JOURNAL OF ANIMAL SCIENCE
The Premier Journal and Leading Source of New Knowledge and Perspective in Animal Science

Models for genetic evaluation of Nelore cattle mature body weight

A. A. Boligon, L. G. Albuquerque, M. E. Z. Mercadante and R. B. Lôbo

J Anim Sci 2008.86:2840-2844.
doi: 10.2527/jas.2007-0823 originally published online May 23, 2008;

Models for genetic evaluation of Nelore cattle mature body weight[1]

A. A. Boligon,* L. G. Albuquerque,*[2,3] M. E. Z. Mercadante,† and R. B. Lôbo‡

*Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, 14884-900-Jaboticabal (SP), Brazil; †Instituto de Zootecnia–Estação Experimental de Zootecnia de Sertãozinho, 14160-000-Sertãozinho (SP), Brazil; and ‡Departamento de Genética, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, São Paulo, Brazil

ABSTRACT: Records of 18,770 Nelore animals, born from 1975 to 2002, in 8 herds participating in the Nelore Cattle Breeding Program, were analyzed to estimate genetic parameters for mature BW. The mature BW were analyzed as a single BW taken closest to 4.5 yr of age for each cow in the data file, considering BW starting from 2 (W2Y_S), 3 (W3Y_S), or 4 (W4Y_S) yr of age or as repeated records, including all BW starting from 2 (W2Y_R), 3 (W3Y_R), or 4 (W4Y_R) yr of age. The variance components were estimated by restricted maximum likelihood, fitting univariate and bivariate animal models, including weaning weight. The heritability estimates were 0.29, 0.34, 0.36, 0.41, 0.44, and 0.46 for W2Y_S, W3Y_S, W4Y_S, W2Y_R, W3Y_R, and W4Y_R, respectively. The repeatability estimates for W2Y_R, W3Y_R, and W4Y_R were 0.59, 0.64, and 0.72, respectively. Larger accuracy values associated with the EBV were obtained in the repeated records models. The results indicated the bivariate repeated records model as the most appropriate for analyzing mature BW.

Key words: beef cattle, genetic correlation, growth, repeatability

J. Anim. Sci. 2008. 86:2840–2844
doi:10.2527/jas.2007-0823

INTRODUCTION

In Brazil, animal breeding programs for beef cattle breeds have prioritized the selection of growth traits, such as BW or BW gain at certain ages. These traits are easy to obtain and present heritability estimates from medium to high, responding rapidly to selection, but show positive genetic correlations with adult BW (Silva et al., 2000; Meyer et al., 2004). Therefore, selecting animals for greater BW at young ages will increase cow mature BW.

In recent decades, there have been concerns about the consequences on herd productivity of increasing cow size. There is evidence that the energy needed to maintain cow adult BW represents the greatest cost in the beef production system. Animals with greater genetic potential for growth are more efficient in environments where feed resources are not limited; however, in restricted environments, medium-sized animals are preferred (Jenkins and Ferrell, 1994).

In this context, to maintain a desirable adult size it is necessary to include adult BW in beef cattle selection indices. However, there are difficulties in using adult BW in genetic evaluations because of the scarcity of BW records obtained after 2 yr of age. Moreover, the best way to analyze these records has yet to be defined.

In studies reporting genetic parameters for adult BW, some authors took a single BW measurement at 4 yr of age (Silva et al., 2000; Rosa et al., 2001), whereas others used repeated measurements from 2 (Arango et al., 2002; Meyer et al., 2004), 3 (Pedrosa et al., 2006), or 4 yr of age (Kaps et al., 1999). Arango and Plasse (2002) and Choy et al. (2002) considered all BW available for females that entered the breeding season, obtained after 2 yr of age. The objective of this study was to estimate genetic parameters for female mature BW by using single or repeated measurements, including BW from 2, 3, or 4 yr of age, in an effort to address the various options for including this trait in genetic evaluations.

MATERIALS AND METHODS

Animal Care and Use Committee approval was not obtained for this study because the data were obtained

[1]This work was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP). We are indebted to the Associação Nacional de Criadores e Pesquisadores (ANCP) for the use of their data.

[2]Corresponding author: lgalb@fcav.unesp.br

[3]Current address: Via de acesso Paulo Donato Castellane s/n. Departamento de Zootecnia, Prédio 2. CEP: 14884-900, Jaboticabal, SP, Brazil.

Received December 21, 2007.
Accepted May 20, 2008.

from an existing database (Nelore Cattle Breeding Program).

Data and Management

Records from 18,770 Nelore breed animals, born from 1975 to 2002, belonging to 8 cattle herds participating in the Programa de Melhoramento Genético da Raça Nelore (Nelore Cattle Breeding Program), a selection program established in 1987, were analyzed. The animals were weighed every 90 d from birth to 18 mo of age, and those that remained in the herds as breeding stock continued to be weighed every 90 d. The births occur throughout the year, with the greatest concentrations in spring and summer. Animals are weaned, on average, at 240 d of age. Animals were included in the analyses if they were a product of AI; raised on pastures without supplementation; nursed by their biological mothers; and born to mothers of age 2 to 20 yr.

Weaning weight (**WW**) was defined as the weight taken closest to 240 d of age, with a maximum interval of 60 d before or after this age, and was used in bivariate analyses to account for the effects of sequential selection. Female mature BW was a single measurement obtained nearest to 4.5 yr of age, considering any BW obtained from 2 (**W2Y_S**), 3 (**W3Y_S**), or 4 (**W4Y_S**) yr of age. Moreover, repeated mature BW measurements taken from 2 (**W2Y_R**), 3 (**W3Y_R**), or 4 (**W4Y_R**) yr of age were analyzed.

Four birth or weighing seasons were defined: December to February (season 1), March to May (season 2), June to August (season 3), and September to November (season 4). For WW, the model included the fixed effects of contemporary groups (**CG**), and the linear and quadratic effects of animal age at recording and age of cow at calving as covariables. For adult BW, the model included the fixed effects of CG, and animal age at recording as a covariable (linear and quadratic effects). The CG for WW was composed of animals of the same sex and born in the same farm, year, and season. For adult BW, the CG included herd, year, and season of recording. Contemporary groups with fewer than 4 animals were excluded. The general structure of the data set is presented in Table 1.

The components of variance were estimated by restricted maximum likelihood by using the software MTDFREML (Boldman et al., 1995) in univariate and bivariate analyses with WW. The mathematical description of the general model used for analyses of adult BW is as follows:

$$\mathbf{y} = \mathrm{X}\boldsymbol{\beta} + \mathbf{Z}_a\mathbf{a} + \mathbf{Z}_c\mathbf{c} + \mathbf{e},$$

where $\mathbf{y}$ is the vector of observations; $\boldsymbol{\beta}$ is the vector of fixed effects; $\mathbf{a}$ is the vector of additive genetic direct effects; $\mathbf{c}$ is the vector of animal permanent environmental effects; and $\mathbf{e}$ is the vector of residuals. $\mathbf{X}$, $\mathbf{Z}_a$, and $\mathbf{Z}_c$ are incidence matrices relating $\boldsymbol{\beta}$, $\mathbf{a}$, and $\mathbf{c}$ to $\mathbf{y}$. It is assumed that $\mathrm{E}[\mathbf{y}] = \mathbf{X}\boldsymbol{\beta}$; $\mathrm{Var}(\mathbf{a}) = \mathbf{A} \otimes \boldsymbol{\Sigma}_a$, $\mathrm{Var}(\mathbf{c}) = \mathbf{I}_N \otimes \boldsymbol{\Sigma}_c$, and $\mathrm{Var}(\mathbf{e}) = \mathbf{I}_N \otimes \boldsymbol{\Sigma}_e$, where $\boldsymbol{\Sigma}_a$ is the additive genetic covariance matrix; $\boldsymbol{\Sigma}_c$ is the animal permanent environmental covariance matrix; $\boldsymbol{\Sigma}_e$ is the residual covariance matrix; $\mathbf{A}$ is the additive numerator relationship matrix; $\mathbf{I}$ is an identity matrix; N is the number of animals with records; and $\otimes$ denotes the direct product. The animal permanent environmental effect was included only in the adult BW analyses by using repeated measurements. In the bivariate analyses, the maternal genetic and permanent environmental effects were included for WW.

In all of the analyses, a pedigree file containing the identification of the animal, sire, and dam was used, with a total of 26,924 animals in the relationship matrix. Spearman correlation coefficients between adult BW breeding values estimated in different analyses (W2Y_S, W3Y_S, W4Y_S, W2Y_R, W3Y_R, and W4Y_R) were calculated.

RESULTS AND DISCUSSION

The observed means and SD, by age, are shown in Figure 1. The cows continued to gain BW until approximately 5 yr of age. The mean BW of the 5-yr-old or older cows (470 kg) was close to that reported in the literature for adult Nelore cows (Rosa et al., 2001; Pedrosa et al., 2006).

The variance components and genetic parameters estimated for adult BW using the bivariate model are described in Table 2. Excluding records from animals less than 4 yr of age from the analyses increased additive genetic variance estimates and decreased residual variance estimates in both single and repeated mea-

Table 1. Data structure

Trait[1]	Animals	Records	Sires	Dams	Contemporary group
WW	18,770	18,770	515	8,546	490
W2Y_S	3,109	3,109	323	2,130	228
W3Y_S	2,439	2,439	306	1,671	187
W4Y_S	1,896	1,896	234	1,406	166
W2Y_R	3,109	18,999	323	2,130	228
W3Y_R	2,439	14,713	306	1,671	187
W4Y_R	1,896	11,142	234	1,406	166

[1]WW = weaning weight; W2Y, W3Y, or W4Y = BW starting at 2, 3, or 4 yr of age; _S = considering only the BW nearest 4.5 yr of age for each cow; _R = considering all records available for each cow, repeated records.

surement analyses. In the latter analyses, exclusion of 2- and 3-yr-old cows led to an increase in permanent environmental variance estimates, consequently increasing the repeatability estimates. This greater correlation between records of the same cow probably occurred because, in this data set, the cows were close to or had already reached their mature size. Similar results were reported by Meyer (1995) and Mercadante et al. (2004). The estimates of repeatability varied from 0.59 to 0.72, and are close to those reported in the literature for adult BW (Arango et al., 2002; Choy et al., 2002; Meyer et al., 2004; Pedrosa et al., 2006).

Preliminary analyses using the univariate model showed estimates of heritability and SE of 0.21 ± 0.04, 0.24 ± 0.05, 0.26 ± 0.06, 0.25 ± 0.02, 0.30 ± 0.03, and 0.34 ± 0.04 for W2Y_S, W3Y_S, W4Y_S, W2Y_R, W3Y_R, and W4Y_R, respectively. The heritability estimates in univariate analyses were less for the 3 definitions of mature BW, considering either single or repeated measurements, as compared with bivariate analyses. With the univariate model, repeated measurements yielded greater heritability estimates than single measurements, with slightly less SE, which suggest that the use of repeated measurements could result in more accurate analyses. Greater heritability estimates for repeated measurements were also observed with bivariate analyses (Table 2). The use of repeated measurements in a multivariate model, including BW before selection for adult BW genetic evaluations, allows better modeling of environmental variations (Kaps et al., 1999).

The heritability estimates for adult BW in the bivariate model were moderate to high. These results agree with those described in the literature (Kaps et al., 1999; Mercadante et al., 2004; Pedrosa et al., 2006), which vary from 0.30 to 0.52 (single records) and 0.35 to 0.53 (repeated records). These estimates suggest that inclusion of adult BW as a sire selection criterion will result in rapid genetic gains. However, to find the BW adequate for a given production system, economic selection indices including this trait will have to be developed.

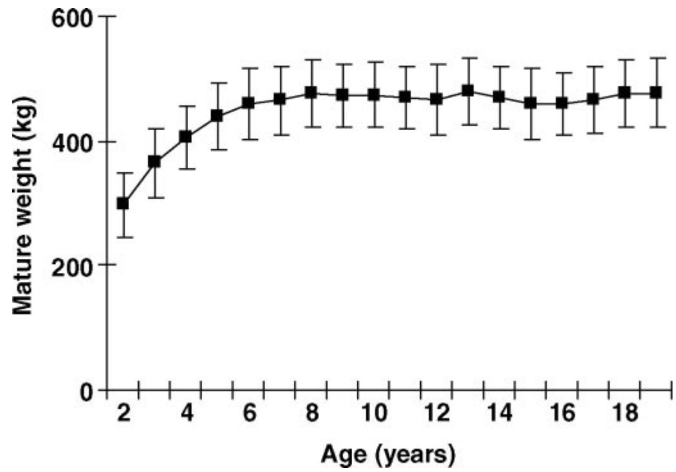

Figure 1. Observed mean (■) and SD (bar) for mature BW, by age class.

The results suggest that 2-yr-old cow BW records should not be considered for genetic evaluations of adult BW. Meyer (1995) observed a similar trend in the variance components, analyzing adult BW including or excluding records of 3-yr-old Hereford and crossbred females. In Brazil, Mercadante et al. (2004) suggested excluding BW of 2-and 3-yr-old cows for evaluating adult BW in Nelore cattle. However, it is important to remember that the trait under study is obtained relatively late in the life of the animal, thus affecting the generation interval. Furthermore, exclusion of 2- and 3-yr-old cow records may lead to information loss, influencing the genetic evaluation of adult BW, especially for younger sires.

The values of accuracy associated with sire breeding values were greater in the repeated measurement models than in the single measurement models (Figure 2). This result was expected, because, when using repeatability models, both heritability estimates and the number of records per animal increased.

For W2Y_S, W3Y_S, W4Y_S, W2Y_R, W3Y_R, and W4Y_R bivariate analyses, the EBV accuracy means for sires of cows with records were 0.65, 0.61, 0.52,

Table 2. Variance components and genetic and phenotypic parameters of mature BW, obtained by bivariate analyses with weaning weight (WW), and, in parentheses, heritability estimates and SE obtained by univariate analyses

Trait[1]	σ_a^2	σ_c^2	σ_e^2	h^2	c^2	t
W2Y_S	680.28	—	1,707.57	0.29 (0.21 ± 0.04)	—	—
W3Y_S	849.01	—	1,699.78	0.34 (0.24 ± 0.05)	—	—
W4Y_S	912.15	—	1,594.08	0.36 (0.26 ± 0.06)	—	—
W2Y_R	619.47	351.40	670.19	0.41 (0.25 ± 0.02)	0.20	0.59
W3Y_R	776.11	370.09	643.82	0.44 (0.30 ± 0.03)	0.21	0.64
W4Y_R	787.29	397.19	487.97	0.46 (0.34 ± 0.04)	0.24	0.72

[1]W2Y, W3Y or W4Y = BW starting at 2, 3, or 4 yr of age; _S = considering only the BW nearest 4.5 yr of age for each cow; _R = considering all records available for each cow, repeated records; σ_a^2 = additive genetic variance; σ_c^2 = permanent environmental variance; σ_e^2 = residual variance; h^2 = heritability; c^2 = proportion of phenotypic variance attributable to the permanent environment; t = repeatability.

Table 3. Spearman correlation coefficients between sire EBV for mature BW, obtained by bivariate analyses

Variable[1]	W2Y_S	W3Y_S	W4Y_S	W2Y_R	W3Y_R	W4Y_R
W2Y_S	—	0.93	0.85	0.89	0.84	0.86
W3Y_S	—	—	0.88	0.83	0.91	0.89
W4Y_S	—	—	—	0.81	0.92	0.95
W2Y_R	—	—	—	—	0.94	0.90
W3Y_R	—	—	—	—	—	0.96

[1]W2Y, W3Y, or W4Y = BW starting at 2, 3, or 4 yr of age; _S = considering only the BW nearest 4.5 yr of age for each cow; _R = considering all records available for each cow, repeated records.

0.94, 0.92, and 0.89, respectively. These results again indicate the superiority in accuracy of estimates obtained with repeated measurement analyses. In both cases, the use of information starting only at 4 yr of age reduced accuracy, compared with the use of repeated measurements considering BW from 2 and 3 yr of age. Excluding records of 2- and 3-yr-old cows is therefore not always beneficial, because it reduces the amount of information available, and consequently the accuracy of the estimates. However, considering BW from 2-yr-old cows in the mature BW analyses could bias the estimates, because at this age the females are probably still far from reaching their adult BW.

These results are even more important for young bulls with no or just a few progeny. Our results showed that EBV accuracy means for young animals with no progeny information changed from 0.44 (W2Y_S), 0.41 (W3Y_S), and 0.39 (W4Y_S) when considering single records to 0.76 (W2Y_R), 0.70 (W3Y_R), and 0.64 (W4Y_R) when considering repeated records. Therefore, when mature BW repeated records are used instead of single records, it is possible to change the EBV accuracies from low to moderate, thus increasing genetic gain.

Sire rank correlations between breeding values for adult BW estimated under different models are shown in Table 3. The correlations varied from 0.83 to 0.96, with greater values for repeated than for single record analyses. When a repeatability model was used, the sire rank correlation between W3Y_R and W4Y_R was close to unity (0.96), suggesting a similar sire rank regardless of the inclusion of BW starting at 3 yr of age.

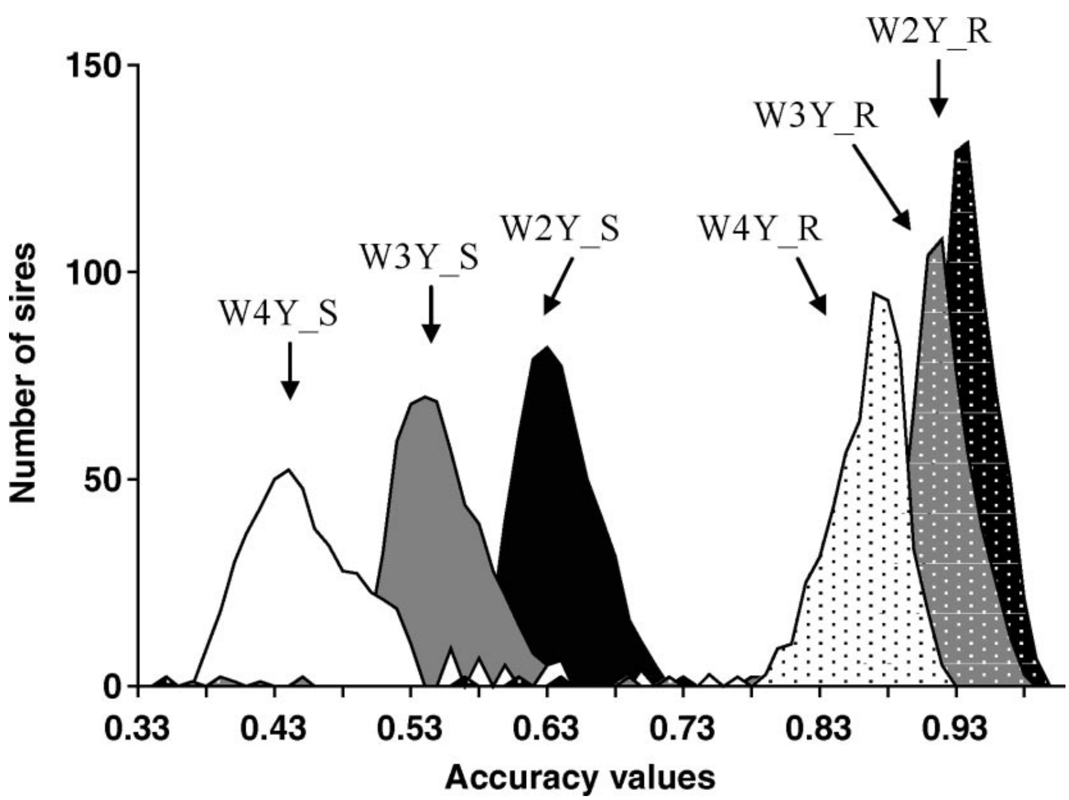

Figure 2. Distribution of accuracy values associated with EBV of sires for W2Y_S, W3Y_S, W4Y_S, W2Y_R, W3Y_R, and W4Y_R, obtained by multivariate analyses. W2Y, W3Y, or W4Y = BW starting at 2, 3, or 4 yr of age; _S = considering only the BW nearest 4.5 yr of age for each cow; _R = considering all records available for each cow, repeated records.

Table 4. Number and percentage of sires selected for mature BW, applying different selection intensities based on EBV for W4Y_S

Trait[1]	Selected sires for W4Y_S, % (animals, n)			
	2 (12 animals)	10 (62 animals)	20 (123 animals)	50 (308 animals)
W2Y_S	61 (7)	72 (45)	79 (97)	87 (268)
W3Y_S	70 (8)	84 (52)	89 (109)	90 (277)
W2Y_R	42 (5)	66 (41)	71 (87)	89 (274)
W3Y_R	52 (6)	76 (47)	81 (100)	84 (259)
W4Y_R	68 (8)	79 (49)	85 (104)	93 (286)

[1]W2Y, W3Y, or W4Y = BW starting at 2, 3, or 4 yr of age; _S = considering only BW nearest 4.5 yr of age for each cow; _R = considering all records available for each cow, repeated records.

In the same way, the sire rank correlation between W4Y_S and W4Y_R was high (0.95); however, less accuracy was expected when using single records.

Considering sires selected for W4Y_S (as used in some Brazilian breeding programs), the degree of coincidence obtained if selection was based on any other trait (W2Y_S, W3Y_S, and so on) is presented in Table 4. Large differences occurred, mainly when the selection intensity was high. Changes in the definition of mature BW and in the model of analyses are not without consequences. When selecting the top 2 or 10% of the sires based on the predicted breeding values for W4Y_R, 84 and 91% of the same sires, respectively, would be selected if W3Y_R were considered as the selection criterion when using the same intensity. Differences in accuracy of the means when using either of these 2 traits was only 0.03. When the variance component estimates and breeding value accuracies were considered, the most appropriate model for genetic evaluation of mature BW would be a repeatability model, including BW starting at 3 yr of age.

LITERATURE CITED

Arango, J. A., L. V. Cundiff, and L. D. Van Vleck. 2002. Genetic parameters for weight, weight adjusted for body condition score, height, and body condition score in beef cows. J. Anim. Sci. 80:3112–3122.

Arango, J. A., and D. Plasse. 2002. Cow weight in a closed Brahman herd. In Proc. 7th World Congr. Genet. Appl. Livest. Prod., Montpellier, France (CD-ROM).

Boldman, K. G., L. A. Kriese, L. D. Van Vleck, C. P. Van Tassel, and S. D. Kachman. 1995. A manual for use of MTDFREML. A set of programs to obtain estimates of variances and covariances. Agric. Exp. Sta., USDA, Clay Center, NE.

Choy, Y. H., J. S. Brinks, and R. M. Bourdon. 2002. Repeated-measure animal models to estimate genetic components of mature weight, hip height, and body condition score. J. Anim. Sci. 80:2071–2077.

Jenkins, T. G., and C. L. Ferrell. 1994. Productivity through weaning of nine breeds of cattle under varying feed availabilities: I. Initial evaluation. J. Anim. Sci. 72:2787–2797.

Kaps, M., W. O. Herring, and W. R. Lamberson. 1999. Genetic and environmental parameters for mature weight in Angus cattle. J. Anim. Sci. 77:569–574.

Mercadante, M. E. Z., A. G. Razook, J. B. F. Trovo, J. N. S. G. Cyrillo, and L. A. Figueiredo. 2004. Parâmetros genéticos do peso no início da estação de monta, considerando indicativo do peso adulto de matrizes Nelore. Rev. Bras. Zootec. 33:1135–1144.

Meyer, K. 1995. Estimates of genetic parameters for mature weight of Australian beef cows and its relationships to early growth and skeletal measures. Livest. Prod. Sci. 44:125–137.

Meyer, K., D. Johnston, and H. Graser. 2004. Estimates of the complete genetic covariance matrix for traits in multi-trait genetic evaluation of Australian Hereford cattle. Aust. Agric. Res. 55:195–210.

Pedrosa, V. B., J. P. Eler, J. A. II V. Silva, I. B. Formigoni, G. B. Mourão, R. S. Bueno, J. B. S. Ferraz, S. Ribeiro, and A. Zampar. 2006. Heritability estimation for mature weight in Nellore cattle. In Proc. 8th World Congr. Genet. Appl. Livest. Prod., Belo Horizonte, Brazil (CD-ROM).

Rosa, A. N., R. B. Lôbo, H. N. Oliveira, L. A. F. Bezerra, and A. R. Borjas. 2001. Peso adulto de matrizes em rebanhos de seleção da raça Nelore no Brasil. Rev. Bras. Zootec. 30:1027–1036.

Silva, A. M., M. M. Alencar, A. R. Freitas, R. T. Barbosa, P. F. Barbosa, M. C. S. Oliveira, L. A. Corrêa, A. P. Novaes, and R. R. Tullio. 2000. Herdabilidade e correlações genéticas para peso e perímetro escrotal de machos e características reprodutivas e de crescimento de fêmeas, na raça Canchim. Rev. Bras. Zootec. 29:2223–2230.