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BREEDING BETTER BEEF. 1. PREWEANING PERFORMANCE OF CALVES SIRED BY ANGUS, HEREFORD, AND CHAROLAIS BULLS

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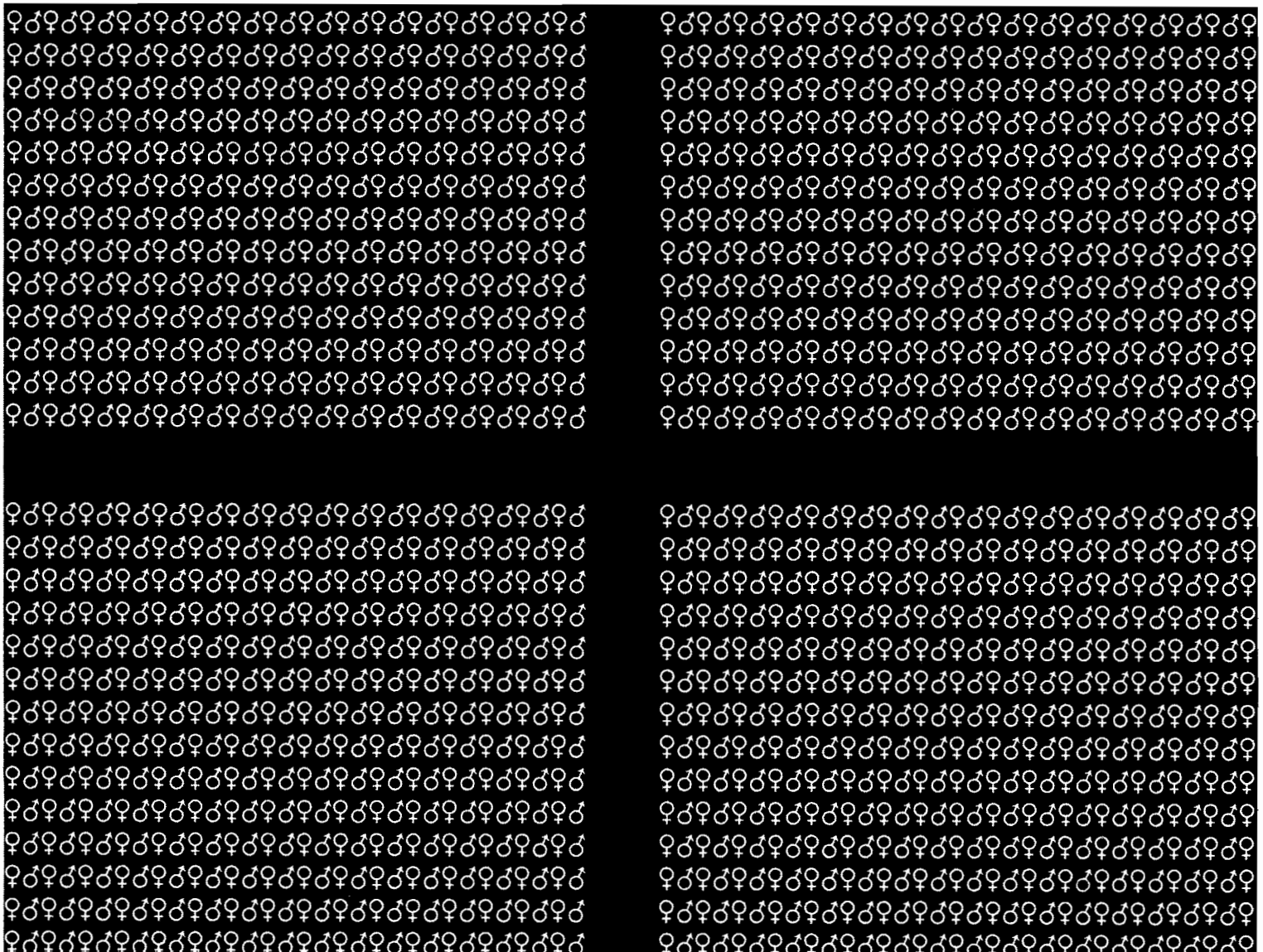

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INTRODUCTION

Crossbreeding has become increasingly important in commercial beef production during the past two decades. Crossbred cattle have gained wide acceptance because they return increased profits to the producer. Drewry et al. (1978) claim that production per cow can be increased 15 to 25 percent by systematic crossing of the British beef breeds. Belcher and Frahm (1979) recommend that different crossbred types be evaluated under various climatic conditions and management systems in order to maximize production efficiency. The choice among breeds for the design of effective crossbreeding programs should be determined by the desirable characteristics inherent in the breeds available and by their adaptability to a particular environment.

The purpose of this study was to evaluate the influence of breed of sire, breed of dam, year-age of dam, heterosis, and crossbreeding effects on preweaning performance of calves sired by Angus, Hereford, and Charolais bulls and out of Angus and Hereford cows.

MATERIALS AND METHODS

The data were collected over a five-year period at the Mealani Experiment Station, Kamuela, Hawaii. The study included 216 male and 238 female calves. The experimental design and the number of calves weaned in each of the breeding groups are shown in Table 1. The cow herd included approximately equal numbers of straightbred Angus and Hereford females purchased as yearling heifers from local ranches. All females were bred to calve first as three-year-olds. Culling of cows was on the basis of infertility (failure to calve for two consecutive years) or permanent physical injury. Purebred Angus, Hereford, and Charolais bulls were obtained from both local and mainland U.S.A. sources. Angus and Hereford bulls sired both straightbred and crossbred calves; Charolais bulls sired crossbred calves only. Different bulls (two of each breed) were used each year and were selected from as many different lines of breeding as possible in order to provide a more representative sample of the breeds involved. Comparisons involving the Charolais breed in this study are not true estimates of heterosis because straightbred Charolais progeny were not available for comparison. The performance of Charolais-cross calves was therefore compared on a within-breed-of-dam basis, i.e., C×A[1] vs. the average of A×A plus H×A calves, and C×H vs. the average of H×H plus A×H calves. The comparative performance of Charolais-sired calves, as defined above, is referred to as crossbred advantage in this report.

Table 1. Experimental design and number of weaned calves by breeding group and sex

	Breed of dam					
	Angus		Hereford		Total	
Breed of sire	M*	F*	M	F	M	F
Angus	39	40	37	36	76	76
Hereford	35	39	50	38	85	77
Charolais	24	41	31	44	55	85
Total	98	120	118	118	216	238

*M = male, F = female.

Cows were allotted at random to single-sire breeding groups for a 75-day breeding period beginning on April 1. Calves were born the following year from early January to late March and remained with their dams on pasture until weaning in late September. Body weights were obtained on all calves within 24 hours after birth. Male calves were castrated at about three months of age. Weaning weights were taken at about eight months of age and were adjusted to 240 days of age by using the calf's own preweaning daily gain. Weaning conformation score values for feeder calves, ranging from 9 to 11 for good, 12 to 14 for choice, and 15 to 17 for prime, were based on skeletal soundness and development and on indications of carcass quality. The score values assigned to each calf at weaning represented the average grade given by three graders. All cows and calves from the different breeding groups were

[1]Breed of sire is listed first in all crosses.

maintained on pasture and were handled under the same management system until weaning. Pastures consisted of pangola grass (*Digitaria decumbens*) and kikuyu grass (*Pennisetum clandestinum*) fertilized with urea to provide approximately 200 lb N per acre per year. Average annual stocking rate during the period of the study was one animal unit per acre. A mineral mixture containing salt, Ca, P, and trace minerals was available to all animals at all times.

The data were analyzed by least-squares analysis of variance for unequal subclass numbers as described by Harvey (1960). Main effects included in the analysis were year-age of dam, breed of sire, and breed of dam; interactions included were year-age of dam with breed of sire and with breed of dam, and breed of sire with breed of dam. The traits under study included birth weight, weaning weight, average daily gain from birth to weaning, and weaning conformation score.

RESULTS AND DISCUSSION

The least-squares means presented in Table 2 are the average performance values for the breeding group subclasses, for sire breeds, and for dam breeds. The standard errors attached to these means are an indication of the variability associated with each of these values. Estimates of heterosis, crossbred advantage, differences between sire breeds and between dam breeds are presented in Table 3. Representative samples of the sires, dams, and progeny used in this study are pictured in Figure 1.

Year-Age of Dam

Differences between years were found to be highly significant sources of variation for all traits. This is not unusual and simply emphasizes the importance of environmental factors and their influence on annual herd performance. Since year and age-of-dam are confounded in this study, their effects cannot be separated or evaluated individually and therefore have to be considered as a single main effect. Calf performance was lowest for all traits during the first calving year when all dams were three years old. Birth weight, weaning weight, and average daily gain tended to peak

Table 2. Least-squares breeding group means and standard errors for preweaning traits of calves

Trait[a]	Breed[b] of sire	Breed of dam: Angus M[c]	Angus F[c]	Hereford M	Hereford F	Mean M	Mean F
BW, lb	A	68.8 ± 1.64	66.1 ± 1.54	77.1 ± 1.54	73.7 ± 1.59	72.9 ± 1.12	69.9 ± 1.10
	H	75.1 ± 1.75	70.9 ± 1.55	76.4 ± 1.35	72.9 ± 1.59	75.7 ± 1.12	71.9 ± 1.12
	C	83.9 ± 2.12	74.0 ± 1.70	90.5 ± 1.73	83.4 ± 1.46	87.2 ± 1.37	78.7 ± 1.09
	Mean	75.9 ± 1.11	70.3 ± .95	81.3 ± .89	76.6 ± .89	78.6 ± .71	73.5 ± .65
ADG, lb	A	1.56 ± .04	1.52 ± .03	1.70 ± .04	1.55 ± .04	1.63 ± .03	1.54 ± .02
	H	1.72 ± .04	1.60 ± .04	1.54 ± .03	1.46 ± .04	1.63 ± .03	1.53 ± .03
	C	1.83 ± .05	1.74 ± .04	1.77 ± .04	1.58 ± .03	1.80 ± .03	1.66 ± .02
	Mean	1.70 ± .03	1.62 ± .02	1.67 ± .02	1.53 ± .02	1.69 ± .02	1.58 ± .01
WW, lb	A	442.3 ± 10.31	431.8 ± 8.86	484.2 ± 9.66	445.4 ± 9.13	463.2 ± 7.01	438.6 ± 6.35
	H	487.3 ± 11.01	455.9 ± 8.90	446.7 ± 8.47	423.0 ± 9.14	467.0 ± 7.04	439.5 ± 6.44
	C	523.5 ± 13.33	491.4 ± 9.77	516.1 ± 10.86	463.4 ± 8.41	519.8 ± 8.61	477.4 ± 6.28
	Mean	484.4 ± 6.96	459.7 ± 5.47	482.3 ± 5.59	444.0 ± 5.12	483.3 ± 4.46	451.8 ± 3.71
CS	A	11.5 ± .15	11.6 ± .13	11.7 ± .14	11.6 ± .14	11.6 ± .10	11.6 ± .10
	H	11.5 ± .16	11.6 ± .13	11.5 ± .12	11.7 ± .14	11.5 ± .10	11.7 ± .10
	C	11.8 ± .19	11.9 ± .15	11.7 ± .15	11.4 ± .13	11.7 ± .12	11.7 ± .09
	Mean	11.6 ± .10	11.7 ± .08	11.6 ± .08	11.6 ± .08	11.6 ± .06	11.7 ± .06

[a]BW = birth weight; ADG = average daily gain; WW = 240-day adjusted weaning weight; CS = conformation score where 11 = high good, 12 = low choice.

[b]A = Angus, H = Hereford, C = Charolais.

[c]M = male, F = female.

Table 3. Estimates of heterosis, crossbred advantage, and differences between sire breeds and between dam breeds

Comparison[a]	Birth weight		Av. daily gain		Weaning weight		Conformation score[c]	
	M[b]	F[b]	M	F	M	F	M	F
Heterosis[d]								
A×H minus ½ (A×A + H×H), lb	4.5**	4.2	.15**	.06	39.7**	18.0	.1	0
%	6.2	6.0	9.7	4.0	8.9	4.2	.9	0
H×A minus ½ (A×A + H×H), lb	2.5	1.4	.17**	.11	42.8**	28.5	-.1	0
%	3.4	2.0	11.0	7.4	9.6	6.7	-.9	0
Crossbred advantage[d]								
C×A minus ½ (A×A + H×A), lb	11.9**	5.5*	.19**	.18**	58.7**	47.6**	.3	.3
%	16.5	8.0	11.6	11.5	12.6	10.7	2.6	2.6
C×H minus ½ (H×H + A×H), lb	13.7**	10.1**	.15*	.08	50.7**	29.2*	.2	-.2
%	17.8	13.8	9.3	5.3	10.9	6.7	1.7	1.7
Breed of sire differences								
H minus A, lb	2.8	2.0	0	-.01	3.8	.9	-.1	.1
%	3.8	2.9	0	-.6	.8	.2	-.9	.9
C minus A, lb	14.3**	8.8**	.17**	.12**	56.6**	38.8**	.1	.1
%	19.6	12.6	10.5	7.8	12.2	8.8	.9	.9
C minus H, lb	11.5**	6.8**	.17**	.13**	52.8**	37.9**	.2	0
%	15.2	9.5	10.5	8.5	11.3	8.6	1.7	0
Breed of dam differences								
H minus A, lb	5.4**	6.3**	-.03	-.09**	-2.1	-15.7*	0	-.1
%	7.1	9.0	-1.8	-5.6	-.4	-3.4	0	-.9

[a] A = Angus, H = Hereford, C = Charolais. Breed of sire is listed first in all crosses; e.g., A×H = Angus sires mated to Hereford cows.
[b] M = male, F = female.
[c] Conformation score of 11 = high good, 12 = low choice, etc.
[d] Heterosis and crossbred advantage is calculated as follows: e.g., heterosis for birth weight for male calves, A×H minus ½(A×A + H×H),

A×H	77.1
½(A×A + H×H) = ½(68.8 + 76.4)	72.6
Difference, lb	4.5
Difference, % = $\frac{4.5}{72.6} \times 100$	6.2

*P < .05, **P < .01.

during the second year, whereas conformation score increased with each successive year of the study.

Breed of Sire

Calves sired by Angus and Hereford bulls did not differ significantly in any of the performance traits measured. Sagebiel et al. (1974) reported a nonsignificant difference in weaning weight of calves sired by Angus and Hereford bulls. Published reports agree quite consistently that Hereford-sired calves are heavier at birth than those sired by Angus bulls, but neither breed of sire is given a distinct advantage for weaning weight or for average daily gain. Some indications are given, however, that Hereford bulls sire calves with slightly heavier weaning weights than do Angus bulls.

Differences in birth weight, daily growth rate, and weaning weight were highly significant when Charolais-sired calves were compared with those sired by Angus and Hereford bulls (Table 3). The magnitude of these differences was greater in male calves than in females. Male calves sired by Charolais bulls were 14.3 (19.6 percent) and 11.5 lb (15.2 percent) heavier at birth than those sired by Angus and Hereford bulls, respectively. Charolais-

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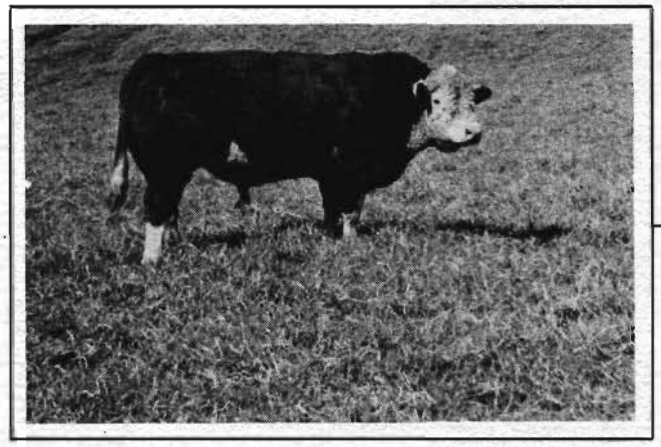
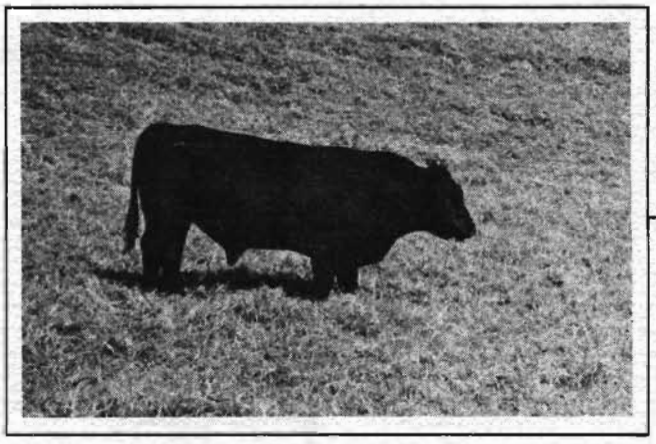
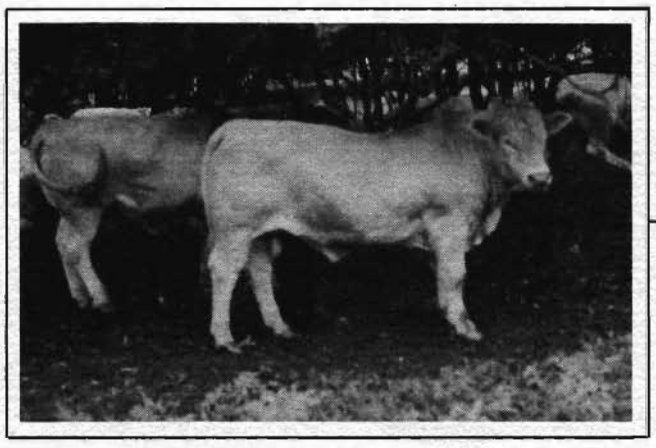


Hereford bull.



Angus bull.



Charolais bull.

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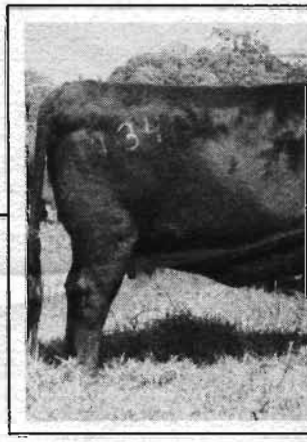

Angus and

Figure 1. Beef cattle
Angus, Her

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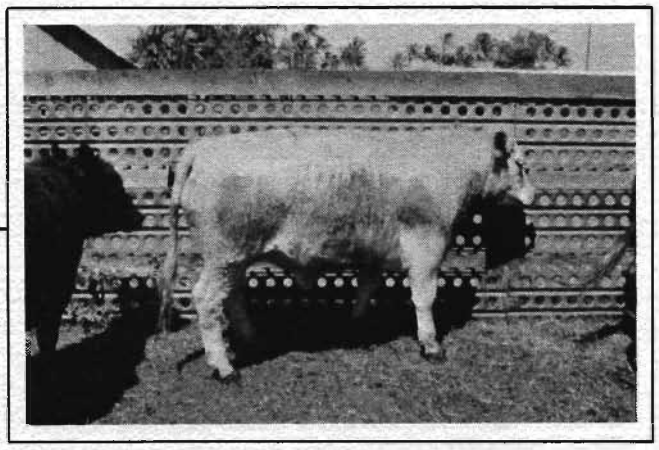
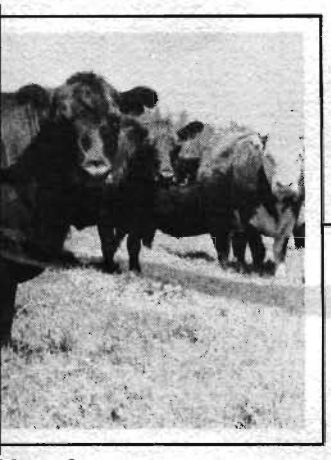
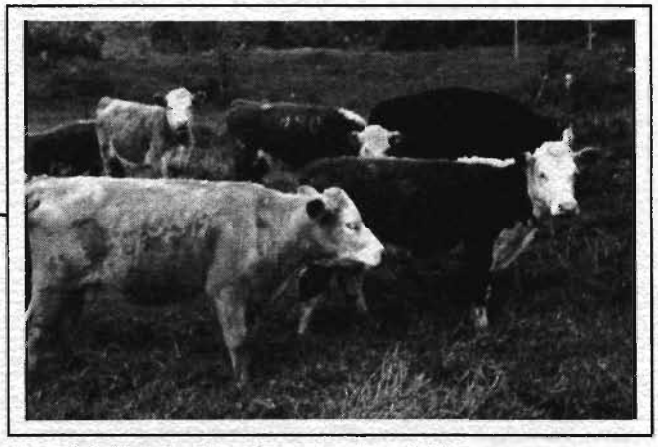


A Charolais-Angus crossbred animal.

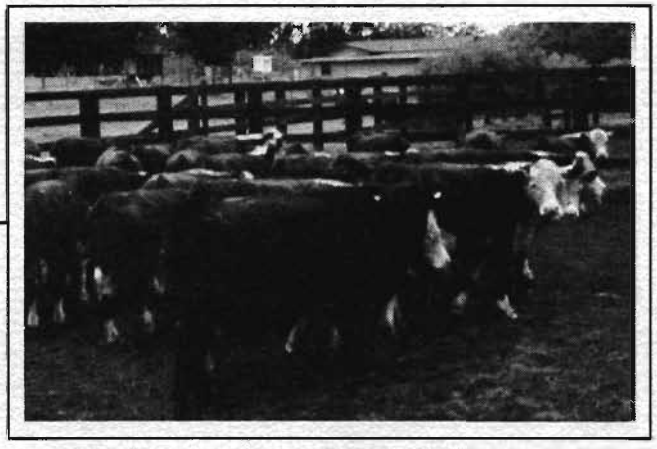
HERD



brood cows.



Charolais-Hereford in foreground with Hereford and Angus animals in background.



Angus-Hereford cross in foreground with Hereford-Charolais cross animals in background.

reeding studies with the
and Charolais breeds.

sired heifer calves were 8.8 (12.6 percent) and 6.8 lb (9.5 percent) heavier at birth than Angus- and Hereford-sired heifers, respectively. Other studies have also reported heavier birth weights for Charolais-cross calves, ranging from 3.7 lb (5 percent) for Charolais vs. Hereford sires (Thrift et al., 1978) to 13.7 lb (18 to 21 percent) for Charolais vs. Angus sires (Pahnish et al., 1969; Turner and McDonald, 1969; and Sagebiel et al., 1973).

Growth rate of Charolais-sired calves was greater by .17 lb per day (10.5 percent) for steers and by .12 to .13 lb per day (7.8 to 8.5 percent) for heifers than for calves sired by Angus and Hereford bulls, respectively. Charolais-sired calves were heavier at weaning by 55 lb (11.8 percent) for males and 38 lb (8.7 percent) for females than the average of calves sired by Angus and Hereford bulls. These results are in general agreement with those reported by Damon et al. (1959), Pahnish et al. (1969), and Turner and McDonald (1969), but considerably higher than those reported by Sagebiel et al. (1974). The small but nonsignificant weaning-weight advantage in favor of Angus- vs. Charolais-sired calves reported by Thrift et al. (1978) was considered to be at least partially due to the fact that most of the Charolais bulls in their study originated from one herd.

Breed of Dam

Calves out of Hereford dams were significantly heavier at birth than those out of Angus dams. These differences amounted to 5.4 lb (7.1 percent) for male and 6.3 lb (9.0 percent) for female calves. Differences in growth rate and weaning weight due to breed of dam were significant only for heifer calves. Average daily gain was higher by .1 lb per day (5.6 percent) and weaning weight was greater by 15.7 lb (3.4 percent) for heifers out of Angus dams compared with those out of Hereford dams. These results are in good agreement with those published in the literature, which consistently report heavier birth weights for calves from Hereford dams and higher daily gains and heavier weaning weights for calves out of Angus dams (Gregory et al., 1965, 1966*a*, *b*; Gaines et al., 1966; Sagebiel et al., 1973, 1974; Long and Gregory, 1974; Gray et al., 1978; and Thrift et al., 1978).

Heterosis

Heterosis is the difference between the performance of crossbred calves and the average performance of calves from the straightbred parental breeds. Comparing the performance of Angus-Hereford reciprocal cross calves with the average performance of straightbred Angus and Hereford calves provides an estimate of heterosis. These results are presented in Table 3. Heterosis was significant for all traits except weaning conformation score. Hereford × Angus crossbreds exhibited slightly higher levels of heterosis in growth rate and weaning weight than did A×H crossbred calves. Estimates of heterosis for A×H and H×A calves respectively were, for male calves, 6.2 and 3.4 percent for birth weight, 9.7 and 11.0 percent for average daily gain, and 8.9 and 9.6 percent for weaning weight. Comparable data for heifer calves were 6.0 and 2.0 percent for birth weight, 4.0 and 7.4 percent for average daily gain, and 4.2 and 6.7 percent for weaning weight. These values are slightly higher than those published in other reports, which range from -0.4 to 3.7 percent for birth weight, -2.7 to 7.2 percent for weaning weight, and 3.6 to 8.2 percent for average daily gain (Damon et al., 1959; Rollins et al., 1969; Long and Gregory, 1974; and Gregory et al., 1978*a*).

Heterotic response in birth weight, weaning weight, and growth rate was consistently higher for male calves than for females. Published reports vary somewhat with regard to differential sex response in heterosis effects on weaning weight and growth rate. Pahnish et al. (1969) showed higher levels of heterosis in males for preweaning daily gain. Stonaker (1963) gave evidence for greater heterosis in females for weaning weight. Gregory et al. (1965) reported a nonsignificant advantage for females in average daily gain and weaning weight, but later studies by Gregory et al. (1978*a*, *b*, *c*) demonstrated higher levels of heterosis in males for these traits. Long and Gregory (1974) reported no significant differences between sexes for heterosis in preweaning traits.

Crossbred Advantage

Crossbred advantage was significant for birth weight, weaning weight, and average daily gain in both sexes with the exception that average daily gain was significant for males only in the C×H breeding group. The advantage for C×A calves over the average of A×A plus H×A calves was, for males and females respectively, 11.9 (16.5 percent) and 5.5 lb (8.0 percent) for birth weight, 58.7 (12.6 percent) and 47.6 lb (10.7 percent) for weaning

weight, and .19 (11.6 percent) and .18 lb (11.5 percent) for average daily gain. Comparable figures for C×H vs. H×H + A×H calves were 13.7 (17.8 percent) and 10.1 lb (13.8 percent) for birth weight, 50.7 (10.9 percent) and 29.2 lb (6.7 percent) for weaning weight, and .15 (9.3 percent) and .08 lb (5.3 percent) for average daily gain. These values are substantially higher than those reported from Ohio (Klosterman et al., 1968), Montana (Pahnish et al., 1969), and Missouri (Sagebiel et al., 1973, 1974); their estimates ranged from .7 to 3.1 lb for birth weight, 6.2 to 20.1 lb for weaning weight, and .03 to .07 lb for average daily gain.

Conclusions

These results show that the Angus and Hereford breeds cross to advantage as measured by improved preweaning performance of crossbred calves, and that somewhat higher levels of heterosis expression may be expected under Hawaiian range conditions than in most other mainland U.S.A. areas. The value of the Charolais as a sire breed is indicated by the superior growth and heavier weaning weights of Charolais-cross calves compared with crossbreds sired by either Angus or Hereford bulls.

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NOTE: As part of a structural reorganization, the Hawaii Agricultural Experiment Station and the Hawaii Cooperative Extension Service have been merged administratively under the name HAWAII INSTITUTE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES, College of Tropical Agriculture and Human Resources, University of Hawaii.

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