Additive, heterotic and recombination losses for direct and maternal effects in growth for British, Continental and Zebu crosses

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Summary

Individual and maternal additive and non-additive effects for weights taken every 3 months from birth to 36 months were estimated for Hereford (H/H), Angus (A/A), Salers (S/S) and Nellore (N/N). For the analysis 45.794 weight records from 4.050 animals (2.036 male and 2.014 females), were used. Data corresponds to 39 different breed combinations, H/H and A/A pure breed and 37 groups whit A/A, S/S and N/N crosses with H/H. Data was grouped into 754 contemporary groups defined by sex, year at birth, calving period, experiment, cow parity and the date of weight. Parameters were estimated through model were genetic crossbreeding effects based on Dickerson full model. British breeds provided improved combinations of additive effects, while Zebu breed provided larger values for heterosis and recombination loss. The benefit of using crossbred females is maintained until 3 years of age for British x British and British x Continental. The benefit is also maintained until 3 years of age for Zebu x British while proportion of British is larger than proportion of Zebu. Additive and non-additive effects relevance are maintained at least until 36 months of age. The best combination for growth until 36 months of age is obtained by F1 N/H females, given the maximum use of maternal heterosis and the use of half of the individual heterosis between these breeds, which compensates the negative additive effects of the Zebu breed.

Keywords: crossbreeding, beef cattle, non-additive effects

Introduction

Meat production depends on the combined effect of genetic resources, environment and the interaction between them. Crossbreeding is an effective tool to optimize these resources in specific environments, allowing local genetics resources to be combined with external and more profitable genetic resources. Some of the more relevant traits are growth and adult weight, which are associated with economically relevant traits like slaughter weight, maintenance requirements and reproduction (Boligon *et al.*, 2008).

For these traits, performance of crossbred cattle can be predicted, when, together with other information, the magnitude of additive and non-additive effects and their interactions are known. To estimate the additive effects (breed differences) and non-additive effects (dominance and epistasis), crossbreeding experiments are needed (Dickerson, 1969). This information is not available for semi-extensive or extensive grazing conditions.

The aim of the present study is to estimate these parameters to predict genetic performance for different British×British, Zebu×British and Continental×British crosses.

Material and methods

Data was recorded in two crossbreeding experiments carried out between 1993 and 2004 at a commercial farm "Capilla Vieja" owned by Caja Notarial de Seguridad Social, located in the department of Paysandú (Uruguay) at 32°13′ S and 57°21′ W.

Four breeds that are representative of different cattle origins or types were included in the two crossbreeding experiments: Hereford (H/H) and Aberdeen Angus (A/A) as representative of British breeds, Salers (S/S) as a Continental breed and Nellore (N/N) as Zebu breed. Both experiments were designed to estimate crossbreeding genetic parameters for the crosses British×British, Zebu×British and Continental×British (Gimeno et al., 1995)

Genetic groups

In this study 45.794 weight records from 4.050 animals (2.036 male and 2.014 females), were used. Data corresponds to 39 different breed combinations included in the following genetic groups (GG): Hereford and Angus pure breed, three simple crosses between AA, HH and NN sires with HH dams, 6 first backcrosses between AH, SH and NH, three F2 groups with AH, SH and NH, with F1 sires AH/A, AH/H, NH/H and SH/H and twenty other groups included second backcrosses, six groups with British breeds (A/H/(AH), H/A/(AH), H/AH/A, A/A/H/(AH), A/AH/AH, H/H/(AH)) eight with Salers and Hereford (S/H/(SH), H/S/(SH), S/S/(SH), H/SH/H, S/SH/H, SH/SH/H, S/S/S/(SH), SH/SH/SH) and six with different breed proportion of Nellore and Hereford (N/H/NH, N/N/NH, H/N/NH, H/NH/H, N/NH/H, NH/NH/NH). Most crossbred females were F1 crosses with different breed combinations. Number of animals decreases as the number of generations increases given the length of the productive cycles within a productive system where first calving occurs at three years of age.

For all combinations of H/H, breed groups with proportions of 0.25, 0.50 and 0.75 of S/S or N/N are present together with F2 crosses from H/H with all used breeds. F1 bulls were mated to female of same breed composition and to pure H/H females and in a lesser extent with females of breed composition different to 0.5. Further details of these experiments are available, in the study of gestation length, birth weight (BW) and weaning weight (WW) of Lema *et al*. (2011).

Traits

Crossbreeding genetic parameters were estimated for thirteen weights from birth (BW) to thirty-six months of age (W36). All intermediate weights are abbreviated as the age in month every 3 months followed by the letter W. Data was grouped into 754 contemporary groups defined by sex, year at birth (1993 to 2002), calving period (early = before October 1st, late = after October 1st), experiment (1,2), cow parity (primiparous, multiparous) and the date of weight. For BW the data was grouped by the same criteria except for date of weight.

All breed combinations were present until 12 months of age, at 24 months. The number of breed combinations was reduced to 35 at 24 months, and to 20 at 36 months of age. Animals with records are between 3.000 and 4.000 until 24 months of age, and then reduced to 1.683 at 36 months of age.

Statistical analysis

Genetic crossbreeding effects based on the full model of Dickerson (1969, 1973) were included as co-variables, with coefficients were calculated based on Wolf *et al.* (1995) The model included the following effects:

$$Y_{ntmo} = \sum_{i=A/A}^{S/S} \alpha_i^{*I}\, g_i^I + \sum_{j=A/A}^{S/S} \alpha_j^{*M}\, g_j^M + \sum_{i=A/A}^{S/S} \delta_{iH}^I\, h_{iH}^I + \sum_{j=A/A}^{S/S} \delta_{jH}^M\, h_{jH}^M + \sum_{i=A/A}^{S/S} ((4\,\alpha_i^I \alpha_H^I) - \delta_{iH}^I)\, r_{iH}^I + \sum_{j=A/A}^{S/S} ((4\,\alpha_j^M \alpha_H^M) - \delta_{jH}^M)\, r_{jH}^M + CG_{mt} + S_s + e_{ntmr}$$

where:

Y_{ntmo} corresponds to trait measured at the nth animal, of the sth sire and from the mth contemporary group. Subscripts i and j describes direct and maternal breed proportions respectively. α_i^I (α_j^M) direct (maternal) proportion of breed i(j) defined as the proportion of genes of i(j) breed in the calf (dam) (($\alpha_{i(j)}^I = \alpha_{i(j)}^P - \alpha_{i(j)}^M) * 0.5$). δ_{ii}^I (δ_{ii}^M) represents probability that at a random locus, alleles come from breed i and δ_{iH}^I,(δ_{jH}^M) represents probability that an allele is from breed i or from breed H/H respectively. All calculations are done in relation to H/H since A/A, S/S and N/N are only crossed with H/H, generating different composition of H/H, but not crossed between each other. These proportions are obtained from $\delta_{ii}^I = \alpha_i^P \alpha_i^M$ and $\delta_{iH}^I = \alpha_H^P \alpha_i^M + \alpha_i^P \alpha_H^M$ with $\sum_{i \le H} \delta_{ii}^I$. To avoid linear dependencies, direct and maternal proportions were expressed as differences to H/H. Individual g_i^I and maternal (g_j^M) are additive effects expressed as differences with H/H. The fitted non-additive effects were individual (h_{iH}^I) and maternal (h_{jH}^M) heterosis and individual (r_{iH}^I) and maternal (r_{jH}^M) recombination losses.

CG_{mt} are fixed effects of the contemporary group (m=1..754)

S_s is sire random effect, S_s~(0, σ_s^2)

e_{ntmr} is random error, e_{ntmr}~(0, σ_e^2)

Analyses were performed using REMLF90 (Misztal *et al.,* 2002).

Results and discussion

The additive and non-additive effects (individual and maternal), expressed as deviations to H/H, are presented in Figure 1 to 3. For BW, estimations are very similar to those obtained in the univariate analysis (Lema et al. 2011), with very slight differences.

In general, g_A^I are not different to H/H, while g_S^I are positive in all ages except for BW. For N/N, negative values were obtained for g_N^I, with a lower expected performance than the H/H breed in all ages (Figure 1).

Additive maternal effects are positive for A/A and S/S, and negative for N/N, which represents a worse expected performance for purebred Zebú dams in comparison to the other breeds. Considering all weights until 36 months of age in purebred breeds, S/S and A/A had an increased expected performance, due to additive and maternal effects in the case of S/S and due to maternal effects in the case of A/A compared to H/H. Meanwhile, N/N has a lower expected performance than H/H.

Individual and maternal heterosis between AH and SH were positive and similar for all traits, and h^I_{NH} is higher than any other breed combination at all ages. Maternal heterosis is positive for all combinations (Figure 2).

Individual recombination losses are negative and similar for AH and SH and larger for NH, r^I has an opposite behavior but of less magnitude. Maternal recombination losses are low and positive in most ages, for AH they are near 0, while positives until 12 months of age for SH and NH. r^I could reduce the positive effect of h^I in advanced crossbred generations, while positive r^Mwould maintain the benefits of using crossbred dams over a longer period (Figure 3).

Non-additive effects are expected to be higher when breeds are more distant, since they are expressed as a function of gene frequencies (Willham & Pollack,1984). Results obtained in this study were in agreement with this asseveration, verified by the distribution of the effects of h^I , h^M and also of r^I and r^M, mainly for Zebu breeds and in a lower extent for continental breeds. Absolute values of these effects are larger at all ages in comparison to British breeds.

For crossbreeding of N/N with H/H, higher proportions of zebu express in a larger extent the negative additive maternal effects that can reduce the positive impact of heterosis together with the maternal recombination loss.

A comprehensive evaluation of cow/calf enterprises demands crossbreeding parameters for other relevant traits including reproductive performance and mature weight of the breeding herd is needed. Furthermore, the analysis of other traits, such as carcass quality will provide the information needed to evaluate breeds and crossbreeding systems from a global perspective.

Conclusions

British breeds provided improved combinations of additive effects, while Zebu breed provided larger values for heterosis and recombination loss.

The benefit of using crossbred females is maintained until 3 years of age for British x British and British x Continental. The benefit is also maintained until 3 years of age for Zebu x British while proportion of British is larger than proportion of Zebu.

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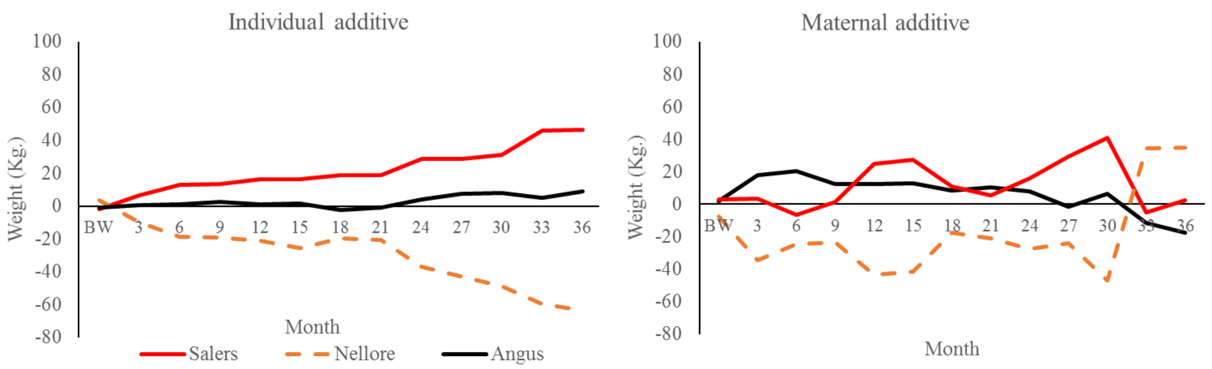

Figure 1. Direct and maternal, additive (as difference with Hereford) and non-additive effects for each weight

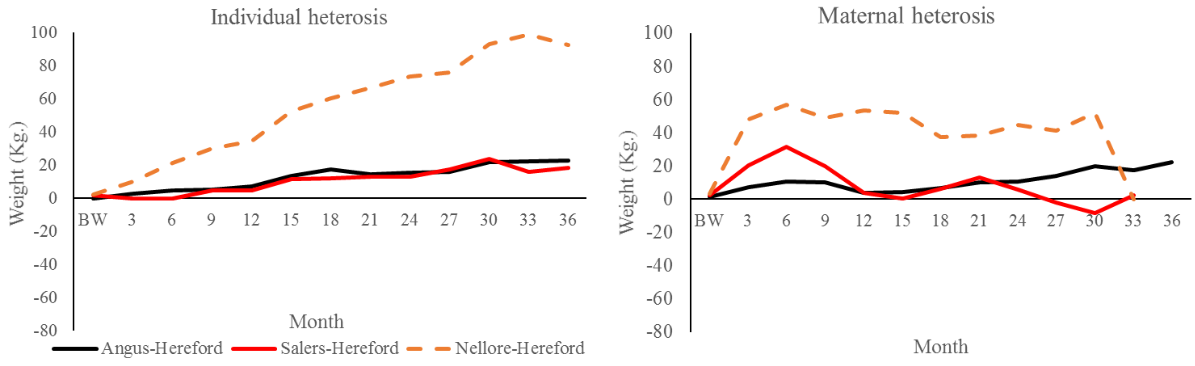

Figure 2. Individual and maternal heterotic effects (as difference with Hereford) for each weight

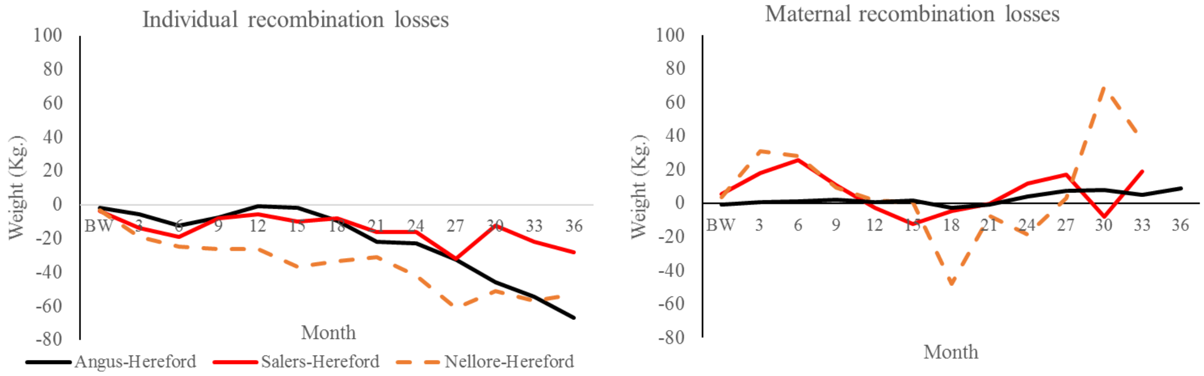

Figure 3. Individual and maternal recombination losses effects (as difference with Hereford) for each weights

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