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Genetic analysis for gestation length, birth weight, weaning weight, and accumulated productivity in Nellore beef cattle

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ABSTRACT

The aim of this study was to estimate variance and covariance components for gestation length (GL), birth weight (BW), weaning weight (WW), and accumulated productivity (ACP), and their respective genetic trends for Nellore cattle raised in Brazil. The ACP trait is a reproduction index developed by the National Association of Breeders and Researchers (ANCP) and comprises the total number of calves born per dam, weight of weaned calves, and age of the dam at calving. A total of 25,085, 46,911, 50,044, and 7351 observations were considered to analyze GL, BW, WW, and ACP. Genetic parameters were estimated by the Average Information Restricted Maximum Likelihood method in single and two-trait analyses. The average direct heritability estimates obtained in two-trait analyses were equal to 0.38 ± 0.03 (GL), 0.25 ± 0.02 (BW), 0.28 ± 0.02 (WW), and 0.11 ± 0.02 (ACP). The highest genetic correlation was found between BW and WW (0.36 ± 0.05), followed by BW and ACP (0.20 ± 0.09), and BW and GL (0.19 ± 0.06). Significant direct genetic trends ($P < 0.001$) were observed for GL, BW, and WW equal to -0.027 days per year, 0.073 kg per year, and 0.8456 kg per year, respectively. Greater emphasis should be given to accumulated productivity and gestation length traits in order to increase the number and weight of weaned calves. As accumulated productivity presents low heritability estimates, genetic improvement through selection could be slow in the Nellore breed. Our study reports genetic progress for weaning weight, since its genetic trend has increased over the years. Similar genetic trend for birth weight was observed, which may be a consequence of selection towards higher body weights at older ages.

1. Introduction

The Zebu cattle are responsible for the expansion of beef cattle industry in Brazil, due to both adaptability to the tropical climate and ability to endure a pasture regime (Millen et al., 2011). Referring to the production system, one of the main concerns is related to the reproductive efficiency of dams, which reflects the total number of calves born each year. In general, the *Bos indicus* heifers start to cycle and are bred at older ages (Millen et al., 2011; Diskin and Kenny, 2014). Thus, breeding programs are

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giving greater emphasis on selection for reproductive traits (Grossi et al., 2009; Buzanskas et al., 2013).

The gestation length (GL) is an important trait to be considered in beef cattle farms. As observed by Crews (2006) and Jamrozik and Miller (2014), calves from shorter GL present lower birth weight, which could result in less calving difficulty. These authors also highlighted the existence of positive genetic correlation between these traits. However, selection on GL would be difficult and using BW information could be a better approach to control calf weight. Generally, Zebu cattle present average for GL and birth weight (BW) of 292 days and 30 kg (Reynolds et al., 1980; Paschal et al., 1991) and are likely to have unassisted birth and low rate of mortality and dystocia.

Commonly considered as selection criteria in beef cattle, growth traits (expressed as body weight) are easily measured, highly correlated from birth until adult age, and respond well to selection due to moderate to high heritability estimates (Yokoo et al., 2007; Boligon et al., 2009; Zuin et al., 2012). The weaning weight (WW) is often used as a correlated trait in genetic evaluation programs and is used for decision-making on culling or selection (Guidolin et al., 2012). Indices that include growth and reproductive traits are also used to evaluate the efficiency of the dams (Mercadante et al., 2000), such as the accumulated productivity (ACP), which is an index that include body weight of the calf at weaning and number of offspring of the dam. Thus, ACP (expressed in kg of calf weaned per year) indicates the abilities of the female to calve at a young age, to maintain the regularity of calving, and to wean heavy calves (Grossi et al., 2008). Therefore, the aims of our study were to estimate variance and covariance components and genetic trends for GL, ACP, BW, and WW to provide support for the genetic evaluation program on Nellore beef cattle.

2. Material and methods

2.1. Animals and traits

The data used in this study was provided by the Nellore Genetic Improvement Program (Nelore Brazil), coordinated by the National Association of Breeders and Researchers (ANCP). Animals were raised in an extensive production system and kept on pastures with mineral supplementation. Weaning occurred at around 6 to 8 months of age. The reproductive management consisted of a breeding season lasting from 90 to 120 days, using artificial insemination or controlled natural breeding. The phenotypic measurements used for the GL trait were from calves data. Body weights were measured at birth and every three months up to at least 18 months of age.

For the ACP trait, an index was calculated by the following expression (Grossi et al., 2008):

$$\mathrm{ACP} = \frac{\mathrm{WW} \times n_c \times 365}{\mathrm{ADC}_n - 550} \quad (1)$$

where WW is the average body weight of weaned calves adjusted for 210 days of age, n_c is the total number of calves born per dam, and ADC_n is the age of the dam at last calving. The constant 365 corresponds to an annual production basis, and 550 refers to the first calving goal at 30 months, with a minimum breeding age of 18 months.

2.2. Contemporary groups and connectedness

The General Linear Model (GLM) procedure of the Statistical Analysis System software (SAS, 2002) was used to define the significant fixed effects ($P < 0.01$). These effects were used to form the contemporary groups (CG), which were included in the genetic parameters analyses. The CG for GL, BW, and WW was composed by the effects of sex of the animal (male or female), farm (22 levels), birth year (from 1998 to 2008), season of birth defined into two levels (from October 1 to March 31 and April 1 to September 30). The age of dam at calving (average of 84.42 ± 39.64 months) was statistically significant ($P < 0.01$) and was considered as a linear covariate for GL, BW, and WW. For ACP the CG was composed by the effects of farm, season of birth, and birth year of the cow (from 1996 to 2006). The assumptions of analysis of variance (normality distributed residual, homogeneity of variance, and independent observations) on each trait were investigated and observations with standardized residuals above 3.5 or below -3.5 were excluded. The final number of records is described in Table 1.

The connectedness between the CGs was verified by means of the program AMC (Roso and Schenkel, 2006) that considers the existence of genetic links attributed to sires and dams. Two contemporary groups were connected if a dam or sire had at least one progeny in each group. It was found that all CGs were connected. CGs presenting less than five records were excluded from data set.

2.3. Genetic parameters

Genetic parameters and standard errors were estimated using the Average Information Restricted Maximum Likelihood method (AIREML) under an animal model (single and two-trait analyses). The total number of animals in the relationship matrix was 182,161. Analyses were conducted using the software WOMBAT (Meyer, 2007) considering the convergence criterion of 10^{-9}. We have considered dams with more than one progeny to properly estimate permanent environmental and maternal genetic effects separately (Van Vleck, 1990) (Table 2).

Two-trait analysis of ACP and WW did not show convergence, which was attributed to the confounding

Table 1
Number (N) of animals, means (M), standard deviations (SD), minimum (Min) and maximum (Max) values, coefficient of variation (CV) for the analyzed data.

Trait	N	M	SD	Min	Max	CV %
GL (days)	25,085	296.60	5.90	273.00	314.00	1.90
BW (kg)	46,911	32.30	3.80	20.00	49.00	11.80
WW (kg)	50,044	185.00	29.20	80.00	317.00	15.80
ACP[a]	7351	144.80	28.20	45.00	253.00	19.50

GL = gestation length, BW = birth weight, WW = weaning weight, ACP = accumulated productivity.
[a] kg of calf weaned/year.