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COMPARATIVE PERFORMANCE OF SIX HOLSTEIN-FRIESIAN x GUZERA CROSSBRED GROUPS IN BRAZIL. 4. RATE OF MILK FLOW, EASE OF MILKING AND TEMPERAMENT

F.E. Madalena[1], R.L. Teodoro[2], J.D. Nogueira[2] and D.P. Moreira[3]

ABSTRACT

Total daily milking time (MT), daily milk yield (DMY) and average rate of milk flow (MF = DMY/MT) were recorded in 142 cows at 27 farms, in the southeast region of Brazil. Milkers scored 88 cows for ease of hand milking (EOM, scale 1 = very easy milker to 5 = very hard milker) and 123 cows for temperament (T, scale 1 = very docile to 5 = very temperamental). Cows were of six red and white Holstein-Friesian (HF) x Guzera (Gu) crossbred groups, with the following expected HF gene fractions: 1/4, 1/2, 5/8, 3/4, 7/8 and $\geqslant$31/32 or HF. HF and 7/8 showed the highest MF but had intermediate DMY. Halfbreds and 3/4 had the highest DMY and intermediate MF. It is shown that they would give higher economic return in spite of their increased milking cost. The 1/4 and 5/8 had the lowest MF and DMY. MT was lower and MF higher for cows milked by hand than for machine milked cows. The interaction of crossbred group x milking procedure was not significant ($P > 0.05$). Estimates were obtained of the direct breed additive difference (g, HF-Gu) and heterosis effects (h). Significant ($P < 0.05$) estimates of g were obtained for DMY (6.51 $\pm$ 1.58 kg), MF (0.74 $\pm$ 0.23 kg/min), EOM (-1.69 $\pm$ 0.48 score units) and T (-2.96 $\pm$ 0.42 score units). Significant estimates for heterosis were obtained for MT (2.85 $\pm$ 1.16 min), DMY (5.56 $\pm$ 1.10 kg) and T (-1.07 $\pm$ 0.32 score units). Heterosis for MT became non-significant ($P > 0.05$) when adjusted for DMY. Variation due to genetic effects other than g or h was not significant ($P > 0.05$).

INTRODUCTION

Labour is a major component of milk production cost in systems with low inputs of concentrate feeds and mechanization. A study in Minas Gerais State indicated

[1] R. Teodoro Coelho, 365, 36050 Juiz de Fora, MG, Brasil. Send correspondence to F.E.M.
[2] EMBRAPA, CNP-Gado de Leite, 36055 Coronel Pacheco, MG, Brasil.
[3] EMBRAPA, UEPAE, 13560 São Carlos, SP, Brasil.

that labour inputs accounted for 24 to 32% of the operational cost in various milk production systems (Gomes *et al.*, 1980). In a demonstration farm, where hand milking and artificial rearing were practised, labour accounted for 32% of the operational cost (Souza and Lobato Neto, 1985) and 19% of total man/hours were spent on milking. Due to its economic importance, traits related to milking time were measured in a sample of animals pertaining to a more comprehensive crossbreeding trial described by Madalena (1981). Temperament was included in this study because of its relation to labour inputs.

The relative frequency of hand and machine milking varies between regions of southeast Brazil. For example, in the relatively industrialized municipality of São Carlos, SP, 27% of the dairy farms have milking machines (J. Ladeira, personal communication), while in some regions of Minas Gerais only 3% of the dairy farms practise machine milking (Costa *et al.*, 1982). Calves are generally utilized to stimulate milk let down by suckling briefly before milking, even in machine milking farms. Stripping is rare because calves usually suckle after milking. Costa *et al.* (1982) reported that 7% of farms practised artificial calf rearing.

In this article, differences between crossbred groups are presented for traits affecting milking time, along with estimates of breed additive differences and heterosis effects. These parameters are relevant to the design of breeding systems aimed at the utilization of breed resources (Dickerson, 1973).

MATERIAL AND METHODS

Animals and management

Heifers of six red and white Holstein-Friesian (HF) x Guzera (Gu) crossbred groups were distributed, for evaluation of dairy performance, to cooperator farms in the main milk producing areas of the southeast region of Brazil. Husbandry in this region is described by Madalena (1981).

The six crossbred groups are designated by their expected HF gene fraction: 1/4, 1/2, 5/8, 3/4, 7/8 and ⩾ 31/32 or HF. The halfbreds were F1 out of Gu dams by HF sires. The 1/4 and 3/4 were first backcrosses of F1 dams to, respectively, Gu and HF sires. The 7/8 were second backcrosses to HF sires and the 5/8 were obtained by *inter se* matings of 5/8 sires and dams. Numbers of sires for each group are in Table I. Further information on the genetic background of the cattle used is given by Lemos *et al.* (1984).

With a few exceptions, each cooperator farm received a batch of six contemporary heifers, one of each crossbred group. In addition, there were two experimental farms (where heifers were raised) keeping unequal numbers of each group. Farmers managed experimental animals in the same way they managed their own.

Table I - Numbers of cows, farms and sires for traits studied.

Trait			Holstein-Friesian gene fraction						Total
			1/4	1/2	5/8	3/4	7/8	HF	
Milking time, daily milk yield and average rate of milk flow	Manual milking	Cows	7	14	8	8	10	6	53
		Farms	7	13	7	8	9	6	17
	Machine milking	Cows	10	18	11	17	21	12	89
		Farms	3	9	8	7	7	5	10
	Total	Cows	17	32	19	25	31	18	142
		Farms	10	22	15	15	16	11	27
		Sires	9	14	6	12	12	11	(19)*
Ease of hand milking	Total	Cows	16	21	12	12	15	12	88
		Farms	15	19	11	11	14	11	21
		Sires	10	11	5	9	10	9	(16)*
Temperament	Total	Cows	23	28	16	22	17	17	123
		Farms	19	24	15	16	17	15	26
		Sires	12	13	6	12	12	13	(19)*

*Total number of HF sires of groups 1/2, 3/4, 7/8 and HF.

The following traits were measured in cows: total milking time (MT), daily milk yield (DMY), ease of hand milking (EOM) and temperament (T). MT was defined as the time elapsed between initiation and termination of milk removal. For machine milking, MT was the time interval between application of the first teatcup to removal of the last one, including stripping in the few cases when it was practised. Milk removal was initiated immediately after the initial calf suckling stimulus. All cows included in this study were milked twice a day and had all four quarters functional and free of clinical mastitis symptoms. MT and DMY were obtained adding up a.m. and p.m. records for each cow. Average rate of milk flow (MF) was obtained as the ratio DMY/MT. On recording days, cows were completely milked out, *i.e.*, no milk was left for the calves.

Milkers at each farm were asked to score cows for EOM on a scale of 1 = very easy milker to 5 = very hard milker. They also scored cows in a similar scale for T, from 1 = very docile to 5 = very temperamental.

All four traits, MT, DMY, EOM and T, were recorded upon a single visit to each farm. Cows in milk at the time of the visit were recorded for MT and DMY, and females that had calved at least once (parity ranged from 1 to 3), were scored for EOM and T. However, due to operational reasons, it was not possible to record all traits in all farms. MT and DMY were recorded in 27 farms, EOM in 21 and T in 26. Distribution of observations and farms for each trait are shown in Table I.

Statistical analysis

Three data subsets were formed to utilize all information available for MF (and MT and DMY), EOM and T. Data were analyzed by least squares using the computer programme of Harvey (1977) with all effects considered fixed.

The following models were used:

$$Y_{ijkl} = \mu + g(q_i - \overline{q}) + h(z_i - \overline{z}) + P_j + F_{jk} + \sum_{n}^{N} b_n (t_{ijkl} - \overline{t})^n + e_{ijkl} \qquad \text{Model 1a}$$

where:

Y_{ijkl} = represents MT, DMY or MF of the 1-th cow at the k-th farm using the j-th milking procedure and of the i-th crossbred group;

μ = represents the general mean;

q_i = is the expected proportion of HF genes of an individual of the i-th crossbred group (i = 1 to 6). q = 1 was used to the HF group. Mean was $\overline{q}$ = 0.676;

z_i = is the expected proportion of loci occupied with one gene of each breed in an individual of the i-th crossbred group. The z_i values for groups 1/4, 1/2, 5/8, 3/4, 7/8 and HF were respectively, 1/2, 1, 30/64, 1/2, 1/4 and 0 (Madalena, 1981). Mean was $\overline{z}$ = 0.491

P_j = represents the effect of the j-th milking procedure (j = 1, 2, for hand and machine milking, respectively);

F_{jk} = represents the effect of the k-th farm within the j-th milking procedure;

t = represents the stage of lactation (days), with mean $\overline{t}$ = 168;

N = was the exponent of the highest significant term for regressions on t, N = 2, 3 and 1 for MT, DMY and MF, respectively;

e_{ijkl} = is a random error assumed normal and independently distributed.

The g parameter corresponds to Dickerson's (1969) average direct individual gene effects for the HF breed, measured from the Gu breed. A linear restriction has to be imposed to estimate breed additive effects since the HF and Gu gene proportions add up to 1. The h parameter measures individual heterosis effects (Dickerson, 1969). The genetic model 1 is based on the model presented by Gardner and Eberhart (1966) and applied to crossbred cattle by Vencovsky *et al.* (1970). Robison *et al.* (1981) used multiple regression to estimate the interpopulation genetic parameters, including maternal and paternal effects. Genetic interpretation of these parameters was discussed by Eisen *et al.* (1983). In the present data, expected additive maternal gene proportions equalled $1-z_i$ for all crossbred groups except for the 5/8, and because of this partial confounding, heterosis estimates are valid on the assumption of nil maternal effects.

A second model was fitted (Model 2a) where G_i, the effect of the i-th crossbred group considered as a classification variable, substituted for the g and h terms in model 1a. Variation due to genetic effects other than g and h (such as epistasis, maternal or paternal heterosis, Kinghorn, 1980; Hill, 1982; Koch *et al.*, 1985) was estimated by the mean squares due to fitting model 2a over and above model 1a which was tested against model 2a residual mean squares. (Robison *et al.*, 1981).

To study effects independently of yield, MT and MF were also analysed substituting DMY for t in models 1a and 2a.

In preliminary analyses the crossbred group x milking procedure interaction was included in model 2a, but was not significant for either MT, DMY or MF ($P < 0.05$) and received no further consideration.

A similar analysis was performed for EOM and T, utilizing the following model:

$$Y_{ijk} = \mu + g(q_i - \overline{q}) + h(z_i - \overline{z}) + F_j + e_{ijk} \qquad \text{Model 1b}$$

where Y_{ijk} represents EOM or T for the k-th cow of the j-th farm and of the i-th crossbred group. Model 2b, with G_i substituting for the g and h terms was also fitted with the same purpose of model 2a. Contrasts were tested by the method of Scheffé (1959).

RESULTS

Cows in this study had a mean DMY of 7.34 ± 0.33 kg and were on average milked in 9.14 ± 0.34 min, mean MF being 0.87 ± 0.05 kg/min.

Analyses of variance are shown in Tables II and III, respectively for MT, DMY and MF under model 2a, and for EOM and T under model 2b. Crossbred group effects were significant for all five traits ($P < 0.05$). Deviations from models 1a or 1b due to

Table II - Analyses of variance for milking time, daily milk yield and average rate of milk flow.

Source	Milking time		Daily milk yield		Average rate of milk flow	
	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
Crossbred group	5	26.11*	5	41.04***	5	0.45*
Milking procedure	1	189.42***	1	11.09	1	0.37
Farms/hand milking	16	15.10*	16	16.80**	16	0.16
Farms/machine milking	9	58.24***	9	34.67***	9	1.06***
Stage of lactation						
Linear	1	237.57***	1	448.20***	1	2.00***
Quadratic	1	54.36*	1	171.18***	–	–
Cubic	–	–	1	52.41**	–	–
Residual	108	8.32	107	7.40	109	0.15
Crossbred groups after fitting g and h regressions	3	2.60	3	5.00	3	0.15

*P <0.05; **P <0.01; ***P <0.005.

genetic effects other than g and h were not significant for all traits. Milking procedure significantly affected MT only.

MT was much longer for machine milking than for hand milking, while the difference in DMY between both procedures was small (Table IV). MF was therefore

Table III - Analyses of variance for ease of hand milking and temperament scores.

Source	Ease of hand milking		Temperament	
	d.f.	m.s.	d.f.	m.s.
Crossbred group	5	2.17*	5	8.57***
Farms	20	0.95	25	0.76
Residual	62	0.68	92	0.70
Crossbred groups after fitting g and h regressions	3	0.55	3	1.60

*P <0.05; **P <0.01; ***P <0.005.

higher for hand milking, although the difference was not significant (P = 0.12). Farm/machine milking effects on MF ranged from +0.58 to -0.47 kg/min.

As may be seen in Table IV, 1/4 and 5/8 cows had relatively high MT but low DMY, showing the lowest MF means. Fls had the highest DMY, their MF being intermediate, and similar to that of 3/4 cows. HF and 7/8 cows had relatively low MT and DMY, but showed the highest MF. However, only extreme differences between crossbred group means were significant. The genetic situation is more clearly described by the additive-dominance models 1a and 1b. The g and h parameters are shown in Table V. The breed additive difference for MT was not significant, while heterosis was significant and positive, indicating longer MT at higher z values. These trends were reversed upon adjustment of MT for DMY: g became significant and of larger negative magnitude, while h became small and non-significant. A positive breed additive difference for MF indicates that this trait was enhanced by direct effects of HF genes.

Table IV - Least squares means (LSM) and standard errors (se) for Models 2a and 2b effects.

Effect	Milking time		Daily milk yield		Average rate of milk flow		Ease of hand milking		Temperament	
	LSM	se	LSM	se	LSM	se	LSM	se	LSM	se
	min.		kg		kg/min.		score[1]		score[2]	
Manual milking	7.47	0.49^{a}	6.93	0.46	0.95	0.07	–	–	–	–
Machine milking	10.81	0.49	7.74	0.46	0.80	0.07	–	–	–	–
Holstein-Friesian gene fraction										
1/4	9.41	$0.82^{a,b}$	5.11	0.77^{a}	0.64	0.11	3.10	0.22^{a}	3.39	0.19^{a}
1/2	10.89	0.55^{a}	9.37	0.52^{b}	0.91	0.07	2.37	$0.19^{a,b}$	2.01	$0.16^{b,c}$
5/8	9.31	$0.73^{a,b}$	6.59	$0.69^{a,b}$	0.71	0.10	2.54	$0.26^{a,b}$	2.54	$0.23^{b,c}$
3/4	8.94	$0.66^{a,b}$	8.28	$0.62^{a,b}$	0.95	0.09	2.53	$0.26^{a,b}$	2.10	$0.20^{b,c}$
7/8	8.19	0.61^{b}	7.15	$0.58^{a,b}$	1.03	0.08	2.25	$0.23^{a,b}$	2.09	$0.22^{b,c}$
HF	8.12	$0.77^{a,b}$	7.53	$0.73^{a,b}$	1.01	0.10	1.83	0.26^{b}	1.37	0.22^{c}
Mean	9.14	0.34	7.34	0.33	0.87	0.05	2.44	0.11	2.25	0.09

1. 1 = very easy milker to 5 = very hard milker.
2. 1 = very docile to 5 = very temperamental.
a,b Means with different superscripts differ significantly (P <0.05).

The g value was reduced upon yield adjustment, but was still significant (Table V). Heterosis was not significant for MF. Both g and h were positive, significant and of large magnitude for DMY.

Table V - Estimates of breed additive differences (g, Holstein-Friesian minus Guzera) and heterosis effects (h), with standard errors (se).

Trait	g	se	h	se
Milking time, min.	- 0.48	1.66	2.85	1.16*
Adjusted for yield	- 3.73	1.54***	0.24	1.12
Daily milk yield, kg	6.51	1.58***	5.56	1.10***
Average rate of milk flow, kg/min	0.74	0.23***	0.25	0.16
Adjusted for yield	0.41	0.18*	- 0.07	0.12
Ease of hand milking, score[1]	- 1.69	0.48***	- 0.44	0.37
Temperament, score[2]	- 2.96	0.42***	- 1.07	0.32***

1. 1 = very easy milker to 5 = very hard milker.
2. 1 = very docile to 5 = very temperamental.
*P $<$0.05, **P $<$0.01, *** P $<$0.005.

HF cows were scored as the easiest to milk by hand and the 1/4 as the hardest, the other groups receiving intermediate and similar scores (Table IV). Mean T scores were also lower for HF cows, higher for the 1/4 and intermediate for the other groups. EOM would be expected to decrease 1.32 score units for a change of 1 unit in q, *i.e.*, changing from Gu to HF (Table V). The breed additive difference for T was more marked, g = -2.96 score units. Heterosis for EOM was not significant (Table V). Heterosis for T was negative, *i.e.*, it increased docility.

DISCUSSION

Average rate of flow in this study was lower than that reported in the literature for high yielding cows. In five reports, mean yield per milking varied between 7.9 and 13.2 kg; average rate of flow - although not always defined in the same way - ranged from 2.0 to 3.0 kg/min and total machine time, between 4.4 and 7.4 min (Smith *et al.*, 1974; Tomaszewski *et al.*, 1975; White and Vinson, 1975; Miller *et al.*, 1976; Blake *et al.*, 1978). Wilson (1963) reported average rate of flow of 1.5 kg/min for cows yielding 4.9 kg per milking in New Zealand. Perez-Beato and Gutierrez (1985) reported rate of flow of 1.03 kg/min for Holstein cows yielding 8.7 kg/day in Cuba. Low rates of flow, similar to those found here, were reported by Johansson (1961) for cows in late lactation, yielding 3.0 kg per milking.

Present low MF values may be attributed to three causes: low milk yield, breeding and overmilking of machine milked cows. Yield at milking is known to influence rate of flow (Blake and McDaniel, 1978), which agrees with the regression equation $MF = 0.95 + 0.069\,(DMY - \overline{DMY}) - 0.003\,(DMY - \overline{DMY})$ from present data. Breeding is another possible cause of discrepancy with literature results, since Gu genes decreased MF. It would also appear that cows in this study were overmilked at most farms using machine milking, because, with this procedure MT was 3.4 ± 0.7 min longer than with hand milking, the additional time yielding only 0.81 ± 0.64 kg of milk. Yield adjusted MF was 0.23 ± 0.05 min longer with machine milking than with hand milking ($P < 0.01$). Only one farm practising machine milking (an experimental one) had values of DMY, MT and MF comparable to those reported by Wilson (1963): 10.28 kg, 6.59 min and 1.39 kg/min, respectively.

Breed differences in rate of flow were found by Schmidt and Van Vleck (1969), who reported Holsteins having higher average rate independent of yield than Brown Swiss and Ayrshires. Batra and McAllister (1984) also reported higher rate of flow independent of yield for Holsteins than for an Ayrshire-based red cattle synthetic line, but Donald (1960) found no breed differences for this trait. Pearson *et al.* (1977) reported similar uncorrected machine time for Holstein and crossbred cows, but the latter had lower yield. Nayak and Mishra (1984) reported higher hand milking time for Red Sindhi than for crossbred cows of similar milk yield.

Anatomical factors may have been involved in the breed difference in rate of milk flow, since the negative g estimate for EOM indicates that more force was needed to milk cows with lower HF gene proportion. Tautness of the teat orifice sphincter muscles has an important influence on rate of milk flow (Schmidt, 1971). Also, cows of higher HF grade had notoriously shorter and narrower teats. A negative association between teat length and rate of milk flow has been found by several authors (Schmidt, 1971; Blake and McDaniel, 1978). The breed difference in rate of milk flow may also have a physiological basis. Purebred zebus or crosses of low European grade are known to require the calf suckling stimulus to sustain lactation. Hayman (1973) reported some success of prolactin treatment in maintaining lactations of AMZ cows after calf removal. It should be mentioned in this context that two cases were recorded of F1 cows re-initiating milk let down upon approaching of their calves after milking had ceased, so the milking machine had to be re-attached.

Crossbred groups with higher yields were not the ones with higher rate of flow, contrary to the high positive correlation between these two traits found within

European breeds (Blake and McDaniel, 1978). An aggregate economic value for group i may be predicted by $\hat{H}_i = D\hat{M}Y_i m - \hat{M}T_i l$, where $D\hat{M}Y_i$ and $\hat{M}T_i$ represent the expected values under model 1a, *m* represents the gross margin for 1 kg of milk and *l* the cost of 1 min of labour. Values of *m* and *l* were obtained from data from a demonstration farm (Souza and Lobato Neto, 1985). Expressed in kg of milk, these were: $m = 0.48$ kg and $l = 0.03$ kg. Estimates of H_i were 4.0, 3.5, 3.3, 3.0, 3.0 and 1.9 kg of milk, respectively, for groups 1/2 3/4, 7/8, HF, 5/8 and 1/4. Thus, the extra benefits obtained from higher yielding crosses outweighed their increased milking cost. The ranking of crossbred groups on $\hat{H}_i$ did not change when the labour cost was quadruplicated ($m = 0.48$, $l = 0.12$).

Genetic effects on temperament are in agreement with results of Hearnshaw *et al.* (1979) and Fordyce *et al.* (1982), who reported that Brahman crosses had worse temperament than European breeds, judged by several objective and subjective criterions. However, Nayak and Mishra (1984) reported similar temperament scores for Red Sindhi and crossbred cows. Tractability of animals influences labour inputs, *e.g.* it takes more time to handle temperamental cattle in yards, to tie them up for milking and, particularly, to get them accustomed to milking facilities. Crosses of low HF grade in this study were often aggressive when recently calved. Measurement of labour inputs other than those required for milking were not attempted because the frequent recording we felt would be necessary to validate them was not feasible. Notwhithstanding, mean temperament scores for groups 1/2, 5/8, 3/4 and 7/8 were slightly higher than 2 (docile) indicating that milkers did not consider cows of these crosses hard to deal with.

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RESUMO

Foram registrados o tempo de ordenha diário (MT), a produção de leite diária (DMY) e o fluxo lácteo médio (MF = DMY/MT) de 142 vacas em 27 fazendas, na Região Sudeste do Brasil. A facilidade de ordenha manual (EOM) de 88 vacas e o temperamento (T) de 123 vacas foram avaliados subjetivamente pelos ordenhadores, em escalas de 5 pontos, respectivamente 1 = muito macia a 5 = muito dura e 1 = muito mansa a 5 = muito brava. As vacas eram de seis grupos de cruzamentos da raça Holandesa, vermelha e branca (HF) x Guzerá (Gu), com as seguintes frações esperadas de genes de HF: 1/4, 1/2, 5/8, 3/4, 7/8 e $\geqslant$31/32 ou HF. As HF e as 7/8 apresentaram o maior MF mas tiveram DMY intermédio. As 1/2 e as 3/4 tiveram o maior DMY e MF intermédio. Foi demonstrado que estes grupos dariam maior retorno econômico apesar de seu maior custo de ordenha. As 1/4 e as 5/8 tiveram o menor MF e o menor MY. O MT foi menor e o MF maior para as vacas ordenhadas manualmente do que para as ordenhadas mecanicamente. A interação de grupo de cruzamento x procedimento de ordenha não foi significativa ($P > 0.05$). Foram obtidas estimativas das diferenças diretas aditivas entre as raças (g, HF-Gu) e dos efeitos da heterose (h). As estimativas de g foram significativas ($P < 0.05$) para DMY (6.51 ± 1.58 kg), MF (0.74 ± 0.23 kg/min), EOM (-1.69 ± 0.48 pontos) e T (-2.96 ± 0.42 pontos). As estimativas de h foram significativas para MT (2.85 ± 1.16 min), DMY (5.56 ± 1.10 kg) e T (-1.07 ± 0.32 pontos). A heterose para MT tornou-se não significativa ($P > 0.05$) após ajuste para DMY. A variação devida a efeitos genéticos diferentes de g ou h não foi significativa ($P > 0.05$).

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