Genetic relationship of temperament with meat quality traits in Nellore cattle

A.C. Sant'Anna[1], T.S. Valente[2], T. Bresolin[3], F. Baldi[3,4], L.G. Albuquerque[3,4] & M.J.R. Paranhos da Costa[3,4]

[1]Universidade Federal de Juiz de Fora, Departamento de Zoologia, 36.036-900, Juiz de Fora, Brazil
ac_santanna@yahoo.com.br *(Corresponding Author)*
[2]University of Alberta, Livestock Gentec, T6G 2C8, Edmonton, Canada
[3]Universidade Estadual Paulista, Departamento de Zootecnia, 14.884-900, Jaboticabal, SP, Brazil
[4]National Counsel of Technological and Scientific Development, CNPq, Brasília, Brazil

Summary

The aim of this study was to estimate genetic correlations between temperament and meat quality traits in Nellore cattle. Temperament was evaluated at yearling age (approximately 550 days of age) using the crush scores (CS), flight speed (FS) and pen score (PS) tests. The animals were slaughtered at 737 ± 31 days old and meat quality traits were tenderness (measured by Warner-Bratzler shear force, SF) and marbling score (MS, using a scale from 1 = practically devoid to 10 = very abundant). Animals were genotyped with BovineHD BeadChip and GeneSeek® Genomic Profiler (GGP) HDi 80K (GeneSeek Inc., Lincoln, NE). The (co)variance components and genetic parameters were estimated by Bayesian inference via Gibbs sampling using a two-trait animal model (single-step GBLUP), which included contemporary group as a fixed effect, direct additive genetic and residual as random effects. The model also included animal age at recording (linear effect) and slaughter age (linear and quadratic effects) as covariates for temperament and meat quality traits, respectively. Heritability estimates for all traits were moderate (0.16 to 0.26). Genetic correlations between SF and temperament traits were 0.19 (CS), 0.09 (FS) and 0.19 (PS). Despite the low values, genetic correlation estimates between MS with FS and PS (r_g = -0.12) were in the favorable direction, i.e. the calmest animals had highest MS. We recommend the inclusion of both temperament and meat quality traits as selection criteria in Nellore breeding programs in order to promote genetic gains for these traits.

Keywords: flight speed, tenderness.

Introduction

Sustainable agriculture practices must consider aspects of animal welfare, contributing to safe, high-quality and ethical production. In the beef chain, the selection for animal adaptability has received special research attention, which might include traits related to resistance to diseases, severe climatic conditions and parasites, efficient use of nutrients and behavior, and temperament (Prayaga *et al*., 2009). Excitable temperaments are associated with detrimental effects on growth and finishing performance traits such as weight at different ages, dry matter intake, average daily gain, and carcass traits (Nkrumah *et al*. 2007; Cafe *et al*., 2011). Furthermore, excitable animals are more susceptible to stress during handling on farm, transport and pre-slaughter management, exposing them to a more pronounced activation of physiological responses mediated by the hypothalamic-pituitary-adrenal axis and sympathetic-adrenomedullary system (Cafe *et al*., 2011). Therefore, it should be expected that there will be a greater depletion in muscle glycogen levels for reactive animals, increasing the risk of meat quality defects (King *et al*., 2006).

Previous studies tested the influence of temperament on meat and carcass traits and found that excitable temperaments were related to lower marbling, higher ultimate pH, greater incidence of dark cuts, tougher meat and more cooking loss (King *et al*., 2006; Cafe *et al*., 2011). However, information is still scarce in the literature for genetic associations between temperament and meat quality (Reverter *et al*., 2003; Kadel *et al*., 2006). Considering the importance of genetic improvement of Zebu breeds for the beef industry in tropical areas, the aim of this study was to estimate genetic correlations between temperament and meat quality traits in Nellore cattle.

Material and methods

Phenotypic, genotypic and pedigree data from commercial Nellore animals born between 2006 and 2014 were used in this study. Cattle temperament was measured during routine handling procedures for performance evaluation at yearling age (approximately 550 days of age) and the dataset was composed of crush score (CS), flight speed (FS) and pen score (PS), as described in Sant'Anna *et al*. (2013). The CS measured overall reactivity inside the squeeze chute, ascribing scores from 1 (animal does not offer resistance, remains with head, ears, and tail relaxed) to 5 (offers great resistance, sclera of the eye is always visible or has a 'freezing' reaction). The FS was measured as the speed (in m/s) at which each animal left the squeeze chute after weighing, and considered faster animals as having poor temperament. The PS assessed the animal reaction in a corral pen after weighing, ascribing scores from 1 (walks slowly, allowing proximity to the observer) to 5 (runs during the entire time of the assessment, jumps against fences and obstacles, and tries to attack the observer). No animals were scored with intermediate grade (PS =3) which was removed to avoid the tendency to concentrate on average score.

The steers were subsequently finished in feedlots for approximately 90 days and slaughtered around two years old (737 ± 31 d) in a commercial slaughterhouse. The carcasses were maintained in a cold chamber for 24 to 48 h *post-mortem* and samples measuring 2.54 cm thickness were collected from *Longissimus thoracis* muscle (between 12/13th ribs). Meat traits were tenderness, measured by shear force (SF, in kg), and marbling score (MS). The SF was measured using a mechanical Salter Warner-Bratzler Shear Force device (Wheeler *et al*., 1995) and the MS was recorded on a scale from 1 (practically devoid) to 10 (very abundant) according to the method of USDA (2000). For all traits, contemporary groups (CG) had at least three animals and were defined by sex, farm and year of birth, management groups at weaning and yearling ages for temperament traits and by year of birth, farm and management group at yearling age for SF and MS.

The animals were genotyped using BovineHD BeadChip (Illumina®, Inc., San Diego, CA, USA) and GeneSeek® Genomic Profiler (GGP) HDi 80K (GeneSeek Inc., Lincoln, NE). Genotypes from GGP HDi 80K chip were imputed to the HD chip using the FImpute Software considering pedigree information (http://www.aps.uoguelph.ca/~msargol/fimpute/). Quality control (QC) was applied to exclude non-autosomal and SNP markers with unknown genomic position, *Call Rate* ≤ 0.98, monomorphic, with MAF ≤ 0.02 and HWE *p*-value ≤ 10^{-5}. Also, samples with call rate < 0.90 were excluded. After QC, a total of 2,682 genotyped animals and 411,466 SNPs remained.

The (co)variance components and genetic parameters were estimated by fitting a two-trait animal model using ssGBLUP (single-step genomic BLUP) method via Bayesian inference in Gibbs sampling. The BLUPF90 programs were used (http://nce.ads.uga.edu/). The model included direct additive genetic and residual as random effects and CG as fixed effect. In addition, the age of each animal at the day of temperament assessment and animal slaughter age were considered as covariates for temperament (linear effect) and meat quality traits (linear and quadratic effects), respectively.

The model used can be written in matrix form as follows: $y = Xb + Za + e$, where y is the vector of observations, b is the vector of fixed effects, a is the vector of direct additive genetic effects, e is the vectors of residual effects and X and Z are incidence matrices relating b and a to the y vector. It was assumed that $E[y] = Xb$, $Var(a) = H \otimes G_0$ and $Var(e) = I \otimes R_0$ where G_0 and R_0 are the additive genetic and residual covariance matrix, respectively. H is the additive-genetic relationship matrix based on pedigree and genomic information as proposed by Aguilar *et al*., (2010), I is the identity matrix with suitable dimensions and $\otimes$ is the direct product between matrices. The genomic matrix was constructed following the procedure proposed by VanRaden, (2008). The Gibbs sampling analyses were implemented running a single chain of 500,000 interactions with a fixed burn-in of 200,000 cycles, taking a sample every 50 iterations. The Gibbs chain convergence was verified by visual inspection.

Results and discussion

The heritability estimates for all traits were moderate (Table 1) and consistent with other studies (Sant'Anna et al., 2013; Mateescu, 2014). These values indicate that selection for temperament and meat quality traits may produce genetic gains in Nellore cattle.

Table 1. Descriptive statistics, estimates of additive (σ_a^2) and residual (σ_e^2) variances, and heritability (h^2) for temperament and meat traits in Nellore cattle.

	N[1]	Mean ± SD[2]	CG[3]	σ_a^2 ± SD	σ_e^2 ± SD	h^2 ± SD
CS	7,440	-	324	0.04 ± 0.01	0.19 ± 0.06	0.19 ± 0.05
FS, m/s	7,386	1.80 ± 0.83	337	0.16 ± 0.03	0.43 ± 0.02	0.26 ± 0.04
PS	29,931	-	1,890	0.08 ± 0.01	0.29 ± 0.04	0.22 ± 0.03
SF, kgf	2,202	6.45 ± 1.68	70	0.35 ± 0.09	1.76 ± 0.09	0.16 ± 0.04
MS	2,181	2.76 ± 0.42	70	0.03 ± 0.01	0.10 ± 0.01	0.20 ± 0.07

[1]N = number of animals; [2]SD = standard deviation; [3]Number of contemporary groups (CG)

Genetic correlations between temperament traits and SF suggest that calmer animals tend to produce more tender meat. Therefore, selection to reduce cattle reactivity during handling procedures, especially by using CS or PS, may contribute to the improvement of Nellore meat tenderness (Table 2). Despite the low values, genetic correlation of MS with FS and PS were in the favorable direction, i.e. selection of calmest animals will result, on the long term, in highest MS. Genetic correlation estimate almost null (0.06) was found among MS and CS, evidenced by its posterior densities shown in Figure 1, which was around zero.

Table 2. Posterior means [95% highest posterior density intervals] of genetic correlations between temperament and meat quality traits.

	Genetic correlations		
Traits	Crush score (CS)	Flight speed (FS)	Pen score (PS)
Shear force (SF)	0.19[-0.17; 0.52]	0.09[-0.21; 0.39]	0.19[-0.07; 0.48]

Marbling score (MS)	0.06[-0.35; 0.45]	-0.12[-0.51; 0.27]	-0.12[-0.44; 0.18]

To date there are only a few published papers reporting genetic and phenotypic correlations for tropically adapted breeds (Kadel *et al*., 2006; Reverter *et al*., 2003). Genetic correlations estimated for FS with SF and intramuscular fat were close to zero (-0.02) for a dataset composed of Brahman, Belmont Red and Santa Gertrudis (Reverter *et al*., 2003). Using these same breeds, Kadel et al. (2006) estimated higher genetic correlations (-0.31) between flight time and SF at *Longissimus thoracis lumborum*. The results found in the present study are in general agreement with these previous estimates, since calmer temperament was genetically associated with better meat quality. On the other hand, for crossbred European cattle, Nkrumah *et al*. (2007) reported r_g = 0.10 for FS and MS, suggesting that more excitable temperament would be related to more marbling.

Figure 1. Posterior distribution of genetic correlations of (A) shear force and (B) marbling score with crush score (CS), flight speed (FS) and pen score (PS).

Tenderness and marbling are important traits since they play a major role on meat quality perception and acceptance by consumers (Troy & Kerry, 2010). These attributes are even more important for Zebu cattle, which present tougher meat with less marbling when compared with European cattle (Reverter *et al*., 2003). Thus, selection should be applied to improve meat quality in Nellore cattle. Additionally, selecting for calmer temperament should help to reduce cattle reactivity to handling and, indirectly, improves meat tenderness over time.

Conclusion

Heritability estimates for temperament and meat quality traits were moderate. Low genetic associations were found between SF with CS and PS, while genetic correlations between marbling and temperament traits were close to zero. Thus, we recommend the inclusion of both temperament and meat quality traits as selection criteria in Nellore breeding programs in order to promote genetic gains for these traits.

Acknowledgments

The authors thank São Paulo Research Foundation (FAPESP) for providing financial support for the project (Grants #2009/53609-7, #2009/16118-5 and #2013/20036-0). We express our gratitude to all the students who collaborated in the data collection and laboratorial analyses of this study, and to Professor Graham Plastow for his helpful review of the text draft.

List of References

Aguilar, I, I. Misztal, D.L. Johnson, A. Legarra, S. Tsuruta & T.J. Lawlor, 2010. Hot topic: a unified approach to utilize phenotypic, full pedigree, and genomic information for genetic evaluation of Holstein final score. J Dairy Sci. 93:743-752.

Cafe, L.M., D.L. Robinson, D.M. Ferguson, B.L. Mcintyre, G.H. Geesink & P.L. Greenwood, 2011. Cattle temperament: Persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits. J Anim Sci. 89:1452-1465.

Kadel, M.J, D.J. Johnston, H.M. Burrow, H.U. Graser & D.M. Ferguson, 2006. Genetics of flight time and other measures of temperament and their value as selection criteria for improving meat quality traits in tropically adapted breeds of beef cattle. Aust. J Agric. Res. 57:1029-1035.

King, D.A., C.E. Schuehle Pfeiffer, R.D. Randel, T.H. Welsh, R.A. Oliphint, B.E. Baird, K.O. Curley, R.C. Vann, D.S. Hale & J.W. Savell, 2006. Influence of animal temperament and stress responsiveness on the carcass quality and beef tenderness of feedlot cattle. Meat Sci. 74:546-556.

Mateescu, R. G. 2014. Genetics of meat quality. In: D. J. G. A. Ruvinsky, editor, The genetics of cattle. CAB International, Wallingford, UK. p. 544–570.

Nkrumah, J.D., D.H.Jr. Crews, J.A. Basarab, M.A. Price, E.K. Okine, Z. Wang, C. Li & S.S. Moore, 2007. Genetic and phenotypic relationships of feeding behavior and temperament with performance, feed efficiency, ultrasound and carcass merit of beef cattle. J. Anim. Sci. 85:2382-2390.

Prayaga, K.C., N.J. Corbet, D.J. Johnston, M.L. Wolcott, G. Fordyce & H.M. Burrow, 2009. Genetics of adaptive traits in heifers and their relationship to growth, pubertal and carcass traits in two tropical beef cattle genotypes. Anim. Prod. Sci. 49:413-425.

Reverter, A., D.J. Johnston, D.M. Ferguson, D. Perry, M.E. Goddard, H.M. Burrow, V.H. Oddy, J.M. Thompson & B.M. Bindon, 2003. Genetic and phenotypic characterization of animal, carcass and meat quality traits from temperate and tropically adapted beef breeds. 4. Correlations among animal, carcass and meat quality traits. Aust. J. Exp. Agr. 54:149-158.

Sant'Anna, A.C., M.J.R. Paranhos Da Costa, F. Baldi & L.G. Albuquerque, 2013. Genetic variability for temperament indicators of Nellore cattle. J Anim Sci. 91:3532-3537.

Troy, D.J. & Kerry, J.P, 2010. Consumer perception and the role of science in the meat industry. Meat Sci. 86: 214-226.

USDA, United States Departament of Agriculture. U.S. 2000. Standards for Grades of Feeder Cattle. Washington: USDA. 4p.

VanRaden, P.M., 2008. Efficient methods to compute genomic predictions. J. Dairy Sci. 91:4414-4423.

Wheeler, T.L., M. Koomaraie & S.D. Shackelford, 1995. Standardized warner-bratzler shear force procedures for meat tenderness measurement. Clay Center: Roman L. Hruska U. S. MARC. USDA. 7p.