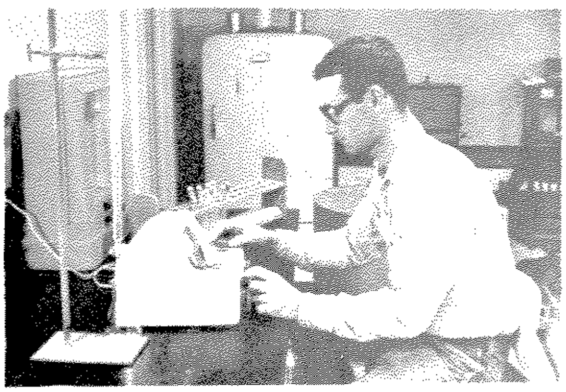
BEEF CATTLE FIELD DAY

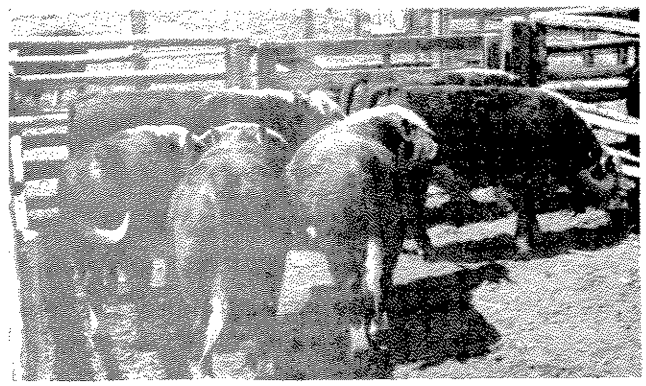
U.S. Range Livestock Experiment Station

Miles City, Montana **APRIL 29, 1966**

PHYSIOLOGY



BREEDING



GRAZING

ANIMAL HUSBANDRY ←*Research Divisions*→ **CROPS**

Agricultural Research Service
United States Department of Agriculture
in cooperation with
Montana Agricultural Experiment Station
and
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TABLE OF CONTENTS

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* This is a second printing of the Beef Cattle Field Day Proceedings. Because it was necessary to change the size of type, the paging differs from that in the initial issue. Page numbers in the initial issue were as shown in parentheses above.

EXPECTED CHANGES IN TRAITS OF ECONOMIC IMPORTANCE THROUGH SINGLE TRAIT SELECTION IN BEEF CATTLE

by
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It seems desirable first, to discuss in general terms the causes of animal differences, the nature of relationships between traits, the concept of a population, and selection as it affects a population.

A trait is a distinguishing character. In terms of economic traits of cattle or other domestic animals, we often identify a trait by the method of measurement or by its value or interest to man. Method of measuring or method of describing the trait usually is for our convenience rather than because it describes some unique biological characteristic of the animal. More often than not, the traits of concern are the result of many body functions acting together to produce distinguishing character than can be measured.

Animals of the same species differ for two basic reasons. First, they have different heredity and second, they experience different living conditions from the moment of conception. Hereditary differences are the basis of population change that can be brought about by selection. An understanding of the principles of genetics helps us to control the heredity of our domestic animals to a limited extent. Although we understand many of the aspects of inheritance, we cannot do all we would like to do in manipulating the transmission of the units of inheritance from parent to offspring. We can control some of the nongenetic differences between animals by management, but all of these differences are not easily controlled by man.

The different degrees of relationship we observe between two or more traits may be due to the way the traits are measured, the time the observations are made, similar external forces such as feed conditions, weather, disease, etc., or the combined heredity which acts with the environment to produce the "thing" we measure. Different traits exhibit relationships to each other for many reasons. We should understand that these relationships can and do change depending upon the circumstances. The total relationship between two traits is often of little use to the cattle breeder in making decisions unless it is broken down into the genetic and non-genetic parts. The total relationship between two traits is easy to obtain from suitable records. Partitioning that correlation into the two parts is much more difficult. We are not always sure of the validity of our estimate of the size of genetic correlations because of limitations in our data. As a result of increased emphasis in cattle breeding research over the past twenty years we are obtaining better answers.

A population can be described many ways, but we usually think of a group of interbreeding organism isolated by some barrier from other organisms potentially capable of intermating. A single herd of cattle could be considered a population or all the cattle in a region could be thought of as a population. Individual animals or herds affect the population in proportion to the number of sperm cells and egg cells contributed to the whole population. This is why bulls are so important in cattle selection. A bull can contribute millions of sperm cells whereas a cow contributes a few egg cells during her lifetime. The industry now has a technology whereby it can use extensively the sperm cells from a single bull. For this reason, we need to understand better than ever the significance of bull selection. Information on single trait selection is of interest because from it we can learn much about the interrelation among traits and predict the consequence of certain selection procedures.

Selection can be defined as differential reproduction. Any event which allows one animal in the population to reproduce at a rate different from another results in selection. Natural selection involves forces, not influenced by man, which allow animals to reproduce at different rates. If these or other forces repeatedly operate on a given population to favor one level of merit over some other level of merit or a trait, or one trait over another trait, the favored animals will tend to dominate the reproductive scene. If heredity is a part of the cause for the differences between animals, the population will begin to change and reflect these characteristics of the selected parents. Today man is able to bring about large selection intensitites. If he directs this selection effort on traits that are largely controlled by heredity, a population change should soon become apparent. If these traits also have economic significance the value of the animals should improve.

The immediate effect of selection within a herd is to raise the level of production of the herd. This results from removing low producers and retaining the high producers. This is good management. The long range effect of selection is to change the heredity of the herd or the population.

The question is often raised by cattle breeders, "If I select for a certain trait, what will happen to the other traits that are also important in the cattle business?" This indicates an awareness of the fact that different traits of cattle bear some relationship to one another. Our purpose here is to review some fairly recent findings on this matter. It is important to have information on this for a number of reasons. It may be that the necessary records on trait of greatest interest cannot be obtained early enough to use effectively in selection, or the records may be very difficult or costly to obtain. We need records on a substitute trait upon which to base our selection decisions. Another use that can be made of information on single trait selection and correlated response in other traits is to provide a basis for deciding the relative attention one should give to several traits in selection. Productive beef cattle must possess superior merit in several traits. Knowledge of selection responses allows breeders to place different emphasis on different traits depending on their value to him and the potential they have for overall improvement. Different breeders may wish to place different values on the same trait in selection.

Birth weight is a trait which is easily measured, which will respond to selection, but it has little market value in itself. The research from the U. S. Range Livestock Station indicates that selection for heavy birth weights should result in greater gains from birth to weaning and greater weaning weight, 12-month weight, 18-month weight or mature weight. Too much selection emphasis on birth weight might lead to other troubles, however. Selecting for weight or gain later in life based on birth weight is expected to be 40-50 percent as effective as selecting directly for later weight.

Weaning weight is a trait of great importance to range cattlemen since many cattle in this state are sold at weaning time. The information on the heritability vary somewhat depending on the kind of management. But on the average 20-30 percent of the weight differences we measure at weaning time are heritable. This means that some progress can be made in increasing weaning weights by selecting directly for it.

Research indicates that selection for weaning weight will also favorably influence weights or gains later in life. The selection of heifers at 18-months of age generally has been found to be effective for increasing body size and productiveness. This is thought by many to be a very desirable time to select for growth rate among range cattle. The research indicates that if we select for 18-month weight by using weaning weight as a criteria for selection, we will be about 70 percent as effective as if we had used 18-month weight. If we select for 18-month weight on the basis of birth weight, the records indicate we will be about 50 percent as effective as basing our selection solely on 18-month weight. Selection for growth rate or weight at one age will in general result in positive responses for growth or weight at other ages. We should remember, however, that if we are particularly interested in weight at a given age, we should attempt to select at that time rather than for some other weight.

Grades and type scores that are based on visual appraisal at weaning time have been found by different workers to be heritable to about the same degree as weaning weight. The relationships of weaning grade to weights or gains at different times in the animal's life has not consistantly been found to be the same by different workers. I believe there is a simple explanation for the different results. If one uses as a standard of excellence the image created by compactness of body form and short legs, as opposed to greater length and thickness, the relationships between such scores and weight or gain should differ. Information from the Miles City Station has consistently shown positive relationships between score and weights and gains. The New Mexico data indicate a negative relationship. The difference is probably due to different scoring standards. In those instances where weaning score was found to be positive related to weight or gain it was not as good a predictor of weight or gain as was weaning weight. This means that the response from selection for weaning score in our attempt to increase weight will be less effective if we select on the basis of weight.

In nearly all cases where a trait is measured by visual appraisal rather than by some objective measure, such as with scales, or some instrument that can repeat its observations accurately, different results are reported from studying relationship between traits. In one study, the heritability of carcass grade was reported to be 17 percent. In another, it was reported to be 59 percent. Estimates of the genetic correlation between carcass grade and weaning weight in the first study was near zero and 0.9 in the other study. It is interesting to note however, that in these two cases the total correlations were about the same, 0.1. Similar results were reported for the relationship between slaughter weight and carcass grade. There was a big difference between the genetic correlations but the total correlations were almost identical in size.

For sometime now, the area of the rib eye has attracted the attention of the cattle breeder in his attempt to improve the meatiness of the beef carcass. In our present state of knowledge, it appears that selection for weaning weight may have limited usefulness in improving the size of eye muscle. Information from the same study indicated that average daily gain was not highly related to rib eye areas.

Another trait of concern to the cattle breeder is the degree of fat in the carcass at normal slaughter weights. Traits which have positive genetic correlations with amount of fat cover over the eye muscle are: weaning weight, average daily gain, final weight, carcass grade, dressing percentage, area of the eye muscle and general body size as measured by length of body and length of leg. Traits that had a negative genetic relationship with amount of fat covering were birth weight and shrink. Weaning score and slaughter grade were for all practical purposes, unrelated genetically to amount of fat covering of the carcass.

Another study of Miles City data was done to study the effect of the hereditary relationship between the maternal environment provided by the dam for her calf and weaning weight. This work indicated that direct selection for weaning weight undoubtedly would place some emphasis on selection for maternal ability. There was an indication of a negative genetic relationship between heredity of the cow to produce a good maternal environment for her calf and heredity for high preweaning gains. It was predicted that part of the gain made in selecting for growth will be nullified by the negative genetic correlation between maternal environment and growth response. We need special experiments to clarify this finding.

If one is concerned about mature weight of cows, selection on the basis of weaning weight or 18-month weight would be from 40 to 70 percent as effective as waiting for mature records to be made and making selections at that late date. This is a good example of using a different criteria or trait on which to base selection at an early age for some trait that will not be evident or measurable until late in the animal's life.

The foregoing discussion of research findings that have been reported from several sources brings us to certain conclusions. One of these is that if the aim of the beef industry is the production of a high tonnage of beef per unit of input, the cattle breeder should select as objectively as possible on the weight at which cattle are sold. There has been no major attempts at subjecting herds of experimental cattle to single trait selection. Information to date is based only on study of large volumes of data that were collected over a number of years. The precision of our information with respect to genetic correlations is not great, but we are beginning to obtain some ideas as to the general magnitude of these genetic correlations. We are beginning to know if they are positive or negative and in some cases if they are large or small. From our knowledge of the magnitude of the genetic correlations between 18-month weight and other weights and gains of cattle and the fact that the heritability of 18-month weight is moderately high, it would appear that this is a good time to evaluate animals for growth potential. Weaning time might be considered a more opportune time to do most of the selection but weaning weight or growth from birth to weaning is apparently a more complex trait in terms of the environmental influences affecting it compared to yearling or 18-month weight. Further, the heritability is generally considered to be less than weight at the older age. From the practical point of view, some selection should be made at weaning time for replacement heifers and young bulls that are going to be further evaluated in some record of performance program. Present evidence indicates that selection for 18-month weight will result in a correlated response in weaning weight that will be 82 percent as effective as direct selection for weaning weight and the correlated response in 12-month weight will be equally as effective as direct selection for 12-month weight. Direct selection for weaning or 18-month score will be generally ineffective in increasing weight or gains.

RATIONS AND PRESENT FEEDING PROCEDURES USED IN MEASURING PERFORMANCE OF BULLS AND STEERS

by
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The purpose of this report is to describe present rations and procedures used on the Station and to present studies conducted to establish present procedures.

All of the calves on the Station are born between March 15 and June 1. The cows and calves are run under range conditions through the summer and fall until weaning time, the latter part of October. When the bull and steer calves are weaned they are put in small pastures or drylots to become accustomed to the test rations until they are weighed onto R.O.P. Feedlot Test November 1.

In previous years the hay and concentrate portions of the ration were fed separately. When the calves went on test they were fed a small amount of concentrate and a large amount of roughage. The concentrate gradually replaced the roughage to approach a 2:1 concentrate to roughage ratio for the test period. The addition of a new feed grinding and mixing mill has made it possible to grind and mix the concentrate and roughage components together to make completely mixed rations. Being equipped to feed completely mixed rations led to the following questions: (1) How rapidly could weaner calves be worked onto standard test rations? In some tests it is desirable to get the test animals on a standard ration during a short warmup period and then hold the ration composition constant thereafter. (2) Would a change in feeding schedule result in higher feed consumption by individually fed cattle?

To try to answer these questions, two preliminary feeding trials were conducted in the fall of 1965. These trials were conducted as guides in establishing standard procedures for experimental cattle normally weaned in October.

The initial feeding trial with 18 weanling steer calves was to determine how rapidly weanling calves could be worked onto high concentrate rations after weaning without detrimental effects. The duration of the trial was from September 1 to October 25. The standard concentrate mix used by the Station consists of ground barley, 55 percent; beet pulp, 30 percent; wheat bran, 10 percent; and linseed meal, 5 percent. Grass hay of variable species composition is the feedlot roughage used.

The 18 steer calves were removed from the cows on August 30 and fed unchopped grass hay on arrival at the feedlot. On September 1, the calves (six per group) were started on three levels of concentrate mix combined with chopped grass hay. Five pounds of beet molasses were added per 100 pounds of mixed ration for dust control. One lot was started on 80 percent concentrate and 20 percent roughage. The other two lots were started on 50 percent concentrate and 50 percent roughage. In one of these groups, the concentrate fraction was increased four percent every other day. In the other group, the concentrate was raised according to animal response until the 80 percent concentrate and 20 percent roughage ration was reached.

The calves were full fed throughout the period and consumed feed equivalent to 3.40 percent of their body weight for the test period. Some scouring occurred in the lot that went right on 80 percent concentrate and 20 percent roughage, but subsided in 1-2 days. When the other two lots reached 80 percent concentrate and 20 percent roughage a few minor cases of scouring were also noted, but the scouring again subsided without treatment. No decrease in feed consumption was associated with the scouring. There was one chronic bloater but otherwise bloat was not a problem.

A second trial was conducted to compare two feeding schedules for individually fed steers. The steers (16 head) were weaned September 13 and fed unchopped grass hay on arrival at the feedlot. The steers were assigned to two groups of eight head each on September 15 and started on test. The 80 percent concentrate ration described in test #1 was used throughout the trial (September 15 to October 25). One group was placed in individual feeding stalls from 7:00 a.m. to 10:00 a.m. and from 12:30 p.m. to 3:30 p.m. This corresponds to the past feeding procedures on the Station. The second group was placed in individual feeding stalls from 6:00 p.m. to 6:00 a.m. and from 10:30 a.m. to 1:30 p.m. Both groups had access to water when they were not in the feeding stalls.

The group on the past feeding procedure consumed feed equivalent to 2.53 percent of their body weight per day while the group on the overnight feeding schedule consumed feed equivalent to 3.31 percent of their body weight. The group on overnight feeding gained 0.53 pounds more per head daily for the 40-day test than did the group fed according to past Station procedure. Some scouring occurred initially but subsided in 1-2 days, with no effect on feed consumption. No other disorders of any consequence occurred.

Standard feeding procedures were established at weaning time (1965) on the basis of the preliminary trials described above.

The R.O.P. Hereford bulls that are in the feedlots now were removed from their mothers October 18-20, 1965. The calves were placed in a small pasture on native grass for about 14 days to avoid feedlot dust while they were adjusting after separation from the cows. The test ration of 68 percent concentrate was offered free-choice in the pasture so the bulls could become somewhat accustomed to it before going on full feed. On November 1, 1965, the bulls were weighed on R.O.P. test. The bulls were started immediately on a full feed of the constant test ration and remain on this ration throughout the 196-day feedlot performance test. The composition of the ration is shown in Table 1.

The R.O.P. ration contains 10.43 percent total protein and 63.33 percent total digestible nutrients. The cost of the ration at current feed prices is $40.72 per ton.

The bulls are group fed in fenceline bunks throughout the feedlot test. Feed for a 24-hour period is weighed in each morning from a mechanical feed wagon.

Table 1. R.O.P. Bull Ration, 1965-66.

	Percent of ration
	%
Grass hay	31.7
Barley	34.9
Dried molasses beet pulp	19.0
Wheat bran	6.4
Linseed meal	3.1
Beet molasses	4.8
Total	99.9

Ground limestone--3.74 lbs. per ton of feed.

Vitamin A--2000 I.U. per lb of feed.

The average daily gain per head of bulls for the first 140 days on test was 2.88 pounds. Feed consumption was equivalent to 2.94 percent of body weight. Feed consumed per pound of gain was 6.20 pounds. The bulls will go off test May 18, 1966. At this time, potential breeding bulls will be selected. Bulls designated for carcass information and cull bulls will go to slaughter.

The steers, from the crossbreeding projects are handled similar to the bulls at weaning time, but a test ration of about 81 percent concentrate is used. The ration composition for the steers is described in Table 2.

Table 2. R.O.P. Steer Ration, 1965-66.

	Percent of ration
	%
Grass hay	19.0
Barley	41.9
Dried molasses beet pulp	22.9
Wheat bran	7.6
Linseed meal	3.8
Beet molasses	4.8
Total	100.0

Limestone--3.2 lbs. per ton offered.

Vitamin A--2000 I.U. per lb. of feed.

The ration contains 11.15 percent total protein and 67.63 percent total digestible nutrients. The cost of the ration at current feed prices is $43.22 per ton.

The steers were started on the test ration as soon as weaning operations were completed and will remain on it until they go to slaughter. An adjustment period of about 14 days preceeded the official feedlot test.

The first phase crossbred steers are individually fed. They are placed in individual feeding stalls from 6:00 p.m. to 6:00 a.m. and from 10:30 a.m. to 1:30 p.m. Each stall contains a self-feeder and individual feed consumption records are kept. The steers will be slaughtered when they reach 1000 pounds. The carcasses are graded and a series of carcass measurements are taken on each individual. Individually fed steers gained 2.45 pounds per head daily for the first 140 days on test. Feed consumption was equivalent to 2.82 percent of body weight. Feed consumed per pound of gain was 7.33 pounds.

The second phase crossbred steers are lot fed in fenceline bunks. These steers will all be slaughtered about May 20, 1966, and carcass information will be obtained.

Average daily gain per head for the first 140 days was 2.73 pounds for the second phase steers. Feed consumption was equivalent to 3.17 percent of body weight. Feed consumed per pound of gain was 7.25 pounds.

The feedlot cattle are vaccinated for IBR (infectious bovine rhinotracheitis) and entrotoxemia (C&D types). Pneumonia and overeating disease have been the two most prevalent causes of death in the feedlot cattle in recent years. Bloat problems have been reduced greatly since a complete mixed ration has been fed and the use of alfalfa hay in the ration has been avoided. However, some bloat cases are still found. Death loss in feedlot cattle has been about two percent in recent years.

Results of the two feeding trials conducted the fall of 1965 and results from the first 140 days of the current R.O.P. feedlot tests indicate that Station feeding procedures used in the future will be about the same as those used in the current 1965-66 feeding program.

IMPROVING BEEF CARCASSES--PRELIMINARY RESULTS

by
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Consumer preference for a low calorie diet has been recognized by beef producers, and they are becoming increasingly interested in methods of satisfying this preference. With this in mind, research people at the Miles City Experiment Station initiated a beef breeding study in 1960 to investigate methods of improving beef carcasses through more accurate live animal selection methods.

Two live animal traits that are given high priority in this selection study are fat thickness (as measured with a somoscope) and weight per day of age up to approximately 13 months. Breeding stock that have been selected for a small fat cover but a high weight per day of age should produce offspring that yield high quality carcasses from the standpoint of total percentage of lean meat. This fact has been established by other workers in recent studies with beef cattle.

This study, at present, is not far enough along to allow evaluation of possible progress that might be obtained. However, we feel that this occasion provides an opportunity to discuss some of the procedures and methods used in this selection study in an attempt to improve beef carcasses.

Procedures Used

The original Hereford grade cows selected for this study from the Station herd were those that had produced steer progeny with desirable carcass merit or were half sisters to cows that had produced these steer progeny. The first two bulls (of Line 1 Advance Domino breeding) that were bred to these cows had previously produced steer progeny of desirable merit. The first herd sire replacement from these matings was selected in 1962. The second one was selected in 1963. Following the selection of the second herd sire, this carcass herd of cattle was closed. Male and female replacements going back into the herd are those it has produced.

Starting in 1963, all male progeny from this herd have been left intact and fed out after weaning for a period of 196 days. No selections are made in this group of bulls prior to completion of the feedlot test.

Selection of Herd Sires

Following the feedlot tests (at approximately 13 months of age), selections are based on the following traits:

1. Weight per day of age to end of feedlot test.
2. Fat thickness estimate over the 12th rib as obtained by somoscope.
3. Final live animal score for thickness of natural fleshing or muscling and structural soundness.

Each year the top indexing yearling bull selected for herd sire is assigned approximately 30 cows and bred to this same herd for two consecutive years. This overlap in repeat matings makes it possible to determine year to year environmental differences and estimate the trend in traits that are selected for.

A summary of performance of the male progeny from our carcass herd in 1964 is shown in Table 1 to illustrate more clearly the procedures used in the selection of herd sire prospects.

Table 1. Summary of performance of bull calves produced in the carcass herd in 1964 and fed on R.O.P. test (winter 1964-65).

Bull No.	Sire No.	Wean. Wt. (lb.)	Wean. Age (da.)	Wean. Score 1/ (%)	Final Test Wt. (lb.)	Wt./Days 2/ Age (lb.)	Avg. Fat Thick. (cm.)	Fat/Cwt. 3/ (cm.)	Sel. Index	Final Score 1/ (%)	Carc. Grade 4/
4145	1273	376	201	76	878	2.22	.31	.035	-1.75	75	18
4335	1273	511	193	82	874	2.17	.21	.024	.20	75	18
4347	1273	508	192	81	1026	2.56	.37	.036	- .25	81	14
4444	1273	464	187	81	888	2.27	.33	.037	-1.90	73	18
4451	1273	457	186	81	962	2.44	.29	.030	.35	81	14
4576	1273	428	176	80	934	2.53	.24	.026	1.60	78	14
4586	1273	455	172	81	934	2.51	.25	.027	1.30	77	18
4587	1273	411	172	81	867	2.26	.23	.027	.05	75	14
4636	1273	366	162	74	906	2.48	.34	.038	-1.05	76	18
Avg.		442	182	80	919	2.38	.29	.031	- .16	77	
4025	2357	501	206	82	946	2.29	.22	.023	1.00	78	26
4141	2357	415	201	83	846	2.06	.32	.038	-3.15	77	26
4142	2357	481	201	84	992	2.46	.32	.032	.05	77	12
4160	2357	475	199	83	1024	2.55	.28	.027	1.50	82	
4175	2357	483	198	82	890	2.19	.40	.045	-3.90	75	28
4230	2357	419	197	80	978	2.41	.23	.024	1.40	80	16
4344	2357	559	192	88	1040	2.60	.33	.032	.75	83	14
4538	2357	436	179	82	920	2.38	.29	.032	- .35	79	14
4546	2357	482	176	83	952	2.48	.32	.034	- .25	81	14
4588	2357	440	172	82	912	2.45	.24	.026	1.20	79	16
4592	2357	450	170	84	954	2.51	.23	.024	1.90	83	
4598	2357	387	166	77	844	2.29	.34	.040	-2.40	76	16
4635	2357	389	162	79	870	2.35	.24	.028	.30	78	28
4637	2357	400	161	81	906	2.55	.22	.024	- .70	80	18
4647	2357	474	154	84	1016	2.81	.23	.023	3.60	82	
Avg.		453	182	82	939	2.42	.28	.030	.06	79	

1/ Weaning and final scores as follows: Fancy, 86-100; Choice, 71-85; Good, 56-70.
2/ Adjusted for age of dam.
3/ Fat thickness per 100 pounds live weight.
4/ USDA carcass grades as follows: Choice, 8-12; Good, 14-18; Standard, 20-24; Utility, 26-30.

The preweaning data as shown in Table 1 is not used in our selection procedures. It is included only to show maternal ability of the cow herd. Likewise, the carcass grades of the slaughtered bulls are presented and illustrate what can be expected in carcass quality of the bulls according to USDA grading standards.

To make our selection procedure as simple as possible and yet accurate, a selection index was computed for each animal as shown in the table. This index is calculated by a formula that combines only two traits: weight for day of age, and fat thickness. Thus, the animals with the high indexes are those that are considerably above average for weight for age and that have below average fat thickness when compared to group averages. This indexing system should result in greater accuracy in the appraisal of each animal for carcass merit. Although the animals selected are generally those with a high index, they must also have sound body structure and desirable conformation.

In Table 1 we note that the bull, No. 4647, selected as first choice gained 2.81 pounds per day of age and had .023 cm. fat thickness/cwt. In both cases he was superior to the average of all animals on test. His final index (3.60) ranked him the top herd sire prospect ofthis group. In body conformation appraisal off test he was given a score of 82 which placed him in the high choice group.

After the first and second choice herd sire prospects are selected each year, the remaining yearling bulls are slaughtered for carcass appraisal. In this study the carcass merit is determined by two important factors (1) the portion of the carcass that is edible, and (2) indicators of quality and palatability of the edible portion. The following are measurement techniques used singly or in combination as indicators of carcass merit:

1. Carcass weight.
2. Rib-eye area at the 12th rib.
3. Fat thickness over the 12th rib.
4. Estimated percent kidney, pelvic, and heart fat.
5. USDA quality grade to 1/3 of a grade with separate scores for marbling, texture of lean, color of lean, firmness of lean, and maturity.

The first four items listed above can be used to estimate cutability (percent trimmed boneless retail cuts from the round, loin, rib and chuck). This procedure of evaluating carcass for cutability has one decided advantage over other more refined evaluation methods since the carcass does not have to be broken down. Numerous carcass measurements in addition to the ones mentioned above are taken each year. Although these additional measurements are not included in the cutability estimate, they will be evaluated critically to determine if they are in any way associated with carcass merit.

Heifer Replacements

All the heifer calves produced in this herd are retained until 18 months of age. The first winter they are wintered to gain approximately 0.70 pounds per day. The following summer they are kept on the range. At approximately 18 months of age (off the range) they are weighed and scored. The herd replacements are then selected on the basis of adjusted weight (adjusted for age, and age of dam) and body score.

Summary

In the discussion today on our beef carcass improvement study, I hope we have made clear our objectives. It is realized that several more years of data will be necessary before any concrete results can be expected. Nevertheless, we are encouraged by the performance of these cattle both from the standpoint of gainability and carcass characteristics. The cattle that we have on display today are typical of the ones produced in this herd.

ADAPTATION OF CATTLE TO DIFFERENT ENVIRONMENTS RESEARCH PLAN AND PRELIMINARY OBSERVATIONS

by
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To what extent does adaptation to a specific location or environment influence the productivity and efficiency of production of beef cattle? Is the effectiveness of selection for certain characteristics influenced materially by the locality or environment in which the selection is practiced? To obtain information needed to answer these and allied questions, a research project known as a genetic-environmental interaction project was initiated in 1961. This is a cooperative study in which the United States Department of Agriculture (Beef Cattle Research Branch--AHRD, ARS) and the Agricultural Experiment Stations of Montana and Florida are participating. Studies contributing to the project are in progress at the U. S. Range Livestock Experiment Station near Miles City, Montana, and at the Beef Cattle Research Station near Brooksville, Florida.

It is the primary intent at this time to inform the public of the procedures involved in the genetic-environmental interaction project. Concrete results are not yet available, as the information that the project is designed to provide must be collected over a period of several years before conclusions can be drawn. A few general comparisons of the cattle bred and selected for range conditions typical of those at the Miles City Station with cattle introduced to the Station from Brooksville, Florida, are presented. These comparisons, although of probable interest, are of a preliminary nature. Most of them do not provide clear-cut indications of differences in adaptation.

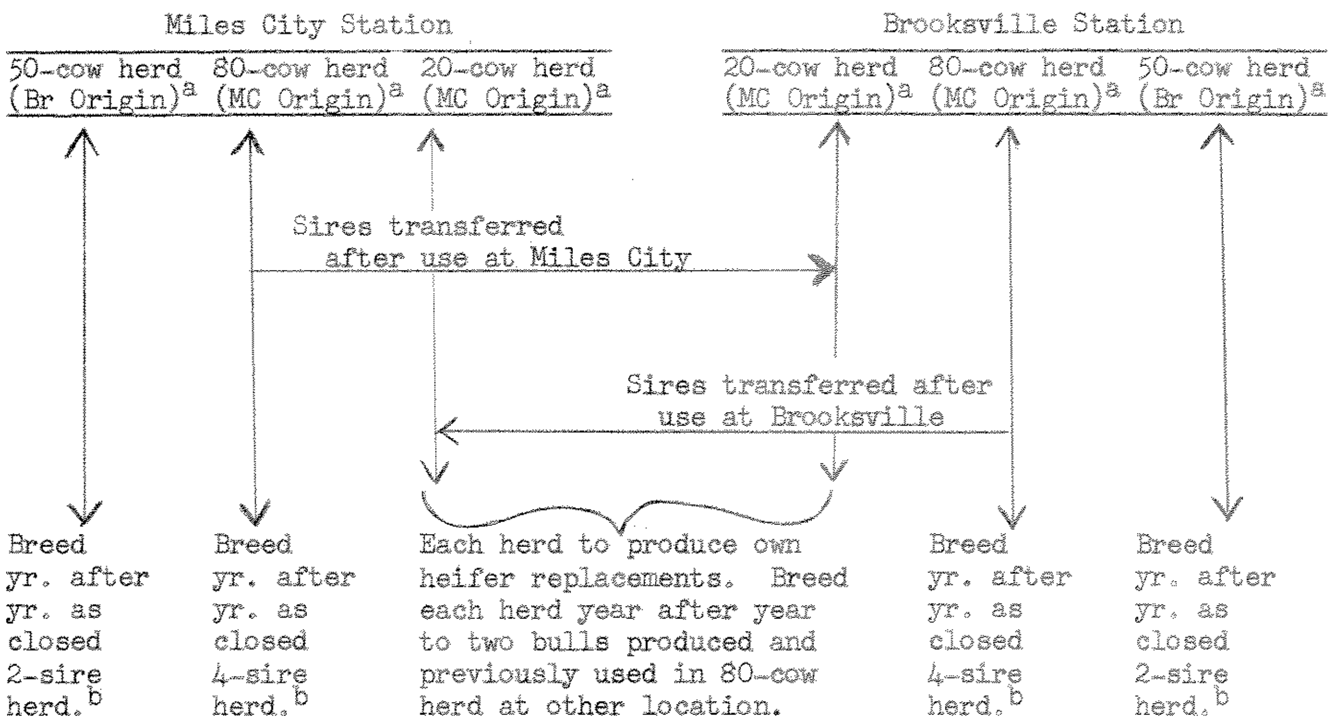
Project Plan

The long-term breeding plan for the genetic-environmental interaction project is shown in Figure 1. Cattle drawn from the Line 1 Hereford herd at the U. S. Range Livestock Experiment Station at Miles City, Montana, were divided between the Miles City and Brooksville Stations from the fall of 1961 to the fall of 1963. This was done to provide uniform foundations composed of cattle bred and selected in a given locality for the 80-cow and 20-cow herds at both stations. Line 1 at Miles City has been bred and selected as a closed line since 1934. From 1961 to 1963, 90 females and four bulls were transferred to Brooksville, with a like number being designated for the study at Miles City. With culling rates and availability of replacements anticipated, the cow herds at both locations should reach the prescribed sizes (Figure 1) by the spring of 1966.

A sample half of a Hereford herd at the Brooksville Station was transferred to the Miles City Station in the fall of 1962 to provide the foundation for the 50-cow herd at the latter location. The remaining half of the herd provided a similar foundation for the 50-cow herd at Brooksville. Two bulls were included in the transfer.

Bulls produced in the 80-cow herd at each location, and selected for use two years as sires in the parent herd, will be transferred to the other location and used one year in the 20-cow herd. The first exchange of such sires between stations was made in the fall of 1965 for use in the 20-cow herds during the 1966 breeding season.

Characteristics on which records will be kept at both locations throughout the course of the study include (1) fertility, (2) cow and calf survival, (3) birth and weaning weights, (4) weights of females taken at about 12 and 18 months of age and in the spring and fall thereafter throughout life in the herd, (5) post-weaning gains of all bull progeny while on performance test, (6) conformation and condition scores of growing cattle when the weights are taken, (7) a variety of carcass evaluations on samples of the performance tested bulls slaughtered each year, and (8) body measurements and physiological data of probable value.



[a] Br--Foundation stock from Brooksville Station.
MC--Foundation stock from Miles City Station.

[b] Closed herd--Both sire and female replacements to come from within the herd.

Figure 1. Long-term breeding plans for Miles City, Montana, and Brooksville, Florida, Stations.

Culling and selection procedures and general management will be kept as uniform as possible for all cattle within stations. Culling and selection procedures will be kept as uniform as possible between stations also. It will be necessary, however, for each station to follow general management practices suitable for the area in which that station is located.

The importance of adaptation and the relative effectiveness of selection under the widely different environmental conditions existing at the two stations will be evaluated by comparison of the herds within stations and by comparing these results between stations. Meaningful results may not be available before about 1975. The following are some of the alternative situations that could arise eventually, although it is possible that the interpretations stated here may be oversimplified. If the 80-cow and 20-cow herds remain essentially alike within each station this will indicate that adaptation is not a very important factor governing performance and that selection is about equal in effectiveness under the two widely differing environments. If the 80-cow herd becomes significantly better than the 20-cow herd at each location, this will indicate that adaptation is an important factor affecting performance. If the 80-cow herd becomes better than the 20-cow herd at one station but not at the other, this will indicate that the selection practices used are not equally effective under the two station environments. Supplemental information, of course, will be obtained by comparing the 50-cow herd of Brooksville origin with the other two herds at each location.

Preliminary Observations

Although the type of information for which this project is designed will not be forthcoming for several years, some of the similarities and differences noted to date in the cattle of Miles City and Brooksville origin under Miles City conditions may be of interest. There are perhaps two factors that should be considered in comparing the cattle of Miles City and Brooksville origin. First, the inbreeding of the Miles City cattle at the beginning of the study was 20 to 24 percent. The inbreeding of the Brooksville cattle forming the foundation for the project, although it has not been computed in detail, appears very low on the basis of pedigree examinations. It is possible, therefore, that the Miles City cattle might be affected more than the cattle from Brooksville by inbreeding depression. Second, the cattle of Brooksville origin appear to have been favored nutritionally during their first year (November 1962 to November 1963) at the Miles City Station. This resulted from the practice of isolating introduced cattle from other station stock for a period of time after introduction as a precautionary measure. It was observed that forage growth in the areas to which the Brooksville cattle were assigned during the first year seemed better than in the areas supporting the other cattle. Weight and gain records support this observation. After the first year, comparable groups of cattle of Miles City and Brooksville origin received essentially the same treatment.

Incidence of deaths and unsoundnesses in the Brooksville females received by the Miles City Station in November 1962 at one year of age and older was similar to the incidence in the Miles City cattle of similar ages up to November 1965.

The females initially introduced from Brooksville in November 1962 at two years of age and over have been consistently lighter in weight than the Miles City females with which they have been compared. The average fall and spring weights and weight differences (fall of 1962 to fall of 1965) are shown in Table 1. Because the Brooksville cows were on a somewhat higher nutritional plane than the other group during their first year at the Miles City Station, the observed differences in average spring weights and fall weights may be somewhat smaller than the true difference between the Miles City and Brooksville cattle. The difference in average spring weights undoubtedly was reduced further because about 40 percent of the Brooksville cows (Table 1) required special treatment during the severe winter of 1964-65 while none of the comparable Miles City cattle required such treatment. It was considered advisable to provide special treatment for the Brooksville cows that were dropping rapidly in condition or becoming lame as a result of the crusted snow to avoid probable losses or complications at calving time. That these cows required special treatment during severe winter conditions appears to be one of the most pronounced indications of differences in adaptation of the Brooksville and Miles City cattle to date. Comparisons of younger females in the manner in Table 1 are omitted because the younger females received from Brooksville were too few in number.

Average calving percentages for the Miles City and Brooksville cattle over a three-year period at Miles City (1963-1965) are shown in Table 2. Losses after birth were attributed to a variety of causes, including accidents. Mortality after birth was actually somewhat higher in the Miles City cattle than in the Brooksville cattle, and this was due largely to losses from the 1965 calf crop. It should be born in mind, however, that the Brooksville cattle had the advantage of a higher nutritional plane prior to and after dropping the 1963 calves and that about 40 percent of these cows also received special treatment during the severe winter of 1964-65 to guard against excessive cow or calf losses. With these factors considered, the differences in mortality (Table 2) may be of little significance.

Table 1. Average Fall (F) and Spring (S) weights of cows--Fall 1962 to Fall 1965.

	MC Females		Br Females		Diff.
	No.[a]	Wt.	No.[a]	Wt.	MC-Br
F. Av.	34	1148	19	967	181
S. Av.	34	1153	19	979	174

[a]Females placed in study at Miles City in fall of 1962 at two years of age and older, and still present in fall of 1965.

Table 2. Average annual calving percentages of Miles City and Brooksville cattle at Miles City over a three-year period (1963-1965)[a].

	Birth		
	Total	Live	Weaned
MC cattle	92.4	86.9	82.6
Br cattle	92.0	88.7	84.5

[a]Percentages based on cows in herds during calving seasons.

Growth data for the heifer and bull progeny of the Miles City and Brooksville cattle are compared in Tables 3 and 4. Summaries were limited to the 1963 and 1964 calf crops. To date, both preweaning and postweaning growth records are available only on these two crops of calves born and raised at Miles City. All cows and calves were maintained under range conditions to weaning time. From weaning to fall yearling age, the heifers were on pasture or range with alfalfa hay and grain up to 5 lb. per day as required during the winter months to assure at least small gains for the group as a whole. The bull calves were placed on 196-day feedlot performance tests after weaning.

Table 3. Heifer growth differences through fall yearling age (MC minus Br)[a].

Year Born	Number		180-day weight	ADG	365-day weight	ADG	540-day weight
	MC	Br	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1963	17	7	58	.04	66	.28	115
1964	17	13	40	.16	69	.24	112

[a]Weights adjusted for differences in age of heifers and further adjusted to a five-year-old age of dam basis.

Table 4. Bull growth differences through postweaning feedlot test of 196-days (MC minus Br)[a].

Year Born	Number		180-day weight	Feedlot gain	365-day weight
	MC	Br	(lb.)	(lb.)	(lb.)
1963	16	13	- 9	40	31
1964	34	11	44	15	59

[a]Weights adjusted for differences in age of bulls and further adjusted to a five-year-old age of dam basis.

Heifers from the stock of Miles City origin were consistently growthier than those from stock of Brooksville origin at all ages observed (Table 3). This was also true of the bulls during all periods except the period up to weaning time in 1963 (Table 4). The explanation for this one exception is not clear.

Loss records or records of disorders for the heifers dropped in 1963 and 1964 indicate no concrete differences between the Miles City and Brooksville groups. For the feedlot bulls, the occurrences of bloat and pneumonia were higher among the Miles City bulls dropped in 1963 and 1964.

Summary

The experimental plan to evaluate the importance of adaptation to beef cattle productivity and to evaluate the efficiency of selection procedures under different environments was described. Meaningful information of the type for which the project was designed may not be available until about 1975.

Cattle bred and selected for range conditions typical of the Miles City area were generally larger and growthier than cattle introduced from Brooksville, Florida.

About 40 percent of the females introduced from Brooksville, Florida, at two years of age or over required special treatment during the severe winter of 1964-65. None of the cattle of Miles City origin in this age range required such treatment. This was the most pronounced indication of differences in adaptation of the Miles City and Brooksville stock over a three-year period.

HYBRID VIGOR FROM CROSSING INBRED LINES OF HEREFORD CATTLE

by
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Hybrid vigor, obtained by crossing breeds, lines, or strains is being utilized in both the plant and animal fields. Hybrid corn, chickens, and crossbred cattle and hogs are some of the better known examples of its use in commercial production.

Hybrid vigor is usually defined as the amount by which the cross exceeds the average of the two parental lines. However, if the cross is to be useful it must exceed the better parental type in overall productivity.

There has been considerable interest here at the United States Range Livestock Experiment Station in the development of superior lines of beef cattle based on performance. Some of the lines were started as early as 1933, and this effort has continued to be an important part of the research program to the present time. Likewise, there is interest in the use of these lines in linecrossing and topcrossing experimentation because of the adaptability of these methods to the industry.

The linecrossing experiment on this Station was started during the breeding season of 1961. The major objective of the first phase of the experiment is to determine the amount of hybrid vigor in economically important traits by comparing the linecross and straightline offspring. In addition, information is being obtained on individual line performance and how each line combines or "nicks" with every other line.

Plan of Experiment and Procedures

Four calf crops were produced in 1962 through 1965 in the first phase of this experiment. The yearling bulls and heifers from the fourth calf crop can presently be seen in the feedlots and on the range.

Cattle from five inbred lines, Lines 1, 4, 6, 9, and 10, were mated to produce all possible straightline and linecross combinations in each of the four years. All sires and dams were produced on the Station within the lines. All sires and dams were inbred and the inbreeding values averaged about 25 to 35 percent in all lines. The best available sire from each line was used each year, with different sires being used each year.

The experimental design along with the total number of offspring weaned by breeding groups is shown in Table 1.

Table 1. Experimental design and number of offspring by breeding group.

	Line of sire					
Line of dam	Line 1	Line 4	Line 6	Line 9	Line 10	Total
	No.	No.	No.	No.	No.	No.
Line 1	19[a]	20	18	19	18	94
Line 4	23	23	18	19	13	96
Line 6	16	19	18	17	15	85
Line 9	18	20	15	20	15	88
Line 10	22	21	20	21	22	106
Total	98	103	89	96	83	469

[a]The numbers on the diagonal (boxed) represent the number of straightline offspring, whereas those above and below the diagonal represent the number of linecross offspring.

Results

Line of sire and line of dam performance: The analyses of data are complete through the weaning state in this experiment. Information on the performance of the lines by line of sire and line of dam is shown in Table 2.

Table 2. Averages by line of sire and line of dam.[a]

Line of sire	Birth weight	Average daily gain birth to weaning	205-day weaning weight	Weaning score
	Lb.	Lb.	Lb.	%
Line 1	78.9	1.78	444	79
Line 4	79.8	1.76	441	79
Line 6	74.6	1.69	421	79
Line 9	73.7	1.77	437	79
Line 10	77.6	1.75	436	80
Average	76.9	1.75	436	79
Line of dam				
Line 1	79.8	1.78	445	79
Line 4	76.9	1.71	427	79
Line 6	71.7	1.80	440	80
Line 9	75.2	1.73	429	79
Line 10	81.0	1.74	437	79
Average	76.9	1.75	436	79

[a]The values are an average of the two sexes and differences due to years, age of dam, age of calf, and lactation status of the cow have been accounted for.

The line of sire averages indicate how well a particular line combines on the average over all lines of dam. These values are characteristic of the line for growth and conformation traits. The line of dam averages indicate how well a line combines over all lines of sire. These values are characteristic of the line for growth, conformation, and in particular the maternal ability of the line.

Lines 6 and 9 are below average in birth weight in both the line of sire and line of dam averages, indicating that lower birth weights are characteristic of these lines. Line 1 ranks among the top in preweaning gain and weaning weight for both line of sire and line of dam, showing the line has both good growth potential and maternal ability. Line 6 is interesting in that it ranks the lowest for preweaning gain and weaning weight by line of sire but is among the best by line of dam averages. This indicates that although the line is lower in growth potential, it excels in maternal ability or milk production. Other line characteristics can be seen by studying Table 2.

Hybrid vigor: The differences between the linecross and straightline calves along with the percent hybrid vigor for each sex is shown in Table 3.

In all traits, the linecross averages exceed the straightline averages and some hybrid vigor is evident. In birth weight, the linecross calves were 2 to 3 pounds heavier and showed 3 to 4 percent hybrid advantage. In average daily gain and weaning weight, the linecross calves exceeded the straightline from 5.2 to 10.6 percent. This is a substantial advantage, amounting to 23 and 36 pounds for bull and heifer calves, respectively.

Table 3. Comparisons of linecross and straightline offspring and percent hybrid vigor.

	Birth weight		Average daily gain birth to weaning		205-day weaning weight		Weaning score	
	Males	Females	Males	Females	Males	Females	Males	Females
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	%	%
Linecross	80.1	74.7	1.83	1.73	455	428	79.4	79.4
Straightline	77.8	71.9	1.73	1.56	432	392	77.5	77.3
Difference	+2.3	+2.8	+.10	+.17	+23	+36	+1.9	+2.1
Percent hybrid vigor	+3.0	+3.8	+5.6	+10.6	+ 5.2	+ 9.3	+2.4	+2.7

The linecross heifers showed approximately twice as much hybrid vigor as did the linecross bull calves. This difference is consistent over years in this experiment and similar results have been obtained in other studies concerned with linecrossing within the Hereford breed. We are not sure why this difference in the amount of hybrid vigor between the two sexes occurs. Possibly a limited milk supply prevents the linecross bull calves from expressing their full growth potential more than is the case for heifers.

Since the last calf crop in phase 1 is still on test, only preliminary results are available for postweaning traits. Information on the first two calf crops is shown in Table 4.

Table 4. Preliminary information on postweaning traits for hybrid vigor.

	Bulls		Heifers
	Average daily gain	Final weight at 13 months	18-month weight
	Lb.	Lb.	Lb.
Linecross	2.84	968	750
Straightline	2.76	931	684
Difference	+.08	+37	+66
Percent hybrid vigor	+2.9	+ 4.0	+ 9.6

These preliminary results indicate that crossline bulls and heifers continue to exceed straightline calves in postweaning traits associated with growth.

Summary

The results indicate that differences exist among the lines for weight and gains of calves and maternal ability of dams. Linecross calves exceeded straightline calves in weights, gains, and conformation scores, indicating the presence of hybrid vigor. These results, in combination with information concerning hybrid vigor in reproduction, calf survival, feed efficiency, and maternal ability should provide an answer on the importance of hybrid vigor in overall production. Through a carefully planned breeding and selection program, it may be possible to raise the level of performance in certain traits within a breed by more fully utilizing hybrid vigor.

HYBRID VIGOR FROM CROSSING BEEF CATTLE BREEDS

by
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Hybrid vigor, as the term applies to this report, is defined as the amount by which crossbreds exceed the average of the parental breeds. Breeding systems that will result in hybrid vigor are becoming of greater interest to commercial beef cattle breeders. That hybrid vigor is utilized commercially in the corn, poultry and swine industries is well known.

Two crossing experiments were initiated at the U. S. Range Livestock Experiment Station near Miles City, Montana, during the breeding season of 1961. One of these involved the crossing of beef cattle breeds; the other involved the crossing of lines within the same breed. The primary objective in the first phase of each experiment is to determine the amount of hybrid vigor that can be obtained in economically important traits by the breeding system used. The experimental plans specified that four crops of calves would be produced to estimate the amount of hybrid vigor obtainable from two-breed or two-line crosses. The four crops of calves have been obtained, and collection of data through weaning age has been completed. Collection of postweaning data will not be completed until October, 1966.

It is the purpose of this report to outline the procedures used in the first phase of the crossbreeding experiment, to summarize results obtained on the four crops of calves to weaning age, and to present preliminary observations on postweaning traits of the first two crops of calves produced. Results from the linecrossing study to date are presented in another report.

Experimental Procedures

The four crops of calves required for the first phase of the crossbreeding experiment were produced in the calving seasons of 1962 through 1965. The mating scheme, with the number of offspring weaned from each breeding group over the four-year period, is shown in Table 1.

Table 1. Mating scheme and number of offspring by breeding group.[a]

	Breed of sire			
Breed of dam	Hereford	Angus	Charolais	Total
Hereford	[55]	58	51	164
Angus	62	[58]	55	175
Charolais	55	49	[55]	159
Brown Swiss	32	30	26	88
Total	204	195	187	586

[a]The numbers in boxes represent the number of straightbred offspring, whereas those above and below the boxed numbers represent the number of crossbred offspring.

This study is based primarily on the crossing of the Hereford, Angus and Charolais breeds. As shown in Table 1, offspring of all possible two-breed crosses were obtained. The mating scheme provided for reciprocal crosses (Hereford bulls X Angus cows and Angus bulls X Hereford cows, for example). Straightbred calves of all three breeds were produced to permit comparisons of straightbreds vs. crossbreds for determinations of the hybrid vigor obtained.

Calves of one half Brown Swiss breeding were obtained by mating bulls of each of the three beef breeds to Brown Swiss cows (Table 1). The part of the study involving crossbreds with Brown Swiss breeding was carried as an addition to the primary study. Brown Swiss bulls were not used, and thus, neither reciprocal crosses nor straight Brown Swiss were among the progeny resulting from the mating scheme. The Brown Swiss crosses thus do not enter into the assessments of hybrid vigor presented in this report.

The Hereford females used in the breeding herd were drawn from a grade Hereford herd maintained at the Miles City Station. Angus, Charolais and Brown Swiss females were purchased from private sources. The bulls used in the breeding program were also obtained from private herds. Three bulls of each beef breed were used annually and the bull battery was changed each year.

The cows and calves were grazed on irrigated, native pasture or native range from the end of the calving season (early May) until weaning time (mid-October). Male calves were castrated at the end of the calving season. After weaning, the steer calves are placed in the feedlot and slaughtered as they reach a live weight of about 1000 pounds. The usual feedlot performance records are kept, and carcass data are obtained after slaughter. Heifer calves are carried from weaning time to puberty the following spring on pasture plus alfalfa hay and grain as required to obtain an average daily gain of about one pound per head daily. Postweaning weights and grades to fall yearling age and sexual development data are recorded on all heifers produced.

Results

The analyses of data are complete through the weaning stage in the crossbreeding experiment. Differences between the straightbred and crossbred calves and the percentage of hybrid vigor for calves of each sex are shown in the top section of Table 2. The Brown Swiss crosses were excluded from these initial comparisons. If there were no hybrid vigor, the average of all crossbreds for any given trait should be about the same as the average of all straightbreds (Hereford + Angus + Charolais) for the same trait. A difference in favor of the crossbreds is an indication of hybrid vigor. Hybrid vigor is this difference expressed as a percentage of the straightbred average.

In all observed growth traits and scores to weaning age, except weaning score of heifers, the crossbred averages exceeded the straightbred averages, and some hybrid vigor was apparent. Hybrid vigor in growth traits of steers ranged from 3.5 to 4.4 percent and resulted in the addition of about 20 lbs. to the average weaning weight of the crossbreds. The hybrid vigor in weaning score of steers, 2.2 percent, raised the score of the crossbreds about one-seventh of a feeder grade. Crossbred heifers showed less than half the amount of hybrid vigor shown by the steers.

That steers showed more hybrid vigor than heifers in this study is the reverse of the results reported by J. S. Brinks in the field day report on hybrid vigor from crossing inbred lines of Hereford cattle. Linecross heifers showed about twice as much hybrid vigor as did linecross bulls. The reasons for the conflict in the results of the two studies is not clear. It seems possible that conditions may have been more nearly optimum for the development of the observed traits in the crossbred steers than they were for the linecross bulls. Records indicate that the quantity and quality of forage available to the crossbreeding herd during the preweaning period may have been more conducive to milk production than was the forage available to the linecrossing herd. There is also existing evidence that inbreeding of the cow may depress milk production. The cows in the linecrossing herd were inbred, while those in the crossbreeding herd, in general, were not.

Table 2. Comparisons of crossbred and straightbred offspring and percent hybrid vigor.

	Birth weight		Av. daily gain birth to wean.		205-day wean. wt.		Wean. score[b]	
	S[a]	H[a]	S	H	S	H	S	H
	lb.	lb.	lb.	lb.	lb.	lb.	%	%
Beef breeds and breed crosses								
Crossbreds[c]	84.9	78.7	2.05	1.95	506	479	80.5	79.7
Straightbreds[d]	81.3	77.5	1.98	1.92	486	470	78.8	79.6
Difference[e]	+3.6	+1.2	+.07	+.03	+20	+9	+1.7	+.1
Hybrid vigor (%)	+4.4	+1.5	+3.5	+1.6	+ 4.1	+1.9	+2.2	0
Beef bulls X Brown Swiss cows								
Crossbreds[f]	96.8	93.6	2.26	2.23	580	550	78.2	78.2
Difference[g]	+15.5	+16.1	+.28	+.31	+94	+80	-.6	-1.4

[a]Steers = S; heifers = H.
[b]Scores of 71-85 represent the choice feeder grade. Scores of 56-70 represent the good feeder grade.
[c]All possible two-breed crosses of Hereford, Angus and Charolais breeds.
[d]Straight Hereford, Angus and Charolais calves.
[e]Crossbreds minus straightbreds.
[f]Crossbred calves by Brown Swiss cows bred to Hereford, Angus and Charolais bulls.
[g]Brown Swiss crossbreds minus straightbreds.

Hybrid vigor from crossbreeding was also somewhat lower in most instances than hybrid vigor from linecrossing as reported by Brinks. This seems reasonable, however, since the straightline calves in the linecrossing study were inbred calves while the straightbred calves in the crossbreeding study were essentially noninbred.

Averages for the crossbred calves from Brown Swiss dams and sired by Hereford, Angus and Charolais bulls are shown at the bottom of Table 2. Differences between these crossbreds and the average of all straightbreds of the three beef breeds are also shown. The growth differences, in favor of the crossbreds, are much higher than the differences shown in the top section of the table where the Brown Swiss breeding was omitted. The marked advantages shown for the Brown Swiss crosses in preweaning gain and weaning weight are probably attributable to hybrid vigor from crossbreeding plus a relatively abundant milk supply furnished by the Brown Swiss females. Both hybrid vigor and the large scale of the Brown Swiss females perhaps contributed to the heavy birth weights of calves with Brown Swiss breeding. Weaning scores of the crossbreds with Brown Swiss breeding were consistently lower than the average scores of the straightbred calves of the three beef breeds, but the differences were less than one-tenth of a feeder grade.

The last calf crop in Phase 1 of the crossbreeding study is still undergoing postweaning tests. Only preliminary postweaning results based on the first two crops of calves are presented in this report. Information on the steers is summarized in Table 3 and information on the heifers is summarized in Table 4.

Preliminary results on the steers (top section of Table 3) indicated some hybrid vigor in postweaning feedlot gain and efficiency of feed utilization as a result of crossbreeding. There were no indications in this data, however, of any hybrid advantage for dressing percentage or carcass grade.

Table 3. Preliminary information on postweaning traits of steers.

	Feedlot record				
	Av. da. gain (lb.)	Days on feed (no.)	Gain/ cwt/TDN (lb.)	Dress. percent (%)	Carcass grade[a] (points)
	Beef breeds and breed crosses				
Crossbred[b]	2.29	239	18.77	63.0	13.6
Straightbred[b]	2.18	258	17.76	63.2	13.7
Difference[b]	+.11	-19	1.01	-.2	-.1
Hybrid vigor (%)	+5.0		6.0	0	0
	Beef bulls X Brown Swiss cows				
Crossbreds[b]	2.28	224	18.46	62.0	14.5
Difference[b]	+.10	-34	+.70	-1.2	+.8

[a]High, medium and low choice = 8, 10, 12, respectively.
High, medium and low good = 14, 16, 18, respectively.
[b]As defined in Table 2.

Crossbred steers with Brown Swiss breeding (bottom section of Table 3) compared favorably with the averages of the other crossbreds and the straightbreds of the beef breeds in growth traits and efficiency of feed utilization. The steers with Brown Swiss breeding were somewhat below the other crosses and the straightbreds in dressing percentage and carcass grade.

Table 4. Preliminary information on postweaning traits of heifers.

	ADG wean. to 18-mo. (lb.)	18-mo. wt. (lb.)	18-mo. score[a] (%)
	Beef breeds and breed crosses		
Crossbreds[b]	1.07	812	77.7
Straightbreds[b]	1.05	801	74.1
Difference[b]	+.02	+11	+3.6
Hybrid vigor (%)	1.9	1.4	4.9
	Beef bulls X Brown Swiss cows		
Crossbreds[b]	1.07	886	71.0
Difference[b]	+.02	+85	-3.1

[a]Scores as defined in Table 2.
[b]As defined in Table 2.

Preliminary results on the heifers (top section of Table 4) indicate some hybrid vigor in postweaning growth traits and 18-month score. The hybrid advantage in growth traits was small, being about 11 lbs. for 18-month weight. The hybrid advantage in 18-month score was equivalent to about one-fourth of a feeder grade.

Crossbred heifers with Brown Swiss breeding (bottom section of Table 4) compared favorably with other straightbreds and other crossbreds in postweaning gain. The big advantage for the Brown Swiss crosses in 18-month weight appears to be largely a carryover of the weight advantage that existed at weaning time. Eighteen month scores of the crossbreds with Brown Swiss breeding were lower than the scores of the straightbred beef heifers by about one-fifth of a feeder grade.

Summary

Crossbred calves consisting of two-breed crosses of the Hereford, Angus and Charolais breeds generally exceeded straightbred calves of these three breeds in weights, gains and conformation scores to weaning age, thus indicating the pres-sence of hybrid vigor. Only preliminary information on postweaning traits is yet available. When the results now complete can be evaluated in combination with information on hybrid vigor in reproduction, calf survival, postweaning growth and feed efficiency, carcass merit and maternal ability, a reasonable appraisal of the importance of hybrid vigor in beef production should be possible.

Information presented on crossbred calves from Brown Swiss dams suggests that an increase in the level of milk production can contribute much to preweaning growth and development. These results indicate that the milk production aspect of maternal ability can be an important factor in beef production.

SOME EFFECTS OF BREED CROSSING ON REPRODUCTIVE PERFORMANCE

by
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The net calf crop of a cow herd is defined as the number of calves weaned and potentially available for sale. Net calf crop percentage is calculated by dividing the number of calves weaned by the number of cows exposed to the bull. The resulting value gives an excellent picture of total reproductive performance.

The net calf crop can be increased by: (1) increasing pregnancy rates, (2) decreasing calf losses at birth and (3) decreasing calf losses from birth to weaning. Some effects of crossbreeding on these three factors have been determined in the crossbreeding study conducted at this Station.

The project involved sires of three breeds--Hereford, Angus and Charolais--mated to Hereford, Angus and Charolais cows. The breeding plan resulted in all possible straight matings and reciprocal breed crosses. In addition, the sires of the three breeds were mated to Brown Swiss cows.

This summary is based on differences obtained from averages of group means calculated within each year. Data have not been subjected to statistical analyses, thus conclusions presented are preliminary in nature. This project was designed to study the effects of breed crossing and should not be interpreted as representing breed differences.

The following tables are presented to show the effects of breed crossing on: (1) calving percentage, which gives an estimate of pregnancy rates; (2) calf losses occurring at birth and from birth to weaning which gives an estimate of livability of the calves; (3) the net calf crop. The percentage of cows calving is based on the number of exposed cows that gave birth to calves regardless of whether the calves were live or dead. Calf losses at birth include calves born dead or that died within four days after birth. Calf losses from birth to weaning include losses occurring during the period from four days after birth until weaning at approximately six months of age. Calf loss percentages are based on the number of cows calving.

Table 1 shows the averages of 286 within-breed matings compared with the averages of 425 breed-cross matings. Differences indicate 4.0% more cows calved as a result of breed crossing, 0.8% more crossbred calves were lost at birth, and 2.4% fewer crossbred calves were lost from birth to weaning. These differences resulted in net calf crop percentages of 75.9% for within-breed matings and 80.9% for breed-cross matings--a difference of 5.0 percentage points in favor of breed crossing.

Table 1. Net calf crop as affected by mating system.

Type of Mating	Cows: Mated	Cows: Calved		Calves lost: At birth		Calves lost: Birth to weaning		Net calf crop weaned	
	No.	No.	%	No.	%	No.	%	No.	%
Within breed	286	229	80.0	4	1.7	8	3.5	217	75.9
Breed cross[a]	425	357	84.0	9	2.5	4	1.1	344	80.9

[a]All reciprocal matings. Brown Swiss matings excluded.

Sire Effects

Table 2 shows the effects of breed crossing summarized within breed of sire. Straight Hereford matings resulted in 80.6% of the cows calving, 1.7% of the calves being lost at birth and 1.7% of the calves being lost from birth to weaning for a net calf crop of 77.8%. When Hereford sires were used in breed-cross matings 87.9% of the cows calved, 1.6% of the calves were lost at birth and 0.8% of the calves died between birth and weaning. This resulted in a net calf crop of 85.8% giving a difference of 8.0 percentage points in favor of breed crossing.

Straight Angus matings resulted in 87.2% of the cows calving, 2.4% of the calves being lost at birth and 3.6% of the calves being lost between birth and weaning for a net calf crop of 81.9%. But when Angus sires were crossed on the other breeds 83.1% of the cows calved, 5.1% of the calves were lost at birth and 1.7% of the calves were lost from birth to weaning. The net calf crop percentage was 77.5% for the breed-cross matings for a difference of 4.4 percentage points in favor of the straight Angus matings.

Table 2. Effects of breed crossing within breed of sire.

Breed of sire	Cows			Calves lost				Net calf	
and type of mating	Mated	Calved		At birth		Birth to weaning		crop weaned	
	No.	No.	%	No.	%	No.	%	No.	%
Hereford sires									
Within breed	72	58	80.6	1	1.7	1	1.7	56	77.8
Breed cross[a]	141	124	87.9	2	1.6	1	0.8	121	85.8
Angus sires									
Within breed	94	82	87.2	2	2.4	3	3.6	77	81.9
Breed cross[b]	142	118	83.1	6	5.1	2	1.7	110	77.5
Charolais sires									
Within breed	120	89	74.2	1	1.1	4	4.5	84	70.0
Breed cross[c]	142	115	81.0	1	0.9	1	0.9	113	79.6

[a]Hereford X Angus and Hereford X Charolais.
[b]Angus X Hereford and Angus X Charolais.
[c]Charolais X Hereford and Charolais X Angus.

Straight Charolais matings resulted in 74.2% of the cows calving, 1.1% of the calves being lost at birth and 4.5% of the calves being lost from birth to weaning for a net calf crop of 70.0%. When Charolais sires were used in breed-cross matings 81.0% of the cows calved, 0.9% of the calves were lost at birth and 0.9% were lost from birth to weaning. This resulted in a net calf crop of 79.6% giving a 9.6 percentage point advantage in net calf crop in favor of breed-cross matings.

Dam Effects

Table 3 shows the effects of breed crossing summarized within breed of dam. Values for within-breed matings are the same as the values for the within-breed matings shown in Table 2. Hereford dams bred to produce crossbred calves had a 2.2% greater calving rate, lost 2.5% more calves at birth, lost 0.9% fewer calves from birth to weaning for a net calf crop 0.8 percentage points larger than Hereford dams bred to produce straightbred calves. Angus dams bred to produce crossbred calves had a 0.6% greater calving rate, lost 1.6% fewer calves at birth and 3.6% fewer calves from birth to weaning than Angus dams bred to produce straightbred calves. These differences resulted in a difference of 5.2 percentage points in net calf crop in favor of breed crossing. Charolais dams bred to produce crossbred calves had a 7.2% greater calving rate, lost 1.5% more calves at birth, and lost 1.9% fewer calves from birth to weaning than Charolais dams bred to produce straightbred calves. These differences led to a 7.1 percentage point difference in net calf crop in favor of breed crossing.

Table 3. Effects of breed crossing within breed of dam.

Breed of dam and type of mating	Cows Mated	Cows Calved		Calves lost At birth		Birth to weaning		Net calf crop weaned	
	No.	No.	%	No.	%	No.	%	No.	%
Hereford dams									
Within breed	72	58	80.6	1	1.7	1	1.7	56	77.8
Breed cross[a]	145	120	82.8	5	4.2	1	0.8	114	78.6
Angus dams									
Within breed	94	82	87.2	2	2.4	3	3.6	77	81.9
Breed cross[b]	140	123	87.8	1	0.8	0	---	122	87.1
Charolais dams									
Within breed	120	89	74.2	1	1.1	4	4.5	84	70.0
Breed cross[c]	140	114	81.4	3	2.6	3	2.6	108	77.1

[a]Hereford dams mated to Angus and Charolais bulls.
[b]Angus dams mated to Hereford and Charolais bulls.
[c]Charolais dams mated to Hereford and Angus bulls.

Hybrid Vigor

Table 4 shows the reproductive performance and net calf crops of within-breed and breed-cross matings summarized to show hybrid vigor resulting from breed crossing. Values for the within-breed matings are the same as those shown in Tables 2 and 3. The expected breed-cross averages if no hybrid vigor existed were obtained by averaging the values of the within-breed matings for the two breeds going into each cross. The breed-cross values are the values actually obtained during the study from the reciprocal crosses.

Table 4. Net calf crops of straight and breed-cross matings summarized to show hybrid vigor.

Type of Mating	Cows Mated	Cows Calved		Calves lost At birth		Birth to weaning		Net calf crop weaned	
	No.	No.	%	No.	%	No.	%	No.	%
Within breed:									
HxH[a]	72	58	80.6	1	1.7	1	1.7	56	77.8
AxA	94	82	87.2	2	2.4	3	3.6	77	81.9
CxC	120	89	74.2	1	1.1	4	4.5	84	70.0
Breed crosses:									
Expected breed-cross averages if no hybrid vigor:									
H and A	--	--	83.9	-	2.0	-	2.6	--	79.8
HxA and AxH avgs. obtained	143	128	89.5	5	3.9	0	---	123	86.0
Difference			+5.6		+1.9		-2.6		+6.2
Expected breed-cross averages if no hybrid vigor:									
H and C	--	--	77.4	-	1.4	-	3.1	--	73.9
HxC and CxH avgs. obtained	143	116	81.1	2	1.7	2	1.7	112	78.3
Difference			+3.7		+0.3		-1.4		+4.4
Expected breed-cross averages if no hybrid vigor:									
A and C	--	--	80.7	-	1.8	-	4.0	--	76.0
AxC and CxA Avgs. obtained	139	113	81.3	2	1.8	2	1.8	109	78.4
Difference	--	--	+0.6	-	± 0	-	-2.2	--	+2.4

[a]H=Hereford; A=Angus; C=Charolais.

First look at the Hereford and Angus comparison. If there were no hybrid vigor we would expect 83.9% of the cows to calve, 2.0% of the calves to be lost at birth and 2.6% of the calves to be lost from birth to weaning for a net calf crop of 79.8%. But averages obtained on the study for the Angus x Hereford and Hereford x Angus matings show 89.5% of the cows calved, 3.9% of the calves were lost at birth and no calves were lost from birth to weaning. The net calf crop was 86.0%. Differences indicate hybrid vigor resulted in 5.6% more cows calving and a 2.6% reduction in calf losses from birth to weaning. Calf losses at birth were increased 1.9% but this, of course, was undesirable. These differences led to an increase of 6.2 percentage points in the net calf crop that can be attributed to hybrid vigor.

The same type of comparisons are shown for the Hereford x Charolais plus Charolais x Hereford matings and Angus x Charolais plus Charolais x Angus matings. Differences indicate hybrid vigor in the Hereford x Charolais and Charolais x Hereford crosses resulted in 3.7% more cows calving, 0.3% more calves being lost at birth, 1.4% fewer calves being lost from birth to weaning for an increase of 4.4 percentage points in the net calf crop. Differences indicate hybrid vigor in the Angus x Charolais and Charolais x Angus crosses resulted in 0.6% more cows calving, no change in the number of calves lost at birth and a 2.2% reduction in calves lost from birth to weaning for an increase of 2.4 percentage points in the net calf crop.

Net calf crop values for Brown Swiss dams are shown in Table 5. Reproductive performance of the Brown Swiss cows was below the averages for the beef breeds. These cows were purchased from various sources and it is probable that at least some were eliminated by prior owners because of unsatisfactory reproduction.

Table 5. Net calf crop of Brown Swiss dams.

Breed of sire	Cows			Calves lost				Net calf crop weaned	
	Mated	Calved		At birth		Birth to weaning			
	No.	No.	%	No.	%	No.	%	No.	%
Hereford	47	33	70.2	0	-	0	-	33	70.2
Angus	48	32	66.7	0	-	1	3.1	31	64.6
Charolais	60	41	68.3	1	2.4	3	7.3	37	61.7

A question is often asked regarding the frequency of calving difficulty encountered when Charolais sires were used. At the outset, remember all heifers on this experiment produced their first calf as three-year-olds. This is important because data from some of our other studies indicate the pelvic opening of a three-year-old heifer averages 20% larger than that of a two-year-old.

A summary of calving difficulty and calves lost due to calving difficulty, including all cows in the crossbreeding study, is shown in Table 6. The summary is divided into first-calf (three-year-old) heifers and mature (four years or older) cows bred to sires of the three beef breeds. Calving difficulty percentages for the first calf heifers were 3.6, 3.1 and 6.8 for those bred to Hereford, Angus and Charolais sires, respectively, while percentages for mature cows were 1.1, 3.5 and 3.9 for the three breed of sire classes. Average percentages over all ages were 1.5, 3.4 and 4.4 for the Hereford, Angus and Charolais sires.

It was interesting to find that 75% of all calving difficulty occurring in mature cows mated to Charolais sires, occurred in 1962. All these cows that experienced calving difficulty in 1962 were mated to the same Charolais bull. Birth weights of calves from this bull averaged 97 lb. Cows that were mated to this bull and experienced calving difficulty had calves with an average birth weight of 112 lb.

Table 6. Calving difficulty classified by age of dam and breed of sire.

	Breed of Sire		
	Hereford	Angus	Charolais
3-yr. old heifers			
No.	28	32	44
% with calving difficulty	3.6	3.1	6.8
Mature cows			
No.	176	202	203
% with calving difficulty	1.1	3.5	3.9
All dams			
No.	204	234	247
% with calving difficulty	1.5	3.4	4.4

Summary

Data from this study indicate breed crossing produced an over-all increase of 5.0 percentage points in the net calf crop. Breed-cross matings resulted in an increased number of cows calving and increased survival of calves from birth to weaning. Breed crossing resulted in a small (0.8 percentage points) increase in calf losses at birth.

Hereford and Charolais sires and Angus and Charolais dams produced greater net calf crops under breed-cross mating systems. Hybrid vigor was evident in the percentage of cows calving for the Angus x Hereford reciprocal and Charolais x Hereford reciprocal matings. Hybrid vigor increased the net calf crop by 6.2, 4.4 and 2.4 percentage points in Hereford x Angus, Charolais x Hereford and Angus x Charolais reciprocal matings, respectively.

MATERNAL QUALITIES IN CROSSBRED AND LINECROSS HEIFERS-- PRELIMINARY OBSERVATIONS

by
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An evaluation of the merits of crossbreeding and linecrossing is not complete without considering the maternal qualities of the crossbred or linecross females. The term, "maternal qualities", includes milk production and the general care provided by the dam for the health and well being of her offspring. A cow, thus makes two important contributions to her calf. First, she contributes about one-half of the overall genetical makeup of her offspring; secondly, she provides an important part of the environment in which her calf must develop during its period of dependence upon her.

Earlier reports on this field day program covered some of the evaluations of hybrid vigor from crossing beef breeds or inbred lines within a breed. Such evaluations were the objectives of the first phase of both the crossbreeding and linecrossing projects. The second phase of each of these projects constitutes a study of maternal qualities in the crossbred and linecross females. This report is devoted primarily to a description of second phase procedures. Although the second phase studies have not been in progress long enough to yield conclusive results, a few preliminary observations are included.

Procedure

Similar mating schemes are being used to assess maternal qualities of both crossbred and linecross females.

Maternal Qualities of Crossbred Females. The general mating scheme used to assess maternal qualities of crossbred females is shown in Table 1. Here, it may be seen that all possible two-breed crosses of the Hereford, Angus and Charolais breeds are included in the crossbred dam classes. These will be compared with straightbred dams of the same three breeds. Crossbred females carrying Brown Swiss breeding are carried as a supplement to the study because Brown Swiss breeding was introduced through female stock only. For this reason, there are no straightbred Brown Swiss females available for comparison. Crossbred sires (Table 1) are used so that all calves will be three-breed crosses and so that all the initial breeds will be represented as equally as possible in the progeny of the breed-of-dam classes or desired combinations of breed-of-dam classes.

Table 1. Mating scheme for a study of maternal qualities in crossbred females.

Breed of sire	Breed of dam[a]								
	HxH	AxA	CxC	CxH HxC	AxH HxA	CxA AxC	HxBS	AxBS	CxBS
HxA			x	x		x	x	x	
HxC		x			x	x	x		x
AxC	x			x	x			x	x

[a]Hereford = H; Angus = A; Charolais = C; Brown Swiss = BS.

Each crop of heifers produced under Phase 1 will be bred to calve once under the study of maternal qualities (Table 1). The resulting calves will be used to evaluate maternal qualities in this study. The first calves were produced in 1965 and the second crop is being dropped at the present time.

Records will be kept on cow fertility, cow and calf survival, birth weights, growth of calves to weaning, and weaning grade. It is possible that maternal effects may carry over into postweaning performance. Growth and grade records will be kept on heifer offspring, to about 12 months of age, under routine winter management conditions. Feedlot performance data plus carcass information on steer offspring will be obtained.

The second phase of the crossbreeding study will run three years. In the 1965 breeding season, yearling heifers as well as 2-year-olds were bred. Thus, it will be possible to make a limited comparison of the merits of calving 2-year-old and 3-year-old heifers in addition to the assessment of maternal qualities.

Maternal Qualities of Linecross Dams. The general mating scheme used to assess maternal qualities of linecross females is shown in Table 2. The linecross females include all possible two-line crosses of inbred lines 1, 4, 6, 9 and 10. Straightline females of these five lines are included. Progeny of the straightline and linecross females can be compared to assess maternal qualities of the linecross females.

All females used for breeding in the Phase 2 study of maternal qualities were produced in Phase 1 of the linecrossing project. Linecross sires are used, and the progeny of the matings indicated in Table 2 will all be three-line crosses. These sires are selected from calves produced in Phase 1 of the linecrossing study. Linecross sires are used so that all lines will be appropriately represented in the line-of-dam classes or desired combinations of these classes. The mating scheme, thus, parallels the scheme described for the crossbreeding study of maternal qualities.

As shown in Table 2, the breeding program was started in 1964 and must extend through the breeding season of 1967 to complete all of the required matings in the numbers desired.

Data to be collected for this study of maternal ability will be as described for the crossbreeding study. The principle difference is that male progeny in the linecross study will be fed out after weaning as bulls rather than as steers.

As was true in the crossbreeding study, both yearling and 2-year-old heifers were bred concurrently in 1965. In addition to information obtainable on maternal ability, it will be possible to obtain information on the comparative merits of calving heifers as 2-year-olds and as 3-year-olds.

Table 2. Mating scheme for a study of maternal qualities in linecross females.

Breeding season	Line of sire	Line of dam														
		1	4	6	9	10	1x4 4x1	1x6 6x1	1x9 9x1	1x10 10x1	4x6 6x4	4x9 9x4	4x10 10x4	6x9 9x6	6x10 10x6	9x10 10x9
64&66	1x4			x	x	x		x	x	x	x	x	x			
64&66	1x6		x		x	x	x		x	x	x			x	x	
65&66	4x10	x		x	x		x			x	x	x			x	x
65&66	4x9	x		x		x	x		x		x		x	x		x
65&67	1x9		x	x		x	x	x		x		x		x		x
65&67	6x9	x	x			x		x	x		x	x			x	x
65&67	4x6	x			x	x	x	x				x	x	x	x	
65&67	6x10	x	x		x			x		x	x		x	x		x
66&67	1x10		x	x	x		x	x	x				x		x	x
66&67	9x10	x	x	x					x	x		x	x	x	x	

Preliminary Results

Information to weaning age is available to date on only one crop of calves produced under the mating schemes described in Tables 1 and 2. Results presented at this time are only general observations, and they are not in any sense conclusive. No formal analyses of these limited data have been made.

Maternal Qualities of Crossbred Dams. Preweaning and weaning records on the first crop of calves obtained in the study of maternal qualities of crossbred females are summarized in Table 3. Calves from females carrying Brown Swiss breeding are listed separately and not included in the averages of progeny of crossbreds because there were no straightbred Brown Swiss dams to contribute progeny to the straightbred dam class.

Table 3. Records of progeny of straightbred and crossbred dams.

Calves	Breed of dam							
	Straightbred				Crossbred			
	Calves (no.)	Birth weight (lb.)	Wean. weight[a] (lb.)	Wean. score (%)	Calves (no.)	Birth weight (lb.)	Wean. weight[a] (lb.)	Wean. score (%)
Heifers	6	74.5	394	78.5	14	74.6	389	79.4
Steers	4	77.3	395	78.0	14	83.8	375	79.8
Sexes Combined[b]	10	78.6	408	78.2	28	82.8	407	79.6
From BS Dams[c]	--	--	--	--	3	90.0	456	79.6

[a]Adjusted to 205 days of age.
[b]Adjusted to steer basis.
[c]Brown Swiss = BS. Calf weights adjusted to steer basis.

Calves from crossbred females averaged about 4.0 lb. heavier at birth, 1.0 lb. lighter in weight at weaning and less than one-tenth of a feeder grade higher in weaning score than did the progeny of the straightbred dams. On the basis of these results, the crossbred dams have shown no advantage in maternal qualities up to this point.

Records on the progeny of crossbred females with Brown Swiss breeding (Table 3), although few in number, suggest that Brown Swiss breeding in crossbred dams contributed to their milking ability. The calves from this group weaned about 49 lb. heavier than the calves from all other crossbred dams.

Maternal Qualities of Linecross Dams. Too few straightline dams produced calves in the first crop under this study to compare maternal qualities of straightline and linecross females. The dams were, however, grouped according to each original line represented (all females with Line 1 breeding, all with Line 4 breeding, etc.) to check the influence of each original line on maternal qualities of the linecross females. The calf records of the females grouped in this fashion are summarized in Table 4. Only Lines 1, 4, 6 and 10 can be considered at this point.

As shown in Table 4, dams with Line 6 breeding weaned the heaviest calves. This suggests that Line 6 possesses reasonably good maternal ability and is consistent with conclusions drawn from other blocks of data.

Table 4. Influence of original lines on maternal qualities of linecross dams.

Calf records	Dams with breeding of line: Line 1	Line 4	Line 6	Line 10
No. of progeny	3	6	7	7
Birth weight (lb.)[a]	82.7	80.0	76.6	79.1
Weaning weight (lb.)[a,b]	391.0	371.0	406.0	388.0
Weaning score (points)	80.3	76.0	79.7	77.4

[a]Adjusted to bull weights.
[b]Adjusted to 205 days of age.

Summary

Studies of maternal qualities in crossbred and linecross females were started in the breeding season of 1964. Information on only one crop of calves from each study is yet available. No definite conclusions can be drawn at this time.

Limited data currently available indicate no maternal advantage of crossbred females over straightbred females.

Data from the linecrossing study are too limited, as yet, to compare maternal qualities of straightline and linecross females. Limited information is available on the contributions of Lines 1, 4, 6 and 10 to the maternal qualities of linecross females obtained by crossing these lines. To date, linecross females carrying Line 6 breeding have weaned the heaviest calves. It appears that Line 6 may be making the greatest contribution to maternal qualities of the linecross females.

EFFECTS OF NUTRITION ON PUBERTY IN BEEF HEIFERS

by
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Puberty is a term used to describe the stage of sexual development at which the young male or female becomes capable of reproduction. In a heifer this is the first time she comes in heat and sheds a potentially fertile egg from the ovary.

Many beef heifers are bred to produce their first calf at approximately two years of age. If this practice is to result in satisfactory calf crops, heifers must reach puberty so fertile estrous periods can be exhibited during the breeding season. If puberty is delayed, heifers that conceive must conceive to fewer services. Heifers conceiving late in the breeding season will calve late, thus weaning a light calf and shortening the time period in which preparation can be made for a second pregnancy.

Data from the Miles City Station show that 3-year-old heifers open after the first breeding season are potentially poor producers. A summary covering a 25 year period showed heifers that did not produce calves after the first breeding season had a lifetime calf crop record of 54.9%. However, heifers that did produce calves after the first breeding season had a lifetime calf crop of 86.8%.

Another research worker found that 2-year-old heifers producing calves early in the first calving season tended to continue calving early through their eighth pregnancy. Heifers producing their first calf late in the first calving season continued to calve late in succeeding calvings and had a lower lifetime pregnancy percentage. Thus, pregnancy resulting from early conception during the first breeding season is important, but if the heifer has not reached puberty conception cannot be expected.

Effects of Nutrition

An experiment designed to study the effects of nutrition on growth and age at puberty in Hereford heifers has been conducted at this Station.

Forty-eight weaned heifer calves were assigned to the study November 30 and grazed on range throughout the trial. The design of the experiment is shown in Table 1. Two levels of supplemental feeding were used during the 137-day winter feeding period (November 30 to April 15) and heifers on each level were individually fed their respective supplements every other day. Supplements were formulated (Table 2) to provide equivalent amounts of protein, phosphorus, and vitamin A, but differed in energy level. Feeding rates were two pounds every other day of the 40% protein pellet and four pounds every other day of the 20% protein pellet.

Table 1. Design of experiment to study effects of supplement energy level on puberty in range heifers.

Wintering phase[a]		Prebreeding phase[b,c]		Treatment[d]
Two lb. 40% protein pellet	(24)[e]	Range	(12)[e]	LL
		Four lb. 20% protein pellet	(12)	LH
Four lb. 20% protein pellet	(24)	Range	(12)	HL
		Four lb. 20% protein pellet	(12)	HH

[a]Fed every other day November 30 to April 15, 137 days.
[b]Fed every other day April 17 to June 14, 59 days.
[c]No supplement during breeding.
[d]Low energy = L; high energy = H.
[e]Number of animals per group.

Table 2. Supplement composition data.

Ingredient	40% protein pellet (L) %	40% protein pellet (L) lb. per ton	20% protein pellet (H) %	20% protein pellet (H) lb. per ton
Barley	——	——	67.00	1340
Soybean oil meal	91.25	1825	26.25	525
Molasses	6.00	120	6.00	120
Monosodium phosphate	2.00	40	0.375	15
Calcium carbonate	0.375	15	0.375	15
Vitamin A (I.U. per lb. feed)	20,000		10,000	
Amount fed every other day (lb)	2		4	
TDN per lb. feed	0.71		0.73	

On April 15 each wintering group was divided into those receiving supplement and those on range only prior to breeding. The supplement was the same as the high level fed during the wintering period, i.e., four pounds of the 20% protein pellet, fed individually every other day. This feeding regime was of 59 days duration and continued until June 14. Prior to the beginning of the breeding season a sterile bull wearing a marking harness containing pigmented grease was run with the heifers to detect heat. After the beginning of the breeding season (June 15) heifers were exposed to fertile bulls wearing marking harnesses so breeding dates could be determined.

Body measurement data indicated little effect of feed level on body growth. Body weights at the beginning of the breeding season are shown in Table 3. The time of first estrus is also shown in Table 3 and it is interesting to note that in this experiment, where supplement level differences were relatively small, a difference of 19.0 days was produced between the LL and HH ration groups and a difference of 22.5 days between the HL and HH groups. Feeding supplement during the 59-day period prior to breeding hastened puberty by 15.8 days (obtain from Table 3). This is important when one considers the estrous cycle is 21 days in length. This means that the heifers on the higher level of energy intake would exhibit approximately one more heat period during the breeding season than those on the lower energy intake level.

Table 3. Effect of level of nutrition on the average time of first heat in Hereford heifers.

	Supplement group LL	LH	HL	HH
Body weights at beginning of breeding season (lb.)	664.5	654.4	652.8	686.5
Time of first heat (days)[a]	208.8[b]	199.8[c]	212.3[d]	189.8[e]
Heifers reaching puberty after beginning of breeding season (%)	75.0	50.0	83.3	66.7

[a]Calculated from November 30 until first heat.
[b]Approximately June 25.
[c]Approximately June 17.
[d]Approximately June 29.
[e]Approximately June 7.

The additional heat period becomes of major importance when we look at the percentage of heifers coming in heat for the first time after the beginning of the breeding season (June 15). The average overall feed treatments was 68.8%, ranging from 50.0% for the LH feed level to 83.3% for the HL level. Thus, in this trial over two-thirds of the heifers did not reach puberty until after the beginning of the breeding season. This means that they would have to conceive to fewer services than heifers that had reached puberty prior to the beginning of the breeding season and that these heifers would also calve later in the calving season. In addition, they would wean lighter calves and would be in danger of calving so late that they could easily fail to produce a calf as a 3-year-old.

This study resulted in another important finding. Analyses revealed that weight gain during the 59-day prebreeding period (April 16 to June 14) was four times more important in its effect on age at puberty than was gain during the wintering period (November 30 to April 15). This indicates that getting heifers through the winter is not enough. They must have access to a high nutritional plane such as good pasture that will insure continued weight gains during the period following wintering and throughout breeding.

Work in Progress

An experiment is now underway which is designed to further study the relationships between winter and prebreeding gains and their effect on age at puberty in beef heifers. The objectives of this experiment are to (1) determine the effects of grain feeding during the winter and prebreeding period on time of puberty; (2) determine the effects of nutrition on conception rates; and (3) determine relationships among winter and prebreeding weight gains and reproduction.

One hundred and twenty-five Hereford and 125 Angus, weaned heifer calves have been assigned to the study shown in Table 4. All heifers graze range forage throughout the study with supplemental feed (grain and/or hay) supplied at rates necessary to obtain the minimum projected weight gains shown in Table 4. Supplemental feeding is divided into a wintering period and prebreeding period.

Table 4. Design of experiment showing projected minimum daily weight gains, body weight ranges at start of breeding and number of heifers per group.

Breed	Feed group	No. heifers	Projected minimum daily weight gain (lb.) during: Winter period[a]	Prebreeding period[b]	Projected minimum body weight ranges (lb.) at start of breeding season[c]
Hereford	I	31	1.2	1.2	
	II	94	0.5	2.0	600-650
Angus	I	31	1.2	1.2	
	II	94	0.5	2.0	550-600

[a]December 15, 1965, to March 30, 1966.
[b]March 31, 1966, to breeding.
[c]July 1, 1966.

The winter period started December 15, 1965, and ended March 30, 1966, giving a total duration of 105 days. Heifers were divided into two groups. Group I received a 20% protein, pelleted supplement fed three times weekly in amounts equivalent to 2 lb. per head daily. These heifers also received hay fed three times weekly in amounts equivalent to 14 lb. per head daily. Heifers in Group II did not receive grain supplement during this period, but were fed hay three times weekly in amounts equivalent to 14 lb. per head daily.

Estrus was determined by sterile bulls wearing marking harnesses containing pigmented grease. Heifers are weighed at 28-day intervals.

Factors studied during this period include the effects of weight gain on the occurrence of estrus.

The prebreeding period started March 31, 1966, and will continue until the individual heifer is bred. Heifers in Group I and II are fed the 20% protein supplement in amounts necessary to obtain the minimum projected weight gains shown in Table 4.

Hay was supplied to both groups during the early part of the prebreeding period in amounts necessary to obtain the minimum weight gains.

Estrus determination is continued as described for the wintering period. Beginning July 1, 1966, heifers will be bred.

Factors studied during the prebreeding period will include the relationships among weight changes of the heifer, the occurrence of estrus, and first service conception rates.

Summary

Research indicates adequate nutrition plays a major role in hastening puberty in range beef heifers. Data show weight gains during the prebreeding period (April 16 to June 14) were four times more important in affecting puberty than were gains during the winter period from November 30 to April 15.

An experiment in progress is designed to further study time periods when grain feeding can best be utilized to hasten puberty.

CRESTED WHEATGRASS-ALFALFA AND RUSSIAN WILDRYE-ALFALFA SPRING PASTURES FOR BEEF CATTLE

by
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Early work with several introduced, cool-season grasses in the region indicated that they could provide adequate forage for young, non-breeding livestock earlier than native range with increased carrying capacity and increased seasonal gains. The effects of these high-producing, early-spring, introduced-grass pastures on breeding cows and calves are unknown.

It is known that early spring is a critical time for breeding cows. The cows are usually in only fair to poor flesh from maintenance levels of nutrition during the winter. Calves are being born at this time which increases stress on the cow from parturition and providing milk for the calf. Both the cow's and the newborn calf's health and resistance to weather stress can be maintained or improved only by adequate nutrition. The nutritional level of native range forage is at its lowest level in early spring just before new plant growth begins. Providing an adequate supply of nutritious green forage at this time would improve health and stress resistance of both the cows and the calves, stimulate milk flow in the brood cows, provide a longer period of high calf gains, and increase the condition of the cow and possibly fertility during breeding which occurs in a short time.

Other research on physiology of beef cattle reproduction has indicated that flushing cows during early spring at the time of calving and immediately prior to breeding significantly improves fertility. This flushing by high energy concentrates possibly may be duplicated by cheaper, high producing, introduced-grass pastures. Providing higher levels of cow fertility and earlier pregnancies directly contribute to increased pounds of calves at weaning and thus increased income.

Stocking Levels on Spring Pasture

The stocking levels obtained on the supplemental spring pastures in 1965 were higher than that of 1964. This was done in an attempt to obtain a higher degree of pasture utilization more in line with the objective of 60-70 mean percent utilization by weight for each seeded pasture mixtures. At the end of the grazing period the cattle were knocking down the utilization cages in the crested wheatgrass-alfalfa pastures and losing weight. Also by midsummer considerable invasion of annual weeds were present in the crested wheatgrass spring pastures. It is believed that the high levels of stocking obtained in the spring of 1965, particularly on the crested wheatgrass-alfalfa pastures, were probably too heavy for long-term sustained, high production.

Stocking on Spring Pasture (Acres per A.U.M.)

		- Pasture -			
Year	Native Range	Crested-Alfalfa #1	Crested-Alfalfa #2	Russian-Alfalfa #3	Russian Alfalfa #4
1964	4.39	1.67	1.63	1.86	1.47
1965	3.07	1.45	1.17	1.45	1.18
Mean	3.73	1.56	1.40	1.66	1.32
		1.48		1.49	

Forage Utilization on Spring Pastures

As the following tabulation indicates forage utilization in 1965 on the crested wheatgrass-alfalfa spring pastures was higher than the planned level of 60-70 percent. Utilization on the Russian wildrye-alfalfa pastures in both 1964 and 1965 has been somewhat higher than planned.

Utilization on Spring Pastures

Pasture and Year	Seeded grass or Western wh.	Other per. grasses	Alfalfa	Total per. vegetation	Total vegetation
	-Vegetation Component-				
Native spring pasture					
1964	60%	30%	---	37%	33%
1965	73%	55%	---	62%	57%
Crested wheatgrass-alfalfa					
1964	50%	---	85%	55%	54%
1965	77%	---	96%	83%	79%
Russian wildrye-alfalfa					
1964	76%	---	71%	75%	73%
1965	69%	---	94%	74%	73%

Herbage Production on Spring Pastures

Herbage Production on Spring Pastures

Season, Pasture, and Year	Seeded grass or Western wh.	Other per. grasses	Alfalfa	Total per. vegetation	Annuals	Total vegetation
	- Vegetation Component -					
	Pounds per acre, air-dry					
Late May or early June -						
Native spring pasture						
1964	89	306	---	395	46	440
1965	245	360	---	605	24	629
Crested wheatgrass-alfalfa						
1964	362	---	52	414	4	418
1965	1335	---	614	1950	40	1990
Russian wildrye-alfalfa						
1964	598	---	146	744	10	752
1965	2194	---	449	2646	34	2677
Early to late August -						
Crested wheatgrass-alfalfa						
1964	807	---	134	941	72	1012
1965	2656	---	1842	4497	2146	6644
Russian wildrye-alfalfa						
1964	1464	---	348	1812	16	1829
1965	2531	---	848	3378	178	3556
Relation of Russian wildrye-alfalfa production to crested wheatgrass-alfalfa production in 1965						
Early June	+64%	---	-27%	+36%	-15%	+35%
August	- 5%	---	-54%	-25%	-92%	-46%

Herbage production was considerably higher in 1965 than in 1964 on all spring pastures. Production during April and May have been higher in the Russian wildrye-alfalfa pastures than the crested wheatgrass-alfalfa pastures in both years. The increase in production from the first of June to August has been higher in the crested wheatgrass-alfalfa in both years pastures. In August of 1965, the crested wheatgrass-alfalfa pastures were producing substantially more vegetation, both perennial and annual, than the Russian wildrye-alfalfa pastures.

Plant Density on Seeded Spring Pastures

In 1964, the third growing for the seeded pastures and the first year for grazing, the crested wheatgrass-alfalfa pastures had 20 percent more seeded grass plants per square-foot, but only 60 percent as many alfalfa plants. In 1965 these differences were greater. The crested wheatgrass pastures had nearly 60 percent more seeded grass plants, but only 25 percent as many alfalfa plants.

Plant Density

Pasture and Year	Seeded grass	Alfalfa
	- No. plants per sq. ft. -	
Crested wheatgrass-alfalfa		
1964	10.42	0.34
1965	8.59	0.57
Russian wildrye-alfalfa		
1964	5.55	0.41
1965	3.51	1.58

Cow and Calf Gains on Spring Pastures

During the 38 day spring grazing period of 1965, the calves on native pasture gained the least and the cows gained the most. Both cows and calves on the Russian wildrye-alfalfa pastures gained more than those on the crested wheatgrass. This is somewhat at variance with 1964 when the cows on the native spring pasture gained the least, and there was no difference in cow gains between the two seeded pastures. In 1964 the calves on the seeded spring pastures gained 11 pounds more than the calves on the native spring pasture, and in 1965 gained 10 pounds more.

Wet Cow and Calf Weights and Changes - Spring Pastures - 1965

Native spring pasture	Crested wheatgrass-alfalfa #1	Crested wheatgrass-alfalfa #3	Russian wildrye-alfalfa #2	Russian wildrye-alfalfa #4
		- Pounds -		
Cows. Initial weights to April 27, 1965				
929	930	931	951	914
Weight changes by June 4, 1965 (38 days)				
+70	+15	+40	+51	+56
Calves. Initial weights April 27 (only calves born by 4-27)				
106	108	106	105	109
Weight changes by June 4 (38 days)				
+68	+75	+79	+82	+77

Calf Response on Spring Pasture Treatments

Spring pasture	Birth* date	Birth weight	Avg. daily gain	Wean. weight	Wean.** grade
Spring Pasture Treatments and Calf Production					
Native spring pasture					
1964	---	---	1.78	439.7	5.6
1965	98.2	77.9	1.66	406.9	5.6
Crested wheatgrass-alfalfa					
1964	---	---	1.86	452.4	5.4
1965	101.3	76.6	1.68	429.4	5.0
Russian wildrye-alfalfa					
1964	---	---	1.88	457.5	5.4
1965	103.2	81.6	1.76	433.4	5.0
Seeded spring pasture mean					
1964	---	---	1.87	455.0	5.4
1965	102.2	79.1	1.72	431.4	5.0

* Number of days since December 31, i.e., April 10-100.
** Lower numbers indicate higher weaning grades.

Residual Effects of Past Range Condition on Calf Production

The residual effects of the past heavily, intermediate, and lightly grazed pastures (see U.S.D.A. Tech. Bull. 1357) on calf production were still evident in 1964 and 1965. In 1964 calves from the old lightly grazed pastures were born earlier (reflecting earlier pregnancy of cow), were heavier at birth, and had higher weaning weights than calves from the heavily and intermediately stocked pastures. In 1964 calves from the old heavy stocking level had the poorest weaning grades.

In 1965 the calves from the old lightly stocked pastures were born the earliest and had the highest weaning weights. At this time the calves from the heavily stocked pastures had the lowest daily gains and weaning weights.

Cow Fertility and Spring Pasture Treatments

Spring pasture	Fall pregnancy	Calf crop weaned	Age of* fetus	Pounds calf weaned/cow
Spring Pasture Treatments and Cow Fertility				
Native spring pasture				
1964	92.3%	---	---	---
1965	92.3%	80.8%	46.1	328.8
Crested wheatgrass-alfalfa				
1964	100.0%	---	---	---
1965	92.8%	93.8%	50.6	402.6
Russian wildrye-alfalfa				
1964	100.0%	---	---	---
1965	100.0%	83.4%	48.4	362.2
Seeded spring pasture mean				
1964	100.0%	---	---	---
1965	96.4%	88.6%	49.3	382.4

*Cows examined August 18, 1965. Breeding season began June 15, 1965. Age in days.

The use of seeded spring pastures by breeding cows has brought about a physiological response influencing their fertility. The fall pregnancy status of cows from the seeded spring pastures was 100 percent in 1964 and 96 percent in 1965 as compared to 92 percent both years from the native spring pasture treatment. In 1965 the cows from the 1964 seeded spring pasture treatment weaned an 89 percent calf crop as compared to 81 percent from the 1964 native spring pasture treatment.

An examination of fetal age in mid-summer of 1965 indicated that the cows from the seeded spring pastures had become pregnant 3 days earlier than those from the native spring pastures.

The effects of spring pasture treatments on fertility of cows and growth of calves may be summarized by the statistic of pounds of calf weaned per cow exposed to breeding in the previous year. On this basis each cow from the seeded spring pastures weaned 54 pounds more calf than those from the native spring pasture.