EFFECTS OF CROSSBREEDING ON FEED CONVERSION[1]

Efecto del cruzamiento en la conversion alimenticia

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Feed costs represent the greatest item of expense in animal production. The profit in the cattle industry is highly dependent on efficient utilization of feed. Feed required by a specific animal is dependent on a weight-time function of maintenance needs, weight gained and composition of weight gain. Maintenance needs may be associated with energy required for digestion, metabolism and physical activity. Rapid rate of gain is generally associated with a lower ratio of feed consumed to units of gain. Since crossbreeding results in heterosis for rate of gain (Drewry et al., 1979; Gregory et al., 1966; and Lasley et al., 1973), crossbred cattle should also require less feed to produce one unit of gain in the postweaning period.

The objective of this study was to estimate the influence of crossbreeding on rate of gain and two measures of feed conversion.

Materials and Methods

Cattle of the Red Poll (RP), Milking Shorthorn (MS) and Red Danish (RD) breeds were mated in a 3 x 3 diallel design resulting in purebreds of each breed and crossbreds of each of the six possible combinations. Crossbred F_1 females produced in the diallel generation were mated to sires of the third breed (i.e., RP x MS females to RD males) and purebred females were mated in a repetition of the diallel design. There were, as a result, fifteen possible breed combinations.

Male offspring, at 3 days of age, were taken from their dams, castrated and placed on a limited feed of milk replacer. Between 6 weeks and 6 months of age, the diet was ad libitum hay and grain mix. The hay was high quality alfalfa and orchardgrass. The grain mix contained 15% crude protein and was primarily maize and soybean oil meal. At 6 months of age, each steer was trained to eat in an assigned stanchion. Individual feed consumption was recorded over a 22-week period beginning at 225 kg liveweight. The diet, fed ad libitum twice daily, was a coarsely ground complete feed consisting of 5% alfalfa meal, 18% corn (maize) cobs, 44% corn grain, 10% oat grain, 5% liquid molasses, 15% soybean meal, 1% salt and 2% steamed bonemeal.

Daily gain was calculated as $\frac{\text{Final wt} - 225}{154}$ and gross feed conversion as $\frac{\text{Total feed consumed}}{\text{Final wt} - 225}$. As much as 75% of the variation in feed consumption may be associated with maintenance needs (Martin and Conrad, 1971). High daily gain will result in increased maintenance needs when starting at a constant weight and feeding over a constant time period. Estimated maintenance requirements (M) for each animal were estimated as

$$M = \sum_{i=1}^{11} F_i = .66 \sum_{i=1}^{11} U_i$$

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where F_i = kilograms feed required for maintenance in the ith of 11 two-week periods and U_i = maintenance units for the ith two-week period. U = weight in kilograms to the 3/4 power estimated by Kleiber (1947) as the constant of proportionality for maintenance. The constant (.66) was derived as K from the equality $K = \frac{14\ (3.86)}{.775\ (500)^{.75}}$ in which 14 is the number of days in the period, 3.86 is the estimated kilograms of Total Digestible Nutrients (TDN) required to maintain a 500-kg animal for one day, .775 is the TDN content of six digestibility trials conducted *in vivo*, and 500 is the weight in kilograms chosen as the reference point. Net conversion was calculated as $\frac{\text{Total feed consumed - M}}{\text{Final wt - 225}}$.

Complete data were available on 110 steers and were analyzed by least squares (Harvey, 1975). The statistical model included main effects due to year of birth, breed of sire and breed of dam, effects of individual sires nested in sire breed and interaction effect of breed of sire and breed of dam. Least-squares means for the breed groups were used to estimate individual breed additive, individual heterosis, maternal breed additive and maternal heterosis effects (Alenda *et al.*, 1980).

Results and Discussion

Least-squares means for the breed classes are in Table 1. Since maternal breed additive effects were not statistically significant (P>.10), the reciprocal crosses were pooled for two-breed crossbreds and the groups having reciprocal cross dams were pooled for three-breed crossbreds. Specific effects estimated from breed class means are in Table 2 and the mean squares associated with those effects are in Table 3.

Maternal heterosis affected (P<.01) variation in all three traits. Steers having crossbred dams gained .05 kg/day more on .59 kg less feed per kilogram gain than steers having purebred dams. Inasmuch as the calves were artificially reared from 3 days of age, the maternal influence on traits expressed after reaching 225 kg liveweight was unexpected. Maternal heterosis did not significantly influence daily gain in a study (Ibrahim and Martin, 1980) involving the Milking Shorthorn and Angus breeds.

Differences between breeds due to breed additive effects produced some apparent inconsistencies. Milking Shorthorn steers gained faster than either Red Danish or Red Poll steers and also required more feed to produce one kilogram of gain. This result could have been associated with differences in either metabolic rate or body composition. Martin and Conrad (1971) reported that increased backfat was associated with increased feed consumption in pigs. It may be simply a positive association between weight (maintenance needs) and feed consumption as reported by Swiger *et al.* (1966).

Individual heterosis effects were more consistent with expectation than were the additive effects. The Milking Shorthorn-Red Danish cross gained more rapidly and required less feed per kilogram gain than either of the other F_1 crosses. Summing values for individual and maternal heterosis values produced estimates of 9.6, 9.1 and 11.0% heterosis, respectively, for daily gain, gross conversion and net conversion. These values are considerably higher than those reported by Gregory *et al.* (1966).

Crossbreeding can be utilized in a systematic manner to improve feed conversion rates of feedlot steers by as much as 10%. The resulting reduction in feed cost and time in the feedlot may result in both greater profits for producers and lower costs for consumers.

Table 1. Least-squares means and standard errors for breed and crossbred classes.

Breeds	No. Steers	Daily Gain	Gross Conversion	Net Conversion
		kg/day	---- kg feed/kg gain ---	
Red Poll (RP)	10	.86 ± .03	8.62 ± .28	4.49 ± .20
Milking Shorthorn (MS)	13	.99 ± .03	8.73 ± .24	5.09 ± .18
Red Danish (RD)	14	.90 ± .03	8.18 ± .23	4.33 ± .17
Av. Purebreds		.92 ± .02	8.51 ± .14	4.64 ± .10
MS x RD[a]	12	1.04 ± .03	7.88 ± .25	4.26 ± .18
MS x RP[a]	14	.93 ± .03	8.78 ± .23	4.59 ± .17
RP x RD[a]	11	.90 ± .03	8.33 ± .26	4.88 ± .19
Av. Two-Breed Crossbreds		.96 ± .02	8.33 ± .14	4.58 ± .10
RP x (MS x RD)[b]	14	1.02 ± .03	8.19 ± .23	3.92 ± .17
MS x (RP x RD)[b]	13	1.03 ± .03	7.28 ± .24	4.50 ± .18
RD x (MS x RP)[b]	9	.96 ± .04	7.75 ± .29	3.95 ± .21
Av. Three-Breed Crossbreds		1.01 ± .02	7.74 ± .15	4.12 ± .11

[a] Reciprocals pooled

[b] Reciprocal dams pooled

Table 2. Estimates of genetic and maternal effects and standard errors for daily gain and feed conversion.

Effect	Daily Gain	Gross Conversion	Net Conversion
	kg/day	--------- kg feed/kg gain --------	
Mean	.94 ± .02	8.51 ± .15	4.64 ± .15
Individual Breed Additive			
Red Poll	-.06* ± .03	.11 ± .21	-.15 ± .15
M. Shorthorn	.07** ± .03	.22 ± .21	.45** ± .15
Red Danish	-.01 ± .03	-.33 ± .21	-.31* ± .15
Individual Heterosis			
RP x MS	.01 ± .04	.11 ± .31	.20 ± .23
RP x RD	.01 ± .04	-.07 ± .31	.47* ± .23
MS x RD	.10* ± .04	-.58 ± .31	-.45* ± .23
Mean	.04* ± .02	-.18 ± .18	-.06 ± .13
Maternal Breed Additive			
Red Poll	-.06 ± .04	-.02 ± .24	.08 ± .17
M. Shorthorn	.07 ± .04	.24 ± .24	.09 ± .17
Red Danish	.01 ± .04	-.22 ± .24	-.17 ± .17
Maternal Heterosis			
RP x MS	-.01 ± .04	.36 ± .31	-.62** ± .23
RP x RD	.04 ± .04	-1.05** ± .31	.08 ± .23
MS x RD	.11** ± .04	-.37 ± .31	-.82** ± .23
Mean	.05* ± .02	-.59** ± .18	-.45** ± .13

* P<.05; ** P<.01

Table 3. Mean squares associated with genetic and maternal effects.

Source of Variance	d.f.	Daily Gain	Gross Conversion	Net Conversion
Individual Additive	2	.0040*	.175	.151
Individual Heterosis	3	.0035*	.107	.134*
Maternal Additive	2	.0021	.050	.040
Maternal Heterosis	3	.0051**	.427**	.230**
Error	72	.0011	.064	.034

* P<.05; ** P<.01

SUMMARY

A complete diet was fed individually to each of 110 steers over a 22-week period beginning at 225 kg liveweight. The mating system was a 3 x 3 diallel using the Red Poll (P), Milking Shorthorn (S) and Red Danish (D) breeds. F_1 females were mated to the third breed (i.e., P x S females to D males) resulting in 12 breed classes. Gross feed conversion (kg feed consumed/kg gain), net feed conversion (kg feed consumed minus maintenance requirements/kg gain) and daily gain (kg/day) were, respectively, 8.51, 4.63 and .92 for purebreds; 8.33, 4.58 and .95 for F_1 steers; and 7.74, 4.12 and 1.01 for 3-breed crossbreds. The maternal heterosis effects were large (P<.01) for all traits; individual heterosis and individual breed additive effects influenced (P<.05) net feed conversion and daily gain; maternal breed additive effects were negligible for all traits.

RESUMEN

Por un periódo de 22 semanas, 110 novillos con peso vivo inicial de 225 kg fuéron sometídos a una dieta completa. El sistema de cruzamiento ultilizado fué dialelico 3 x 3, con las razas Red Poll (P), Milking Shorthorn (S) y Red Danish (D). Las hembras F_1 fuéron cruzadas con la tercera raza (por ejemplo, hembras P x S cruzadas con machos D) obteniendo 12 classes. La conversión alimentícia total (kg de alimento consumido/ganancia de peso en kg), la conversión alimentícia neta (kg de alimento consumido menos el alimento requerido pora mantenimiento/ganancia de peso kg) y la ganancia diaria (kg/dia) fuéron para las razas puras 8.51, 4.63 y 0.92 respectivamente; para los novillos F_1 8.33, 4.58 y 0.95; y para la triple cruza 7.74, 4.12 y 1.01, respectivamente. Los efectos de heterósis maternos fuéron importantes (P<.01) para todas las características; los efectos de heterósis individual así como aditívos de la raza influenciaron (P<.05) conversión alimentícia neta y ganancia diaria; los efectos aditívos maternos no fuéron importantes en ninguna de las características.

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