Bayesian estimates of genetic parameters for reproductive traits in Nellore cows raised on pasture in the tropics

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ABSTRACT: We estimated (co)variances and genetic parameters for calving interval (CI), age at first calving (AFC), gestation length (GL) and days open (DO). Using multi-trait Bayesian procedures and a dataset composed of 9663, 28785, 24529 and 27944 records of AFC, CI, DO and GL, respectively, collected on Polled Nellore cows from 1977 to 2009. Heritabilities for AFC, CI, GL and DO averaged 0.36, 0.05, 0.10 and 0.04, respectively. The permanent environmental components associated with CI, GL and DO were also low, averaging 0.08, 0.07 and 0.15, respectively. The genetic correlations between AFC and CI, AFC and GL, AFC and DO, CI and GL, CI and DO and GL and DO were 0.20, 0.12, 0.11, 0.02, 0.92 and -0.21, respectively. Despite of the low heritability estimates, there is genetic variability to select the best cows and to reduce, mainly, age at first calving and calving interval.

Key words: animal breeding, beef cattle, fertility, reproductive efficiency, zebu

Introduction

Fertility or reproductive performance is one of the most important components of production efficiency in beef production systems. Cattle producers aim for each female to produce a healthy calf each year. The earlier the age at first calving (AFC), the greater the lifetime productivity and profitability of the cow. Calving interval (CI) directly influences the profitability of beef cattle systems, since it determines the number of calves born and the generation interval, which limits the intensity of selection. A delay in conception due to poor fertility prolongs the calving interval, and causes a shift in calving pattern, which can lead to higher culling rates. Days open (DO) and gestation length (GL) are both included in the calving interval. Days open refers to a period between calving and the next fertile cover. Thus, the ideal DO can vary between two and three months. Thus, reducing CI and DO can improve reproductive efficiency (Azevêdo et al., 2006).

Thus, development and productivity of cattle is associated with the implementation, monitoring and adjustment of program's nutrition, health, selection, breeding, and especially reproductive (Lopes et al., 2011; Santos et al., 2012). However, reproductive traits in cattle are difficult to measure, report and interpret. This is particularly true for pasture mating situations, where information on females is extremely limited. In these situations, the only information readily available is whether or not a cow produces a calf, and when she calves (Cammack et a., 2009; Yagüe et a., 2009).

Polled Nelore cows have long and prolific reproductive lives, thriftiness, hardiness and adaptability to a wide range of feed and climate. Studies of reproductive performance in Polled Nellore cows are limited. Therefore, this research was carried out to estimate and to analyze the genetics parameters for reproductive traits of Polled Nellore cows.

Materials and Methods

Data on reproductive performance, collected from 1977 to 2009 were obtained from the OB Group, located near Pontes e Lacerda, Mato Grosso, Brazil. It is a region of humid tropical climate, with an average altitude of 254 meters and average annual precipitation of 1,500 mm. Data were edited for consistency of pedigree information and correct dates of birth, calving and weighing. Records with anomalies in pedigree information and dates were discarded. Also discarded were records of animals with AFC greater than 2200 days, CI less than 300 and greater than 750 days, DO less than 40 and greater than 280 days and GL less than 260 and greater than 310 days. After data editing, the dataset was composed of 9663, 28785, 24529 and 27944 records from 388, 346, 351 and 390 sires and 5,590, 4,854, 4,901 and 5,785 dams for AFC, CI, DO and GL, respectively.

Genetic analyses were carried out fitting models that included the following effects: age of the cow as covariate; sex of the calf coded at two levels (male or female); season of birth, calving season and mating season all coded at four levels (from January 1 to March 31, from April 1 to June 30, from July 1 to September 30, and from October 1 to December), calving year, years of birth and mating years and herd. Fixed effects included in the models were: for AFC, herd-year-season of birth of cow and sex of the calf; CI and DO, herd-year-season of calving and sex of the calf, and for GL, herd-year-season of mating and sex of the calf. To define the fixed effects included in the contemporary groups (CG), statistical analyses were performed using the GLM and REG procedures (SAS, 2004). The CG with fewer than three records and sires with fewer than three offspring were also removed from the final data file.

The animal model used for AFC included fixed effects of CG and mating type (controlled mating or artificial insemination), random effects of animal and residual and age of cow as covariate (linear and quadratic effects). For CI, DO and GL random effects of animal, permanent environmental and residual were included. For GL, CG and mating type were also included. For DO, CG and age of cow as covariate (linear and quadratic effects) were also included.

The analyses were conducted by fitting single and two-trait animal models. Genetic parameters for the four analyzed traits were estimated via a Bayesian procedure using MTGSAM software (*Multiple Trait using Gibbs Sampler under Animal Model*; Van Tassell and Van Vleck, 1996) assuming normal multivariate prior distributions of the additive values, permanent environmental effects and the residuals. It was also assumed that both the systematic effects listed above and the (co)variance components included in the fitted model have a uniform Gaussian a priori distribution, whilst the conditional distributions of the additive, permanent environmental and residual variances are inverse Wishart distributed (Sorensen and Gianola, 2001).

The marginal posterior distribution for each parameter was obtained via integration of multivariate density functions using a Gibbs sampling procedure, with a period of data collection for multi-traits of 1,500,000 iterations and a burn-in period of 500,000 iterations and for ingle-trait of 2,500,000 iterations and a burn-in period of 500,000 iterations. The final file was composed of samples collected each 1,000 and 2,000 interactions for multi- and single-traits analyses. The estimates for each parameter included in the model were given with the corresponding Bayesian interval, defined by 95% highest posterior density (HPD95).

Breeding values were calculated utilizing all pedigree information available. Genetic trends were computed as a linear regression of average predicted breeding values for the traits versus the dam's birth year using the REG procedure (SAS, 2004) according to Filho et al. (2005).

Results and Discussion

Means for AFC, CI, GL and DO were 1,235 ± 250 days, 434 ± 101 days, 297 ± 7.6 days and 100 ± 52.3 days, respectively. Days open is above the ideal (60-90) for producing a calf/cow/year. These results are in accordance with a previous study (Azevêdo et al., 2006) which showed average of 166 ± 110 d and 295 ± 5.9 d for DO and GL, respectively.

The means, modes, and medians for the reproductive trait variance components appear similar to each other. For genetic parameters values, the measures of central tendency were identical, indicating that these posterior marginal distributions tended to symmetry (Table 1). Three of the four traits showed heritabilities, averaging of 0.05, 0.10 and 0.04 for CI, GL and DO, respectively. On the other hand, the moderate heritability for AFC (0.36 ± 0.03) indicates that selection for this trait should decrease AFC over time. The permanent environmental components associated with CI, GL and DO were also low, averaging 0.08, 0.07 and 0.15, respectively. All the estimates, regardless of whether they were of heritability or repeatability, showed narrow HPD95 bounds.

Table 2 gives the estimates of the mean, standard-deviation, median and bounds of HPD95 of the marginal posterior distributions of genetic correlations between AFC

Table 1. (Co)variance components and genetic parameters for age at first calving (AFC), calving interval (CI), gestation length (GL) and days open (DO).

Trait	Parameter	Mean	SD	Median	Credibility region (%)	
					2.5	97.5
AFC	h_a^2	0.36	0.03	0.36	0.35	0.36
	σ_a^2	5,459	507	5,461	5,437	5,481
	σ_e^2	9,702	386	9,698	9,685	9,719
CI	h_a^2	0.05	0.01	0.05	0.05	0.06
	t	0.08	0.01	0.08	0.08	0.09
	σ_a^2	63.32	10.46	62.95	62.86	63.78
	σ_{pe}^2	35.11	9.19	34.89	34.71	35.52
	σ_e^2	1,204	13.27	1,204	1,204	1,205
GL	h_a^2	0.10	0.01	0.10	0.10	0.11
	t	0.15	0.01	0.15	0.15	0.16
	σ_a^2	2.77	0.34	2.76	2.76	2.79
	σ_{pe}^2	1.45	0.29	1.44	1.43	1.46
	σ_e^2	24.39	0.26	24.39	24.38	24.40
DO	h_a^2	0.04	0.01	0.04	0.03	0.04
	t	0.07	0.01	0.07	0.07	0.08
	σ_a^2	24.79	4.89	24.67	24.58	25.01
	σ_{pe}^2	23.11	5.01	22.90	22.89	23.33
	σ_e^2	680	7.33	680	680	680

SD: standard deviation; t: repeatability; h^2: heritability; σ_a^2: genetic additive variance; σ_{pe}^2: genetic additive variance; σ_e^2: residual variance

Table 2. Genetic correlations for age at first calving (AFC), calving interval (CI), gestation length (GL) and days open (DO).

Trait	Mean	SD	Median	Credibility region (%)	
				2.5	97.5
AFC and CI	0.20	0.07	0.19	0.19	0.20
AFC and GL	0.12	0.05	0.12	0.12	0.13
AFC and DO	0.11	0.07	0.11	0.11	0.11
CI and GL	0.02	0.11	0.02	0.01	0.03
CI and DO	0.92	0.02	0.93	0.92	0.93
GL and DO	-0.21	0.11	-0.21	-0.22	-0.20

and CI, GL, and DO; between CI and GL and DO; and between GL and DO. The samples obtained for the genetic correlations did not show wide dispersion, i.e. the oscillations remained stable, thus indicating that the burn-in period considered in the analysis was reliable and allowed convergence of the chain (Gelfand and Smith, 1990).

Age at first calving is routinely recorded and has showed genetically correlated (0.20 ± 0.07) with calving interval (Table 2). So, due to these relationships, this measure is often used to evaluate heifer fertility. Calving interval is the number of days between successive calving and is an easily measurable trait used as an indicator of female fertility. Although this measure has been a principal measure of reproductive health throughout the productive life of the cow, it may not be the most appropriate measure of overall reproductive ability. Some authors (Cammack et a., 2009; Gutiérrez et al., 2002) have reported that later age at first calving is associated with a decrease in lifetime productivity of the beef female. Therefore, due to positively genetic correlation between the age at first calving and calving interval, and moderate heritability (0.36) for age AFC it's possible decrease both traits by the selection of precocious animals for AFC.

Genetic trends for AFC, CI, GL and DO were highly significant ($p<0.0001$) with coefficients of determination of 0.42, 0.21, 0.28 and 0.20, and slopes of -2.082, -0.071, 0.019 and -0.049 days, respectively. Over 32 years, AFC, CI and DO decreased from 5.24 to -1.08 days, 15.03 to -58.01 days and 4.89 to -0.32 days per year respectively. Gestation length increased from -1.52 to 0.26 days per year over the same period. The decreasing trend observed for AFC and CI indicated an improvement in the genetic merit of these traits (Gunawan et al., 2011a; Makgahlela et al., 2008), possibly as a correlated response to selection for increase daily gain (Gunawan et al., 2011b). A possible cause of the undesirable positive trend in GL and great fluctuation of values observed for AFC, CI and DO might be due to intense selection for productive traits (Santos et al., 2012; Lopes et al., 2013), with less attention given to reproductive traits.

Conclusions

Despite of the low heritability estimates, there is genetic variability to select the best cows and to reduce, mainly, age at first calving and calving interval. Genetic trends for AFC, CI, and DO were negative and due to positive genetic correlations among AFC, CI, and DO, the selection response for these traits would be favorable. Our results indicate that age at first calving presents medium heritability and is recommended as a selection criterion for sexual precocity. Moreover, changes in management and environmental factors could improve reproductive performance of polled Nellore herds.

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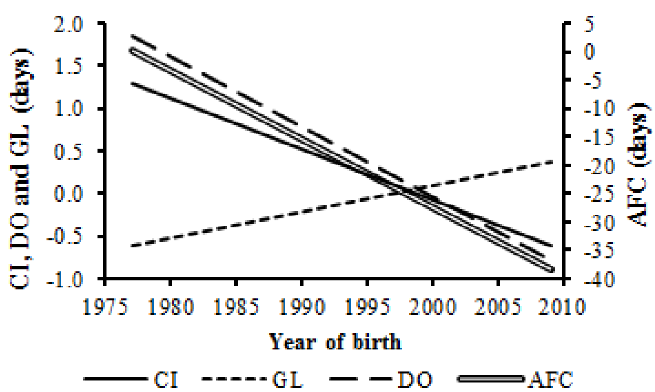

Figure 1. Regression line of breeding values (days) for calving interval (CI), days open (DO), gestation length (GL) and age at first calving (AFC) by year of birth