Rev. Brasil. Genet. 15, 3, 595-601 (1992)
(Brazil. J. Genetics)

COMPARATIVE PERFORMANCE OF SIX HOLSTEIN-FRIESIAN X GUZERA GRADES IN BRAZIL. 6. BREED ADDITIVE AND HETEROSIS EFFECTS ON COMPONENTS OF FEED CONVERSION EFFICIENCY IN HEIFERS

F.E. Madalena[1], J.A.J. Paiva[2] and R.L. Teodoro[3]

ABSTRACT

Holstein-Friesian (HF) minus Guzera breed additive differences (*g*) and heterosis effects (*h*) were estimated for components of food conversion efficiency in 180 yearling heifers of six crossbred groups (1/4 to ≥ 31/32 HF), in six 112 d duration feeding trials. These were conducted in two treatments: A, based on chopped elephant grass fed in the rainy season; B, based on elephant grass silage in the dry season. Each treatment was replicated in three years (1979 to 1981), with five heifers per crossbred group per replicate. Average daily liveweight gains in treatments A and B were 533 and 314 g/d. In treatment A, *g*-estimates were positive for dry matter and crude protein intakes, both per animal and per unit liveweight, but were negative for daily gain and for daily gain adjusted for dry matter intake. HF direct gene effects were unfavourable for the feed/gain conversion ratio. Heterosis enhanced daily gain, feed intake per animal and feed conversion efficiency, but did not affect feed intake per unit liveweight. In treatment B, positive *g* and *h* estimates were found for crude protein intake per animal. For crude protein intake per unit liveweight, *g* was positive and *h* non-significant ($P > 0.10$) when adjusted for initial weight, but *g* was non-significant and *h* positive upon adjustment for initial age. For all other traits, similar results were obtained with age or weight adjustments. The additive-dominance model fitted the data for all traits in treatment A, but not for daily gain, crude protein intake per unit liveweight and food conversion ration in treatment B.

[1] EPAMIG, Departamento de Zootecnia, Escola de Veterinária, UFMG, Caixa Postal 567, 30161 Belo Horizonte, MG, Brasil. Send correspondence to F.E.M.
[2] EMBRAPA/EPABA-DPA, Av. Adhemar de Barros, 967, Ondina, 40000 Salvador, BA, Brasil.
[3] EMBRAPA-CNP-GL, 36155 Coronel Pacheco, MG, Brasil.

INTRODUCTION

Feed cost is a major part of the cost of rearing dairy heifers. Differences between Holstein-Friesian x Guzera crosses in components of feed conversion efficiency were shown in a previous paper (Paiva *et al.*, 1992). A genetic analysis of those differences is presented in this paper.

MATERIAL AND METHODS

Six feeding trials of 112 day duration were conducted during two seasons replicated over three consecutive years (1979 to 1981), with 180 yearling heifers of six red and white Holstein-Friesian (HF) x Guzera (Gu) crossbred groups. These were F_1, first backcross to Gu, first, second and fifth or higher backcrosses to HF, and 5/8 HF from inter se matings. The design was balanced, with five heifers per group in each replicate (i.e., 30 heifers per replicate and 90 per season).

Chopped elephant grass (*Pennisetum purpureum*, Schum.) was fed in the rainy season and elephant grass silage in the dry season, both *ad libitum*. Concentrates were fed in both seasons to attain target daily liveweight gains of 0.5 and 0.3 kg/d in the rainy and dry seasons. Since there were feed differences associated with seasons the joint effects will be referred to as "treatments" (A = rainy, B = dry season). All heifers in a replicate trial received the same amount of concentrates, but this amount was periodically adjusted (on an individual basis) to attain target liveweight gains.

Individual liveweight gains, consumption of food dry matter (DM), crude protein (CP), and acid detergent fiber (ADF) were recorded. A detailed description of methods and experimental animals was given by Paiva *et al.* (1992).

Data were analysed by least squares methods using the LSMLMW Programme (Harvey, 1987). The following (additive-dominance) model was fitted separately within each treatment:

$$Y_{ijk} = \mu + gq_i + hz_i + R_j + bx_{ijk} + \varepsilon_{ijk} \qquad \text{(Model 1)}$$

where Y_{ijk} represents a trait of the i-j-k heifer, q_i is the expected proportion of HF genes and z_i the expected proportion of loci with one gene of each breed, in individuals of the i crossbred group (i = 1, ... , 6), R_j is the fixed effect of the j replicate year (j-1, ... , 3), and x_{ijk} is either the initial weight or the initial age of the i-j-k animal in alternative analises. *g*, *h* and b are the partial regression coefficients of Y_{ijk} on q_i, z_i and x_{ijk}. Values of q_i and z_i are in Table I.

Goodness of fit of the above model was tested against that of a second model, (Model 2) in which the genetic regression terms $gq_i + hz_i$ were replaced by the crossbred group classification effect (Madalena, 1989). The rationale of models to describe crossbred performance may be found in Eisen (1989).

Table I - Expected fraction (q) of individual Holstein-Friesian (HF) genes and expected fraction (z) of loci with one gene from HF and one from Guzera (Gu).

Crossbred group	q	z
First backcross to Gu	1/4	1/2
F_1	1/2	1
Inter se 5/8 HF: 3/8 Gu	5/8	30/64
First backcross to HF	3/4	1/2
Second backcross to HF	7/8	1/4
Fifth⁺ backcross to HF	1*	0*

* Values assumed for genetic models, actual values $q \geq 31/32$ and $z \leq 1/16$.

RESULTS AND DISCUSSION

Average initial weights were 166 kg in both treatments. Averages for treatments A and B were, respectively: daily gains, 533 and 314 g/d; daily dry matter intake, per animal, 6330 and 4530 g/d, per kg liveweight, 32.5 and 25.1 g/d; daily crude protein intake, per animal, 569 and 402 g/d, per kg liveweight, 2.92 and 2.23 g/d, dry matter intake/gain ratio, 12.5 and 15.8 kg/kg.

Results for traits adjusted for initial weight and for initial age were very similar so that only the weight adjusted analyses are presented.

F-values for group class effects and for lack of fit of the additive-dominance model relative to the classification model are shown in Table II. With model 1, lack of fit was significant for four traits in treatment B: daily gain, actual and adjusted by DM intake, crude protein intake per unit liveweight and feed conversion ratio.

The estimates of breed additive differences and heterosis effects are presented in Table III. In treatment A, the *g* estimate for daily gain was negative, i.e., the direct effect of HF genes reduced growth, in comparison with the direct effect of Gu genes, while the effect of heterosis was positive. Under environmental conditions supporting higher growth rates than those of treatment A, a positive *g*-value would be expected from literature results (Paiva *et al.*, 1992). Intake of dry matter and crude protein per animal were increased by direct HF gene effects and by heterosis. Positive *g*-values were also observed for the intakes per unit of liveweight, but heterosis was not significant (Table III). The feed conversion ratio was increased by HF direct gene effects, i.e., feed conversion efficiency was decreased with increases in the fraction of HF genes.

Table II - F-values for tests of crossbred group class effects and for lack of fit of the additive-dominance model[1].

	df^2	Daily LW^3 gain		Dry matter intake		Crude protein intake		Dry matter
		non-adj.	adj^4	per day	per kg LW	per day	per kg LW	intake/gain
		F-values						
Treatment A								
Crossbred class	5	6.76***	9.25***	1.67	4.31***	2.36*	8.06***	6.07***
Lack of fit	3	1.19	1.37	0.68	0.89	0.92	2.18	1.19
Treatment B								
Crossbred class	5	2.65*	2.67*	1.04	1.00	1.58	4.81***	2.46*
Lack of fit	3	3.69*	3.92*	0.65	0.62	0.35	5.00***	3.82*

[1] Lack of fit - variation due to fitting group class over and above breed additive and heterosis regressions.
[2] Degrees of freedom for residual error - 81. For residual variances see Paiva *et al.* (1991).
[3] LW - liveweight.
[4] Adjusted for dry matter intake.
*, P < 0.05; **, P < 0.01; *** < 0.005.

Heterosis for feed conversion was not significant in treatment A (P = 0.12). However, heterosis approached significance (P = 0.06) for daily gain adjusted for dry matter intake, an alternative measure of the efficiency of food utilization for growth (Koch *et al.*, 1963). Residual coefficients of variation for adjusted gain were 0.133 and 0.181, respectively, in treatments A and B, as compared to those for the intake/gain ratio, 0.182 and 0.337. Heterosis tended to enhance feed conversion efficiency.

For two traits - dry matter intake per animal in treatment A, and crude protein intake per animal in treatment B - the crossbred group classification effects were not significant (Table II), but the *g* and *h* estimates were (Table III). Thus, although group means were apparently similar, the concealed breed additive differences and heterosis effects were detected by the use of model 1.

Table III - Estimates of Holstein-Friesian minus Guzera breed additive differences (*g*), heterosis effects (*h*) and standard errors (SE) for weight adjusted traits.

	Daily LW[1] gain		Dry matter intake		Crude protein intake		Dry matter intake/gain
	non-adj.	adj[2]	per day	per kg LW	per day	per kg LW	kg/kg
	g/d						
Treatment A							
g	-72	-133***	433*	3.13***	25**	0.211***	3.41*
SE	48	42	186	0.80	9	0.047	1.32
h	118	68+	355*	0.79	20**	0.021	-1.75
SE	40	35	155	0.67	7	0.039	1.10
Treatment B							
g	12	-22	173	0.94+	12*	0.076***	0.41
SE	39	33	114	0.54	4	0.029	0.31
h	40	8	163+	0.64	8*	0.025	-1.41
SE	32	27	93	0.44	4	0.024	2.51

[1] LW - liveweight.

[2] Adjusted for dry matter intake.

+ $P < 0.10$; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.005$.

The deviations of estimates of crossbred group means based on the additive-dominance model 1 ($\hat{Y}1_i$) from the group classification least squares means under model 2 ($\hat{Y}2_i$), expressed as 100 ($1-\hat{Y}1_i/\hat{Y}2_i$), were examined for the four traits in treatment B for which model 1 did not adequately fit the data. No particular association with the HF fraction was detected, but deviations for 5/8 and 7/8 HF were much larger than for other groups. For 5/8 HF, these deviations were 18%, 19% and -20%, respectively, for daily gain, DM adjusted daily gain and food/gain ratio, indicating that the additive-dominance model overestimated gain and feed conversion efficiency of this group. Conversely, these traits were underestimated for 7/8 HF, with corresponding deviations of -8%, -9% and 17%. It is difficult to explain why these two particular groups departed so markedly from the general trend.

The deviations for protein intake per unit liveweight in treatment B were rather small for all groups, ranging from -2.6% to +2.3%. Residual variation for this trait was small under both models, 1 and 2 (CV = 0.225 and CV = 0.211, respectively). Thus, in spite of the significant differences between goodness of fit of both models, we are inclined to accept the positive *g* - estimate of Table III.

F-values for crossbred group effects were generally lower than 1 for all three digestibilities (Paiva *et al.*, 1992). However, model 1 estimates approached significance for the digestibility of crude protein in treatment A (g = -9.81 ± 4.96, P = 0.05) and for the digestibility of acid detergent fiber in treatment B (h = -9.84 ± 5.15, P = 0.06).

The only important difference between age adjusted and weight adjusted estimates was found in crude protein intake per unit liveweight. Age adjusted estimates for this trait in treatment A were g = 0.089 ± 0.113 and h = -0.242 ± 0.093, so the significance of *g* and *h* was reversed with respect to the weight adjusted parameters (Table III), while the *g*-estimate in treatment B became non-significant (P > 0.05) upon age adjustment.

ACKNOWLEDGMENTS

While preparing this paper the senior author was a visiting Professor at the Department of Genetics, Faculty of Medicine, USP, Ribeirão Preto, through CNPq financing.

RESUMO

Foram estimadas as diferenças aditivas (*g*) entre as raças Holandesa (HF) e Guzerá e os efeitos da heterose (*h*), para componentes da conversão alimentar em 180 novilhas de ano, de seis grupos de cruzamento (1/4 a ≥ 31/32 HF), em seis provas de ganho de peso de 112 dias de duração. Estas provas foram realizadas sob dois tratamentos repetidos em três anos (1979 a 1981), com cinco novilhas de cada grupo em cada repetição. As médias de ganho de peso diário nos tratamentos A e B foram 553 e 314 g/dia. No tratamento A, as estimativas de *g* foram positivas para os consumos de matéria seca e proteína bruta, tanto por animal quanto por kg de peso vivo, mas foram negativas para ganho diário e para consumo de matéria seca ajustado por ganho diário. Os efeitos gênicos diretos de HF foram desfavoráveis para a conversão alimentar (alimento/ganho). A heterose melhorou o ganho diário, o consumo de alimentos por animal e a conversão alimentar, mas não afetou o consumo de alimentos por kg de peso vivo. No tratamento B, foram obtidas estimativas positivas de *g* e *h* para consumo de proteína bruta por animal. Para consumo de proteína bruta por kg de peso, *g* foi positiva e *h* não significativa (P > 0.10) quando se ajustou por peso inicial, mas quando se ajustou por idade inicial, *g* tornou-se não significativa e *h* positiva. Para todas as outras características foram obtidos resultados semelhantes ajustando por idade ou por peso inicial. O modelo aditivo-dominante foi adequado para todas as características no tratamento A, mas não o foi para ganho diário, consumo de proteína bruta por kg de peso e conversão alimentar no tratamento B.

REFERENCES

Eisen, E.J. (1989). Genetic models to predict crossbred performance. *Rev. Bras. Genet.* (Suppl.) *12*: 13-26.

Harvey, W.R. (1987). *LSMLMW. Computing procedures and applications*. Ohio.

Koch, R.M., Swiger, L.A., Chambers, D. and Gregory, K.E. (1963). Efficiency of feed use in beef cattle. *J. Anim. Sci. 22*: 486-494.

Madalena, F.E. (1989). Cattle breed resource utilization for dairy production in Brazil. *Rev. Bras. Genet.* (Suppl.) *12*: 183-220.

Paiva, J.A.J., Madalena, F.E., Teodoro, R.L. and Campos, A.T. (1992). Food conversion efficiency in six groups of Holstein-Friesian x Zebu crosses. *Livest. Produc. Scien. 30*: 213-222.

(Received July 18, 1991)