QUANTITATIVE GENETIC STUDY ON GROWTH TRAITS OF BRAHMAN CATTLE IN BRAZIL

ESTUDO GENÉTICO QUANTITATIVO DE CARACTERÍSTICAS DE CRESCIMENTO DE BOVINOS DA RAÇA BRAHMAN NO BRASIL

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SUMMARY

This research aimed at estimating genetic parameters for birth weight (BW), weight at 120 days (W120), weaning weight (W210), yearling weight (W365), weight at 455 days (W455) and weight at 550 days (W550) and direct and indirect efficiencies for selection based on these traits for Brahman cattle in Brazil. We analyzed 15,664; 7,432; 6,585; 4,223; 3,362 and 2,517 records on BW, W120, W210, W365, W455 and W550, respectively, from animals enrolled in the Genetic Breeding Program of Brahman Breed (PMGRB) under management of the National Association of Breeders and Researchers (ANCP). Heritability and variance components were estimated by restricted maximum likelihood using bi-trait models. The models considered the effects of contemporary groups as fixed and age of dam, at calving as covariate (linear and quadratic) and the genetic direct animal effect and permanent environment of the cow effect as random. The genetic maternal effect was also included for BW, W120 and W210. Estimates of direct heritability ranged from 0.28 to 0.41 for BW, from 0.36 to 0.52 for W120, from 0.36 to 0.46 for W210, from 0.40 to 0.41 for W365, from 0.33 to 0.35 for W455 and from 0.28 to 0.36 for W550. Genetic correlations between BW and the other weights ranged from 0.51 to 0.79, between W120 and subsequent weights from 0.78 to 0.93, between W210 and subsequent weight from 0.98 to 0.99, while the estimates between W365 to W455 and W550 were 0.99 and 0.98, respectively, and between W455 and W550, 0.98. The results showed all traits could be used as selection criteria. The genetic correlation indicated that selection applied to any trait would bring change in the others. Weaning weight (W210) is the more appropriate trait for selection criterion for the Brahman breed.

KEY WORDS: Body weight. Genetic correlation. Heritability. Relative efficiency of selection.

RESUMO

Os objetivos foram estimar parâmetros genéticos para os pesos ao nascer (PN), aos 120 (P120), 210 (P210), 365 (P365), 455 (P4555) e 550 (P550) dias de idade e eficiências relativas de seleção indireta versus direta entre as referidas características, para bovinos da raça Brahman, no Brasil. Foram analisados 15.664, 7.432, 6.585, 4.223, 3.362 e 2.517 dados de PN, P120, P210, P365, P455 e P550, respectivamente. Os componentes de variância e as herdabilidades foram estimados pelo método de máxima verossimilhança restrita, em modelos bicaracterísticas. Foram considerados como efeitos fixos grupos de contemporâneos e idade da vaca ao parto como covariável (efeitos linear e quadrático) e, como aleatórios, o efeito de animal e de ambiente permanente da vaca. Para PN, P120 e P210 considerou-se ainda o efeito aleatório genético materno. As estimativas de herdabilidade direta variaram de 0,28 a 0,41 para PN, de 0,36 a 0,52 para P120, de 0,36 a 0,46 para P210, de 0,40 a 0,41 para P365, de 0,33 a 0,35 para P455 e de 0,28 a 0,36 para P550. As correlações genéticas entre PN e os demais pesos variaram de 0,51 a 0,79, entre P120 e os pesos subsequentes, de 0,78 a 0,93, entre P210 e os pesos subsequentes, de 0,98 a 0,99, enquanto que entre P365 com P455 e P550, foram 0,99 e 0,98, respectivamente, e entre P455 e P550, 0,98. As caracteristicas estudadas podem ser usadas como critério de seleção e as correlações genéticas estimadas indicaram que, ao se selecionar os animais para qualquer uma das características, automaticamente promoverá também respostas nas demais. O P210 em termos de eficiência relativa de seleção indireta seria o mais indicado como critério de seleção, com a ressalva de que esse peso não apresentou efeito materno importante.

PALAVRAS-CHAVE: Correlação genética. Eficiência relativa de seleção. Herdabilidade. Peso corporal.

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INTRODUCTION

Increasing competitiveness in the Agribusiness Sector is a reality in Brazilian cattle industry. The search for economically productive breeds has led farmers to invest more in applying new technologies. Moreover, globalization has exposed the national product to foreign competition, thus emphasizing the need to increase productivity.

Animals that have greater longevity, high reproductive efficiency, efficient food conversion, and belong to types and patterns that will transmit to their descendants a desirable carcass composition should be selected as breeders in order to increase herd productivity. The expression of these characteristics is due to two factors: genetics and the environmental conditions to which the animal is submitted. In modern production systems, it has become easy to use performance information to determine animal genetic potential and its ability to respond to the environment. Therefore, it is necessary to produce superior quality beef using production systems that are able to maintain cost effectiveness during several generations.

To develop a breeding program it is necessary to know the estimates of heritability and genetic correlations among traits of interest. These parameters determine the selection strategies to be adopted. In some situations, direct selection for one trait may lead to higher response to another trait, even higher if selection had been applied in the latter. This mechanism is called correlated response to genetic gain resulting from indirect selection applied to another trait (TURNER & YOUNG, 1969).

Heritability estimates, in Nellore breed, for standard weights at 205, 365 and 550 days old, reported by Ribeiro et al. (2001) were 0.16±0.05; 0.40±0.11 and 0.76±0.2, respectively; while the genetic correlations among these weights varied from 0.28 (PÁDUA & SILVA, 1994) to 0.91 (SOUZA & RAMOS, 1995). As age intervals decreased, estimates increased.

Therefore, the objectives of this study were to estimate genetic parameters for birth weight (BW), and at 120 (W120), 210 (W210), 365 (W365), 455 (W455), 550 (W550) days old as well, and relative efficiencies of indirect versus direct selection among these traits in Brahman cattle, in order to establish selection criteria for the breeding program of Brahman in Brazil.

MATERIAL AND METHODS

Animals and management

The analyzed data file consisted of a set of data of the animals participating in Programa de Melhoramento Genético da Raça Brahman (PMGRB), managed by National Breeders and Researchers (Associação Nacional de Criadores e Pesquisadores - ANCP), which included 43 herds located in the states of São Paulo (SP), Minas Gerais (MG), Mato Grosso (MT), Mato Grosso do Sul (MS), Tocantins (TO) and Goiás (GO).

The climate in these farms varied from equatorial; subtropical, hot and humid, to tropical humid.

Most farms adopted a breeding season that lasted from 60 to 90 days, from October to March, depending on the region and herd management level. Reproduction techniques such as artificial insemination, *in vitro* reproduction and embryo transfer, as well as bulls in natural service after first or second service, may also have been used in some farms. Calves were weaned at about 7 months.

The animals were born between 2000 and 2005, and weighed every 90 days (January, April, July and October) and at weaning from each batch as well. The weights of every animal were standardized to their ages by linear interpolation.

Statistical Analysis

Consistencies and statistical analysis were performed using SAS® (SAS 9.1, SAS Institute, Cary, North Carolina, USA). The consistency data supplied information of outliers, that is, animals from *in vitro* fertilization and embryo transfers, animals with no weight information, animals with unknown parents and bulls with less than five descendants belonging to contemporary groups (CG) with less than three animals. From the total of 19,442 Brahman animals, 15,664 resulted from information of birth weight (BW); 7,432 from weight at 120 (W120); 6,585 from weight at 210 (W210); 4,223 from weight at 365 (W365); 3,362 from weight at 455 (W455) and 2,517 from weight at 550 (W550) (Table 1).

The components of variance and covariance among studied traits were estimated by restricted maximum likelihood method under bi-trait animal models, using the computer program MTDFREML (*Multiple Trait Derivative-Free Restricted Maximum Likelihood*), described by Boldman et al. (1995). The models considered the effects of contemporary groups as fixed and age, of dam at calving as covariate (linear and quadratic) and genetic direct effect of animal as random. For all traits, dam permanent environment was considered as non-correlated random effect. Maternal genetic effect was included in the model as random for the traits birth weight, and weights at 120 and 210 days. The usual assumptions were valid in the models.

Contemporary groups were composed of animals of the same sex, born on the same farm, in the same quarter, in the same year and under the same diet.

Relative efficiency in terms of genetic gain, considering selection applied to a trait over another genetically correlated was estimated according to Turner & Young (1969), using the formula:

$$G = r_{a_i a_j} \times \sqrt{\frac{h_i^2}{h_j^2}}$$

where: $r_{a_i a_j}$ is the genetic correlation between the traits i and j; while h_i^2 and h_j^2 are direct heritability of traits i and j, respectively.

When G>1 indirect selection is more efficient and when G<1 direct selection is more efficient. The value of G indicates the proportion of decrease or increase in genetic gain for direct selection.

Genetic correlations ($r_{a_i a_j}$) between traits i and j were estimated as the ratio between estimated additive genetic covariance between them ($\hat{\sigma}_{a_i a_j}$) and the product of the respective additive genetic standard deviation ($\hat{\sigma}_{a_i}$ and $\hat{\sigma}_{a_j}$).

In some situations, when the convergence criterion of bi-trait analysis was not met, Pearson correlation was used to analyze the estimated genetic value by uni-trait analysis, as an approximate way of estimating the genetic correlations.

Table 1 - Number of observations, mean, minimum and maximum values, standard deviation and coefficient of variation of birth weight (BW), and weights at 120 (W120), at 210 (W210), at 365 (W365), at 455 (W455) and at 550 days (W550) for Brahman cattle in Brazil.

traits (kg)	Number of observations	Mean	Minimum	Maximum	Standard deviation	Coefficient of variation (%)
BW	15,664	33.10	15	60	4.17	12.60
W120	7,432	131.01	55	258	21.25	16.22
W210	6,585	192.08	75	339	34.34	17.88
W365	4,223	255.97	110	561	61.10	23.87
W455	3,362	295.88	80	684	72.04	24.35
W550	2,517	338.25	115	747	77.85	23.02

RESULTS AND DISCUSSION

Variance estimated means increased as age increased (Table 2). It is worth mentioning that information regarding heritability estimates for different traits of the Brahman breed is scarce, particularly in Brazil where the breed was introduced recently.

The mean estimate of heritability (h^2_a) observed in this study (Table 3) for birth weight was similar to the estimate of 0.37 reported by Parra-Bracamonte et al. (2006), also for the Brahman breed. On the other hand, for weight at 120 days of age, mean estimate of h^2_a (Table 3) was higher than the values reported by Garnero et al. (2001), Marcondes et al. (2002) and Rezende et al. (2005), of 0.26, 0.33 and 0.24, respectively, for Nellore.

Mean estimates of heritability for the weights at 210, 365, 455 and 550 days old (Table 3) were virtually identical to the values reported for Nellore, respectively by Rezende et al. (2005), Ribeiro et al. (2001), Marcondes et al. (2002) and Garnero et al. (2001).

These heritability estimates suggest that in the studied herds, phenotypic selection for both traits at weaning and yearling, would be effective.

Table 4 shows that with increasing age of standardized weight, genetic correlation values decreased, particularly for the weights from W210 on and BW (birth weight). This result is expected, since there is a partial-whole relationship between each pair of traits, because the previous weight is always contained in the last. Genetic correlation estimate between BW and W120 is close to the one reported by Mascioli et al. (2000), 0.73±0.07, for the Canchim breed. The estimate between BW and W210 was higher compared to the values reported by Nájera Ayala et al. (1991), 0.28, and by Pádua & Silva (1994), 0.34, for Nellore; however, lower that the value of 0.91 estimated by Souza & Ramos (1995), also for Nellore.

Because estimation of genetic correlation was positive between birth and weaning weights, this seems to suggest that selection based on heavier calves at birth should be an efficient technique to obtain heavier animals at 210 days old. Although this is not a recommended procedure due to the possibility of increasing the incidence of calving difficulty. Table 4 also shows that genetic correlations for weights at birth, and at 365, 455 and 550 days, suggest that selection based on these weights may also lead to increasing birth weight, and consequently, as aforementioned, the increased rate of dystocia in dams.

Estimates of genetic correlations for weights at 210, 365, 455 and 550 days old (Table 4) were also high, indicating that selection based on any of these weights, the response correlated in the others must be favorable and in the same direction. The estimates observed in this study for P210 and P550, and P455 and P550 were higher than the values obtained by Pádua & Silva (1994), 0.33 and 0.58, respectively, in Chianina x Nellore crossbreed.

Weaning weight showed moderate heritability and high genetic correlations with future weight (Table 4). Mascioli et al. (1996) suggested that weaning weight may be used as the first criterion for disposal, since it is also an indicative trait of the maternal ability of the cow, mainly related to milk production; however, one to be used with caution as single selection criterion for breeders. In the present study, maternal influence of W210 was small ($h^2_m = 0.05 \pm 0.01$).

Table 2 - Estimates of variance components, obtained by bi-trait analysis for birth weight (BW), and weights at 120 (W120), at 210 (W210), at 365 (W365), at 455 (W455) and at 550 days (W550) for Brahman cattle in Brazil.

Traits	Value intervals ($\hat{\sigma}_a^2$)	Mean $\hat{\sigma}_a^2$	Value intervals ($\hat{\sigma}_p^2$)	Mean $\hat{\sigma}_p^2$	Value intervals ($\hat{\sigma}_e^2$)	Mean $\hat{\sigma}_e^2$
BW	3.71 a 4.25	3.87	10.94 a 11.10	10.99	6.72 a 7.08	6.96
W120	116.18 a 189.11	163.78	333.07 a 375.96	363.72	166.20 a 223.44	186.44
W210	285.33 a 380.59	332.96	792.07 a 833.13	812.60	391.61 a 447.37	419.49
W365	608.11 a 611.68	609.98	1468.45 a 1546.25	1507.35	858.37 a 934.56	896.46
W455	670.56 a 676.64	673.60	1938.00 a 2021.63	1979.81	1261.18 a 1351.07	1306.12
W550	528.76 a 735.65	632.20	1916.76 a 2041.59	1979.17	1305.94 a 1384.78	1345.36

$\hat{\sigma}_a^2$ = additive genetic variance, $\hat{\sigma}_p^2$ = phenotypic variance, $\hat{\sigma}_e^2$ = residual variance

Table 3 - Estimates of direct heritability (h^2_a), obtained by bi-trait analysis for birth weight (BW), and weights at 120 (W120), at 210 (W210), at 365 (W365), at 455 (W455) and at 550 days (W550) for Brahman cattle in Brazil.

Traits	BW	W120	W210	W365	W455	W550	h^2_a mean
BW	0.38	0.41	0.46	0.41	0.35	0.28	0.38
W120	0.41	0.31	0.36	0.51	0.51	0.52	0.43
W210	0.46	0.36	0.36	*	*	*	0.41
W365	0.41	0.40	*	*	*	*	0.40
W455	0.35	0.33	*	*	*	*	0.34
W550	0.28	0.36	*	*	*	*	0.32

*Convergence criterion fulfilled, but overestimated values

Table 4 - Estimates of genetic correlations, obtained by bi-trait analysis for birth weight (BW), and weights at 120 (W120), at 210 (W210), at 365 (W365), at 455 (W455) and at 550 days (W550) for Brahman cattle in Brazil.

traits	W120	W210	W365	W455	W550
BW	0.79	0.62	0.60	0.54	0.51
W120		0.93	0.78	0.78	0.82
W210			0.98*	0.99*	0.99*
W365				0.99*	0.98*
W455					0.98*

*Pearson correlations estimated between breeding values obtained by uni-trait analysis.

Weights at 365, 455 and 550 days showed moderate heritability estimates (Table 3) and high positive genetic correlations with other weights (Table 4). Therefore, these weights may be an effective selection criteria to obtain animals with higher meat production in Brahman herds. Moreover, the weights at 455 and 550 days represent a balance between the ability of early growth and adaptability, because at these ages the animals have already been through a dry and rainy season, when food shortages and overgrazing, respectively, have occurred. These weights have the added advantage of presenting a small maternal effect, since the animal was weaned about a year ago, and can, therefore, be considered an appropriate selection criterion.

In Table 5, it can be seen that indirect selection based on weight at birth would be less efficient than direct selection for weights at 120, 365, 455 and 550 days. The comparison between indirect selection based on weight at 120 days and direct selection for the weights in later ages, shows that indirect selection would be less efficient.

When the goal is selection for the weights at 455 and 550 days, it appears that indirect selection based on the weight at 210 days would be more efficient than direct selection for them, because of the high heritability of W210 and the high genetic correlation value. As for the weights at 455 and 550 days,, it appears that selection at 455 days would be more efficient to improve the weight at 550 days, than to select directly this weight. In view of this, it can be recommended that Brahman cattle, for economical reasons of time and space, have the selection based on the weight at 210 days (W210). Thus, the selection focused on this weight should enhance further development of the animals. Moreover, as already mentioned, the maternal effect on W210 (weaning) was not important in this work.

Table 5 - Relative efficiency estimates of indirect selection compared to direct selection for birth weight (BW), and weights at 120 (W120), at 210 (W210), at 365 (W365), at 455 (W455) and at 550 days (W550) for Brahman cattle in Brazil.

Correlated traits	Selection relative efficiency (G)
BW(1) x W120 (2)	0.71
BW (1) xW210 (2)	0.59
BW (1) x W365 (2)	0.58
BW (1) x W455 (2)	0.57
BW(1) x W550 (2)	0.55
W120 (1) x W210 (2)	0.98
W120 (1) x W365 (2)	0.83
W120 (1) x W455 (2)	0.90
W120 (1) x W550 (2)	0.98
W210 (1) x W365 (2)	0.99
W210 (1) x W455 (2)	1.08
W210 (1) x W550 (2)	1.12
W365 (1) x W455 (2)	1.07
W365 (1) x W550 (2)	1.09
W455 (1) x W550 (2)	1.01

(1) Direct selection   (2) Indirect selection

CONCLUSIONS

Growth traits analyzed displayed enough additive genetic variability to ensure that the response to the selection based on the phenotype is positive; when selecting any of these traits, there should be a favorable correlated response on the others, and weight at W210 days old could be used as a criterion to improve growth traits of Brahman cattle in Brazil.

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REFERENCES

BOLDMAN, K. G.; KREISE, L. A.; VAN VLECK, L. D.; VAN TASSEL, C. P.; KACHAMAN, G. D. **A manual of MTDFREML**. A set of programs to obtain estimates of variances and covariances [DRAFT]. Lincoln: Agricultural Research Service, 1995. 120p.

GARNERO, A. V.; LÔBO, R. B.; BEZERRA, L. A. F.; OLIVEIRA, H. N. Comparação entre alguns critérios de seleção para crescimento na raça Nelore. **Revista Brasileira de Zootecnia**, v.30, n.3, p.714-718, 2001.

MARCONDES, C. R.; GAVIO, D.; BITTENCOURT, T. C. C.; ROCHA, J. C. M. C.; LOBO, R. B.; BEZERRA, L. A. F.; TONHATI, H. Estudo de modelo alternativo para estimação de componentes de (co) variância e predição de valores genéticos de características de crescimento em bovinos da raça Nelore. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.54, n.1, p.93-99. 2002.

MASCIOLI, A. S.; ALENCAR, M. M.; BARBOSA, P. F.; NOVAES, A. P.; OLIVEIRA, M. S. C. Estimativas de parâmetros genéticos e proposição de critérios de seleção para pesos na raça Canchim. **Revista da Sociedade Brasileira de Zootecnia,** v.25, n.1, p.72-82. 1996.

MASCIOLI, A. S.; FARO, L. E.; ALENCAR, M. M.; FRIES, L. A.; BARBOSA, P. F. Estimativas de parâmetros genéticos e fenotípicos e análise de componentes principais para características de crescimento na raça Canchim. **Revista da Sociedade Brasileira de Zootecnia**, v.29, n.6, p.1654-1660. 2000.

NÁJERA AYALA, J. M.; PEREIRA, J. C. C.; OLIVEIRA, H. N. Efeitos genéticos e não genéticos

sobre características ponderais de duas populações da raça Nelore. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.43, n.1, p.81-91. 1991.

PARRA-BRACAMONTE, G. M.; MARTINEZ-GONZÁLES, J. C.; TEWOLDE-MEDHIN, A.; GONZÁLEZ-REYNA, A.; BIONES-ENCINIA, F.; GARCIA-ESQUIVEL, F.; CIENFUEGOS-RIVAS, E. G. Alternative models in genetic parameter estimation of weaning weight of registry Brahman cattle from Mexico. In: 8th WORD CONGRESS ON GENETICS APPLIED TO LIVESTOCK PRODUCTION, 2006, Belo Horizonte, Brasil. **Proceedings…**, 2006, CDRom.

PÁDUA, J. T.; SILVA, R. G. Avaliação genética do desempenho de bovinos mestiços Chianina x Nelore. 1. Fatores envolvidos e estimação de parâmetros genéticos. **Ars Veterinária**, v.10, n.1, p.15-25, 1994.

REZENDE, F. M.; FIGUEIREDO, L. G. G.; MOURÃO, G. B.; BALIEIRO, J. C. C.; CINTRA, D. C.; ELER, J. P.; FERRAZ, J. B. S. Estimativas de parâmetros genéticos para vigor ao nascimento e algumas características de desenvolvimento ponderal em bovinos da Nelore. In: 42ª REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 2005, Goiânia, Brasil. **Anais...** 2005, CDRom.

RIBEIRO, M. N.; PIMENTA FILHO, E. C.; MARTINS, G. A.; SARMENTO, J. L. R.; MARTINS FILHO, R. Herdabilidade para efeitos direto e materno de características de crescimento de bovinos Nelore no estado da Paraíba. **Revista Brasileira de Zootecnia**, v.30, n.4, p.1224-1227, 2001.

SOUZA, J. C.; RAMOS, A. A. Efeitos de fatores genéticos e do meio sobre os pesos de bovinos da raça Nelore. **Revista da Sociedade Brasileira de Zootecnia**, v.24, n.1, p.164-172, 1995.

TURNER, H. N.; YOUNG, S. S. Y. **Quantitative genetics in sheep breeding**. New York: Cornell University Press, 1969, 332p.