Test-day model for milk yield of dairy buffaloes in Colombia

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Abstract

The test-day model is the preferred method for genetic evaluations in dairy cattle. For this study, 28372 test-day records of 1220 lactations from 1997 to 2009 were used. The (co)variance components for milk in test-day were estimated using a Uni and multiple-traits repeated animal model with the Restricted Maximum Likelihood method (REML). The Contemporary Group (herd, year, and season of parity) and the age of parity (linear and quadratic) fixed effects, and the additive genetic, permanent environmental, and residual random effects were included in the model.

The heritabilities ranged between 0.06 and 0.45 during lactation. The genetic correlations were greater than 0.93. In conclusion, the test-day model is appropriate for the genetic evaluation of dairy buffaloes in Colombia.

Key words: Buffalo, Genetic correlation, Milk yield, Test-day model

Introduction

Test-day models are widely used for genetic evaluations in dairy cattle because they allow to incorporate many records, allow to include relevant fixed effects. These models use longitudinal data of each individual to describe the lactation curve (Wiggans and Goddard 1997; Rodriguez-Zas et al 2000; Schaeffer et al 2000; Swalve 2000). It has been suggested the existence of high genetic association between the milk test-day model and total milk production. Furthermore, higher heritabilities have been reported in mid-lactation for dairy buffaloes in South America (Duarte et al 2004; Hurtado-Lugo et al 2006; Aspilcueta-Borquis et al 2009; Hurtado-Lugo et al 2009; Aspilcueta-Borquis et al 2010a,b).

The population of buffaloes in Colombia is small compared with other countries, and it is of great strategic importance to meet the existing demand for superior genetic material. The aim of this study was to estimate genetic parameters for milk yield using a test-day model in dairy buffaloes.

Materials and Methods

Test-day records were collected from seven dairy herds, members of the Colombian Buffalo Breeders Association (ACB). The data was made available by the Milk Control Program (Universidad de Antioquia and ACB, Colombia). These herds represent the largest buffalo population in Colombia. Most Colombian herds have crossbred animals with high proportion of the Murrah breed. Animals, which are descendants from Bulgarian and Brazilian lines, were raised on native grasses with minimum hay supplementation - only during the dry season (December to March).

Files included milk test-day records spanning from 1997 through 2009. Nine monthly milk controls were considered during lactation (TD, 1 to 9). Lactations with more than three test-day were considered. Data structure is shown in Table 1. Genealogical records (3201 animals) were constructed using information from the Brazilian Buffalo Breeder Association, available through the Universidade Estatual Paulista, Campus de Jaboticabal-Brazil and ACB-Colombia.

Uni and multi-traits analyses were conducted with an animal model with repeated measurements, using the derivative-free restricted maximum likelihood method. The (co)variance components were estimated with the MTDFREML software (Boldman et al 1995). Each TD was considered as a different trait. The effects included were: the fixed effects of contemporary group (herd, year and season of calving) and age of calving (linear and quadratic effects), as well as the random effects of animal, permanent environmental and residual. The calving seasons were January-April, May-July, August-October and November-December.

Milk yield during lactation was analyzed as a test day model considering different arrays of monthly combinations:

The (co)variance components for daily milk yield in several lactation days were estimated using four-trait animal model analyses and the REML method, considering the three following combinations of lactation months: (3, 5, 6, 7); (3, 4, 7, 8); (3, 4, 6, 7). This model can be represented as:

$$y_i = X_i\beta_i + Z_i a_i + W_i pe_i + e_i$$

with:

$$y = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} X_1 & 0 & 0 & 0 \\ 0 & X_2 & 0 & 0 \\ 0 & 0 & X_3 & 0 \\ 0 & 0 & 0 & X_4 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 & 0 & 0 \\ 0 & Z_2 & 0 & 0 \\ 0 & 0 & Z_3 & 0 \\ 0 & 0 & 0 & Z_4 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \begin{bmatrix} W_1 & 0 & 0 & 0 \\ 0 & W_2 & 0 & 0 \\ 0 & 0 & W_3 & 0 \\ 0 & 0 & 0 & W_4 \end{bmatrix} \begin{bmatrix} pe_1 \\ pe_2 \\ pe_3 \\ pe_4 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \end{bmatrix}$$

where:

y_i= vector of observations for test-day in the i^{th} month, in three-traits analysis (3,5,6 and 7; 3,4,7 and 8; 3,4,6 and 7 months)

β_i= vector of fixed effects for the i^{th} trait;

a_i=Vector of random additive genetic effect of animal for the i^{th} trait;

pe_i Vector of random permanent environmental effect of female with lactation for the i^{th} trait;

e_i Vector of random residual effect for the i^{th} trait.

X_i, Z_i and W_i are the incidence matrix relations to fixed, additive, and permanent environmental effects, respectively.

Results and Discussion

Milk yield of dairy buffaloes in Colombia varied from 3.21±1.24 to 4.84±1.60 kg/day (Table 1). These mean yield values seem low because they come from dual-purpose systems (meat and milk) with one daily milking. The Coefficients of Variation (CV) fluctuated from 33.00 to 38.56% across lactations, being higher in the middle and the last third of lactation. Other researchers from Brazil and Colombia reported milk yield in buffaloes fluctuating from 3.04 ± 1.11 to 8.61± 3.17 kg/day across lactation, and CVs between 27.16% and 41.54%, with the highest values occurring in the first and last third of lactation (Duarte et al 2004; Hurtado-Lugo et al 2005; Hurtado-Lugo et al 2006; Aspilcueta-Borquis et al 2009).

The (co)variance components and heritabilities for the uni-trait test-day model are shown in Table 1.

Table 1. Means, standard deviations (SD), number of records, coefficient of variation (CV), Genetic (v_a^2), permanent environmental (v_{ap}^2), residual (v_e^2) and phenotypic (v_p^2) variances and heritabilities (h^2) for milk yield of dairy buffaloes in Colombia, in a uni-trait test-day model.

Test-day	Days in milk	Records	Milk yield Mean ±SD (kg/day)	CV (%)	v_a^2	v_{ap}^2	v_e^2	v_p^2	h^2
TD 1	30	2,877	4.67±1.54	33.00	0.21	0.15	1.36	1.72	0.12±0.05
TD 2	60	3,456	4.84±1.60	33.16	0.10	0.34	1.38	1.82	0.06±0.08
TD 3	90	3,625	4.66±1.60	34.31	0.14	0.23	1.25	1.62	0.09±0.05
TD 4	120	3,610	4.49±1.53	34.05	0.23	0.14	1.10	1.47	0.16±0.04
TD 5	150	3,496	4.29±1.42	33.18	0.06	0.17	1.01	1.24	0.07±0.07
TD 6	180	3,364	4.09±1.37	33.43	0.09	0.12	0.92	1.14	0.08±0.05
TD 7	210	3,158	3.84±1.29	33.57	0.08	0.15	0.86	1.09	0.07±0.08
TD 8	240	2,727	3.52±1.27	36.17	0.11	0.08	0.95	1.15	0.10±0.06
TD 9	270	2,059	3.21±1.24	38.56	0.14	0.03	1.03	1.17	0.12±0.07

The highest genetic variances were observed at the beginning of the lactation (in TD1 and TD4, with 0.21 kg^2 and 0.23 kg^2, respectively), decreasing thereafter until the end of lactation (0.06 kg2). Aspilcueta-Borquis et al (2009) reported higher values, ranging from 1.23 kg^2 (TD3) to 0.38 kg^2 (TD9).

The heritabilities found fluctuated between 0.06±0.08 and 0.16±0.04, being higher for the TD4 (Table 1). Similar values were reported by Aspilcueta-Borquis et al (2009), with higher values for TD3 and TD4 (0.23 and 0.24, respectively), while Hurtado-Lugo et al (2006) reported values from 0.01 (TD9) to 0.20 (TD5). On the other hand, Gadini et al (1997) and Jamrozik and Schaeffer (1997) suggested animal selection should use the breeding values of TD4 and TD5 in a uni-trait test-day model, since they correspond to greater genetic variances and higher heritabilities.

In a Multi-trait test-day model, the genetic, permanent environmental and residual variances were higher compared to the uni-trait. The genetic variances varied between 1.49 kg^2 and 2.42 kg^2, being greatest at the beginning of lactation (Table 2). The heritabilities ranged between 0.31 and 0.45 (Table 3). These heritabilities were higher than those reported in the uni-trait test-day models, and higher than those by Aspilcueta-Borquis et al (2010c), which were between 0.15 and 0.24.

Table 2. Genetic (v_a^2), permanent environmental (v_{ap}^2), residual (v_e^2), and phenotypic (v_p^2) variances for milk yield of dairy buffaloes in Colombia, in a Multi-traits test-day model

Test-day	V_a^2	v_{ap}^2	v_e^2	v_p^2
Model for months 3, 5, 6 and 7				
TD 3	2.42	2.27	1.25	5.94
TD 5	1.94	2.21	1.54	5.69
TD 6	1.54	1.02	0.85	3.42
TD 7	1.49	1.80	1.44	4.74
Model for months 3, 4, 7 and 8				
TD 3	2.41	2.25	1.19	5.86
TD 4	1.88	2.20	1.56	5.64
TD 7	1.59	1.12	0.84	3.56
TD 8	1.51	1.86	1.42	4.79
Model for months 3, 4, 6 and 7				
TD 3	2.42	2.25	1.18	5.85
TD 4	1.86	2.21	1.56	5.62
TD 6	1.60	1.00	0.86	3.46
TD 7	1.51	1.86	1.42	4.79

Table 3. Genetic correlations (below the diagonal), permanent environmental (above the diagonal) and heritabilities (diagonal) for milk yield of dairy buffaloes in Colombia, in a Multi-traits test-day model.

Test-day	TD 3	TD 5	TD 6	TD 7
Model for months 3, 5, 6 and 7				
TD 3	**0.41**	0.97	0.96	0.95
TD 5	0.99	**0.34**	1.00	0.95
TD 6	0.98	0.99	**0.45**	0.99
TD 7	0.97	0.99	1.00	**0.31**
Model for months 3, 4, 7 and 8				
	TD 3	**TD 4**	**TD 7**	**TD 8**
TD 3	**0.41**	0.97	0.89	0.99
TD 4	0.99	**0.33**	0.96	0.96
TD 7	0.98	0.95	**0.45**	0.93
TD 8	0.99	1.00	0.93	**0.31**
Model for months 3, 4, 6 and 7				
	TD 3	**TD 4**	**TD 6**	**PDC7**
TD 3	**0.41**	0.99	0.97	0.98
TD 4	1.00	**0.33**	1.00	1.00
TD 6	0.96	0.93	**0.43**	1.00
TD 7	0.98	0.99	1.00	**0.32**

Genetic correlations were higher than 0.93, and were higher among consecutive test-days. These results are similar to those reported by

Aspilcueta-Borquis et al (2010c; 2010b) where genetic correlations ranged from 0.79 to 0.99. The permanent environmental correlations were greater than 0.89, and showed the same trend as the genetic correlations (Table 3).

Conclusions

- The results of this study suggest buffalo selection for mil yield in Colombia should use breeding values obtained in a test day with a multi-trait test-day model, because of their high heritability. These would allow farmers to quickly cull those low performing animals at the beginning of their lactation or productive life.

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