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ANIMAL PRODUCTION

Genetic trends for mature body weight, visual scores, and growth traits in Nellore cattle

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ABSTRACT: *Mature weight (MW) of cows is related to the costs of their production. Usually, cows with moderate MW are more efficient in challenging environments, such as those available in the production systems in Brazil. In the present study, the selection index comprises the following traits: conformation, finishing precocity, musculature at weaning (WC, WP, WM) yearling (YC, YP and YM), scrotal circumference at yearling (SC), days to gain 160kg from birth to weaning (D160) and 240kg after weaning (D240). This are related to birth weight gain at weaning (WG) and from weaning to yearling (YG). The mature (MW) and birth weight (BW) traits were not considered in the selection index. The aim of this study was to estimate the values for the genetic trends (GT) of some important selection (MW) and economic traits (BW). A bi-character analysis of MW and other characteristics was performed to estimate the (co)variance components and genetic parameters. The GT results obtained for MW were null (0.0065% or 0.02718kg per year) in the period 1990-2007. The GT values were determined for BW (-0.0650% or -0.02017kg), WG (0.0758% or 0.0865kg), YG (0.1051% or 0.11377kg), and MW (0.0393% or 0.11276kg) per year. The visual score values (in score units) were also determined for GTat weaning [WC (0.2310%; 0.00707), WP (0.3624%; 0.3623%),aWM (0.01149; 0.01087)] yearling [YC (0.3256%; 0.00990), YP (0.4795%; 0.01496),YM (0.5041%; 0.01457)] per year. Index-based selection was effective to promote genetic progress in WG, WC, WP, WM, YG, YC, YP, and YM characteristics keeping BW and MW constant.*
Key words: *beef cattle, productive traits, selection.*

Tendência genética para peso adulto, escores visuais e características de crescimento em bovinos de corte da raça Nelore

RESUMO: *O peso adulto das vacas (PV) está relacionado com os custos de produção. Em geral, vacas com PV moderados são mais eficientes em ambientes desafiadores, como aqueles disponíveis nos sistemas de produção no Brasil. No presente estudo, o índice de seleção compreende as seguintes características: conformação, precocidade e musculatura nas fases da desmama (CD, PD e MD) e sobreano (CS, PS e MS), circunferência escrotal no sobreano (CE), dias para ganhar 160kg do nascimento até a desmama (D160) e 240kg pós-desmama (D240), que estão relacionadas com os ganhos de peso do nascimento à desmama (GD) e, da desmama ao sobreano (GS). As características PV e PN não foram consideradas no índice de seleção. O objetivo deste estudo foi estimar os valores das tendências genéticas (TG) das importantes características de seleção (PV) e econômicas (PN). Para estimar os componentes de (co)variâncias e os dados genéticos, foram realizadas análises bi-caracter de PV com as demais características. Os resultados de TG obtidos para PV foram nulos (0,0065% ou 0,02718kg por ano) no período de 1990 á 2007. Os valores de TG foram estimados para PN (-0,0650% ou -0,02017kg), GD (0,0758% ou 0,0865kg), GS (0,1051% ou 0,11377kg) e PF (0,0393% ou 0,11276kg) por ano. Os valores dos escores visuais (em unidades de escore) foram determinados para TG à desmama [CD (0,2310%; 0,00707), PD (0,3624%; 0,3623%) e MD (0,01149; 0,01087)] e sobreano [CS (0,3256%; 0,00990), PS (0,4795%; 0,01496) e MS (0,5041%; 0,01457)] ao ano. A seleção baseada no índice foi efetiva para promover o progresso genético nas características de GD, CD, PD, MD, GS, CS, PS e mantendo PN e PV constantes.*
Palavras-chave: *bovinos de corte, características produtivas, seleção.*

INTRODUCTION

The productive and reproductive efficiency of beef cattle operations is directly related to the genotype and its capacity for adaptation to the environmental factors that characterize the production system (TEIXEIRA et al., 2006). However, this efficiency is not static, as it changes as a function of both production environment and farmers' economic requirements. In addition, they can determine new

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production parameters of genotypes that are already used in the production systems. Thus, these genetic parameters must meet new production targets, although the parameters are established.

The speed of these genetic changes is determined by selection accuracy and intensity, genetic variation, and generation interval, being directly proportional to the first three and inversely proportional to the fourth one (BOURDON, 2000). According to PITA & ALBUQUERQUE (2001), efficiency of genetic changes should be estimated by the responses to selection or genetic tendency of characteristics of economic interest. Selection efficiency can be assessed by direct response of the characteristics included in the selection index and responses correlated with economically important characteristics, such as birth weight (BW) and mature weights (MW) of cows, which are not included in the selection index. Monitoring these characteristics through genetic tendency and redirecting the selection criteria, if necessary, is of great importance for livestock profitability, as increase in birth weight is directly related to the increase indystocic delivery incidence (BELLOWS et al., 1971) and increase in cows' mature weight results in increased maintenance costs (DICKERSON, 1978). Thus, evaluating the impact of selection programs, growth characteristics, and weight gain on the herd frame size is essential.

Therefore, the aim of this study was to estimate and analyze the values for genetic trend of birth, yearling, and mature weights of cows, weight gains from birth to weaning and after weaning, and the conformation, finishing precocity, and musculature visual scores at weaning and yearling in a program for genetic improvement of Nellore cattle.

MATERIALS AND METHODS

The data used in this study were extracted from a genetic breeding program (Conexão Delta G) for Nellore cattle. The data for live weight (LW) in adult age were collected from 40,340 cows born in the period 1990-2007, in commercial herds distributed in the states of Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, São Paulo, and Tocantins. The pedigree file contained data from 397,900 animals, and 1,361 sires with 99 progenies/sire were used for trait weight gains from birth to weaning (WG), 1,178 sires (77 progenies/sire) for weight gain in the weaning-yearling (YG) period, and 624 sires (17 progenies/sire)for the end weight (MW).

On farms where these data were generated, the animals were selected based on an index formed by conformation, finishing precocity, and musculature characteristics at weaning and yearling, scrotal circumference at yearling, and days to gain 160kg from birth to weaning and 200kg in the post weaning-yearling periods.

The number of observations per characteristic, as well as their respective averages, standard deviations, and minimum and maximum values are shown in table 1.

Two-character analyzes were performed to estimate the (co)variance components and genetic parameters of the MW character, with the birth weight (BW), weight gains from birth to weaning (WG) and after weaning (YG), and final weight (MW; in kg) characteristics, conformation (WC), finishing precocity (WP), musculature (WM) scores at weaning and conformation (YC), finishing precocity (YP), musculature (YM) scores at yearling, and final index (INDF).

Scores for conformation (C), finishing precocity (P), and musculature (M) scores (1-5 range) were individually assigned to each animal, being related to the management group, and the highest notes indicate a stronger presence of the characteristic, as described by SEVERO (1994).

Animals were selected based on an index composed by the D160, WC, WP, WM, D240, YC, YP, and YM characteristics, scrotal circumference (SC), and D160 and D240 are the numbers of days to gain 160kg from birth to weaning and 240kg after weaning, respectively.

Herd, weighing year and season, and management group formed the contemporary groups (CGs) for the MW character. For other characteristics, the CGs were formed by animals of the same herd, birth year and season, sex, and management group.

The percentage weightings applicable on the standard expected progeny differences (EPD) of the characteristics included in the final index (INDF) are as follows: INDF = 25 D160 + 4 WC + 8 WP + 8 WM + 25 D240 + 4 YC + 8 YM + 8 YM + 10 SC.

For data analysis, a two-character animal model was employed (SHAEFFER, 2011), which is described by the equation:

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{X}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{X}_2 \end{bmatrix} \begin{bmatrix} \mathbf{b}_1 \\ \mathbf{b}_2 \end{bmatrix} + \begin{bmatrix} \mathbf{Z}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{Z}_2 \end{bmatrix} \begin{bmatrix} \mathbf{a}_1 \\ \mathbf{a}_2 \end{bmatrix} + \begin{bmatrix} \mathbf{W}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{W}_2 \end{bmatrix} \begin{bmatrix} \mathbf{m}_1 \\ \mathbf{m}_2 \end{bmatrix} \begin{bmatrix} \mathbf{S}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{S}_2 \end{bmatrix} \begin{bmatrix} \mathbf{p}_1 \\ \mathbf{p}_2 \end{bmatrix} + \begin{bmatrix} \mathbf{e}_1 \\ \mathbf{e}_2 \end{bmatrix}$$

where: $\mathbf{y}_1$ = phenotypic observation vector for character MW; $\mathbf{y}_2$= phenotypic observation vector for the second characteristic of the pair of characteristics (BW, WG, WC, WP, WM, YG, YC, YP, YM, and MW) analyzed; $\mathbf{b}_1$ = classification vector for fixed effects on MW of CG, body condition (1, 2, 3, 4, or 5), pregnancy

Table 1 - Number of observations, average, standard deviation, minimum and maximum values for the birth weight (BW), weight gain from birth to weaning (WG) and conformation (WC), finishing precocity (WP), and musculature (WM) at weaning and weight gain from weaning to yearling (YG) and conformation (YC), finishing precocity (YP), and musculature (YM) at yearling, mature weight (MW), and final index (INDF) characteristics.

Characteristics	Number of observations	Mean values	Standard deviations	Minimum values	Maximum values
MW (kg)	40.340	417.65	56.26	300.00	674.00
AGE (days)	40.340	5.88	2.88	2.00	20.00
BW (kg)	241.471	31.00	3.77	15.00	60.00
WG (kg)	339.963	144.12	26.38	41.00	367.21
WC (1-5 score)	285.632	3.06	1.07	1.00	5.00
WP (1-5 score)	285.640	3.17	1.10	1.00	5.00
WM (1-5 score)	285.638	3.00	1.12	1.00	5.00
YG (kg)	181.426	108.18	36.11	34.5	514.04
YC (1-5 score)	186.293	3.04	1.03	1.00	5.00
YP (1-5 score)	186.292	3.12	1.08	1.00	5.00
YM (1-5 score)	186.285	2.89	1.09	1.00	5.00
MW (kg)	137.562	286.69	45.94	143.76	618.63
INDF[a]	113.571	7.27	5.07	0.19	32.58

[a]The weighting factors of characteristics included in index calculation were defined for a base equal to 10, i.e., as if each animal was evaluated by 10 characteristics measured in their progenies. Thus, index 10 indicates that, on average, the animal is superior by one EPD standard deviation in every characteristic integrating the index.

stage (1, 2, 3, or 4), and cow age linear and quadratic co variable on the weighing day; $\mathbf{b_2}$ = classification vector for CG fixed effects on characteristics BW, WG, WC, WP, WM, YG, YC, YP, YM, and MW, and calf and cow ages linear and quadratic co variables; $\mathbf{a_i}$ = direct additive genetic effect vector for character i (i=1,2); $\mathbf{m_i}$ = maternal additive genetic effect vector for character i; $\mathbf{p_i}$ = maternal permanent environmental effect vector for character i; and $\mathbf{e_i}$ = random residual effect vector for characters i, $\mathbf{X_i}$, $\mathbf{Z_i}$, $\mathbf{W_i}$, $\mathbf{S_i}$ are incidence matrices relating the character i observations to the fixed, direct genetic, maternal genetic, and maternal permanent environmental effects, respectively. The maternal additive genetic and maternal permanent environmental effects were not considered in the statistical model for MW.

The direct additive genetic (σ_a^2) maternal additive genetic (σ_m^2), maternal permanent environmental (σ_p^2),and residual (σ_e^2) variance estimates were expressed as phenotypic variance proportions (σ_t^2), and $\sigma_t^2 = \sigma_a^2 + \sigma_m^2 + \sigma_{am} + \sigma_p^2 + \sigma_e^2$.

The direct (h_a^2) and maternal (h_m^2) heritabilities and permanent maternal (p^2) and residual (e^2) environmental effect were calculated by dividing the respective variances by the total variance, according to the equation $h_a^2 = \sigma_a^2/\sigma_t^2$, $h_m^2 = \sigma_m^2/\sigma_t^2$, $p^2 = \sigma_p^2/\sigma_t^2$, $e^2 = \sigma_e^2/\sigma_t^2$, respectively. The correlation between the additive direct and maternal genetic effects, was calculated by $r_{am} = \sigma_{am}/(\sigma_a\sigma_m)$.

The genetic trends for MW, WG, WC, WP, WM, YG, YC, YP, YM, BW, and MW were calculated by regression for the mean genetic (EPD x 2) value of cows as a function of birth year, weighing by the number of observations that generated each mean value. The Statistical Analysis System (SAS, v. 6) program (REG procedure) was used. The genetic values used were obtained in a two-character analysis of MW and the characteristics WG, WC, WP, WM, YG, YC, YP, YM, BW, and MW, by means using the digital mockup (DMU) software package, for analysis of multivariate mixed models (MADSEN et al., 2006).

RESULTS AND DISCUSSION

Results obtained in the period 1990-2007 are shown in table 2 and figure 1. They indicated a null genetic trend for PV of 0.02718kgyear^{-1}, which represents a genetic trend of 0.0065% year^{-1}.

For birth weight (BW), the genetic trend observed in the study population was negative (-20g year^{-1}) and its effect was significant ($P<0.0001$), representing -0.0650%/year (Table 2). This value is lower than that f reported by other authors (FERRAZ FILHO, 1997; VAN MELIS et

Table 2 - Direct heritability (h^2), annual genetic trend (GT) expressed in the character unit (GT/year) and relative to the phenotypic mean (GT%/year), significance (Pr>t) and determination coefficient (R²) of the live weight (MW), weight gain from birth to weaning (WG), weight gain after weaning (YG), conformation (WC), finishing precocity (WP), and musculature (WM) at weaning, conformation (YC), finishing precocity (YP), and musculature (YM) yearling, birth weight (BW) and yearling weight MW) characteristics.

Characteristics	h2	GT/year	GT (%)/year	Pr>t	R²
MW (kg)	0.45	$2.72 \pm 11.3\ 10^{-2}$	0.007	0.8123	0.004
WG (kg)	0.18	$8.65 \pm 1.03\ 10^{-2}$	0.076	<0.0001	0.816
WC (1-5 score)	0.18	$7.07 \pm 0.52\ 10^{-3}$	0.231	<0.0001	0.929
WP (1-5 score)	0.20	$1.15 \pm 0.07\ 10^{-2}$	0.362	<0.0001	0.949
WM (1-5 score)	0.17	$1.09 \pm 0.06\ 10^{-2}$	0.021	<0.0001	0.956
YG (kg)	0.18	$1.14 \pm 0.15\ 10^{-1}$	0.105	<0.0001	0.787
YC (1-5 score)	0.25	$9.90 \pm 0.73\ 10^{-3}$	0.326	<0.0001	0.918
YP (1-5 score)	0.27	$1.50 \pm 0.16\ 10^{-2}$	0.518	<0.0001	0.852
YM (1-5 score)	0.27	$1.46 \pm 0.16\ 10^{-2}$	0.504	<0.0001	0.839
BW (kg)	0.34	$-2.02 \pm 0.33\ 10^{-2}$	-0.065	<0.0001	0.697
MW (kg)	0.27	$1.13 \pm 0.36\ 10^{-1}$	0.039	0.0064	0.401

al., 2001), who estimated positive values of 80 and 70g year^{-1}, respectively. This indicated that selection for growth characteristics in the herd is not promoting an increase in birth weight, which it is desirable as high birth weights result in birth difficulties, longer anestrus period, and increase in cost of labor. WEBER et al. (2009) studied the Angus cattle and estimated a genetic trend of 17.5g year^{-1} for BW in the study population. This indicated a small genetic progress in the period studied and its effect was significant (P<0.0001), representing 0.0527% of the phenotypic average, although the increase in weight was low.

Regarding WG, YG, and MW growth characteristics, the annual increases were 0.08652, 0.11377, and 0.11276kg year^{-1}, respectively, which

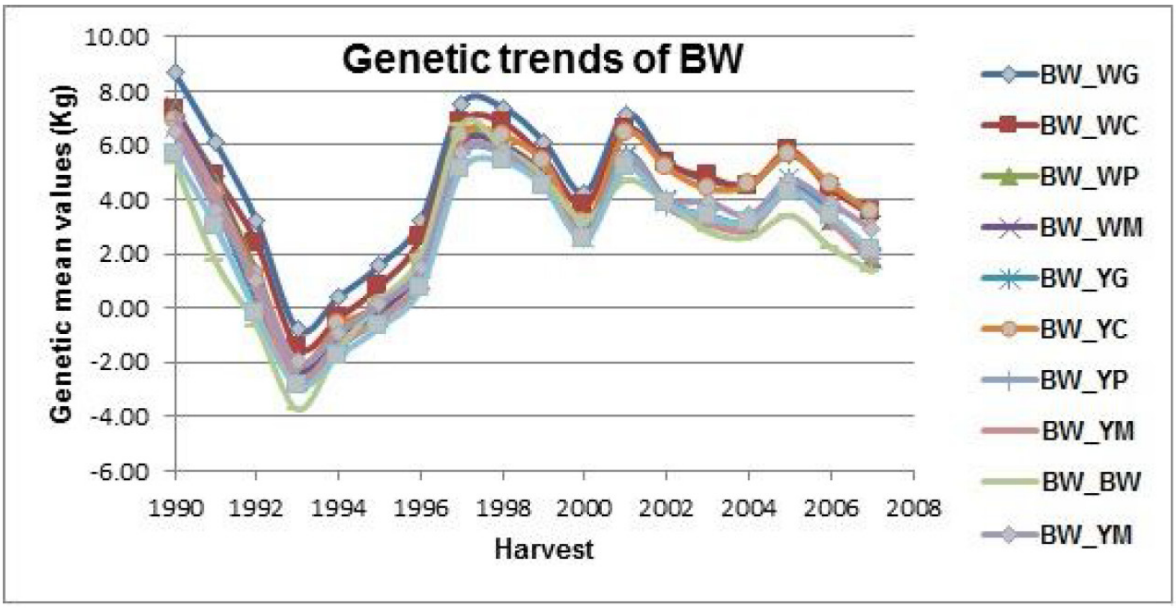

Figure 1 - Mean annual genetic values for body weight (BW) in two-character analysis with weight gain from birth to weaning (WG), conformation (WC), finishing precocity (WP), and musculature (WM) at weaning, weight gain after weaning (YG), conformation (YC), finishing precocity (YP), and musculature (YM) after weaning, birth weight (BW), and yearling weight (YW).

in percentage terms correspond to the annual values of 0.0758, 0.105, and 0.0393 %/year, respectively. LAUREANO et al. (2011) estimated the genetic changes for WG (0.186kgyear^{-1}) and YG (0.224kg year^{-1}), which corresponded to an annual average trend of 0.13 and 0.22%, respectively.

The genetic trend for MW was 0.112kg year^{-1}, which reaches a cumulative value of about 2kg in the period studied. These values are lower than those obtained by LAUREANO et al. (2011), who reported a trend of 0.219kg year^{-1}, corresponding to an annual increase of 0.08% (or 5kg) in genetic change in the study period. In figure 2, a trend for stabilization can be observed in the MW genetic values since 2001, which could be attributed to an increased use of moderate-size (and weight) bulls in the program.

Genetic trends estimated for weight gains from birth to weaning (WG) and from weaning to yearling (YG) and yearling weight (MW) showed favorable values. These characteristics are not included in the selection index, but they are positively correlated with D160 and D240. In the present study, the correlations between EPD in weight gain (GS and YG) and days to reach certain weights (D160 and D240) were greater than 90% (data not shown).

Genetic trends were estimated (Table 2) for conformation (WC; 0.00707), finishing precocity (WP; 0.01149), and musculature (WM; 0.01087) at weaning in terms of score units per year. They represent annual genetic gains relative to phenotypic means (0.2310, 0.3624, and 0.3623%, respectively), indicating genetic progress in the selection by visual evaluation scores. FORNI et al. (2007) also reported conformation (0.013), precocity (0.022), and musculature (0.018) gains for Nellore cattle. They represent an increase (0.42, 0.67, and 0.60% per year respectively) relative to the phenotypic average and; are therefore, superior to those observed in the present study. Both cases indicate that genetic improvement of characteristics evaluated with visual scores is possible, and use of selection indices can contribute to genetic gain of greater expression.

Genetic trends for conformation (YC), finishing precocity (YP), and musculature (YM) at yearling are shown in table 2. During the study period, genetic gains were observed in score units for the YC (0.00990), YP (0.01496), and YM (0.01457) characteristics, corresponding to 0.3256, 0.517 and 0.5041% per year, respectively. These values are higher than those reported by VAN MELIS et al. (2003) for the YC (0.030), YP (0.031), and YM (0.030) scores. FORNI et al. (2007) and WEBER et al. (2009) stated that they have not found in the literature genetic trend estimates for visual scores that could serve as a basis for comparison.

The characteristics evaluated through scores (WC, WP, WM, YC, YP, and YM) as expected, especially those (YC, YP, and YM) evaluated yearling. The greater genetic trend values for visual scores compared to those for weight gain characteristics is

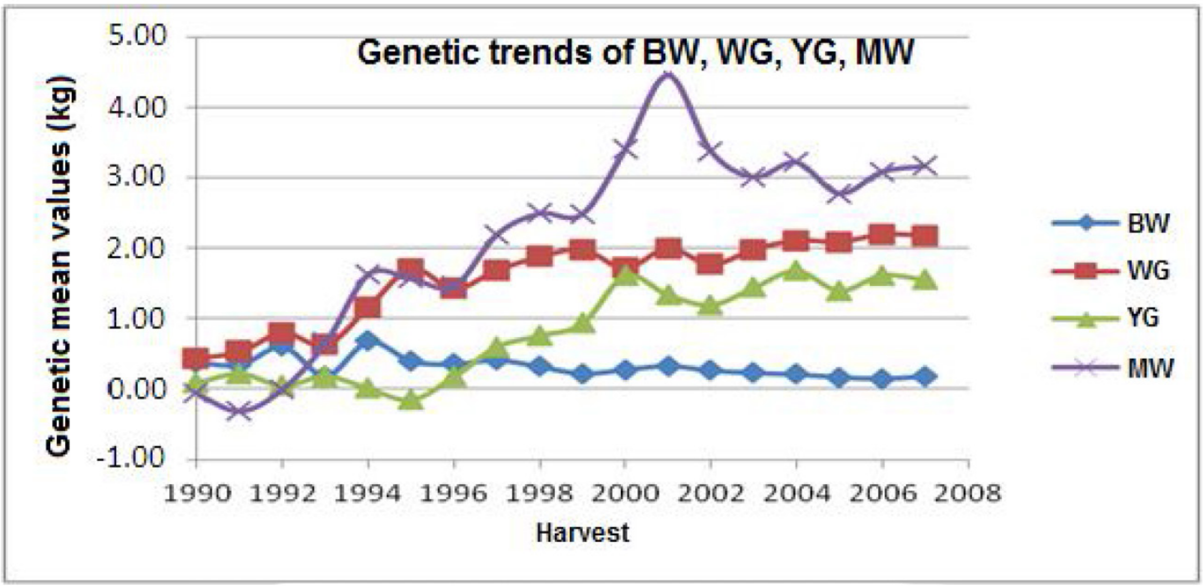

Figure 2 - Genetic mean values for birth weight (BW), weight gain from birth to weaning (WG), weight gain after weaning (YG), and yearling weight (MW) obtained in the two-character analysis with adult weight of Nellore cows.

in agreement to the heritability estimates, which were higher for visual scores.

CONCLUSION

Genetic trends for growth characteristics and visual scores indicated that a genetic progress has occurred in the herd during the evaluation period. Conversely, the genetic trend for birth weight was slightly negative and for cows adult weight was zero. These results indicated that the selection criteria used in this study were effective in the sense of improving animal performance, without significantly altering the birth and adult weights.

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