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Food conversion efficiency in six groups of Holstein-Friesian × Zebu crosses

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ABSTRACT

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Food conversion efficiency components in 180 yearling heifers of six Holstein-Friesian (HF) × Guzera grades (1/4 to ≥ 31/32 HF) were compared in two "treatments": (A) fresh chopped elephant grass during the rainy season and (B) elephant grass silage during the dry season. Concentrate supplement was fed to attain respective target liveweight gains of 0.5 and 0.3 kg/day. In both treatments daily gain adjusted for initial weight was higher for F1 and decreased as the HF fraction departed from 1/2. Because of small differences between grades in daily dry matter intake per animal, the food conversion ratio (food/gain) followed a trend inverse to the trend of liveweight gain. Results for age-adjusted traits were similar to those for weight-adjusted traits in treatment A, while in treatment B no significant grade differences were found for any trait ($P > 0.05$). Dry matter and crude protein intake per unit liveweight followed an increasing linear trend with higher HF grade in treatment A, but no trend was apparent in treatment B. F values for HF grade variation in the digestibilities of dry matter, crude protein and acid detergent fiber were < 1 in both treatments.

Keywords: heifers; Holstein-Friesian/Zebu crosses; food efficiency.

INTRODUCTION

Crossbreeding European × Zebu breeds is an important tool to increase the economic efficiency of tropical dairy production systems (e.g. Madalena et al., 1990a). To compare crossbreeding strategies, a trial measuring lifetime performance of females of six crossbred groups was conducted in Brazil (reviewed by Madalena, 1989).

Differences in food conversion efficiency between crosses of Zebu × European breeds might be expected due to breed effects on digestive

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and physiological processes (e.g. Preston and Leng, 1987). The experiment described in this paper was performed to provide information on food conversion characteristics of the six genotypes being compared in the main trial, utilizing a sample of heifers of that trial.

MATERIAL AND METHODS

Feeding trials were conducted at Santa Monica Experiment Station, Municipality of Valença, State of Rio de Janeiro, with 180 yearling heifers of six red and white Holstein-Friesian (HF) × Guzera (Gu) grades. Throughout this paper grade is the expected proportion of HF genes, the implicit complement adding up to 1 coming from the Gu breed. The six HF grades were: 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 were first backcrosses to Gu sires. The 3/4, 7/8 and HF were respectively first, second and fifth or higher backcrosses to HF sires. The 5/8 were obtained from inter se matings of 5/8 sires and dams. There were 17 HF sires, 14 Gu and eight 5/8. Further information on the genetic background of these animals was given by Lemos et al. (1984).

Six feeding trials were conducted in two seasons replicated over three consecutive years. Five different heifers of each grade were tested in each replicate (i.e. 30 heifers per replicate and 90 heifers per season). Experimental animals were chosen among larger contemporary groups on the basis of age and weight homogeneity. Although the average initial weights could be equalized in both treatments, heifers in treatment B were younger than in treatment A (Table 1).

The trials lasted 112 days, following a 14-day adjustment period. Heifers were kept in an adapted old pig nursery, in 3 × 2 m individual pens with access to 5.2 × 2.0 m external paddocks.

TABLE 1

Description of feeding trials

"Treatment"	A	B
Season	Summer	Winter
Elephant grass fed as	Fresh	Silage
Data replicate initiated 1	1 Feb. 79	18 Jul. 79
2	20 Dec. 79	11 Jun. 80
3	9 Dec. 80	14 Jun. 81
No. heifers per replicate	30	30
Days duration	112	112
Average initial age (months)	13	11
Average initial weight (kg)	166	166
Average daily gain (g/day)	533	314
Average roughage DM intake (kg/day)	4.66	2.80
Average concentrate DM intake (kg/day)	1.67	1.73

Target daily liveweight gains, chosen to be similar to those of the main trial, in the rainy and dry seasons, were, respectively, 0.5 and 0.3 kg/day. Chopped elephant grass (*Pennisetum purpureum* Schum.) was fed in the rainy season and elephant grass silage in the dry season, both ad libitum. 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 was periodically readjusted to attain target gains. Ration feed was composed of (g/kg): 615 ground maize grain, 350 cottonseed meal, 15 limestone and 20 mineral mix. The latter was composed (g/kg) of: 500.0 bone meal, 496.7 salt, 1.5 $CuSO_4$, 1.2 ZnO, 0.5 $CoSO_4$ and 0.2 KI, and was permanently available in addition to that fed in the ration. In the first replicate year of treatment A, only cottonseed meal was fed. Feed composition is shown in Table 2. Heifers were sprayed against ticks and treated for gastrointestinal parasites during the adjustment period. Management before initiation of feed trials was described by Teodoro et al. (1984) and climate by Lemos et al. (1984).

Average liveweight daily gain (DG) was calculated from 16 h fasting initial and final weights. Feed offered and refused was recorded daily; samples of both were taken thrice a week for determination of dry matter, crude protein (DM and CP, AOAC, 1970) and acid detergent fiber (ADF, Van Soest, 1963) on the composite weekly sample, to calculate daily dry matter (DMI) and crude protein (CPI) intakes, which were also expressed relative to mid-trial liveweight (DMI/LW and CPI/LW) Food conversion efficiency was measured by the food conversion ratio (FCR=DMI/DG). In vivo digestibilities of DM, CP and ADF were determined according to Andreasi et al. (1962). Heifers received 5 g Cr_2O_5 pellets twice daily (at 07.30 and 15.30 h) during the last 12 days of each feeding trial. Rectal fecal samples were taken daily during the last 7 days and frozen. Daily samples of food offered and refused were also taken. The digestibilities were based on the composite 7-day sample for each individual. Cr concentration was determined by atomic-absorption spectrophotometry following Williams et al. (1962).

TABLE 2

Feed composition

	Dry matter (%)	Crude protein	Acid detergent fiber
		←(% of DM)→	
Elephant grass fresh	21.4	5.2	48.0
silage	29.7	3.4	53.6
Ration	85.8	16.9	13.8
Cottonseed meal	86.9	30.5	36.9

TABLE 3

Analyses of variance (within treatments) of feed conversion efficiency components

Source	d.f.	DG	DMI	CPI	DMI/LW	CPI/LW	FCR	DMD	CPD	ADFD
		←F-values→								
		"Treatment" A: rainy season, summer, fresh chopped elephant grass								
Grade	5	6.76***	1.67	2.36*	4.31***	8.06***	6.07***	0.65	0.47	0.89
Replicates	2	35.52***	4.90**	2174.47***	1.24	1613.19***	26.54***	25.74***	0.93	10.10***
Initial weight	1	0.47	53.69***	51.86***	131.59***	563.33***	0.76	0.44	0.01	2.07
		"Treatment" B: dry season, winter, elephant grass silage								
Grade	5	2.65*	1.04	1.58	1.00	4.81***	2.46*	0.45	1.00	0.47
Replicates	2	12.02***	91.61***	23.89***	74.28***	28.77***	1.04	8.74***	71.72***	8.92***
Initial weight	1	4.08*	42.81***	32.42***	154.97***	969.77***	9.40***	0.18	0.01	0.18

		Residual standard deviations								
		DG (g/d)	DMI (kg/d)	CPI (g/d)	DMI/LW (kg/100 kg)	CPI/LW (g/100 kg)	FCR (kg/kg)	DMD (%)	CPD (%)	ADFD (%)
"Treatment" A	81	83	0.32	15	0.14	8	2.3	8.8	7.9	10.8
"Treatment" B	81	65	0.20	8	0.09	5	5.1	8.9	8.7	13.1

DG = daily gain, DMI = dry matter intake, CPI = crude protein intake, LW = liveweight, FCR = food conversion ratio, DMD, CPD, ADFD = digestibilities of dry matter, crude protein and acid detergent fiber.
*$P<0.05$, **$P<0.01$, ***$P<0.005$.

Data were analysed by least squares methods using the LSMLMW program (Harvey, 1987). The variances within treatments were not homogeneous for most traits (see below) and for this reason weighted analyses of variance were performed for each trait under a model including the (fixed) effects of grades, treatments, and replicate years within treatments, the grade×treatment interaction, and the linear regression of the trait studied on either initial age or initial weight. Because the grade×treatment interaction was significant for some traits (see below), separate analyses were performed for each treatment.

RESULTS AND DISCUSSION

Weight-adjusted traits

The grade×treatment interaction was significant for traits DG, CPI/LW and for FCR ($P<0.02$) and approached significance for DMI/LW ($P<0.08$).

The separate analyses of variance within treatments are presented in Table 3. Effects associated with replicate years influenced most traits but will not be discussed further since they were included in models only to increase the accuracy of the comparisons of genetic groups.

Residual variances were higher in treatment A than in treatment B for traits GD, DMI, CPI, DMI/LW and CPI/LW, and lower for FCR and fiber digestibility ($P<0.05$). Residual standard deviations are shown in Table 3.

Weight gain was higher in treatment A than in treatment B, as intended, and so were food consumption and food conversion efficiency (Table 4). Mean digestibilities of DM, CP and ADF in treatments A and B, respectively, were: 45.9 ± 0.9 and 53.6 ± 0.9, 54.1 ± 0.8 and 46.2 ± 0.9, and 30.1 ± 1.2 and 40.3 ± 1.4. These values resulted both from differences in the roughage fed and in the amount of concentrate needed to attain the target gains in each treatment.

In both treatments the F1 showed the highest daily gain, which decreased with increasing HF fraction (Table 4). DMI and CPI showed trends similar to that of daily gain, but grade effects were significant only for CPI in treatment B (Table 3). Because grade differences in dry matter intake were small, food conversion ratios followed a trend inverse to daily gain with respect to HF grade. The 1/4 had lower DG and DMI than the F1, although the differences between these two grades were not significant ($P>0.05$), and both had similar FCR (Table 4).

Dry matter and crude protein intakes per unit liveweight increased with HF fraction in treatment A, with no peak for the F1, while no such trend was apparent for these traits in treatment B (Table 4). Hunter and Siebert (1986) reported that Hereford and Brahman steers had similar organic matter intakes per unit liveweight of poor quality roughages, but the Hereford consumed progressively more than the Brahman as the nitrogen content in the diet increased and its fiber content decreased.

TABLE 4

Least squares means and regression coefficients (b) for components of feed conversion efficiency

	"Treatment" A Rainy season, summer, fresh elephant grass							"Treatment" B Dry season, winter, elephant grass silage						
	N	DG (g/d)	DMI (kg/d)	DMI/LW (kg/100 kg)	CPI (g/d)	CPI/LW (g/100 kg)	FCR (kg/kg)	*N*	DG (g/d)	DMI (kg/d)	DMI/LW (kg/100 kg)	CPI (g/d)	CPI/LW (g/100 kg)	FCR (kg/kg)
Mean	90	533	6.33	3.25	569	292	12.5	90	314	4.53	2.51	402	223	15.8
s.e.		9	0.03	0.01	2	1	0.2		7	0.02	0.01	1	1	0.5
HF grade														
1/4	15	567	6.19	3.14	562	284	11.1	15	323	4.48	2.46	398	219	14.7
1/2	15	619	6.51	3.26	577	289	10.9	15	347	4.63	2.52	406	222	13.6
5/8	15	543	6.24	3.21	563	288	12.0	15	269	4.49	2.53	401	226	18.9
3/4	15	525	6.35	3.26	575	294	12.6	15	306	4.52	2.51	403	225	17.4
7/8	15	463	6.34	3.34	570	299	14.5	15	335	4.53	2.49	403	222	13.9
HF	15	478	6.37	3.32	570	296	14.0	15	301	4.55	2.52	404	224	16.3
Avg. s.e.		22	0.08	0.04	4	2	0.6		17	0.05	0.02	2	1	1.3
b[1]		35	1.46	−0.98	68	−115	1.5		−95	0.94	−0.85	33	−106	11.2
s.e.		51	0.20	0.09	9	5	1.4		47	0.14	0.07	6	3	3.7

DG = daily gain, DMI = dry matter intake, LW = liveweight, CPI = crude protein intake, FCR = food conversion ratio.
[1]Units of trait per 100 kg initial weight increase.

Higher growth potential has been shown under non-tropical environments for Holsteins and Friesians than for their Zebu crosses, but that superiority was not expressed when liveweight gains were of the order of 0.5 kg/day; in this case the Holsteins and the crosses grew at similar rates (Branton et al., 1966; Long et al., 1979; Reardon et al., 1983). However, in Cuba, at a gain level of 0.9 kg/day, purebred Holstein and 3/4 and 5/8 Holstein×Zebu males had similar rates of gain, while the crosses grew faster at lower levels of gain (Lopez et al., 1982).

F1 of Holstein, Friesian or Brown Swiss crosses with Zebu had higher gains and food consumption, and better food conversion efficiency, than purebred Zebus, under a wide range of systems (Miranda et al., 1970; Willis et al., 1973; Bhatnagar et al., 1979; Thorpe and Cruickshank, 1979; Razook et al., 1986). Thus, present results on growth rates, food consumption and food conversion efficiency are in general agreement with published results at comparable rates of gain. The superiority of the F1 indicates the presence of heterosis for these traits, as discussed in more detail elsewhere (Madalena et al., 1990b).

The digestibilities of DM, CP and ADF were not influenced by the genetic group, F values for this source of variation being 1 or less in both treatments (Table 3). Literature results generally indicate higher digestibility of low quality diets for *Bos indicus* and its crosses than for *B. taurus*, but the reverse may be true in better quality diets (Vera, 1978; Manzano et al., 1987).

It is now well established that maintenance requirements of Zebus and their crosses are lower than those of European beef, and, particularly, European dairy breeds (Frisch and Vercoe, 1984; Taylor et al., 1986; Frisch, 1987; Teixeira et al., 1987; Solis et al., 1988), so it is likely that the grade differences in food conversion efficiency were influenced by differences in their maintenance requirements and relative food intakes.

Age-adjusted traits

Grade effects for age-adjusted traits in treatment A were very similar to those described for weight-adjusted traits and will not be shown, while in treatment B grade effects were non-significant for all age-adjusted traits ($P>0.05$).

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RESUME

Paiva, J.A.J., Madalena, F.E., Teodoro, R.L.et Campos, A.T., 1992. Efficacité alimentaire de six groups de croisées Holstein×Zebu. *Livest. Prod. Sci.*, 30: 213–222 (en anglais).

Les composantes de l'efficacité alimentaire de 180 génisses d'un an provenant de six niveaux de croisement Holstein (HF)×Guzera (1/4 à plus de 31/32 HF) ont été comparées sous deux traitements: (A) napier (*Pennisetum purpureum*) fraîchement haché pendant la saison humide; (B) ensilage de napier pendant la saison sèche. Une supplémentation en concentré a été effectuée de manière à obtenir des croisssances de 0,5 et 0,3 kg par jour. Dans les deux traitements, la vitesse de croissance ajustée pour le poids initial a été maximum pour les F1. En raison des faibles différences entre types génétiques pour la consommation journalière de matière sèche par animal, l'indice de consommation (aliment/croissance) a suivi une tendance inverse de celle de la vitesse de croissance. Après ajustement des croissances pour l'âge initial, les résultats ont été identiques dans le traitement A mais il n'y a plus eu de différences significatives entre types génétiques dans le traitement B ($P>0,05$). Les consommations de matière sèche et de protéines brutes par unité de poids ont augmenté linéairement avec le degré de croisement Holstein dans le traitement A mais aucune tendance n'a été apparente dans le traitement B. Les valeurs de F du test des différences entre types génétiques pour la digestibilité de la matière séche, des protéines brutes et des fibres ont été inférieures à 1 dans les deux traitements.

KURZFASSUNG

Paiva, J.A.J., Madalena, F.E., Teodoro, R.L. und Campos, A.T., 1992. Futterverwertung in sechs Gruppen von Holstein-Friesian×Zebu Kreuzungen. *Livest. Prod. Sci.*, 30: 213–222 (auf englisch).

Die Futterverwertung von 180 einjährigen Färsen sechs verschiedener Holstein-Friesian (HF)×Guzera-Kreuzungen (1/4 bis 31/32 HF) wurde in zwei Behandlungen verglichen: (A) Frisch gewonnenes Elefantengras während der Regensaison (B) Elefantengrassilage während der Trockenperiode. Konzentrate wurden zugefüttert, um die angestrebten Lebendgewichtszunahmen von 0,5 bzw. 0,3 kg je Tag zu ereichen. In beiden Behandlungen war die auf das Anfangsgewicht korrigierte Zunahme der F1 höher und nahm entsprechend ab, wenn der HF-Anteil von 50% abwich. Wegen der geringen Differenzen in der Trockensubstanzaufnahme je Tier zwischen den Kreuzungen, folgte die Futterverwertung einem der täglichen Zunahme entgegengesetzten Trend. Die Ergebnisse der alterskorrigierten Merkmale waren denen der gewichtskorrigierten in der Behandlung A ähnlich, während in der Behandlung B keine signifikanten Differenzen der Merkmale zwischen den HF-Anteilen gefunden wurden ($P>0,05$). Die Trockensubstanz- und Rohproteinaufnahme je kg Lebendgewicht nahm in der Behandlung A linear mit dem HF-Anteil zu, aber in der Behandlung B war kein Trend erkennbar. Die *F*-Werte für die durch den HF-Anteil verursachte Variation in der Verdaulichkeit der Trockensubstanz, des Rohproteins und der säuregereinigten Rohfaser waren in beiden Behandlungen größer eins.