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THE UNIVERSITY OF ALBERTA

THE USE OF LARGE DAIRY BREEDS IN CROSSBREEDING FOR RANGE BEEF PRODUCTION

by

© PAUL FELIX ARTHUR

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

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ABSTRACT

Studies were undertaken to evaluate the use of large dairy breeds in crossbreeding for beef production. These studies involved the assessment of reproduction and maternal productivity of Dairy-Beef Crossbred cows and the growth characteristics of their offspring.

The Dairy-Beef Crossbred cows were obtained by using Brown Swiss, Holstein and Simmental bulls on Hereford and Beef Synthetic cows, hence three dairy-beef crosses were obtained; Brown Swiss cross(BSX), Holstein cross(HOX) and Simmental cross(SIX). These Dairy-Beef Crossbred(DBC) cows as a group were also compared with four other breeding groups of cows maintained at The University Ranch, Kinsella, Alberta; Hereford(HE), Beef Synthetic(SY), Dairy Synthetic(DY) and Beef Crossbred(BC). DBC and BC cows were mated to HE bulls while in the other breeding groups bulls from the same breeding group as the cows were used. Data from 1972 to 1980 consisting of a total of 1420 calvings by 1026 cows were subjected to least-squares analyses to compute various statistics for comparison purposes.

In the first study (Chapter I) the reproduction and maternal productivity of the DBC cows were assessed by comparing the different crosses of DBC and also by comparing DBC with the other breeding groups of cows. Traits considered included calving difficulty and birth weight, calf crop traits, cow retention, cummulative calf production per cow exposed to breeding, and disposal traits. No

significant differences were obtained between the crosses within DBC in all the traits except for birth weight and weight of calf weaned per cow exposed to breeding. Calves of HOX cows had a heavier mean birth weight than those of SIX cows but similar to those of BSX cows (P<0.05). Mean weight of calf weaned per cow exposed to breeding followed a similar pattern as for birth weight. Reproductive failure was responsible for most of the disposals; 76.2 percent. Troubles with the udder did not appear to be a major problem with the DBC cows, accounting for only 2 percent of the disposals.

Calves of SY and DBC cows had similar mean birth weights while calves of DY cows were the heaviest and calves of HE cows the smallest (P<0.05). DBC and DY cows had the highest mean weights of calf weaned per cow exposed to breeding. They were followed by SY, BC and HE cows in that order. The differences between the breeding groups were significant except those between DBC and DY cows (P<0.05). As a percentage of the original cows exposed to breeding, DBC had 11 percent more cows still in the herd after 6 years of age than HE cows but this was not significantly different from the other breeding groups (P<0.05). For the cummulative calf production per cow for 3 calf crops DBC cows had a significantly higher number of calves weaned than HE, SY and BC cows (P<0.05). The same was true for the total weight of calves weaned, adjusted to a male basis. No significant differences were obtained between the breeding groups of cows for the other traits considered.

In the second study (Chapter II) the growth characteristics of the offspring of the DBC cows were assessed in a similar way. Traits considered included preweaning and postweaning growth traits. Within the DBC breeding group significant dfferences were obtained in all the preweaning growth traits. Calves of HOX dams were significantly heavier at birth than those of SIX dams (P<0.05). The adjusted weaning weight of calf followed the same pattern. Calves of BSX and HOX dams had similar preweaning average daily gains and these were significantly higher than that of SIX dams(P<0.05). For the postweaning growth traits the only significant differences obtained between the crosses were for the adjusted 365-day weight of male calves whereby male calves of HOX dams were heavier than those of SIX dams but similar to those of BSX dams (P<0.05).

Mean birth weight of calves of DBC dams was significantly (P<0.05) smaller than those of DY dams; however, no significant differences were observed between the calves of DBC dams and those of SY and BC dams. The adjusted weaning weight and preweaning average daily gain for calves of DBC dams were significantly higher than those of calves of SY and BC dams (P<0.05), a reflection of the superior milk production of DBC dams. Calves of HE dams had the lowest mean values for all the preweaning growth traits.

No significant differences were obtained between the male calves of the different breeding groups for the postweaning test period average daily gain. For adjusted 365-day weights, calves of HE dams had significantly smaller weights than those of DBC and the other breeding groups ($P<0.05$). The differences between the other breeding groups in this trait were not significant. Female calves of DBC dams were significantly heavier ($P<0.05$) than those of HE dams but significantly lighter than those of SY and DY dams at 540-days of age.

The results of the studies suggest that the Dairy-Beef Crossbred cows maintained their reproduction and productivity, and they weaned heavier calves under Kinsella conditions than beef or beef crossbred groups.

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GENERAL INTRODUCTION

Crossing of breeds is a potential method of obtaining genetic improvement in livestock. Combined with selection, additive and non-additive variance can be utilized to the utmost. Crossbreeding allows for the utilization of heterosis and combining of desired characteristics in cattle that would not otherwise be present in any single breed.

Crossbreeding beef cattle is becoming a widespread practice for increasing productivity in commercial herds. In his extensive review, Long (1980) reported that crossbreeding results in positive heterosis for most economic traits. Crossbred beef cows have been shown to be more productive than purebred cows (Gaines *et al.* 1971; Parker *et al.* 1972). Production per cow exposed to breeding could be increased 15 to 25 percent by crossbreeding (Cundiff 1970).

Interest in crossing dairy with beef breeds to increase the productivity of beef cows is also on the increase and this has stimulated research into evaluating the productivity of the dairy-beef crossbred female and the performance of the offspring it produces. Some work has been done with dairy-beef crossbred cows under feedlot conditions however more work needs to be done under range conditions.

The overall objective of the studies was to evaluate the use of large dairy breeds in crossbreeding for beef production under range conditions. It involves the evaluation of the maternal productivity and reproduction of the dairy-beef crossbred females, and the assessment of the growth potential of their offspring.

I. REPRODUCTION AND PRODUCTIVITY OF DAIRY-BEEF CROSSBRED COWS

A. INTRODUCTION

Cows are the production units in a beef cattle operation and their regular reproduction is essential to the returns obtained from the operation. It is also important that the calves born be nurtured and well cared for by their dams until they are weaned.

The amount of milk produced by the dam is very important in the weight of its calf at weaning. Incorporation of dairy breeds in crossbreeding for beef production has the effect of increasing the milk production potential of the crossbred cows (Deutscher and Whiteman 1971). Higher weaning weights have been reported from crossbreed Angus x Milking Shorthorn cows compared to purebred Angus and Milking Shorthorn cows (Spelbring *et al.* 1977a). In a study by Cundiff *et al.* (1974) it was observed that more than half of the cummulative effects of heterosis were due to heterosis for fertility and maternal ability in crossbred cows. Interest in the use of dairy breeds in crossbreeding with beef breeds is on the increase but very little research has been done under range conditions.

The use of large dairy breeds in crossbreeding may, however, result in the birth of heavier calves (Pahnish *et al.* 1969) which may lead to an increase in calving difficulty. Lower reproductive efficiency has also been reported in dairy cows as compared to beef cows (Deutscher and Whiteman 1971). The performance of dairy-beef crossbred cows, under range conditions compared to beef cows in reproductive efficiency needs to be adequately studied.

The objectives of this study were:

1. To evaluate and compare the maternal productivity of dairy-beef crossbred cows from three different dairy breeds.
2. To compare the maternal productivity of the dairy-beef crossbred cows, as a group, with four breeding groups of cows maintained at Kinsella.

The study includes the reproduction, retention and the cummulative calf production performance of these cows.

B. MATERIALS AND METHODS

Data for the study were collected from 1972 to 1980 at The University of Alberta, Beef Cattle Ranch at Kinsella, Alberta. It included data on cows born in 1972 through to 1978, and calves born from 1974 to 1980. The data included a total of 1420 calvings by 1026 cows.

The Kinsella Ranch is at the edge of the boreal forest and is characterized by groves of aspen poplar and other brush. The total land area is about 2,800 hectares. About 800 hectares consist of improved pasture, made up of brome, alfalfa and creeping red fescue. Of the native grass, rough fescue and western porcupine grass predominate. The annual precipitation at Kinsella is about 500mm.

The management and breeding plan of the Kinsella Project was described in detail by Berg (1975,1978). The breeding herd was on the range all year round and depended on natural grazing except for three or four months in the winter when supplementary maintenance feed, compatible with health and reproduction, was provided. Yearling and two year old heifers were separated from older cows during the winter. During this period older cows lost up to 50 kg. while heifers normally maintained their precalving weights.

A surplus cow herd was maintained at Kinsella. This consisted of crossbred cows, which were a progeny of cross breeding among Hereford and Beef Synthetic breeding groups, and cows culled from the Hereford and Beef Synthetic breeding groups either because of minor udder defects or because of low weaning indices on their calves. About 30% of the surplus cow herd was crossbred and the remainder were culls. Since 1971, surplus cows have been bred to Brown Swiss, Holstein and Simmental bulls to produce cows for the Dairy-Beef Crossbred (DBC) breeding group. Therefore, within the DBC breeding group of cows there were the Brown Swiss cross (BSX), Holstein cross (HOX) and Simmental cross (SIX). The above crossbreds were mated to Hereford bulls producing offspring of 25% dairy breeding which were included in the study. Thus in this study about one-third of the cows had 25% dairy breeding while the other two-thirds had 50% dairy breeding (Table I.1).

Other breeding groups of cows used in the study, mainly for comparison, were Hereford (HE), Beef synthetic (SY), Dairy synthetic (DY) and Beef crossbred (BC). The HE breeding group is a purebred population open to artificial insemination from superior industry bulls. The SY breeding group is a composite of approximately 36% Angus, 35% Charolais, 21% Galloway and the remaining 8% consists of other breeds including Hereford, Holstein, Brown Swiss and Brahman. The DY breeding group is also a composite of approximately 30% Brown Swiss, 33% Holstein, 6% Simmental and the remainder traditional beef breeds. The BC breeding group consists of crossbred cows which have at least 50% Hereford breeding and the remainder other beef breeds. The number of cows for the different breeding groups were 217 for DBC, 220 for HE, 445 for SY, 95 for DY and 49 for BC.

Table I.1 Compostion of the different crosses within DBC.

Dairy Breed Percentage		Breeding group			Overall
		BSX	HOX	SIX	
25%	No.	27	20	24	71
	%	35.1	29.4	33.3	32.6
50%	No.	50	48	48	146
	%	64.9	70.6	66.7	67.4
Total	No.	77	68	72	217
	%	100	100	100	100

The formation of some of these breeding groups was described by Berg (1980).

All sound heifers were bred as yearlings to calve as two-year olds. Cows and heifers were bred mainly in July and August. Breeding was in single-sire groups of twenty to twenty-five cows except for the DY breeding group which was bred as a multiple-sire group. DBC and BC cows were bred to Hereford bulls while in the other breeding groups, cows and bulls within the same breeding group were mated to produce the calves used in the study. Calves from only the first three possible calvings of each cow were used in the study to compare cow productivity traits. Two year olds were calved separately and were more closely supervised during calving. They remained separated until breeding commenced. Calves were born mainly in April and May and remained with their dams until weaning. All breeding females were run together as much as possible. Calves were weighed at birth and monthly to weaning. Except for 1974 where weaning was in early November, weaning has been in early October.

Heifers and cows failing to wean a calf each year were culled. Heifers and cows were also culled for unsoundness and defects such as requiring Caesarian section, bad udders, goiters, cancer eye, crippling, etc.

Traits considered included birth weight, and calving difficulty in which normal unassisted births were differentiated from assisted births of any form, from slight pull to requiring Caesarian section. Calf crop traits and weight of calf weaned per cow exposed to breeding for the first three calvings were also considered.

Cow retention was measured by whether or not a cow remained in the herd each successive year after her original exposure to breeding at a year of age. It should be remembered that in this study any heifer or cow failing to wean a calf each year was culled. Cummulative calf production per cow was calculated for number of yearly exposures to breeding which a cow had, number of calves born and weaned, all up to a maximum of three to cover the three year reproductive period studied. The total weaned weight per cow, expressed on male basis, was also calculated.

Disposal age was calculated as the age of the cow at the time of disposal, using records of all cows disposed during the period of the study. Under reasons for disposal, cows culled for reproductive failure included cows which aborted and cows which failed to calve. Cows culled for calving problems included cows which had stillbirths, cows whose calves died immediately after birth, cows with insufficient milk for their calves and cows requiring Caesarian section. Cows culled for udder problems included cows which had mastitis, bottle or large teats or pendulous udders. Culling for bottle or large teats was done only in the breeding groups where the number of cows needed to maintain herd size was not limiting. All other reasons for disposal, including deaths, were pooled under "other" reasons.

Statistical Analyses

Least-squares analyses for unequal subclass numbers (Harvey 1975) were computed. Two sets of analyses were done. The first set was a comparison of the different crosses within DBC. Preliminary analyses showed no significant differences between cows with 25% and cows with 50% dairy breeding, so within each cross cows were grouped together irrespective of the percentage of dairy breeding. In the second set of analyses the DBC cows were taken as one group and compared to the other four breeding groups of cows. Age of dam and sex of calf effects were considered in both sets of analyses.

A fixed effects model was used with the main effects being age of dam, breeding group of cow, sex of calf and year of birth. Only the interactions believed to be of the most biological significance were included in the model. These interactions were the age of dam by breeding group of cow interaction, age of dam by sex of calf interaction and breeding group of cow by sex of calf interaction. The model used was:

$$Y_{ijklm} = u + A_i + B_j + AB_{ij} + S_k + AS_{ik} + BS_{jk} + R_l + e_{ijklm}$$

where

Y=trait under consideration

u=overall mean

A=age of dam

B=breeding group of cow

S=sex of calf

R=year of birth

AB=age of dam by breeding group interaction

AS=age of dam by sex of calf interaction

BS=breeding group by sex of calf interaction

e=random error.

This model was used for birth weight and calving difficulty. For calf crop traits and cummulative calf production performance per cow, sex of calf and its interactions were removed. For the cow retention and disposal traits, both the sex of calf and age of dam plus their interactions were removed.

Levels for the main effects were:

1. Age of dam (A) classified as 2, 3 and 4.
2. Breeding groups of cow (B) classified as BSX, HOX and SIX for the first set of analyses and DBC, HE, SY, DY

and BC for the second set of analyses.

3. Sex of calf (S) classified as male and female.

4. Year of birth (R) classified as 1,2,3,4,5,6 and 7.

Using the procedure for mean separation for unequal numbers as outlined in Harvey (1975), Student-Newman-Keuls test was used to test differences between means when significant differences were established by least-squares analyses.

C. RESULTS AND DISCUSSION

1. COMPARISON OF CROSSES WITHIN DBC

Birth Weight and Calving Difficulty

Least-squares means and standard errors for birth weight and calving difficulty for the different crosses within DBC are presented in Table I.2. Heavier progeny birth weights from heavier dams have been noted in cattle by Joubert and Hammond (1958) and Donald *et al.*(1962). The heaviest cross, which was the HOX, had significantly heavier calves at birth than the lightest cross, SIX ($P<0.05$). There was no significant difference in the birth weight of the progeny of the BSX cows compared to those of either HOX cows or SIX cows.

Calving difficulty was estimated by the percentage of assisted births encountered during the study. This accounted for 18 percent of all calvings. No significant differences were observed between the different crosses in DBC in this trait.

Calf Crop Traits

Least-squares means and standard errors for calf crop traits for the crosses within DBC are presented in Table I.3. HOX tended to have lower means for percent calf crop born, weaned and calf survival to weaning compared to BSX and SIX. The differences were however not significant. Percent calf crop born and weaned were 77 and 75

Table I.2 Least-squares means and standard errors for birth weight and calving difficulty for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[1]	130	96	105	331
Birth wt.,kg	Mean	36.1[ab]	37.6[a]	35.7[b]	36.5
	S.E.	0.6	0.7	0.6	0.4
Assisted births,%	Mean	15.8	19.0	19.2	18.0
	S.E.	4.7	5.6	4.7	3.5

[ab]Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Number of calvings.

Table I.3 Least-squares means and standard errors for calf crop traits for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[1]	157	126	137	420
Calf crop born,%[2]	Mean	78.3	76.4	77.4	77.4
	S.E.	9.5	10.5	9.5	6.4
Calf crop weaned,%[2]	Mean	77.0	71.2	75.8	74.7
	S.E.	9.9	10.9	9.9	7.0
Calf survival,%[3]	Mean	99.0	94.2	98.2	97.2
	S.E.	7.1	7.7	7.0	5.2
Wt. of calf weaned per cow exposed,kg	Mean	152.6[ab]	159.4[a]	147.6[b]	153.2
	S.E.	2.4	3.0	2.4	1.8

[ab]Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Total number of exposures to breeding.
[2]On the basis of number of cows exposed to breeding.
[3]From birth to weaning.

respectively. These percentages are slightly lower than those reported by Berg (1978) for the Kinsella herds. Calf crop born and weaned have been observed to increase with parity until the 5th or 6th parity (Rogers 1972). This increase lowers the expected mean for the first three parities compared to the mean for, say, the first five parities. In this study only the first three possible calvings of each cow were used and this could have account for the disparity in the two results. Up to 97 percent of all calves born survived to weaning. This is very high and it is a reflection of the mothering ability of these dams. Losses from birth to weaning have been from 5 to 6 percent in the Kinsella herds (Berg 1978). No significant differences were observed between the crosses when these calf crop traits were studied within parity.

Weight of calf weaned per cow exposed is a function of calf crop weaned and weight of calves at weaning. SIX cows weaned significantly lighter calves per cow exposed to breeding compared to HOX cows ($P<0.05$).

Cow Retention

Longevity usually is defined as length of life. In usage regarding livestock this definition is often qualified to denote length of productive life. It should be remembered that under the management system for this study cows and heifers failing to wean a calf each year were culled and cows born in 1978 had only an opportunity to calve once to the end of the study in 1980; cows from 1977 could have calved twice etc.

The economics of replacement rates in beef herds was discussed by Rogers (1972). Heifers are usually sold at top prices compared to the salvage prices obtained from culls. Cows which can be retained longer, allow one to take advantage of this. The lowering of replacement needs also allows for strict selection of replacement heifers. It has a disadvantage, however, of increasing the generation interval, thus reducing the potential genetic gain per year.

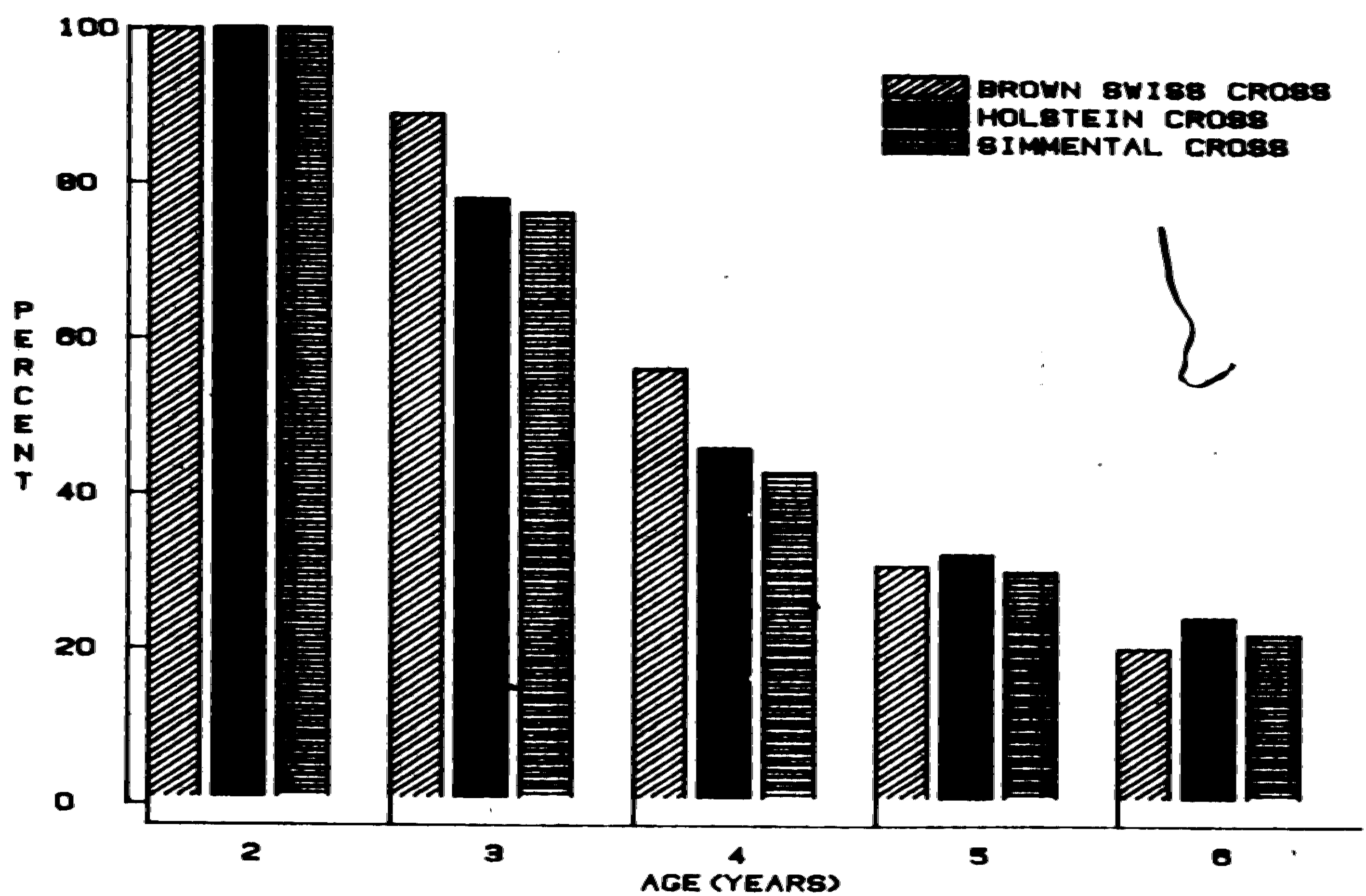
Least-squares means and standard errors for cow retention rate for the crosses in DBC are presented in Table I.4. This is represented graphically in Fig I.1. All the cows originally exposed to breeding were still in the breeding herd at 2 years of age. The percentages of cows remaining in the herd at 3,4,5 and 6 years of age were 81,48,31 and 22 percent respectively. Although these percentages are only slightly lower than those reported for various breeds by Robertson and Barker (1966) they are far lower than those reported by various other workers (Dickinson and Touchberry 1961; White and Nichols 1965; Everett *et al.* 1976; Spelbring *et al.* 1977b). Dickinson and Touchberry (1961) working with Holstein and Guensey cattle found that 69.8 percent of the crossbreds and 47.7 percent of the purebreds completed six lactations. Working with Angus and Milking Shorthorn, Spelbring *et al.* (1977b) had 68 percent of their cows returning to the breeding herd after 4 years. The lower cow retention rates obtained in this study

Table I.4 Least-squares means and standard errors for cow retention rate[1] for the crosses within DBC.

Age		Breeding group			Overall
		BSX	HOX	SIX	
2 years	No.[2]	77	68	72	217
	Mean	100	100	100	100
3 years	No.[2]	72	65	69	206
	Mean	89.0	78.0	76.3	81.1
	S.E.	5.0	5.2	4.8	3.1
4 years	No.[2]	68	62	64	194
	Mean	56.2	45.9	43.0	48.4
	S.E.	6.3	6.4	6.0	3.9
5 years	No.[2]	58	56	60	174
	Mean	30.9	32.4	30.2	31.4
	S.E.	6.2	6.1	5.7	3.7
6 years	No.[2]	51	52	56	159
	Mean	20.3	24.2	22.1	22.2
	S.E.	6.2	6.0	5.5	3.6

[1]Cows remaining as a percentage of cows exposed to breeding in their yearling year.
[2]Number of cows which had the opportunity to be *Ith* year old by the end of the study period:where *I*=2-6.

FIG I.1 COW RETENTION RATE* FOR THE CROSSES WITHIN DBC



* COWS REMAINING AS A PERCENTAGE OF COWS EXPOSED TO BREEDING

is not unexpected, since unlike the other studies, cows in the breeding herd were not only expected to calve but also to wean a calf each year. Cows failing to do that were considered culled. In the study by Spelbring *et al*. 1977b, only cows failing to wean a calf the second time were culled. In this study no significant differences were observed in the cow retention rate between the different crosses.

Cummulative Calf Production Performance per Cow

The cummulative calf production performance of a cow is influenced by fertility, maternal ability and retention in the herd. Results for the first two calvings are presented in Table I.5. The average number of exposures to breeding was 1.74. Number of calves born and weaned was 1.26 and 1.19 respectively. The total weight of calves weaned per cow was 239.9 kg. No significant differences were obtained in these traits between the different crosses in DBC.

Least-squares means and standard errors for the cummulative calf production per cow for all three calf crops are presented in Table I.6. The average number of exposures to breeding was 2.36. Number of calves born and weaned was 1.45 and 1.38 respectively. The total weight of calves weaned per cow was 280.6 kg. No significant differences were obtained between the crosses. The effect of sex of calf was removed by expressing the weaning weight on male basis for the cummulative weight of calves weaned.

Table I.5 Least-squares means and standard errors for cummulative calf production per cow for the first two calf crops for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[1]	64	55	57	176
Exposures to breeding, no.	Mean	1.85	1.71	1.68	1.74
	S.E.	0.06	0.07	0.06	0.04
Calves born, no.	Mean	1.43	1.21	1.15	1.26
	S.E.	0.09	0.10	0.09	0.06
Calves weaned, no.	Mean	1.36	1.11	1.09	1.19
	S.E.	0.10	0.10	0.10	0.07
Weaned wt., kg[2]	Mean	274.0	231.5	214.2	239.9
	S.E.	21.2	22.4	20.6	13.4

[1]Number of original cows exposed to breeding in their yearling year which had the opportunity to have two calves.
[2]Expressed on male basis, per cow originally exposed to breeding.

Table I.6 Least-squares means and standard errors for cummulative calf production per cow for all three calf crops for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[1]	46	39	47	132
Exposures to breeding, no.	Mean	2.50	2.35	2.23	2.36
	S.E.	0.14	0.15	0.12	0.08
Calves born, no.	Mean	1[illegible]	1.45	1.34	1.45
	S.E.	0.14	0.15	0.13	0.09
Calves weaned, no.	Mean	1.51	1.34	1.28	1.38
	S.E.	0.15	0.16	0.14	0.09
Weaned wt., kg[2]	Mean	306.5	281.1	254.3	280.6
	S.E.	31.2	33.0	28.3	19.4

[1]Number of original cows exposed to breeding in their yearling year which had the opportunity to have three calves.

[2]Expressed on male basis, per cow originally exposed to breeding.

Reasons for Disposal

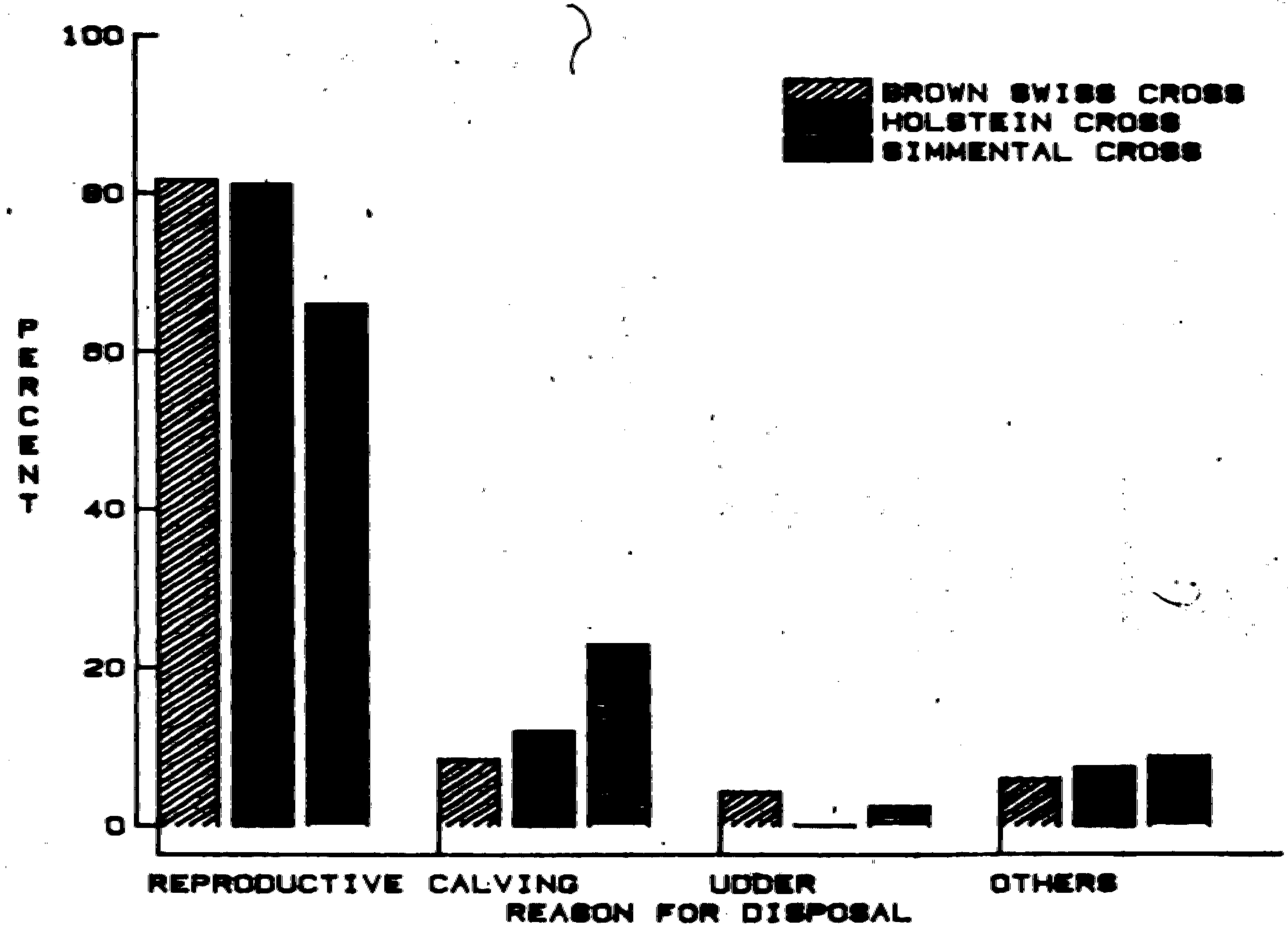
Least-squares means and standard errors for disposal age and reasons for disposal are presented in Table I.7. The reasons for disposal are represented graphically in Fig I.2. No significant differences were obtained between the different crosses in DBC in the average age at which the cows were disposed which was 3.2 years. Disposal age was estimated from all the disposals which occurred during the period of the study. Cows which were used in the study but were still in the herd at the termination of the study in 1980 were not included. The disposal age would be higher than the 3.2 years obtained if all cows used in the study could be followed until they were eventually disposed. Reproductive failure accounted for the bulk of the disposals: 76 percent. Calving problems accounted for 14 percent. Problems with the udder accounted for only 2 percent of the disposals. 7.5 percent of cows disposed was due to all other reasons, such as, death, cancer eyes and leg problems. No significant differences were obtained between the different crosses in all the different reasons for disposal. Parker *et al*. (1960) worked with Holstein-Friesian and Jersey cows. In their study 41 percent of Holstein-Friesian and 21 percent of Jersey cows were disposed as non-breeders, while udder problems accounted for 10.5 percent and 9.5 percent for the Holstein-Friesian and Jersey cows respectively. O'Bleness and VanVleck (1962) found that 16 to 19 percent of the New York dairy herd were

Table I.7 Least-squares means and standard errors for disposal age and reasons for disposal[1] for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[2]	37	41	45	123
Disposal age, years	Mean	3.2	3.2	3.1	3.2
	S.E.	0.2	0.2	0.2	0.1
Reproductive failure,%	Mean	81.6	81.0	68.9	76.2
	S.E.	7.6	7.2	6.6	4.2
Calving problems,%	Mean	8.3	11.8	22.8	14.3
	S.E.	6.5	6.1	5.6	3.6
Udder problems,%	Mean	4.2	0.0	2.4	2.0
	S.E.	2.7	2.5	2.3	1.5
Others[3],%	Mean	5.9	7.2	8.8	7.5

[1]As a percentage of all cows disposed during the study period.
[2]Total number of cows disposed during the study period.
[3]Obtained by difference.

FIG I.2 REASONS FOR DISPOSAL* FOR THE CROSSES WITHIN DBC



* AS A PERCENTAGE OF ALL COWS DISPOSED

culled due to sterility and 14 to 20 percent were culled due to udder trouble and mastitis. The higher percentage of disposals due to reproductive failure in this study was due to the fact that a cow was not given a second opportunity to wean a calf if it failed to do so in any year. Problems with the udder do not appear to have been a problem in this herd.

The effects of age of dam, sex of calf and interactions obtained in the comparison of the crosses in DBC were similar to those obtained from the comparison of DBC, as a group, with the other breeding groups for all the traits considered. These effects will, therefore, be discussed when discussing the results from the comparison of DBC with the other breeding groups because of the larger data set involved in that comparison.

2. COMPARISON OF DBC WITH OTHER BREEDING GROUPS

Birth Weight and Calving Difficulty

Least-squares means and standard errors for birth weight and calving difficulty for all breeding groups are presented in Table I.8. DY cows had the heaviest calves at birth while HE cows had the lightest calves. DBC, SY and BC cows had calves with similar, but significantly higher ($P<0.05$) mean birth weight than calves of HE cows. The pattern for birth weight followed the observation that heavier dams tend to have heavier progeny birth weights while lighter dams give lighter progeny birth weights.

Table I.8 Least-squares means and standard errors for birth weight and calving difficulty for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[1]	331	264	619	139	67	1420
Birth wt.,kg	Mean	36.2[b]	33.6[c]	36.6[b]	38.9[a]	36.2[b]	36.3
	S.E.	0.3	0.3	0.2	0.5	0.6	0.2
Assisted births,%	Mean	21.9	29.0	23.0	32.0	34.1	28.0
	S.E.	2.6	3.0	2.0	4.1	5.7	1.7

[abcd] Means within the same row with different superscripts are significantly different($P<0.05$).
[1] Number of calvings.

DBC cows had the fewest assisted births while BC cows had the most. Differences between the breeding groups in calving difficulty were, however, not significant. Makarechian *et al*. (1981) obtained significant breed group differences in calving difficulty. In their study calving difficulty was categorized into 5 groups. In this study however, calving difficulty was looked at as whether a cow had assistance at birth or not. This could be responsible for the difference in the two results.

Calf Crop Traits

Least-squares means and standard errors for calf crop traits for all breeding groups are presented in Table I.9. DBC cows showed the best performance in calf crop traits while HE cows showed the poorest. The differences between the breeding groups in the calf crop traits were, however, not significant. DBC and DY cows weaned the heaviest calves per cow exposed to breeding. They were followed by SY, BC and HE cows in that order. These differences were significant ($P<0.05$).

The results indicate that DBC cows were able to maintain their reproduction as well as the other breeding groups.

Cow Retention

Least-squares means and standard errors for cow retention rate for all the breeding groups are presented in Table I.10. This is represented graphically in Fig I.3. Differences between the breeding groups in cow retention

Table I.9 Least-squares means and standard errors for calf crop crop traits for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[1]	420	370	821	179	87	1877
Calf crop born,%[2]	Mean	80.0	72.3	75.0	78.0	78.4	76.7
	S.E.	8.5	9.5	6.2	13.2	18.5	5.5
Calf crop weaned,%[2]	Mean	75.0	60.9	66.4	73.6	66.9	68.6
	S.E.	9.2	10.3	6.7	14.2	19.9	6.0
Calf survival,%[3]	Mean	93.2	80.8	87.4	93.8	85.2	88.1
	S.E.	7.1	8.1	5.3	11.1	15.6	4.7
Wt. of calf weaned per cow exposed,kg	Mean	150.0^{a}	95.6^{d}	128.2^{b}	150.5^{a}	117.5^{c}	128.4
	S.E.	1.2	1.4	0.9	1.8	2.7	0.8

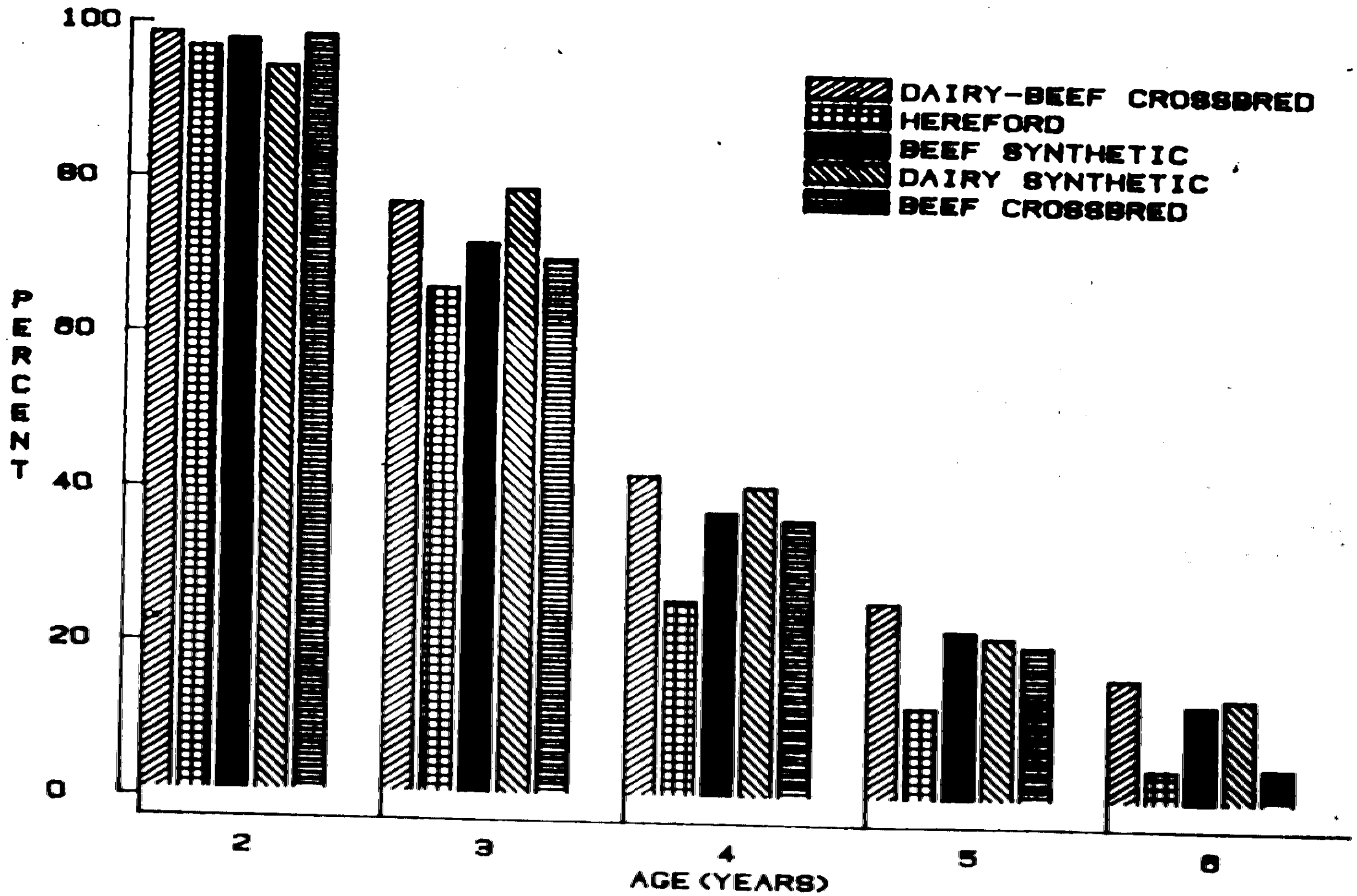
abcd Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Total number of exposures to breeding.
[2]On the basis of number of cows exposed to breeding.
[3]From birth to weaning.

Table I.10 Least-squares means and standard errors for cow retention rate[1] for all breeding groups.

Age		Breeding group					Overall
		DBC	HE	SY	DY	BC	
2 years	No.[2]	217	220	445	95	49	1026
	Mean	98.6	96.9	97.8	94.4	98.8	97.3
	S.E.	1.0	1.0	0.7	1.4	2.0	0.6
3 years	No.[2]	206	207	428	86	43	970
	Mean	77.1	66.1	71.8	79.0	70.0	72.8
	S.E.	3.0	3.0	2.1	4.5	6.3	1.8
4 years	No.[2]	194	195	379	77	38	883
	Mean	42.2^{a}	26.1^{b}	37.5^{ab}	40.9^{ab}	36.7^{ab}	36.7
	S.E.	3.5	3.3	2.4	5.2	7.5	2.1
5 years	No.[2]	174	192	354	75	35	830
	Mean	26.1^{a}	12.7^{b}	22.6^{a}	21.8^{ab}	20.9^{ab}	20.8
	S.E.	3.3	3.0	2.2	4.7	6.9	2.0
6 years	No.[2]	159	186	332	73	34	783
	Mean	16.7^{a}	5.1^{c}	13.3^{ab}	14.2^{abc}	5.4^{abc}	10.9
	S.E.	2.9	2.5	1.9	3.9	5.8	1.7

abc Means within the same row with different superscripts are significantly different ($P<0.05$).
[1] Cows remaining as a percentage of cows exposed to breeding in their yearling year.
[2] Number of cows which had the opportunity to be *i*th year old by the end of the study period: where *i*=2-6.

FIG I.3 COW RETENTION RATE* FOR ALL BREEDING GROUPS



* COWS REMAINING AS A PERCENTAGE OF COWS EXPOSED TO BREEDING

rate were not significant at 2 and 3 years of age. There were 16 percent more DBC cows remaining in the breeding herd than HE cows at 4 years of age. This difference was significant ($P<0.05$). The remaining breeding groups did not differ significantly from each other or from DBC. They did not also differ significantly from HE. The same trend was obtained at 5 years and 6 years of age except that SY cows differed significantly from HE cows ($P<0.05$). Although at 6 years of age 13.3 percent of SY cows compared to 14.2 percent of DY cows were still in the breeding herd, the cow retention rate for SY was significantly different from that of HE while that of DY was not significantly different from that of HE. This is because with unequal numbers it is possible that the difference between means farther apart with fewer numbers will be insignificant, while smaller differences of means with larger number of observations would be significant. DBC cows did better than HE cows in cow retention. Crossbred cows have been reported to live longer than purebred cows in most studies. Dickinson and Touchberry (1961) had 69.8 percent crossbreds completing six lactations while only 47.7 percent of purebreds did so. Spelbring *et al.* (1977b) also obtained crossbred superiority in longevity.

Cummulative Calf Production Performance per Cow

Least-squares means and standard errors for the cummulative calf production per cow for the first two calf crops for all breeding groups are presented in Table I.11.

Table I.11 Least-squares means and standard errors for cummulative calf production per cow for the first two calf crops for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[1]	176	199	380	79	37	871
Exposures to breeding, no.	Mean	1.71[a]	1.51[b]	1.65[ab]	1.75[a]	1.66[ab]	1.65
	S.E.	0.04	0.03	0.03	0.05	0.08	0.02
Calves born, no.	Mean	1.28[a]	1.03[b]	1.18[ab]	1.25[ab]	1.17[ab]	1.18
	S.E.	0.06	0.05	0.04	0.08	0.12	0.03
Calves weaned, no.	Mean	1.18[a]	0.84[b]	1.01[a]	1.18[a]	0.92[ab]	1.02
	S.E.	0.06	0.06	0.04	0.09	0.13	0.04
Weaned wt., kg[2]	Mean	236.3[a]	138.1[c]	193.0[b]	246.9[a]	170.7[bc]	197.0
	S.E.	11.5	10.8	7.7	17.1	25.1	7.0

[abc] Means within the same row with different superscripts are significantly different($P<0.05$).
[1] Number of original cows exposed to breeding in their yearling year which had the opportunity to have two calves.
[2] Expressed on male basis, per cow originally exposed to breeding.

For the first two calf crops DBC and DY cows had significantly more exposures to breeding than HE cows (P<0.05). No significant differences were obtained between the other breeding groups with either DBC and DY cows or HE cows. DBC cows were superior to HE cows in number of calves born (P<0.05). No significant differences were obtained in all the other comparisons. Number of calves weaned favoured DBC, SY and DY cows over HE cows (P<0.05). BC cows did not differ significantly from either HE cows or cows from the other breeding groups. In the cummulative weight of calves weaned DBC and DY cows had significantly higher mean weaned weights than SY and BC cows. SY cows in turn had significantly higher mean weaned weight than HE cows. The differences between SY and BC cows, and BC and HE cows in this trait were not significant (P<0.05).

Results from all three calf crops considered, are presented in Table I.12. DBC cows were superior to HE cows in the total number of exposures to breeding (P<0.05). DBC cows did not, however, differ significantly from the other breeding groups. HE cows did not differ significantly from the remaining breeding groups as well. The same pattern was obtained for the number of calves born. There were no significant differences between HE, SY, DY and BC cows in the number of calves weaned. There was also no significant difference between DBC cows and DY cows. DBC cows ,however, had significantly higher number of calves weaned than SY, BC and HE cows (P<0.05). For the cummulative weight of calves

Table I.12 Least-squares means and standard errors for cummulative calf production per cow for all three calf crops for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[1]	132	160	317	57	30	696
Exposures to breeding, no.	Mean	2.31[a]	1.85[b]	2.11[ab]	2.17[ab]	2.14[ab]	2.12
	S.E.	0.08	0.07	0.05	0.12	0.16	0.06
Calves born, no.	Mean	1.88[a]	1.37[b]	1.58[ab]	1.63[ab]	1.63[ab]	1.62
	S.E.	0.10	0.09	0.06	0.15	0.21	0.06
Calves weaned, no.	Mean	1.77[a]	1.18[b]	1.40[b]	1.56[ab]	1.28[b]	1.44
	S.E.	0.10	0.10	0.07	0.16	0.22	0.06
Weaned wt., kg[2]	Mean	363.6[a]	195.0[c]	274.7[b]	333.1[ab]	254.1[bc]	284.1
	S.E.	20.8	18.9	13.3	31.3	43.7	12.3

[abc] Means within the same row with different superscripts are significantly different ($P<0.05$).
[1] Number of original cows exposed to breeding in their yearling year which had the opportunity to have three calves.
[2] Expressed on male basis, per cow originally exposed to breeding.

weaned, DBC cows did not differ significantly from DY cows. The difference between SY, DY and BC cows were also not significant, neither was the difference between BC and HE cows. The cummulative weight of calves weaned by DBC cows was significantly higher than those of the other breeding groups, except that of DY cows. HE cows had the smallest cummulative weight of calves weaned and this was significantly different from those of the other breeding groups except BC ($P<0.05$).

Reasons for Disposal

Least-squares means and standard errors for disposal age and reasons for disposal for all breeding groups are presented in Table I.13. The reasons for disposal are represented graphically in Fig I.4. No significant differences were obtained between the breeding groups in the average age at which the cows were disposed. Also no significant differences were obtained between the breeding groups in the percent of cows disposed due to reproductive failure and problems with the udder. Significantly more cows were disposed of due to calving problems in the HE breeding group compared to DY($P<0.05$). The percentage of cows disposed of from DBC compared to the other breeding groups was not significant.

3. AGE OF DAM EFFECT

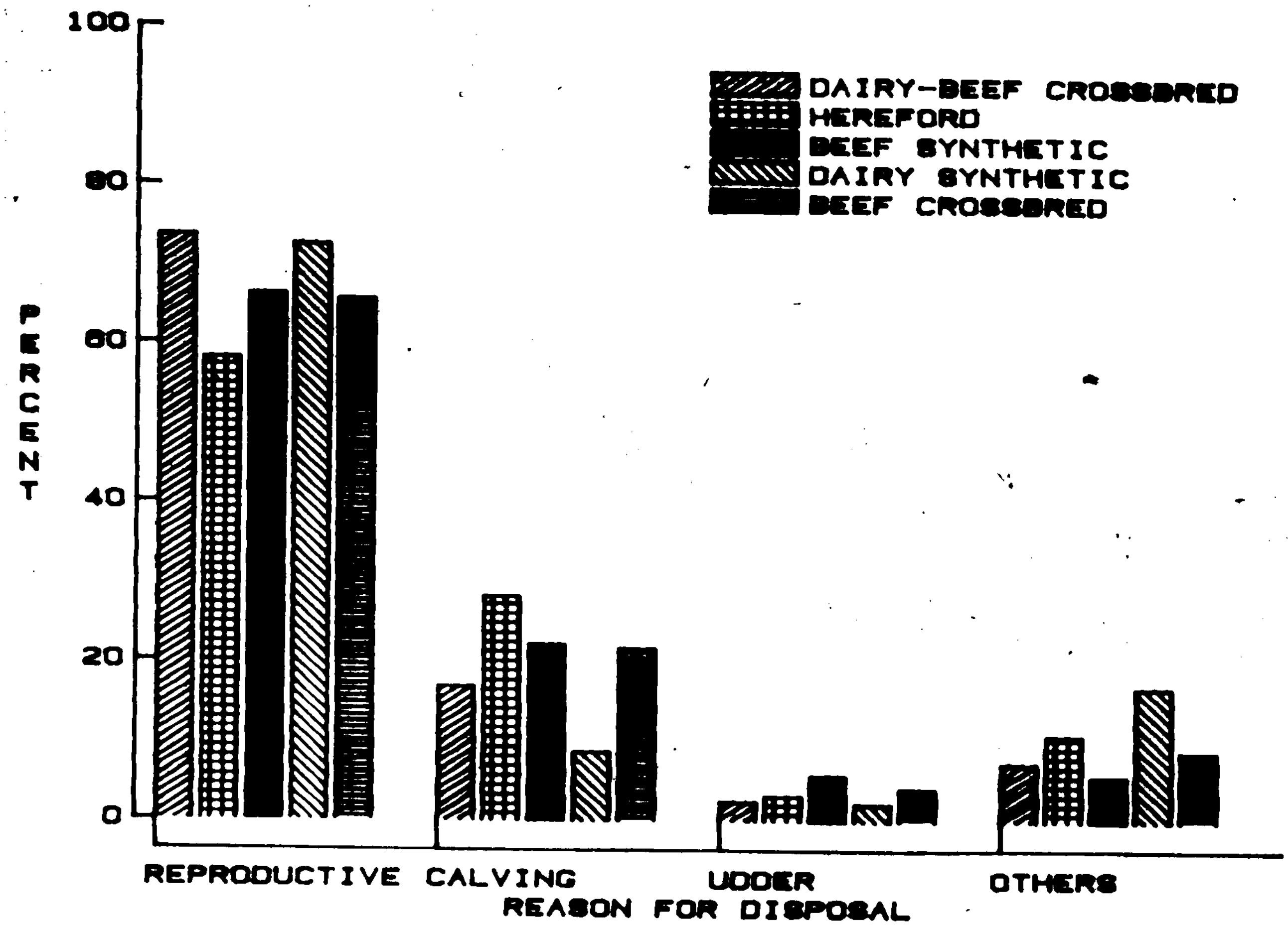
The effect of age of dam on the traits considered are presented using results from the complete data set. All heifer calves were bred as yearlings and had their first

Table I.13 Least-squares means and standard errors for disposal age and reasons for disposal[1] for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[2]	123	174	296	64	34	691
Disposal age, years	Mean	3.1	2.8	3.0	3.2	3.3	3.1
	S.E.	0.1	0.1	0.1	0.2	0.2	0.1
Reproductive failure, %	Mean	73.6	58.1	66.1	72.5	65.8	67.2
	S.E.	4.3	3.7	2.7	5.6	8.2	2.4
Calving problems, %	Mean	16.8[ab]	28.0[a]	22.1[ab]	8.6[b]	21.6[ab]	19.4
	S.E.	3.7	3.2	2.4	5.1	7.1	2.1
Udder problems, %	Mean	2.3	3.1	5.6	2.1	4.0	3.4
	S.E.	1.7	1.5	1.1	2.4	3.4	1.0
Others, %[3]	Mean	7.3	10.8	5.6	16.9	8.8	10.0

[ab]Means within the same row with different superscripts are significantly different ($P<0.05$).
[1]As a percentage of all cows disposed during the study period.
[2]Total number of cows disposed during the study period.
[3]Obtained by difference.

FIG I.4 REASONS FOR DISPOSAL* FOR ALL BREEDING GROUPS



* AS A PERCENTAGE OF ALL COWS DISPOSED

calves at two years of age. Cows failing to wean a calf each year were culled. In this study, therefore, age of dam corresponds to parity, with two year olds in parity 1 and three year olds and four year olds in parities 2 and 3 respectively.

Birth Weight and Calving Difficulty

Least-squares means and standard errors for birth weight and calving difficulty for the age of dam effect are presented in Table I.14. The mean birth weight of calves from 3 year old cows was significantly higher than that of 2 year olds while that of 4 year olds was significantly higher than that of 2 year olds and 3 year olds (P<0.01). This is in agreement with reports in the literature where birth weight has been reported to increase with increases in age of dam and parity (Burris *et al.* 1952; Lasley *et al.* 1961; Koonce and Dillard 1967; Fisher and Williams 1978).

Heifers required 40 and 45 percent more assistance at birth than 3 and 4 year olds respectively. These differences in assistance at birth were significant (P<0.01). This is in agreement with the findings of Makarechian and Berg (1981) who found the frequency of calving difficulty considerably higher in heifers. It is also in agreement with the results from the studies by many other workers (Bar-Anan *et al.* 1976; Burfening *et al.* 1978; Gregory *et al.* 1979). The difference in assistance at birth between 3 and 4 year old cows was not significant.

Table I.14 Least-squares means and standard errors for birth weight and calving difficulty for age of dam effect.

Trait		Age of dam			Overall
		2 years	3 years	4 years	
	No.[1]	780	405	235	1420
Birth wt.,kg	Mean	33.3[c]	37.2[b]	38.2[a]	36.3
	S.E.	0.2	0.3	0.4	0.2
Assisted births,%	Mean	56.6[a]	16.1[b]	11.3[b]	28.0
	S.E.	2.0	2.8	3.8	1.7

[abc]Means within the same row with different superscripts are significantly different($P<0.01$).
[1]Number of calvings.

Calf Crop Traits

Least-squares means and standard errors for calf crop traits for age of dam effect are presented in Table I.15. Percent calf crop born and weaned, and percent calf survival to weaning tended to increase with increase in age of dam. The differences between the dam age groups in each of these traits were not significant. Weight of calf weaned per cow exposed to breeding increased significantly with increase in age of dam ($P<0.01$).

4. SEX OF CALF EFFECT

The effect of sex of calf on the traits considered are presented using results from the complete data set.

Birth Weight and Calving Difficulty

Least-squares means and standard errors for sex of calf effect on birth weight and calving difficulty are presented in Table I.16. Male calves were significantly heavier than female calves at birth ($P<0.01$). Workers like Foote *et al.* (1959), Koonce and Dillard (1967), Winks *et al.* (1978) and Sharma *et al.* (1981) obtained similar results.

Male calves required significantly more assistance at birth than female calves ($P<0.01$). This is in agreement with the findings of several workers (Smith *et al.* 1976; Burfening *et al.* 1978; Makarechian *et al.* 1981). The higher incidence of dystocia in male calves could be due to the higher birth weight of bull calves (Philipson 1976).

Interactions were generally unimportant. The only significant interaction effect was the sex of calf by age of

Table I.15 Least-squares means and standard errors for calf crop traits for age of dam effect.

Trait		Age of dam			Overall
		2 years	3 years	4 years	
	No.[1]	1026	544	307	1877
Calf crop born,%[2]	Mean	77.1	74.4	78.7	76.7
	S.E.	6.3	8.8	12.1	5.5
Calf crop weaned,%[2]	Mean	64.6	67.7	73.4	68.6
	S.E.	6.8	9.5	13.1	6.0
Calf survival,%[3]	Mean	81.8	89.7	92.8	88.1
	S.E.	5.3	7.5	10.2	4.7
Wt. of calf weaned per cow exposed,kg	Mean	121.8[a]	129.3[b]	134.0[c]	128.4
	S.E.	1.0	1.3	1.7	0.8

[abc]Means within the same row with different superscripts are significantly different($P<0.01$).
[1]Total number of exposures to breeding.
[2]On the basis of number of cows exposed to breeding.
[3]From birth to weaning.

Table I.16 Least-squares means and standard errors for birth weight and calving difficulty for sex of calf effect.

Trait		Sex of calf		Overall
		Male	Female	
	No.[1]	732	688	1420
Birth wt.,kg	Mean	37.2[a]	35.4[b]	36.3
	S.E.	0.3	0.3	0.2
Assisted births,%	Mean	31.4[a]	24.6[b]	28.0
	S.E.	2.4	2.3	1.7

[ab]Means within the same row with different superscripts are significantly different(P<0.01).
[1]Number of calvings.

dam interaction for percent assisted births ($P<0.05$). This was the result of male calves needing more assistance at birth than female calves born to heifers and no difference in male calves and female calves for other ages. This is in agreement with the findings of Makarechian *et al*. 1981.

D. CONCLUSIONS

Data from 1971 to 1980 from The University of Alberta, Beef Cattle Ranch, Kinsella were analysed to assess the reproduction and productivity of dairy-beef crossbred cows. Except for the weight traits no significant differences were observed between the three different crosses in the dairy-beef crossbred breeding group of cows. For birth weight and weight of calf weaned per cow exposed to breeding, calves from the Holstein cross cows were superior to calves from the Simmental cross cows. Calves from Brown Swiss cross cows did not differ significantly from calves from either Holstein cross or Simmental cross cows in birth weight. Mean weight of calf weaned per cow exposed to breeding for Brown Swiss cross cows was similar to that of Holstein cross cows but significantly higher than that of Simmental cross cows. These differences may be reflections of the differences between the Brown Swiss, Holstein and Simmental breeds in these traits.

Calf crop traits were slightly lower than those reported by Berg (1978). These differences could be due to the fact that in this study only the first three possible calvings of each cow were used. Problems with the udder does not appear to be of any significance in this study.

Reproductive failure accounted for 76.2 percent of all disposals. This high percentage is a reflection of the management practice in which a cow or heifer is expected to wean a calf each year or it is culled. Cow retention rate was lower than reports from most studies for the same reason. At 6 years of age only 22.2 percent of the original cows exposed to bulls were still in the breeding herd.

Generally the Dairy-Beef Crossbred cows, as a group, were superior to Hereford cows in calf birth weight and weight of calf weaned per cow exposed to breeding when compared to other breeding groups of cows at Kinsella. The dairy-beef crossbred cows were also superior to Hereford cows in cow retention rate and cummulative calf production performance per cow. No general trend was observed between the Dairy-Beef Crossbred cows and the remaining breeding groups of cows except that calves from Dairy Synthetic cows were either heavier than, or of similar weight to those of Dairy-Beef Crossbred cows in the weight traits. No significant differences were obtained between the Dairy-Beef Crossbred cows and the other breeding groups of cows in percent assisted births and percent calf crop traits and also for each of the different reasons for disposal. On the whole Dairy-Beef Crossbred cows were able to maintain compatible reproduction under Kinsella conditions and even outperformed other breeding groups of cows, especially Hereford, in some traits.

Assistance at birth was highest in heifers compared to older cows. Birth weight and weight of calf weaned per cow exposed to breeding increased with increases in age of dam. This is in agreeement with reports in the literature.

Birth weight was significantly higher in male calves than in female calves. Assistance at birth was highest with the calving of males than with females.

II. GROWTH CHARACTERISTICS OF OFFSPRING OF DAIRY-BEEF CROSSBRED COWS

A. INTRODUCTION

The weight of an animal at slaughter is one of the most important factors which influence the amount received from the sale of the animal. This weight is affected by the growth characteristics of the animal. The growth of the animal can be divided into two phases: the preweaning phase and the postweaning phase. Heterosis effect has been reported for both phases of growth in beef cattle. Out of 13 experiments summarized by Warwick (1968), 12 of them showed crossbred calves superior to straightbreds by about 4.9 percent in a weighted average weaning weight. Postweaning growth has also been reported to favour crossbred over straightbred calves by 2 to 4 percent (Cundiff 1970). Generally heterosis is greatest for early growth and least for postweaning growth. The magnitude of heterosis effect differs from cross to cross. The effect is also affected by variations in final weight, feeding and management, and sex. It is therefore essential to look at the growth characteristics of different crosses of cattle for beef production.

The objectives of this study were:

1. To assess and compare the preweaning and postweaning growth characteristics of calves of dairy-beef crossbred cows from three different dairy breeds.

2. To compare the growth characteristics of calves of the dairy-beef crossbred cows with calves of the other breeding groups of cows maintained at Kinsella.

B. MATERIALS AND METHODS

The data used for this study were the same data used in Chapter I. The breeding group of dams used in this study corresponds to the breeding group of cows used in Chapter I. DBC and BC cows were bred to Hereford bulls while in the other breeding groups, cows and bulls within the same breeding group were mated to produce the calves used for this study. Calves from only the first three calf crops were used.

Calves were born in April and May and remained with their dams until weaning. All cows with calves were run together as much as possible. Except for 1974 where weaning was in early November weaning has been in early October. After weaning male and female calves were treated differently. Male calves were put on test on full concentrate feed plus limited roughage for 140 days following weaning and an adjustment period. Females were restricted in both grain and hay intake and had only straw available to appetite. The postweaning growth characteristics of male and female calves were therefore analysed separately.

Traits considered included birth weight, adjusted weaning weight (Appendix) and preweaning average daily gain (Preweaning ADG) (Appendix). For the postweaning traits only records on calves on the standard ration for each sex were used in the analyses. Test period average daily gain (Test period ADG) and adjusted 365-day weight for male calves were considered while for females adjusted 365-day weight and adjusted 540-day weight were considered (Appendix).

Statistical Analyses

Least-squares analyses for unequal subclass numbers (Harvey 1975) were computed. Two sets of analyses were done. The first set was a comparison of the calves of the different crosses within DBC breeding group of dams. The second set of analyses involved calves of DBC dams as a group compared with calves of the other breeding group of dams. Age of dam effect was considered in both sets of analyses.

A fixed effects model was used with main effects being age of dam, breeding group of dam, sex of calf and year of birth. Age of dam by breeding group of dam interaction, age of dam by sex of calf interaction and breeding group of dam by sex of calf interaction were included in the model. The model used was:

$$Y_{ijklm} = u + A_i + B_j + AB_{ij} + S_k + AS_{ik} + BS_{jk} + R_l + e_{ijklm}$$

where

Y=trait under consideration

u=overall mean

A=age of dam

B=breeding group of cow

S=sex of calf

R=year of birth

AB=age of dam by breeding group interaction

AS=age of dam by sex of calf interaction

BS=breeding group by sex of calf interaction

e=random error.

This model was used for the analyses for preweaning growth traits. For postweaning growth traits, sex of calf and its interactions were removed from the model. The postweaning growth traits for each sex were analysed separately because male calves were treated differently from female calves during this period.

Levels for the main effects were:

1. Age of dam (A) classified as 2, 3 and 4.
2. Breeding groups of cow (B) classified as BSX, HOX and SIX for the first set of analyses and DBC, HE, SY, DY and BC for the second set of analyses.
3. Sex of calf (S) classified as male and female.
4. Year of birth (R) classified as 1,2,3,4,5,6 and 7.

Using the procedure for mean separation for unequal numbers as outlined in Harvey (1975), Student-Newman-Keuls test was used to test differences between means when significant differences were established by least-squares analyses.

C. RESULTS AND DISCUSSION

1. COMPARISON OF CROSSES WITHIN DBC

Preweaning Growth Traits

Least-squares means and standard errors for preweaning growth traits for the crosses within DBC are presented in Table II.1. Calves from dams of the heaviest cross, which was HOX, were significantly heavier at birth than calves from the lightest cross, SIX ($P<0.05$). There were no significant differences in the birth weights of calves from BSX dams compared to those from either HOX dams or SIX dams.

At weaning, mean weight of calves from dams in the different crosses followed the same pattern as birth weight. Calves from SIX dams were significantly lighter than their counterparts from HOX dams ($P<0.05$). The differences between calves from BSX dam and HOX dams, and BSX dams and SIX dams were not significant.

Calves in DBC had a mean average daily gain of 1.01 kg. before weaning. Calves from SIX dams gained significantly less than those from dams of the other two crosses ($P<0.05$).

Postweaning Growth Traits

Least-squares means and standard errors for postweaning growth traits for the crosses in DBC are presented in Table II.2. On full concentrate feed during the test period male calves from dams in DBC gained an average of 1.46 kg. a day. Test period average daily gain of the male calves of dams

Table II.1 Least-squares means and standard errors for preweaning growth traits for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
	No.[1]	130	96	105	331
Birth wt.,kg	Mean	36.1[ab]	37.6[a]	35.7[b]	36.5
	S.E.	0.6	0.7	0.6	0.4
Adj. weaning wt.,kg[2]	Mean	224.3[ab]	230.9[a]	218.2[b]	224.5
	S.E.	2.9	2.2	2.9	2.2
Preweaning ADG kg/day[3]	Mean	1.05[a]	1.07[a]	1.01[b]	1.04
	S.E.	0.02	0.02	0.02	0.01

[ab]Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Number of calves.
[2]Weaning wt adjusted to 180 days.
[3]Preweaning average daily gain.

Table II.2 Least-squares means and standard errors for postweaning growth traits for the crosses within DBC.

Trait		Breeding group			Overall
		BSX	HOX	SIX	
Test period ADG kg/day[1] Male	No.[2]	41	44	29	114
	Mean	1.45	1.52	1.42	1.46
	S.E.	0.05	0.05	0.05	0.04
Adj. 365-day wt.,kg Male	No.[2]	41	44	29	114
	Mean	455.8[ab]	474.6[a]	442.0[b]	457.5
	S.E.	11.1	10.2	11.9	8.1
Female	No.[2]	63	27	43	133
	Mean	264.2	265.6	268.4	266.0
	S.E.	5.0	7.5	5.6	4.0
Adj. 540-day wt.,kg Female	No.[2]	47	25	37	109
	Mean	375.9	386.5	386.8	383.1
	S.E.	6.6	8.6	7.0	5.0

[ab]Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Test period average daily gain.
[2]Number of animals.

from the different crosses in DBC were not significantly different. Significant differences were however observed in the adjusted 365-day weight of male calves from the different dam crosses (P<0.05). These differences followed a similar pattern as for weaning weight. Male calves from HOX dams had significantly higher mean adjusted 365-day weight than those of calves from SIX dams. Male calves from BSX dams did not differ significantly from male calves from either HOX dams or SIX dams in this trait.

The mean adjusted 365-day weight for female calves was 266 kg. This is far lower than the 457.5 kg. obtained by their male counterparts. This is mainly due to differences in the feeding and management of calves of different sexes. The mean adjusted 540-day weight for female calves was 383.1 kg. No significant differences were obtained between the calves from the different dam crosses in both the 365-day weight and 540-day weight of female calves.

The effect of age of dam and sex of calf and their interactions for the growth traits will be discussed when discussing the results from the comparison of DBC with the other breeding groups because of the larger data set involved in that comparison.

2. COMPARISON OF DBC WITH OTHER BREEDING GROUPS

Preweaning Growth Traits

Least-squares means and standard errors for preweaning growth traits for all breeding groups are presented in Table II.3. At birth calves from DY dams were significantly heavier than calves from DBC and HE dams (P<0.05). Calves from DBC dams were however not significantly different from those of calves from SY and BC dams in birth weight. There were also no significant differences in the mean birth weights of calves from SY and BC dams. Although calves from DBC dams had birth weights similar to those of calves from SY and BC dams, at weaning they had outgrown their contemporaries significantly. At weaning calves from DBC dams had weights similar to weights of calves from DY dams. Although they weighed significantly less at birth. Calves from DBC dams were significantly heavier than those from SY and BC dams (P<0.05). Calves from HE dams had the lightest calves at weaning while those from SY and BC were similar.

Calves from DBC and DY dams had similar preweaning average daily gain. Their gains were significantly higher than the gains of calves from the other breeding groups (P<0.05). The gains of calves from SY dams were significantly higher than those of calves from BC and HE dams (P<0.05). Calves from HE dams had the lowest preweaning average daily gains.

Although calves from DBC dams had birth weights similar to those of calves from SY and BC dams, calves from DBC dams were significantly heavier at weaning and had significantly

Table II.3 Least-squares means and standard errors for preweaning growth traits for all breeding groups.

Trait		Breeding group					Overall
		DBC	HE	SY	DY	BC	
	No.[1]	331	264	619	139	67	1420
Birth wt.,kg	Mean	36.2[b]	33.6[c]	36.6[b]	38.9[a]	36.2[b]	36.3
	S.E.	0.3	0.3	0.2	0.5	0.6	0.2
Adj. weaning wt.,kg[2]	Mean	219.5[b]	178.9[d]	210.7[c]	225.2[a]	208.0[c]	207.9
	S.E.	1.6	1.9	1.2	2.3	3.5	1.0
Preweaning ADG kg/day[3]	Mean	1.02[a]	0.81[d]	0.97[b]	1.03[a]	0.95[c]	0.96
	S.E.	0.01	0.01	0.01	0.01	0.01	0.01

[abcd]Means within the same row with different superscripts are significantly different($P<0.05$).
[1]Number of calves.
[2]Weaning wt. adjusted to 180 days.
[3]Preweaning average daily gain.

higher mean preweaning average daily gain when compared to calves from dams of these two breeding groups ($P<0.05$). Dam milk yield has been known to be of great importance in the preweaning performance of calves (Drewry *et al.* 1959; Neville 1962; Jeffery *et al.* 1971; Rutledge *et al.* 1971; Totusek *et al.* 1971; Butson *et al.* 1980). Jeffrey *et al.* (1971) found that 60 percent of the variation in preweaning average daily gain and 40 to 50 percent of the variaton in weaning weight were due to milk yield. Butson *et al.* (1980) found that approximately 40 percent of weaning weight variance was accounted for by milk yield. In most dairy-beef crossbred studies it has been shown that crossbred dams produced more milk than the purebred beef dam (Deutscher and Whiteman 1971 and Long 1980). Butson (1981) working with Kinsella cows found that DBC cows produced more milk than HE and SY cows in 1977. In 1976, however, the milk production of the DBC cows was similar to that of the SY cows. The lack of differences in 1976 may have been due to the small sample size.

Heterosis effect on weaning weight has also been observed in crossbreeding experiments. In the work by Parker *et al.* (1972), Cundiff *et al.* (1974b) and Spelbring *et al.* (1977a) heterosis effect on weaning weight was observed. Although heterosis effect could not be estimated in this study, this might have contributed to the significant difference observed in the weaning weight of calves of DBC cows compared to those of SY and BC cows. SY and BC breeding groups are composed primarily of beef breeds while DBC has both dairy and beef breeds thus giving it a wider genetic base.

Postweaning Growth Traits

Least-squares means and standard errors for postweaning growth traits for all breeding groups are presented in Table II.4. Differences between male calves from the different breeding groups of dams were not significant for the test period average daily gain. Male calves from HE dams had significantly smaller mean adjusted 365-day weight compared to those of calves from dams of the other breeding groups ($P<0.05$). Differences between male calves from DBC, SY, DY and BC dams in this trait were not significant.

Adjusted 365-day weight of female calves from dams of the different breeding groups follow a similar pattern as was obtained for male calves in the same trait. Female calves from HE dams were lighter than those from dams of the other breeding groups ($P<0.05$). Female calves from DBC dams were significantly heavier than those from HE dams but significantly lower than those from SY and DY dams for the adjusted 540-day weight ($P<0.05$). Female calves from SY, DY and BC dams were significantly heavier than those from HE dams in this trait ($P<0.05$). The differences between female calves from SY, DY and BC dams were not significant. This is also true for the difference between female calves from DBC and BC dams.

Table II.4 Least-squares means and standard errors for postweaning growth traits for all breeding groups.

Trait		Breeding group DBC	HE	SY	DY	BC	Overall
Test period ADG kg/day[1] Male	No.[2]	114	74	207	45	17	457
	Mean	1.42	1.31	1.49	1.41	1.49	1.42
	S.E.	0.02	0.03	0.02	0.03	0.06	0.02
Adj. 365-day wt.,kg Male	No.[2]	114	74	207	45	17	457
	Mean	457.7[a]	404.5[b]	461.4[a]	472.9[a]	448.3[a]	449.0
	S.E.	5.4	6.5	4.0	7.8	17.8	4.7
Female	No.[2]	133	91	263	54	30	571
	Mean	263.5[a]	239.4[b]	263.7[a]	263.7[a]	253.7[a]	256.8
	S.E.	3.1	3.9	2.1	5.8	6.3	2.1
Adj. 540-day wt.kg Female	No.[2]	109	75	223	41	20	468
	Mean	375.6[b]	352.2[c]	391.0[a]	398.9[a]	377.9[ab]	379.1
	S.E.	4.3	5.5	2.8	7.3	9.7	3.0

[abc] Means within the same row with different superscripts are significantly different($P<0.05$).
[1] Test period average daily gain.
[2] Number of animals.

3. AGE OF DAM EFFECT

The effect of age of dam on the traits considered are discussed using results from the complete data set. As stated in Chapter I the age of dam corresponds to parity in this study. Two year olds are in their first parity while three and four year olds are in their second and third parities respectively.

Preweaning Growth Traits

Least-squares means and standard errors for preweaning growth traits for age of dam effect are presented in Table II.5. Mean birth weight, adjusted weaning weight and preweaning average daily gain increased significantly with increases in age of dam (P<0.05). These results are in general agreement with results reported by other workers (Cundiff *et al.* 1966; Cardellino and Frahm 1971; Anderson and Wilham 1978; Winks *et al.* 1978).

Postweaning Growth Traits

Least-squares means and standard errors for postweaning growth traits for age of dam effect are presented in Table II.6. The mean average daily gain of male calves during the test period for calves of 2 year old dams was not significantly different from that of calves of 3 year old dams. Calves of 4 year old dams however gained significantly higher than those of 2 and 3 year old dams (P<0.05). Adjusted 365-day weight of male calves increased significantly with increase in age of dam (P<0.05).

Table II.5 Least-squares means and standard errors for preweaning growth traits for age of dam effect.

Trait		Age of dam: 2 years	3 years	4 years	Overall
	No.[1]	780	405	235	1420
Birth wt.,Kg	Mean	33.3^{c}	37.2^{b}	38.2^{a}	36.3
	S.E.	0.2	0.3	0.4	0.2
Adj. weaning wt.,Kg[2]	Mean	191.5^{c}	211.6^{b}	220.4^{a}	207.9
	S.E.	1.2	1.7	2.2	1.0
Preweaning ADG Kg/day[3]	Mean	0.88^{c}	0.97^{b}	1.02^{a}	0.96
	S.E.	0.01	0.01	0.01	0.01

[abc] Means within the same row with different superscripts are significantly different ($P<0.05$).
[1] Number of calves.
[2] Weaning wt adjusted to 180 days.
[3] Preweaning average daily gain.

Table II.6 Least-squares means and standard errors for postweaning growth traits for age of dam effect.

Trait		Age of dam: 2 years	3 years	4 years	Overall
Test period ADG					
kg/day[1]	No.[2]	225	148	84	457
Male	Mean	1.37[b]	1.41[b]	1.50[a]	1.42
	S.E.	0.02	0.02	0.05	0.02
Adj. 365-day					
wt.,kg	No.[2]	225	148	84	457
Male	Mean	424.1[c]	450.7[b]	472.0[a]	449.0
	S.E.	4.8	5.5	10.9	4.7
Female	No.[2]	321	159	91	571
	Mean	249.8[b]	259.6[a]	261.0[a]	256.8
	S.E.	2.1	3.6	4.6	2.1
Adj. 540-day					
wt.,kg	No.[2]	276	121	71	468
Female	Mean	370.5[b]	385.7[a]	381.2[a]	379.1
	S.E.	2.9	5.3	6.2	3.0

[abc]Means within the same row with different superscripts are signinficantly different(P<0.05).
[1]Test period average daily gain.
[2]Number of animals.

The mean adjusted 365-day weight of female calves of 2 year old dams was significantly smaller than that of calves from older dams (P<0.05). The difference between calves of 3 year old dams and those of 4 year old dams in this trait was however not significant. A similar pattern was obtained for the adjusted 540-day weight of female calves.

4. SEX OF CALF EFFECT

The effect of sex of calf on preweaning growth traits are presented using results from the complete data set.

Preweaning Growth Traits

Least-squares means and standard errors for preweaning growth traits for sex of calf effect are presented in Table II.7. Birth weight, weaning weight and preweaning average daily gain of male calves were significantly higher than those of female calves (P<0.01). This is in agreement with reports in the literature (Bailey *et al*. 1975; Anderson and William 1978; Butson 1981; Sharma 1981).

No significant effects of interactions were obtained for any of the growth traits considered.

Table II.7 Least-squares means and standard errors for preweaning growth traits for sex of calf effect.

Trait		Sex of calf		Overall
		Male	Female	
	No.[1]	732	688	1420
Birth wt.,kg	Mean	37.2[a]	35.4[b]	36.3
	S.E.	0.3	0.3	0.2
Adj. weaning wt.,kg[2]	Mean	213.6[a]	202.1[b]	207.9
	S.E.	1.5	1.4	1.0
Preweaning ADG kg/day[3]	Mean	0.98[a]	0.93[b]	0.96
	S.E.	0.01	0.01	0.01

[ab]Means within the same row with different superscripts are significantly different($P<0.01$).
[1]Number of calves.
[2]Weaning wt adjusted to 180 days.
[3]Preweaning average daily gain.

D. CONCLUSIONS

The growth characteristics of calves from DBC dams as well as calves from four other breeding groups of dams were studied. Calves from HOX dams outperformed calves from SIX dams in preweaning growth traits. The differences between calves from BSX dams and SIX dams were not significant except for preweaning average daily gain. In this trait the difference between the performance of calves from BSX dams was similar to that of calves from HOX dams, but significantly higher than that of calves from SIX dams. The postweaning growth traits of the calves from dams of the different crosses in DBC did not differ significantly except for the adjusted 365-day weights where, again, male calves from HOX dams weighed significantly heavier than those from SIX dams.

Comparing calves from DBC dams with those from the other breeding groups, the higher milk production capacity of DBC and DY dams was evident. Generally calves from dams of these two breeding groups were superior to calves from HE dams for all preweaning growth traits. Calves from DBC dams were significantly superior to those from HE dams for all postweaning growth traits except for test period average daily gain.

In general the growth potential of calves from DBC dams was superior to that of the calves from dams of the other breeding groups, except DY, for preweaning growth traits, and equal or superior to calves from dams of the other breeding groups in postweaning growth traits.

GENERAL SUMMARY AND CONCLUSIONS

The objective of the overall study was to examine the suitablility of using large dairy breeds in crossbreeding with beef cattle for beef production under range conditions. The first study examined the reproduction and productivity of dairy-beef crossbred cows and the second the growth characteristics of the offspring of the dairy-beef crossbred cows. In both studies the three different crosses within the dairy-beef crossbred breeding group of cows were compared, then the dairy-beef crossbred cows as a group were compared to four other breeding groups of cows maintained at Kinsella.

Reproduction and Productivity

The three crosses in DBC did not differ from each other in most of the reproduction and productivity traits. Cross differences were observed only in the weight traits. For birth weight calves of HOX were heavier than calves of SIX. Calves of BSX did not differ significantly from those of both HOX and SIX. The same trend was observed for weight of calves weaned per cow exposed to breeding. This is probably due to the fact that the Holstein breed is generally bigger than the Simmental breed while the Brown Swiss lies in between.

Udder troubles did not appear to be a problem in DBC. Reproductive failure accounted for most of the disposals; 76.2 percent. This is due to the fact that cows failing to wean a calf each year are culled. At 4 years of age 48.5 percent of the cows originally exposed to breeding were still in the herd. This figure dropped to 22.2 percent at 6 years of age. These figures are lower than those reported in the literature and it is because of the severe culling practice in this study where cows failing to wean a calf each year are culled.

The merit of the dairy-beef crossbred cows as a group compared to the other breeding groups of cows was favourable. The general trend for most of the reproduction and productivity traits was for DBC cows to be superior to HE cows where ever significant differences were observed. This trend was observed in cow retention rate and cummulative calf production performance per cow. The calves of DBC cows were also heavier than those of HE cows at birth. No general pattern was observed between DBC and the other breeding group of cows except HE. On the whole dairy-beef crossbred cows were able to maintain compatible reproduction under Kinsella conditions. They outperformed HE cows in cow retention but were at par with the other breeding groups of cows. The superiority of DBC over HE cows in cow retention might be due to heterosis effect where DBC cows with very wide genetic bases outperformed the purebred HE cows .

Age of dam and sex of calf effects in most of the traits followed the general pattern reported in the literature. Interactions were unimportant except for the sex of calf by age of dam interaction for percent assisted births due to the fact that the male calves born to heifers needed more assistance at birth.

Growth Characteristics of Offspring

Calves of the dams of the different crosses in DBC did not differ much in both the preweaning and postweaning growth traits. For the adjusted weaning weight calves of HOX dams were significantly heavier than those of SIX dams. The same was true for the adjusted 365-day weight for male calves.

The effect of the higher milk production capacity of DBC dams was evident in the preweaning growth characteristics of their calves when they were compared with calves of the other breeding groups of cows. Calves of DBC dams were superior to their couterparts of HE dams in all preweaning growth traits. Although calves of DBC, SY and BC dams had similar mean birth weights, the preweaning average daily gain of calves of DBC dams were better than those of SY and BC cows. Calves of DBC dams were superior to calves of HE dams for all postweaning growth traits except for test period average daily gain.

In general, except for the weight traits no differences were observed between the crosses in DBC in all the traits. In the weight traits HOX dams and their calves tended to do better than SIX dams and their calves while BSX dams and their calves did not differ from either of the two. DBC cows were able to maintain compatible reproduction under Kinsella conditions and even outperformed HE cows in most traits. Their calves also outperformed calves of HE cows in all growth traits except in test period average daily gain. In view of these two studies and the preliminary work done by Price (1976) on the carcass characteristics of dairy-beef crossbred bulls, the three dairy-beef crosses have great potential for beef production under Kinsella conditions management and practices.

The author suggests further studies be conducted to investigate the longevity of the cows at Kinsella with particular reference to the dairy-beef crossbreds to see whether heterosis effect for longevity is present in these crosses. The carcass characteristics of the male offsprings of the dairy-beef crossbred cows for the same period of time as this study should be looked at. In this study the DBC cows were taken as a group and compared with the other breeding groups. It is suggested that the different crosses in DBC be compared separately with all or some of the other breeding groups since significant differences between the crosses were observed in the weight traits.

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APPENDIX

FORMULAE USED FOR COMPUTING CERTAIN GROWTH TRAITS

Preweaning ADG = (actual weaning wt. - birth wt.)/
age at weaning

Adjusted weaning wt. = (180 * preweaning ADG)
+ birth wt.

Test period ADG = (final wt. on test - initial wt. on test)/
no. of days on test

Adjusted 365-day wt. =
((actual 365-day wt. - actual weaning wt.)/
(365-day weighing date - weaning date)*
(365 - age at weaning)) + actual weaning wt.

Adjusted 540-day wt. =
actual 540-day wt./
(540-day weighing date - birth date) * 540