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Effect of inbreeding on growth and reproductive traits of Nellore cattle in Brazil

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ABSTRACT

The objective of this study was to identify and quantify the influence of *F* (inbreeding coefficient) on weaning weight (WW), weight gain from weaning to 18 months of age (WG345), finishing visual score (precocity) at 18 months of age, muscling visual score at 18 months of age (MUS), hip height (HH), scrotal circumference at 18 months of age (SC), heifer probability of pregnancy at 14 months of age (PP14), and stayability (STAY) in Brazilian Nellore cattle. The complete pedigree included 417,552 animals born between 1984 and 2007 on 12 farms located in the states of Mato Grosso do Sul, São Paulo and Bahia. Following the observation of a statistically significant effect ($P<0.05$) of the covariates individual inbreeding coefficient (*F*) and maternal inbreeding coefficient, regression analysis of each trait, adjusted for all other effects, was performed as a function of the linear and quadratic effect of *F* and maternal *F* (when significant). Inbreeding negatively affected all traits studied ($P<0.05$), except for muscling. A quadratic effect of individual *F* on WW, WG345, HH and PP14, and a quadratic effect of maternal *F* on WG345 and HH were observed. Levels of inbreeding higher than 7–11% affected negatively growth and reproductive performance of Nellore cattle. Therefore, inbreeding should be avoided, except for purposes of genetic breeding whose main objective is the fixation of certain alleles in the population.

1. Introduction

Inbreeding is the mating of individuals more closely related to each other than the average relationship in the population (Lush, 1945). As a consequence, there is increased homozygosity, which may also increase the frequency of deleterious recessive genes. Inbreeding depression, a term proposed by Dickerson (1963), is the result of this whole process and is characterized by a decrease in the average phenotypic performance of animals.

Some hypotheses have been developed to explain the unfavorable influence of inbreeding on the mean phenotypic values of traits. According to Crow and Kimura (1970), the heterozygote generally presents a higher phenotypic value than the homozygote. In contrast, Lush (1945) suggested that favorable genes tend to be dominant or partially dominant. On the basis of these two hypotheses, inbreeding depression can be defined as a linear function of the inbreeding coefficient. However, according to Lynch and Walsh (1998), if epistatic interactions are considered as a mechanism to explain the genetic basis of inbreeding depression, the decline in the phenotypic mean can be defined as a nonlinear function of the inbreeding coefficient.

Several studies on beef cattle have demonstrated an unfavorable effect of inbreeding of the animal on economically important traits (Dinkel et al., 1968; Burrow, 1993, 1998; Mc Parland et al., 2007a, 2008), but few investigations have been conducted studying animals under tropical conditions. Keller and Brinks (1978) concluded that the deleterious effects of

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inbreeding might be more marked in stressful environments. According to Burrow (1998), in these environments, the immune system might be less effective due to inbreeding and the magnitude of the effects of inbreeding may increase because of reduced resistance to stressful factors that affect reproduction, growth, carcass, and meat quality.

Inbreeding has been investigated in studies on beef cattle using basically two experimental designs: 1) use of regression analysis in which the inbreeding coefficient is modeled as a covariate in models including other genetic and environmental effects, and 2) comparison of the performance of inbred and non-inbred populations. One variation of these two approaches is to model inbreeding as a fixed effect, with inbreeding being divided into discrete classes (Queiroz et al., 2000). For traits influenced by maternal effects, both individual and maternal inbreeding coefficients are expected to have a damaging effect on animal performance and both should therefore be considered when evaluating the impact of inbreeding (Carolino and Gama, 2008).

Modern animal breeding programs, which are characterized by the accurate estimation of breeding values and the use of advanced reproduction techniques, lead to rapid genetic progress but increase inbreeding through the strong impact of few individuals or families selected (Weigel, 2001). This fact has been a matter of concern for researchers worldwide, who attempt to determine and overcome the damaging effect of inbreeding on animal performance (Queiroz et al., 2000; Falcão et al., 2001; González-Recio et al., 2007; Goméz et al., 2008).

Brazil has a cattle herd estimated at 190 million head (about 80% are Nellore or crossbred Nellore) in continuous growth and has made advances in the productivity rates. The cattle-cut represents the largest share of Brazilian agribusiness, generating revenue of more than $ 50 billion per year, offering about 7.5 million jobs (ABIEC, 2010). Thus, the objective of the present study was to identify and quantify the influence of inbreeding on eight economically relevant traits in Brazilian Nellore cattle.

2. Materials and methods

The data used in this study were obtained from the Genetic Breeding Program of Agro-Pecuária CFM Ltda. These data have been stored and analyzed by the Animal Breeding and Biotechnology Group, Faculdade de Zootecnia e Engenharia de Alimentos (FZEA/USP), Pirassununga, State of São Paulo, Brasil, since 1994.

The complete pedigree, up to the sixth generation, included 417,552 animals born between 1984 and 2007 on 12 farms located in the states of Mato Grosso do Sul, São Paulo and Bahia. These farms belong to the same company and the basic procedures of data collection and storage were standardized. The animals were kept on pasture without supplementation, except for minerals plus salt, until 18 months of age. The breeding season ranged from November to January for cows and from October to January for heifers. Artificial insemination and natural mating in groups containing single or multiple sires were used. Sons of multiple sire groups were classified as sons of unknown sire, since paternity could not be established with precision. The following traits were analyzed: weaning weight (WW), weight gain from weaning to 18 months of age (WG345), precocity at 18 months of age, muscling at 18 months of age, hip height (HH), scrotal circumference at 18 months of age (SC), probability of pregnancy at 14 months of age (PP14), and stayability (Table 1). WW was measured at about 180 days of age. Precocity is a measure of the ability of the individual to store fat reserves and is used to identify animals that will deposit finishing fat earlier. This variable was obtained by attributing visual scores from 1 to 6, with a score of 6 indicating animals with greater fat reserves. Muscling takes into account the muscle mass of the animal and is one of the visual variables receiving attention from various breeders who aim to select animals adequate for the standards requested by the meat industry. This variable was also measured by attributing scores from 1 to 6, with animals with more muscle mass receiving a score of 6. HH was measured at the time of weighing of the animals using a metric tape placed inside the scale and corresponds to the distance (in cm) from the ground to hip. SC was measured transversely in the region of the major diameter of the scrotum with a metal metric tape. PP14 was defined as the probability of a heifer being pregnant at a mean age of 14 months (12 to 16 months), with pregnancy being diagnosed by rectal palpation 90 days after the end of the breeding season (Evans et al., 1999; Eler et al., 2004, 2006). When pregnancy was confirmed, heifers received a value of one (success), whereas those diagnosed as empty received a value of zero (failure). Stayability was defined as the probability of a cow to be present in the herd at a specific age, given the opportunity to reach that age (Hudson and Van Vleck, 1981; Silva et al., 2006; Van Melis et al., 2007). If the cow remained in the herd until 6 years of age or more, it received a value of one (success); otherwise, a value of zero was attributed (failure). All records exceeding 3.5 standard deviations above or below the mean were excluded.

The inbreeding coefficient (*F*) was calculated as proposed by Meuwissen and Luo (1992) using the Poprep program (Groeneveld et al., 2009). The average relatedness (AR) was obtained by Endog program (Gutiérrez and Goyache, 2005). Pearson's correlation between the inbreeding coefficient of the individual and its respective mother was calculated using the CORR procedure of the SAS program (SAS Institute, Inc., Cary, NC) to evaluate the correct separation of the direct and maternal effects of inbreeding.

Statistical analysis was carried out to determine the significance of fixed effects on the traits studied and to perform the appropriate adjustments. The GLM and GENMOD procedures of the SAS program (2003) were used.

Table 1
Number of observations (*N*), mean ($\overline{X}$), standard deviation (SD), and coefficient of variation (CV) of the traits studied.

Trait [a]	*N*	$\overline{X}$	SD	CV
WW (kg)	416,018	170.68	28.07	16.44
WG345 (kg)	128,607	112.46	33.03	29.37
Precocity (1 to 6)	114,724	3.66	0.93	25.59
Muscling (1 to 6)	118,830	3.57	0.94	26.49
HH (cm)	97,615	135.25	6.93	5.13
SC (cm)	58,388	27.14	3.38	12.46
PP14 (1 or 0)	28,737	0.16	0.36	228.24
Stayability (1 or 0)	91,776	0.29	0.45	156.84

[a] WW = weaning weight, WG345 = weight gain from weaning to 18 months of age, HH = hip height, SC = scrotal circumference, PP14 = probability of pregnancy at 14 months of age.