# Animal Production and Nutrition Session

Dr. Dave McKay, *Presiding*

# Lifetime Reproductive Performance of Brood Cows Representing First-Crosses Between Three Exotic and Three British Breeds

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Prior to 1900, the North American beef industry was dominated by the three British breeds, the Angus, Hereford and Shorthorn introduced to this continent by early settlers. Differences in their ability to adapt to the wide range in environmental conditions were reflected in differences in rates of expansion and geographical dispersion. Cattle of predominantly Hereford breeding proved most adaptable to extensive rangeland management and they had come to predominate on the semi-arid Western plains. Elsewhere the three breeds were of approximately equal importance with some preference for Shorthorn under circumstances where both milk and beef production were desired.

The period of 1900 to 1950 saw a gradual decline in the popularity of the Shorthorn, a gradual westward expansion of the Angus, increasing popularity of Hereford-Angus brood cows for production on Western rangelands;and expanding use of Brahman crosses in the area of the Florida gulf. During the latter part of this period a direct conflict arose between show ring standards and production utility. Seed stock herds pursued goals of reduced size and earlier fattening both of which were detrimental to the economic goals of the commercial industry. Some commercial producers responded by establishing their own seed stock operations and one by-product was the Beefmaster breed developed by Tom Lasater. Others responded by searching for "new" breeds. Initially, this search was limited by health considerations to breeds available outside continental Europe. Thus the Charolais, which was available from other sources, was a logical first choice. Its influence spread slowly but steadily, reaching Canada in the early 1950's, but the outstanding performance of its crosses revived efforts to resolve the difficulties of direct importation from Europe. The Canada Department of Agriculture responded in 1964 by creating a maximum security quarantine station at Grosse Ile., Quebec, supported by a stringent system of health control pre- and post-import. This development opened the door to a wide variety of new genetic material. The first imports arrived in 1967. Since that date more than 9000 breeding animals representing 28 breeds new to North America have passed through the quarantine facility (Fredeen, 1980).

From the outset, it was evident that the potential contribution of these new breeds would have to be realized through crossbreeding, particularly through the breeding use of first cross females. Accordingly, the Research Branch of Canada Agriculture designed a comprehensive program for evaluation of the various crossbred combinations expected to result from use of these breeds. Specific attention was focussed on the $F_1$ performance of progeny sired by the three breeds which dominated the early imports, namely the Charolais, Simmental and Limousin. This program, in place by 1968, comprised four distinct phases to be conducted under two contrasting environments:

Phase 1: Comparative evaluation of pre- and post-weaning performance (including carcass evaluation) of $F_1$ progeny (1969 to 1973).
Phase 2: comparative evaluation of the lifetime reproductive performance of $F_1$ females (1970-1979).
Phase 3: Comparative evaluation of the feed requirements for maintenance (winter gestation period) and nursing (1978-1982) of the $F_1$ cows.
Phase 4: Comparative evaluation of $F_1$ vs back cross females for reproductive performance (1981-1988).

Phase 1 was open ended with provision for pre-weaning and feedlot evaluation of $F_1$ crosses sired by any other new breeds that might gain prominence. Breeds that have been or are being evaluated have included Beefmaster, South Devon, Maine Anjou, Chianina, Romagnola, Murray Grey and Machigiana. The other phases have concentrated on the nine $F_1$ crosses produced by mating Charolais, Simmental and Limousin sires with dams representing the Angus, Hereford and Shorthorn breeds. In all of the studies, these nine crosses have been compared with a contemporary

group of Hereford x Angus females. This specific $F_1$ cross was chosen as a control because of its wide popularity as a brood cow among commercial cattle producers.

Phase 2 has been completed and analyses of the wealth of information it provided are well advanced. This report summarizes the salient results in respect of lifetime reproductive performance of the breed crosses evaluated.

### Project design and management

Production of the $F_1$ breeding population from the exotic sires was contracted with the private sector. The Department provided semen, insemination services and progeny identification for the contract herds, purchased the females at weaning (approximately 7 mo of age), and reared them to one year of age in the research station facilities located at Lacombe, Alberta and Brandon, Manitoba. The HA control females were purchased at weaning from private cow-calf operators and reared at the two research locations along with their contemporary age groups of oxotic crosses. At one year of age the females were allocated at random within each breed-cross to two contrasting environments for evaluation of lifetime reproductive performance. One environment was in west-centralManitoba (Brandon), an area of semi-intensive management characteristics of the cultivated pasture system employed throughout the central area of the three prairie provinces (Manitoba, Saskatchewan, Alberta). The other environment was extensive range management (Manyberries) characteristic of the semi-arid short grass plains extending far south of the south-eastern portion of Alberta.

The exotic-cross females were sired by 22 Charolais, 13 Simmental and 19 Limousin bulls chosen at random from those available to the industry in the breeding years of 1969, 1970 and 1971. With minor exceptions the size of the cooperator herds ranged between 50 and 100 cows. The HA control females were obtained from 20 different herds. The total $F_1$ herd assembled for the project was 1150 head with a reasonable balance of numbers representing each cross at each location (Table 1).

Management at each location was in close accordance with the commercial production practices characteristic of their respective areas. One exception was age at initial breeding exposure and method of breeding. In contrast with many practical operations, all females were first exposed at approximately 15 months of age, all matings were made by AI during a 9 week breeding season (mid-June to mid-Aug), and clean-up bulls were not employed.

For their first production year, heifers were mated with Beefmaster and Red Angus sires. Subsequently, all matings were to sires of the Charolais, Chianina, Limousin and Simmental breeds. There were no back crosses; all females were bred to produce three-way cross valves to ensure a common degree of hybrid vigor.

A few heifers that failed to conceive were culled on the basis of anatomical defects revealed in the process of pregnancy testing. Cows were culled if barren two

Table 1. Number of $F_1$ females entering the project

| Breed cross† Sire | Dam | Total Brandon | Manyberries | Total |
|---|---|---|---|---|
| H | A | 75 | 75 | 150 |
| C | H | 54 | 53 | 107 |
| | A | 51 | 52 | 103 |
| | N | 45 | 43 | 88 |
| S | H | 61 | 64 | 125 |
| | A | 60 | 60 | 120 |
| | N | 62 | 62 | 124 |
| L | H | 48 | 49 | 97 |
| | A | 51 | 50 | 101 |
| | N | 65 | 70 | 135 |
| C | | 150 | 148 | 298 |
| S | | 183 | 186 | 369 |
| S | | 164 | 169 | 333 |
| | H | 163 | 166 | 329 |
| | A | 162 | 162 | 324 |
| | N | 172 | 175 | 347 |
| Total | | 572 | 578 | 1150 |

†Sire breed: H = Hereford; C = Charolais; S = Simmental; L = Limousin.
Dam breed: A = Angus; H = Hereford; N = Shorthorn.

consecutive years and, in the latter years of the project, a few were culled because of physical deterioration. Cows were weighed on the date of calving with drys weighed at the mid-point of the calving season (about April 10). Breeding weight was taken about June 10 and weaning weight on the date the herd was weaned. Calf data included calving ease, birth weight, weaning weight, and age and cause of disposal.

### Results and Discussion

Cow growth patterns: Sequential cow weights commencing at breeding age (approximately 15 months) and taken at weaning, calving and breeding in each consecutive year to weaning in 1979 provided the growth patterns illustrated in Figure 1 for one input group (females born in 1971). For the Brandon females, growth was rapid to approximately 30 months of age (weaning, 1973) with subsequent weight changes characterized by winter (gestation) gains and minimal growth (or weight loss) during the summer nursing period. Manyberries females, after their initial period of development (to 24 months of age), showed a distinctly different growth pattern with weight losses recorded during gestation and gains recorded during the summer. These losses and gains were particularly large in two consecutive years, 1973-74 and 1974-75 with cow weights at breeding in 1975 (approximately 51 months of age) averaging less than those taken two years previously. Gains made in the summer of 1975 brought the Manyberries herd to weight equivalence with Brandon but this was followed by two years of almost continuous weight loss. During their final 18 months the Manyberries females gained 140 kg to give a final weight (at 8.5 years) of 610 kg, 5 kg heavier than their contemporaries at Brandon.

Growth patterns for the females born in 1970 and 1972 were parallel with those shown for the 1971 females (Figure 1). The only difference was the age at which the marked

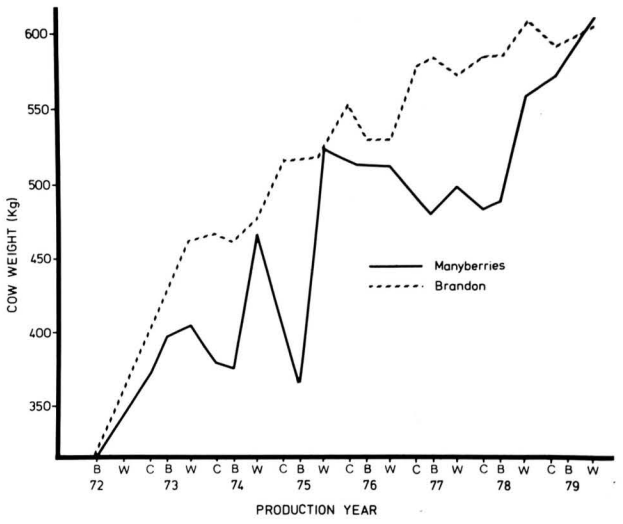


FIGURE 1: Location differences in growth patterns of $F_1$ females.

annual changes occurred. For the females born in 1972 the severe environmental conditions which culminated in the low weights at breeding in 1975 reduced their weight below that taken when they entered the program at 15 months of age.

Asymptotic growth to maturity at 7 to 8 years of age is the normal expectation for beef females. Most of this growth would be expected to occur during mid to late gestation with minimal gains, or perhaps slight losses, during the nursing period. This pattern of cow development was observed at Brandon but not at Manyberries and the difference was clearly associated with environment. Winter grazing on the semi-arid range of south-eastern Alberta is highly dependent on the rainfall of the previous summer. During periods of drought the summer growth of forage may be inadequate to replenish the winter range and this, particularly if combined with harsh winters, will place considerable winter stress on the range cows. One direct result is minimal weight gain, or actual weight loss, during the winter with compensatory weight recovery the following summer. Drought at Manyberries during the period 1970 to 1973 resulted in severe depletion of grazing and at weaning in 1973 the herd was moved to a higher rainfall area with considerably higher potential for forage production. However, heavy winter snowfall inhibited winter grazing and, despite supplemental winter feeding, the cow herd suffered substantial weight losses during the two winters at this location. The herd returned to Manyberries in the fall of 1975. Range conditions here, partially restored by the 2-year rest period, were adequate to prevent major winter weight losses but no real improvement was obtained until Phase 3 (involving winter feeding in confinement) was inaugurated in the fall of 1978.

The average weights at breeding, weaning and calving represented in Figure 1 included all cows, whether nursing, dry or barren, present at each weighing period. For a more critical evaluation of weight changes during each production cycle these data were analyzed separately for three groups defined by nursing status in year (n) vs year n+1). Cows of NN status nursed in two consecutive years. Those of ND status were dry in year (n+1) while DN cows were dry in year (n) and nursed in year (n+1). Cows of ND status at Manyberries were always lighter at breeding in year (n) than their contemporaries of NN or DN status (Figure 2). This

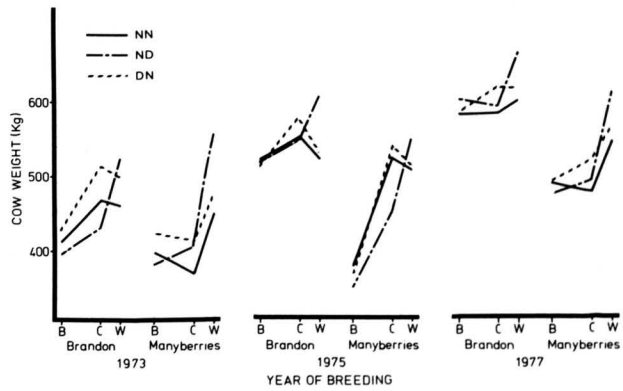


FIGURE 2: Location differences in weight changes from breeding in year n (B) to calving (C) and weaning (W) in year n+1 for cows of NN, ND and DN nursing status (see text)

suggested that cows sustaining the largest winter weight losses were most likely to display extended anestrus during the subsequent breeding season. However, these same cows invariably made the largest summer gains (C to W) at both locations with the largest gains occurring at Manyberries. Cows of NN status made gestation weight gains (B to C) at Brandon but lost weight during this period at Manyberries in 1973 and 1977. Cows of DN status, though usually heavier at all weights than the NN cows, followed the same pattern of weight change.

Extension of this method of analysis to all input groups of females for all years in the program, confirmed the interrelationships of cow weight with conception rates, and nursing status with subsequent weight changes. Conception rates for nursing cows were adversely affected by light weights at breeding and barren years provided an opportunity for substantial compensatory gains. These points were particularly important at Manyberries where the frequency of barren matings was greatest (22% vs 16% at Brandon).

Cows of NN status only were used to evaluate weight differences at weaning among the various $F_1$ crosses (Figure 3). Cows from Charolais (C) sires were larger than any of the other exotic sire groups, exceeding the HA cross by 17 to 23% at Brandon and 18 to 22% at Manyberries. Cows by Simmental (S) and Limousin (L) sires were similar in size averaging about 10% heavier than the control (HA) females. Ranking by dam cross averaged Hereford (H) > Shorthorn (N) > Angus (A) at both locations.

*Cow attrition:* Cow survival to the end of the experiment

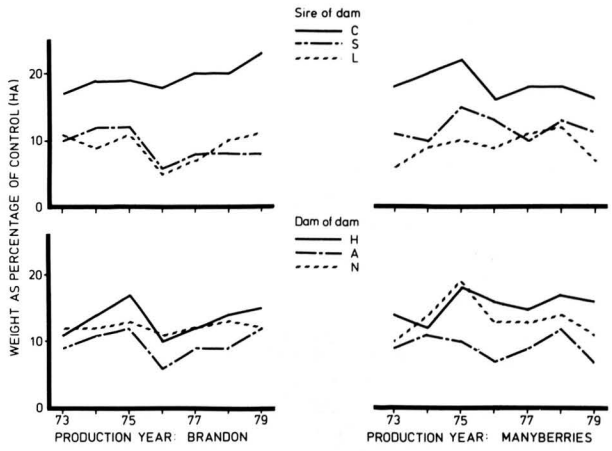


FIGURE 3: Annual weaning weights of cows expressed as percentages of their contemporary control (HA) population.

was 68% at Manyberries and 73% at Brandon. Breeding failure (barren two consecutive years) was the primary cause of losses with 21% of the females at Manyberries and 18% at Brandon culled for this reason. The $F_1$ crosses by Charolais sires or out of Angus dams recorded the lowest attrition rates at both locations (Figure 4). With one exception (the SN cross at Brandon), the highest attrition rates occurred among the crosses out of Shorthorn dams and attrition was particularly high among the LN crosses (46.2% at Brandon and 41.4% at Manyberries). This specific cross also recorded the highest proportion of barren culls.

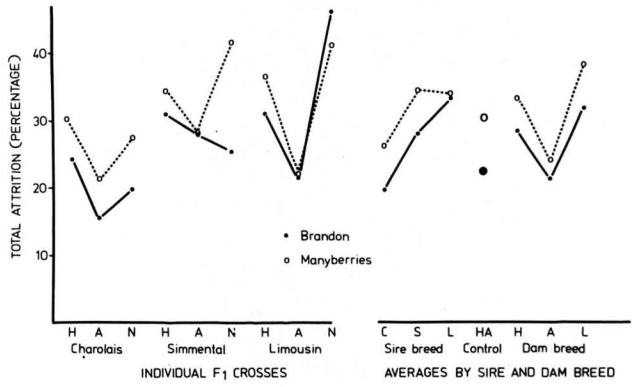


FIGURE 4: Breed cross differences in percentage attrition of $F_1$ females at two locations.

*Longevity,* calculated as the ratio of years in the program vs the maximum possible years, was highly variable among the three $F_1$ crosses sired by Limousin bulls. Averages for the LN and LA crosses were .76 and .93 at Brandon vs .74 and .90 at Manyberries. These differences resulted primarily from the frequency of early reproductive failure (and hence age at culling). Least variable were the Charolais sired females which ranged from .90 (CH) to .91 (CN) at Brandon and .87 (CH) and .89 (CN) at Manyberries. Averages for the HA control females were .88 and .84 at Brandon and Manyberries respectively.

*Calving ease and mortality:* Calving ease was primarily a function of sex of calf with 91% of the female births and 78% of the male births occurring without assistance. Breed of dam differences were evident only for male births with the HA (control) dams requiring less assistance than the $F_1$ cows produced by the three exotic sire breeds. The frequencies of unassisted male births were 85.1% (HA) vs 77.9, 76.9 and 79.9% for the C, S and L crosses respectively. Difficult male calvings for these same dam crosses averaged 4.6, 7.0, 9.1 and 8.1%.

Calf mortality at birth averaged 2.5% with no real difference associated with sex or location. Mortality after birth was greater among males than females, particularly at Manyberries, and total losses were greatest among progeny from Limousin sires (9.2%) and least for the HA (6.1%) and C crosses (6.8%)

Location differences in birth weights were negligible and the sex difference (M > F by approximately 8%) was not influenced by either location, breed cross of dam within location, or breed of terminal sire. Calves by Chianina sires averaged 2.2, 3.9 and 9.3% heavier than calves by Charolais, Simmental and Limousin sires respectively. At weaning, Brandon calves were 10% heavier than those at Manyberries and females were 5.8% lighter than males at Brandon and 5.6% lighter at Manyberries. Average weaning weights at Brandon for Chianina sired calves were 1.2, 0.8, and 7.0% heavier than calves by Charolais, Simmental and Limousin sires respectively. At Manyberries the differences, all in favor of Chianina sired calves, were 1.5, 1.2 and 4.8%.

Among the exotic cross cow groups, those sired by Limousin produced the smallest calves at birth with deviations from the HA progeny of −4% at Brandon and +1% at Manyberries (Figure 5). Calves out of C and S sires

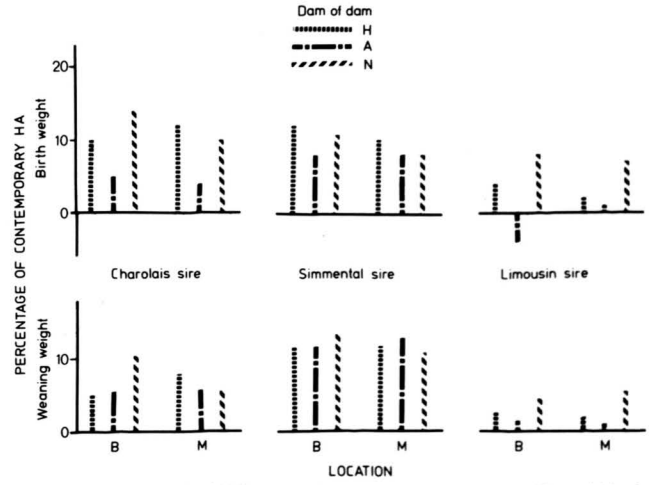


FIGURE 5: Calf weights at birth and weaning expressed as a percentage of the weights of contemporary progeny from the control (HA) dams at Brandon (B) and Manyberries (M).

averaged 8 to 10% heavier than HA progeny with Angus cross cows generally producing smaller calves than the Hereford or Shorthorn crosses. Breed cross rankings were not influenced by location. For weaning weight, dam rankings by sire breed of dam were S > C > L > HA at both locations with progeny from S crosses averaging 12% heavier and L crosses 3% heavier than the control. The heaviest calves at Brandon were weaned by the SN cross (13.5% above HA) while the SA (12.5% above HA) was superior at Manyberries.

**Lifetime productivity:**

The lifetime productivity for each breeding female was estimated on the basis of number of pregnancies (conception rate), number of calves weaned (calf survival) and weight of calf weaned (nursing capability) per mating opportunity. Each completed mating season (9 weeks duration, artificial insemination only) was considered as one mating opportunity.

Heifer matings provided 1150 mating opportunities during the three input years of 1971, 1972 and 1973 (i.e. equivalent to the total females entering the program). Annual mating opportunities decreased steadily during the years that followed, a direct reflection of cow attrition, and the total number of mating opportunities achieved during the program was 6245. These resulted in 5053 pregnancies (conception rate of 80.9%, 4640 calves weaned (weaning rate of 74.5%) and 153 kg of calf weaned per mating opportunity.

The cow herd at Brandon produced at a higher level for each of these criteria than the Manyberries herd (Table 2). Conception rates were higher by approximately 6%, or stated in an alternative form the frequency of barren matings was 16% at Brandon vs 22% at Manyberries. This difference augmented by the 4% greater calf mortality at Manyberries resulted in a difference of 8.7% in the number of calves weaned per mating opportunity. Lower average weaning weights were also recorded at Manyberries (194 kg vs 217 kg at Brandon) and the combined effect of these three productivity factors was a location difference of 20.4% in weight of calf weaned per mating opportunity.

Breed cross rankings (based on sire breed of the dam) of Brandon females were C > S > HA = L for conception rate and C = S > HA > L for weaning rate (Figure 6). Much wider differences were recorded at Manyberries where the overall ranking for both conception and weaning was C > HA > S > L. At Brandon, the best cross (C sires) recorded 84% conception and 75% weaning compared with 75% conception and 66.5% weaning for the L crosses. Ranking at Manyberries was C > HA > S > L for both traits. Differences associated with dam breed of dam were generally small apart from the lower conception rates for H females and low weaning rates for both H and A females at Manyberries (Figure 7). As is evident from both figures (6 and 7), the HA control at Manyberries gave weaning rates somewhat greater than the average for the 3 exotic crossbred groups.

Table 2. Summary of location differences in the primary production factors associated with cow productivity

| | Brandon | Manyberries | Total |
|---|---|---|---|
| Total mating opportunities (MO) | 3168 | 3077 | 6245 |
| Total pregnancies (P) | 2653 | 2400 | 5053 |
| Total calves weaned (W) | 2489 | 2151 | 4640 |
| Conception rate (% P of MO) | 83.7 | 78.0 | 80.9 |
| Weaning rate (% W of MO) | 78.6 | 69.9 | 74.5 |
| Barren (B) (% B of MO) | 16.3 | 22.0 | 19.1 |
| Calf loss (% W of P) | 6.2 | 10.4 | 8.2 |
| Wt. of calves weaned (kg/MO) | 170.0 | 135.4 | 153.0 |

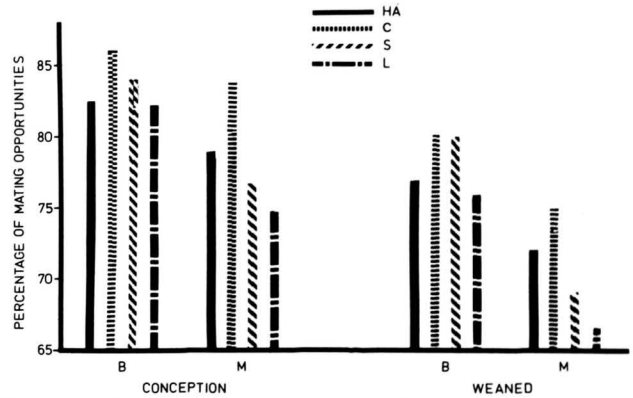


FIGURE 6: Conception and weaning rates expressed as percentages of total mating opportunies for the control (HA) females and females by Charolais (C), Simmental (S) and Limousin (L) sires, at Brandon (B) and Manyberries (M).

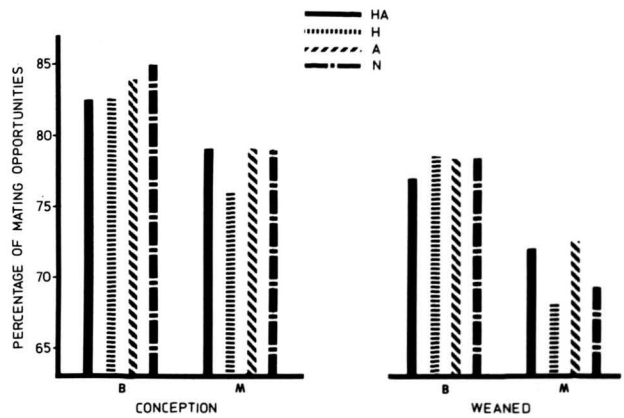


FIGURE 7: Conception and weaning rates expressed as percentages of total mating opportunities for the control (HA) females out of Hereford (H), Angus (A) and Shorthorn (N) dams at Brandon (B) and Manyberries (M).

At Brandon, the weight of calf weaned per mating opportunity from the $F_1$ cows by Charolais, Simmental and Limousin sires exceeded by 10.4, 13.6 and .9% the production from HA dams. The estimates for Manyberries were 11% (Charolais), 7.2% (Simmental) and .4% (Limousin). The best $F_1$ cross at Brandon was the SN (16.0% of the HA) with the CN (17.4) best at Manyberries (Figure 8). The HA gave higher productivity than the LA at Brandon (1.6%) and the LH at Manyberries (4.2%).

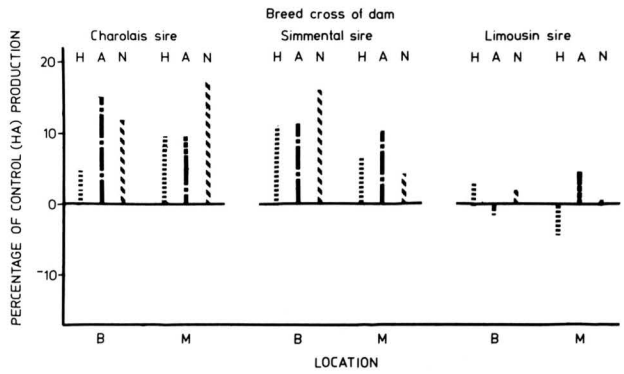


FIGURE 8: Weight of calf weaned per mating opportunity expressed as a percentage of production from control (HA) females at Brandon (B) and Manyberries (M).

### Interpretation

The reproductive process, while a regular occurrence in the normal life cycle, imposes a considerable degree of stress on the breeding female. To minimize the adverse effects of this stress, the environment must be reasonably matched with the genetic capability of the female. Failure to achieve the required balance will lead to reproductive failure.

This has been well illustrated by the results documented in this report. Nutritional inadequacy associated with and/or caused by the climatic extremes experienced at Manyberries had an adverse effect on growth of the breeding females, on their conception rates, on calf mortality and on pre-weaning growth of the calf. The contrast between the two locations in the annual patterns of weight change (i.e. minimal nursing gains and substantial gestation gains at Brandon with the reverse pattern at Manyberries) suggests that the winter period was particularly crucial at Manyberries. Summer droughts which resulted in inadequate replenishment of winter range were a contributing factor but the larger problem was created by winter and spring snowstorms which curtailed grazing and impeded attempts to provide supplemental feed. This interpretation is supported by the substantial summer gains recorded in most years, including those considered drought years, at the Manyberries location.

The large location differences in cow weights at calving during the period 1972 to 1978 were not reflected in differences in the calving traits of ease, calf mortality at birth or calf birth weight. Thus it appeared that the gestation process, once initiated, had prior claim on the nutrients available to the cow. Prolonged anestrus was one defence mechanism available to the cow with failure to conceive, most commonly observed among the lightest females, providing a rest period for replenishment and compensatory gains. Another defence mechanism may have been the limitation of milk production. The Manyberries females made large summer weight gains but weaned calves substantially lighter than those at Brandon, suggesting that demands for replenishment of their own bodies took precedence over lactation.

This hypothesis is supported by the location differences in the ranking of $F_1$ females for average weight of calf weaned. At Brandon, the highest weights were recorded by the three $F_1$ crosses by Simmental sires and by the three $F_1$ crosses out of Shorthorn dams. The Simmental sired dams were also superior at Manyberries but of the three Shorthorn groups only the Limousin cross was superior. Location differences in ranking of the Shorthorn and Simmental crosses were also evident in conception rates, weaning rates, and weight of calf weaned per mating opportunity with the Simmental-Shorthorn cross ranking substantially higher at Brandon than at Manyberries.

**Based on the reputation for milking potential of the 6 breeds employed for production of the $F_1$ females in this study the highest lactation would be expected from the Simmental x Shorthorn cross. This expectation was fulfilled at Brandon in terms of calf weaning weight and weight of calf weaned per mating opportunity. Under the more stringent environment of Manyberries, however, the milking potential may have been a handicap. This cross ranked well in calf weaning weights but productivity was compromised by reduced conception rates, increased culling of cows for breeding failure, and increased calf mortality.**

Net productivity of a beef cow, a combination of conception rate, calf mortality and calf weaning weight, may be summarized in the single estimate of weight of calf weaned per mating opportunity. This does not give a complete representation of the productive potential of a herd of beef cows since it does not reflect differences in rates of attrition or in cow weight, and hence her potential market value when culled from the herd. It is evident from the results shown in Figure 8 that $F_1$ females produced by Charolais sires gave the highest net productivity (weight of calf weaned per mating opportunity) at Manyberries and were approximately equivalent to the crosses by Simmental sires at Brandon. At both locations, however, the Charolais crosses had the lowest attrition rates (i.e. the greatest longevity) and substantially greater weights at all ages than contemporary females sired by the other breeds of exotic sires. Thus the results of this study indicate that the high reputation of Charolais cross females in the commercial cattle industry has been well earned. Least productive of the ten crosses evaluated were the Limousin x Angus at Brandon and the Limousin x Hereford at Manyberries, both producing less weight of calf per mating opportunity than the HA control. Limousin sired females also had the lowest conception rates, the lowest weaning rates, the lowest average cow weights, and high cow attrition.

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