Estimation Of Heritability And Repeatability For Ultrasound Carcass Traits In Nelore Cattle Using Random Regression Models

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Introduction

The use of ultrasound technology allowed including some carcass traits in beef cattle breeding programs due the possibility of measuring a great number of animals *in vivo*. Nowadays, EPD of carcass traits using both ultrasound and slaughter progeny records are included in several sire summaries of beef breeds (Golden *et al.* 2009). In Brasil, the use of ultrasound techniques to estimate some carcass traits in beef cattle dates back the 1990's. However, there are few studies reporting genetic parameters of ultrasound carcass traits in *Bos indicus* obtained at different ages. Yokoo *et al.* (2009) reported heritability estimates of 0.46 and 0.33 for longissimus muscle area and 0.42 and 0.59 for backfat thickness in Nelore cattle measured at 370 and 570 days of age, and Lima-Neto *et al.* (2009) reported lower estimates in Guzerat cattle measured between 304 to 974 days of age, fitting a repeatability model. The objective of this study was to estimate genetic and phenotypic parameters of serial ultrasound carcass traits in Nelore cattle, from 1 to 2 years of age.

Material and Methods

Animals and Scanning Procedure. Purebred Nelore (*Bos indicus*) cattle from three selection lines reared at the Estação Experimental de Zootecnia de Sertãozinho (São Paulo, Brazil), Instituto de Zootecnia, since 1981 (Mercadante *et al.* 2003), were evaluated for carcass traits using ultrasound technology. All the animals were kept on pasture until weaning at seven months of age. The males were then submitted to a feedlot performance test for 168 days up to 12 months of age and the females remained on pasture (except heifers born in 2004, 2005 and 2008 which were supplemented in an individual feed intake experiment). After yearling, all animals were kept on pasture (except a very few males which were finished in an individual feed intake experiment). The animals were scanned approximately at 12, 15, 18 and 24 months of age. Longissimus muscle area (LMA) and backfat thickness (BF) were obtained from a cross-sectional image on the longissimus muscle measured between the 12th and 13th ribs. The rump fat thickness (RF) was measured at the intersection between the gluteus medius and biceps femoris muscles located between the hooks and pin bones. Real-time ultrasound images were collected using 2 types of devices depending on the occasion: Aloka 500V (Corometrics Medical Systems Inc., Wallingford, CT) equipped with a linear probe of 17.2 cm and a 3.5-MHz transducer (Aloka Co. Ltd., Tokyo, Japan), and PIE Medical 401347-Aquila (Esaote Europe B.V., Maastricht, the Netherlands) equipped with a linear probe of 18 cm and a 3.5-MHz transducer. The images were stored and subsequently interpreted using the Echo Image Viewer 1.0 program (PIE Medical Equipment B.V.), with 1 decimal place.

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Data Analysis. Ages at measurements (282 to 786 days) included 14 age points (from 343 to 773, where the age point express the average of age). The contemporary group (CG1) included selection line, year of birth, month and year of measure, sex and management (pasture or other, as described above). CG1 with less than 5 records were excluded, remaining 74 GC1. After data edition, 2476 observations of 358 bulls and 748 heifers, offspring of 77 sires and 533 dams, born from 2003 to 2008, were used for further analysis. The full relationship matrix had 8354 animals. Thirty nine percent of animals had only one record, 28% had two, 10% three, 18% four and 5% had five records. A multiple trait analysis (MTM) was initially performed using REMLF90 package (Misztal 2001). The records of LMA, BF e RF were split into five subsets, excluding repeated records into subsets (11 to 13; 14 to 16; 17 to 19; 20 to 22 and ≥23 months of age). Data were analyzed using a five-trait model that included fixed effects of CG2 (line, birth year, sex and management) and age of dam (only for first two subsets), linear effect of age at scan, and random effects of animal and error. Random regression models (RRM) were performed to estimate additive genetic and permanent environmental covariance functions. Variance components were estimated using DXMRR package (Meyer, 1998). The RRM included fixed effects of CG1, age of dam, and the fixed regression of age at measurement, fitted by a quadratic Legendre polynomial. Random regression coefficients for direct additive genetic and direct permanent environmental effects were fitted on Legendre polynomial of age at measurement for all traits. The order of additive genetic (ka) and permanent environmental effects (kc) ranged from 1 to 3 and residual variances were considered heterogeneous, modeled by a step function with 14 classes of variances. RRM were compared by Akaike's (AIC) and Schwarz's Bayesian (BIC) information criteria.

Results and discussion

In general, the LMA means and the variation coefficient decreased when there was less bull than female records, with the exception of the final ages (Figure 1). The opposite happened to BF and RF means which increased during the intermediate ages, between 500 and 700 days of age, the period when the number of bull records decreased. Besides, this trait mean increase coincides with the onset of puberty in Nelore heifers raised on pasture. These values are in agreement with results of *Bos indicus* (Yokoo *et al.* 2008) and high variation coefficients for BF e RF were also reported in most of the studies (Meyer *et al.* 2004; Yokoo *et al.* 2008; Lima-Neto *et al.* 2009), even though they were higher in our study, BF mainly (Figure 1).

Small orders of direct additive genetic and direct permanent environmental covariance functions were sufficed to fit the data for LMA, BF and RF, probably because of the small number of repeated measurements and the space time. For LMA, the inclusion of parameters at the functions (ka and kc) did not change considerably the LogL, resulting in small changes in AIC and BIC. The same trends were observed for the other traits. The best order of fitting for ka was 1, 2 and 2, to LMA, BF and RF respectively; while the same order (kc=2) fitted permanent environmental effect for the traits (Table 1). Regardless of the model and trait analyzed, the main eigenvalue estimated for additive genetic covariance function accounted for 84 to 99% of the total variance. The corresponding values for permanent environmental covariance function ranged from 88 to 92%.

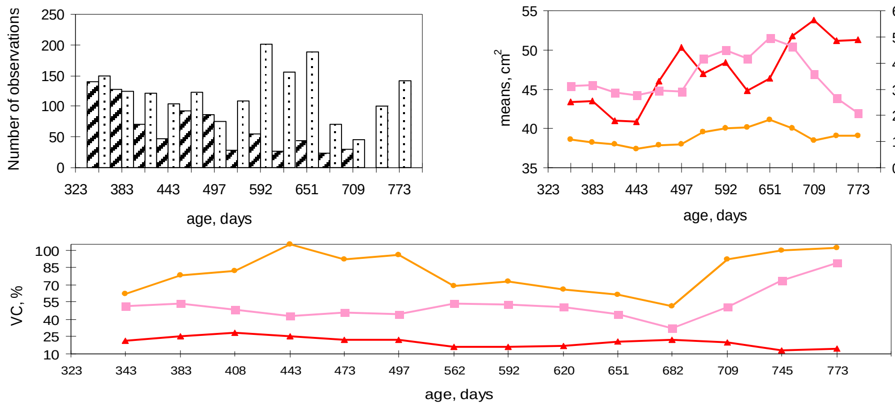

Figure 1: Number of observation of bulls (striped bar) and heifers (dotted bar), means and variation coefficients (VC%) of ultrasound longissimus muscle area (red line), backfat (orange line) and rump fat thickness (pink line)

Table 1: Values of Log likelihood function (LogL), Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) from random regression analyses for models with different orders of polynomial covariance functions

Model[1]	ka	kc	parms	LogL	AIC	BIC
			Longissimus muscle area			
Leg1-2	1	2	17	-4859.74	9755.47	**9860.13**
Leg2-2	3	3	20	-4857.99	9755.98	9872.26
Leg2-3	3	6	23	-4853.01	9752.02	9885.76
			Backfat thickness			
Leg2-2	3	3	20	-256.39	**552.78**	**668.95**
Leg2-3	3	6	23	-254.44	554.89	688.48
			Rump fat thickness			
Leg2-2	3	3	20	-1382.37	**2804.74**	**2920.84**
Leg2-3	3	6	23	-1379.78	2805.56	2939.07

[1]models were named according ka (the order of fit for animal direct genetic effect) and kc (the order of fit for direct permanent environmental effect); parms is the number of parameters estimated, which included 14 residual variances for all analysis.

The heritability estimates (h^2) from MTM analysis (Figure 2) showed great oscillation through the age, for RF mainly, whose estimates were close to zero at intermediate ages. This drop was not observed for LMA, whose h^2 estimates were closer to the RRM estimates at these ages. The MTM analysis for BF did not reach the convergence. The h^2 estimated by RRM (Figure 2) ranged from 0.31 to 0.42 for LMA and were higher around 550 days of age. These values are in accordance with previous estimates from *Bos indicus* (Yokoo *et al.* 2008; Lima-Neto *et al.* 2009). However, Yokoo *et al.* (2009) reported higher LMA h^2 estimates at yearling (0.46) than at 550 days of age (0.33). For BF and RF, the h^2 estimates ranged from 0.13 to 0.32 and from 0.13 to 0.42, respectively, and they were higher at yearling. Another important question was to verify whether these measurements were made with sufficient repeatability. These values for LMA (Figure 2), around 0.74, were considered good, close to values (0.80 to 0.88) reported by Hassen *et al.* (2004) with a 4 to 6 week interval between scans in Angus cattle. The values for BF and RF were lower (around 0.63), but higher than those reported by Araujo (2003) and close to Lima-Neto *et al.* (2009), both measuring *Bos indicus*.

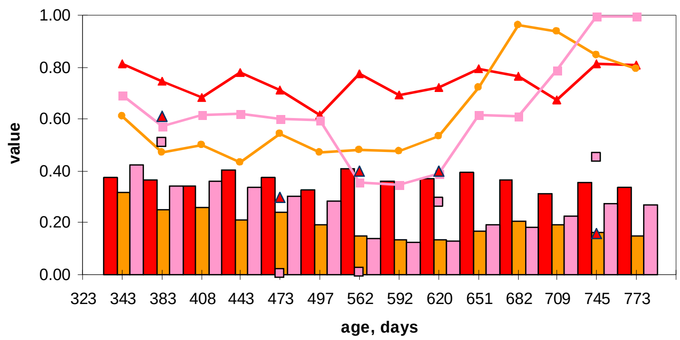

Figure 2: Estimates of heritability (bars) and repeatability (lines) of ultrasound longissimus muscle area (red), backfat (orange) and rump fat thickness (pink) by age class. Multi-trait model heritability estimates are represented by dots without lines.

Conclusion

For the range of ages considered in the study, results suggest a medium level of genetic variability for longissimus muscle area, backfat thickness and rump fat thickness, measured by ultrasound in Nelore cattle. The maximum heritability was estimated at yearling for fat thickness and at 550 days of age for longissimus muscle area. Considering the heritability of longissimus muscle area was similar through the ages and the start of rainy season in the South hemisphere coincides with yearling age of animals, the scanning could be made around 13-15 months of age. However, more studies are necessary to confirm these results.

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