# Genetic Evaluations of Lactation Persistency for Italian Simmental Cows Based on Multivariate Principal Component Analysis

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## Abstract

Lactation persistency is defined as the ability of a cow to maintain as high as possible milk daily yield during lactation. This property, also so called "flatness" of lactation curve, has positive effects on health and reproduction status, because of a less negative energetic balance. Principal component analysis were used to decompose correlation matrix of test-day milk yields of 145,812 lactations of 90,655 Italian Simmental cows. The two leading principal components were associated, with whole lactation yield and lactation curve shape, respectively. The second principal component (PC2) was treated as new quantitative phenotype and analized under a BLUP animal model for a genetic evaluation. Genetic trends of cows and bulls show a substantial flat pattern. Empirical comparison among average lactation pattern of groups daughters of bulls which were very different on PC2 ebvs, confirmed the goodness of this indicator. Correlations between these ebvs and those calculated in Germany/Austria on bulls evaluated in both countries were moderate, that means ebvs for this trait calculated in this study are quite comparable.

#### Introduction

Persistency of lactation, defined as the ability of a cow to maintain a constant milk yield after the peak has been reached, represents a trait of interest for dairy cattle selection due to its relationships with health status, reproduction and feeding costs (Dekkers, 1998). Moreover, such lactation curve pattern allows to reduce feeding costs because a lower quantity of concentrate feeding is needed. Several measures of lactation persistency have been proposed (Cole and Van Raden, 2006; Gengler, 1996; Solkner and Fuchs, 1987; Strabel and Jamrozik, 2006; Togashi and Lvin, 2006), most of them show low to moderate heritabilities, suggesting that a genetic modification of the shape of the lactation curve is feasibile.

Therefore, in some cattle populations bulls breeding values for persistency are calculated and published since several years, in order to take into account also this trait in selection (Emmerling,2004).

The Principal Component Analysis (PCA) applied to the correlation matrix of test day

yields recorded at different stages of lactation allows to derive two linear combinations of original variables that can be considered as phenotypic indexes of the general level of production along the whole lactation and of lactation persistency (Macciotta *et al.*, 2006).

A previous study carried out on Italian Simmental cows has estimated an heritability of 0.21 and 0.09 for the level of production and persistency, respectively (Vicario *et al.*, 2007). In the present study, the genetic trend of these multivariate indices of lactation curve shape in the Italian Simmental cows in the last 30 years is investigated.

#### Data

Data were 145,812 lactations of 90,655 Simmental cows with 7 records each. Tests within lactation were considered as different correlated traits(MILK1, MILK2,..., MILK7) and analysed with Principal Component Analysis. Table 1 reports the eigenvectors and the corresponding eigenvalues of the 7 extracted principal components.

	Eigenvectors						
	PC1	PC2	PC3	PC4	PC5	PC6	PC7
MILK1	0.340	-0.557	0.569	-0.417	0.252	-0.116	-0.003
MILK2	0.382	-0.375	0.049	0.407	-0.575	0.446	0.126
MILK3	0.398	-0.195	-0.287	0.441	0.147	-0.565	-0.430
MILK4	0.403	-0.007	-0.435	-0.252	0.435	0.091	0.670
MILK5	0.399	0.182	-0.312	-0.441	0.044	0.461	-0.549
MILK6	0.382	0.386	0.046	-0.349	-0.558	-0.472	0.218
MILK7	0.336	0.573	0.550	0.385	0.285	0.158	-0.032
Eigenvalues (%)	77	12	4	2	2	2	1

**Table 1.** Eigenvectors and eigenvalues of the Principal Components of the correlation matrix of milk tests.

It can be seen that the first two leading principal components, accounting for about the 89% of the total original variability, are related with all MILK traits (**PC1**) or negatively with the first and positively with the second part of lactation (**PC2**). These results agree with previous research on the decomposition of genetic covariance matrix for TD milk (Druet *et al.*, 2005), and confirm the meaning of PC1 and PC2 scores as phenotypic indicators of level of production (YIELD) for the whole lactation and lactation persistency (PERS), respectively.

## Model

YIELD and PERS scores were calculated, treated as new variables and analysed with the following univariate animal model :

$$y_{ijklmn} = \mu + H_i + Y_j + S_k + Par_l + a_m + p_n + e_{ijklmno}$$

where:

$$\begin{split} Y_{ijklmn} &= PC1 \text{ and } PC2 \text{ scores}; \\ \mu &= \text{overall mean;} \\ H_i &= \text{fixed effect of herd (5,566 levels);} \end{split}$$

 $Y_j$  = fixed effect of calving year (16 levels, 1989 to 2004);

 $S_k$  = fixed effect of calving season (1= Jan to Feb, ..., 6= Nov to Dec);

 $Par_1 = fixed effect of parity (1 to 6);$ 

 $a_m$  = random additive genetic effect of animal (180,056);

 $p_n$  = random effect of permanent environment (180,056);

 $e_{ijklmno} = random residual.$ 

Breeding values were predicted by using BLUPF90IOD software developed by I. Misztal (2002), under LINUX environment. Variance components for the two principal components were those estimated by Macciotta et al. (2006). Official proofs of lactation persistency for Simmental bulls are published in Germany-Austria since 2004. Trait definition in such case, is the deviation between EBV for milk production at 300th day and that at 60th day (Emmerling R., 2004). As in the Italian Simmental population a large number of foreign bulls is used, mostly coming from Germany and Austria, simple correlations between national ebvs computed as previously stated and those from countries of origin were estimated.

#### **Results and discussion**

The phenotypic trends of two principal component scores during the period 1989-2004 (Figure 1) highlight an increase of the YIELD variable whereas a rather stable pattern, except for an increase in 2001 and 2002s, can be observed for the PERS.

These results clearly indicated that selection in the past has been mainly oriented towards an increase of level of production rather than on a modification of lactation persistency.



**Figure 1.** Phenotypic trends for the principal components related to the average level of production (YIELD) and to lactation persistency (PERS) in the Italian cows in the period 1989-2004.

Genetic trends of bulls (figure 2) confirm the phenotypic patterns: an increase of the YIELD variable could be observed whereas the PERS shows a substantial flat pattern except for a slight tendency to increase after the 1990.





Finally, Same behaviour, even if rather smoothed can be observed for the genetic trend of cows (Figure 3). Of particular interest are correlations among of cow EBVs of PERS and YIELD with milk yield (MY) and Somatic Cell Score (SCS) (predicted with a repeatability test day model (TDM) (Table 2). YIELD is highly related (about 0.80) to MY, confirming its meaning as indicator of the general level of production of the animal, and shows a favourable correlation (near to zero) with SCS. Correlation between SLOPE and the two indicators of production level, MY and YIELD are moderate, of the same order than those reported by Weller *et al.* (2006).

**Table 2.** Correlations among cow EBV for daily milk yield by TDM, average lactation yield (PC1), persistency (PC2), SCS by TDM (88,423 cows).

	YIELD	SLOPE	SCS-TDM
MY-TDM	0.79	0.28	-0.06
YIELD		0.30	-0.14
SLOPE			0.13

Although this value is higher than zero, i.e. the phenotypic correlation between YIELD and SLOPE scores, it confirms a certain independence between the proposed measure of persistency and level of production. Finally, correlation between EBVs of SLOPE and SCS are favourable (EBVs for SCS are transformed and with a change in sign) both for bulls and cows.





Average lactation curves for daughters of bulls with different EBV for SLOPE are reported in figure 4. A relevant difference in flatness between curves can be observed. Considering the mean difference between milk yield at  $1^{st}$  and  $7^{th}$  test respectively, the best bull (FAUCON, ebv = 0.6373) shows a value corresponding to the half of the value for the of worst bull (RENNMER, ebv = -0.4604).





This empirical comparison confirms the usefulness of the SLOPE scores as indicator of lactation curve persistency and support the proposal of this multivariate index to be considered in breeding strategies aimed at improving lactation persistency in the Italian Simmental cow breed. However, further investigations on relationships with other traits (fertility, longevity) are needed before a decision of its possible inclusion into current selection index (IDA) can be made.

Correlation on 106 bulls evaluated either in Italy as in Germany-Austria with at least 40 daughters was .64. Increasing number of daughters requirement up to 100, correlation increased, as well, up to .71 while number of common bulls went down to 48. Therefore, ebvs calculated according this study approach are quite comparable with those calculated abroad and according other trait definition.

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