Rev. Brasil. Genet. 15, 1, 73-83 (1992)
(Brazil. J. Genetics)

COMPARATIVE PERFORMANCE OF SIX HOLSTEIN-FRIESIAN X GUZERA GRADES IN BRAZIL. 5. AGE AT FIRST CALVING

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ABSTRACT

As part of a trial on crossbreeding strategies, age at first calving of 463 Holstein-Friesian (HF) x Guzera (Gu) heifers (1/4 to ≥ 31/32 HF grade) was studied. Heifers were born between 1977 and 1981 at Santa Monica Experimental Farm, Valença, State of Rio de Janeiro, and were distributed to cooperator farms in Southeastern Brazil, at a mean age of 22 mo. Farms were grouped into high and low management level classes (5 and 58 farms respectively). Separate least squares analyses were performed within each class, using a model including farm-birth period and HF grade classification effects. In an alternative model, the latter were replaced by an additive dominance, additive x additive epistatic model. F_1 heifers had the lowest age at first calving, their superiority being more marked in the low management level farms. Estimates of breed additive difference (HF-Gu) were negative (i.e. favourable to HF), as were the dominance deviations, the latter being more important, especially for the low management level. Additive x additive epistatic deviations were significant ($P < 0.05$) in the low management level only.

INTRODUCTION

Age at first calving is an important economic trait influencing the cost of replacements. El Amin (1976) suggested that in the tropics first calving is delayed in european breeds due to feeding and management, and in zebus due to genetic factors.

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Crossbred group effects have been shown in several studies, F_1 generally having a better performance than other crosses of European x Zebu breeds (Freitas *et al.*, 1980; Rao and Taneja, 1980).

Published results were summarized by Cunningham and Syrstad (1987), who reported an average breed additive difference of -10.2 mo. in favour of European vs. local breeds, and an average heterosis of -5.2 mo. Barlow (1981) pointed out that for several traits, including sexual maturity, heterosis is more important under stressful conditions, which was confirmed for age at first calving by Syrstad (1985).

Information on the performance of breeds and crosses and estimates of inter-population genetic parameters is needed to predict crossbred performance aiming at the economic utilization of genetic resources (Dickerson, 1973; Eisen, 1989). In this paper, genetic effects on age at first calving were studied, as part of a more comprehensive trial aimed at the evaluation of crossbreeding strategies of Holstein-Friesian x Zebu (reviewed by Madalena, 1989).

MATERIAL AND METHODS

Animals and management

Data on age at first calving (AFC) of 463 females from six red and white Holstein-Friesian (HF) x Guzera (Gu) crossbred groups were studied. These groups (described in Table I) are referred to by their expected HF gene fractions: 1/4, 1/2, 5/8, 3/4, 7/8 and ≥ 31/32 or HF. Animals were born between March 1977 and December 1981 at the Santa Monica Experimental Station, Municipality of Valença, State of Rio de Janeiro. Calf raising was described by Teodoro *et al.* (1984). Heifers were distributed at a mean age of 22 mo. to commercial cooperator farms, for further evaluation. Farms were grouped into two classes - high and low management level (HML and LML) - with 127 and 336 observations, respectively. With a few exceptions, each farm received a batch of six contemporary heifers, one of each group. There were five HML and 58 LML cooperator farms. In addition, 97 heifers were retained at Santa Monica (HML), which were grouped into three contemporary batches, and 29 heifers were kept at another experimental farm (LML) and were grouped into two contemporary batches.

The number of sires in the HML were: 14 HF, four 5/8 and nine Gu, and corresponding numbers in the LML were, respectively 27, 8 and 15. In the HML 82.35 percent of the 5/8 heifers were sired by one bull. Sires in the HML were contained in the LML set. Other details on genetic background, management and climate were given by Lemos *et al.* (1984) and Madalena *et al.* (1990a). Abortions were not counted as calvings.

Table I - Description of Holstein-Friesian (HF) x Guzera (Gu) crossbred groups and expected proportions of HF genes (x_1), proportion of loci with one gene of each breed (x_2) and expected value of parental breed additive x additive epistatic effects recovered in crossbred (x_3).

Crossbred group	Description	x_1	x_2	x_3
		Experimental		
1/4	First backcross to Gu	0.250000	0.500000	0.625000
1/2	F_1 of HF sires x Gu dams	0.500000	1.000000	0.500000
5/8	*Inter se* matings	0.625000	0.468750	0.531250
3/4	First backcross to HF	0.750000	0.500000	0.625000
7/8	Second backcross to HF	0.875000	0.250000	0.781250
HF	Advanced backcrosses to HF	1.000000*	0.000000*	1.000000*
		Theoretical		
Crisscrossing				
1/3	Gu sire	0.333333	0.666667	0.555556
2/3	HF sire	0.666667	0.666667	0.555556
	Cycle mean	0.500000	0.666667	0.555556
Modified crisscrossing				
3/7	Gu sire	0.428571	0.857143	0.510204
5/7	HF sire	0.714286	0.571430	0.591836
6/7	HF sire, repeated	0.857143	0.285714	0.755102
	Cycle mean	0.666667	0.571430	0.619048

* - Values assumed for analysis, actual $x_1 > 31/32$.

Statistical analysis

Genetic models were tested separately for each management level because preliminary analysis showed significant crossbred group x management level interaction.

Data were analyzed by least squares techniques using procedure GLM of Statistical Analysis System (SAS, 1985). The following models were tested:

$$Y_{ijk} = b_o + g\,x_{1i} + d\,x_{2i} + gg\,x_{3i} + FB_j + e_{ijk} \qquad \text{Model 1}$$

$$Y_{ijk} = b_o + g\,x_{1i} + d\,x_{2i} + FB_j + e_{ijk} \qquad \text{Model 2}$$

$$Y_{ijkl} = b_o + g_k x_{1i} + d_k x_{2i} + FB_j + MT_k + e_{ijkl} \qquad \text{Model 3}$$

$$Y_{ijk} = b_o + G_i + FB_j + e_{ijk} \qquad \text{Model 4}$$

where,

Y_{ijk} (or Y_{ijkl}) represents age at first calving of the i-j-k-th (or the i-j-k-l-th) animal;
b_o = intercept;
g = breed additive difference (HF-Gu). In model 3 this parameter (g_k) was estimated within the F_1 and backcrosses only;
x_{1i} = expected fraction of HF genes for the i-th crossbred group ($i = 1, \dots, 6$);
d = breed dominance effect. In model 3 this parameter (d_k) was estimated within the F_1 and backcrosses only;
x_{2i} = expected fraction of loci with one gene of each breed, in individuals of the i-th crossbred group;
gg = breed additive x additive epistatic effects
x_{3i} = expected fraction of additive x additive epistatic effects in parental breeds that are recovered in individuals of the i-th crossbred group;
MT_k = effect of the k-th mating type ($k = 1$ for F_1 and backcrosses, $k = 2$ for *inter se*);
G_i = effect of the i-th crossbred group considered as a classification variable;
FB_j = effect of the j-th farm-batch class; and
e_{ijk} (or e_{ijkl}) = residual error, assumed NID.

Values of x_1, x_2 and x_3 are in Table I. Derivations of these were given by Dickerson (1973) and Eisen (1989). Model 1 corresponds to the model described by Koch *et al.* (1985), except that g is measured from the Gu breed and that the dam and grandam effects are ignored. Koch *et al.* (1985) discussed the relations between similar models found in the literature.

Model 3 was used by Madalena *et al.* (1990b) to avoid specifying a particular type of epistasis. Values of x_1 and x_2 for the *inter se* group were set to zero to run model 3. The d parameter in model 3 contains gg effects in F_1 and backcross data (Dickerson, 1973; Alenda *et al.*, 1980). Goodness of fit of models 1, 2 and 3 was assessed by F-tests on the mean squares due to fitting model 4 after each of those models (Robison *et al.*, 1981). Expected AFC under the crossbreeding strategies, discussed by Madalena *et al.* (1990b), was predicted by standard regression methods, utilizing the values of x_1, x_2 and x_3 shown in Table I.

RESULTS AND DISCUSSION

Effects of crossbred groups

Genetic group and farm-batch affected AFC in both management levels (Table II). Animals in the HML calved 149 d earlier than those in the LML (Table III), although differential environmental effects could only have an affect after distribution to cooperator farms, at a mean age of 22 mo.

Table II - F-values for model 4 analysis of variance.

Source	High management level			Low management level		
	df	F	Prob. > F	df	F	Prob. > F
Crossbred group	5	3.34	0.0075	5	11.66	0.0001
Farm-batch	8	3.55	0.0010	58	3.04	0.0001
RSD[1], (days)	113	(138.2)		272	(204.5)	

[1]Residual standard deviation.

Farm-batch effects ranged from +124.15 to -103.03 d in the HML and from +835.40 to -275.86 d in the LML. These effects will not be discussed further, since they were included in the models only to increase the precision of the genetic analyses.

Least squares means for genetic groups are in Table III. In both management levels the F_1 calved at the youngest age, although this superiority was more marked in the LML. Superior F_1 performance was also reported by other authors (Rao and Taneja, 1980; Alberro, 1983; Nobre, 1983; Hegade and Bhatnagar, 1985; Vij and Basu, 1986; Zinjarde *et al.*, 1987). In Brazil, Freitas *et al.* (1980) reported lower AFC for F_1 than for 3/4 HF: 1/4 Gir and for purebred HF under poor management. Junqueira Filho (1989) reported lower AFC for F_1 than for 3/4 and 7/8 HF x Gir crosses only during poor management periods. Nonetheless, Sacco *et al.* (1987) reported HF superiority over the zebu crossbreds under improved management. In their study, the AFC of Holstein heifers was 718 d, which was less than the 1273 d observed for HF in the HML (Table III). Thus, the HML may not be considered high in absolute terms. In a previous study (Teodoro *et al.*, 1984) estimated weight gain from birth to age at puberty of a sample of the HF heifers as 0.33 kg/d, much lower than recommended growth rates for intensive systems (e.g. 0.63 kg/d, Schmidt and Van Vleck, 1974). Differential parasite burdens between crossbred groups (Lemos *et al.*, 1985; Madalena, 1990), may also have contributed to crossbred group effects on AFC, since age at puberty is known to be adversely affected by tick and gastrointestinal parasite infestations (O'Kelly *et al.*, 1988).

Table III - Model 4 least squares means (LSM) and standard errors (SE).

Crossbred group	High management level			Low management level		
	N	LSM	SE	N	LSM	SE
			days			
1/4	28	1238	30	59	1384	27
1/2	23	1110	32	63	1190	26
5/8	17	1184	35	54	1445	28
3/4	17	1185	35	58	1300	28
7/8	26	1181	30	55	1410	28
HF	16	1273	36	47	1345	31
Mean/Total	127	1196	17	336	1345	12

The 5/8 *inter se* had the highest AFC in the LML. Poor performance of *inter se* groups has been generally found in the reports reviewed by Cunningham and Syrstad (1987), Syrstad (1989) and by Hegade and Bhatnagar (1985), while Parmar *et al.* (1986) found a lower AFC for F_2 than for F_1 crosses.

Genetic models

In the HML, all three regression models fitted the data as well as the classification model 4 (Table IV). However, neither the gg nor the MT terms of models 1 and 3 were significant. In the LML, on the other hand, only model 1 fit the data as well as model 4. Models to predict crossbred performance have been discussed by Eisen (1989).

The negative signs of g and d estimates (Table V) agree with published results indicating favourable heterosis and direct gene effects favourable to the European breeds (Parmar *et al.*, 1986; Cunningham and Syrstad, 1987; Martinez *et al.*, 1988; Mbap and Ngere, 1990).

Table IV - F-values for extra variation accounted for by fitting model 4 over and above models 1, 2 and 3 in the high management level (HML) and low management level (LML).

Model	Num.[1] df	HML	LML
1	2	0.75	2.61
2	3	0.67	7.19**
3	2	0.94	3.96**

1 Numerator of F value - (sums of squares, due to fitting the model 4 minus sums of squares due to fitting the regression models)/(d.f. due model 4 minus d.f. due to regression models). Denominator of F value - residual mean squares due to fitting the group class model.

** $P < 0.01$.

Table V - Estimates (b) of breed additive differences (g, HF-Gu), dominance effects (d) and additive x additive epistatic effects (gg), with standard errors (SE).

	Management level			
	High		Low	
	b	SE	b	SE
		days		
g	-126.8	60.5*	-80.3	65.9
d	-201.5	52.5***	-528.9	76.9***
gg	-	-	-625.5	155.5***

* $P < 0.05$.

*** $P < 0.002$.

The d/g ratios were 1.58 in the HML and 6.58 in the LML. Thus, although the crossbred group x management level interaction was not specifically tested, present results agree with Syrstad's (1985) analysis of literature results, indicating that heterosis is more important, relative to additive breed differences, in stressful environments, as suggested by Barlow (1981).

Epistatic effects were detected in the LML but not in the HML, although this difference should be interpreted with caution because of the large influence of one sire in the HML *inter se* group. Differential selection of parental breeds could result in different epistatic combinations accumulating over time (Griffing, 1960). However, the analysis of Cunningham and Syrstad (1987) did not indicate lack of fit of the additive-dominance model.

Model 2 was chosen to predict crossbred performance in the HML because it yielded lower standard errors of predicted values than models 1 and 3, while model 1 was adopted for the LML since it was the only regression model adequately fitting the data. Expected AFC under different crossbreeding strategies is shown in Table VI. Continuous F_1 heifer replacement would result in the lowest AFC. Conventional and modified crisscrossing (of HF sires for two generations followed by one generation of Gu sires) would result in similar AFC in both management levels. These strategies were the second best alternatives after the F_1. Poor results would be expected for a new breed derived from *inter se* matings of 5/8 HF, if no sire selection is made, and for a strategy of upgrading to HF. The implications of crossbreeding strategies in relation to overall performance in practical situations were discussed by Madalena *et al.* (1990b).

Table VI - Predicted performance for groups in rotational crossing (Y) and standard errors (SE)*.

Crossbred Group^{+}	Management level			
	High^{a}		Low^{b}	
	Y	SE	Y	SE
F_1	1105	29	1181	26
5/8	1197	17	1433	24
HF	1243	27	1357	27
	Crisscrossing			
1/3	1194	23	1336	19
2/3	1151	20	1309	16
Mean	1173	19	1323	14
	Modified crisscrossing			
3/7	1143	23	1256	19
5/7	1165	19	1333	16
6/7	1204	20	1371	16
Mean	1171	18	1320	13

a - Prediction under model 2; b - Prediction under model 1.

+ - Expected HF fraction.

ACKNOWLEDGMENTS

The second author (FEM) was a visiting Professor at the Department of Genetics, Faculty of Medicine, USP, at Ribeirão Preto, SP, Brazil, through CNPq financing.

Publication supported by FAPESP.

RESUMO

Com o objetivo de avaliar estratégias de cruzamentos entre Holandês e Zebu, foi estudada a idade ao primeiro parto (AFC) de 463 animais de seis graus de sangue Holandês: Guzerá (1/4 a ≥ 31/32 Holandês) nascidas entre 1977 e 1981, no Campo Experimental Fazenda Santa Mônica, Valença, RJ. Estas novilhas foram distribuídas com a idade aproximada de 22 meses, a cinco fazendas de nível alto e 58 de nível baixo de manejo, na região Sudeste do Brasil. Foram realizadas análises estatísticas por quadrados mínimos, para cada nível de manejo, cujo modelo incluiu o efeito de fazenda-período de nascimento e os grupos genéticos ou a proporção esperada de genes de Holandês, a proporção de "loci" ocupados por um gene de cada raça e o valor dos efeitos epistáticos aditivos x aditivos das raças paternas recuperados nos indivíduos de cada grau de sangue. As F_1 foram as mais precoces, em ambos os níveis de manejo, sendo sua superioridade mais marcante no baixo. A diferença aditiva entre Holandês e Guzerá e os efeitos da heterose foram negativos, diminuindo a AFC, sendo o efeito aditivo mais importante no nível alto e a heterose no baixo.

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(Received December 3, 1990)