

Genetic parameters and environmental effects on temperament score and reproductive traits of Nelore cattle

D. Barrozo^{1,2}, M. E. Buzanskas³, J. A. Oliveira³, D. P. Munari³, H. H. R. Neves² and S. A. Queiroz^{2†}

¹Secretaria da Agricultura e Abastecimento, CODEAGRO, Caixa Postal 14, 14870-970, Jaboticabal, São Paulo, Brazil; ²Departamento de Zootecnia, FCAV/UNESP, Via de acesso Prof. Paulo Castelane, s/n, 14884-900, Jaboticabal, São Paulo, Brazil; ³Departamento de Ciências Exatas, FCAV/UNESP, Jaboticabal, São Paulo, Brazil

(Received 22 December 2010; Accepted 9 May 2011; First published online 1 August 2011)

Animal temperament is a trait of economic relevance and its use as a selection criterion requires the identification of environmental factors that influence this trait, as well as the estimation of its genetic variability and interrelationship with other traits. The objectives of this study were to evaluate the effect of the covariates dam age at calving (ADC), long yearling age (YA) and long yearling weight (YW) on temperament score (T) and to estimate genetic parameters for T, scrotal circumference (SC) at long YA and age at first calving (AFC) in Nelore cattle participating in a selection program. The traits were analyzed by the restricted maximum likelihood method under a multiple-trait animal model. For all traits, contemporary group was included as a fixed effect and additive genetic and residual as random effects. In addition to these effects, YA, YW and ADC were considered for analyzing T. In the case of SC and AFC, the effect of long YW was included as a covariate. Genetic parameters were estimated for and between traits. The three covariates significantly influenced T. The heritability estimates for T, SC and AFC were 0.18 ± 0.02 , 0.53 ± 0.04 and 0.23 ± 0.08 , respectively. The genetic correlations between T and SC, and T and AFC were -0.07 ± 0.17 and -0.06 ± 0.19 , respectively. The genetic correlation estimated between SC and AFC was -0.57 ± 0.16 . In conclusion, a response to selection for T, SC and AFC is expected and selection for T does not imply correlated responses with the other traits.

Keywords: age at first calving, scrotal circumference, long yearling age, long yearling weight

Implications

Animal temperament is a trait that exerts a marked influence on the beef cattle production system in Brazil because the management applied on the farms has direct repercussions on the profitability of rural enterprises, implying less labor and a reduction in work accidents, with consequent benefits for the animals and people involved. Therefore, temperament has been the focus of studies aiming at its inclusion in genetic breeding programs. For a trait included in the breeding objective, it is necessary to identify environmental factors that influence this trait for the correct modeling of its genetic effects and prediction of expected progeny differences. In addition, the study of genetic correlations between temperament and the reproductive traits may contribute to the selection process of animals.

Introduction

Temperament can be defined as the intensity at which the animal reacts to humans or the situations created by them (Spironelli and Paranhos da Costa, 2008).

There are several ways to measure temperament. In cattle, the majority of research on temperament explored the responses to a novel testing arena, a novel object or to the human presence or handling (Phocas *et al.*, 2006). According to Burrow (1997), the definition of temperament in cattle breeding and genetics has been restricted to the behavioral response of the animal handling by humans.

Burrow (2001) used the flight speed score of animals to measure temperament. This score refers to the time taken (s) for an animal to cover 1.7 m after leaving a weighting crush. The aggressiveness score (AG) used by Phocas *et al.* (2006) indicates whether the animal threatened the handler in order to measure temperament in heifers. They also defined a docility score (DO) combining several ways of measuring the

[†] E-mail: saquei@fcav.unesp.br

behavioral response of the animal to the handler in a linear equation to analyze temperament.

As this trait directly affects the enterprise's profitability and the well-being of the animals, alternatives that facilitate handling on the farms are investigated in order to minimize the stress on humans and animals and to reduce hematomas on animals during transport to the abattoir (Silveira *et al.*, 2006).

One alternative would be the inclusion of animal temperament in the breeding objective, with genetic evaluations being corrected for environmental factors. These factors could be divided into two groups: classificatory effects, such as contemporary group, and effects generally used as covariates, such as age of dam at calving (ADC), long yearling age (YA) and long yearling weight (YW) of the animal (Cardoso *et al.*, 2004).

The reproductive traits are always important for all production systems and should be part of the breeding objective, despite them generally presenting small heritability values. Scrotal circumference (SC) is an indicative trait of reproduction potential in males because size of the testes is related to sperm production, semen quality and production of sexual hormones (Baker *et al.*, 1981; Trocóniz *et al.*, 1991). SC is easily measured at young ages (e.g. at weaning, 365 days of age and long yearling). This trait has been used as a selection criterion in programs designed to improve the productive and reproductive efficiency of beef cattle herds. For females, the trait most commonly used for measuring sexual precocity is age at first calving (AFC). According to Martin *et al.* (1992), the reproductive performance of heifers depends on the age at which they calve for the first time, with heifers calving earlier having a longer productive life than those calving later. Selection for sexual precocity has been applied directly to AFC and also indirectly, using SC as an indicator trait because SC usually presents a favorable genetic correlation with AFC and shows higher heritability estimates than AFC.

The objectives of this study were to evaluate the effects of the covariates ADC, YA and YW on temperament score and to estimate genetic parameters for temperament, SC and AFC in Nelore cattle participating in a breeding program to infer the usefulness of these traits as selection criteria.

Material and methods

Animals and data

Data from Nelore cattle participating in the PAINT[®], the commercial breeding program of the Brazilian company CRV Lagoa Ltda. (Sertãozinho, São Paulo, Brazil) were used. This company includes productive and reproductive traits and visual scores in its selection index. Records on Nelore cattle calved from 1994 to 2007 belonging to 173 herds located in the Southeast and West central regions of Brazil (tropical climate) were used in this research. The animals were raised in a production system based on pasture and mineral salt during the whole year. Heifers and cows were bred using

artificial insemination sires, and in a second step, unless they had conceived, they were mated to sires in natural services. The breeding season occurred in the rainy season from December to February and the calves were weaned during the dry season (May to July).

Description of the studied traits

SC was measured at long YA (500 days) with a metric tape at the widest point of the scrotum and comprised the two testes and scrotal skin. AFC were obtained from the regular records in the data file. For temperament score (T), the animals received grades ranging from 1 to 4 according to their reaction to the individual in the presence of the examiner (CRV Lagoa. Sumário Consolidado PAINT, 2009). The grades were attributed after weight recording of the animal at long YA. The animal was released into the corral and the examiner attributed the grade according to the following criteria:

1. The animal is very gentle, quiet and easy to handle, is not bothered by the environment of the corral or human presence, does not look for escape and moves slowly and quietly.
2. The animal is not bothered by the environment of the corral or human presence, does not look for escape and moves with agility without presenting sudden movements. The animal is aware of the environment and what occurs around it, but shows no aggression.
3. The animal is agitated, bothered with the environment of the corral and human presence and looks for escape but does not try to break or jump over the fence of the corral. The animal moves with agility, presents sudden movements and is aware of the environment and what occurs around it, but shows no aggression.
4. The animal is aggressive, is bothered with the environment of the corral and human presence and presents agile and sudden movements. The animal is aware of the environment and what occurs around it, tries to break and rupture the fence of the corral.

Data editing and contemporary groups

Statistical analysis using the SAS[®] 9.1 program (SAS Institute Inc., Cary, NC, USA) was conducted through the GLM procedure. Outlier data, records of animals without information for the traits studied, animals with unknown parents or progeny of sires with fewer than five progenies and contemporary groups with fewer than five animals were removed. The contemporary groups were the same for all traits and consisted of the combination of farm, year and birth season (spring, summer, autumn and winter), sex, management group at birth, farm and management group at weaning and farm and management group at long YA.

Covariate analysis

After absorption of the contemporary group effect using the ABSORB tool of the GLM procedure (SAS 9.1, SAS Institute Inc.), regression analyses were performed to determine the significance of the models containing the covariates ADC, YA

and YW. For definition of the models, the data were analyzed in order to determine the influence of each covariate on T. First, the following model was considered:

$$T = b_1 \times Z_j + b_2 \times Z_j^2 + b_3 \times Z_j^3 + e$$

where T is the predicted score for temperament; b_1 , b_2 and b_3 are linear, quadratic and cubic regression coefficients, respectively; Z is the effect of the j th covariate on T , where $j = \text{ADC}$, YA and YW ; and e is the vector of residual effects. The degree (linear, quadratic and cubic) of the covariates was defined by the coefficient of determination (R^2) and the level of significance. These criteria were used to choose the best models for each covariate.

Statistical analyses and models

(Co)variance components and genetic parameters for T, SC and AFC were estimated by restricted maximum likelihood (REML) methodology using a derivative-free algorithm, in a multiple-trait animal model. For all traits, direct genetic additive and residual effects were considered as random effects. Contemporary group was included in the model as a fixed effect. The environmental effects that significantly influenced T (ADC, YA and YW) were included as covariates for this trait. In the case of SC and AFC, the effect of YW (linear and quadratic) was included as covariate.

In matrix notation, the multiple-trait animal model can be represented as:

$$y = Xb + Zu + e,$$

where y = vector of observations; b = vector of fixed effects; u = vector of direct additive genetic effects; and e = vector of random residual effects. X and Z are incidence matrices relating b and u to y , respectively. It was assumed that $E[y] = Xb$, $\text{Var}(u) = G \otimes A$ and $\text{Var}(e) = I \otimes R$, where G is the matrix of direct additive genetic covariances between traits; A is the numerator relationship matrix, obtained with pedigree information on 70 488 animals; R is a residual covariance matrix such that the environmental covariance between SC and AFC (measured on different sexes) was assumed to be 0; I is an identity matrix (of appropriate order); and \otimes is the Kronecker product.

The model above was fitted using the multiple-trait derivative free REML programs (Boldman *et al.*, 1995). In multiple-trait analyses with this software, the s.e. of genetic parameters are reported only when all traits were measured on animals with records, which is not the case in this study. Hence, the approach proposed by Kachman and Van Vleck (2007) was used to obtain estimates of s.e. Three cold restarts using different starting values were run to ensure that a global maximum of the log likelihood function was found. Convergence was assumed when the variance of simplex function was $<10^{-9}$.

Results

The results of descriptive statistics of the traits studied and the variables used as covariate effects for temperament

Table 1 Descriptive statistics of T, SC, AFC, long YA, long YW and ADC in Nellore cattle

Trait	<i>n</i>	Mean	s.d.	CV (%)	Minimum	Maximum
T	37 692	1.92	0.79	41.15	1	4
SC (cm)	18 891	23.77	3.13	13.17	13.60	38.76
AFC (days)	1402	1053.96	131.44	12.47	721	1639
YA (days)	37 692	507.20	49.44	9.75	334	714
YW (kg)	37 692	247.38	39.37	15.91	104.99	508.16
ADC (years)	37 692	6.21	3.08	49.59	2	20

T = temperament score; SC = scrotal circumference; AFC = age at first calving; YA = long yearling age; YW = long yearling weight; ADC = age of dam at calving; n = number of observations.

Table 2 Summary of regression analysis for T in Nellore cattle using models including ADC, YA and YW as covariates

Source of variation	d.f.	Solution (b)	m.s.
ADC (linear)	1	0.0053008534* ± 0.00212912	
Model ADC	2338		5.946**
Residual	46 441		1.13178
R^2	0.21		
YA (linear)	1	-0.0755856467* ± 0.03003087	
YA (quadratic)	1	0.0001448329* ± 0.00005898	
YA (cubic)	1	-0.0000000943* ± 0.00000004	
Model YA	2330		5.960**
Residual	46 214		1.13308
R^2	0.21		
YW (linear)	1	-0.0067691183** ± 0.00020026	
Model YW	2338		6.417**
Residual	45 939		1.10525
R^2	0.23		

T = temperament score; ADC = age of dam at calving; YA = long yearling age; YW = long yearling weight.

* $P < 0.05$; ** $P < 0.01$.

are shown in Table 1. A decline in the number of animals per trait can be observed, with increasing age of measurement. Regression analysis for T considering the models that include ADC (linear effect), YA (linear, quadratic and cubic effect) and YW (linear effect) as covariates indicated that these covariates significantly influenced ($P < 0.05$) T (Table 2).

The trend in T for each effect (ADC, YA and YW) obtained with the models studied is shown in Figure 1. T decreased as YA and YW increased, whereas they increased as age of the dam at calving increased. The values for T showed on y axis (Figure 1a and c) were smaller than those in the original scale because of the small regression coefficient estimates (b ; Table 2) used to predict the curves presented in Figure 1. The small values estimated for the regression coefficients were due to the absorption of contemporary group effect in the statistical analyses.

The estimates of (co)variance components and genetic parameters for T, SC and AFC obtained by multiple-trait analysis are shown in Table 3. They ranged from 0.18 ± 0.02 for T to 0.53 ± 0.04 for SC.

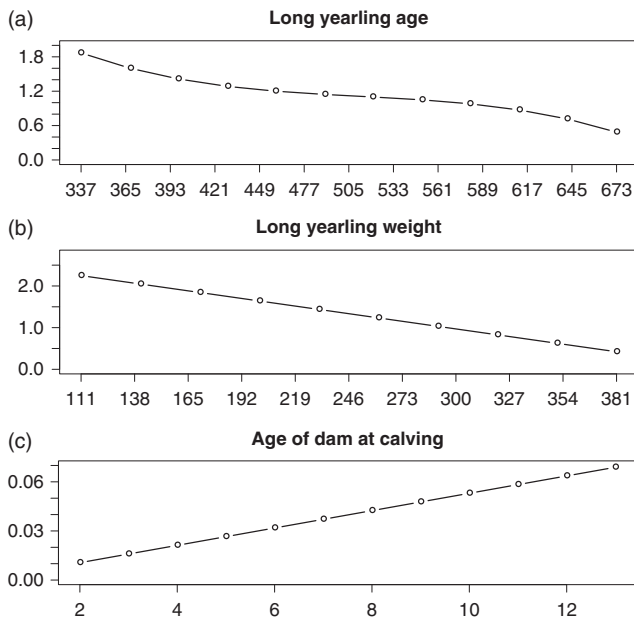


Figure 1 Trend in temperament score of Nelore cattle corrected for the effect of contemporary group according to long yearling age of the animal in days (a), long yearling weight in kg (b) and age of dam at calving in years (c).

Discussion

The decrease in the number of animals for AFC (Table 1) might be explained by the fact that, because T is a trait recently introduced in genetic evaluations, the number of cows with information for T and AFC was still small. The CV estimated for the traits studied were of low magnitude, except for T (41.15%) and ADC (49.59%), whereas the CV for AFC (12.47%) was close to the reported value by Boligon *et al.* (2007) for Nelore cattle (10.13%). The low CV values for SC and YA could be due to the short calving season. ADC presented a high range (18 years) showing the long productive life of Nelore cows.

All models used for the analysis of T, even when significant ($P < 0.01$), presented R^2 of low magnitude (~ 0.22), suggesting poor goodness-of-fit of the regression equations (Table 2). Nevertheless, T tended to increase with increasing ADC (Figure 1c). For YA and YW, changes in T were observed with increasing age and weight. Older and heavier animals tend to present less stressed and gentler behavior because they are more accustomed to human handling and spend more time on feeding and less time in vigilance. This tendency was also observed by Voisin *et al.* (1997) and Gauly *et al.* (2001), who suggested a higher productive performance for animals with a better temperament.

The heritability estimates for T of 0.18 ± 0.02 (Table 3) was similar to those reported by Mishra *et al.* (1975), Mourão *et al.* (1998) and Phocas *et al.* (2006), but were lower than those observed by Burrow (2001) for animals of tropical breeds (0.40 to 0.44). Nevertheless, the magnitude of the estimate obtained in this study, together with the low magnitude of its respective standard error, which confers

Table 3 (Co)variance components and genetic and environmental parameters for T, SC and AFC of Nelore cattle obtained in multiple-trait analysis

	Variance components and heritability estimates		
	T	SC	AFC
σ_a^2	0.09	2.26	2194.95
σ_e^2	0.42	2.58	7189.29
h^2	0.18 (0.02)	0.53 (0.04)	0.23 (0.08)
Covariance and genetic and environmental correlations			
	T, SC	T, AFC	SC, AFC
Cov_a	-0.03	-0.90	-42.81
Cov_e	-0.01	2.51	0.00
r_a	-0.07 (0.07)	-0.06 (0.19)	-0.57 (0.16)
r_e	-0.02 (0.03)	0.05 (0.05)	0.00 (0.00)*

T = temperament score; SC = scrotal circumference; AFC = age at first calving; σ_a^2 = additive genetic variance; σ_e^2 = environmental variance; h^2 = heritability estimates; Cov_a = additive genetic covariance; Cov_e = environmental covariance; r_a = genetic correlation; r_e = environmental correlation.

*SC and AFC are measured on different sexes, the covariance was set to 0. Standard errors are given within parentheses.

reliability, suggests that temperament presents sufficient additive genetic variability in the Nelore breed to respond to selection. However, genetic progress is expected to be slow because of the small magnitude of the estimated parameter.

The heritability for SC of 0.53 ± 0.04 (Table 3) was higher than those reported by Gressler *et al.* (2000), Grossi *et al.* (2008) and Frizzas *et al.* (2009), who found estimates of 0.31, 0.46 and 0.42, respectively, for Nelore cattle at long YA. The heritability estimate for AFC (0.23 ± 0.08) was higher than those reported by Boligon *et al.* (2007) and Grossi *et al.* (2008) for Nelore cattle (0.14 in both studies). On the basis of these heritability estimates, we can expect that the response to selection for sexual precocity using SC of Nelore animals participating in this breeding program would be much higher and faster than the response to the other traits. AFC presented heritability estimates of moderate magnitude and the genetic correlation estimate between SC and AFC (-0.57 ± 0.16) shows an antagonist and moderate relationship between them. AFC and SC, as an indirect selection criterion, should be included in the breeding objective aiming at improving conception rates in beef cattle herds.

The genetic and phenotypic correlations obtained from this study (Table 3) between T and SC and AFC were very weak, suggesting a mild antagonism between this trait and SC and AFC. Therefore, selection applied to T will practically not lead to correlated changes in the other traits. On the other hand, a favorable and moderate genetic correlation (-0.57) was estimated between SC and AFC indicating that SC could be used as an indirect criterion for sexual precocity of Nelore heifers and also as a direct criterion for increasing fertility of bulls.

We found no studies in the literature estimating genetic correlations between T and reproductive traits. Nevertheless, Burrow (2001) measuring temperament as fight speed,

reported that genetic correlation estimates among temperament and SC and pregnancy and days to calving equal to 0.11, 0 and 0.15, respectively. Phocas *et al.* (2006) estimated genetic correlation between AG and DO of -0.97 and among DO and fertility and age at puberty and calving ease equal to 0.55, -0.32 and 0.13, respectively. The authors reported that estimates for genetic correlation among AG and fertility and age at puberty and calving ease equal to -0.44 , 0.19 and -0.25 , respectively.

The results found in this study show all studied traits could be included in the breeding objective of the Nelore cattle in order to improve the reproductive performance and to facilitate the handling of animals. Despite this, further studies on T using a threshold model and/or other approaches are needed to consider the discontinuous variation of this trait.

Conclusion

The covariates YA, YW and ADC should be included in the temperament model. T, SC and AFC should present genetic gain under selection, with this gain being more expressive for SC, an indirect criterion for sexual precocity of Nelore heifers. Few shared genes act on the determination of T and the reproductive traits SC and AFC.

Acknowledgements

The authors are thankful to the PAINT[®] breeding program (CRV Lagoa Ltda.) for providing the data used in this study. DB thanks CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior/Programa de Pós-Graduação em Genética e Melhoramento Animal – FCAV/UNESP) for his fellowship. HHRN was supported by a FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) fellowship. MEB, JAO and SAQ were supported by a CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) fellowship.

References

Baker JH, Kroo JR, Turman EJ and Buchanan DS 1981. A comparison of different breeds for growth rates, performance traits and scrotal circumference in young beef bulls. *Animal Science Research Report*, Blacksburg, Stillwater, 15–18.

Boldman KG, Kriese LA, Van Vleck LD and Kachman SD 1995. A manual for use of MTDFREML. A set of programs to obtain estimates of variance and covariance. SDA-ARS, Clay Center, NE, USA.

Boligon AA, Rorato PRN and Albuquerque LG 2007. Correlações genéticas entre medidas de perímetro escrotal e características produtivas e reprodutivas de fêmeas da raça Nelore. *Revista Brasileira de Zootecnia* 36, 565–571.

Burrow HM 1997. Measurements of temperament and their relationship with performance traits in beef cattle. *Animal Breeding Abstracts* 65, 477–495.

Burrow HM 2001. Variances and covariances between productive and adaptive traits and temperament in composite breed of tropical beef cattle. *Livestock Production Science* 70, 213–233.

Cardoso FF, Cardellino RA and Campos LT 2004. Componentes de (co)variância e parâmetros genéticos de características pós-desmama em bovinos da raça Angus. *Revista Brasileira de Zootecnia* 33, 313–319.

CRV Lagoa. Sumário Consolidado PAINT 2009. Lagoa da Serra Ltda. Sertãozinho, SP, Brazil. Retrieved December 25, 2009, from <http://www.lagoa.com.br>

Frizzas OG, Grossi DA, Buzanskas ME, Paz CCP, Bezerra LAF, Lôbo RB, Oliveira JA and Munari DP 2009. Heritability estimates and genetic correlations for body weight and scrotal circumference adjusted to 12 and 18 months of age for male Nelore cattle. *Animal* 3, 347–351.

Gauly G, Mathiak K, Hoffmann K, Kraus M and Erhardt G 2001. Estimating genetic variability in temperamental traits in German Angus and Simmental cattle. *Applied Animal Behaviour Science* 74, 109–119.

Gressler SL, Bergmann JAG, Pereira CS, Penna VM, Pereira JCC and Gressler MGM 2000. Estudo das associações genéticas entre perímetro escrotal e características reprodutivas de fêmeas Nelore. *Revista Brasileira de Zootecnia* 29, 427–437.

Grossi DA, Frizzas OG, Paz CCP, Bezerra LAF, Lôbo RB, Oliveira JA and Munari DP 2008. Genetic associations between accumulated productivity, and reproductive and growth traits in Nelore cattle. *Livestock Science* 117, 139–146.

Kachman SD and Van Vleck LD 2007. Technical Note: calculation of standard errors of estimates of genetic parameters with the multiple-trait derivative-free restricted maximal likelihood programs. *Journal of Animal Science* 85, 2375–2381.

Martin LC, Brinks JS, Bourdon RM and Cundiff LV 1992. Genetic effects on beef heifer puberty and subsequent reproduction. *Journal of Animal Science* 70, 4006–4017.

Mishra RR, Chauhan RS and Gupta SC 1975. Studies of dairy temperament of Karan Swiss cows. *Indian Journal of Dairy Science* 8, 85–88.

Mourão G, Bergmann JAG and Ferreira MBD 1998. Diferenças genéticas e estimação de coeficientes de herdabilidade para temperamento em fêmeas zebu e F1 Holandês × Zebu. *Revista Brasileira de Zootecnia* 27, 722–729.

Phocas F, Boivin X, Sapa J, Trillat G, Boissy A and Le Neindre P 2006. Genetic correlations between temperament and breeding traits in Limousin heifers. *Animal Science* 82, 805–811.

Silveira IDB, Fischer V and Soares GJD 2006. Relação entre o genótipo e o temperamento de novilhos em pastejo e seu efeito na qualidade da carne. *Revista Brasileira de Zootecnia* 35, 519–526.

Spironelli ALG and Paranhos da Costa MJR 2008. Avaliação da reatividade de bovinos dos grupos genéticos Braford e Nelore e suas relações e influências nas contusões e rendimentos de carcaças. In *Congresso Latinoamericano de Etologia Aplicada 1*, International Society for Applied Ethology, Montevideo, p. 114.

Trocóniz JF, Beltrán J, Bastidas H, Larreal H and Bastidas P 1991. Testicular development, body weight changes, puberty and semen traits of growing Guzerat and Nelore bulls. *Theriogenology* 35, 815–826.

Voisinnet BD, Grandin T, Tatum JD, o'Connor SF and Struthers JJ 1997. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. *Journal of Animal Science* 75, 892–896.