Genotype-environment interaction for growth and reproductive traits in Nellore cattle, using reaction norms†

H. L. J. Chiaia**, M. V. A. de Lemos*, G. C. Venturini*, C. Aboujaoude*, R. Carvalheiro*, L. G. de Albuquerque*, H.N. de Oliveira*, F. Baldi

*Universidade Estadual Paulista "Júlio de Mesquita Filho"- UNESP, Faculdade de Ciências Agrárias e Veterinárias, Jaboticabal, Brazil

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ABSTRACT: The aim of this study was to verify the importance of genotype-environment interaction (GEI) for age at first calving (AFC), scrotal circumference (SC) and yearling weight (YW) in Nellore cattle, using reaction norms in multi-trait random regression models and analyze the efficiency of selection for AFC based on SC and YW in different environments. The research was conducted using 28,871, 41,386 and 89,152 records for AFC, SC and YW, respectively. Environmental groups (EGs) were defined based on farm and year of birth and management group (at birth, weaning and yearling) for all traits. For YW sex of animal was added to EGs. Average post-weaning weight gain was used to assess environmental conditions. Models for SC and YW included contemporary group and the covariate, age of animal at evaluation, as fixed effects, and the residual and direct additive genetic effects as random effects. The same model was used for AFC, excluding age of animal effects. The (co)variance components were estimated using Wombat software. The additive genetic and phenotypic variances estimates for AFC, SC and YW increased as the environmental conditions improved, with a greater intensity for AFC. The heritability estimates for all traits increased as the environment became more favorable and ranged from low to medium for AFC (0.04 to 0.48), high for SC (0.51 to 0.67) and medium to high for YW (0.23 to 0.76). The genetic correlation estimates between AFC and SC, AFC and YW, YW and SC in different environments, ranged from -0.15 to -0.68, -0.18 to -0.35, -0.1 to +0.68, respectively. The efficiency of indirect selection for AFC using YW and SC ranged from 4 to 395 and from 12 to 333, respectively. There is an important GEI effect for AFC, SC and YW traits, so the expected genetic gain for these traits depend on the environment in which the animals are exploited. The SC and YW traits can be used as a selection criterion for sexual precocity in unfavorable environments.

Keywords: Age at first calving, Genetic correlation, Nellore, Scrotal circumference, Yearling weight

Introduction

In Brazil, most of the cattle breeding programs have given priority to growth trait selection, such as yearling weight and scrotal circumference. Selection for higher weight, particularly YW, can affect other genetically correlated traits. Various researchers (Boligon et al. (2007); Regatieri et al. (2012); Yokoo et al. (2012)) have studied the genetic correlations between age at first calving (AFC), scrotal circumference (SC) and yearling weight (YW), assuming only one environment, without considering the possible effect of genotype-environment interaction (GEI).

There are few studies that consider the effect of GEI on genetic correlation between these traits. In order to develop strategies to maximize genetic gain, the importance of GEI for genetic correlations between traits in different environments has to be considered. The aim of this study was to verify the occurrence of GEI for AFC, SC and YW in Nellore cattle, using reaction norms in multi-trait random regression models and analyze the efficiency of selection for age at first calving based on scrotal circumference and yearling weight in different environments.

Material and Methods

Data. This study was conducted with 28,871 (AFC), 41,386 (SC) and 89,152 (YW, considering both sex) Nellore cattle phenotypic records. Data were collected on properties located in the North (Tocantins - TO), Northeast (Bahia – BA), Midwest (Goiás – GO, Mato Grosso – MT and Mato Grosso do Sul – MS) and Southeast (São Paulo – SP) of Brazil, belonging to the Genetic Improvement Program of Conexão Delta G®. The animals were born between the years 1984 and 2010.

Environmental groups. Environmental groups (EGs) were defined based on farm and year of birth and management group (at birth, weaning and yearling). For YW sex was added to the EGs definition. Post-weaning weight gain was used as a criterion to evaluate the environmental conditions. After estimate the effect of environmental groups (EGs), the mean effect of EG was standardized to a mean of zero and an standard deviation of one. The standardized values were then multiplied by 10 and the EG were obtained by considering only the integer part of those values. The integer format is a convenience for subsequent software analyses. The EGs with means for post-weaning weight gain above +2.5 were considered EG=+2.5 (upper limit) and EGs below -2.5 were considered EG =-2.5 (lower limit). The standardized EGs underwent an iterative process as described by Calus et al. (2004) to correct the bias of the EG estimates caused by the non-random use of sires or by the small number of animals in some herds.

Model. Models for SC and YW included contemporary group and the covariate, age of animal at evaluation, as fixed effects, and the residual and direct additive genetic effects as random effects. The same model was used for AFC, excluding age of animal effects. Linear Legendre polynomials of EGs were used to model the additive genetic effects and the average population trend. The residual variance for each trait was considered homogeneous. The (co)variances components were estimated by the restricted maximum likelihood method, using the WOMBAT computer program developed by Meyer (2006). A three-trait analysis was performed using a random regression model involving AFC, SC and YW. The pedigree file included 156,212 animals in the relationship matrix. There were 106,301 animals with records, 268 sires and 19,056 dams.

Estimation of selection efficiency. The efficiency of indirect selection (G) for AFC, in terms of genetic gain from selecting a genetically correlated trait (YW and SC) was estimated for environments with high environmental restrictions (EG: -2.0), moderate environmental restrictions (EG: 0.0) and low environmental restrictions (EG: +2.0). To estimate the selection efficiency for AFC, it was considered the same selection intensity and generation interval for all the traits.

Results and Discussion

The additive genetic and phenotypic variance estimates for AFC, SC and YW increased with environmental improvement, mainly for AFC. Heritability estimates showed the same trend as the genetic variances and ranged from low to medium magnitude for AFC (0.04 to 0.48), high for SC (0.51 to 0.67) and medium to high for YW (0.23 to 0.76) (Figure 1). In contrast with this result, Pegolo et al. (2009) reported superior estimates of heritability for weight at 450 days in extreme environments and lower in intermediate environments. Genetic correlations between AFC and SC in different environments ranged from -0.15 to -0.68. In the less favorable environment for both traits, the genetic correlation estimates was moderate and favorable (-0.68), decreasing with the improvement of AFC environmental conditions. The genetic correlation estimates between AFC and SC decreased as the environment for these traits became more favorable (Figure 2). Similar results in terms of low and negative estimates (-0.10, -0.23) were reported by Gressler et al. (2000); Boligon et al. (2007) respectively. The genetic correlations between AFC and YW in different environments were low and negative, ranging from -0.18 to -0.35 (Figure 3). As the environment became more favorable for YW and less favorable for AFC, the genetic correlations presented low ranges, from -0.18 to -0.12, reaching -0.20 in intermediate environments. The selection of sires for higher SC or YW, may result in a favorable correlated response in AFC. It is expected that the reduction in AFC should be higher at environments with high environmental restrictions. The genetic correlation estimates between SC and YW varied from low to high (-0.10 to 0.68), and decreased as the environment became more favorable for YW and less favorable for SC (Figure 4).

Table 1 shows the efficiency of indirect selection for AFC, using YW or SC as selection criterion, considering different environments. The efficiency of indirect selection for AFC using YW in the same environment was unfavorable and direct selection for AFC was more advantageous in this case; indirect selection for AFC being an advantage only in cases where environments are more favorable for YW and less favorable for AFC. Indirect selection for AFC by SC in the same environment was acceptable only in cases of less favorable environments and when considering different environments, indirect selection for AFC was an advantage when the environment was more favorable for SC and less favorable for AFC.

Table 1. The efficiency of indirect selection (G) for AFC, expressed as percentage, using YW and SC in different environments.

Trait	G for AFC, %			
	EG	-2	0	2
YW	-2	69	15	4
	0	164	35	10
	2	395	85	24
SC	-2	189	41	12
	0	220	47	14
	2	333	72	20

AFC: age at first calving; SC: scrotal circumference; YW: yearling weight; EG: enviromental group.

Based on these results, in order to genetically improve growth and sexual precocity traits, should take account the difference between environments where the animals are selected and bred. Models that include GEI should be considered in animal breeding programs in order to maximize the correlated response for target traits. Improving female's sexual precocity by selecting for greater SC will be more effective in adverse environmental and management conditions.

Conclusion

There is an important GEI effect for AFC, SC and YW traits, so the expected genetic gain for these traits depend on the environment in which the animals are raised. The SC and YW traits can be used as a selection criterion for sexual precocity in unfavorable environments for AFC.

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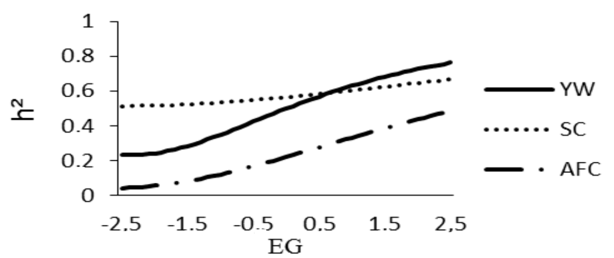

Figure 1: Heritability estimates (h^2) for age at first calving (AFC), scrotal circumference (SC) and yearling weight (YW) according to the environmental group (EG).

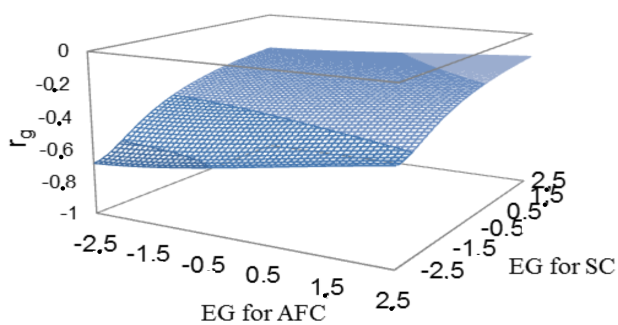

Figure 2: Estimates of genetic correlation (rg) between age at first calving and scrotal circumference in different environmental groups (EG).

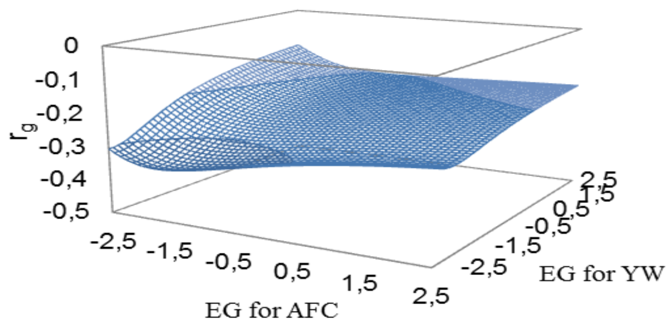

Figure 3: Estimates of genetic correlation (r_g) between age at first calving and yearling weight in different environmental groups (EG).

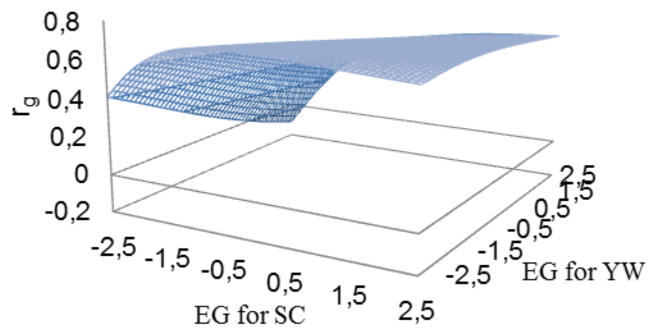

Figure 4: Estimates of genetic correlation (r_g) between scrotal circumference and yearling weight in different environmental groups (EG).