sires, eliminating the individuals in which this character is situated under the standard limits.

In this study, the linear regression relationship and correlations among studied parameters were estimated, in order to have an indicator of the improvement method for these parameters. Evaluation of the relation between milk yield and milk fat yield (Figure 1) indicates a high correlation ($r = 0.9973$). The same high correlation ($r = 0.96$ to 0.99) between these milk traits was found in Holstein cows (Boujenane, 2002; Hashemi and Nayebpoor, 2008), whilst Ptak *et al.* (2004) and Al-Seaf *et al*. (2007) found a lower correlation ($r = 0.73$ and $r = 0.70$, respectively) in Holstein cows than in our study.

Concerning the relation between milk yield and milk protein yield in our study (Figure 2), the correlation coefficient ($r = 0.1403$) showed a little or

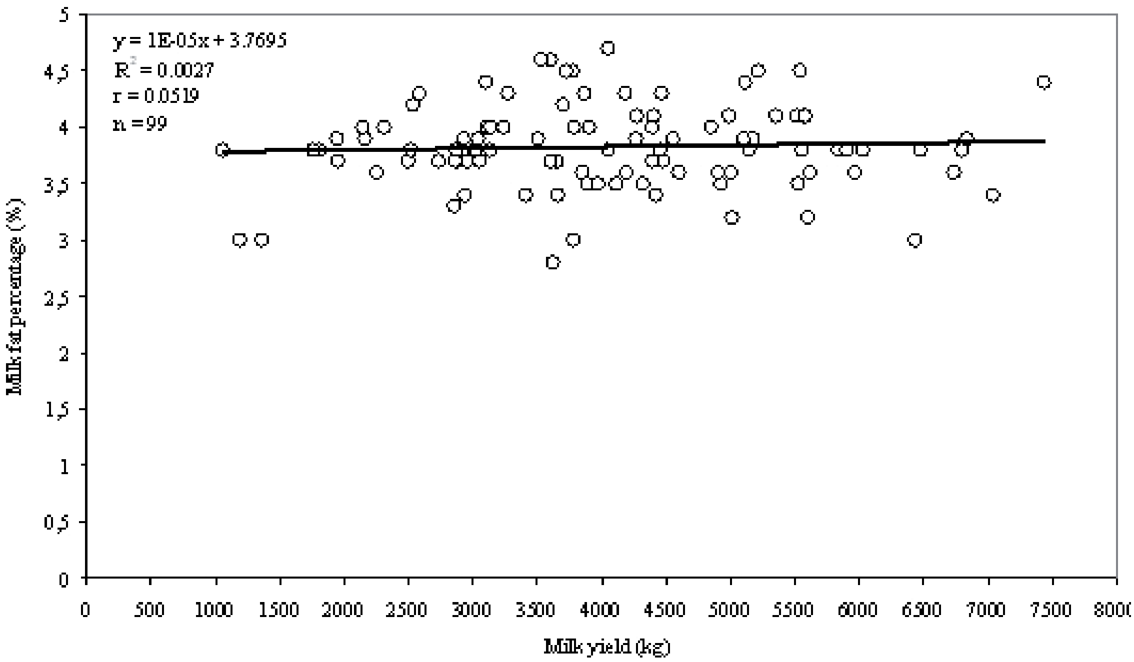

Fig. 3: The linear regression relationship between milk yield (kg) and milk fat percentage (%)

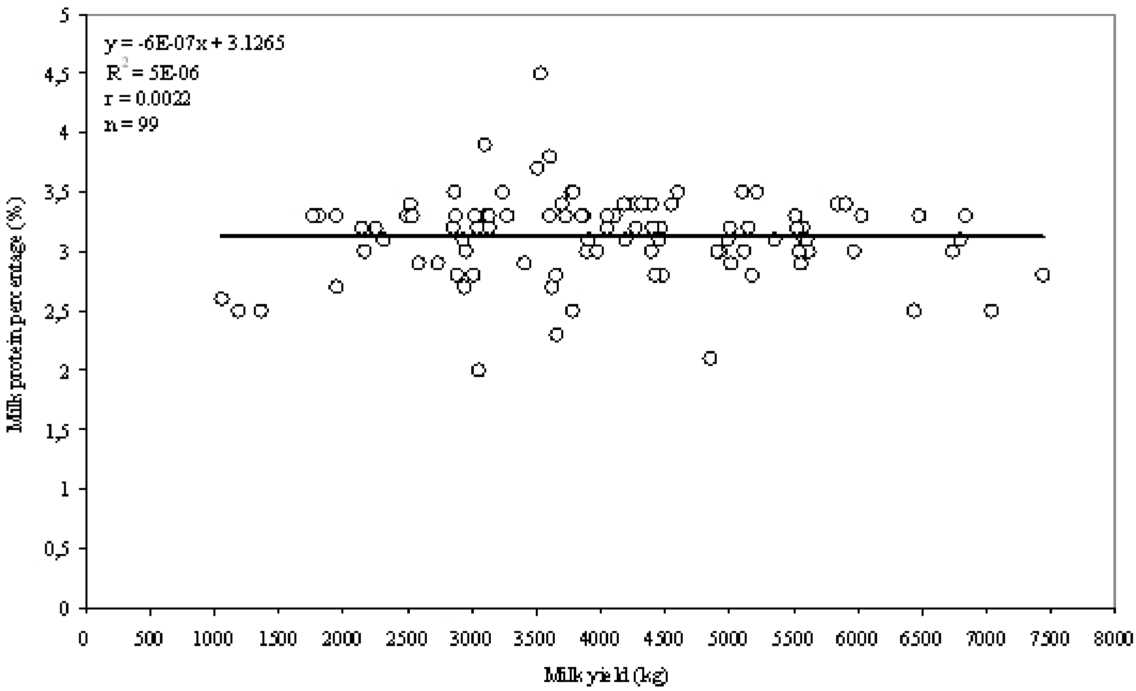

Fig. 4: The linear regression relationship between milk yield (kg) and milk protein percentage (%)

no association between analysed traits. In contrast, Ptak *et al*. (2004) and Al-Seaf *et al.* (2007) reported in Holstein cows a higher correlation (r = 0.89, and r = 0.92, respectively) between milk yield and milk protein yield than in our study.

Low correlation coefficient (r = 0.0519) was found between milk yield and milk fat percentage (r = 0.0519; Figure 3), as well as between milk yield and milk protein percentage (r = 0.0022; Figure 4), which denote no association between these two couples of milk traits. For milk yield and milk fat percentage, Gaines (1940) found r = -0.199, which suggests that this is associated with the low ratio of variability in fat percentage to variability in milk yield, whilst Boujenane (2002) and Hashemi and Nayebpoor (2008) also found in Holstein cows a negative and moderate phenotypic correlation between milk yield and milk fat percentage (r = -0.28 and r = -0.27, respectively). Moreover, Boettcher *et al.* (2004) found in Holstein cows a higher correlation coefficient between milk yield and milk fat percentage (r = 0.62) and between milk yield and milk protein percentage (r = 0.54).

Linear regression between milk fat yield and milk protein yield is shown in Figure 5, and between milk fat percentage and milk protein percentage in Figure 6. The correlation coefficient of r = 0.1414 in Figure 5 indicates that the milk protein yield did not increase similarly to milk fat yield. Al-Seaf *et al*. (2007) found in Holstein cows a higher phenotypic correlation (r = 0.74) between milk fat and protein yields. In Figure 6, the best estimate of the relationship of milk fat and protein percentages is expressed by a coefficient correlation of r = 0.5139. Musgrave and Salisbury (1952) found a lower coefficient correlation (r = 0.30) between these milk traits in Brown Swiss herd.

Excepting the phenotypic correlation value obtained between milk yield and milk fat yield, which was 0.99, all correlations values concerning other milk traits were fairly low. It is known that there is a negative correlation between milk yield and milk fat and protein percentage. As milk yield increases, milk fat percentage and milk protein percentage declines (Bilal and Khan, 2009).

CONCLUSION

The average milk yield in the studied primiparous Romanian Simmental herd was of 4053 kg, which allows the selection of individuals that produce over 4000 kg milk/lactation. Milk fat yield, in the same herd, had an average of 157.6 kg, and milk protein yield - an average of 131.6 kg. The strong phenotypic correlation between milk yield and milk fat yield indicates that the population of dairy cows can be improved by selection using the independent level of selection.

REFERENCES

AL-SEAF, A. – KEOWN, J. F. – VAN VLECK, L. D. 2007. Estimates of correlations among yield traits and somatic cell score with different models to adjust for bovine somatotropin effects on Holstein dairy cows. *Genetics and Molecular Research*, vol. 6 (1), 2007, p. 67-78.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (AOAC). 1990. Official Methods of Analysis of the AOAC, Helrich, K. (Ed.), 15th ed. Arlington, VA, USA. ISBN: 0-935584-42-0.

BILAL, G. – KHAN, M. S. 2009. Use of test-day milk yield for genetic evaluation in dairy cattle. *Pakistan Veterinary Journal*, vol. 29 (1), 2009, p. 35-41.

BOETTCHER, P. J. – CAROLI, A. – STELLA, A. – CHESSA, S. – BUDELLI, E. – CANAVESI, F. – GHIROLDI, S. – PAGNACCO, G. 2004. Effects of casein haplotypes on milk production traits in Italian Holstein and Brown Swiss cattle. *Journal of Dairy Science*, vol. 87 (12), 2004, p. 4311-4317.

BOUJENANE, I. 2002. Estimates of genetic and phenotypic parameters for milk production in Moroccan Holstein-Friesian cows. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux*, vol. 55 (1), 2002, p. 63-67.

BOUŠKA, J. – ŠTÍPKOVÁ, M. – PYTLOUN, P. – PYTLOUN, J. – KUBEŠOVÁ, M. 2008. Relationships among body condition score, milk yield and sires' breeding value for beef production efficiency in Czech Fleckvieh cattle. *Czech Journal of Animal Science*, vol. 53 (11), 2008, p. 453-461.

ČERMÁK, B. – FRELICH, J. – VONDRÁŠKOVÁ, B. – LÁD, F. – VÁVROVÁ, L. 2008. Milk yield and quality in the pasture season on some South Bohemian farms: Preliminary communications. In: Proceedings of the 43rd Croatian and 3rd International Symposium on Agriculture (18-21 February 2008, Opatija, Croatia), p. 834-837.

CHLÁDEK, G. – KUČERA, J. 2002. Relationships between milk yields in the first three lactations of Czech Pied cows. *Czech Journal of Animal Science*, vol. 47 (11), 2002, p. 445-450.

DECHOW, C. D. – ROGERS, G. W. – COOPER, J. B. – PHELPS, M. I. – MOSHOLDER, A. L. 2007. Milk, fat, protein, somatic cell score, and days open among Holstein, Brown Swiss, and their crosses. *Journal of Dairy Science*, vol. 90 (7), 2007, p. 3542-3549.

DELORENZO, M. A. – WIGGANS, G. R. 1986.

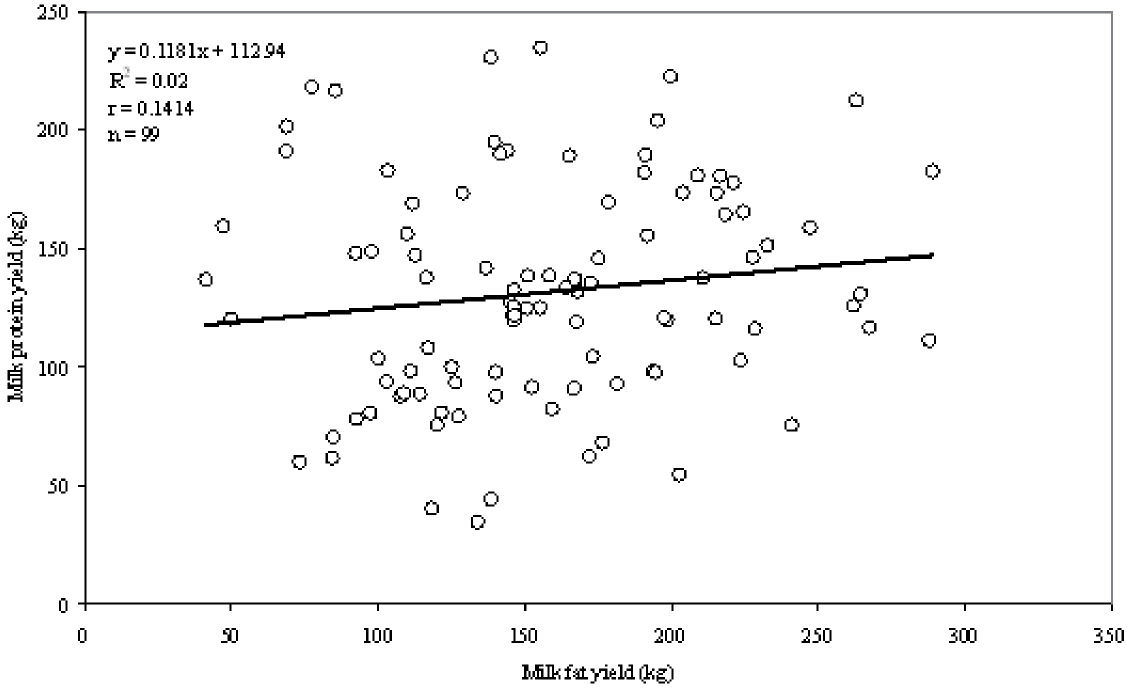

Fig. 5: The linear regression relationship between milk fat yield (kg) and milk protein yield (kg)

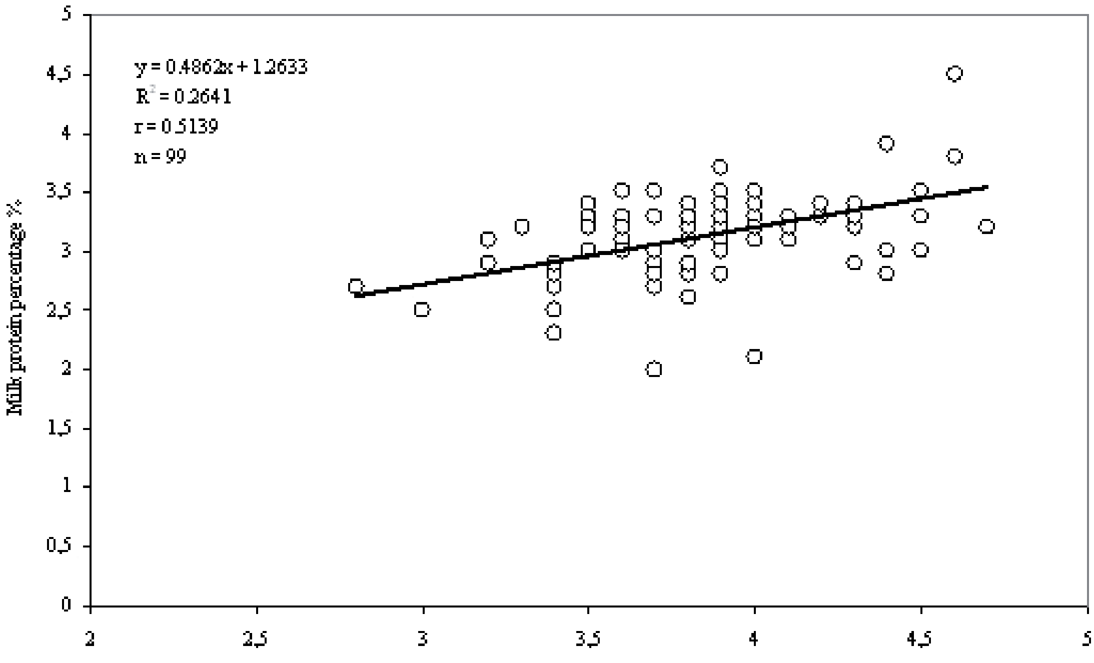

Fig. 6: The linear regression relationship between milk fat percentage (%) and milk protein percentage (%)

Factors for estimating daily yield of milk, fat and protein from a single milking for herds milked twice a day. *Journal of Dairy Science*, vol. 69 (9), 1986, p. 2386-2394.

DEMATAWEWA, C. M. B. – BERGER, P. J. 1998. Genetic and phenotypic parameters for 305-day yield, fertility, and survival in Holsteins. *Journal of Dairy Science*, vol. 81 (10), 1998, p. 2700-2709.

EEC. 1986. Council Directive (EC) No 609/86 of 24 November 1986 on the approximation of laws, regulations and administrative provisions of the Member States regarding the protection of animals used for experimental and other scientific purposes. *Official Journal*, vol. L 358, 18-12-1986, p. 1-28.

FILISTOWICZ, A. – JERZY, J. – LEWTER, S. – BOLESLAW, Z. 1993. Genetic and breeding investigation on crossbreds between local Black-and-White and Holstein Friesian cattle. II. Genetic and phenotypic parameters of dairy production in heifers. *Prace i Materialy Zootechniczne*, vol. 43, 1993, p. 19-25.

GAINES, W. L. 1940. Milk energy yield and the correlation between fat percentage and milk yield. *Journal of Dairy Science*, vol. 23 (4), 1940, p. 337-342.

GILMORE, H. C. – GAUNT, S. N. 1963. Variation in per cent of protein, milk fat and solids-not-fat between milking and during milk process. *Journal of Dairy Science*, vol. 46 (7), 1963, p. 680-685.

GRANT, R. 2007. Feeding to maximize milk protein and fat yields. University of Nebraska – Lincoln Extension, Institute of Agriculture and Natural Resources, IANR Neb Guide, G1358. NB, USA.

HALLOWELL, G. J. – VAN DER WESTHUIZEN, J. – VAN WYK, J. B. 1998. Variance component and heritability estimates for first and second lactation milk traits in the South African Ayrshire breed. *South African Journal of Animal Science*, vol. 28 (1), 1998, p. 46-49.

HANUŠ, O. – FRELICH, J. – JANŮ, L. – MACEK, A. – ZAJÍČKOVÁ, I. – GENČUROVÁ, V. – JEDELSKÁ, R. 2007. Impact of different milk yields of cows on milk quality in Bohemian Spotted cattle. *Acta Veterinaria Brno*, vol. 76 (4), 2007, p. 563-571.

HARDIE, A. R. – JENSEN, E. L. – TYLER, W. J. 1978. Genetic and economic implications of single trait selection for protein and solids-non-fat. *Journal of Dairy Science*, vol. 61 (1), 1978, p. 96-101.

HARGROVE, G. L. – MBAH, D. A. – ROSENBERGER, J. L. 1981. Genetic and environmental influences on milk and milk component production. *Journal of Dairy Science*, vol. 64 (7), 1981, p. 1593-1597.

HASHEMI, A. – NAYEBPOOR, M. 2008. Estimates of genetic and phenotype parameters for milk production in Iran Holstein-Friesian cows. *Research Journal of Biological Sciences*, vol. 3 (1), 2008, p. 678-682.

HENDRICKS, W. A. – ROBEY, K. W. 1936. The sampling distribution of the coefficient of variation. *The Annals of Mathematical Statistics*, vol. 7 (3), 1936, p. 129-132.

JANŽEKOVIC, M. – ŠKORJANC, D. – SMOLINGER, J. 2004. The influence of various origins of first calving Simmental and Black-White cows on production and content of milk. *Mljekarstvo*, vol. 54 (4), 2004, p. 275-283.

JEŽKOVÁ, A. – DŘEVO, V. 2002. The breeding of various performance types of cattle. *Journal of Central European Agriculture*, vol. 3 (4), 2002, p. 363-378.

JÍLEK, F. – PYTLOUN, P. – KUBEŠOVÁ, M. – ŠTÍPKOVÁ, M. – BOUŠKA, J. – VOLEK, J. – FRELICH, J. – RAJMON, R. 2008. Relationships among body condition score, milk yield and reproduction in Czech Fleckvieh cows. *Czech Journal of Animal Science*, vol. 53 (9), 2008, p. 357-367.

KLOPČIČ, M. – MALOVRH, Š. – GORJANC, G. – KOVAČ, M. – OSTERC, J. 2003. Prediction of daily milk fat and protein content using alternating (AT) recording scheme. *Czech Journal of Animal Science*, vol. 48, 2003, p. 449-458.

KOLB, E. 1987. Veterinary Physiology (Fisiologia Veterinária). 4th ed., Ed. Guanabara, Koogan - Rio de Janeiro (Brasil), p. 306-386.

KRUPA, E. – WOLFOVÁ, M. – PEŠKOVIČOVÁ, D. – HUBA, J. – KRUPOVÁ, Z. 2005. Economic values of traits for Slovakian Pied cattle under different marketing strategies. *Czech Journal of Animal Science*, vol. 50, 2005, p. 483-492.

KRUPOVÁ, Z. – HUBA, J. – DAŇO, J. – KRUPA, E. – ORAVCOVÁ, M. – PEŠKOVIČOVÁ, D. 2009. Economic weights of production and functional traits in dairy cattle under a direct subsidy regime. *Czech Journal of Animal Science*, vol. 54, 2009, p. 249-259.

LEE, A. J. – WARDROP, J. 1984. Predicting daily milk yield, fat percent, and protein percent from morning or afternoon tests. *Journal of Dairy Science*, vol. 67, 1984, p. 351-360.

LINN, J. – ALLEN, D. – NIERMAN, P. 1999. Understanding milk protein. *Dairy Initiatives Newsletter*, vol. 8, 1999, p. 15-17.

LOGAR, B. – MALOVRH, S. – KOVAČ, M. 2007. Multiple trait analysis of genotype by environment interaction for milk yield traits in Slovenian cattle. In: Proceedings of the 15th International Symposium "Animal Science Days" entitled "Recent Advances and Future Priorities of Animal Product Quality in EU" (19-21 September 2007, Osijek, Croatia), *Agriculture: Scientific and Professional Review*, vol. 13 (1), 2007, p. 83-88.

MEINERT, T. R. – KORVER, S. – VAN ARENDONK, J. A. M. 1989. Parameter estimation of milk yield and composition for 305 days and peak production. *Journal of Dairy Science*, vol. 72 (6), 1989, p. 1534-1539.

MUSGRAVE, S. D. – SALISBURY, G. W. 1952. The relationship of milk energy and total protein to per cent fat in Brown Swiss herd milk. *Journal of Dairy Science*, vol. 35 (2), 1952, p. 174-178.

NATIONAL RESEARCH COUNCIL, 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC, USA.

PETROVIĆ, M. M. – SRETENOVIĆ, L. – BOGDANOVIĆ, V. – PERIŠIĆ, P. – ALEKSIĆ, S. – PANTELIĆ, V. – PETROVIĆ, M. D. – NOVAKOVIĆ, Ž. 2009. Quantitative analysis of genetic improvement of milk production phenotypes in Simmental cows. *Biotechnology in Animal Husbandry*, vol. 25 (1-2), 2009, p. 45-51.

PTAK, E. – SATOLA, A. – CZAJA, H. 2004. Prediction of 305-day lactation milk, fat and protein yields using Legendre polynomials and test-day yields from different parts of lactation. *Animal Science Papers and Reports*, vol. 22 (2), 2004, p. 173-183.

SABBIONI, A. – BARATTA, M. – BERETTI, V. – ZANON, A. – SUMMER, A. – SUPERCHI, P. 2007. Prediction of milk, fat and protein yields in first lactation from serum β-lactoglobulin concentrations during gestation in Italian Brown heifers. *Italian Journal of Animal Science*, vol. 6 (2), 2007, p. 205-211.

SAS, E. – SAS, L. V. 1996. Animal Husbandry, Ethology and Modelling. Ed. Brumar, Timişoara (Romania), p. 85-138.

STATSOFT. 2007. Statistica Six Sigma, Statistica Release 8.0.360.0. StatSoft, Inc. Tulsa, Oklahoma, USA.

SYRSTAD, O. 1977. Day-to-day variation in milk yield, fat content, and protein content. *Livestock Production Science*, vol. 4, 1977, p. 141-151.

TIBSHIRANI, R. 1996. Regression shrinkage and selection via the Lasso. *Journal of the Royal Statistical Society. Series B* (*Methodological*), vol. 58 (1), 1996, p. 267-288.

WOLFOVÁ, M. – WOLF, J. – KVAPILÍK, J. – KICA, J. 2007. Selection for profit in cattle: I. Economic weights for purebred dairy cattle in the Czech Republic. *Journal of Dairy Science*, vol. 90 (5), 2007, p. 2442-2455.