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Genetic parameters for milk production traits and breeding goals for Gir dairy cattle in Brazil

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ABSTRACT: Genetic and phenotypic parameters were estimated based on 22,468 lactations records of Gir Dairy cows. Statistical analyses were carried out by an animal model, in multitrait analyses using the REML method. A bioeconomic model was developed to calculate economic values. Expected economic responses to selection were compared for two breeding goals: 1) only milk yield (HGL1); 2) milk yield plus fat and protein yields (HGL2). Heritability estimates for milk, protein and fat yields were 0.33 ± 0.02, 0.26 ± 0.02 and 0.24 ± 0.02, respectively. All phenotypic and genetic correlations were high and positive. Economic values for milk, fat and protein were US$0.18, US$0.27 and US$7.04, respectively. The expected responses for HGL1 and HGL2 were US$79.82, and US$127.37, respectively. These results indicated that milk components traits should be included in breeding goals for the National Dairy Gir Breeding Program in Brazil.
Keywords: Gir dairy cattle; economic selection index; economic value

Introduction

To implement an animal breeding program, it is important to survey the production circumstances in which the improved animals will be used, in order to define which traits would be of economic interest to select (breeding goals) and which traits will be measured (selection criteria). Miglior et al. (2005) surveyed the selection indexes of fifteen countries, from different geographical regions, and showed that the average relative emphasis for milk production traits across all countries, was 59.5%, showing that this group of traits is still the most important component in selection indexes used in dairy cattle.

Studies involving economic selection indexes for dairy cattle have been only recently developed in Brazil and are still scarce for a variety of reasons, such as the diversity of production systems and slow implementation and diversity of payment policies for milk quality. Madalena (2000), simulated the expected response to selection indexes including milk, fat and protein yields, using economic values (EV`s) obtained for the payment policies prevailing in the states of Minas Gerais and Parana, resulting from the use of semen of imported bulls positive for fat and protein productions. Expected responses were positive when using EV's obtained for payment circumstances of Parana, where payment policies included bonus for milk components and negative when EV's were obtained for the payment system of a major dairy industry of Minas Gerais, which was only based on milk volume at that time.

After the implementation of Brazilian Agriculture Ministry regulation polices, released in 2002 (Brasil (2002)), which established health and quality standards for raw and processed milk and milk products, some dairies started to adopt payment systems for milk based on quality, applying bonuses or penalties for fat and protein content and somatic cell count. The aim of this study was to obtain genetic parameters and EV's of milk production traits in order to estimate genetic and economic responses to different selection indexes for Dairy Gir cattle, taking into account the production circumstances of crossbred commercial herds in the Southeast Brazil region.

Materials and Methods

Genetic parameters. Genetic and phenotypic parameters were estimated based on productive performance data from the National Dairy Gir Breeding Program. The data included milk production records from 22,468 first lactation Dairy Gir cows and its crosses, with calving occurred between 1970 and 2011. The statistical analyses used to estimate genetic parameters for 305-day milk, fat and protein productions were carried out by an animal model, using multitrait analyses. The model included the fixed effects of contemporary groups (herd and year of calving), calving season, cow's genetic composition and the age at calving as covariable (linear and quadratic effects). Direct additive genetic and temporary environmental effects were included as random effects. The variance components were estimated by restricted maximum likelihood method (REML), using the WOMBAT software (Meyer (2007)).

Production circumstances. Data of productive and reproductive performance obtained between 2005 and 2008, from a rotational system crossbred dairy herd involving Holstein (H) and Gir (G) cattle (H x H x G), kept by EMBRAPA Dairy Cattle (Crossbred Milk Production System – CMPS) were used. Lactating cows were managed exclusively in elephant grass (*Pennisetum purpureum*), during the rainy season (November-May), receiving corn silage supplementation during the dry season (June-October) and concentrates throughout lactation in the ratio of 1.0 kg concentrate: 3.0 kg milk. In the dry season, 80.0% of roughage consumed came from corn silage and the remaining 20.0% came from the pasture.

Economic value (EV) calculation. A bioeconomic model using Excel sheets was developed to calculate productive performance, revenues and costs for milk, fat and protein production traits and EV's. For this purpose, biological and economic parameters were used (Tables 1 and 2). Fat and protein contents of milk were obtained from two herds located in the states of São Paulo and Minas Gerais. Variable costs considered refer to all feeding components and prices were obtained from cost worksheets of the CMPS and from Anualpec (2011). Revenues from milk selling were calculated by adding respective bonus (or penalties) for fat and protein contents to the milk base price (US$0.38). Information on class definition and bonus (or penalty) values were obtained from payment tables of two important industries in the Southern region of Brazil. To circumvent the differences between payment tables, all classes and respective additional values paid by the two companies were combined and a linear regression analysis was used to establish a relationship between fat and protein contents and their additional values paid across industries. The EV's were calculated as the marginal difference in profit from an increase of one unit of improvement in the original level of each trait, while maintaining the level of the other traits constant, taking into account the interest of maximizing profit and fixed herd size (Groen et al. (1997)).

Table 1. Productive and reproductive performance of the Crossbred Milk Production System - Embrapa Dairy Cattle.

Traits	Means
305-d milk production (kg)	3278.42
Lactation length (days)	309.57
Daily milk production/cow (kg)	10.46
*Protein (%)	3.26
*Fat (%)	3.71
Calving interval (days)	446.01
Cows in milk (%)	69.41
Lactating cow weight (kg)	486.27
Dry cow weight (kg)	532.76

* Source: Boa Sorte Farm, MG, and Boa Esperança da Serra Farm, SP.

Table 2. Diet components and prices.

Components of the diet	DM (%)*	CP (%)*	Price/kg DM (US$)
Corn silage	30.00	7.26	0.10**
Elephant grass	16.00	8.43	0.03**
Concentrate	90.00	22.00	0.55***

DM = dry matter; TDN = total digestible nutrients; CP = crude protein. *Valadares Filho, 2006. ** Anualpec, 2011. *** EMBRAPA Dairy Cattle (Crossbred Milk Production System – CMPS). Brazilian currency, US$1.00: R$1.75.

Breeding goals and selection index. Using the same production circumstances and prices, responses to selection for two alternative breeding goals were compared: Situation 1) only milk production as the breeding goal, that is still the most common practice in Brazil (HGL1); Situation 2) milk, fat and protein yields as the breeding goal (HGL2). Indexes were obtained based on the methodology described by Hazel (1943).

Weighting factors (b) were derived to maximize response in the aggregate genotype (H) to the selection of individuals on their index value (I). Index weights were derived using the following matrix system equations: $b = P^{-1}Gv$, where b is weighting factors vector, P is the matrix of phenotypic covariances among the observations in the selection index, G is the matrix of genetic covariances among the index observations and the traits in the aggregate genotype and v is a column vector of EV's of traits in the breeding goal. Total expected selection response for each index (R) was given by: $R = ir_{IH}\sigma_H$ where i is the selection intensity, r_{IH} is the correlation between breeding goal and selection index and σ_H is the breeding goal standard deviation. The R were expressed in dollars (US$) (Brazilian currency, US$1.00: R$1,75).

Results and Discussion

The estimates of genetic and phenotypic parameters for first lactation milk, fat and protein yields are described in Table 3. There was a high genetic correlation among the traits, indicating that direct selection for increased milk production would also lead to increased fat and protein production.

Table 3. Estimates of genetic parameters[&] for 305-d milk production (kg), fat (kg) and protein (kg) for first lactation of Gir dairy cows.

Trait	Milk	Fat	Protein
Milk	0.33 ± 0.02	0.92 ± 0.01	0.97 ± 0.01
Fat	0.88 ± 0.00	0.24 ± 0.02	0.95 ± 0.01
Protein	0.91 ± 0.00	0.92 ± 0.00	0.26 ± 0.02

[&]Heritabilities on diagonal, genetic correlations above the diagonal and phenotypic correlations below the diagonal.

Figures 1 and 2 show the additional payment values estimated for fat and protein production by regression equations. These values were close to zero when fat and protein contents were close to the minimum value established by the government (3.0 and 2.9 for fat and protein content, respectively).

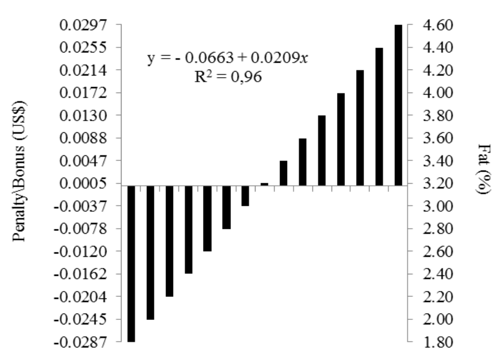

Figure 1: Regression analysis of the average class intervals on the additional payment values across the two milk companies for fat content (Brazilian currency: US$1.00: R$1.75).

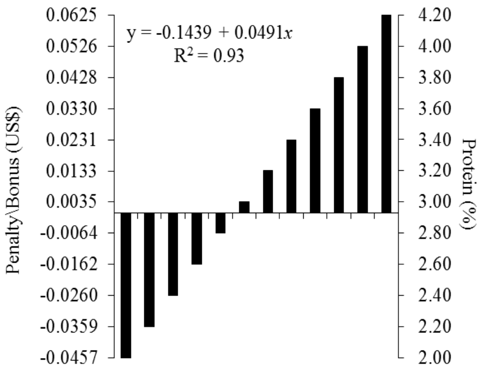

Figure 2. Regression analysis of the average class intervals on the additional payment values across the two milk companies of two companies for protein content. (Brazilian currency: US$1.00:R$1.75).

The EV's for milk, fat and protein were US$0.18, US$0.27 and US$7.04, respectively. The EV's calculated for milk, fat and protein production were positive, indicating that increasing their production through selection would result in increased profit. In other words, selection for these traits, and especially for increased protein production, would provide an advantageous economic gain for the producer, following the tendency observed in several countries, where EV for protein was greater, followed by smaller values for fat and negative values for milk volume (Amer et al. (2013)).

The expected genetic gains for milk production in the HGL1 and HGL2 indexes (Table 4) were similar. However, there was a notable difference in genetic gains for fat and protein production. Since the breeding goal in HGL2 included the solid components of milk (fat and protein), the genetic gains for these two traits were approximately 3.4 times greater than in HGL1. The genetic gains for milk yield, 332.03 kg for HGL1 and 337.73 kg for HGL2 per generation, were greater than the 206 kg reported by Herrera et al. (2008) for Dairy Gir cattle, which may be related to the greater estimate for additive genetic variation for this trait in this study. The expected genetic gains for fat and protein yields were higher for HGL2 than for HGL1, since in the first case (HGL2) there was direct selection for milk components.

Table 4. Expected genetic gain for the different traits, overall expected response to selection per generation (*R*) and accuracy (r_{IH}) of the selection indexes.

Index	Expected genetic gain[1]			*R*	r_{IH}
	Milk (kg)	Fat (kg)	Protein (kg)	(US$)	
HGL1	332.03	2.92	2.60	79.82	0.57
HGL2	337.73	10.15	8.92	127.37	0.57

[1]Genetic gain calculated assuming selection intensity of one and the same generation interval for every trait. Brazilian currency, US$1.00: R$1.75.

Dairy cattle selection in Brazil has been practiced only on milk production for decades. However, the results from the present study show that the economic selection index, including fat and protein, would increase the economic genetic efficiency of herds in this country, taking into account the current production components and milk payment policies. When fat and protein were also included in the breeding goal (HGL2), the expected economic response to selection was 37.33% greater (US$127.37) when compared to the response for HGL1 (US$79.82). It is quite difficult to compare these results with similar studies in Brazil, since milk payment policies are quite recent in the country. In the simulation study developed by Madalena (2000), who calculated EV's for the state of Parana, where a bonus policy for milk components was applied, a positive selection response to an index including milk volume and components was obtained.

Other traits related to health, fertility, conformation and other relevant functional traits could be also included in breeding objectives in dairy breeding programs in Brazil, as they are already widely used in developed countries (Miglior et al. (2005)). However, data recording systems in the country are still insufficient. As data on these traits become available, new studies will be possible by adding new traits in selection indexes to evaluate and compare selection responses.

Conclusion

Selection for milk, fat and protein yields could increase the economic genetic efficiency of herds taking into account the current production components and milk payment policies. The achieved results suggest that it is feasible and economically desirable to include, in addition to milk yield, protein and fat yields in breeding goals for Gir dairy cattle selection programs in Brazil.

Acknowledgments

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