Multivariate Animal Model Estimates of Genetic, Environmental and Phenotypic Correlations for Early Lactation Milk Yield and Composition in Tunisian Holstein-Friesians

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Abstract

Correlations between milk yield and composition traits (milk, fat and protein yields, and fat and protein percentages) were estimated from 10024 monthly test-day records from 1254 first lactations of Holstein-Friesian cows belonging to seventeen dairy herds. Variance and co-variance components were estimated using a multitrait repeatability animal model. All correlations between yields were positive and close to unity. Correlations between yields and constituent percentages in general were negative except for those of the same constituent. Expected possible correlated changes in traits resulting from selection on other traits were discussed: whether, and how, single-trait selection for milk yield could enrich or impoverish constituent contents in milk and *vice-versa*.

Keywords: Holstein-Friesians; Test-day record; Multivariate animal model; First lactation; Correlations.

1. Introduction

The fast and continuous evolution of the production tools, and the constraints of milk collection and transformation during the last years, is likely to involve modifications in milk quality with effects on quantity and quality of the processed products. These modifications are particularly important, a good part of produced milk being transformed into cheese. These significant changes of milk composition are always genetically and phenotypically correlated. Although softened by some fragmentary studies, where interest focussed only on lactation traits (305 d milk yield), choice of the appropriate models of genetic evaluation of animals and the selection criteria is still needing a major knowledge of the genetic and non genetic relationships between milk composition traits if we want a genetic improvement of milk quality. Either the characteristics of milk composition variation are due to environmental or genetic factors, these variations obey strictly types of linear relations, which are thus defined by three experimentally determinable coefficients for any trait couple. Objectives of the present research were 1) to estimate the genetic, environmental and phenotypic correlations for milk yield and composition in Tunisian conditions; the knowledge of the narrowness of relationships between milk traits being today much simpler to establish with increased precision, with the vertiginous evolution of means and tools of the statistical and genetic analyses; and 2) to discuss the possible correlated changes in traits when selection for other traits is applied.

2. Material and Methods

2.1. Data

Data were collected on Tunisian dairy herds recorded by the Breeding and Pastures Office (Office de l'Elevage et des Pâturages, OEP). A total of 10024 test-day records were available from 1254 Holstein-Friesian early lactations and were recorded during 1993 through 2002. The herds were on the standard A4 plan of testing. According to the testing programme applied for Tunisian dairy cows, the first test-day record was obtained at least 5 d following calving. Subsequent records were obtained at approximately monthly intervals thereafter.

From the data file of the OEP genetic improvement station other available pertinent information included date of milk sampling, number of lactation, date of birth of cows and calving date.

The mean number of test-day records per lactation was 8. Animals included in the relationship matrix (two generations) were 2380 cows and 296 sires. Some cows having their own data were also listed as dams of cows.

2.2. Statistical analysis

Data were gathered according to the different levels of the main environmental variables that were thought to affect milk yield and composition. There were 20 days-in-milk (DIM) groups, 7 calving-first test-day intervals, and 1066 levels of herd-test-day.

All known relationships among individuals were considered in the model of analysis that included the previous fixed effects. Data were analysed with the following multivariate repeatability animal model:

$$Y_{ijklm} = \mu + HTD_i + DIM_j + CI_k + A_l + PE_l + e_{ijklm}$$

where

Y_{ijklm} = dependent variable; μ = population mean; HTD_i = fixed effect of herd-test-day i; DIM_j = fixed effect of days-in-milk j; CI_k = fixed effect of calving-1st test-day interval k; A_l = additive genetic random effect of the individual l; PE_l = permanent environmental random effect on the individual l; and e_{ijklm} = random residual effect.

The (co)variance components and genetic, environmental and phenotypic correlations were estimated by the Analytical Gradients-REML procedure (Neumaier and Groeneveld, 1998) using the VCE package (Groeneveld, 1998).

3. Results and Discussion

Table 1 shows the estimates of the additive genetic and environmental correlations from analytical-gradient REML (co)variance components. Estimates of the phenotypic correlations are in table 2. Our estimates were similar to other findings that used various methods for this and other dairy cattle breeds elsewhere (Meinert *et al.,* 1989; Chauhan & Hayes, 1991; Campos *et al.,* 1994; Jairath *et al.,* 1995; Roman *et al.,* 1999). As a whole, examination of genetic, environmental and phenotypic correlations between traits leads to some important considerations.

For trait yields, genetic and phenotypic correlations indicated high and positive association between milk yield and fat or protein yield, with usually the genetic correlation being higher than the phenotypic correlation. This pattern already true for almost all traits is often found in dairy cattle (Seegers & Girmard-Ballif, 1994) and in dairy sheep (Othmane *et al.,* 2002*a,b*). Genetic correlations were in the range of 0.94 to 0.97, whereas the phenotypic counterparts ranged from 0.81 to 0.91. The genetic correlation, that was already high between milk yield and protein yield (0.94), was even higher between milk yield and fat yield (0.97). The genetic correlation between fat and protein yields, which directly conditions the possibilities for preferential or exclusive improvement of one of both traits, was in fact very high (0.96). Thus, any possible evolution arising from any preferential improvement is reduced when selecting for either of them.

Genetic correlations between milk and percentage traits were negative and in the range of those reported in literature for dairy cattle (Meyer, 1985; Boichard & Bonaiti, 1987; Welper & Freeman, 1992). Genetic association between milk yield and fat percentage (-0.42) was higher than that between milk yield and protein percentage (-0.25). Genetic association between fat and protein percentages was positive (0.60) and lower than that observed between fat and protein yields, which leaves *a priori* more room of manoeuvre for preferential improvement of each percentage trait, compared with yield traits. The negative genetic association observed between milk yield and fat and protein percentages indicates that selection for milk yield is expected to reduce milk composition. Such a situation may imply the necessity of including those traits in selection programs if their levels are to be maintained, which would reduce selection intensities for milk yield. However, it can be pointed out that the expected adverse effects on milk composition as a consequence of selecting for milk yield alone would be either small or would show up only over a long term (Moya *et al.,* 1985; Roman & Wilcox, 2000). Another alternative to avoid declines in milk composition is to think about yield traits.

Table 1. Additive genetic (below the diagonal) and environmental (above the diagonal) correlation estimates from multivariate test-day animal model in early lactation in Holstein-Friesian cows.

Trait (i/j)[1]	1	2	3	4	5
1 Milk yield, l/d		0.89	0.98	-0.33	-0.31
2 Fat yield, kg	0.97		0.93	0.12	0.07
3 Protein yield, kg	0.94	0.96		-0.23	-0.15
4 Fat, %	-0.42	-0.17	-0.19		0.82
5 Protein, %	-0.25	-0.12	0.09	0.60	

[1] i/j = trait i and trait j.

Yield traits and their corresponding percentages had low association that ranged from -0.23 to 0.46. Genetic correlation between protein yield and protein percentage was very low and positive (0.09). Those observed between fat yield and fat percentage, protein yield and fat percentage, and fat yield and protein percentage were however negative with intermediate values (Table 1). Although the very strong mentioned association between milk and fat and protein yields, milk yield behaved differently of the two composition trait yields (fat and protein), the association between yields and percentages of milk composition traits being lower. These results indicated that consideration of yield traits rather than percentages in selection programs is expected to improve milk yield and probably to maintain the percentages of fat and protein, and it may be then conceivable.

Table 2. Phenotypic correlation estimates from multivariate test-day animal model in early lactation in Holstein-Friesian cows.

Trait (i/j)[1]	1	2	3	4
1 Milk yield, l/d				
2 Fat yield, kg	0.81			
3 Protein yield, kg	0.91	0.82		
4 Fat, %	-0.11	0.46	0.04	
5 Protein, %	-0.16	0.08	0.22	0.38

[1] i/j = trait i and trait j.

Finally, as regards the repercussion of these results and their impacts on Tunisian Holstein-Friesian dairy cattle population under actual conditions, we consider that this study is only a first step. Additionally, it will be necessary to have other estimates before considering a possible interpretation related to the absence of selection on milk quality in such a population.

4. Conclusions

The magnitude and tendency of correlation estimates found in this study agreed with other reports using other methods of analysis. Genetic correlations between percentage traits and almost all yield traits were negative and relatively high, suggesting the necessity of following the milk composition progress closely when selection for milk yield is applied. Favorable genetic correlations were however found between milk yield and constituent yield traits, which could help to avoid some adverse effects on milk composition. Although these results allowed useful information, more studies are still needed to put them into practice in our actual conditions.

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