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Genetic parameters for pre-weaning traits in Braunvieh cattle

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ABSTRACT. The objective of this study was to estimate genetic parameters for pre-weaning traits of Braunvieh cattle raised under tropical conditions in Brazil. The weight and weight gain parameters were birth weight (BW, N = 9955), weight at 120 days of age (W120, N = 5901), weaning weight at 205 days (WW, N = 6970), weight gain from birth to 205 days (GAIN205, N = 6013), weight gain from birth to 120 days (GAIN120, N = 5135), and weight gain from 120 to 205 days (GAIN85, N = 4482). Variance components were estimated using the animal model with the MTDFREML software. The relationship matrix included 35,188 animals; phenotypic measures were available for 18,688. Direct and maternal heritability increased from birth to weaning, with estimates of 0.23 ± 0.037, 0.25 ± 0.050, 0.41 ± 0.059 for direct heritability for BW, W120 and WW, respectively, 0.08 ± 0.012, 0.15 ± 0.032, 0.22 ± 0.036 for maternal genetic effects, and 0.18, 0.14 and 0.16 for total heritability estimates. For pre-weaning gains, estimates of heritability were 0.36 ± 0.059, 0.30 ± 0.059, 0.12 ± 0.035 for direct genetic effects of the traits GAIN205, GAIN120 and GAIN85, respectively, 0.23 ± 0.038, 0.17 ± 0.037, 0.03 ± 0.029 for estimates of maternal heritability, and 0.12, 0.13, 0.16 for total heritability, respectively. Genetic correlations between weights were greater between measures taken at shorter intervals. This information can be used to optimize the design of programs for genetic improvement of Braunvieh cattle raised under tropical conditions.

Key words: Beef cattle; Genetic and phenotypic correlation; Heritability; Maternal effect; Suizo cattle; Weight gain

INTRODUCTION

To improve our genetic knowledge of cattle breeds, all phases of the development of the animal should be studied in detail. This study supplies information that helps in the correct selection of animals with better breeding values. In this context, the pre-weaning phase is of fundamental importance, where in this period the first records of performance can be collected and even the maternal ability and the maternal permanent environmental effects must be evaluated.

Several performance traits are considered important from birth to weaning. Birth weight (BW) is important because it can indicate eventual problems in calving, where calves can be too big or heavy. Studies in several breeds of beef cattle, including Braunvieh (Hagger and Hofer, 1990), have indicated that the selection of sires must avoid large breeding values for birth weight, due to the high correlation with calving problems. Campos et al. (1986) studied the genetic and environmental effects on birth weight in Braunvieh-Guzerat animals and concluded that sex, age of cow, and month and year of birth influence this weight.

During this initial development of the animal, when it still depends almost exclusively on the cow's ability to raise the calf, weight at 120 days (W120) is measured and this measure evaluates the maternal ability of the dam (Karsburg, 2003). The weight at this age is very dependent on milk yield of the cow and it is little influenced by environment according to Siqueira et al. (2003). However, there are not many studies on W120 in the literature.

Weaning, usually realized around seven months of age (around 205 days), indicates the end of direct influence of the cow on the calf. It is very important to measure weaning weight (WW) because approximately 50% of final weight is reached at weaning (Everling et al., 2001).

The growth of the calf is perhaps the most important factor for meat productivity in production systems (Corrêa et al., 2006). Weights and weight gains during the pre-weaning period reflect the general ability of cows to raise their calves, but also reflect the capability of development of the animal (Martins et al., 2000).

There are few reports about genetic parameters in Braunvieh cattle according to Bennett and Gregory (1996). These authors published one of the only works with this breed; however, they reported results with an experimental herd. To get better results in selection programs, it is necessary to determine genetic parameters and performance of breeding programs for each region (Cardoso et al., 2001).

Thus, due to the shortage of studies in this area with Braunvieh cattle, especially in the tropics, and the need to estimate the genetic parameters for each population, this study aimed to determine the heritability and genetic correlations for weights and weight gains in the pre-weaning period in this breed. To better understand animal development and the maternal effects in the pre-weaning period in Braunvieh cattle raised in the tropics, weight gain was measured for different periods from weights determined at 1, 120 and 205 days of age.

MATERIAL AND METHODS

The dataset used came from the Nucleus of Braunvieh Breeders of Brazilian Breeders Association of Braunvieh and Brown Swiss Cattle - ABCGPS. Analyses were carried out in the

Animal Breeding and Biotechnology Group of the College of Animal Science and Food Engineering, University of São Paulo, Brazil (GMAB - FZEA/USP).

The databank contained records from 28 farms located in Mato Grosso do Sul and São Paulo (tropical region) and Paraná and Santa Catarina States (sub-tropical region) in a total of 18,688 animals with records and 35,188 animals on pedigree (369 sires and 12,284 dams).

Traits analyzed were BW, W120 and WW, and weight gains from birth to 205 days of age (GAIN205), from birth to 120 days of age (GAIN120) and from 120 to 205 days of age (GAIN85). The criteria for the standardization of weights and weight gains can be observed in the work of Cucco (2008). Descriptive statistics of all traits are in Table 1.

Table 1. Descriptive statistics for weight and weight gains.

Traits	Records	CG	Mean	Coefficient of variation	Standard deviation	Minimum phenotype	Maximum phenotype
BW	9955	352	37.31	20.73	7.73	16.00	62.00
W120	5901	320	136.79	24.70	33.79	49.00	235.00
WW	6970	438	205.62	19.93	40.98	95.00	320.00
GAIN205	6013	376	166.97	21.73	36.27	67.28	270.28
GAIN120	5135	276	99.95	27.53	27.52	17.14	182.61
GAIN85	4482	323	70.76	26.81	18.97	18.59	123.72

Traits were measured in kg; CG = number of contemporary groups; Minimum and maximum value of phenotype evaluated in dataset. BW = birth weight; W120 = weight at 120 days of age; WW = weaning weight at 205 days; GAIN205, GAIN120, GAIN85 = weight gain from birth to 205 days, from birth to 120 days, and from 120 to 205 days, respectively.

Contemporary group (CG), class of age of the dam at calving, and breeding type (embryo transfer or not) were considered in the model as fixed effects. Direct and maternal heterozygosity, and age of animal at measurement were used as covariates. The contemporary group at birth contained farm, birth season, sex, and year of birth. The subsequent contemporary groups had all these effects plus management group at measurement. All contemporary groups with less than two sires and three animals were discarded due to lost of connectivity.

Age of dams at calving was classified into seven classes, divided by different ages of the dam. Age of recipients was also considered, because the maternal effect comes from them and not from the biological dam of the calf. This procedure aimed to better adjust the effect of maternal ability.

All fixed effects and covariates were analyzed using the GLM procedure (SAS, 2004), where the level of significance was set at $P < 0.05$. In all traits, box plot diagrams (SAS, 2004) were applied, to eliminate outliers from the dataset. The effects considered as random were direct additive genetic, maternal additive genetic, maternal permanent environmental, and residual effects. The mathematical model used was:

$$y = X\beta + Zu + Sm + Wc + e \qquad \text{(Equation 1)}$$

where y is the vector of dependent variables (BW, W120, WW, GAIN205, GAIN120, GAIN85); β is the vector of fixed effects; u is the vector of random effects of animal genetic value; m is the vector of random effects of maternal genetic value, c is the vector of random maternal permanent environmental effect, and e is the vector of random residual effect. Incidence matrices X, Z, S, and W relate phenotype with β, u, m, and, c effects, respectively.

Single- and two-trait analysis were carried out using MTDFREML - multiple trait derivative free restricted maximum likelihood (Boldman et al., 1995). The convergence criterion was simplex variance of 10^{-9}. Several reboots were performed with parameters estimated in the previous round until no change was observed in the last decimal of the log -2 λ for two consecutive reboots. Heritability for total genetic merit, h^2_t, was obtained according to Willham (1972).

RESULTS AND DISCUSSION

Variance components and genetic parameters for pre-weaning weights are presented in Table 2. Maternal proportion of variance (c^2) effect was smaller at birth and increased thereafter, reaching a maximum value at weaning, when maternal effect had accumulated. This should have been a consequence of the milk yield and maternal ability of the cow or the recipient cow.

Table 2. Variance components and genetic parameters of weights from birth to weaning in Braunvieh cattle.

Parameter	BW	W120	WW
Variance components			
σ^2_a	4.18	97.94	256.36
σ^2_m	1.44	57.53	140.26
$\sigma_{a,m}$	-1.16	-49.71	-151.84
σ^2_c	1.25	27.28	25.56
σ^2_e	12.17	252.74	357.61
σ^2_p	17.89	385.78	627.96
Genetic parameters			
h^2_a	0.23 ± 0.037	0.25 ± 0.050	0.41 ± 0.059
h^2_m	0.08 ± 0.012	0.15 ± 0.032	0.22 ± 0.036
h^2_t	0.18	0.14	0.16
$r_{a,m}$	-0.47 ± 0.106	-0.66 ± 0.092	-0.80 ± 0.057
c^2	0.07 ± 0.019	0.07 ± 0.029	0.04 ± 0.027
e^2	0.68 ± 0.030	0.66 ± 0.040	0.57 ± 0.044

σ^2_a = the additive variance; σ^2_m = the maternal variance; $\sigma_{a,m}$ = the covariance between additive and maternal effects; σ^2_c = the variance of maternal permanent environmental effect; σ^2_e = the residual variance; σ^2_p = the phenotypic variance; h^2_a = the direct heritability; h^2_m = the maternal heritability; h^2_t = the total heritability; $r_{a,m}$ = the genetic correlation between direct and maternal effects; c^2 = the fraction of total variance that corresponds to maternal permanent environmental effect; e^2 = the fraction of total variance that corresponds to environmental variance. For other abbreviations, see legend to Table 1.

The proportion of phenotypic variance due to direct genetic effect (h^2) was similar at birth and at 120 days of age, but showed a notable increase at weaning. This result demonstrates that the animals' genes have a greater impact at this age, with the animals becoming less dependent on the dam. The proportion of phenotypic variance due to maternal permanent environmental effect of the dam (c^2) remained unchanged, with a slight decrease at weaning, when calves are less dependent on dam when compared to previous periods.

The analysis of the three weights resulted in negative covariances between direct and maternal genetic effects, with increased absolute value from birth to weaning. Residual effects, expressed as the proportion of phenotypic variance due to residual (e^2), were similar at birth and at 120 days of age, and reduced at weaning, when they explained 57% of the phenotypic variance.

Direct and maternal heritability estimates for BW were similar to those reported by Marques et al. (1999) in Simmental cattle. However, these authors presented a different value for total heritability (0.31). This was due to the larger genetic correlation between direct and maternal effects estimated in the present study. Direct heritability for BW close to 0.30 was described by Corrêa et al. (2006), in Devon cattle. Nevertheless, Wilson et al. (1986) reported 0.19 for heritability of BW in Angus cattle, and they had doubts about the quality of the dataset for birth weight collected by breeders. This could have also happened in the present study, as the coefficient of variation was greater than 20%.

For W120, estimates of direct and maternal heritability were similar to those observed in Santa Gertrudis cattle by Karsburg (2003), and total heritability was very close to the estimate of 0.12 obtained by Marques et al. (1999) in Simmental cattle. Total heritability was similar at all ages in this study, although heritability for direct additive genetic effect (h^2) increased with age. This was due to the increase in absolute values of the negative covariances between direct and maternal effects, which affects estimation of total heritability.

In a review paper about genetic parameters in cattle under tropical conditions, Lôbo et al. (2000) reported an average heritability for weight at weaning of 0.30, lower than that in the present study. Maternal heritability for WW was higher than those reported by Koots et al. (1994). Eler et al. (1996) studying weaning weights in Nellore cattle raised in similar environments reported estimates for direct heritability of 0.29 and maternal heritability of 0.08, lower than the estimates of the present research.

Direct and maternal variance components and genetic parameters for weight gains are reported in Table 3. Larger covariance components for direct and maternal effects were observed for GAIN120, and a little lower for GAIN205, but a smaller estimate was found for GAIN85. This reduction in additive genetic variance for GAIN85 is a consequence of the increased environmental effect in this period. Besides, with regard to the maternal effects, the calves become less dependent on their dams after 120 days of age.

Table 3. Variance components and genetic parameters of weight gains from birth to weaning in Braunvieh cattle.

Parameter	GAIN205	GAIN120	GAIN85
Variance components			
σ^2_a	200.91	99.75	29.08
σ^2_m	128.93	57.77	7.06
$\sigma_{a,m}$	-132.40	-56.82	2.36
σ^2_c	13.60	25.59	2.07
σ^2_e	351.98	208.12	192.47
σ^2_p	563.03	334.40	233.05
Genetic parameters			
h^2_a	0.36 ± 0.059	0.30 ± 0.059	0.12 ± 0.035
h^2_m	0.23 ± 0.038	0.17 ± 0.037	0.03 ± 0.029
h^2_t	0.12	0.13	0.16
$r_{a,m}$	-0.82 ± 0.059	-0.75 ± 0.081	0.17 ± 0.385
c^2	0.02 ± 0.029	0.07 ± 0.032	0.008 ± 0.036
e^2	0.63 ± 0.045	0.62 ± 0.046	0.83 ± 0.038

σ^2_a = the additive variance; σ^2_m = the maternal variance; $\sigma_{a,m}$ = the covariance between additive and maternal effects; σ^2_c = the variance of maternal permanent environmental effect; σ^2_e = the residual variance; σ^2_p = the phenotypic variance; h^2_a = the direct heritability; h^2_m = the maternal heritability; h^2_t = the total heritability; $r_{a,m}$ = the genetic correlation between direct and maternal effects; c^2 = the fraction of total variance that corresponds to maternal permanent environmental effect; e^2 = the fraction of total variance that corresponds to environmental variance. For other abbreviations, see legend to Table 1.

Variance of maternal permanent environmental effect in pre-weaning has a large influence on GAIN120, because the peak of milk yield occurs between 1 and 120 days of lactation. After 120 days and up to 205 days, the permanent environmental effect on weight gain is practically insignificant. Meyer et al. (1992) emphasize that the importance of this component increases in breeds with more milk yield potential. A large negative covariance between direct and maternal additive effects for GAIN205 and GAIN120 was found, but for GAIN85 this covariance was positive and small.

Weight gain from birth to 120 days needs more studies, because W120 is little measured in most breeds. The results of this research can be biased by the large number of embryo transferred calves in the dataset, nursed by crossbred recipients. As related to the trait GAIN85, the coefficients of heritability for direct and maternal effects of 0.12 and 0.03, respectively, were lower than that reported by Paneto et al. (2002) in Nellore cattle for weight gain between 120 and 240 days of age, where they observed 0.32 and 0.13 for direct and maternal heritabilities, respectively.

Direct and maternal estimates of heritability for GAIN205 are similar to those reported by Meyer et al. (1992) in a review study. However, the results presented in this paper were higher than those presented by Lôbo et al. (2000) in their review, as well as by Fernandes et al. (2002) studying Charolais cattle and Cardoso et al. (2001) with the Angus breed. All these studies reported a negative correlation between direct and maternal effects, which was also found in the present study.

According to Fernandes et al. (2002), when the correlation between direct and maternal effects is negative and high, the maternal heritability becomes substantial in the contribution to total heritability, as can be observed in Table 3. However, many breeding programs set this covariance at zero in genetic evaluations (Cardoso et al., 2001). This can explain lower genetic gains in several breeding programs and should be considered in Braunvieh cattle in Brazil.

Genetic and phenotypic correlations among pre-weaning weights are shown in Table 4. When measurements were closer in time, the genetic correlation observed was high. Phenotypic correlation followed the behavior of genetic correlation, but with generally lower values. Similar results were reported in the review by Lôbo et al. (2000). In general, high correlations between the weights were as expected, since the weight at the youngest age is a component of the weight at later age.

Table 4. Genetic correlation above diagonal and phenotypic correlation below diagonal for weights at different ages.

Trait	BW	W120	WW
BW	-	0.73 ± 0.078	0.76 ± 0.069
W120	0.60	-	0.91 ± 0.027
WW	0.54	0.78	-

For abbreviations, see legend to Table 1.

The highest genetic correlations were observed between the weight gain and the weight at the upper limit of weight gain (Table 5). Similar results were reported by Lôbo et al. (2000) and Mascioli et al. (2000), namely estimated genetic correlations of 0.96 and 0.97, respectively, for the correlation between WW and GAIN205.

Table 5. Genetic (r^2_g) and phenotypic correlation (r^2_p) between weights and weight gains.

Trait	GAIN205 r^2_g ; r^2_p	GAIN120 r^2_g ; r^2_p	GAIN85 r^2_g ; r^2_p
BW	0.70 ± 0.089 ; 0.50	0.65 ± 0.093 ; 0.53	0.28 ± 0.171 ; 0.10
W120	0.88 ± 0.039 ; 0.69	0.99 ± 0.002 ; 0.85	0.33 ± 0.140 ; 0.09
WW	0.99 ± 0.033 ; 0.88	0.88 ± 0.037 ; 0.75	0.67 ± 0.089 ; 0.58

For abbreviations, see legend to Table 1.

In selection for GAIN120 and GAIN205, it is necessary to observe the genetic value for birth weight of the selected animal, due to moderate genetic correlation between GAIN205 and GAIN120 with BW, to avoid high birth weights.

Lôbo et al. (2000) reported an average genetic correlation between BW and GAIN205 of 0.39, lower than that observed in this study on Braunvieh cattle. In Angus cattle, Cardoso et al. (2001) estimated a genetic correlation between BW and GAIN205 of -0.06. For all traits analyzed, phenotypic correlations were lower than genetic correlations, thus demonstrating the high importance of the genetic analysis before selection.

CONCLUSION

For pre-weaning weights, the coefficients of direct and maternal heritability increased from birth to weaning, while the permanent environmental effect decreased. Correlations between direct and maternal effect were always negative, and also increased from birth to weaning, contributing to lower total heritability, being higher at birth and lower at weaning.

Maternal effect was very important for GAIN120, and reduced for GAIN85. In this trait, the residual effect on variance of GAIN85 was greater than maternal genetic effects. A large negative correlation between direct and maternal components for GAIN120 and GAIN205 was estimated, but that was not found for GAIN85.

When measurements were closer, the genetic correlation observed was high. Genetic correlation between birth weight and other traits indicates that caution is necessary in selecting to prevent calving problems. Weight gain was strongly influenced by the weight of the upper limit of the gain. Therefore, the greater the weight at a determined age, the greater the weight gain will be up to this age.

This study will help to have a better knowledge about genetic aspects of pre-weaning growth traits in Braunvieh cattle, especially raised in tropical and sub-tropical areas, allowing new selection criteria to be included in breeding programs of this breed.

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