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# Estimates of genetic correlations between days to calving and reproductive and weight traits in Nelore cattle<sup>1</sup>

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**ABSTRACT:** Data comprising 53,181 calving records were analyzed to estimate the genetic correlation between days to calving (DC), and days to first calving (DFC), and the following traits: scrotal circumference (SC), age at first calving (AFC), and weight adjusted for 550 d of age (W550) in a Nelore herd. (Co)variance components were estimated using the REML method fitting bivariate animal models. The fixed effects considered for DC were contemporary group, month of last calving, and age at breeding season (linear and quadratic effects). Contemporary groups were composed by herd, year, season, and management group at birth; herd and management group at weaning; herd, season, and management group at mating; and sex of calf and mating type (multiple sires, single sire, or AI). In DFC analysis, the same fixed effects were considered excluding the month of last calving. For DC, a repeatability

animal model was applied. Noncalvers were not considered in analyses because an attempt to include them, attributing a penalty, did not improve the identification of genetic differences between animals. Heritability estimates ranged from 0.04 to 0.06 for DC, from 0.06 to 0.13 for DFC, from 0.42 to 0.44 for SC, from 0.06 to 0.08 for AFC, and was 0.30 for W550. The genetic correlation estimated between DC and SC was low and negative (−0.10), between DC and AFC was high and positive (0.76), and between DC and W550 was almost null (0.07). Similar results were found for genetic correlation estimates between DFC and SC (−0.14), AFC (0.94), and W550 (−0.02). The genetic correlation estimates indicate that the use of DC in the selection of beef cattle may promote favorable correlated responses to age at first mating and, consequently, higher gains in sexual precocity can be expected.

Key Words: Age at First Calving, Beef Cattle, Days to Calving, Scrotal Circumference, Weight, Zebu Breeds

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## Introduction

Interest in incorporating days to calving (DC) in beef cattle selection programs requires the estimation of genetic components that act on the phenotypic expression of this trait, as well as its possible genetic association with other economically important traits. In general, studies correlating DC and productive and reproductive traits in beef cattle report favorable genetic correlations, but few studies for Zebu breeds in Brazil are available.

The association between DC and age at first calving (AFC) is still unknown. The knowledge of this correlation would be useful for genetic improvement because AFC has been emphasized as a trait indicating sexual precocity. Scrotal circumference (SC) has been used as

a fertility selection criterion because it shows favorable genetic correlations with sperm quality, age at puberty in males and females, and growth traits (Nelly et al., 1982; Gressler et al., 2000; Sarreiro et al., 2000). The genetic correlations reported between SC and DC are in general negative (Meyer et al., 1991; Notter et al., 1993; Pereira et al., 2000), suggesting that the inclusion of DC in selection programs might increase genetic gain in fertility.

In Angus cattle, DC has shown genetic correlations with weight traits close to zero (Meyer et al., 1991; Johnston and Bunter, 1996). Brazil has a dry season, which often represents a period of food restriction, and might cause more marked differences in reproductive performances of animals of different sizes. Investigations about the genetic correlation between weight performance traits and DC in females might help in the establishment of relationships between growth and reproduction.

Our objective was to estimate the genetic correlation of days to calving and days to first calving (DFC), with scrotal circumference, age at first calving, and weight adjusted for 550 d of age (W550) in a Nelore population.

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## Materials and Methods

The data used in the present study were provided by Agropecuária Jacarezinho Ltda., located in Valparaíso, northeast of the State of São Paulo, Brazil. This company specializes in rearing and selecting beef cattle, mainly Nelore cattle in an extensive system. The animals were raised on tropical species of pasture and received a mineral mixture supplement.

At birth, the animals are assigned to management groups separated by sex. Animals in the same group, in general, are a maximum of 30 d of age apart and are kept together until weaning (approximately 210 d of age). At weaning, weight and visual scores are recorded and a genetic evaluation is performed. Based on an index which includes growth and visual scores, approximately 25% of the males and 10% of the females are culled at weaning. Selected animals are reassigned to management groups until 550 d of age, when a new genetic evaluation is performed. Selection is based on an index including growth and visual scores at weaning and at 550 d of age and scrotal circumference. Half the males and 10% of the females are culled.

The data provided all information about traits considered in selection indexes, including the date of measurements and management practices. After elimination of 366 incomplete records, a total of 53,181 calving records from 1984 to 2000 remained; 43,094 from mating using multiple sires; 6,187 from AI; and 3,900 from mating using single sires.

Days to calving was calculated as the difference in days between the first day of the breeding period and calving date for each breeding season. Noncalvers were not considered in analyses because an attempt to include them, attributing a penalty, did not improve the identification of genetic differences between animals (Forni and Albuquerque, 2003).

(Co)variance components were estimated using bivariate animal models with different sets of fixed effects for each trait. For DC, the fixed effects were month of previous calving, age at breeding season (linear and quadratic effect) and contemporary group (herd, year, season, and management group at birth; herd and management group at weaning; herd, season, and management group at mating; and sex of calf and mating type [multiple sires, single sire, or AI]).

For SC, fixed effects considered were age at measuring (linear and quadratic effect), weight adjusted to 550 d of age (linear effect), and contemporary group (herd, year, season, and management group at birth, and herd and management group at weaning and at measurement). For AFC, effects considered were the age of dam at calving, (linear and quadratic effect) and the contemporary group (herd, year, season, and management group at birth; herd and management group at weaning and at mating; and mating type [multiple sires, single sire, or AI]). For W550, the only fixed effect considered was the contemporary group (herd, year, season, and management group at birth; herd and management

group at weaning; herd and management group at measurement; and sex). For all traits, contemporary groups with fewer than three observations were excluded.

For DFC, the set of fixed effects was the same used for DC excluding the month of last calving. The variables birth and mating seasons were included in some definitions of contemporary groups because there were two distinct breeding periods during the year, one during spring (November, December, and January; approximately 75 d) and the other during summer (February and March). Before 1990, females were first exposed to mating close to 24 mo during the spring. After that, two breeding seasons were implemented; females close to 16 mo of age were exposed to mating during the summer without changes in management practices in an attempt of early identify sexually precocity. Only heifers close to 16 mo of age that did not conceive during their first exposure received another opportunity to conceive, at 24 mo of age. Older females were culled if they were not pregnant after a breeding season.

For analyses of DC, once there were repeated records for the same cow, the permanent environmental effect of animal was included in the model. For analyses including SC, residual covariances could not be estimated as this trait was measured only on males, and other traits were only measured in females.

The (co)variance components were estimated by the REML method using the multiple-trait derivative-free restricted maximum likelihood (MTDFREML) programs (Boldman et al., 1993). The convergence criterion was considered to have been fulfilled when the variance of the logarithmic value of the likelihood function was equal to or lower than  $10^{-9}$ . Because convergence can be wrongly obtained at local maximum sites (Press et al., 1986), the analyses were repeated to ensure the convergence in the overall maximum of the likelihood function.

## Results and Discussion

The number of observations, contemporary groups, means, SD, and ranges observed for each trait are shown in Table 1. The estimated means are close to those reported in other studies analyzing the same traits (Meyer et al., 1990; Johnston and Bunter, 1996; Pereira et al., 2001; Dias et al., 2003, 2004). Days to first calving mean was approximately 2 d higher than DC mean, probably because DC records were a selected sample of the population, as females that did not become pregnant after one breeding season were culled. In addition, DFC is measured in younger animals, and Forni and Albuquerque (2003) found that DC tends to decrease with increasing age of the animal up to approximately 7 yr.

Heritability estimates for DC ranged from 0.04 to 0.06, and repeatability ranged from 0.10 to 0.11 (Table 2). Higher estimates from 0.05 to 0.14 were reported for European breeds (Meyer et al., 1990, 1991; Johnston and Bunter, 1996); however, similar results were re-

**Table 1.** Number of observations, contemporary groups, means, standard deviations, minimum and maximum values of days to calving (DC), days to first calving (DFC), scrotal circumference (SC), age at first calving (AFC), and weight adjusted for 550 d of age (W550) in Nelore beef cattle

Trait	No. of observations	No. of contemporary groups	Mean	SD	Minimum	Maximum
DC, d	53,181	1,809	309	24	260	365
DFC, d	17,824	2,070	308	23	234	365
SC, cm	12,964	481	26	3	16	45
AFC, d	18,615	1,324	1,064	80	757	1,197
W550, kg	35,409	999	289	41	190	477

ported for Nelore herds in Brazil (Pereira et al., 2001; Mercadante et al., 2002). The DFC heritability estimates were slightly higher, 0.06 and 0.13. In general, studies analyzing calving date have reported lower heritability coefficients for the second calving date compared with the first one (Meacham and Notter, 1987; Gressler et al., 2000; Simioni and Tonhati, 2004). These lower estimates might be a reflection of culling females that did not become pregnant and/or of true changes in the magnitude of environmental genetic variances during animal's reproductive lives.

The results showed high heritability estimates for SC of 0.42 and 0.44 (Tables 2 and 3), within the range reported in the literature from 0.24 (Gressler et al., 2000) to 0.71 for the Nelore breed (Quirino and Bergmann, 1997). The genetic correlations observed between DC and SC (-0.10) and between DFC and SC (-0.14) were favorable, although not very large, indicating that the selection for SC had a positive influence on female reproductive performance. Pereira et al. (2000) also found a favorable genetic correlation between DC and SC in Nelore cattle (-0.04), and Meyer

et al. (1991) reported higher negative correlations in Angus cattle, from -0.25 to -0.36. These results suggest that including DC in selection programs might increase the genetic gains for sexual precocity and fertility.

The heritability estimates for AFC of 0.06 and 0.08 (Tables 2 and 3) agreed with those reported in recent studies in Brazil, ranging from 0.02 to 0.18 (Pereira et al., 2000, 2001; Talhari et al., 2003; Dias et al., 2004). The heritability estimates could have been influenced by the fact that some of the females evaluated had been exposed to breeding only at 24 mo of age. Exposure of 16- to 18-mo-old heifers to breeding started in the early 1990s. Before this time, the animals were bred only in the spring reproductive season; thus, females entering heat before 2 yr of age did not have the chance to demonstrate their genetic potential for sexual precocity. Another factor that might have contributed to the low estimates of heritability is the short duration of the breeding seasons, which were 75 d for cows and 60 d for heifers. With a longer period of mating, more animals probably would have conceived, which could contribute to identifying genetic differences between animals.

**Table 2.** (Co)variance components estimates for days to calving (DC), scrotal circumference (SC), age at first calving (AFC), and weight adjusted for 550 d of age (W550) in Nelore beef cattle

Estimate <sup>a</sup>	DC, d	SC, cm	DC, d	AFC, d	DC, d	W550, kg
$\sigma_a^2$	15.53	2.48	14.23	138.72	11.18	171.43
$\sigma_c^2$	16.62	—	17.19	—	17.33	—
$\sigma_e^2$	249.53	3.46	258.55	2,051.55	249.70	399.81
$\sigma_p^2$	281.70	5.95	289.98	2,190.28	278.21	571.25
$h^2$	0.06	0.42	0.05	0.06	0.04	0.30
$c^2$	0.05	—	0.06	—	0.06	—
$e^2$	0.89	0.48	0.89	0.94	0.90	0.70
$\sigma_{a1a2}$		-0.65		33.61		3.05
$\sigma_{e1e2}$		0.00		333.11		-20.27
$\sigma_{p1p2}$		-0.65		366.72		-17.22
$r_a$		-0.10		0.76		0.07
$r_e$		0.00		0.46		-0.06

<sup>a</sup> $\sigma_a^2$  = additive genetic variance;  $\sigma_c^2$  = permanent environment variance;  $\sigma_e^2$  = residual variance;  $\sigma_p^2$  = phenotypic variance;  $h^2$  = heritability;  $c^2$  = fraction of phenotypic variance due to permanent environment;  $e^2$  = fraction of phenotypic variance due to temporary environment;  $\sigma_{a1a2}$  = additive genetic covariance;  $\sigma_{e1e2}$  = residual covariance;  $\sigma_{p1p2}$  = phenotypic covariance;  $r_a$  = additive genetic correlation; and  $r_e$  = residual correlation.

**Table 3.** (Co)variance components estimates for days to first calving (DFC), scrotal circumference (SC), age at first calving (AFC), and weight adjusted for 550 d of age (W550) in Nelore beef cattle

Estimate <sup>a</sup>	DFC, d	SC, cm	DFC, d	AFC, d	DFC, d	W550, kg
$\sigma_a^2$	34.98	2.61	35.66	182.36	15.61	172.36
$\sigma_e^2$	247.02	3.30	246.16	2,006.71	266.18	399.85
$\sigma_p^2$	282.00	5.91	281.82	2,189.07	281.79	572.21
$h^2$	0.12	0.44	0.13	0.08	0.06	0.30
$e^2$	0.88	0.56	0.87	0.92	0.94	0.70
$\sigma_{a1a2}$		-0.87		76.12		-1.27
$\sigma_{e1e2}$		0.00		513.96		-17.27
$\sigma_{p1p2}$		-0.87		590.08		-18.55
$r_a$		-0.14		0.94		-0.02
$r_e$		0.00		0.73		-0.05

<sup>a</sup> $\sigma_a^2$  = additive genetic variance;  $\sigma_e^2$  = residual variance;  $\sigma_p^2$  = phenotypic variance;  $h^2$  = heritability;  $e^2$  = fraction of phenotypic variance due to temporary environment;  $\sigma_{a1a2}$  = additive genetic covariance;  $\sigma_{e1e2}$  = residual covariance;  $\sigma_{p1p2}$  = phenotypic covariance;  $r_a$  = additive genetic correlation; and  $r_e$  = residual correlation.

The genetic correlation estimates between DC and AFC (0.76) and between DFC and AFC (0.94) indicated the possibility of obtaining a favorable correlated response in terms of reduced age at first mating using DC as a selection criterion. Simioni (2002) also found a favorable genetic correlation between AFC and first calving date (0.39), concluding that simultaneous selection for these traits could be an effective method to obtain genetic gains in sexual precocity and reproductive performance. Studies using experimental data in which age at first mating is not predetermined as a function of management practices, or in which breeding season is not limited, should contribute to a more precise identification of the genetic variability in AFC and its association with other fertility-indicating traits.

The estimated heritability coefficients of 0.30 (Tables 2 and 3) for W550 were within the range reported in the literature for Nelore cattle, although most studies obtained higher heritabilities for this trait than those observed here (Lôbo et al., 2000). The genetic correlation estimates between DC and W550 (0.07) and between DFC and W550 (-0.02) were almost null. Although close to zero, the estimates had opposite signs. The correlation between DFC and W550 was negative, suggesting that larger females would not be at a disadvantage upon first exposure to the sire as also was reported by Mercadante et al. (2003). These authors estimated the correlated response to DFC in a Nelore herd in which females were selected for weight gain. It should be noted that the data analyzed here were from animals selected for rate of weight gain at early ages, which therefore did not have high weights at mature ages.

Conversely, the genetic correlation estimate between W550 and DC was positive, suggesting that females with higher mature weights might have worse reproductive performance during their lifetimes. The genetic correlations between DC and weight traits reported by Meyer et al. (1991) for European breeds were negative

(from -0.10 to -0.66). In contrast, Johnston and Bunter (1996) analyzed Angus data and found positive genetic correlations between DC and weaning weight (0.10) and yearling weight (0.08). For the Johnston and Bunter (1996) study, the growth potential of animals might contribute to the differences observed in re-conception and, consequently, in subsequent exposures to breed. In Brazil, Pereira et al. (2001) also reported positive genetic correlations from 0.28 to 0.48 between DC and weight traits.

Although selection for weight at young ages did not affect cow reproductive performance under the conditions of the present study, the results could differ in more restricted environments. In this case, an increase in adult BW or possible changes in the female growth curve could have implications for management practices and reproductive performance.

## Implications

The use of days to calving as a selection criterion in beef cattle may promote favorable correlated responses in age at first conception and, consequently, it could contribute to increasing gains in female sexual precocity. Under the conditions of the present study, selection for weight gain at young ages should not affect the cow reproductive performance.

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