EFFECTS OF USING SIRES SELECTED FOR YEARLING WEIGHT AND CROSSBREEDING WITH BEEF AND DAIRY BREEDS: BIRTH AND WEANING TRAITS

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ABSTRACT

Data consisting of 948 calf records collected from 1978 to 1982 were analyzed to determine the effects of breeding methods used to improve commercial herds genetically on birth and weaning traits. Four distinct groups were used in the project: Group 1 (G1), an unselected, random mating Hereford control line; Group 2 (G2), a Hereford group using sires selected for yearling growth; Group 3 (G3), a rotational cross with Angus, Hereford, Charolais and Simmental breeds; and Group 4 (G4), a rotational cross with Angus, Hereford, Simmental and Holstein-Friesian breeds. Traits analyzed were birth weight (BW), calving difficulty (CD), percent assisted births (%AB), percent born alive (%BL), preweaning average daily gain (PWDG), relative growth rate (RGR), weaning weight (WWT) and percent weaned (%WND). The use of high yearling weight sires in G2 increased calf size (P<.01) at birth and weaning by 8.9 and 28.1 kg, respectively, along with increased CD (P<.01). Use of rotational crossbreeding systems increased calf size and growth from birth to weaning (P<.01), but decreased CD and %AB (P<.01) by .17 units and 13.5%, respectively. Including Holstein-Friesian in G4 resulted in further increases in preweaning growth (P<.01) and calving ease was improved without affecting BWT compared with G3.

(Key Words: Selection, Cross Breeding, Beef Cattle.)

Introduction

The commercial beef cattle industry has two genetic tools available to improve performance. The first is selection performed in the seedstock industry. Secondly, crossbreeding schemes are used to utilize additive and nonadditive effects.

The seedstock industry is responsible for the long-term genetic improvement of the commercial industry (Magee, 1971; Nielsen, 1978). Two important aspects of crossbreeding were discussed by Hill (1971). The first is the choice of breeds and methods of utilizing them in crossbreeding schemes to maximize economic returns. The second involves schemes to improve performance of the purebreeds used in cross-breeding so that continued improvement can be made. Crossbreeding is an effective tool for increasing performance but after the initial heterotic response, further improvement must come from within-breed selection.

Cundiff (1984) showed the importance of the crossbred female in providing the genetic potential for growth and the nutritional environment required to express this growth. The use of dairy breeding to improve the maternal ability of commercial cow-calf herds has gained increased interest, particularly in dairy-intensive states such as Michigan. Cartwright (1983) suggested that simple averaging of breeding values for milk production would dramatically increase weaning weight but nutritional stress could delay postpartum return to estrus.

The objective of this study was to compare several breeding schemes for the improvement of fitness and preweaning growth traits in the cow-calf production system.

Materials and Methods

Data from 948 calves from a long-term selection and crossbreeding project were collected at the Lake City Experiment Station, Lake City, Michigan from 1978 to 1982. A herd of grade Hereford cows was donated to
Michigan State University in 1967. The cattle were typical of Hereford cattle found in northern Michigan during the late 1960s. Two hundred cows were chosen to form the base population. The cows were stratified by age and randomly allotted to four breeding groups of 50 cows each. The first matings were made in 1967 and the first crossbred females entered production in 1970.

**Design of the Breeding Project.** The breeding project was designed to evaluate selection criteria and mating systems for commercial beef cattle production. Group 1 (G1) was an unselected, random mating Hereford control line that has been closed since the beginning of the project. Another Hereford group, designated Group 2 (G2), used sires produced by seedstock herds that were placing emphasis on yearling weight. Group 3 (G3) was a rotational crossbreeding system using Angus, Hereford, Charolais and Simmental. The feasibility of using a dairy breed in crossbreeding schemes was evaluated in Group 4 (G4) by replacing Charolais sires with Holstein-Friesian sires. Angus, Charolais and Simmental sires were acquired from herds placing emphasis on yearling weight performance. Holstein-Friesian sires were selected using estimated breeding values obtained from own yearling weight performance.

Group 1 was used to monitor environmental trends, which allowed the genetic change due to selection to be separated from environmental effects (Hill, 1972). The first four bull calves born, each by a different service sire, were chosen as replacements. The bulls chosen to be replacements were used for 2 yr. In their first year of service, these yearling bulls were used as natural service sires. Following their first breeding season, semen was collected from the bulls for use in the next breeding season. The 15 oldest heifers were saved for breeding each year. In the fall, the 10 heifers with the earliest expected calving dates were saved to replace 10 cows. The only deviations from random mating occurred in the prevention of mating closely related bulls and females to keep inbreeding at low levels. Females were culled if they were determined to be open at weaning time. Additional cows were removed at random, stratified by age, to keep the number of cows in the group at 50.

Three to four Hereford sires were randomly mated by artificial insemination (AI) to females in G2 each year. The sires were chosen by a committee of staff personnel from a list of high yearling weight bulls available from herds selecting for yearling weight. Natural service sires were obtained from seedstock herds for use after the AI breeding season.

In G3 and G4, females were mated to the breed of AI sire that they were least related to. Two to three AI sires of each breed were used each year. When the same breed was used in G3 and G4, AI sires of that breed were used in both groups. Hereford sires used in G2 were also used in G3 and G4. In 1978, the Simmental breed was introduced into G3 and G4. As a result, most calves born in G3 and G4 from 1978 to 1982 were Simmental-sired since their dams did not have any Simmental breeding. The Angus, Charolais and Simmental sires were evaluated using the criteria used on the Hereford sires. Angus, Hereford and Simmental natural service bulls were used in G3 and G4.

Within G2, G3 and G4, 15 heifer calves were retained as replacements based upon their actual weaning weight performance. The number of replacement heifers was reduced to 10 based upon 1) pregnancy status and 2) yearling weight. Any open females that were 4 yr of age and older were culled. Additional culling of cows was based upon calf performance at weaning.

Because sires used in G2, G3 and G4 were from outside sources, the amount of selection practiced in each group could not be determined. Because 15 heifers were selected per group per year, the amount of selection practiced on the heifers was small.

**Management of the Cow Herd at Lake City.** The breeding season began in mid-April and lasted 90 d, with the cows being bred artificially during the first 45 d. During the winter months prior to the calving season, the cow herd received alfalfa-grass hay and sorghum-sudan silage. At the start of the calving season, G1 and G2 females were fed a diet of haylage and corn silage; G3 and G4 females were placed on a corn silage diet. The duration of the pasture season ranged from 160 to 180 d, with the cows grazing improved and unimproved pastures. At weaning time, the cows were palpated to determine pregnancy status.

Each calf was weighed after birth and given a calving difficulty score. The calving difficulty scores assigned were 1) no difficulty, 2) slight pull, 3) hard pull, 4) Cesarean section or 5) abnormal presentation. All male calves were castrated with the exception of the G1 bull calves designated to be replacements. The calves
did not receive creep feed. Replacement heifers were grouped and fed together after weaning. Following the first 45 d of the breeding season during which the heifers were bred by AI, breeding season heifers were grouped with the mature cows of their respective groups and assigned to breeding pastures.

Traits Analyzed. Birth and survival traits investigated were birth weight (BWT), percent born alive (%BL), calving difficulty (CD) and percent assisted births (%AB). Percent BL was defined as the number of calves alive 24 h after birth of the calves that were born. Calves with a CD score of 5 (abnormal presentation) were deleted from the data set.

Weaning traits investigated were preweaning average daily gain (ADG), actual weaning weight (WWT), relative growth rate (RGR) and percent weaned (%WND). Relative growth rate was calculated from birth to weaning [(ln (WWT)− ln (BWT))/age at weaning] and describes the percent increase in body weight per day or the growth rate relative to the current size of the animal (Fitzhugh and Taylor, 1971). Percent WND was defined as the percentage of calves weaned that were alive at birth.

Statistical Analysis. The following linear model was used to analyze BWT, %BL, CD, %AB, %WND, ADG, and RGR:

\[ Y_{ijklm} = \mu + Y_{Ri} + G_j + A_{GEk} + S_{EXl} + (Y_{R}G)_{ij} + (G \cdot A_{GE})_{jk} + E_{ijklm}, \]

where

- \( \mu \) is a constant common to all observations;
- \( Y_{Ri} \) is the fixed effect of the \( i \)th year with \( i = 1, 2, \ldots, 5; \)
- \( G_j \) is the fixed effect of the \( j \)th group with \( j = 1, 2, 3, 4; \)
- \( A_{GEk} \) is the fixed effect of the \( k \)th age of dam with \( k = 1, 2, 3, 4, \) which represents 2, 3, 4 and 5 y of age and older;
- \( S_{EXl} \) is the fixed effect of the \( l \)th calf sex with \( l = 1, 2; \)
- \( (Y_{R}G)_{ij} \) is the interaction of the \( i \)th year and \( j \)th group;
- \( (G \cdot A_{GE})_{jk} \) is the interaction of the \( j \)th group and the \( k \)th age of dam; and
- \( E_{ijklm} \) is the random residual peculiar to the \( m \)th observation, which was assumed to be \( \mathcal{N}(0, \sigma^2) \).

Based upon preliminary analysis, other interactions concerning the main effects were found to be nonsignificant sources of variation. Age at weaning (DAYS) was included as a covariate in the analysis of WWT. A sire effect was not included in the model because of confounding of sire with group and year. Also, a considerable number of calves were sired by natural service bulls, thus sire could not be identified, particularly in G1 and G2.

Contrasts were set up to evaluate the effect of within-breed selection for yearling weight (G2 vs G1), the use of rotational crossbreeding systems (G3 and G4 vs G2), and to compare the use of beef and dairy breeding vs all beef breeding in crossbreeding schemes (G4 vs G3). Least-squares means were obtained for each class within the main effects and subclass within the interaction terms. The statistical analyses were performed using SAS (1982).

Results and Discussion

Mean squares are presented for birth and survival traits in table 1 and for preweaning and weaning traits in table 2. Group least-squares means and contrasts for birth and survival traits, and preweaning and weaning traits are shown in tables 3 and 4, respectively.

Birth and Survival Traits. Significant sources of variation in BWT were group, age of dam and sex of calf. BWT increased as age of dam increased and male calves were heavier at birth than female calves. Year and interactions of year x group and group x age of dam were not significant sources of variation. Groups maintained the same ranking for BWT over the time span of the study and in each age of dam classification.

The main effects of group, age of dam and sex of calf were significant sources of variation in CD and %AB. For both CD and %AB, the interaction of group x age of dam was an important source of variation (P<.01). Group x age of dam least-square means for CD and %AB are shown in table 5. The difference between calves in G2 and G3 and, G1 and G4 for CD and %AB was the largest when calves were born to 2-yr-old females.

The use of Hereford sires selected for yearling weight in G2 increased BWT and CD compared with G1. Use of sires selected for yearling weight increased BWT 8.9 kg, CD .27
TABLE 1. ANALYSIS OF VARIANCE FOR BIRTH AND SURVIVAL TRAITS

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Birth wt, kg²</th>
<th>Born alive, %²</th>
<th>Calving difficulty, units²</th>
<th>Assisted births, %²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (YR)</td>
<td>4</td>
<td>38</td>
<td>269</td>
<td>.21</td>
<td>2,600</td>
</tr>
<tr>
<td>Group (G)</td>
<td>3</td>
<td>6,640**</td>
<td>130</td>
<td>3.00**</td>
<td>22,000**</td>
</tr>
<tr>
<td>Dam age (AGE)</td>
<td>3</td>
<td>640**</td>
<td>1,018**</td>
<td>9.95**</td>
<td>81,200**</td>
</tr>
<tr>
<td>Sex (SEX)</td>
<td>1</td>
<td>1,408**</td>
<td>525</td>
<td>4.13**</td>
<td>35,100**</td>
</tr>
<tr>
<td>(YR·G)</td>
<td>12</td>
<td>36</td>
<td>202</td>
<td>.21</td>
<td>1,700</td>
</tr>
<tr>
<td>(G·AGE)</td>
<td>9</td>
<td>34</td>
<td>269</td>
<td>.55**</td>
<td>4,200**</td>
</tr>
<tr>
<td>Residual</td>
<td>915 b</td>
<td>24</td>
<td>317</td>
<td>.18</td>
<td>1,200</td>
</tr>
</tbody>
</table>

*aResidual degrees of freedom for birth weight and percent born alive.

*bResidual degrees of freedom for calving difficulty and percent assisted births.

**P<.01.

units and %AB 23.6%. Selection did not affect %BL, even though G2 calves did experience more dystocia than calves in G1. Birth weight would be expected to increase in response to yearling weight selection because BWT is genetically correlated, positively, with yearling weight. The increased dystocia was probably caused by the increased calf size at birth in G2 compared to G1.

Data from several selection studies summarized by Koch et al. (1982b) indicated that BWT increased genetically in response to selection on yearling weight performance in beef cattle. Hough et al. (1985) found that BWT was increased 1.4 kg (P<.01) in response to open-line selection that used Hereford sires ranked on the basis of their progeny yearling weight performance. Frahm et al. (1985) determined that BWT increased .26 kg·yr⁻¹ (P<.01) in response to yearling weight selection.

Koch et al. (1982a) reported that selection for increased yearling weight and on an index

TABLE 2. ANALYSIS OF VARIANCE FOR PREWEANING AND WEANING TRAITS

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Weaned, %²</th>
<th>Preweaning avg daily gain, (kg·d⁻¹)²</th>
<th>Relative growth rate, %²</th>
<th>Weaning wt, kg²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (YR)</td>
<td>4</td>
<td>920</td>
<td>.224**</td>
<td>.202**</td>
<td>55,413**</td>
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<tr>
<td>Group (G)</td>
<td>3</td>
<td>400</td>
<td>3.889**</td>
<td>.152**</td>
<td>208,051**</td>
</tr>
<tr>
<td>Dam age (AGE)</td>
<td>3</td>
<td>10,660**</td>
<td>.178**</td>
<td>.059**</td>
<td>9,380**</td>
</tr>
<tr>
<td>Sex (SEX)</td>
<td>1</td>
<td>3,620†</td>
<td>.691**</td>
<td>.008</td>
<td>32,406**</td>
</tr>
<tr>
<td>(YR·G)</td>
<td>12</td>
<td>840</td>
<td>.020</td>
<td>.012*</td>
<td>665</td>
</tr>
<tr>
<td>(G·AGE)</td>
<td>9</td>
<td>1,040</td>
<td>.024*</td>
<td>.009</td>
<td>7,561**</td>
</tr>
<tr>
<td>Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>63,974**</td>
</tr>
<tr>
<td>Linear</td>
<td>1</td>
<td></td>
<td></td>
<td>.012</td>
<td>.006</td>
</tr>
<tr>
<td>Residual</td>
<td>915 a, 787b, 793c</td>
<td>990</td>
<td>.012</td>
<td>.006</td>
<td>551</td>
</tr>
</tbody>
</table>

*aResidual degrees of freedom for percent weaned.

*bResidual degrees of freedom for preweaning average daily gain and relative growth rate.

*cResidual degrees of freedom for weaning wt.

†P<.10.

*P<.05.

**P<.01.
**GENETIC IMPROVEMENT OF COMMERCIAL HERDS**

### TABLE 3. GROUP LEAST-SQUARES MEANS AND CONTRASTS FOR BIRTH AND SURVIVAL TRAITS

<table>
<thead>
<tr>
<th>Group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Birth wt, kg</th>
<th>Born alive, %</th>
<th>Calving difficulty, units</th>
<th>Assisted births, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>28.7</td>
<td>96.5</td>
<td>1.22</td>
<td>20.4</td>
</tr>
<tr>
<td>G2</td>
<td>37.6</td>
<td>95.3</td>
<td>1.40</td>
<td>34.2</td>
</tr>
<tr>
<td>G3</td>
<td>40.8</td>
<td>95.8</td>
<td>1.30</td>
<td>26.8</td>
</tr>
<tr>
<td>G4</td>
<td>41.5</td>
<td>97.2</td>
<td>1.15</td>
<td>14.6</td>
</tr>
<tr>
<td>Avg SE&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.4</td>
<td>1.3</td>
<td>.03</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**Contrasts**

- G2 vs G1: 8.9 ± .5**  
  -1.2 ± 1.8  
  .18 ± .04**  
  13.8 ± 3.6**

- G3, G4 vs G2: 3.5 ± .5**  
  1.2 ± 1.7  
  -.17 ± .04**  
  -13.5 ± 3.3**

- G4 vs G3: 1.8 ± .5  
  1.4 ± 1.8  
  -.15 ± .04**  
  -12.2 ± 3.6**

<sup>a</sup>G1: Unselected random mating Hereford control line; G2: Hereford group using sires from seedstock herds selected for yearling weight; G3: Rotational cross using Angus, Hereford, Charolais and Simmental; G4: Rotational cross using Angus, Hereford, Holstein-Friesian and Simmental.

<sup>b</sup>Average standard errors for the group means.

**P<.01.

of yearling weight and muscling score increased CD in 2-yr-old, first-calf heifers. Also, selection for weight in all selection lines resulted in increased calf mortality compared with the control line. Selection for growth and muscling in the Charolais breed resulted in dystocia by increasing calf size at birth without proportional increases in dam pelvic area (Ménissier, 1976). Hough et al. (1985) concluded that selection for yearling weight would increase dystocia if BWT was increased substantially without increasing pelvic area of the dam.

Given knowledge of the estimates of the genetic correlations between BWT and yearling weight, an increase in BWT of the magnitude realized in this study was improbable and implied a genetic correlation between BWT and yearling weight greater than 1.0. A possible cause for the increase in BWT could be the result of a positive covariance between the

### TABLE 4. GROUP LEAST-SQUARES MEANS AND CONTRASTS FOR PREWEANING AND WEANING TRAITS

<table>
<thead>
<tr>
<th>Group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Weaned, %</th>
<th>Preweaning avg daily gain, kg·d⁻¹</th>
<th>Relative growth rate, %</th>
<th>Weaning wt, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>88.1</td>
<td>.613</td>
<td>.844</td>
<td>148.9</td>
</tr>
<tr>
<td>G2</td>
<td>87.5</td>
<td>.713</td>
<td>.795</td>
<td>176.5</td>
</tr>
<tr>
<td>G3</td>
<td>86.2</td>
<td>.849</td>
<td>.834</td>
<td>205.7</td>
</tr>
<tr>
<td>G4</td>
<td>89.7</td>
<td>.963</td>
<td>.870</td>
<td>230.5</td>
</tr>
<tr>
<td>Avg SE&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.3</td>
<td>.009</td>
<td>.006</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Contrasts**

- G2 vs G1: -.6 ± 3.1  
  .10 ± .01**  
  -.05 ± .01**  
  28.1 ± 2.5**

- G3, G4 vs G2: .5 ± 2.9  
  .19 ± .01**  
  .06 ± .01**  
  41.6 ± 2.4**

- G4 vs G3: 3.5 ± 3.2  
  .12 ± .07**  
  .04 ± .01**  
  24.8 ± 2.6**

<sup>a</sup>G1: Unselected random mating Hereford control line; G2: Hereford group using sires from seedstock herds selected for yearling weight; G3: Rotational cross using Angus, Hereford, Charolais and Simmental; G4: Rotational cross using Angus, Hereford, Holstein-Friesian and Simmental.

<sup>b</sup>Average standard error of group means.

**P<.01.
direct and maternal effects for BWT. Because of the high genetic correlation between BWT and yearling weight, selection for yearling weight could increase BWT directly and maternally if a positive covariance between the direct and maternal effects for BWT existed. Koch (1972) indicated that genetic correlations estimated by the regression of unselected offspring on parent could be greater than 1.0 if large maternal effects were present.

Rotational crossbreeding schemes with Angus, Hereford, Charolais, Simmental and Holstein-Friesian breeds increased BWT 3.5 kg compared with G2. The use of large breeds such as Charolais, Simmental and Holstein-Friesian provided increased breeding values for BWT, and nonadditive effects may have caused additional increases in BWT. Charolais and Simmental-cross calves averaged 4.6 kg more at birth than Hereford-Angus calves (Smith et al., 1976b). Notter et al. (1978a) showed that progeny from Simmental and Charolais-cross dams weighed more at birth than calves from Hereford-Angus dams by 3.0 and 4.5 kg for 2- and 3-yr-old dams, respectively.

Crossbreeding with the Holstein-Friesian breed did not significantly increase BWT compared with a crossbreeding scheme using all beef breeds of cattle. The difference between G4 and G3 was .76 kg. The similarity in BWT between G3 and G4 indicate that the Holstein-Friesian breed was comparable in genetic potential for BWT to the Charolais breed it replaced. The difference in calf BWT between Simmental-cross and Brown Swiss-cross, 2-yr-old females was not significant (Belcher and Frahm, 1979). Progeny of Brown Swiss × beef cows had 3.4 kg greater BWT than progeny from beef × beef-cross cows (Knapp et al., 1980). Calves born from Brown Swiss-Hereford dams weighed 3.9 kg more than calves from Angus-Hereford and Charolais-Hereford cows (Nelson and Beavers, 1982).

Calving difficulty and %AB were decreased in G3 and G4 compared with G2 by .10 units and 7.1%, respectively. The utilization of large, crossbred females probably was the primary cause of the decreased dystocia, even though BWT was increased as a result. Sagebiel et al. (1969) indicated that crossbreeding using Angus, Hereford and Charolais breeds increased dystocia, but calves from Charolais and Charolais-cross females had the least amount of CD. The use of Simmental and Charolais sires increased dystocia and early mortality by 20.5% and 6.9%, respectively, compared with Hereford-Angus calves (Smith et al., 1976b). Calves born to Simmental- and Charolais-cross, 3-yr-old dams had less CD than Hereford-Angus dams (Notter et al., 1978a). Data presented by Nelson and Beavers (1982) showed that calves from Angus-Hereford, Charolais-Hereford, and Brown Swiss-Hereford cows had decreased severity and incidence of dystocia compared with calves from straightbred Hereford cows. Cundiff (1984) concluded that the incidence of
dystocia appeared to be reduced by using large F₁ crossbred females.

Including the Holstein-Friesian breed in a rotational crossbreeding system did not increase calf size at birth but decreased the incidence of CD. The differences between G4 and G3 were .14 units and 10.8% for CD score and %AB, respectively. In an analysis of data from 1972 to 1976, McPeake (1977) found a similar difference between G3 and G4, with the mean CD scores of 1.36 for G3 and 1.24 for G4. Calves born to Brown Swiss-cross cows had a lower CD score by .5 units and a lower incidence of dystocia by 19.7% than calves from Simmental-cross cows (Belcher and Frahm, 1979). Brown Swiss x Hereford cows required 6.2% less assistance and their calves had a lower dystocia score by .13 units than Angus x Hereford and Charolais x Hereford cows (Nelson and Beavers, 1982).

Differences in calf shape and(or) anatomical characteristics of the cow at parturition could be the cause of decreased CD observed in G4 compared with G3. Laster (1974) determined that measures of calf shape were not significant sources of variation in the occurrence of dystocia when BWT was accounted for in the analysis. Belcher and Frahm (1979) hypothesized that beef x dairy-cross females possessed a biological advantage for ease of calving over beef x beef cows, e.g., less exterior fat, decreased muscling, or a more flexible pelvic area.

*Preweaning and Weaning Traits.* Preweaning average daily gain and WWT were influenced by year (P<.01), group (P<.01), age of dam (P<.01) and sex of calf (P<.01). The year x group interaction was not an important source of variation in both traits, but the group x age of dam interaction was significant for ADG and WWT. Group x age of dam least-square means for ADG and WWT are in table 6. In G1 and G2, calves nursing 3-yr-old cows had the heaviest WWT compared with the other age of dam classes, whereas calves in G3 and G4 had higher WWT suckling dams 5 yr of age or older. The same trends were reflected in ADG. The group ranking with each age of dam class did not change as age of dam increased. Smith et al. (1976b) and Nelson et al. (1982) found the breed x age of dam interaction to be an unimportant source of variation in weaning traits.

Significant sources of variation in RGR were year, group, age of dam, and year x group interaction. Examination of year-group least-square means indicated that changes in ranking and magnitude of group means across years occurred in this study. This interaction could reflect environmental influences affecting the rate of calf growth from year to year. Year x group least-square means were not presented because the years included in the study could not be duplicated. The difference in RGR between male and female calves was slight and nonsignificant, which was contrary to data reported by Smith et al. (1976a).

Age of dam and sex of calf were significant sources of variation in %WND. A greater

<table>
<thead>
<tr>
<th>TABLE 6. GROUP X AGE OF DAM LEAST-SQUARES MEANS FOR PREWEANING AVERAGE DAILY AND WEANING WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>Preweaning avg daily gain, kg·d⁻¹</td>
</tr>
<tr>
<td>G1ª</td>
</tr>
<tr>
<td>G2</td>
</tr>
<tr>
<td>G3</td>
</tr>
<tr>
<td>G4</td>
</tr>
<tr>
<td>Weaning wt, kg</td>
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<tr>
<td>G1</td>
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<tr>
<td>G2</td>
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<td>G3</td>
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<td>G4</td>
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ªG1: Unselected, random mating Hereford control line; G2: Hereford group using sires from seedstock herds selected for yearling weight; G3: Rotational cross using Angus, Hereford, Charolais and Simmental; G4: Rotational cross using Angus, Hereford, Holstein-Friesian and Simmental.
percentage of calves was alive at weaning when nursing cows 5 yr and older compared with other dam ages. A greater number of male calves was alive at weaning than female calves. Group was not an important source of variation in %WND.

The incorporation of within-breed selection of yearling weight increased ADG and WWT, .10 kg·d⁻¹ and 28.1 kg, respectively. Because WWT is genetically correlated with yearling weight, WWT and ADG should increase in response to selection for yearling weight. McPeake (1977) reported that selection for yearling weight within the Hereford breed increased WWT by 17 kg. Hough et al. (1985) determined that correlated response and genetic trend for WWT in response to sire selection based upon yearling weight EPDs were 15 ± 2 kg (P<.01) and 4.6 ± .7 kg (P<.01), respectively. Selection for yearling weight increased ADG and WWT, 3.61 ± 1.44 g·d⁻¹·yr⁻¹ (P<.01) and 1.00 ± .31 kg·yr⁻¹ (P<.01), respectively (Frahm et al., 1985).

Relative growth rate from birth to weaning of G1 calves was .05% greater than G2 calves. The difference in RGR would indicate that G1 calves had a greater percent increase in body size per day up to weaning than G2 calves. The decreased RGR was probably due to the increased BWT in G2, even though WWT was also increased. Because RGR is equal to relative maturing rate (Fitzhugh and Taylor, 1971), G2 calves may have been less mature for their age than G1 calves.

The difference in %WND between G1 and G2 was only .60%. No difference was detected in %WND between G1 and G2, even though there was more CD and a higher %AB in G2 than G1.

Calves in G3 and G4 had heavier WWT and greater ADG by 41.6 kg and .19 kg·d⁻¹, respectively, compared with G2 calves. The use of Angus, Charolais, Holstein-Friesian and Simmental breeds increased weaning growth by providing increased direct effects for growth and improving the maternal ability of the crossbred cow as well as increasing hybrid vigor. Notter et al. (1976b) determined that Charolais- and Simmental-sired calves possessed lower RGR (P<.05) than Hereford-Angus calves. Notter et al. (1978b) found that Simmental-cross cows produced progeny with a higher RGR (P<.05) than Hereford-Angus or Charolais-cross cows. This increase in RGR was attributed to a relationship between high milk production and high BWT for the Simmental-cross cows. Calves in G4 had a higher preweaning RGR than G3 calves by .04%. Part of the increase in RGR was due to the increased growth in response to the increased milk production of G4 cows. The beef × dairy-cross calves may have been earlier maturing for their body size than beef × beef-cross calves. Notter et al. (1978b) showed that Holstein-sired calves had a lower RGR than Hereford and Angus sired calves (P<.05).

Using rotational crossbreeding systems (G3 and G4) did not significantly improve %WND.
compared with G2. A lower percentage of calves born alive in G3 were weaned than in G2 or G4. McPeake (1977) reported that crossbreeding improved calf survival to weaning, particularly for Charolais-sired calves nursing British-cross cows. Compared with straightbred Hereford cows, a greater percentage of calves nursing crossbred cows were alive at weaning than calves nursing straightbred Hereford cows (Nelson et al., 1982).

The difference between G3 and G4 for %WND was -3.5%. The improved maternal environment provided by the beef × dairy-cross cow coupled with the decreased calving difficulty at birth was probably the cause for the improved survival of G4 calves at weaning. McPeake (1977) determined that 8.2% more calves survived the preweaning growth phase in G4 than in G3. Nelson et al. (1982) found 6.2% more calves nursing Brown Swiss-Herford cows were alive at weaning than progeny from Charolais- or Angus-Hereford cows.

Conclusions

The use of sires from herds selecting for yearling weight increased calf growth up to weaning. However, this increased growth was accompanied by a substantial increase in BWT and an associated increase in dystocia, particularly for calves born to 2-yr-old cows. Selection for yearling weight should increase BWT but the increase realized in this study is surprising. Rotational crossbreeding systems (G3 and G4) increased preweaning growth rate and WWT with only a small increase in BWT. Even though breeds such as Charolais, Simmental and Holstein-Friesian were used in the two crossbreeding systems, calving difficulty was not increased compared with G2. The incorporation of dairy breeding (Holstein-Friesian) into a rotational crossbreeding system provided substantial increases in ADG and WWT. These increases in calf growth were primarily the result of increased milk production provided by Holstein-Friesian genes. Also, BWT was not increased, along with a further decrease in the degree and incidence of dystocia, by using a dairy breed in a rotational crossbreeding system in contrast to all beef breeds.

Literature Cited


Notter, D. R., L. V. Cundiff, G. M. Smith, D. B. Laster and K. E. Gregory. 1978a. Characteristics of biological types of cattle. VI. Transmitted and


