COMPARISON OF MATERNAL PERFORMANCE OF RECIPROCAL CROSSBRED COWS

by

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I. INTRODUCTION

Cattlemen know that reciprocal crosses between two breeds of cattle do not wean at the same weights if the two breeds used for crossing differ in mothering ability. It would seem reasonable to expect and has been generally assumed that reciprocal crosses would be equally productive when used as dams since their genetic composition should, on the average, be the same with the possible exception of sex linkage. Since cattle have thirty pairs of chromosomes, sex linkage in polygenic or qualitative traits would likely be small or nil. No convincing evidence appears in the literature to support any significant sex linkage in polygenic characters. This study is designed to compare the maternal performance of reciprocal crossbred cows among the Angus, Hereford and Shorthorn breeds, using data collected at the Shenandoah Valley Research Station, Steeles Tavern, Virginia. The objectives of this study were:

1. To determine if there are differences in the performance of calves from reciprocal crossbred cows with respect to:
   (a) Birth weight.
   (b) Average daily gain, birth to weaning.
   (c) 205 day weight.
   (d) Weaning grade.
   (e) Gain in feedlot following weaning.
   (f) Carcass grade.

2. To determine if fertility is equally high in reciprocal crossbred cows as measured by the number of calves born and weaned per cow bred.
3. To determine if reciprocal crossbred cows are equally productive for use as brood cows.

II. REVIEW OF LITERATURE

A. Maternal Performance of Reciprocal Crossbreds.

England, Mullins, Boulware, Phillips, Sullivan and Williams (1965) of the Louisiana Station reported weaning weights of calves from dams that were reciprocal two-breed crosses among the Angus, Hereford, Brahman and Brangus breeds. In every case crossbred cows whose mothers were Brahman weaned heavier calves than cows of the reciprocal crosses whose mothers were Angus or Hereford. A similar advantage was shown for crossbred cows from Brangus dams compared with reciprocal crosses from Angus or Hereford dams. The differences between Brahman and Brangus reciprocal crossbred cows were not significant. They found no difference however, in the weaning weight of calves from reciprocal crossbred cows of the Angus and Hereford breeds. The authors concluded that when the breeds were similar in geographic origin, such as Angus and Hereford, there was little difference in the calf weaning weights of the reciprocal crosses, but among breeds that are widely different in origin, such as Hereford and Brahman, there were differences in calf weaning weights.

Pani, Day, Tribble and Lasley (1963) studied the production of crossbred sows from reciprocal two-breed crosses. The sows consisted of 29 crossbred Landrace x Poland (sire breed first) and 31 reciprocal crosses. The sows were all bred to Duroc boars. The crossbred Landrace x Poland sows raised larger litters that were

heavier from birth to 154 days of age than litters raised from Poland x Landrace sows. The weight per pig at birth, 56 days, and 154 days was also in favor of the Landrace x Poland sows. The authors stated that chance could be an important factor in the differences, however, several of the differences reached the 0.25 level of probability and one the 0.10 level. They concluded that a further study with larger numbers of sows would have to be made before the maternal influence of reciprocal crossbreds on the fertility of the daughters could be proved or disproved.

Gaines, Thomas, Carter and Kincaid (1958) found no significant differences in maternal performance when they compared crossbred Poland x Landrace sows and their reciprocals. They indicated there were no differences in maternal performance due to the way in which the two breeds were crossed.

B. Influence of Plane of Nutrition During Early Life Upon the Performance of Dairy Cows.

Flux (1950) demonstrated the advantage of good condition at calving time in identical twin heifers fed alike up to ten weeks before calving. During the ten weeks before calving, one group lost twelve pounds and one group gained 79 pounds each. The five twins gaining weight before calving produced an average of 694 pounds more milk than those losing weight. They were fed alike after calving, so those losing weight before first calving caught up in body weight and produced equally well in the second lactation.

Plum, Singh and Schultze (1952), at the Nebraska Station, found no significant relationship between size and their later producing ability in Holstein and Guernsey heifers. There was a slight correlation between gain in weight and later producing ability, but this characteristic apparently was not heritable. The authors concluded that farms that feed their heifers well also feed the milking herd well. Conversely, farms that feed heifers poorly also feed milking herds poorly. This does not establish that good milk production is due to rapid growth of the heifers but was advanced as an explanation of the slight correlation between milk yield and weight gain in the heifers.

Hansson (1956) used a large number of twins of the Swedish Red and White breed with one of each pair fed a normal ration as a control and the mates allocated to 60, 80, 120, or 140 per cent of the normal growth ration. The highest efficiency of feed use for growth of these Swedish heifers was at a level allowing an average daily gain of one pound which was the 60 and 80% feeding level. Thirty-six week milk yields from the heifers fed 60 and 80% of the normal ration were greater than the normal and above normal groups.

Reid, Loosli, Trimberger, Turk, Asdell and Smith (1964) reported on the effects of the plane of nutrition during early life on the performance through fifth calving of Holstein cows. Heifer calves were fed at 62% of a normal growth ration (low), 100% of a normal growth ration (medium) and 146% of a normal growth ration (high),

After calving all heifers were fed according to body size and milk production. The size of heifers at calving was correlated with the level of nutrients fed previously. Heifers fed on the low nutrient level made remarkable increases in size after calving. There were differences in age at puberty but the body size of the heifers at the time of the first heat period was about the same regardless of the feeding level. Birth weight of calves at first calving was related to the early feeding level but not at subsequent calvings. Four high level cows failed to conceive but none of the lower level cows failed. Feeding levels were not different in their effect on the milk yield during any of the first four lactations. Appreciably more 4% fat corrected milk per unit of metabolic size was produced by cows of the low and medium feeding levels. The milk yield of cows reared on high levels of nutrition was inferior to the performance of those raised on lower levels. Intensive rearing was not economical when heifers were bred after eighteen months of age. The authors concluded that the plane of nutrition during lactation affected milk yields much more than early feeding levels.

Miller and McGilliard (1959) studied 6,179 D.H.I.A. heifer records consisting of Holsteins, Guernseys and Jerseys in Michigan. The correlation between age and milk yield was greater than the correlation between size (weight) and 305 day milk yield in the same herd. When all of the herds were combined this correlation was reversed.

Thomas, Sykes and Moore (1959) reported work with five pairs of Jerseys reared on a below normal ration compared to a normal ration. One heifer in each pair was fed on the below normal ration and one on the normal ration. More milk was produced in the first two lactations by the heifers reared on the below normal ration.

Menge, Mares, Tyler and Casida (1960) found that heifers which were large at six months of age reached puberty at an earlier age, calved at heavier weights and produced more milk with a higher fat test in the first three months of lactation than smaller heifers. The study also showed that heifer calves having scours were slower to develop and lighter in weight. They concluded that the higher fat test and 90 day production indicated a lactation advantage due to body condition at calving rather than a true effect of growth superiority.

Swanson (1960) compared the effects of normal growth, and rapid growth with fattening, on the future lactational ability of dairy heifers. Seven pairs of identical twins were divided into two groups. One group was fed a normal control ration and the other group was fed heavily on concentrates to produce fattening with rapid growth. The rapidly grown fattened heifers weighed 32% more than the controls at two years of age. All heifers were fed the same ration after calving The average fat corrected milk production of the rapidly grown fattened heifers was 84.8% of the controls in the first and second lactations; however the results were not always consistent with

individual pairs. Udder structure of three of four of the fattened twins examined was abnormal, with areas lacking development of secretory tissue. The authors concluded that rate of gain is not a satisfactory criterion for the rate of feeding for dairy heifers. A normal growth rate of heifer calves followed by heavier feeding just before calving was indicated as desirable.

Swanson and Spann (1954) conducted a similar experiment with white rats in which lactation was measured by the growth of equalized litters, 11 young per mother. Rats raised on ad libitum feeding raised only 59% of their young to 21 days with a litter gain of 136 gm. Rats fed 80% as much as the above group raised 93% of their young with a litter gain of 235 gm. The rapidly grown rats produced only 60% as much as the restricted rats in the second lactation. The authors concluded that "excess fattening during growth is detrimental to the lactating ability."

Crichton, Aitken and Boyne (1960) reported on plane of nutrition at four feeding levels: HL (high level 44 weeks, low level until two months before calving); HH (continuous high level feeding); LH (low level first 44 weeks followed by high level); LL (low level until two months before calving). The high plane was 110% and the low was 70% of the normal growth ration recommended by Ragsdale (1934). The HL group produced fat corrected milk at a significantly lower level than the other groups in the first two lactations.

C. Performance of Reciprocal Crossbreds with Respect to Their Birth Size, Growth Rate and Mature Size.

Walton and Hammond (1938) reported on reciprocal crosses between the large Shire horse and the small Shetland pony, mated artificially. At birth foals were in proportion to the weights of their mothers and equal to foals of the pure breeds to which their mothers belonged. The crossbred foals from Shire mares were three times as large as those from Shetland mares. Maternal regulation of foetal growth was very marked and obscured any genetic effects. After weaning, genetic effects appeared. The foals from Shire mares grew less rapidly than pure Shire foals and foals from Shetland mares grew more rapidly than pure Shetlands. At three years of age the difference in size of the reciprocal crosses was still marked and was apparently permanent.

Dickinson (1960) reported on a crossbreeding experiment involving matings among British Fresian, Ayrshire and Jersey cattle. He found a tendency of the smaller born reciprocal crosses between two breeds to equal the larger at twelve months after birth. This is known as compensatory growth, letting the calves from the small breed of cow catch up with the calves from the larger breed of cow in reciprocal crosses.

Gerlaugh, Kunkle and Rife (1951) found little difference in the birth weights of calves that were reciprocal crosses between the Angus and Hereford breeds. Weaning weights showed a difference of

38 pounds between the reciprocal crosses in favor of the calves from Angus dams. They concluded that milk production was probably the most important factor.

Damon, McCraine, Crown and Singletary (1959) found a 43 pound advantage in weaning weights of crossbred calves from Angus dams and Hereford bulls over reciprocal crossbred calves from Hereford dams and Angus bulls. Slaughter calf grades showed a significant difference of 1.5 grade points in favor of Hereford x Angus over Angus x Hereford calves indicating a similar maternal effect existed after weaning.

Lawson and Peters (1964) found average birth weights of reciprocal crosses between the Highland and the Hereford breeds to exceed the average of the parental breeds by 4.7 pounds indicating a considerable degree of heterosis. The crossbred calves from Hereford dams were 3.5 pounds heavier than those from Highland dams indicating a maternal effect due presumably to the larger size of the Hereford dams.

Gaines, McClure, Vogt, Carter and Kincaid (1966) studied calves from reciprocal crosses of purebred Angus, Herefords, and Shorthorns. Birth weight differences were not significant between reciprocal cross calves. There was little evidence of maternal influence on birth weight. In both comparisons involving Angus dams, the smaller breed, the crossbred calves were slightly heavier at birth than the reciprocals involving Hereford or Shorthorn cows.

Large differences were evident in average daily gain from birth to weaning and in age adjusted weaning weight between reciprocal crosses involving the Hereford and Angus as well as the Hereford and Shorthorn breeds. This indicated substantial maternal effects due to the breed of dam. Calves from Hereford dams by Angus bulls were 31 pounds lighter at weaning than those from Angus dams by Hereford bulls. Calves from Hereford cows by Shorthorn sires were 61 pounds lighter than the reciprocals from Shorthorn dams by Hereford sires. Differences between reciprocal crosses of the Angus and Shorthorns were small.

Gaines and co-workers also reported strong evidence for heterosis in daily gain to weaning, and weaning weight. The two-breed reciprocal crosses outweighed the straight breeds by an average of 16 pounds at weaning which was a highly significant difference. When particular reciprocal crosses were compared with the average of the two parental breeds (mid-parent), there appeared to be some confounding of heterosis and maternal effects. Hereford x Angus (sire breed first) calves were 32 pounds heavier at weaning than the mid-parent average but the reciprocal crosses from Hereford dams were only one pound heavier. More striking, Hereford x Shorthorn calves were 39 pounds heavier but the reciprocal cross was actually 22 pounds lighter than the mid-parent. The authors concluded that the superiority of the Hereford x Angus and Hereford x Shorthorn crosses over their mid-parental averages was a proper measure of heterosis in weaning weight. This was based on the presumption that heterosis

was potentially as great in the reciprocal crosses but was masked by the poor maternal environment furnished by the Hereford cows. This interpretation is at variance with the usual procedure of expressing heterosis as the difference between the average of the two reciprocal crosses and the mid-parent. It does have important practical application, however. Differences in feeder grades at weaning followed the same pattern as daily gain and weaning weights. However, there was more evidence of difference due to maternal effects and less due to heterosis than was the case with the other weaning traits.

D. Other Literature

Black and Knapp (1936) found that calves gaining faster while on milk up to weaning tended to gain slower after weaning. Gain from birth to weaning was highly correlated with pounds of milk received up to weaning.

Knapp, Lambert and Black (1940) studied birth and weaning weights in Beef and Milking Shorthorn cattle. They found that a large proportion of the variation in these weights could be attributed to the weight of the cow, calving sequence, length of gestation period and pounds of milk the calf received during the suckling period.

Vogt and Marlowe (1966) studied relationships between a cow's own growth rate, as a calf, from birth to weaning and the pre-weaning growth rate of her offspring, using records collected through the on farm performance testing program of the Virginia Beef Cattle

Improvement Association (B.C.I.A.) Pre-weaning growth records were available for 1779 Angus and Hereford cows which had one or more offspring recorded in the B.C.I.A. program. The correlation between the cow's own pre-weaning growth and that of her offspring was large and negative ranging from -1.26 to -1.63 in the two breeds. The authors concluded that the results indicated "a negative relationship (genetic or environmental or both) between the dam's weaning performance and the maternal environment she subsequently provides for her offspring." The same investigators (personal communication 1966) studied the genetic relationship between sire and offspring for pre-weaning daily gain using records on 750 Angus and Hereford bulls, for which pre-weaning performance of both the sire and offspring were recorded through the Virginia B.C.I.A. program. They found a positive genetic covariance of 0.20 for pre-weaning growth of the sire and his offspring.

Christian, Hauser and Chapman (1965) mated 52 identical twin Hereford heifers to the same bulls. All of the twins and their offspring from the time of their birth or purchase until slaughter were fed in the dry lot. A significant negative correlation was found between the weaning weight of the dam and her butterfat production to 60 days of age. There was also a fairly large negative correlation between weaning weight and subsequent milk production. The authors

concluded that the results indicated a negative genetic or environmental correlation, or both, between weaning performance of the dam and the maternal environment the cow provides for her calf.

Hill, Legates and Dillard (1966) studied 180 day weights of 717 Hereford calves, which included 141 offspring-dam pairs, to determine the importance of the calf genotype for weight and the dam's genotype for maternal effects on calf weight. The authors concluded that there was "a negative genetic correlation between the genotype for weight and maternal effects."

III. MATERIALS AND METHODS

Cows

The data were obtained from records on a herd of beef cows at the Shenandoah Valley Research Station, Steeles Tavern, Virginia. This herd was used in an experiment in which crossbred cows among the Angus, Hereford and Shorthorn breeds were compared with straight bred cows of the same breeds with respect to fertility and maternal performance.

One half of the cow herd consisted of crossbreds (reciprocal two-breed) and the other half straightbreds of these breeds. The cows were purchased as calves in 1960 from breeders who had contracted with the Station to make crossbred matings to produce the two-breed cross heifers. Contracts were made with six breeders, two for each of the three breeds involved. The breeders mated a random one half of their cow herd to bulls of a different breed and the remaining one half to bulls of the same breed as the cows. A minimum of 10 crossbred and 10 straightbred heifers were purchased from each breeder. The herds in which the contract matings were made were considered as typical high grade or unregistered purebreds of the three breeds. Selection of the herds was primarily on the basis of availability and willingness of the herd owner to cooperate with the Station in making the matings. No attempt was made to select on performance of the herd. While the herds were not by any means a

random sample, it is believed that they were representative of the commercial beef cow herds in the area.

This study is a by-product of the original experiment and is concerned only with the maternal performance of the crossbred cows. These cows consisted of sets of reciprocal two-breed crosses among the three breeds. The differences in maternal performance of the sets of reciprocal crosses were studied. The study involved 11 Angus x Hereford cross cows (sire breed first), 13 Hereford x Angus, 10 Angus x Shorthorn, 12 Shorthorn x Angus, 12 Hereford x Shorthorn, and 9 Shorthorn x Hereford. Most of these 67 cows produced calves in all four years, however, a few produced calves for three or fewer years. There were a total of 249 offspring from these matings over the four year period.

Bulls

In the experimental matings the crossbred cows were mated to purebred bulls and the purebred or straight bred cows were mated to crossbred bulls, so that all cows would produce either three-breed or backcross calves. This study is of course concerned with only the crossbred cows that were mated to purebred bulls. Most of the bulls used were obtained as calves from private breeders but some were produced in the V.P.I. Experiment Station herds. All bulls used had completed a 168-day performance feeding test following weaning at the Front Royal Beef Cattle Research Station. Bulls were selected as close to the average for the breed as practical for type and weight gain on

the performance test. Two different bulls of each breed were used each year; usually one of each breed pair was two years old or older and one a yearling. The two bulls were turned with the herd alternately for 3 or 4 week periods. Each year the older bull was replaced so that most bulls were used for two breeding seasons.

Experimental Matings

The plan of experimental matings is shown in Table 1. Equal numbers of three-breed and backcross matings were made each year. (A secondary objective of the experiment was to determine how much additional hybrid vigor, if any, resulted from crossing with a third breed in the three-breed cross over use of one of the parental breeds in the backcross.) The crossbred cows of each set were assigned at random in the numbers shown in Table 1, to the Angus, Hereford and Shorthorn bulls. A set consisted of both reciprocal crosses between two breeds. No distinction between the two reciprocal crosses was made in assignment to mating groups. The cows were reassigned at random to mating groups each year.

Management

Cows were pasture bred as two year olds to calve first as three year olds. Calving was done on pasture with little shelter except wooded areas and natural depressions. Some calves were lost during deep snows and extremely cold periods. Calves were identified

Table 1. Original Plan of Experimental Matings Showing Theoretical Number of Cows Assigned to Each Bull Each Year.

Bulls	Cows*		
	A x H H x A	S x A A x S	S x H H x S
Angus	5	5	10
Hereford	5	10	5
Shorthorn	10	5	5

* A = Angus; H = Hereford; S = Shorthorn

by duplicate ear tag numbers and were weighed within 24 hours after birth.

Cows and calves were grazed together during the pasture season on permanent blue grass-white clover pasture without creep feeding of calves. The cows and calves were grazed as a single herd after the breeding season. There were exceptions when pasture conditions or drought caused the herd to be divided, in which case the herd was divided at random into smaller groups.

All calves were weaned in October on the same day in a particular year. A feeder calf grade was placed on each calf at weaning by a committee consisting of three members of the Animal Science Department and one official grader from the Division of Markets of the Virginia Department of Agriculture. Federal-State standards for feeder calf grades were followed, and the scores of the graders were averaged for each calf. Cows were culled only when they failed to calve in two successive years or if a permanent injury or disease necessitated removing them from the herd.

After weaning the calves were placed in dry lot to be fed out for slaughter. After a 30 day adjustment period, they were full fed a growing-fattening ration of corn silage, ground ear corn, and protein supplement. Steers and heifers were fed in different locations. Heifers finished out earlier and were slaughtered at around 700 to 800 pounds. Steers were fed to weights of 900 pounds or heavier.

The cattle were weighed and graded before slaughter and carcass weights and grades were also recorded.

Adjustment of Data

Birth weights of calves were adjusted for sex differences by adding the weighted mean difference between the birth weights of heifer and bull calves to the heifer birth weights. Five pounds were added to the heifer birth weights.

Calf weaning weights were adjusted for age to 205 day standard weights. This was done by multiplying the average daily gain from birth to weaning by 205 and adding the birth weight for each calf. The 205 day weights were also adjusted for sex. This consisted of adding the weighted mean difference in 205 day weights between heifers and steers to the age adjusted weight of the heifers. Twenty-four pounds were added to heifer 205 day weights. Average daily gain to weaning was also adjusted for sex difference in the same manner. Daily gains of the heifers were adjusted to a steer equivalent by adding 0.09 pounds per day to observed daily gain of each heifer.

There were approximately equal numbers of calves born in each of the four years. Calves were sired in approximately equal numbers by Shorthorn, Angus and Hereford bulls each year, therefore, there was no adjustment made for year of birth or breed of sire.

Tests of Differences

Comparisons between Shorthorn x Angus, Hereford x Angus, Shorthorn x Hereford and their respective reciprocals were made in birth weight, average daily gain from birth to weaning, 205 day weight and weaning grade for steers and heifers combined. Since the steers

and heifers were handled somewhat differently after weaning, they were considered separately with respect to feedlot daily gain and carcass grade. Each of these comparisons was tested statistically by the t test.

$$t = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{s^2_p \left(1/n_1 + 1/n_2\right)}}$$

$\bar{y}_1$ = mean of calves from a group of crossbred dams.

$\bar{y}_2$ = mean of calves from the reciprocal group of crossbred dams.

n_1 = number of calves from a group of crossbred dams.

n_2 = number of calves from the reciprocal group of crossbred dams.

s^2_p = pooled variance of calves from a group of crossbred dams, and the calves from their reciprocal crosses

$$= \frac{SS_1 + SS_2}{v_1 + v_2}$$

$$SS_1 = \sum (y - \bar{y}_1)^2$$

$$SS_2 = \sum (y - \bar{y}_2)^2$$

$v_1 = (n_1 - 1)$ degrees of freedom.

$v_2 = (n_2 - 1)$ degrees of freedom.

Fertility and livability of crossbred groups and their reciprocal crosses were tested statistically by Chi Square according to Snedecor (1946).

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

χ^2 = Chi Square numerical value.

O = observed proportion.

E = expected proportion.

IV. RESULTS AND DISCUSSION

Fertility and Livability

Fertility of the cows expressed in number and per cent of cows calving and number and per cent of cows weaning calves of cows bred as well as average calving date is shown by reciprocal cross groups in Table 2.

The average calving date of Shorthorn x Angus cows (sire breed first) was 13 February and 10 February for their reciprocals. Hereford x Angus cows calved on an average date of 16 February with their reciprocals averaging 21 February; Shorthorn x Hereford dams averaged 13 February and their reciprocals 16 February. These differences were small and are considered random.

The largest difference between reciprocal crosses in cow fertility or calf livability was with Shorthorn x Angus versus their reciprocal, Angus x Shorthorn. In the 44 matings of Shorthorn x Angus cows, 39 calved and 33 weaned calves, for calving and weaning percentages of 88.6 and 75% respectively. The reciprocal cross, Angus x Shorthorn with 40 matings produced 39 born and 37 weaned for percentages of 97.5 and 92.5%. When expressed as percentages these differences appear large, 8.9% for calving and 17.5% for calves weaned. However, with the small numbers involved, the differences did not approach statistical significance. Differences between the other two pairs of reciprocal crosses were smaller and in neither case statistically significant.

Table 2. Calving Dates, Cows Bred, Cows Calving, and Cows Weaning Calves by Breed Cross of Dams (Average for Four Years, 1963-66)

Breeding of Dams	Av. Calving Date	Cows Bred	Cows Calving No.	Cows Calving %	Cows Weaning Calves No.	Cows Weaning Calves %
S x A	Feb. 13	44	39	88.6	33	75.0
A x S	Feb. 10	40	39	97.5	37	92.5
Difference	3 days			8.9		17.5
H x A	Feb. 16	46	41	89.1	39	84.8
A x H	Feb. 21	41	40	97.6	39	95.1
Difference	5 days			8.5		10.3
S x H	Feb. 13	31	29	93.5	27	87.1
H x S	Feb. 16	46	43	93.5	42	91.3
Difference	3 days			0.0		4.2

Since none of the differences in fertility and livability were significant, and with the small numbers involved, no conclusions as to breed or breed order seem justified. No information on fertility differences among reciprocal crossbred cows was found in the literature. Pani et al. (1963) did find that Landrace x Poland sows weaned larger litters than crossbred sows from Landrace dams but the differences were not significant. Since the differences in fertility and livability among the groups of cows in the present study were not significant, it would seem logical to assume at present that there are no differences.

Birth Weights

Adjusted birth weights are shown in Table 3. Calves from Shorthorn x Angus dams weighed 75.4 pounds at birth; those from the reciprocals weighed 70.6 pounds. The difference of 4.8 pounds was significant at the .01 probability level. Calves from Hereford x Angus dams weighed 77.6 pounds at birth while those from the reciprocals weighed 74.8. Shorthorn x Hereford dams had calves weighing 75.5 pounds at birth compared to 76.7 pounds for calves from their reciprocals. The differences in calves from Hereford x Angus, Shorthorn x Hereford and their respective reciprocals were not significant.

Pani et al. found that Landrace x Poland crossbred sows farrowed pigs heavier at birth but not significantly so than the reciprocal Poland x Landrace sows. England, et al. (1965) found

Table 3. Birth Weights, Daily Gain Birth to Weaning, Adjusted 205 Day Weight and Weaning Grades of Calves by Breed Cross of Dams. (Average for Four Years, 1963-66)

Breeding of Dams	Birth Weights	Average Daily Gain	205 Day Weights	Weaning[1] Grade
	(lbs.)	(lbs./day)	(lbs.)	
S x A	75.4	1.74	432	12.7
A x S	70.6	1.68	416	12.5
Difference	4.8	0.06	16	0.2
S. E. of Diff.	1.4	0.03	7.1	0.2
t	3.24**	1.88	2.25*	0.68
H x A	77.6	1.53	391	11.5
A x H	74.8	1.72	428	12.5
Difference	2.8	0.19	37	1.0
S. E. of Diff.	3.5	0.04	8.4	1.0
t	0.81	4.81**	4.40**	1.05
S x H	75.5	1.67	419	12.6
H x S	76.7	1.48	381	10.8
Difference	1.2	0.19	38	1.7
S. E. of Diff.	2.3	0.02	10.4	0.9
t	0.52	7.76**	3.65**	1.94

[1]Grade Code: 13, Choice; 12, Choice Minus; 11, Good Plus.

* $P < 0.05$

** $P < 0.01$

significant differences in birth weights of calves from reciprocal crossbred cows in only one of six comparisons involving the Angus, Brahman, Brangus and Hereford breeds. Since significant differences in birth weight of calves were found in only one of the three sets of reciprocal crosses in this study, and in one of six in that of England and co-workers, it is suggested that such differences are not likely to be common or important in crosses among the breeds involved.

Average Daily Gain and 205 Day Weight

Adjusted average daily gains from birth to weaning and adjusted 205 day weights are shown in Table 3. Shorthorn x Angus cows weaned calves gaining 1.74 pounds per day of age; their reciprocals weaned calves averaging 1.68 pounds. Calves from Hereford x Angus cows averaged 1.53 pounds; those from the reciprocals, 1.72 pounds; calves from Shorthorn x Hereford cows averaged 1.67 while those from the reciprocals averaged 1.48 pounds.

Adjusted 205 day weight differences in calves from Shorthorn x Angus cows minus calves from their reciprocals averaged 16 pounds; differences of those from Angus x Hereford cows minus their reciprocals were 37 pounds; calves from Shorthorn x Hereford cows minus their reciprocals had a 38 pound difference. Differences in adjusted average daily gain from birth to weaning and adjusted 205 day weights were significant at the 0.01 probability level between calves from Angus x Hereford cows and Shorthorn x Hereford cows when they were compared

with the calves of the crossbred cows from their respective reciprocal crosses. In both cases the calves from the crossbred cows whose mothers were Herefords were heavier and gained faster to weaning than calves from crossbred cows whose mothers were Angus or Shorthorn. The other set of reciprocal crossbred cows, Shorthorn x Angus, weaned calves that were significantly heavier ($P < .05$) in adjusted 205 day weights than Angus x Shorthorn. The difference in average daily gain from birth to weaning for this set was not statistically significant, however, both differences were in favor of the calves from the crossbred cows whose mothers were Angus.

England et al. (1965) reported calves heavier at weaning from crossbred cows whose mothers were Brahman or Brangus than calves from crossbred cows whose mothers were Angus or Hereford.

The highly significant differences found between calves from crossbred Angus x Hereford cows, Shorthorn x Hereford cows and their respective reciprocal crosses indicate that it is quite possible that the differences in maternal performance of the reciprocal crossbred cows could be due to a permanent effect of their own early maternal environment. It is likely that the crossbred cows, whose mothers were Angus or Shorthorn, were grown more rapidly with fattening from birth to weaning because of the superior maternal environment generally found in Angus and Shorthorn dams. The crossbred cows, whose mothers were Hereford, were probably furnished a maternal environment of growth without fattening from their Hereford dams that generally do

not provide as much milk as found in Angus and Shorthorn dams.

This difference in maternal environment provided by the three British breeds can be substantiated from calf weaning weights of work done by several workers. Gaines et al. (1966) showed a maternal effect in weaning weights demonstrated by the breed of cow. Calves from purebred Hereford bulls x Angus cows showed 0.18 pound per day more daily gain than reciprocal cross calves from purebred Angus bulls on Hereford cows. They also found a 0.32 pound per day difference in favor of Hereford x Shorthorn calves over Shorthorn x Hereford calves. Gerlaugh et al. (1951) showed a 38 pound difference in favor of Hereford x Angus calves over Angus x Hereford calves at weaning. Damon et al. (1959) reported a 43 pound difference in favor of Hereford x Angus calves over Angus x Hereford calves. Lawson and Peters (1964) found a maternal difference of six pounds in the reciprocal cross calves of Hereford x Highland in favor of the calves from Highland dams.

The conclusion that level of nutrition, particularly energy intake, during the first few months of a heifer's life may affect her future milk production is supported by work done with dairy heifers.

Considerable evidence was found in the dairy field which points out that heifer calves fed at a nutritional level that allows for rapid growth with fattening from birth to two years of age do not produce as much milk after freshening as those fed at a level permitting

normal growth without fattening. Swanson (1960) reported dairy heifers fed too heavily did not produce milk yields comparable to heifers fed a normal diet without fattening. Crichton et al. (1960), Hansson (1956), and Thomas et al. (1959) found similar results with dairy heifers. Swanson reported from studies of growth and lactation that it appeared that very high and very low feeding of heifers should be avoided. He favored a moderate rate of growth in the early stages with an increase just before calving for the best lactation potential.

The most likely explanation of the consistent differences in weaning weights of calves from cows of different reciprocal crosses, found in this study, would seem to lie in the pre-weaning nutritional level of the cow herself. Literature reviewed cited several workers who found that crossbred calves from Hereford mothers were significantly lighter at weaning than their reciprocal crosses from Angus or Shorthorn mothers. It seems reasonable to conclude, on the average, Hereford cows did not furnish the maternal environment furnished by Shorthorn and Angus dams. The crossbred cows with Angus or Shorthorn mothers may have been grown at too high a nutritional level prior to weaning resulting in excessive fattening which has been shown from research with dairy cows to result in lowered milk production. If true this could result in a negative relationship between a cow's own weaning weight and that of her offspring.

Vogt and Marlowe (1966) did work which supports this conclusion. Correlations between the dams and their offspring for average daily

gain were -1.26 to -1.63 in Herefords and Angus. They concluded that there was a negative relationship (genetic or environmental, or both) between the dam's weaning performance and the maternal environment she provides for her calf. Work done by Christian et al. (1965) and Hill et al. (1966) is in agreement.

Feeder Grade at Weaning

Feeder grades at weaning are shown in Table 3. Feeder grade differences at weaning were not significant. There was practically no difference between calves from Shorthorn x Angus dams and those from the reciprocals. There was one third of grade difference of calves from Hereford x Angus dams and the reciprocals in favor of the reciprocals. There was less than two thirds of a grade difference of calves from Shorthorn x Hereford dams minus their reciprocals. Since the differences were small and non-significant it was concluded that they were largely due to chance.

Feedlot Daily Gain and Carcass Grade

Average feedlot daily gains and carcass grades are shown in Table 4. Steers from Shorthorn x Hereford cows gained 2.11 pounds per day on full feed while steers from the reciprocal cross cows 2.37 pounds per day. The difference of 0.26 pound per day was significant at the 0.01 probability level in favor of steers from Hereford x Shorthorn dams. Heifers from Angus x Shorthorn cows gained 0.21 pound per day more than heifers from Shorthorn x Angus

Table 4. Feedlot Daily Gain and Carcass Grade of Steers and Heifers by Breed Cross of Dams. (Average for three years, 1963-65)

Breeding of Dams	Feedlot Daily Gain		Carcass Grade[1]	
	Steers	Heifers	Steers	Heifers
	(lbs./day)	(lbs./day)		
S x A	2.27	1.81	11.7	11.5
A x S	2.22	2.02	12.1	12.0
Difference	0.05	0.21	0.4	0.5
S. E. of Diff.	.05	0.11	0.4	0.4
t	0.92	1.95	1.11	1.49
H x A	2.38	2.03	12.0	11.5
A x H	2.35	1.99	11.7	11.5
Difference	0.03	0.04	0.3	0.0
S. E. of Diff.	0.10	0.02	0.5	0.26
t	0.33	1.67	0.67	0.0
S x H	2.11	2.03	11.6	11.2
H x S	2.37	2.13	11.6	11.7
Difference	0.26	0.10	0.0	0.5
S. E. of Diff.	0.09	0.06	0.4	0.3
t	2.99**	1.55	0.0	1.49

[1]Grade Code: 13, Choice; 12, Choice Minus; 11, Good Plus.

* $P < 0.05$

** $P < 0.01$

cows, however this difference was not significant at the 0.05 level. Although none of the other groups of steers and heifers were significantly different in feedlot daily gains, most of the differences showed a compensatory gain in favor of the calves that were lighter at weaning.

Carcass grade differences of both steers and heifers from the crossbred cows and their respective reciprocal crosses were less than 1/6 of a grade and were not significant. Since carcass grade differences were small and non-significant, it is concluded that there was no difference in carcass grades.

V. SUMMARY AND CONCLUSIONS

Maternal performance of reciprocal two-breed cross cows between Angus, Herefords and Shorthorns was compared in 249 matings over a four year period. These cows were mated to bulls of the same three breeds to produce three-breed and backcross calves. Shorthorn x Angus cows (sire breed first) weaned 17.5% fewer calves and Hereford x Angus cows 10.3% fewer calves than their respective reciprocal crosses. These differences while large were not statistically significant presumably due to the small numbers involved. There was little difference between Shorthorn x Hereford and Hereford x Shorthorn cows in percentage calf crop. The calves from Shorthorn x Angus cows were significantly heavier at birth than the calves from their reciprocals. Birth weight differences of calves from the other two sets of reciprocal cross cows were not significantly different. Differences in average daily gain from birth to weaning were highly significant in calves from Angus x Hereford cows over calves from Hereford x Angus cows as well as Shorthorn x Hereford over Hereford x Shorthorn. The third set of reciprocal crosses, Angus x Shorthorn versus Shorthorn x Hereford, did not show significant differences in average daily gains. Differences in 205 day weights of calves from Angus x Hereford and Shorthorn x Hereford cows were highly significant over their respective reciprocals. Differences

in 205 day weights in the third set were significant at the 0.05 probability level in favor of calves from Shorthorn x Angus cows over Angus x Shorthorn. Feedlot gains following weaning for both steers and heifers were generally in reverse order to pre-weaning gains indicating compensatory growth; one of the six differences was significant at the 0.01 probability level. Differences in feeder grade at weaning and carcass grade were small and non-significant.

These results are interpreted, not as a genetic (sex-linked) effect, but as a negative phenotypic relationship between a cow's own weaning weight and her maternal performance.

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COMPARISON OF MATERNAL PERFORMANCE OF RECIPROCAL CROSSBRED COWS

by

B. E. Leonard

ABSTRACT

Maternal performance of reciprocal two-breed cross cows between Angus, Herefords and Shorthorns was compared in 249 matings over 4 years. These cows were mated to bulls of the same three breeds to produce three-breed and backcross calves. Shorthorn x Angus (SA) cows (sire breed first) weaned 17.5% fewer calves and HA cows 10.3% fewer than their respective reciprocal crosses. There was little difference between SH and HS in percentage calf crop. Mean differences in birth weight, daily gain to weaning and 205 day weight (kg.) of calves from cows of the three pairs of reciprocal crosses were: SA minus AS (2.2 ± 0.7, 0.03 ± 0.01, 7.3 ± 3.2); AH minus HA (-1.3 ± 1.6, 0.09 ± 0.02, 16.8 ± 3.8); SH minus HS (-.5 ± 1.0, 0.09 ± 0.01, 17.2 ± 4.7). Feedlot gains following weaning for both steers and heifers were generally in reverse order to pre-weaning gains indicating compensatory growth; one of the six differences was significant. Differences in feeder grade at weaning and carcass grade were small and non-significant. The results are interpreted, not as a genetic (sex-linked) effect, but as a negative phenotypic relationship between a cow's own weaning weight and her maternal performance.