FORT KEOGH

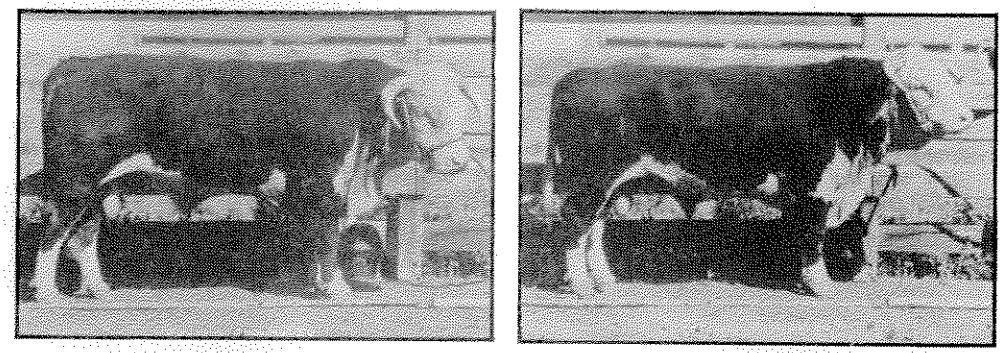
LIVESTOCK AND RANGE RESEARCH STATION

MILES CITY, MONTANA

1984 FIELD DAY

LINE 1

1934



RESEARCH IN ACTION

1984

RESEARCH IN ACTION

GOLDEN ANNIVERSARY

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
IN COOPERATION WITH
MONTANA AGRICULTURAL EXPERIMENT STATION

SEPTEMBER 10, 1984

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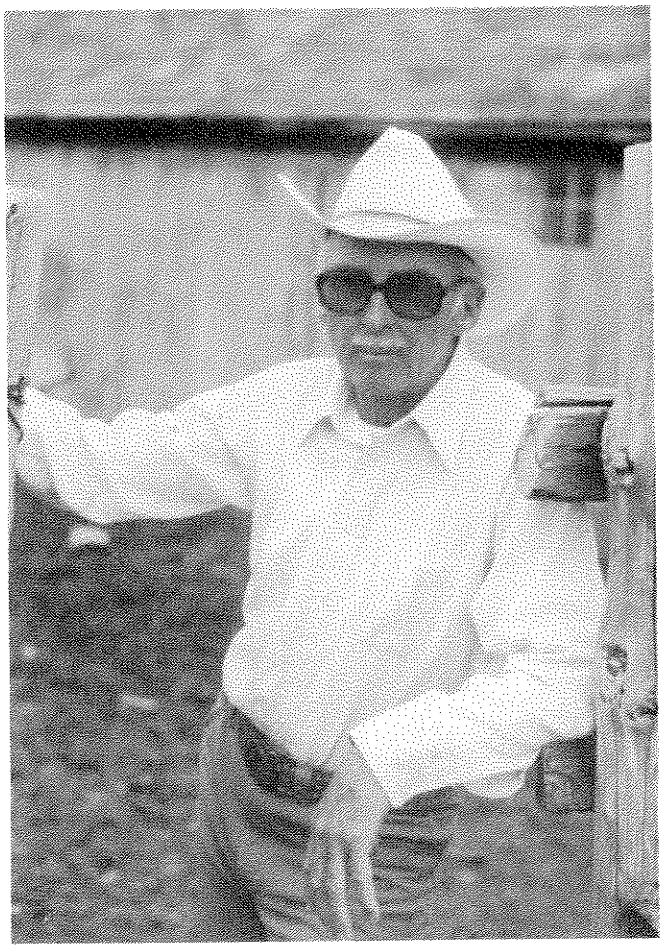
1984

PRODUCER RECOGNITION AWARD

G. CURTIS HUGHES

Stanford, Montana



Support of the livestock industry is an essential ingredient to the success of research programs such as those here at the Fort Keogh Livestock and Range Research Station. A Liaison Committee composed of industry people representing Montana, Wyoming and North and South Dakota have provided such guidance for a number of years. We here at the Research Station simply want to say "Thank You" and take this opportunity to recognize Curt Hughes for his continuing support of our program and as the first recipient of this award by the Station.

BIOGRAPHY

G. Curtis Hughes

G. Curtis (Curt) Hughes was born December 29, 1912, the son of pioneer Montana ranchers. He graduated from Montana State College (University) in 1939 with a degree in Animal Science. While a student, he became interested in the reasons for differences in gaining ability shown by steer groups from different sire lines. This was the beginning of his life-long interest and work in livestock development based on progeny performance.

Curt served on the staff of the Montana Agricultural Experiment Station from 1939 to 1943. His work and research was with sheep and wool. He tested the first whole bags of wool for shrinkage, which was the basis for the now-standard core test for wool shrinkage. Because of this work, he was offered and accepted a Brownell Fellowship at the University of California, Davis, California in 1940.

He served as Secretary of the Montana Wool Grower's Association from 1943 to 1944 and as Executive Officer with the U. S. Navy in the Pacific from 1944 to 1946. From 1946 to 1950, he was supervisor of the Montana Wool Laboratory. During this time, he designed and supervised the equipping of the Laboratory for wool research and testing, and student instruction. Curt served as President of the U. S. Targhee Sheep Association from 1951 to 1959.

In the fall of 1950, he returned to the family ranch at Stanford, Montana, to assist with operation of the ranch. This was the beginning of his life-long work of breeding and development of cattle and sheep, resulting in the Newford and Poly-Gro Hybrid lines of cattle. Curt was one of the first to recognize the potentially superior genetic material available from Line 1 Herefords and, over the years, has purchased 175 to 200 Line 1 bulls from the Miles City herd for use in developing the Newford line. The Poly-Gro Hybrid is a combination of breeds or "composite". The original cross consisted of five breeds and has been selected for black color, growth rate, disposition and carcass traits.

Curt has been a member of the Society of Range Management since 1952 and has served on many committees of that organization. He was President of the International Mountain Section of that Society in 1963-1964. He is a member of the Montana Stockgrower's Association, Judith Basin Livestock Association--serving as President from 1973 to 1975, and is a charter member of the Liaison Committee for the Fort Keogh Livestock and Range Research Station.

Curt married Ruth (Tommy) Undem on August 4, 1941. The family has four daughters: Beverly Kologi of Havre, Nonnie Hughes of Bozeman, Kathy Buckingham of Fort Benton and Betty Sampsel on the home ranch at Stanford.

The contributions G. Curtis Hughes has made to animal agriculture are many and varied. They have had a significant impact on both research and production in the livestock industry, and his influence will be felt far into the future.

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Bob Short	Genetics and Physiology Supervisor
Joe Urick	Animal Geneticist
Lamar Reynolds	Animal Geneticist
Terry Nelsen	Animal Geneticist
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THE ORIGIN OF LINE 1

R. R. Woodward[1]

Seniority has its rewards. Since I am apparently the senior surviving member of the research team that has worked with the development of Line 1 at Miles City, I presume that is why I have the opportunity to talk to you tonight.

Bear with me if you will if I recall for a few minutes my personal recollections of the early days of this very interesting and productive group of cattle. My first exposure came during my undergraduate year at Montana State and then for a few years at the Station at Havre prior to World War II. Then after about 3 years of Air Force duty, I returned and came to Fort Keogh--again working with the inbred lines and initial research in performance testing.

Backing up a few years--who were the researchers who conceived the idea of starting inbred lines of beef cattle and selecting by records instead of "eyeballing" or using visual standards only? We know the names of those who were in the decision-making process at least--names which probably are totally unfamiliar--like Sheets, McPhee and Black of the USDA and Winters of Minnesota. More personally involved were Dick Quesenberry, long-time Superintendent of the LARRS and R. T. Clark of MSU. The idea of inbred lines had to be derived from the then new hybrid corn research. Slightly earlier, the idea of performance testing beef cattle was put into action by the USDA, primarily at Miles City. Thus, Line 1 and subsequent lines were the foundation of performance testing research and, for a number of years, there were only two major beef cattle breeding projects conducted at the Station. They were: (1) Development of superior lines of beef cattle, and (2) Testing methods of measuring performance. It is fortunate that the two studies were concurrent.

Brad Knapp, Jr. was a key figure in that early research. I well remember in 1946 Brad was right in the middle of computing the first heritability estimates. He was in constant communication with Jay Lush of Iowa because, initially, estimates tended to exceed 100%. Needless to say when finally completed, heritability estimates placed the seal of approval upon the validity of performance testing and insured the continuation of the linebreeding program.

As is generally known, Advance Domino 20 and Advance Domino 54 were the foundation sires of Line 1. Both were bred by Fred DeBerard of Kremmling, Colorado. Dick Quesenberry purchased AD 20 at the 1933 Denver show and AD 54 by private treaty a year later. Both bulls were bred to unrelated cows of Panama, Stanway and other families. Then after several years, reciprocal crosses were made between the progeny of both sires. AD 20 generally sired more acceptable daughters and AD 54 sired sons with faster growth.

When the herd grew to about 90 breeding females and more it was sub-lined with L1A, L1B and L1C, each a separate breeding entity of 25-30 cows. In L1A and

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[1] Research Geneticist, Fort Keogh, 1946-1960.
Station Director, Fort Keogh, 1976-1979.

L1B, sires were replaced as soon as their first sons were performance tested. In L1C, sires were replaced by sons with superior progeny records based upon outcross matings which allowed for carcass evaluation to enter into the selection process. However, after several generations, it was determined that L1 carcasses were at least equivalent to breed average and it was decided to turn generations as rapidly as possible. In the meantime, the Line grew to about 150-180 breeding cows that for a time were operated as a single inbred pool. These numbers were reduced in the 1960's by the transfer of a portion of the herd to Florida for a genetic-environmental study and some surplus cattle also were sent to the Northern Montana Research Center in Havre.

Lines 2 and 3 were initiated shortly after Line 1 at Miles City in the 1930's. Then in the 1940's and early 1950's, a total of 14 registered lines of Hereford and Polled Hereford cattle were formed. Most of the lines were started with related males and females from various herds in Montana, Wyoming, Nebraska, New Mexico and Colorado.

In line comparisons, Line 1 was essentially the top group in growth rate. As a matter of fact, almost all of the male calves in all of the lines were selected for WDA at 12-15 months. Single trait selection was not the practice for heifer and cow replacements, however. Weaning weights of calves from first calf heifers were an important selection criterion.

The emphasis on single trait selection evolved for two reasons: (1) high heritabilities for growth, and (2) relative similarity between lines for other traits. It is interesting that with 14 lines under study, only one was found to have so-called lethal genes, one had serious reproductive problems and one was almost self-eliminated because of calving losses.

The eventual ascendance of Line 1 was due, I am sure, to the superior genetics for growth in the initial selections and, perhaps to some extent, in the large numbers available in this Line. Proof of their improvement was discussed earlier today but is worth repeating. The increase in pounds produced by 1953 vs. 1975 (or approximately four generations) was 9 lbs. at birth, 41 lbs. at weaning and 82 lbs. off test. Remember that this is sire effect alone measured by mating unrelated cows with semen from 1953 sires vs. 1975 sires on unrelated cows. Obviously, we would expect progeny from L1 sires and cows to be again superior.

The paramount question after 50 years has to be--what now? I most strongly urge that this irreplaceable herd be maintained in their present closed scheme until such time as it is determined that they have "plateaued" in terms of genetic gain. This is a relatively easy process through the use of frozen semen and provides an answer to an otherwise unanswerable question insofar as linebreeding of beef cattle are concerned.

After that, attempts should be made to further utilize and improve these cattle through such means as mild outcrossing--perhaps with industry Line 1 cattle, ova transplant within the herd (because it is my observation that retention of sufficient highly productive females is the big problem in the herd).

I hope that these suggestions by a long-time participant in the development of Line 1 will be considered.

THE INFLUENCE OF LINE 1 IN THE HEREFORD BREED

H. H. Dickenson[1]

The assignment given me is to discuss the influence of Line 1 cattle in today's registered Hereford industry. Let me begin by saying that anyone who is involved in or knowledgeable of the Hereford industry would immediately recognize that Line 1 influence is indeed significant in our breed and anything I might add would have little meaning. But, to me, the interesting side of the story is how this influence came about and how it brought with it a fresh approach to performance testing. Also of interest is the 50-year story of how these Line 1 cattle moved from oblivion to the limelight in our breed.

In 1977, Ray Woodward wrote a detailed and informative article for Hereford Journal concerning linebreeding and the history of the Line 1 program. He noted then that the program began in 1934. That's 50 years ago! The interesting aspect of this time period is that popular lines of cattle generally come and go in a space of 10 years and thus their influence on the breed is generally shortlived. Yet, here we are 50 years later with Line 1's as a major component of today's Hereford breed. As a comparison, the Line 1's originated about the time Prince Domino sons were impacting this breed. The Prince Domino era was followed by the WHR lines and the Anxiety 4ths in the 40's, followed by the Baca Dukes and Larrys in the early 50's, the Zato Heirs and Real Silvers in the late 50's and early 60's, followed by the Onwards in the late 60's and into the Evan Mischief, Line 1 era. So, although Line 1's were introduced back in the Prince Domino era, at least 8 to 10 other lines preceded them into prominence within the breed structure.

While other lines rose and fell based on their showring winnings and subsequent price structure, the Line 1 cattle made its inroads into the breed through years of selection based on performance criteria. Herein lies the main difference between the continued and stable demand for this line as compared to the sharp rise and fall of other popular lines. Line 1 cattle became a part of the breed when economics dictated that breeders become more objective in their breeding programs. The emergence of the Line 1 cattle as a significant force in breeder programs coincided with the introduction of performance genetics and the need for a different type animal for our breed.

The reason that Line 1 cattle were available to the breed at this point in time can be attributed solely to the research programs at Miles City and to the rigid beliefs of a few solid Hereford breeders. Up to this point in time, the Line 1 program at Miles City and the handful of breeders utilizing these cattle had been virtually ignored by the American Hereford Association, by the showring, and by the "master breeders" of the breed.

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[1] Executive Vice President, American Hereford Association.

The first contact I had personally with Line 1 cattle was a happenstance that I had forgotten until they surfaced as a significant force in 1970. In 1959, I was an Extension Beef Specialist for Virginia Tech working exclusively with the state BCIA program. I traveled by train that summer to Miles City to attend the PR1 meeting. Ray Woodward met me and Dr. Tom Marlowe and took us on a tour of the Research Station. Having been schooled in the Larry Domino type of Hereford, I can assure you I was not particularly impressed with the Hereford cattle I saw. I simply put it down as another crazy research project. But, I wondered what an old cowboy like Ray was doing here and why he was excited about these cattle.

In 1969, the AHA sponsored a national type conference. That conference sent a message to the breeders that a different type animal was needed for the decade of the 70's. At the same time, AHA got serious about performance testing. Art Linton had been hired as our TPR Director and we suddenly began an earnest search for a more economic Hereford animal. The breeders discovered Montana and they discovered Line 1 cattle.

Breeders being breeders, they didn't head straight for Miles City. Rather, they looked up breeders who had performance-tested, big, Hereford cattle. It just happened that quite a few of these had Line 1's.

I think it fair to say that three breeders of Line 1 could be singled out as having the first impact on sending Line 1's into the mainstream of the breed. Those are Les Holden, along with son Scott, and Jack Cooper, long-time advocates of not only the Line 1 cattle but the total performance and selection guidelines used in this project. They had to be believers for, up until then, their herds could hardly be described as foundation cattle for the breed.

I could find no sale reports for Cooper-Holden in the early 60's but I know the sale averages were under $1,000 and the number of bulls sold was very dependent on just how badly ranchers needed bulls in mid-April.

Word had leaked out to the knowledgeable few in 1969 when Les, Jack and Scott Holden sold 44 bulls for $1,207. Their total advertising that year consisted of a 1/4-page herd bull ad from Les and one page advertising the sale in April. One interesting sidelight to this sale is that the top bull went to a reputation outfit--Fulscher Herefords of Colorado, the same ranch that bred and sold the Prince Domino cattle of the 30's.

By 1970, Hereford breeders had heard about these cattle. The sale that year averaged $2,180 on 54 bulls. The Cooper-Holden group was smart, too, so by 1971 they had increased the offering to 68 bulls and averaged a solid $2,000. The 1972 sale averaged $2,235 on 68 bulls and you know the story from there. Record sales, record-selling calves and record-selling cows. For these Montana families, it was 9 months of winter and 3 months of visitors with dollars in their jeans trying to buy herd bulls.

Following this initial unveiling of the Cooper-Holden Line 1's, the demand moved to more and more producers. Even the Station got in the act as breeders overnight became experts on the Miles City Line 1 program. One sale at the

Station, which I attended in the mid-70's, had more AHA members in attendance than any event other than Denver that year.

The cattle that came from these performance-oriented herds found their way into the showring under new ownership. That they did well is evidenced by the fact that six of the eight Denver champions from 1977 through 1984 were of Line 1 pedigrees.

The demand for Line 1 cows and the generation turnover concept used at Miles City helped make a rapid transition for the Hereford breed at a time when a transition was necessary.

The performance background of the Line 1 cattle paid dividends when AHA began producing a sire evaluation summary. Again, Line 1 bred cattle dominated the listing.

Now to the point of my talk as to what impact have these Station-developed Line 1 cattle had on our breed. Let me try to give you a few figures to chew on.

We consider the sire evaluation summary to be the most important genetic improvement project we conduct each year. This year, our summary carries 697 proven sires and 880 young sires. From a rough count, we can identify nearly 400 of the 697 proven bulls as being either straight or predominately of Line 1 ancestry. Approximately 500 of the 880 young bulls are of predominately Line 1 ancestry. A high percent of the trait leaders are Line 1 and many of the high bulls in each trait are Line 1.

With a computer, you can do interesting things. For the purpose of this talk, I asked our computer people to give me the percentage of Line 1 cattle among total registrations in 1968 and compare that with the percent in 1983, 15 years difference. To do this, I used six of the principal Station bulls in the 1950's and 1960's. Those bulls were L1 Domino 171, L1 Domino 181, L1 Domino 220, L1 Domino 253, L1 Domino 284, and L1 Domino 286. We then asked the computer to tell us how many of the calves registered in 1968 and again in 1983 traced to these sires either on the top or bottom side. In 1968, 1/2 of 1% of the cattle recorded contained Line 1 blood. In 1983, that had increased to 68%. I submit this as an indication of the influence of Line 1 blood in this breed over the past 15 years. I also submit it as evidence of why popular lines need to be fundamentally sound, efficient and devoid of economic defects. Otherwise, a breed can be ruined in a short period of time.

Now while readily and enthusiastically citing the impact of Line 1's on this breed, I don't want to give the impression that I feel they are the only line contributing to the breed. There are several other lines now which also contribute greatly as indicated in the sire summary listing. Not all the great sires of the breed are Line 1 and that is healthy for the breed. Also, much of the expansion, popularity and performance of the Line 1's can be partially attributed to their ability to outcross well with other lines in the breed. Most of our recent show winners and several of our high EPD bulls are Line 1 crossed on other high performing Hereford lines. But, it is still true that the Line 1 cattle have had and are having a positive impact on the fortunes of this breed.

I think, without question, that a goodly portion of the credit for these accomplishments goes to the breeding program adhered to here at the Station. Unlike some other lines of the past, the Line 1 cattle are not the product of a single sire line breeding. This has expanded the genetic base for this line and allowed more versatility in selection for breeders using these cattle. In other words, this research project also fit the needs of a breed from the standpoint of how it was developed. Few lines or few breeds can withstand the impact of a single sire line. Spreading the genetic base is important for a breed and the Line 1 program complemented rather than deteriorated this genetic base.

Finally, I want to add that perhaps of equal importance to the influence of Line 1 cattle is the fact that their emergence in the breed brought with it a fresh approach to performance testing. The fact that they were the product of a rigid performance program gave breeders a confidence in performance concepts that couldn't be communicated through talks and articles. That the Line 1 emergence coincided with the acceptance of performance concepts by this breed is more than just coincidence. When the breeders discovered Line 1's, they also found that Line 1 breeders were performance advocates and that they applied these concepts to their breeding programs. Perhaps this aspect, more than anything else, is the basis for the breed's strength today. Miles City and Line 1 cattle played a major role in this positive development.

If linebreeding and performance selection was the basis for the emergence of Line 1 cattle, auction sales prices were the catalyst for the rapid expansion of the line. The economic aspect of producing Line 1's increased the demand and this increased demand further strengthened the prices received. The sale ring is the final authority on the acceptance and expansion of a bloodline.

Up until 1976, six-figure prices in this breed were few and far between. The flurry of $100,000-plus bulls over the 1977-1983 years had Line 1 cattle figuring prominently in auction sale reports. The breed's record production sales were established with Line 1 offerings and most of the really successful cow sales have been of Line 1 breeding.

The combination of a multi-sire linebreeding program, strict selection based on performance criteria, high prices in auction sales, and ownership by good cattlemen have combined to make the Line 1 cattle, which started in 1934, a major part of this breed in 1984. It's been a 50-year success story.

In conclusion, I want to say I think it would be a real shame if the Station Line 1 program was discontinued. This is one research project that can be evaluated in economic value to the tax-paying public. The continuance of this program can further add to the value of the nation's livestock industry.

SOME EFFECTS OF GENOTYPE X LOCATION INTERACTIONS ON PRODUCTIVITY OF HEREFORD CATTLE

R. A. Bellows and O. F. Pahnish

Interactions between genotype and environment are potentially important because of widespread exchange of breeding stock and the wide variation in production-management systems common in today's beef production. If cattle are selected for performance in a given locality or environment, how does this affect their ability to perform in a different locality or environment? A project designed to study interactions between genotype and environment was conducted at Miles City, MT, and Brooksville, FL. This work is commonly referred to as the Genotype x Environmental Interaction or GEI study.

Project Plan

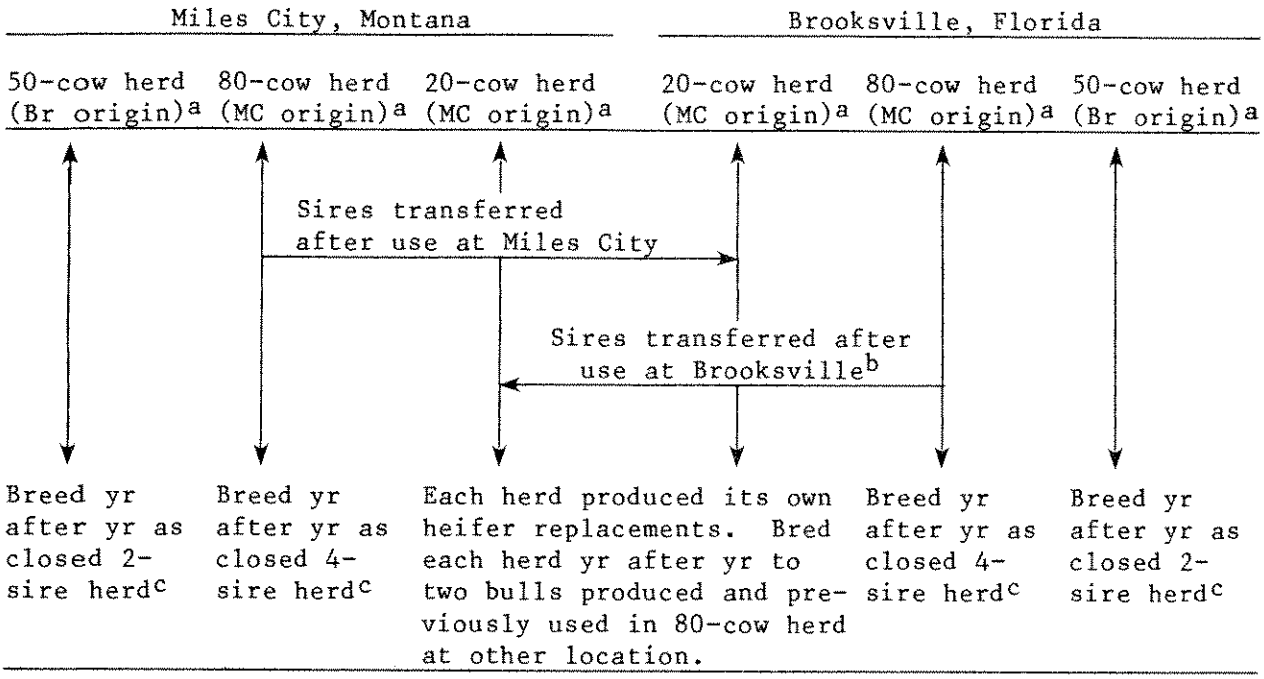
The long-term breeding and experimental plan for this GEI project is shown in figure 1. Cattle 5 years old and younger were drawn from the Line 1 Hereford herd at the Fort Keogh Livestock and Range Research Station at Miles City and were divided between the Miles City and Brooksville Stations from the 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.

A sample half of a Hereford herd at the Brooksville Station (Florida) was transferred to the Miles City Station (Montana) 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 Florida herd. Two bulls were included in the transfer. The original Florida herd was more heterogeneous in genetic background than the Montana Line 1 and was <u>not</u> inbred. Animals in the herd were the survivors and descendents remaining after about 10 years of selection for ability to reproduce and grow in Florida.

Bulls produced in the 80-cow herd at each location and selected for use for 2 years as sires in the parent herd were transferred to the other location and used 1 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.

The primary selection criterion in bulls was an index placing equal emphasis on weaning weight and postweaning gain with some attention given to color, soundness and parentage. From 85 to 90% of all heifers weaned entered the breeding herds, and heifer selection was primarily on adjusted yearling weight. To the extent that numbers permitted, first-exposure heifers that failed to conceive during the mating season, cows over 11 years of age, unsound cows, open cows and cows with inferior calves were culled in the order given.

FIGURE 1. GENERAL BREEDING PLAN FOR MILES CITY AND BROOKSVILLE STATIONS



a Br = foundation stock from Brooksville Station.
MC = foundation stock from Miles City Station.

b This herd eventually designated F_4; see text for description of Phase 2.

c Closed herd = both sire and female replacements came from within the herd.

Cattle were maintained under management regimes considered appropriate for the respective locations. In Florida, calves were born in December, January and February and weaned at an average of 220 days during the last week of August. In Montana, they were born during March, April and May and weaned the third week in October at an average age of 187 days. Calves were not creep-fed at either location. Heifer calves were provided a growing ration during their first winter and maintained on pasture during their yearling summer at both locations. Bull calves in Montana were placed on a 196-day full feed test postweaning. Evaluation of bulls was at the end of this test period. Bulls born in 1962, 1963 and 1964 at the Florida location were handled in a similar fashion. Beginning with the 1965 bull calf crop in Florida, the postweaning test period was changed to 365 days. Rations for the 365-day test contained grain equivalent to approximately 1% of body weight plus harvested forage or pasture, depending on the time of year.

Data suitable for Phase 2 of the project were not available until Florida Line 4 had been in existence long enough to be considered as a "Florida genotype". This point was considered to have been reached when the sire of the cow involved was born and selected in Florida. The first such cows appearing in F_4 in Montana were born in 1967. The description of the various subgroups and herd number designations are shown in table 1.

TABLE 1. DESCRIPTION OF EXPERIMENTAL GROUPS, NUMBER OF MATINGS PER YEAR AND LINE BY LOCATION DESIGN FOR THE TWO PHASES OF THE STUDY

Location and herd no.	Matings per year	Origin of foundation females[a]	Source of sires	Line by location designation	
				Phase 1	Phase 2
Montana:					
1	80	M_1	Herd 1	M_1 in MT	M_1 in MT
2	20	M_1	Herd 5	M_1 in MT	F_4 in MT
3	50	F_6	Herd 3	F_6 in MT	——[b]
Florida:					
4	80	M_1	Herd 4	M_1 in FL	F_4 in FL
5	20	M_1	Herd 1	M_1 in FL	M_1 in FL
6	50	F_6	Herd 6	F_6 in FL	——[b]

[a] M_1 = Montana Line 1; F_6 = Florida Line 6.
[b] Line 6 was excluded from phase 2, the objective being to compare herds descending from Montana Line 1.

Results

The pregnancy, calf survival to weaning and weaning rates are summarized for Phase 1 in table 2 and Phase 2 in table 3.

Pregnancy rate. Yearly variations in pregnancy rates were large with years of high pregnancy tending to be followed by low, and vice versa. Time trends for pregnancy and weaning rates suggested that selection in Florida among cattle of Montana origin (F_4 in Florida) resulted in positive effects on reproduction in Florida.

Calf survival. No significant main effects or trends were apparent.

Weaning rate. The value of this trait is equal to the product of pregnancy rate and calf survival. Weaning and pregnancy rates tended to be correlated and time trends were similar to those noted for pregnancy. There was a positive trend for F_4 in Florida, a negative trend for M_1 in Florida and a negative trend for F_4 in Montana. These trends suggest that selection among F_4 cattle in Florida resulted in adaptive changes.

TABLE 2. REPRODUCTIVE PERFORMANCE OF LINES M_1 AND F_6 AT EACH OF THE TWO LOCATIONS DURING PHASE 1 OF THE STUDY (1964-1974)

Group or items	No. of matings	Pregnancy rate, %	Calf survival, %	Weaning rate, %
Subgroups:				
M_1 in MT	948	81.6	90.3	73.7
F_6 in MT	526	82.8	91.9	76.1
M_1 in FL	1007	72.0	90.3	65.0
F_6 in FL	464	86.5	92.1	79.7
Line:				
M_1	1955	76.8	90.3	69.4
F_6	990	84.7	92.0	77.9
Significance level		P<.01	ns	P<.01
Location:				
MT	1474	82.2	91.1	74.9
FL	1471	79.3	91.2	72.3
Significance level		P<.01	ns	P<.01
Origin:				
(a) Local	1412	84.1	91.2	76.7
(b) Introduced	1533	77.4	91.1	70.6
(a) minus (b)		6.7	.1	6.1
Significance level		P<.01	ns	P<.01

Additional data were summarized on birth and weaning traits and cow productivity. These results are summarized for Phases 1 and 2 in tables 4 and 5. In general, the values indicate the performance of the local or native cattle exceeded the performance of those introduced into a location.

Summary

Results of this study suggest that genetic adaptation of cattle to local conditions can affect productivity. Trends further suggest that introduced cattle experience an "adjustment" period in which they become more acclimatized to the new location. Performance can apparently be improved by selection of high-performing animals within the new environment. This work did not clearly identify the causes of genetic environmental interaction nor did it account for the effect of inbreeding on the results. Further studies on genetic environmental interaction appear warranted.

TABLE 3. REPRODUCTIVE PERFORMANCE OF LINES M_1 AND F_4 AT EACH OF THE TWO LOCATIONS DURING PHASE 2 OF THE STUDY (1970-1974)

Group or item	No. of matings	Pregnancy rate, %	Calf survival, %	Weaning rate, %
Subgroups:				
M_1 in MT	398	83.0	90.5	75.1
F_4 in MT	93	80.9	86.8	70.2
M_1 in FL	98	55.0	86.8	47.7
F_4 in FL	370	76.1	89.1	67.8
Line:				
M_1	496	69.0	88.6	61.1
F_4	463	78.5	87.9	69.0
Significance level		P<.01	ns	P<.01
Location:				
MT	491	81.9	88.6	72.6
FL	468	65.6	87.9	57.7
Significance level		P<.01	ns	P<.01
Origin:				
(a) Local	768	79.6	89.8	71.5
(b) Introduced	191	68.0	86.8	59.0
(a) minus (b)		11.6	3.0	12.5
Significance level		P<.01	ns	P<.01

TABLE 4. BIRTH AND WEANING WEIGHTS AND COW PRODUCTIVITY FOR PHASE 1, 1964-1974

Group or item	No. calves born	Birth wt. (lb.)	Weaning wt. (lb.)	Annual production per cow (lb.)[a]
M_1 in MT	727	81	435	321
F_6 in MT	405	77	403	307
M_1 in FL	677	64	366	238
F_6 in FL	363	66	404	322
Line:				
M_1	1404	73	401	280
F_6	773	71	404	314
Significance level		P<.05	ns	___
Location:				
MT	1132	79	419	314
FL	1045	65	385	280
Significance level		P<.01	P<.01	___[a]
Origin:				
(a) Local	1090	73	420	321
(b) Introduced	1082	70	385	272
(a) minus (b)		3	35	49
Significance level		P<.01	P<.01	___

[a] Product of weaning rate x weaning weight. Data not analyzed statistically.

TABLE 5. BIRTH AND WEANING WEIGHTS AND COW PRODUCTIVITY FOR PHASE 2, 1970-1974

Group or item	No. calves	Birth wt. (lb.)	Weaning wt. (lb.)	Annual production per cow (lb.)
M_1 in MT	275	83	448	336
M_1 in FL	41	61	348	166
F_4 in MT	60	79	426	299
F_4 in FL	239	63	368	250
Line:				
M_1	316	72	397	251
F_4	299	71	397	274
Significance level		ns	ns	[a]
Location:				
MT	335	81	436	318
FL	280	62	357	208
Significance level		P<.01	P<.01	[a]
Origin:				
(a) Local	514	73	408	293
(b) Introduced	101	70	388	232
(a) minus (b)		3	20	61
Significance level		P<.05	P<.01	[a]

[a] Product of weaning rate x weaning weight. Data not analyzed statistically.

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A SELECTION EXPERIMENT TO CONTROL BIRTH WEIGHT IN BEEF CATTLE

J. J. Urick, W. L. Reynolds and R. A. Bellows

Selection for increased growth rate in beef cattle has caused an apparent increase in calving difficulty. This problem is of particular concern when sires from herds with a long history of performance testing are outcrossed on herds that have not been selected for growth rate. Also, the importation of cattle from Europe has focused increased attention on calving difficulties as sires of large-type breeds are used on females of small-type breeds. The entire problem is magnified by the present practice of breeding yearling heifers. Research studies have identified birth weight as the single most important factor affecting difficult parturition, but birth weight has not been a consideration in sire selection in most herds of seedstock cattle.

Results from calving difficulty studies indicate that production of genetically growthy bulls with the genetic potential for relatively light birth weights would be an asset to the commercial cattle industry. Estimates of genetic correlations of birth weight with subsequent weights in cattle at Miles City ranged from .5 to .6. This indicates that there should be some latitude for control of birth weight while continuing to increase subsequent gains and ultimate weight. Some reduction in rate of improvement in postnatal growth might be an acceptable trade-off if controlled birth weight results in less calving difficulty and a higher calf survival rate.

Line 1, the oldest of the inbred Hereford lines developed on the Station at Miles City, has been utilized since the breeding season of 1977 in an experiment to develop a selection procedure which includes genetic control of birth weight. The objective is to stabilize or decrease birth weights while continuing to improve growth from birth to breeding or market age.

To initiate the selection experiment in 1977, the Line 1 herd of about 160 females was randomly divided into two groups designated as Y and YB. The Y subherd is selected for high yearling weight, which is measured at 365 days (bulls) and 18 months (heifers). Subherd YB is selected for the same criteria plus light birth weights adjusted for dam age. Birth weight ratios of bulls selected in the YB herd do not exceed 100 and most often range below. In the Y herd, most all sires had birth weight ratios which exceeded 100.

All ratios calculated on individual bulls and heifers for selection purposes are on the basis of averages for all Line 1 progeny within year of selection. Ratios for bulls and heifers are calculated separately.

For this report, data were from sires used in the breeding seasons of 1978-1982, and their progeny produced in years 1979-1983 within each of the Y and YB herds.

Results

The average performance data for the sires used to produce calves in the years 1979-1983 are shown in table 1, and the corresponding preweaning and postweaning performance of their bull progeny is shown in table 2.

TABLE 1. AVERAGE PERFORMANCE OF SIRES SELECTED FOR Y- AND YB-HERDS (CALF YEARS, 1979-1983)

Herd	Calf years	No. sires tested	Average birth weight (lbs.)[1]	Average 180-day weaning weight (lbs.)[1]	Average daily gain on feedlot test (lbs.)	365-day[2] yearling weight (lbs.)
Y	79-80	4	94.4	506	3.34	1092
	80-81	4	92.2	480	3.18	1023
	81-82	4	95.5	459	3.41	1020
	82-83	4	93.5	495	3.52	1106
	83-84	4	91.0	534	3.10	1155
	Average		93.3	495	3.31	1079
YB	79-80	4	79.4	534	3.20	1092
	80-81	4	78.5	470	3.13	1006
	81-82	4	77.3	472	2.97	1011
	82-83	4	80.8	485	3.25	1074
	83-84	3	82.4	476	3.36	1073
	Average		79.7	487	3.18	1051
Y minus YB sires (lb.)			13.6	8.0	.13	28.0
% reduction			14.6%	1.6%	3.9%	2.6%

[1] Adjusted for age of dam to the 5-9 year mature age group.

[2] 365-day weight = [(final weight off test-actual weaning weight ·/. days weaning to off-test weight] x 185 + 180-day adjusted weaning weight.

In previous reports, data from both bulls and heifers were used to evaluate the growth responses in progeny from selection in the two sets of sires. The growth responses in the two sexes were not consistent within herds. For this report, bull progeny only were used to study the selection responses for growth since the performance traits and conditions under which the sires and bull progeny were tested are similar and the data can be more precisely interpreted.

Effectiveness of selection of sires in the two herds can be observed by the average performance of the sires and their bull progeny for the same traits. Sires used in YB were 13.6 pounds lighter at birth (14.6%) than those in Y. This sire selection differential between the two herds resulted in a 4.4-pound (5.0%) reduction in the birth weights of YB progeny.

TABLE 2. AVERAGE PERFORMANCE OF BULL CALF PROGENY IN Y AND YB HERDS (CALF YEARS 1979-1983)

Herd	Calf years	No. bull progeny	Average birth weight (lb.)[1]	Average 180-day weaning weight (lb.)[1]	Average daily gain on feedlot test (lb.)	365-day[2] yearling weight (lb.)
Y	79-80	21	84.0	400	2.79	915
	80-81	20	86.2	466	3.07	1028
	81-82	23	91.8	490	2.76	978
	82-83	22	86.2	505	2.80	990
	83-84	22	89.5	453	2.61	880
	Average		87.5	463	2.81	958
YB	79-80	21	76.5	396	2.73	904
	80-81	24	85.8	473	3.05	1010
	81-82	24	90.5	484	2.72	960
	82-83	26	81.8	470	2.74	954
	83-84	25	80.7	441	2.66	879
	Average		83.1	453	2.78	941
Y minus YB (lbs.)			4.4	10	.03	17
% reduction			5.0%	2.2%	1.1%	1.8%

[1] Adjusted for age of dam to the 5-9 year mature age group.
[2] See footnote under table 1 for yearling weight adjustment.

In comparison to the Y sires, the YB sires had lighter (8 pounds) 180-day weights, smaller (28 pounds) 365-day yearling weights, and gained less (.13 pound) per day on test. Bull calf progeny from the YB sires were 10 pounds lighter in 180-day weight, gained .03 pounds less daily and were 17 pounds lighter at 365-day weight than bull calves from Y sires. The results indicate that direct selection for smaller birth weights in the sires was effective in reducing size of birth weights in the calves, but this advantage was also accompanied by a reduction of weaning weights and postweaning growth.

To evaluate the effectiveness of selection for smaller birth weights on calving performance, the calving data (bulls and heifers combined) were summarized for the 6-year period from 1979-1984. There were large yearly variations in birth weight of calves. High to low year ranges in birth weights were 11.9, 13.0, 13.0 and 9.9 pounds, respectively, in the 2, 3, 4, and 5+ cows in the 6-year period. The average birth weights of the combined Y and YB calves from 2, 3, 4 and 5+ age dams, respectively, were 70.1, 77.2, 81.1 and 81.1 pounds.

If selection for low birth weights produces a subsequent decrease of calving difficulties, we might expect an increase in numbers of calves weaned. During the 6-year period, 51 and 44% of the 2-yr-old heifers in Y and YB, respectively, were given some assistance at calving, indicating a slight benefit for

selecting for smaller birth weights in YB. In YB 2-year-old heifers, 87% of calves were born alive as compared to 85% in Y. In the 3-year-old, second-calf heifers and 4 years and older cows, respectively (Y and YB combined), 22 and 4% were given assistance at calving; and in these age groups, the differences in the amount of assistance given between the two herds was negligible. There was no evidence of fertility differences in the production of calves among the Y and YB herds that could be related to the selection practice.

Differences in progeny birth weight between Y and YB were mostly in the 2- and 3-year-old heifers; and in these age heifers, the birth weight of Y calves exceeded the YB calves by 4.2 and 4.4 pounds on the average, respectively. These herd differences for the 2- and 3-year-old dams were consistent for all years, except 1983 when there was no difference and 1982 when the calves from 3-year-old dams in YB were 4.9 pounds heavier than those of Y. Birth weights of the 4 and 5+ age dams in Y and YB were similar. Part of the reason for the smaller differences in birth weights between the older cows of the two herds was probably due to a higher percentage of those cows still being the original cows assigned to the study.

From these data, we concluded that sire selection was effective in reducing calf birth weight, but this reduction in progeny birth weight was beneficial mainly in the 2-year-old heifers. There was a small decrease in birth to yearling growth in bull progeny as the result of the selection in YB.

SELECTION CRITERIA STUDY

T. C. Nelsen, R. E. Short, J. J. Urick and W. L. Reynolds

Since 1976, a herd of crossline Herefords (Lines 1, 4, 6 and 10) have been managed under a random selection procedure. The purpose of the study is to examine as many growth and reproduction measurements as possible in order to determine direct and correlated effects of selection. In most herds, we can study direct response in the trait for which selection is made and possible indirect effects on other traits. In a random selection herd, we can study responses and correlated responses for any traits we can measure. We are reporting here some preliminary summaries of portions of the data. A more thorough analysis will be done after 2 more years of data collections.

In this nonselected herd, there were large weaning weight differences between years. For the 7-year period from 1977 to 1983, records of seasonal precipitation from the Miles City Weather Station were used to evaluate year differences for the growth traits studied. A previous study at LARRS showed that May-June precipitation was more useful for predicting weaning weights of calves than other periods studied. In this study, when April-June precipitation ranged from 4.0 inches to slightly over 8.0 inches (years 1977, 1980, 1981, 1982), the weaning weights were fairly similar but improved slightly with increased moisture. However in 1978, there was a total of 8.7-inches of April-June precipitation and, during that year, the lowest weaning weights were obtained.

There were also year variations for birth weight of calf (low-high range = 9.5 pounds) which was attributed to the effects of environment. The study indicated that following a more severe winter smaller birth weights were obtained than in the moderate winters.

Resemblances among half-sibs and between offspring and parent were used to estimate heritabilities of birth weight and preweaning average daily gain. A calf's birth weight is determined by the genes for growth that it received one-half from each parent, plus the environment in utero provided by its dam. This maternal environment, however, was determined in part by the genes the dam received from its parents. We estimated that heritability of the direct growth effect was .36 and the heritability of the maternal effect was about .81 but a negative genetic correlation existed between the two traits. The negative correlation plus possible nonadditive gene effects complicated prediction of responses to selection for birth weight. Sire selection resulted in responses from 25 to 39% of expected while dam selection resulted in 60 to 88% of response. We have concluded that the genetics of the maternal effect on birth weight are very important, and we are continuing our studies in this area.

The heritability of preweaning average daily gain was estimated at about .15, but estimates of the heritability of the maternal effect were near zero. We suspect that a negative environmental correlation may have biased this result. Dams that were faster growing may have produced slower growing calves and vice versa.

We also evaluated the effect that the age of maternal granddam has on subsequent calf production. Other workers have reported that heifer replacements born from 2-year-old heifers produced calves with heavier weaning weights than those from older aged dams. In this herd, calves representative of the 2-year maternal granddams were almost 11 pounds heavier than those representing the 4- to 5-year-old maternal granddams. The reason for this difference is not clear; however, other workers have offered the explanation that as the heifer calves receive higher levels of milk from their dams in the nursing period they have become fatter and have a higher percentage of fat deposited in their udder. This fat then has a negative influence on their own milk production when producing calves. In most range herds, the age-of-dam effect on weaning weight of calf is quite large and calves from the older dams are generally heavier and fatter than those from the younger dams.

Reproduction data collected in this project include measurements on both females and males. Female data includes age at puberty, milk production, interval from calving to first heat, pelvic area, calving difficulty, breeding dates, pregnancy rate and estimates of fatness. Male data includes scrotal circumference, semen evaluation, pelvic area, fertility (pregnancy rate) from those used as breeding bulls and an estimate of breeding ability and desire (usually referred to as serving capacity). Most of our analysis of data at this time has been on serving capacity.

The serving capacity test was conducted four times each year--twice in May or early June before the breeding season and twice in late August after the breeding season. All bulls were tested as yearlings and those that were

randomly selected as breeding bulls (plus a reserve for each bull) were again tested as 2-year-olds. The test was conducted by turning 6-10 bulls into a pen with six stanchioned, estrogenized cows. Mounts and services were recorded for each bull over a 20-minute test period. Of yearling bulls, 3.9% did not have any mounts or services and 55% had one or more mounts but no services. The same percentages for 2-year-old bulls were 3.7% and 10%.

Repeatabilities of several traits are shown in table 1. Both growth and reproduction measurements were moderately to highly repeatable with the exception of condition score in 2-year-old bulls. These bulls were consistently moderately thin and no variation existed to estimate repeatability. Further analysis showed that reproduction measures (serving capacity and scrotal circumference) were not related to other traits except that testicle weight at slaughter was correlated to preslaughter scrotal circumference (yearlings, .55; 2-year-olds, .67) and weight (.27; .33). These analyses will be carried on to further determine the relationship among these growth and reproduction traits in order to evaluate possible selection schemes to improve total production.

TABLE 1. REPEATABILITY OF SELECTED MEASUREMENTS

Measurement	Age of bull	
	Yearling	2-year-old
Serving capacity:		
Mounts	.64	.62
Services	.59	.45
Scrotal circumference	.59	.77
Weight	.79	.89
Hip height	.85	.81
Heart girth	.76	.81
Condition score	.66	.11
Pelvic width	.45	.75
Pelvic height	.52	.42

COMPARISONS OF TWO- AND THREE-BREED ROTATION AND A BEEF X BEEF SYNTHETIC VARIETY FOR PRODUCTION OF BEEF CALVES. II. BEEF X BROWN SWISS SYNTHETIC AS A SYSTEM FOR CALF PRODUCTION

J. J. Urick, W. L. Reynolds and B. Knapp

A crossbreeding study, initiated in 1961, was conducted in three phases to evaluate the effects of heterosis (hybrid vigor) for increasing calf growth. In Phase 1, Angus (A), Hereford (H) and Charolais (C) breeds were crossed in all possible combinations to produce first-cross calves which were compared to the straightbreds. In Phase 2, the first-cross females from Phase 1 were compared with the straightbred A, H and C females when both groups were bred to produce three-breed cross calves. The Phase 3 crossbreeding study was initiated in 1966 with the straightbreds and crosses used in Phases 1 and 2 to compare two- and three-breed rotational crossing and a three-breed synthetic crossing system over an extended time period. In addition, a beef x Brown Swiss synthetic was produced as an adjunct to the other systems. The design for this experiment is shown in table 1.

TABLE 1. BREEDING PLANS FOR INITIATING THE TWO-WAY, THREE-WAY ROTATIONAL CROSSING AND THE BEEF AND DAIRY SYNTHETIC VARIETY SYSTEMS[a]

Breed of sire	Breed of dam								
	H	A	C	A x H H x A	A x C C x A	H x C C x H	AB	HB	CB
H	H			2W	3W	2W	SV_2	SV_2	SV_2
A		A		2W	2W	3W	SV_2	SV_2	SV_2
C			C	3W	2W	2W	SV_2	SV_2	SV_2
AC				SV_1	SV_1	SV_1			
HC				SV_1	SV_1	SV_1			

a Abbreviations: A, H, C, B = Angus, Hereford, Charolais and Brown Swiss straightbreds. In the F_1 dams and sires, the first letter represents the sire breed and the second letter the dam breed. 2W = two-breed rotational cross; 3W = three-breed rotational cross; SV_1 = beef synthetic variety; SV_2 = beef x brown Swiss synthetic variety.

Rotational crossing and synthetic variety crossing systems produce both maternal heterosis from the crossbred dam and individual calf heterosis from the crossbred calf. The potential of these crossing systems to maintain high levels of heterosis and to generate their own replacement seedstock has many advantages. The beef x Brown Swiss synthetic herd was started by crossing the H, A and C sires with the B cows to produce the first-cross HB, AB and CB dams. Each of these first-cross dams were mated alternately with one of the other two sire breeds to produce the three-breed progeny. Three-breed cross bulls were mated to three-breed cross females to produce the synthetic variety. Since B straightbred sires were not used to produce reciprocal crosses, heterosis estimates for this herd were not obtained.

For this report, the discussion is limited mainly to the average performance of all the specific crosses within each of the two- and three-way rotational

crossing systems. There were six types of two-way crosses and three types of three-way crosses as shown in table 1. Where some specific crosses were different for their growth characteristics, they are mentioned briefly. For this study, the calves of the synthetics are compared to the average of the two-way and three-way calves.

Traits of the calves used for making comparisons were birth and weaning weights, daily gain from birth to weaning, and weaning score.

Results

Average performances of the parental straightbreds and the crossing systems for preweaning traits are shown in table 2. In this study, heterosis was estimated as the differences in the performance of the crosses and the straightbreed parental average. In a comparison of the two- and three-way rotations, the percent heterosis in three-way was higher for birth to weaning growth and for weaning weight. These results were in close agreement with genetic expectation as reported by other workers. The three-way systems should, on the average, generate higher levels of heterosis than two-way. The three-way calves were similar to two-way calves for birth weight but were 15 pounds heavier at weaning. The three-way calves had slightly higher weaning scores. There was no evidence of a downward trend in heterosis over the period of this study.

In comparisons of specific two-way crosses, those which combined Charolais with either of the Angus or Hereford breeds produced heavier calves at birth and weaning than the H-A crosses and were similar to all three-way crosses. In three-way crosses, the H, A and C straightbreds were all represented in the three types of crosses; therefore, we expected that there would be less variation between those three types of crosses than among the six two-way crosses.

Breed of sire comparisons in two-way and three-way crosses showed some differences among the three breeds of sires when performing as sire breeds with the same crossbred dams. In two-way crosses, the H-sired calves were 25 pounds heavier at weaning than A-sired calves when both sets of calves were from H x A two-way cross dams. In two-way matings with H x C two-way cross dams, the H-sired calves were 15 pounds heavier than the C-sired calves. The advantage of the H sires over the A and C sires in two-way crosses resulted from a larger heterosis effect in calves by H sires. In three-way crosses, when all three breeds of sires were mated to three-breed cross dams, calves by H and C sires grew at about the same rate and on the average were slightly heavier (11 pounds) than those from A sires. In three-way crosses, estimates of heterosis for each sire breed showed a slight advantage for the H sires. In both two-way and three-way crosses, the C-sired calves were heavier for birth weight than H-sired which, in turn, were heavier than A-sired (table 2).

TABLE 2. MEANS FOR BIRTH TO WEANING TRAITS AND PERCENT HETEROSIS ESTIMATED IN 2- AND 3-WAY ROTATIONAL CROSSING SYSTEMS

Item	Sex:	Birth weight, pounds		Actual weaning weight, pounds		ADG, birth - weaning, pounds		Weaning score, units	
		Male	Female	Male	Female	Male	Female	Male	Female
Herd average		85.3	78.3	448	433	1.92	1.85	81.2	80.5
Straightbred average (SB)		82.4	75.7	429	411	1.83	1.74	79.7	78.1
2-way rotational avg (2W)		85.9	78.2	446	431	1.91	1.84	81.7	80.7
3-way rotational avg (3W)		85.7	78.0	463	444	1.98	1.89	81.8	82.1
Beef synthetic (SV_1)		86.4	81.4	454	445	1.94	1.90	81.7	81.2
		--Estimated heterosis in the beef-crossing systems--							
2W minus SB (pounds)		3.5**	2.5**	17**	21**	.08**	.10**	2.0**	2.6**
2W advantage (%)		4.2	3.3	4.0	5.1	4.4	5.7	2.5	3.3
3W minus SB (pounds)		3.3**	2.3*	34**	33**	.15**	.15**	2.1**	4.0*
3W advantage (%)		4.0	3.0	7.9	8.0	8.2	8.6	2.6	5.1
SV_1 minus SB (pounds)		4.0**	5.7**	2.5**	34**	.11**	.16**	2.0**	3.1**
SV_1 advantage (%)		4.8	7.5	5.8	8.3	6.0	9.2	2.5	4.0

* P<.05.
** P<.01.

Beef x beef synthetic variety (SV_1). The first-cross dams initially used to develop this herd were selected at random from those used in the rotations. The first three sires in this herd were C x H and A x C first crosses from Phase 1. As the initial two- and three-breed cross progeny were available for breeding as yearlings, they were bred to other two- and three-breed crosses. The original first-cross dams were also randomly assigned each year to this herd, concurrently with those assigned to the rotations, until removed because of age. After three-breed matings were initiated and to minimize the effects of inbreeding in this 60-cow synthetic herd, one-half of the sires for this herd were drawn from three-way. The average percentages of each breed representation in this herd were: H = 34.3, A = 28.8, C = 36.9.

The heterosis estimates for preweaning traits (table 2) of SV_1 calves (steers and heifers combined) were slightly higher than expectations. We expected that the three-breed synthetic should generate a similar level of heterosis to the two-breed rotations. However, the slightly better than expected performance of the SV_1 calves could have resulted if the sires selected within the SV_1 herd had growth advantages over the straightbred sires that were purchased from outside sources for the rotations. All the sires used in two-way, three-way and SV_1 were selected for yearling weight.

Beef x Brown Swiss Synthetic Herd (SV_2). The average performance data of this herd for the steers and heifers, respectively, are as follows: birth weight, 91 and 85 pounds; actual weaning weight, 471 and 458 pounds; average daily

gain from birth to wean, 2.03 and 1.96 pounds; weaning score, 79 and 78 units. For all these performance measures within sex, the beef x Brown Swiss calves were significantly heavier at birth and at weaning than the two-way, three-way and SV_1 calves. Comparisons of the performance of this herd, using the averges presented above, can be made with the performances of the beef crosses shown in table 2. The differences in the performance of the beef x Brown Swiss herd in comparison to that of the beef x beef crosses were attributed to the Brown Swiss breeding in the beef x Brown Swiss herd. The average percentages of the four breeds represented in the beef x Brown Swiss were: H = 23.5, A = 23.0, C = 21.0 and B = 33.5. In comparison of the beef x Brown Swiss calves with the average of the two-way, three-way and SV_1 calves, the beef x Brown Swiss calves were 17.3 pounds heavier at weaning, but a portion of this difference resulted from the heavier (5.4 pounds) birth weights of the calves. The slightly lower weaning scores of this herd were of little practical importance in this study.

From observations made in the beef x Brown Swiss herd, we concluded that these crossbred dams gave more milk than the crossbred cows of the other systems, which was partly the reason for the heavier weaning weights of these calves. In the Phase 1 crossbreeding study, workers reported the first-cross beef x Brown Swiss calves were heavier at weaning than the beef crosses which they attributed both to the increased supply of milk of the Brown Swiss dams plus the ability of calves of that breeding to grow at a more rapid rate than the average representation of the beef breeds used.

Since reciprocal crosses of the Brown Swiss sires and dams were not made with the three beef breeds used, estimates of heterosis were not made for this herd. Other workers, however, have reported that the estimates of heterosis for the Brown Swiss breed in crosses with other breeds were not different than for the other breeds. Part of the differences in growth of the calves in the beef x Brown Swiss herd in comparison to the other herds in this crossbreeding study probably resulted from the favorable effects of heterosis on growth, similar as in the beef crosses.

General Conclusions

The results of this 15-year crossbreeding study indicate that there were benefits from the use of crossbreeding mating schemes in which both calf and dam heterosis were utilized to increase calf weaning weights. In this experiment, the two- and three-way rotational crossing schemes both produced their own crossbred replacement females and subsequent crossbred progeny. The purebred sires were purchased from outside sources. All yearling straightbred and crossbred females produced in Phase 3 were used as replacements. A limited culling was practiced in all females, mostly for fertility. Averaged over all the types of crosses within two- and three-way, the three-way system produced higher levels of heterosis than two-way. Three-way crossing requires more facilities and management than two-way and, therefore, these disadvantages may offset advantages of the faster growth rates. Also, the favorable performances of some specific two-way combinations could offset the lower level of heterosis in two-way.

The three-breed beef synthetic compared favorably to the two- and three-way rotational crossing in the production of high levels of heterosis. All of the crossbred females produced in this herd were used as replacements and they were mated to crossbred replacement sires selected from within this herd and from the three-way rotations. Progeny from these matings compared favorably with all other beef crosses for weaning score. We concluded that this crossbreeding system requires less facilities and management than the rotational systems and may be as easily managed as straight breeding and offers the most advantage for the smaller type herd operation.

While the beef x Brown Swiss synthetic herd produced the heaviest calves, we concluded that maximum benefits from this type of crossing scheme would be realized under more favorable environmental conditions than those at this location. Cows in this herd maintained lower body condition than most other types of crossbred cows in the study.

In conclusion, the merit for use of each of these crossing schemes will depend largely on the type of each operation. Also, the advantages that result from each type of crossing scheme could vary in environments which are different from this range area.

PERFORMANCE OF RANGE-RAISED, FIRST-CROSS BEEF CATTLE OF DIFFERENT BIOLOGICAL TYPES ON THE RANGE

W. L. Reynolds and J. J. Urick

Biological types of beef cattle differing in size and milk production needed to be evaluated under western range conditions to provide guidelines to selection and management practices for optimum beef production. An objective was to evaluate these biological types as cows and the performance of their progeny from birth to market.

Initially for this study, four types of F_1 crossbred females representing different biological types of cattle were produced. The four biological types were determined on breed characterization information available based on size of the sire breed (medium or large) and level of milk production of the breed (medium or higher). The medium-size sire breed, medium level of milk production was represented by the Angus x Hereford; the medium-size, higher level of milk production by the Red Poll x Hereford; the large-size, medium level of milk production by the Pinzgauer x Hereford; and the large-size, higher level of milk production by the Simmental x Hereford. These animals were produced in years 1975 through 1978. A herd of approximately 280 Hereford females were bred by artificial insemination to produce the F_1 crossbreds. This program was repeated yearly until at least 60 F_1 females by each sire breed were obtained. In 1977, a group of Tarentaise x Hereford F_1 females were donated by breeders throughout Montana; and in 1977, Tarentaise bulls were included as a sire breed. Information suggests the Tarentaise to be a medium-size breed with a higher level of milk production than the Angus and will be referred to as medium-size, higher milk level II throughout the paper to distinguish them from the medium-size higher milk level group in the original experimental design.

The first-cross heifers were kept to form a herd of breeding females and were fed to gain about 1.25 pounds daily during the winter after weaning. Yearling crossbred heifers were exposed to Shorthorn bulls in multiple-sire breeding herds while the 2-year-old and older crossbred cows were exposed to Charolais bulls in multiple-sire herds. All of the offspring, both male and female, from the first-cross dams are placed on feed after weaning in the fall.

The Shorthorn-sired calves were fed for 140 days on corn silage and a protein supplement. Cracked barley was then added to the ration (4 pounds per head daily) until the steers or heifers were sold for slaughter. The Charolais-sired steers and heifers are fed a cracked barley-corn silage ration where barley makes up 20% of the total amount fed to the heifers but barley makes up to 30% of the total amount fed to the steers. When 70% of the offspring from Angus x Hereford cows mated to Charolais bulls were considered to grade U.S. Choice, the steers and heifers were slaughtered.

Table 1 shows the pregnancy rate of the 18-month-old heifers and the lactating 2- to 6-year-old cows of each biological type. Pregnancy rates of the large-size, higher milk level biological type appears to be lower than the other groups in this range environment. Table 2 shows calf death loss. Death losses of calves from the 2-year-old heifers were higher from the medium-size, medium milk level heifers than the other biological types and lowest from the medium-size, higher milk level cows. Calves from 3- to 6-year-old large-size, medium level cows had a higher death loss than the other biological types and greater calving difficulty (table 3), which appeared to be caused primarily by a heavier birth weight of the calves as shown in table 4. Table 5 shows the 200-day weight of calves from the 2-to 6-year-old crossbred dams. The calves from medium-size, higher milk level II and the large-size, higher milk level first-cross dams were heavier at weaning than calves from the other biological types. Table 6 summarizes the pounds of calf weaned per cow exposed if all calves were weaned at 200 days of age. The two groups of cows producing the lighter weight calves at weaning, the medium-size, medium milk level and the medium-size, higher milk level cows, both produced more actual pounds of beef than the large-size, medium milk level and large-size, higher milk level cows.

TABLE 1. PREGNANCY RATE OF F_1 FEMALES

Biological type of F_1 dam				
Size of sire breed	Milk production	No.	Yearlings (% preg.)	2- to 6-year-old cows (% preg.)
Medium	Medium	66	92	93
Medium	Higher	72	90	92
Medium	Higher II	57	86	89
Large	Medium	67	88	87
Large	Higher	72	79	83

TABLE 2. CALF DEATH LOSSES AND WEANING RATES OF CALVES FROM F_1 FEMALES

Biological type of F_1 dam		Calf death loss, %		Weaning rate, %	
Size of sire breed	Milk production	2-year-old dams	Older cows	2-year-old dams	Older cows
Medium	Medium	20.0	4.4	72.7	88.4
Medium	Higher	6.2	4.3	81.3	84.2
Medium	Higher II	14.3	9.1	73.7	81.7
Large	Medium	12.1	11.3	76.5	75.0
Large	Large	6.9	9.7	73.9	75.7

TABLE 3. THE PERCENT OF COWS REQUIRING ASSISTANCE AT CALVING

Biological type of F_1 dam		Age at calving			
		2-year-old[a]	3-year-old[b]	4-year-old[b]	5-year-old[b]
Size of sire breed	Milk production	% assisted	% assisted	% assisted	% assisted
Medium	Medium	45	16	7	6
Medium	Higher	53	17	7	7
Medium	Higher II	50	9	12	--
Large	Medium	59	33	12	8
Large	Higher	60	24	20	11

[a] Calves sired by Shorthorn bulls.
[b] Calves sired by Charolais bulls.

TABLE 4. BIRTH WEIGHT (POUNDS) OF CALVES

Biological type of F_1 dam		Age of dam (year)		
Size of sire breed	Milk production	2[a]	3[b]	4 and 5[b]
Medium	Medium	71	83	92
Medium	Higher	74	84	94
Medium	Higher II	73	86	89
Large	Medium	79	92	99
Large	Large	75	88	94

[a] Sired by Shorthorn bulls.
[b] Sired by Charolais bulls.

TABLE 5. 200-DAY WEIGHT (POUNDS) OF CALVES[a] FROM F_1 DAMS

Biological type of F_1 dam		Age of dam (year)		
Size of sire breed	Milk production	2[b]	3[c]	4 to 6[c]
Medium	Medium	403	468	517
Medium	Higher	402	474	531
Medium	Higher II	440	506	557
Large	Medium	411	486	530
Large	Higher	421	490	552

[a] Adjusted for sex to females.
[b] Sired by Shorthorn bulls.
[c] Sired by Charolais bulls.

TABLE 6. 200-DAY WEIGHT OF CALF WEANED PER COW EXPOSED

Biological type of F_1 dam		Age at breeding		
		1 year	2 years	3 to 5 years
Size of sire breed	Milk production	Age at calving		
		2 year	3 year	4 to 6 years
Medium	Medium	293	395	468
Medium	Higher	327	406	460
Medium	Higher II	324	405	444
Large	Medium	315	320	426
Large	Large	311	356	434

Table 7 summarizes weights of the cows at different periods. The medium-size, higher milk level females were lighter in weight at each weigh period than any of the other biological types. Cows of this breed type also had the lowest condition scores. All the other breed groups were similar in weight at each weigh period. The medium-sized, medium milk level had the highest condition scores. These weight and condition patterns were typical for all years.

TABLE 7. FALL WEIGHTS AND CONDITION SCORES OF FIRST-CROSS CATTLE

Biological type of F_1 dam		All years,	Age of dam (years)	
Size of sire breed	Milk production	18-month weight	5-year-old, 1983	6-year-old, 1983
Weights of cows (pounds):				
Medium	Medium	833	1229	1255
Medium	Higher	798	1100	1156
Medium	Higher II	836	1136	--
Large	Medium	852	1258	1296
Large	Higher	862	1221	1306
Condition score of cows[a]:				
Medium	Medium		7.0	7.3
Medium	Higher		4.2	5.1
Medium	Higher II		6.1	--
Large	Medium		6.2	6.8
Large	Large		6.4	6.2

[a] Condition score 1 to 10; 10 = most conditioned.

Since the fall of 1979, all cows that were not pregnant and cows that lost calves have been removed from the project. The number and percent of females of each herd group remaining in the project in the fall of 1983 are shown in table 8. The medium-size, higher milk level II cows were omitted from this comparison since they were not represented in all years and the results would not be applicable. This reduction in cow numbers represents an economic loss since cows that are sold for lack of pregnancy or various other reasons must be replaced in order for livestock numbers to be held constant.

TABLE 8. NUMBER OF YEARLING HEIFERS EXPOSED (1976-1979) AND COWS STILL ON EXPERIMENT IN THE FALL, 1983

Biological type of F_1 dams			Reached 6 years of age and pregnant or still on experiment and pregnant		
Size of sire breed	Milk production	Number yearlings	Number remaining	% remaining	% removed
Medium	Medium	66	42	64	36
Medium	Higher	73	40	55	45
Large	Medium	66	27	41	59
Large	Higher	72	27	38	62

Table 9 summarizes the feedlot performance of the Shorthorn-sired, three-breed-cross steers. There was little difference in the gains of the steers by biological types during the growing phase, but steers from large-size, medium milk level and large-size, higher milk level dams grew faster in the finishing phase. Differences were also observed among breed groups in the carcass grades of the steers, but little difference was found in the heifers. The feedlot and carcass data for the Charolais-sired, three-breed-cross steers and heifers born in 1981 and 1982 are shown in table 10. The postweaning growth

rate of steers by breed were very similar. The final weights and carcass weights were more alike than different. The major difference was in carcass grade with a higher percentage of the steers from the medium-size, medium milk level cows grading U.S. Choice than for the other breed groups.

TABLE 9. FEEDLOT PERFORMANCE OF SHORTHORN-SIRED STEERS AND HEIFERS (4-YEAR DATA)

Biological type of F_1 dams			Average daily gain (lb.)						
Size of sire breed	Milk prod.	No. fed	Growing phase[1]	Finishing phase[2]	Entire period	Final weight (lb.)	Carcass weight (lb.)	Dressing %[3]	Choice %
					Steers				
Medium	Medium	25	2.01	2.33	2.33	995	572	57.5	92
Medium	Higher	32	2.02	2.32	2.16	988	561	56.8	73
Medium	Higher II	23	2.08	2.34	2.20	1009	583	57.8	84
Large	Medium	26	2.04	2.41	2.21	1008	578	57.3	67
Large	Higher	21	2.00	2.40	2.18	997	575	57.7	96
					Heifers				
Medium	Medium	22	1.94	2.13	2.03	925	526	56.9	100
Medium	Higher	25	1.83	1.88	1.85	865	494	57.1	96
Medium	Higher II	18	2.00	2.20	2.08	981	560	57.1	83
Large	Medium	21	1.92	2.20	2.04	959	551	57.5	81
Large	Higher	30	1.94	2.12	2.02	940	538	57.2	83

[1] Growing phase = 140 days, corn silage and protein supplement.
[2] Finishing phase = steers, average 118 days, corn silage, protein supplement and four pounds of cracked barley. Heifers, average 111.3 days, same rations as steers.
[3] Calculated from final weight off test (no shrink).

TABLE 10. SUMMARY OF FEEDLOT PERFORMANCE OF CHAROLAIS-SIRED, THREE-BREED-CROSS STEERS[a] AND HEIFERS[b] BORN IN 1981 AND 1982

Size, milk production	Biological characterization of breed of sires and dams by size and level of milk production				
	Medium, medium	Medium, higher	Medium, higher II	Large, medium	Large, higher
	Steers				
Number	31	34	20	29	30
Initial wt., lb.	539	541	526	551	562
Daily gain, lb.	2.62	2.59	2.55	2.59	2.50
Final wt., lb.	1191	1185	1159	1194	1183
Carcass wt., lb.	715	705	692	708	707
Dressing %	60.0	59.5	59.7	59.3	59.8
Choice %	84	74	70	62	57
	Heifers				
Number	44	32	25	25	29
Initial wt., lb.	512	519	515	520	526
Daily gain, lb.	2.23	2.18	2.21	2.26	2.24
Final wt., lb.	1035	1029	1034	1052	1050
Carcass wt, lb.	624	621	618	628	628
Dressing %	60.3	60.3	59.8	59.7	59.8
Choice %	73	84	84	68	72

[a] 1981-1982 steers fed 231 days; 1982-1983 steers fed 265 days.
[b] 1981-1982 heifers fed 224 days; 1982-1983 heifers fed 244 days.

GROWTH RATE AND CARCASS CHARACTERISTICS OF CROSSBRED STEERS ON DIFFERENT MANAGEMENT SYSTEMS

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and M. E. Stanley

Introduction

Historically, much of the grassland in the western United States has been grazed by stocker steers of the British breeds. Steers were wintered on low quality forages then placed on the range in the summer and sent to the feedlots to be finished. In crossbreeding programs, major emphasis has been placed on calf growth rate to weaning and most of the crossbreds go directly into the feedlot after weaning. The purpose of this study was to evaluate performance of crossbred stocker steers sired by bulls selected for rapid growth rate on different winter and summer management systems.

Materials and Methods

Eighty steers, whose dams contained varying percentages of Angus, Hereford, Charolais and Simmental breeding, were used in the study. The crossbred dams were 2 and 3 years of age at calving and had been bred by

artificial insemination during a 45-day breeding season. The 2-year-old heifers had been mated to a Hereford bull and the 3-year-olds had been mated to a Simmental bull.

At weaning in October, the steers averaged 191 days of age and weighed 497 pounds. They were placed in drylot and fed a diet of ground grass hay, protein supplement and a small amount of ground barley for 23 days (table 1). They averaged 537 pounds at the beginning of the study. All steers were implanted with 36 mg of zeranol and reimplanted periodically thereafter in accordance with the recommendation of the manufacturer.

TABLE 1. COMPOSITION AND CHEMICAL ANALYSIS OF THE WINTER DIET

Ingredient (as-fed basis)	Diet, %
Alfalfa	16
Fescue hay	16
Oat hay	47
Barley[a]	21
----------Composition % (dry matter basis)----------	
Dry matter	89.0
Ash %	7.8
Protein %	10.6

[a] Barley was ground and pelleted, and pellet contained monensin mixed to provide 180 mg daily for steers.

The design of the study is shown in table 2. The four treatments were: (1) Drylot from November 11 to April 15 [winter, 155 days] and fed a hay-barley diet [table 1], then fed a corn silage-protein supplement-30% barley diet [table 3] in drylot from April 15 to July 27 [spring to midsummer, 102 days]; (2) Drylot in winter and fed the hay-barley diet for 155 days, pasture from spring to midsummer for 102 days, then fed the corn silage-protein-barley diet from July 27 to October 26 [midsummer to fall, 90 days]; (3) Pasture in winter and fed the hay-barley diet for 155 days, the corn silage-protein-barley diet in drylot from spring to midsummer for 102 days; (4) Pasture in winter and fed the hay-barley diet for 155 days, pasture from spring to midsummer then fed the corn silage-protein-barley diet in drylot from midsummer to fall (90 days).

TABLE 2. DESIGN OF EXPERIMENT AND NUMBER OF STEERS

Treatment				
Winter[a]	Drylot		Pasture	
Spring to midsummer[b]	Drylot	Pasture	Drylot	Pasture
Midsummer to fall[c]		Drylot		Drylot
Sire breed:				
Hereford, number	7	7	7	8
Simmental, number	13	12	13	13
Total	20	19	20	21
Date, end of study	7/27	10/26	7/27	10/26

[a] Winter period, 11/11 to 4/15, 155 days.
[b] Spring to midsummer, 4/15 to 7/27, 102 days.
[c] Midsummer to fall, 7/27 to 10/26, 90 days.

During the 155-day winter period, steers in all four treatments (drylot or on pasture were offered the same hay-barley diet free choice (table 1). The barley was pelleted and monensin mixed in the pellet to provide 180 mg daily. After the winter period, one group of drylot steers and one group of steers from pasture were placed together in drylot and fed the corn silage-protein supplement-barley diet (table 3) for 102 days and then slaughtered. All steers in drylot were group fed.

The other group of steers wintered together in drylot or on pasture were placed together on pasture for this 102-day period. Pasture grasses consisted of crested wheatgrass (Agropyron desertorum) and a mixture of western wheatgrass (Agropyron smithii), and blue grama (Bouteloua gracilis). After this 102-day period, these steers went to drylot and were fed the corn silage-protein-barley diet for 90 days.

TABLE 3. COMPOSITION AND CHEMICAL ANALYSIS OF FINISHING DIET[a]

Ingredient, %	Diet	
	As fed, %	Dry matter, %
Corn silage	64.0	37.6
Barley	30.0	51.8
Supplement	6.0	10.6
Barley	3.81	
Soybean oil meal	1.19	
Urea	.33	
Salt	.30	
Calcium carbonate	.21	
Dicalcium phosphate	.12	
Commercial mineral mix	.03	
Chemical composition, % dry matter basis:		
Dry matter	50.0	
Ash %	5.8	
Crude protein	9.6	

[a] The diet fed in drylot from spring and midsummer, and the diet fed from midsummer to fall was the same.

Results and Discussion

During the winter period, steers in drylot were offered 19.1 pounds of feed/head daily while the steers on pasture were fed 15.7 pounds of the diet daily (table 4).

TABLE 4. FEED OFFERED, DAILY GAIN AND FEED/POUND GAIN IN WINTERING PERIOD

Item	Drylot	Pasture
No. head	39	41
Feed offered, pounds	19.1	15.7
Daily gain, pounds	1.72	1.43
Feed/pounds gain	11.1	11.0

The amount of diet fed to steers in the drylot finishing periods, from April 15 to July 27 (102 days), and after the summer grazing period, from July 27 to October 26 (90 days), are shown in table 5. Steers in drylot from April 15 to July 27 were offered 20.0 pounds of dry matter (DM) daily, while steers in drylot from July 27 to October 26 were offered 29.0 pounds of DM daily.

TABLE 5. ESTIMATED FEED FED STEERS IN FINISHING PERIOD

Item	Finishing period in drylot: Spring to midsummer	Finishing period in drylot: Midsummer to fall
Number of head	40	40
Days on feed	102	90
Feed fed daily, pounds	50.9	57.4
Dry matter offered, pounds	26.0	29.0
Gain ADG, pounds	3.39	3.67

The means for the four treatments are shown in table 6. In the winter, steers in drylot gained 1.72 pounds per day while those on pasture gained 1.43 pounds per day.

TABLE 6. MEANS FOR STEERS BY TREATMENTS

Winter treatment	Drylot		Pasture	
Spring-midsummer	Drylot	Pasture	Drylot	Pasture
Midsummer-fall		Drylot		Drylot
Item				
Number of head	20	19	20	21
Average daily gain, lb.:				
11/11 to 4/15	1.72	1.72	1.48	1.37
4/15 to 7/27	3.15	1.91	3.57	2.65
4/15 to 5/12	3.49	-1.26	4.23	.91
5/12 to 7/27	3.04	3.04	3.33	3.27
Midsummer weight, lb.	1129	1021	1123	1024
End of trial weight, lb.	1129	1359	1123	1349
Carcass weight, lb.	658	795	648	789
Dressing %	58.3	58.5	57.6	58.4
Ribeye area, square inches	11.5	13.4	11.8	13.4
Fat thickness, inches	.24	.33	.22	.32
Kidney fat, %	1.6	1.8	2.1	1.7
Carcass grade:				
Choice, %	25	21	10	24
Good, %	65	68	80	71

During the first 27-day feed period after steers were placed on the spring to midsummer treatments, steers from the winter pasture treatment gained 4.23 pounds when placed in the drylot and fed the corn silage-protein-barley diet and .91 pound when placed on the summer pastures. Steers moved from drylot to pasture lost 1.26 pounds daily during the first 27 days, which could be due to loss of fill or to poor digestibility of forage until rumen flora was changed to accomodate the range grasses--or a combination of these. Steers, which

remained in drylot with only a diet change, gained 3.49 pounds during this 27-day period.

From May 12 until July 27 (75 days), steers that had been wintered on pasture continued to gain slightly faster (.26 pounds) than the steers wintered in drylot (table 7). Differences in gain (1.1 pounds) between steers in drylot on the corn silage-protein-barley diet and the summer pasture (table 7) for the 102-day period can be explained by the lack of adjustment from drylot feeding to the summer pasture grasses and a rapid adjustment of the steers from pasture to the corn silage-protein-barley diet in the first 27 days of the period. The average midsummer weights (July 27) for the steers wintered in drylot and on pasture differed by 2.2 pounds. Other research has shown lighter weight steers on a lower energy diet compensated in growth rate and gained more rapidly in subsequent periods than heavier steers on a higher energy level.

Steers wintered in drylot and placed on the summer pastures to July 27, then placed on the corn silage-protein-barley diet for 90 days gained 3.78 pounds; while the steers wintered on pasture, placed on the summer pasture and then placed on the same diet for the same time gained 3.61 pounds daily.

TABLE 7. DIFFERENCES IN TREATMENT MEANS

	Treatment differences			
	Breed	Winter	Spring to midsummer	Time of slaughter
Item	Simmental minus Hereford	Drylot minus pasture	Drylot minus pasture	Fall minus summer
Average daily gain, pounds:				
Winter period, 155 days	.04	.30**		
Spring to midsummer, 102 days	.04	-.58**	1.1**	
4/15 to 5/12, 27 days	-.09	1.45**	3.67**	
5/12 to 7/27, 75 days	.09	-.26**	.03	
Midsummer weight, pounds	3.1	1.5	103.5**	
End of trial weight, pounds	0.0	8.0		228.0**
Carcass weight, pounds	0	8.0		139.0**
Dressing %	1.1**	.4		.5*
Ribeye area, square inches	.8**	.15		1.7**
Fat thickness, inches	1.4**	.02		1.0**
Kidney fat, %	.2	-.2		-.1

* P<.05.
** P<.01.

Dressing percentages ranged from 57.6% to 58.5%, which are similar to dressing percentages for steers finished on corn silage diets reported in other studies. Steers allowed to graze summer pasture and then placed in the feedlot had a .5 percentage point higher dressing percentage (table 7) than steers which were placed in the feedlot at the end of the winter treatment. Part of this increased dressing percent of the steers could be attributed to increased fat thickness over the ribs but percent kidney fat was similar for steers slaughtered in July and in October.

Carcass weights of steers wintered in drylot or on pasture were not different (table 7); however, grazing the steers on pasture followed by a 90-day feeding period increased the carcass weight by 139 pounds. In the 102-day spring-midsummer feeding period, steers were offered a total of 2640 pounds DM; while in the 90-day feeding period, the steers were allowed to graze pastures, then placed in drylot and were offered a total of 2620 pounds of DM. Most of the difference in carcass weight can be attributed to grazing steers for 102 days on the summer pasture. This is a carcass increase of 1.36 pounds per day. Allowing steers access to the summer pasture and then placing them in the drylot had no effect on carcass grade.

Breed differences in growth traits between the progeny of the Hereford (H) and the Simmental (S) bulls (table 7) were small and showed no difference for breed of sire. Bulls in the two breeds had been selected for similar traits with the same intensity. However, Hereford-sired steers had a significantly lower dressing percent (H=57.7 vs S=58.7) greater fat thickness over the ribs:; (H=.32 inches vs S=.23 inches) and a smaller ribeye area (H=12.1 inches vs S=12.9 inches); but did not differ in other carcass traits measured. The effects of breed of sire and age of dam were confounded in this study.

In this study, day born had a significant effect on weights at all periods with the oldest steers being the heaviest. Day born had no effect on calf growth rate at any period.

Initial weight had no relationship to growth rate of steers on pasture (table 8) in the winter period; but in drylot, correlations between initial weight and gains between periods were positive. Rate of winter gain was also positively correlated with subsequent gain at all periods. These data indicate that the faster gaining steers within a treatment in the winter continued to gain more rapidly in subsequent periods. Previous research has shown gains made by steers in the first periods on feed were positively correlated with subsequent feedlot gains; and also, the slower gaining steers in the first 56 days on feed continued to gain at a slower rate than the average of all steers.

These results show winter management had no effect on carcass weight but grazing crossbred steers on the range for 102 days increased the carcass weight by 139 pounds. Crossbred steers gained rapidly on good quality spring and summer forages.

TABLE 8. RESIDUAL CORRELATIONS AMONG TRAITS

Item	ADG[a] 11/11 to 4/15	ADG 4/15 to 7/27	ADG 4/15 to 5/12	ADG 5/12 to 7/27
Initial weight:				
Drylot	.16	.14	.02	.18
Pasture	.06	.00	-.10	.06
ADG, 11/11 to 4/15:				
Drylot		.35**	.26*	.26*
Pasture		.27*	.16	.24*
ADG, 4/15 to 7/27:				
Drylot			.65**	.79**
Pasture			.55**	.89**

Item	ADG in feedlot	Midsummer weight	Slaughter weight	Carcass weight
Initial weight:				
Drylot	.36**	.70**	.73**	.71**
Pasture	.06	.66**	.62**	.67**
ADG, 11/11 to 4/15:				
Drylot	.25*	.61**	.58**	.62**
Pasture	.26*	.60**	.56**	.59**
ADG, 4/15 to 7/27:				
Drylot	---	.73**	.67**	.56**
Pasture	---	.63**	.6488	.46**

INFLUENCE OF MATURE COWS ON GROWTH RATES AND PUBERTY IN HEIFERS[1]

T. C. Nelsen, R. E. Short, D. A. Phelps and R. B. Staigmiller

This study was designed to test a theory that heifers may grow faster and reach puberty earlier if they are raised in the presence of older cows rather than in heifer-only groups. We had noticed that older cows can sometimes have a calming effect on a group of calves and we wanted to see if the effect was carried over into performance measures. Also, other researchers working with laboratory animals have reported that sexual development in growing animals can be influenced by exposure to sexually active adults in the same pens or cages. Another objective of this experiment was to observe and record a phenomenon we called nonpuberal estrus (NPE). The biological processes which lead to puberty are not all understood. We took measurements to determine if heifers sometimes undergo only a portion of these processes so that they will have their first behavioral estrus without completely reaching puberty.

After weaning in October, 1982, when heifers were approximately 180 days old, they were placed in feedlots until June 15, 1983. A total of 153 heifers were

[1] Commonly referred to as the "Granny" project.

used in the study, seventy were progeny of Hereford sires and dams of various crosses. Eighteen were progeny of Charolais sires and crossbred dams and 31 were of Charolais sires and Red Angus dams. Thirty-four heifers had Tarentaise sires and Red Angus dams. All heifers were from dams which were 3 years old or older. Initial comparisons showed there were no differences between the heifers from Charolais sires and crossbred dams and those born of Charolais sires and Red Angus dams so the two groups of Charolais-sired heifers were analyzed as one breed type. Hereford-sired heifers were considered a second breed type and Tarentaise-sired, the third. Within each of these breed types, the heifers were randomly assigned to one of six pens. Three of the pens contained 25 or 26 heifers each plus a sterile marker bull. These were designated the control pens. The other three pens each contained 25 or 26 heifers, a sterile marker bull and four mature, nonpregnant cows. These three pens were called the "Granny" pens. All heifers were fed a growing diet consisting of 95% corn silage, 3.4% rolled barley, 1% soybean meal, .3% urea, and the rest calcium, phosphate, vitamin A-10 and trace minerals. All values were calculated on a dry matter basis.

Heifers were weighed every 28 days. Any time a heifer was marked by a bull, she was brought in for a series of three workings where she was rectally palpated for ovarian status, and a blood sample drawn. Puberty was defined by three criteria: (1) marked by a bull, (2) a corpus luteum detected by palpation, and (3) a rise in blood progesterone levels. By June 15, 125 heifers had reached puberty. Eighteen more heifers reached puberty during the June 15-August 15 breeding season. By August 15, eight heifers had never been observed in estrus and were dropped from the experiment. In addition, two heifers had been culled for chronic sickness during the experiment. No breed type or treatment differences were noted in these odd groups.

Results

The Hereford-sired heifers were the lightest weight animals on test but gained the fastest during the test so that no significant breed type differences were found for weight off test or yearling weight (table 1). No significant differences were found for any performance measures between the control heifers and the heifers grown with the mature cows. We concluded from this experiment that the presence of mature cows did not affect the growth of heifers in the same pens.

TABLE 1. FEEDLOT PERFORMANCE AND YEARLING WEIGHT FOR HEIFERS OF EACH SIRE BREED

		Feedlot performance			
Sire breed	No.	Initial weight**	Final weight	Average daily gain**	Yearling weight
Hereford	68	481	748	1.45	719
Tarentaise	33	498	734	1.28	703
Charolais	42	523	757	1.27	731

** Differences were significant P<.01).

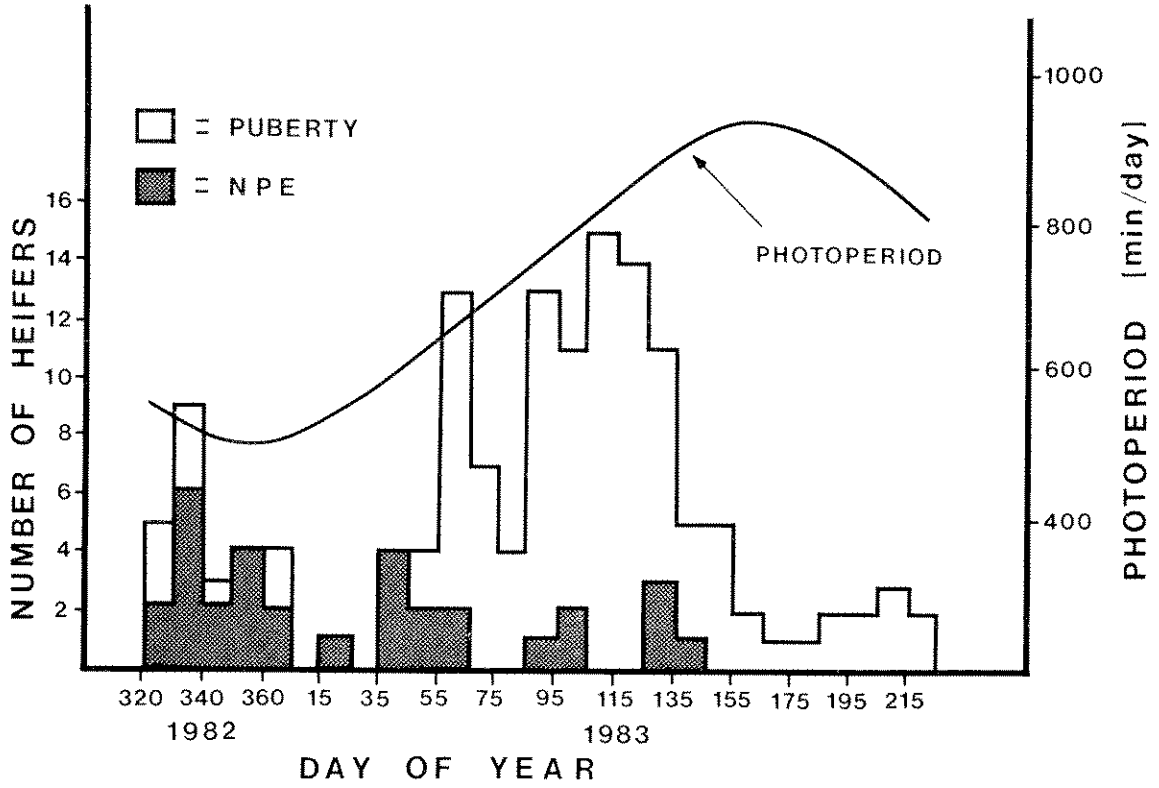
In the control group, the Hereford-sired heifers reached puberty latest at 760 pounds and 389 days. The Charolais- and Tarentaise-sired heifers were younger and lighter (table 2). The Hereford-sired heifers in the presence of the mature cows reached puberty 35 pounds lighter and 26 days earlier than the Hereford-sired control heifers. Tarentaise-sired heifers were 58 pounds lighter and reached puberty 40 days earlier when with the mature cows, but the Charolais-sired heifers with the mature cows were 42 pounds heavier and 29 days older. We concluded that the presence of sexually active adults does affect the maturation process of heifers of some genotypes but there may be some genetic variations in the sensitivity to this outside stimulus. We are repeating this experiment with a wider range of breed types.

Thirty-two of the heifers had at least one occurrence of a nonpuberal estrus (NPE). Of the 32, 16 were in the control group and 16 were with the mature cows. Fewer Hereford-sired heifers and more Charolais-sired heifers ($P<.01$) had NPE than would have been expected from their overall distributions. Of the 25 heifers that had a first estrus before January 1, 16 (64%) were NPE. Only 13% of the first estruses were NPE after January 1. This distribution is shown in figure 1. October, 1983, pregnancy rates were 84% for the heifers that had NPE compared to 86% overall. We have concluded that NPE occurs frequently during the early part of the season. There are genetic and seasonal differences in the various processes that lead to sexual maturation in heifers. We can learn more about the entire process by studying these differences.

TABLE 2. WEIGHT (IN POUNDS) AND AGE (IN DAYS) AT PUBERTY FOR HEIFERS OF EACH SIRE BREED IN EACH TREATMENT

	Breed of sire								
	Hereford			Tarentaise			Charolais		
Treatment	No.	Weight	Age	No.	Weight	Age	No.	Weight	Age
Bulls + cows	34	725	363	17	661	319	19	773	384
Bulls only	34	760	390	16	719	359	23	731	355
Difference		-35	-26		-58	-40		+42	29

Figure 1. Distribution of NPE.



USE OF RALGRO IN THE BEEF INDUSTRY

R. B. Staigmiller and R. M. Brownson[1]

Growth implants have been, and are continuing to be, used rather extensively in the beef cattle industry. These compounds are administered as implants and are used to increase the efficiency of gains in animals destined for slaughter. One commonly used growth stimulant, and one which we have used here at the Miles City Station, is Ralgro[2].

Ralgro-implanted calves have shown increased rates of gain at all stages of growth from birth to slaughter, and many producers using Ralgro find it convenient to implant calves when they are handling them for other purposes--such as at birth, branding, pasture changes, weaning, etc. However, Ralgro, like other growth stimulants, is not recommended for use in breeding stock. This presents a problem for producers since they are implanting their calves before selecting their replacement stock. Hence, the question often asked is, "What is the risk involved in selecting as a replacement heifer, one that has been previously implanted with Ralgro?"

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[1] Cooperative Extension Service, Montana State University, Bozeman 59717.

[2] Mention of a trade name, proprietary product or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may be suitable.

To answer this question, we have tried to review most of the research reports available on the reproductive performance of heifers implanted with Ralgro at various times and frequencies from birth on. The following are some of the generalizations that we feel can be made on the basis of those research results.

1. Heifers should not be implanted earlier than at branding time if there is any chance they will go into the breeding herd. The systems within the body that control the reproduction process may not be fully developed at birth, and the changes which occur the first 20-30 days of life may be more vulnerable to damage from implants than at any other time.

2. A single 36-mg implant of Ralgro administered any time from branding up to 100 days prebreeding seems to have minimal effect on reproductive performance. Few studies have shown more than a 5% drop in conception rate of replacement heifers as the result of a single Ralgro implant.

3. Multiple implants of Ralgro given between branding and breeding tends to decrease conception rate in replacement heifers. Drops in conception as high as 20% or more have been verified in heifers implanted at branding age and every 80 to 100 days thereafter until breeding.

The research results available make it rather clear that a producer must be very familiar with the economics of raising replacement heifers if he plans to implant them more than once. This does not necessarily mean that it is economically unsound. What it does mean is that the increased rate of gain in the heifers which will be sold must offset the cost of having a greater percentage of replacement heifers that will not produce a calf.

The most widespread use of implants, of course, has been in beef animals destined for slaughter. Hence, it is helpful to look at the effect of implants at different times during the growing and finishing of beef animals.

Starting with suckling calves, most research indicates an increase of from 15 to 35 pounds of gain at weaning in calves receiving a single 36-mg Ralgro implant. The following table shows the results of single-implant studies from 10 representative studies conducted across the United States. These studies resulted in an average of 25.9 pounds of gain per animal.

TABLE 1.

State	Total gain improvement due to Ralgro (lb.)	Average initial weight (lb.)	Days on test
California	20.0	245.0	133
Idaho	23.5	171.0	168
Indiana	23.7	250.0	91
New Mexico	22.8	139.0	120
Oklahoma	27.0	211.0	135
Pennsylvania	25.5	235.0	75
South Carolina	31.0	103.0	148
Texas	23.2	293.0	155
Washington	38.0	266.0	223
Wisconsin	24.3	75.6	205
Average =	25.9		

The use of a second 36-mg implant during the suckling period shows an additional increase in gain over that of a single implant. While the effect of the second implant is not always double, it is often an increase of 60 to 80% of the single implant and certainly more than enough to pay for the implant. Some studies with good feeding conditions have shown the increases from the second implant to be greater than from the first implant. Usually, the feasibility of a second implant during the suckling period depends on the labor involved with gathering and working the herd at a time when they might not otherwise be worked.

Studies of implanted steers on pasture as yearlings have also shown a rate of gain from 4 to 10% greater than steers without implants. One study indicated that the response to Ralgro implants in grazing animals was greater when additional phosphorus and potassium were offered in a mineral lick mix during the grazing period. That particular study may mean nothing more than that good nutritional programs will provide the maximum growth response, whether with or without implant.

Studies on the effect of Ralgro are probably most numerous in animals during the finishing phase. The combined results of studies, which involved over 15,000 steers in the feedlot, showed an increase of 14.5% in average daily gain from implanting with Ralgo. Along with the increase in average daily gain, there was a 7.2% improvement in feed efficiency. For heifers, the rate of improvement in the feedlot was 10.2% for average daily gain and 7.8% in feed efficiency. The number of heifers studied, however, was much smaller than the number of steers. As in the suckling period, repeated implants every 80-100 days during the finishing period continued to give additional returns over a single implant.

Two other classes of cattle have made use of Ralgro implants and deserve mentioning. Cull cows have been implanted and pastured on native range prior to slaughter. In two such study trials at Miles City, the implanted cows gained

10.3% and 17.1% more than nonimplanted control cows. This represents an appreciable increase in gain and would be of economic value to producers who have pasture available for grazing animals of this type.

Lastly, Ralgro implants have been used in raising intact bulls for beef. Since bulls grow faster and more efficiently than steers, they are receiving more attention in feedlots. While some studies with intact bulls have shown a small growth rate advantage to implanted animals, these results have not been consistent. In two studies with bulls at Miles City, there was no growth rate advantage resulting from Ralgro implants. In some larger feedlot trials, however, there is some evidence that Ralgro decreases the aggressiveness of males held in confinement as well as a possible decrease in homosexual activity. A decrease in both of these characteristics would reduce some of the major problems of handling bulls under feedlot condition.

In summary, Ralgro provides the beef producer, whether they be producers of calves, yearlings, or finished animals, with an additional margin of profit with a minimal investment in either implant cost or additional labor. Implanting early in life does not appreciably decrease the response to implants later. This means that under those conditions where cattle do not go from birth to slaughter under a single owner, a profit can be realized from implanting by each owner of the beef animal during the growing and finishing phases.

There are presently several other growth stimulant implants on the market. Most studies show them to be generally equivalent in effectiveness. It is the producer's own challenge to select the one most compatible to their production and management program.

PINE NEEDLE ABORTION IN CATTLE: A REVIEW AND REPORT ON RECENT RESEARCH[1]

R. E. Short and L. F. James[2]

Introduction

Abortions in cattle are a significant factor in determining production efficiency. Causes of these abortions are quite varied and include disease, genetic disorders, physiological abnormalities, environment and nutrition. Information gathered in the last two to three decades has clearly identified consumption of pine needles as one of those causes. Research efforts are now at the point where we need answers to many questions.

1. What is there in pine needles that cause abortions?

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[1] This is a cooperative project with the Poisonous Plant Research Laboratory, USDA-ARS, Logan, Utah.

[2] Poisonous Plant Laboratory, Logan, Utah.

2. Does this substance exist in all pine needles at all times of the year and in both fresh and dried needles?

3. How or why does this substance cause abortions?

4. Are cows susceptible at all stages of gestation?

5. Is there any way to prevent these abortions?

Most of the recent research activity has been centered around answering question number 1 with little effort directed to the others. By a cooperative effort between the Poisonous Plant Laboratory (PPL) and LARRS, we have been able to expand our efforts, especially in the area of question 4 and to find out the endocrine and metabolic causes of this abortion. Our goal in this cooperative research effort is to answer the last three questions on how to prevent abortions. The present report is to review our present knowledge and summarize current research.

Review

Ponderosa pine, Pinus ponderosa, is abundant in every state west of the Great Plains and occurs at some locations in the Plains States. It is also abundant in western Canada and is the State tree of Montana. Total geographic acreage of ponderosa pine is greater than any native tree except Douglas fir. Ponderosa pine is quite drought resistant and can reach a height of over 200 feet and 5 to 8 feet in diameter under the best environmental conditions. It is used extensively for lumber. During early growth, the bark is dark brown to black hence the common name "black jackpine" and bull pine. As it matures, the bark becomes light brown to yellowish from which comes the common name yellow pine. The needles are bluish-green, 3 to 10 inches long and grow usually in clusters of three needles per bundle. Occasionally two needles per bundle are present but not typically.

Cows grazing the needles of the ponderosa pine during pregnancy may abort. Abortions occur primarily during the late fall, winter and early spring when most cows are in the last 1/3 of gestation and also when they are most likely to graze the needles. Abortions have been associated with the grazing of green needles directly from the trees, slash from logging, windfalls and dried needles that have fallen from the trees. Apparently drying does not destroy the needle's properties that cause abortions.

Abortions may occur as early as 24 hours following the consumption of the needles or they may not occur until 2 to 3 weeks later. The udder may start to fill and the external genital organs may swell after a cow starts eating the needles. If the cow continues to graze the needles, she may abort. If grazing is discontinued, the swelling disappears and she will have a calf at the proper time. However abortions frequently occur following a single exposure to the needles. The abortions are characterized by weak parturition contractions, excessive uterine hemorrhage, incomplete dilation of the cervix and often a characteristic nauseating odor. There may or may not be any indications of the impending abortion. Because of the condition of the genital tract, the cow ofttimes needs assistance. If the cow is in the later stages

of gestation, the calf generally survives but some of these calves may be weak at birth. However, the earlier in gestation the calf is aborted, the more a decrease in size and vigor of the calf is seen. It has been observed in some herds of cattle, located where they have access to pine needles, that there is a high incidence of retained placentas with seemingly few or no abortions. Therefore, these may actually be abortions occurring late in gestation. However, there are some indications that some of these calves may be smaller than normal. Pine needles could well be the cause of these retained placentas.

In some instances, the cow seems to have a toxemia at the time of the abortion. They may die before or anytime up to several days after the abortion. The death of the cow may be so rapid as to suggest a toxic effect from the needles. Observations in the field and of experimental animals would seem to bear this out. It has been observed that in an outbreak of pine needle abortions there may be a number of cows that will have a marked bloody discharge from the genital tract and yet not abort. The source of the blood is not known.

The actual extent of the pine needle abortion problem is not known but it is known that it occurs in most areas where the ponderosa pine grows. The incidence of the abortions in an outbreak may vary from only a few up to 100%. Mortality in cows that abort is high if they do not receive supportive medical treatment. A survey conducted by the National Cattlemen's Association and another conducted in the Black Hills area of South Dakota, Wyoming and Montana as well as contact with practicing veterinarians, livestockmen and county agents suggests that pine needle abortion is indeed a serious problem and indicates pine needles must be listed as one of the most important poisonous plant problems in cattle. In addition to the losses due to the abortions, there is the added cost to management for preventing losses, i.e., pruning, fencing, lost forage, etc.

Although pine needles were suspected as a cause of abortions in cattle as early as 1920, the first published report suggesting pine needles could cause abortion in cattle was not made until 1927 (Bruce, 1927). These observations were questioned by Gunn (1948) who suggested that these abortions were probably due to nutritional imbalances and disease. In 1952, MacDonald (in a feeding experiment with cattle) demonstrated that pine needles can cause abortions. This observation has been verified by feeding trials in Colorado and Utah. These feeding trials--plus the many reports from livestockmen, veterinarians, and others--leave no doubt that ponderosa pine needles can cause abortion in cattle.

Although a number of different agents associated with ponderosa pine needles have been suggested as the abortiofacient agent in pine needle abortion, it is obvious that the agent has not been identified. Not only is there variation in suggested toxins, there is variation in the stage of gestation and other differences in the physiological effects in the way these toxins express themselves. Also, it must be borne in mind that most of the research was done with mice which have a different type of placentation and a different kind of gastrointestinal tract, either of which could result in a different kind of a response to the pine needles than is observed in the cow.

Several studies showed a toxic effect of the various extracts on mice. Some mortality in cows has been associated with pine needles; however, they seem to be attributed to complications associated with the abortion itself. However, there is some justification, both from field observations and experimental feedings, that under some conditions pine needles could be toxic. There are good indications that pine needles have a greater abortiofacient or toxic effect during periods of cold weather than during moderate weather.

Ponderosa pine is the only species of Pinus that is associated with abortion in cattle in the United States and Canada. New Zealand researchers have reported abortions in cattle grazing Pinus radiata. The consistent features of the condition were the delivery of an aborted fetus or weak and small calves during the last 2 months of pregnancy. Aborting cows were occasionally sick.

There are reports from practicing veterinarians and others that suggest that sheep may be susceptible to pine needle abortion. This has not been demonstrated experimentally.

Current Research

Ponderosa pine needles (Pinus ponderosa) were fed to pregnant cows and sheep as shown in table 1. The ponderosa pine needles were collected for each year's feeding trials in late November, brought to the laboratory, and dried at a temperature of about 65°F. The needles were then stripped from the woody part in preparation for feeding. Both cows and sheep were group fed pine needles mixed with chopped hay or straw. All calves were examined by a veterinarian at the time of the abortion or parturition to determine the status of the calf, i.e., normal, premature or abortion.

Daily blood samples during the feeding period were taken from the cows fed pine needles in 1983 and 1984 for analysis as follows: (A) Chemistry - complete blood count, hemaglobin, phosphorus, calcium, creatinine, lactic dehydrogenase, creatine phosphokinase, glucose, blood urea nitrogen, alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, total protein albumin, amylase and immunoglobins (IG-G, IG-M, IG-A) ; (B) Steroid hormones - progesterone (P_4) and estradiol-17b (E_2); analysis was performed by radioimmunoassay (RIA).

Results

The cattle in all years ate the needles quite well. They ate the needles more readily in the cold than in warm weather and dried needles much better than green ones. The results of feeding pine needles are summarized in table 1.

TABLE 1. RESULTS OF FEEDING PONDEROSA PINE NEEDLES TO COWS DURING THE LAST TRIMESTER OF GESTATION

Year	No.	Parturition			Amount fed (lb.)	
		Normal	Abort or premature	Retained placentas	Pine needles	Hay or straw
Cows:						
1972	2	2	0	1	8	8
1973	2	2	0	1	8	8
1974	8	0	8	2	8	8
1977	5	2	3	2	4	12
1978	10	10	0	2	4	12
1979	10	8	2	5	1-11[a]	1-15[a]
1980	6	3	3	4	8	8
1983	7[b]	1	6	5	4	12
1984	6[b]	0	6	6	4	12
Total	56	28	28	28		
% cows fed		50%	50%	50%		
Sheep:						
1976	16	16	0	0	1	.5
1978	12	12	0	0	1	2

[a] Amount of pine needles was increased gradually as hay was decreased.
[b] Additional control cows (three in 1983 and four in 1984) were not fed any pine needles and did not have any abortions or premature deliveries.

Fifty percent of the cows fed pine needles were classified as either aborting or having premature delivery. Some of the deliveries classified as normal had retained placentas so the percentage of cows affected by pine needles may actually be higher. Percentages from year to year varied from 0 to 100%. The interval from the start of feeding pine needles to abortion or premature delivery averaged about 15 days. Most occurred from 9 to 21 days, although one did occur in 24 hours. No effect of feeding pine needles was observed in sheep.

No differences in blood chemistry were found between cows fed pine needles and those fed only hay. Steroid hormone concentrations are summarized in figures 1 to 6. E_2 increased markedly the day before and the day of parturition but was not affected by feeding pine needles (figures 1 and 2). P_4 was increased by feeding pine needles with the highest concentrations occurring 4 to 8 days after feeding was started (figures 3 and 4). When the data were summarized by when parturition occurred (figures 5 and 6), P_4 started a steep decline 8 days before abortion. Control cows had a more gradual decline starting at 20 days before normal calving with an abrupt drop at day -2.

Discussion

Reports on naturally occurring pine needle abortions suggest that cows can abort within 24 to 48 hours after having the opportunity to graze needles for very short periods of time, i.e., less than an hour. Our own experience in

feeding pine needles would indicate that this may be true since one cow aborted within 24 hours after the first feeding of pine needles. However, the main response is for cows to abort about 2 to 3 weeks after feeding starts. Our research does not establish how long feeding must last before an effect is observed. In 1974 and 1977, feeding was for only 5 days, which was sufficient to induce a response. All other years feeding pine needles was continuous until parturition occurred.

The incidence of abortions and/or premature births varied from 0% to 100% during the 8 years in which the pine needles were fed. This is similar to what is observed under the natural field conditions. The reason for the variation is not known although there has been some suggestion that the pine needles are more potent during the colder weather conditions. The severe cold and nutritional stress placed on the cows fed in 1979 was to test the relation of stress on the cows to the incidence of the abortions. On that particular year, the incidence of abortions (20%) was low. However, a similar stress was placed on the cows in 1974 and the incidence of abortions was high (100%). With the exception of 1978, 1983 and 1984, breeding dates were not available; thus, we have no expected date for parturition of the cows fed in the other years. Thus, some cows could have been approaching parturition when the needles were fed and the calf could have been near term. If there was any question during the experiment as to whether a calf was premature or a normal birth, it was termed a normal birth.

Some researchers and producers have suggested that stress, i.e., cold, poor nutrition or wind, may influence the incidence of abortion. Our observations would indicate that stress may encourage the cows to eat the needles but has little influence on the rate of abortion.

The lack of any clinical changes in the blood of the cows fed pine needles would suggest that they do not have any toxic effect on the cow. However, our observation is that under certain conditions pine needles are toxic to the cow. This toxicity seems to be more related to complications related to the abortions (retained placentae, uterine infections, etc.) rather than direct toxicity. Feeding pine needles to nonpregnant heifers resulted in no discernable problems.

The effect of pine needle feeding on hormone patterns is most interesting. P_4 concentrations were more than doubled for a few days while E_2 seemed to follow normal patterns. Elevated concentrations of P_4 could be a result of increased production by the corpus luteum and/or by a decrease in the metabolic inactivation by the body. We really have no clue as to which mechanism is at work or whether the interference with metabolic inactivation would be by the uterus or liver (both metabolically inactivate P_4). We intend to pursue this lead in an attempt to solve the problem of how pine needles induce abortions. Once we understand that process, the next step would be to pursue possibilities for preventing abortions when pine needles are consumed.

Recommendations

Unfortunately, the only viable alternative available now is to prevent pregnant cows from grazing in areas with pine needles during the last 3 to 4

FIGURE 1. 1983 E_2 DATA SUMMARIZED BY TIME OF PARTURITION

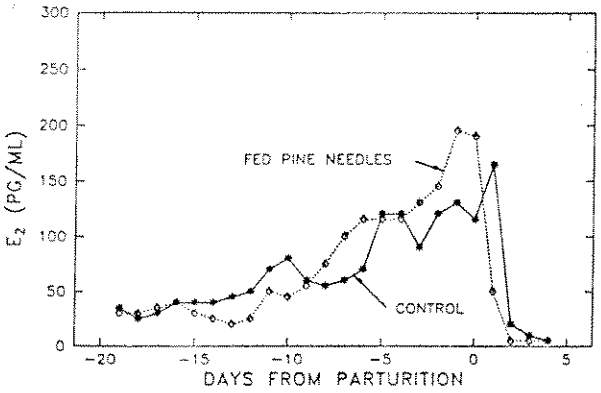


FIGURE 2. 1984 E_2 DATA SUMMARIZED BY TIME OF PARTURITION

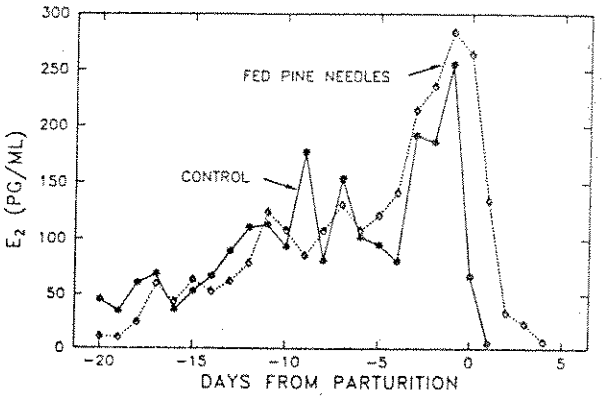


FIGURE 3. 1983 P_4 DATA SUMMARIZED BY START OF PINE NEEDLE FEEDING

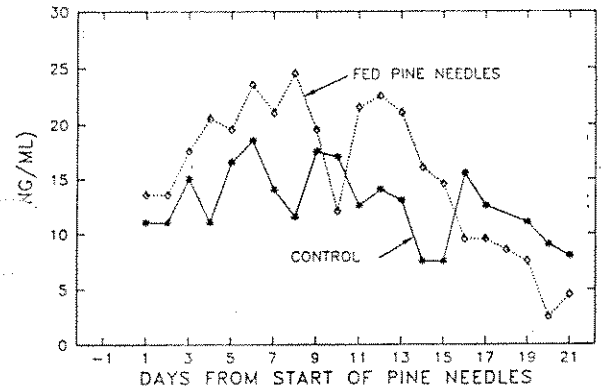


FIGURE 4. 1984 P_4 DATA SUMMARIZED BY START OF PINE NEEDLE FEEDING

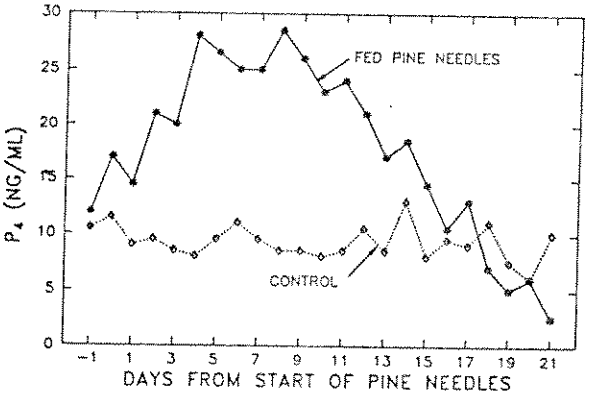


FIGURE 5. 1983 P_4 DATA SUMMARIZED BY TIME OF PARTURITION

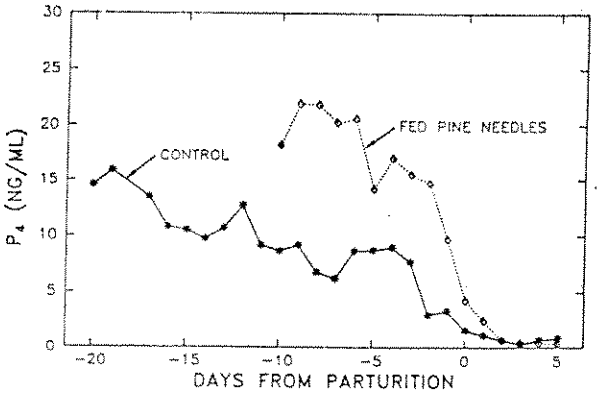
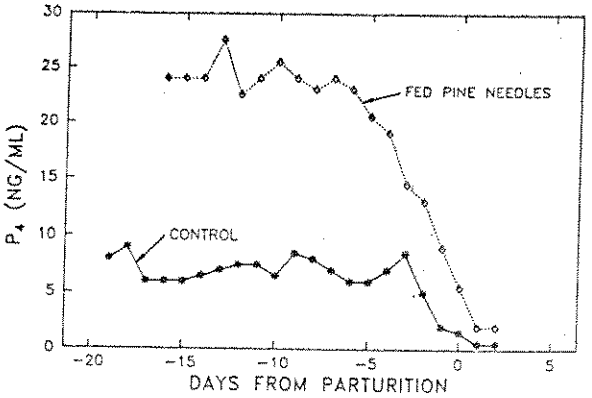


FIGURE 6. 1984 P_4 DATA SUMMARIZED BY TIME OF PARTURITION



months of pregnancy. This is probably most critical during cold periods. We do not have available any means to predict if specific sources of pine needles have a potential for inducing abortions or if certain cows are more susceptible nor can we prevent abortions once exposure has occurred. Our research efforts are aimed at being able to come up with better advice than is given here.

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GRAZING BEHAVIOR AND SUPPLEMENTATION OF RANGE CATTLE DURING THE FALL-WINTER PERIODS

D. C. Adams

Winters in the Northern Great Plains are often long and cold. At Miles City, temperatures as low as 0 F have been recorded as late as April 1 and as early as October 28 and a record low temperature of -65 F was recorded in 1888. The combination of cold stress high maintenance requirements and low quality forages often result in loss of weight and condition of range cows during the fall-winter periods. Determining the nutrient requirements and management practices for range cattle during this time period to make better use of our range forages and to produce beef more efficiently is an important part of the nutrition research at this Laboratory. Results of two studies have provided guidelines for better management practices for range cattle during the fall-winter period.

1. Age of Cow and Winter Grazing Behavior

Winter grazing behavior of range cattle has been studied at other locations, but generally these studies have been conducted under more moderate climatic conditions than those typically experienced in the Northern Great Plains. In our study, the effects of air temperature, wind velocity and age of cow on winter grazing behavior of unsupplemented cows grazing native range was made under more severe conditions. Three and six year old crossbred cows were fitted with 8-day vibration recorders (The recorder is strapped to the neck of the cow and operates self-sufficiently without external power, when the head of the cow is down or in a grazing position, the device transfers the swinging movements from harvesting forage onto a recording chart by means of a pendulum and stylus.) and animal gazing activity was recorded continuously from December 9 to January 14. Concurrent measurements of air temperature and wind velocity were recorded.

Air temperatures during the study ranged from a high of 46° F to a low of -29° F. The average minimum air temperature during the study period was 1 F. Average daily wind velocity ranged from 3.5 to 17.5 miles per hour with an average of 9.5 miles per hour. Grazing activity was recorded at all hours of the day and night. Minimum and maximum time spent grazing in a day for individual cows was .5 and 11.6 h, respectively. Over the study period, the average time spent grazing in a day was 7.0 hours and 7.5 hours for three and six year old cows, respectively, but differences were greater at colder temperatures. Time spent grazing in a day declined for all cows as air temperatures became colder and wind velocity increased. From the grazing and weather data, equations were developed to predict grazing time for various combinations of minimum daily air temperatures and wind velocities (table 1). Results showed that starting from 30° F for each decrease in temperature of 15 degrees a one hour reduction in daily grazing time would be expected and for each five mile per hour increase in wind velocity a .4 hour reduction in grazing time would be expected.

TABLE 1. PREDICTED GRAZING TIME OF COWS AT VARIOUS AIR TEMPERATURES AND WIND VELOCITIES

Minimum daily air temperature °F	Average daily wind velocity (MPH) 0	5	10	15
30	9.1	8.8	8.4	8.0
15	8.1	7.8	7.4	7.0
0	7.1	6.7	6.4	6.0
-15	6.0	5.6	5.3	4.9
-30	5.0	4.6	4.3	3.9

These reductions in daily grazing time as a result of changes in air temperature and wind velocity can result in lower forage intake. Low forage intake and high maintenance requirements associated with grazing and cold places cows in a large negative energy balance, which contributes to losses in body weight associated with winter conditions.

2. Time of Supplementation for Steers Grazing Fall Forage

Behavior research with range cattle has shown two intensive grazing periods, one at daybreak for three to six hours and another again in the afternoon with less intensive and intermittant grazing occurring at other times of the day and night. In the Northern Great Plains, many stockmen feed protein or energy supplements early in the morning during the fall-winter months. This activity coincides with and disrupts normal grazing

activity, but little is known about its effects on the performance and behavior of foraging beef cattle.

Crossbred yearling steers (average weight = 645 pounds) were assigned to three supplement treatments. Treatments consisted of (1) Russian wild ryegrass only (forage only) and forage only plus .3 pounds of cracked corn/100 pounds of body weight fed to steers individually at 7:30 AM or 1:30 PM daily (treatments two and three respectively). The study began September 1 and continued for three 28-day periods. Observations of time spent grazing, ruminating, standing or lying were taken by technicians at five minute intervals over 24 hours on one steer from each treatment group on day 21 of each period. A different steer was observed in each period. Total fecal collections were made on days 22 through 28 of each period and esophageal fistula samples were collected during each total collection. In vitro dry matter digestibility of fistula forage samples and total fecal collections were used to estimate forage intake.

A summary of the behavior data is presented in table 2. The A.M. supplemented steers grazed .6 hours more/day than those receiving forage only and 1.7 hours per day more than the steers receiving supplements in the afternoon. Supplemented steers did not graze for 2 to 4 hours following supplementation but compensated by shifting grazing activity to other time periods of the day compared to those steers not receiving any supplementation. Time spent ruminating and standing were similar for steers in all treatment groups. Time spent lying down resting tended to be greater for steers receiving the P.M. supplement than steers in the other treatment groups.

TABLE 2. BEHAVIORAL DATA OF STEERS ON FALL SUPPLEMENT TREATMENTS.

	Treatment		
Activity [a]	Forage only	A.M. supplement	P.M. supplement
Grazing, hours/day	8.4	9.0	7.3
Ruminating, hours/day	7.0	6.9	7.1
Standing, hours/day	4.2	3.7	4.1
Lying down, hours/day	10.5	10.3	11.3

[a] Activities do not sum to 24 hours because ruminating occurs while steers are standing or lying and time spent in activities such as eating supplement are not presented in the table.

Forage intake was more for steers not receiving any supplement than it was for those supplemented and was more for steers receiving the P.M. supplement than for those receiving the A.M. supplement (table 3). Differences in forage intake and time spent grazing between steers in the three treatments indicate that ingestive behavior was altered or that rate of intake

was not consistent for steers among the treatment groups. These data also indicate that steers supplemented in the P.M. were substituting corn for a similar weight of forage and that corn probably depressed forage intake of steers supplemented in the A.M. beyond that observed for the P.M. steers.

TABLE 3. INTAKE AND PERFORMANCE DATA OF STEERS ON FALL SUPPLEMENT TREATMENTS.

	Treatment		
Item	Forage only	A.M. supplement	P.M. supplement
Forage Intake[a], (pounds/day)	20.0	16.8	18.7
Forage intake + corn[a], (pounds/day)	20.0	18.7	20.6
Average daily gain, (pounds/day)	1.4	1.4	1.8

[a] Adjusted for body weight.

The average daily gain for steers not receiving any supplement and A.M. supplemented steers were similar (table 3), but average daily gain was about 30% or .4 pounds/day greater for steers supplemented in the P.M. than for those in the other treatment groups. Activities such as grazing, standing, etc. require an energy expenditure by the steer so alterations in behavior can affect their energy requirements. A higher energy requirement reduces the energy in the diet that is available for gain. The combination of reduced forage intake and an increased energy expenditure for grazing of the AM steers may explain differences in performance between the AM and PM supplemented steers. These data indicate that disruption of normal grazing activity by supplemental feeding has a marked affect on animal behavior and performance. It also indentifies an important need for additional research to determine the effects of management practices on the behavior and performance of grazing livestock.

CUBED ALFALFA HAY AS A PROTEIN SUPPLEMENT FOR COWS GRAZING FALL-WINTER RANGE

R. C. Cochran and D. C. Adams

The supplementation of cattle wintering on native range in the Northern Great Plains is a common and frequently costly practice. Present economic constraints dictate the need to maintain desirable levels of production while minimizing economic inputs. Minimum economic input implies maximizing the use of the most economical feed resources available. For stockgrowers in the Northern Great Plains, native range forage is typically the most economical feed source. Protein supplements have been shown to improve forage digestibility and intake, thus maximizing forage utilization. In contrast, energy

supplements have been shown to decrease forage utilization by depressing forage digestibility and intake. Alfalfa is a protein rich feed which is frequently available to the rancher (it is often grown directly on the ranch). Compared to traditional protein supplements such as barley cake, cottonseed meal, soybean meal, etc. alfalfa possesses an economic advantage in that it generally costs less. Therefore, a study was initiated to evaluate the performance of wintering cows supplemented with low levels of alfalfa compared to those supplemented with a more traditional protein source (cottonseed meal-barley cake).

During the fall-winter of 1982-83 and 1983-84 cows were assigned to one of the following three treatments:

1) Forage only - no supplement

2) Cubed alfalfa hay - fed to supply 50% of the cows crude protein requirements (approximately 2.5 lbs/head/day).

3) Cottonseed meal-barley cake - fed to supply the same levels of protein and energy as the alfalfa (approximately 2.0 lbs/head/day of a 30% CSM - 70% barley cake; levels calculated for a 1000 lb cow).

Data collected on each cow included a body condition score or degree of fatness taken at the beginning and end of the trial and a biweekly body weight measurement. Trial periods extended from November 3 to January 25 during 1982-83 and from October 4 to January 24 during 1983-84. Forage intake and digestibility data were also collected during the 1983-84 period, however, laboratory analyses have not yet been completed.

Data analysis for cows grazing moderately hilly native range indicates supplementation with alfalfa results in equal or improved performance compared to cows consuming forage alone or forage plus cottonseed meal-barley cake (table 1).

TABLE 1. COW PERFORMANCE ON MODERATELY HILLY NATIVE RANGE.[a]

	1982-83			1983-84		
Item	A	CSM/B	FO	A	CSM/B	FO
Weight change[c] (lbs)	12.3	-37.9	-67.3	52.6	28.2	-97.3
Condition score[b] change[c]	-.4	-.5	-.6	.6	.2	-1.2

[a] A = Alfalfa, CSM/B = Cottonseed meal-barley, FO = Forage only.
[b] Condition score ranked from 1-10; 1 = thinnest, 10 = fattest.
[c] All values are reported as the difference between beginning weight or condition score and that recorded at the end of the trial.

How cattle respond to supplementation appears to vary with the severity of winter. There were larger differences between cows receiving protein

supplements (CSM/B or A) compared to those consuming forage alone during more severe winters (e.g. 1983-84). However, even during a moderate winter (1982-83) differences between the treatment groups appeared substantial.

Type of pasture may also affect how cattle respond to supplementation. A similar experiment was conducted simultaneously on another set of pastures which had a history of being able to support larger numbers of animals (or to produce an increase in animal performance when stocked at rates similar to those pastures referred to in table 1). The cause for the increased response on these pastures is unclear, but may relate to more complete forage utilization due to the level topography. Cow performance (table 2) on these more productive rangelands was not improved by supplementation during a moderate winter (1982-83).

TABLE 2. COW PERFORMANCE ON MORE PRODUCTIVE RANGELANDS[a].

	1982-83			1983-84		
Item	A	CSM/B	FO	A	CSM/B	FO
Weight change[c] (lbs)	54.2	57.7	67.3	87.5	75.2	-1.2
Condition score[b] change[c]	-.2	-.1	-.2	.5	.1	.1

[a] A = Alfalfa, CSM/B = Cottonseed meal-barley, FO = Forage only.
[b] Condition score ranked from 1-10; 1 = very emaciated, 10 = very fat.
[c] All values are reported as the difference between beginning weight or condition score and that recorded at the end of the trial.

However, during a more severe winter (1983-84) there were large differences in the weight change of protein supplemented cows compared to those consuming forage alone. In both periods, supplementation with alfalfa appeared to yield similar results as supplementing with a more expensive cottonseed meal-barley cake.

Given adequate forage availability, a third year of performance and intake data will be collected during the fall-winter of 1984-85. In addition, rumen cannulated steers will be subjected to the same treatment conditions in an effort to understand relationships between digestive processes, rates of particulate and liquid passage, forage intake and protein supplementation.

COMPARATIVE EVALUATION OF MECHANICAL, CHEMICAL, AND BURNING PRACTICES FOR PLAINS SILVER SAGEBRUSH CONTROL

Richard S. White and Pat O. Currie

Mechanical, chemical and burning practices are all effective methods of reducing plains silver sagebrush (Artemisia cana cana) on rangelands. Since many factors have a bearing on which technique is most effective, no single

method can be recognized as superior. In this report, we have summarized more than 5 years research data on silver sagebrush control and have identified some of the variables that should be considered in selecting a method.

Silver sagebrush is geographically widespread in western rangelands of the United States and Canada, occupying some 33 million acres. Among sagebrush species, it ranks second to big sagebrush (Artemisia tridentata) with respect to area occupied. In the Northern Great Plains of North America, silver sagebrush usually grows on highly productive soils that have considerable forage production potential. When infestations become severe, forage productivity is reduced; and livestock access to available forage is restricted. Ground cover can also be reduced and accelerated soil erosion increased. Under these circumstances, brush control practices are desirable. In contrast to big sagebrush, silver sagebrush presents distinct attributes that make it much more difficult to control. It can resprout from adventitious buds after the tops have been killed, and it commonly produces daughter plants from underground rhizomes.

Traditional methods employed through the years to control Artemisia cana include grubbing, chopping, scraping and treatment with herbicides. Hand grubbing is effective but economically prohibitive. Scraping plants on frozen ground with a bulldozer in winter is commonly practiced, but it is seldom very effective. Chemical treatment with 2,4-D has produced mixed results. Sometimes good results are obtained, but more frequently plants are simply top-killed. Additional research efforts have been needed to establish effective alternative control methods; but this need had been generally neglected until our research efforts were initiated about 5 years ago.

This report has two principle objectives: (1) to summarize the brush control techniques that we have examined during the past 5 years; (2) to identify and discuss some of the factors that should contribute to selection of a control method.

Research work at the Ft. Keogh Livestock and Range Research Laboratory has focused upon three principle methods of controlling plains silver sagebrush. These have been burning, mechanical cutting, and herbicide application. Burning research compared the effects of fall and spring treatments. Mechanical cutting at two week intervals between April and October was examined to evaluate the effects of cutting date and phenological development on mortality. Herbicide application of tebuthiuron or picloram was evaluated to determine if low herbicide amounts are effective in reducing plains silver sagebrush. All techniques achieved good results under some conditions and poor results under others.

Fall burning was more effective than spring burning in killing plains silver sagebrush. When fire intensity was sufficient to burn stems and foliage completely, kills of 72% were achieved. When only the foliage was burned and stems remained standing, mortality was about 40%. Comparative results for spring burning resulted in death of 38 and 10% of the plants, respectively, for the same burning intensities. Burning is best conducted in the fall, therefore, when fuel conditions are favorable for generating intensive fires. The primary advantage of burning is that it is usually more economical than

other methods and is effective on both large and small plants. The potential hazards of fire escaping must be considered, however, and this may necessitate additional manpower. Furthermore, potential forage is temporarily lost, and burned areas may need grazing deferment.

Mechanical cutting of plains silver sagebrush was practical as a control measure only during June and early July. This corresponds to the time of year when plants were undergoing rapid shoot elongation. When plants were cut in June, mortality of 50% was achieved regardless of plant size. However, considerably higher mortality was observed in smaller plants. Kills of up to 67% were obtained in plants that were 0.25 m^3 (12-13 inches ^{3}) or less in crown volume, and the technique was generally effective for plants that were 1.00 m^3 (39-40 inches ^{3}) or smaller. Mortality was much less for larger plants (>1.00 m^3) and for all plants treated in April and May or between late July and October. Kills ranged between 8 and 25%. The technique is best suited, therefore, to smaller plants that can be cut when they are actively growing. Mechanical cutting is readily applicable to small areas or in situations where larger areas will be treated on an intermittant basis. It has limited value in large-scale brush control operations because it is relatively expensive. The practice is not suited to rough terrain, and it requires specialized equipment (rotobeater or brush hog) that may not be economical on smaller ranches.

Single applications of either tebuthiuron or picloram in a pelleted formulation was effective in reducing plains silver sagebrush cover for at least a 5 year period. As such, the technique offers long-lasting effects. Application rates of 1.7 kg/ha seemed to provide the best balance with respect to brush and herbaceous response. Higher rates resulted in excessive death of herbaceous species, while lower rates had sub-optimum effects on shrubs. Chemical control was effective on both large and small plants. It could be effectively used on any size area, although specialized equipment would be needed for aerial application on larger areas. Tebuthiuron was most effective on undisturbed sites with large, mature plants. It was less effective on disturbed sites where resprouts were less than 5 years old. Time of herbicide application was not crucial, but precipitation shortly afterwards is important to obtain optimum soil incorporation.

At least three additional general constituents are important with respect to selection of a method to control silver sagebrush. They are: treatment efficacy, economics, and personal preference. Each must receive due consideration prior to final selection.

None of the methods that we examined were 100% effective in controlling plains silver sagebrush. Nevertheless, good mortality of about 70% was attainable with each of them according to individual circumstances. This is sufficient, therefore, to justify using any one practice for brush control purposes.

Selection of a specific method would be dependent upon individual field circumstances as alluded to previously. For example, if plants were large or the terrain rough, mechanical control would probably not be the chosen method.

Economic considerations are important with reference to cost-benefit relationships. Unfortunately, the benefits that can be realized from brush control pratices have not been well defined. The primary unanswered question pertains to how much increase in forage production or availability can be realized by proportional decreases in silver sagebrush cover. We are currently attempting to ascertain some of these relationships although factors such as amount of precipitation, plant density, and forage species can alter the observed response considerably. Currently, it is possible to evaluate benefits only on a relative basis. The assumption must be made that a uniform forage response will be observed along with a given reduction in brush cover. When this is done, burning appears to be the least expensive control method, and mechanical cutting seems to be the most expensive. However, it should also be recognized that factors such as the size of the treated area, shrub density, and accessbility can have a substantial effect on the actual cost per unit area.

Personal preference will most frequently be the deciding factor in selecting a brush control method. Previous experience is an important factor in this regard. The choice that is made by a professional manager on public land might be entirely different than the one by a rancher on private land. Factors such as individual brush control objectives, degree of infestation, amount of management flexibility, type and intensity of management, and time available for imposing treatments will all have a bearing on the method that is implemented.

In summary, we have determined that burning, mechanical cutting, or chemical treatment can be used to control plains silver sagebrush. Selection of a control method should consider each option that is available and should evaluate carefully some of the factors that may influence that choice. We have attempted to elucidate some of these variables.

FACTORS AFFECTING REPRODUCTION IN PLAINS SILVER SAGEBRUSH

Todd P. Walton[1], Richard S. White, and Carl L. Wambolt[1]

Shrub control is an important consideration in the management of many Northern Great Plains rangelands. Once this objective has been achieved, it is equally important to maintain plant communities in as productive a condition as possible, while minimizing the amount of shrub reinvasion that occurs. In plant communities dominated by plains silver sagebrush (Artemisia cana cana), this is a particularly difficult task because the plant reproduces by both vegetative sprouts and seeds. To complicate matters further, there is only a limited understanding of some of the mechanisms that contribute to successful reproduction in the plant. Therefore, during the past two years, intensive research efforts have been underway to gain insight into how environmental factors affect silver sagebrush reproduction.

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This study was designed to gain a greater appreciation of plant population dynamics and to enhance the limited biological information available for plains silver sagebush. Specifically it investigated reproductive characteristics and mechanisms important in plains silver sagebrush. In particular, studies examined: (1) seed dispersal from individual plants and among sites, (2) factors affecting seed germination, (3) emergence, growth and survival of seedlings under growth chamber, greenhouse, and field conditions, and (4) whether the primary origin of individual plants was from seed or vegetative sprouts. Hopefully, results from this study will assist range managers in making more informed management decisions regarding habitats or areas where this species is a constituent.

Wind appears to be the most influential factor in the dispersal of seeds from plains silver sagebrush plants. A three-lobed stellar distribution of dispersed seed was observed. The largest proportion of seed was dispersed downwind in direct line with the prevailing northwest wind, but secondary areas of seed deposition were also found upwind at 120° on either side of the primary line. The mechanism for this type of distribution is unknown. Dispersal in these secondary regions was, at times, more prevalent depending on date and associated winds (or storms). Most seed was dispersed close to, or under, the shrub. However, in at least one case the largest proportion of seed was dispersed up to three meters (10 feet) from the parent plant. In this instance, seed was evenly dispersed out to three meters with little decrease in dispersed seed until the three meter distance was reached. Seed numbers then dropped off sharply.

There were no major differences in dispersal patterns among three different study sites, but plant phenology was sufficiently variable so that the majority of seed fell at different times depending on site. In one site, dispersal was evenly distributed throughout the study period due to heterogeniety of phenological development. In the other two sites there were well-defined dispersal peaks in late fall.

Plains silver sagebrush seed can germinate under a variety of environmental conditions, but definite situations did favor higher germination percentages. Stratification had no effect on germination success, probably due to seed not being dormant and therefore not requiring any dormancy breaking cold treatment. However, there may have been some inherent stratification present because of cold temperatures during the late fall and early winter when seeds were collected from the field. Date of seed collection, light and dark regime, temperature, and water stress had important influences on germination success, but sagebrush seeds were not noted to have specific germination requirements.

Higher germination percentages were observed in later seed collection periods. Most seeds germinated in complete darkness than in light except when they were under no water stress. Temperatures of 20 C (68°F) were generally most favorable for germination. However, on the last seed collection date, seed germination at 10 C (50° F) was not different from germination at 20°C. Rates of germination increased as temperature increased. Germination percentages and rates dropped off steeply under the influence of more negative osmotic potentials. Light-affected seeds in the 10°C temperature regime showed

favorable germination, but under dark conditions, 20° C became more important with slower rates than in light. Heterogeniety in the seed population was probably the most important variable explaining the germination results of this study. As combinations of factors such as temperature, osmotic potential or light changed, this heterogeniety allowed at least some seeds to germinate.

After seeds have germinated, the environment that the seedling is subjected to determines how successful that seedling will be. Temperature was found to be important in the growth of seedlings. Higher temperatures that had adverse effects on germination favored seedling growth. This might be expected because higher temperatures are normally present in the later stages of the seedling growing season. Seedling response was enhanced by the addition of supplementary water. More seedlings emerged and survived throughout the summer. Seeds that had been planted at 5 mm (1/4 inch) produced the most seedlings in the field, while those at the surface and at 15 mm (5/8 inch) produced about the same numbers. Mortality was greatest among seedlings emerging from 5 mm and the least for those emerging from 15 and 25 mm (1 inch).

On a quantitive basis, seedling size was relatively unaffected by additional water, but recognizable growth patterns could be discerned. Watered seedlings showed somewhat greater growth, especially from the 5 and 25 mm planting depth. Burial places the seeds in a less severe environment in terms of temperatures and water stress. Despite the large number of seeds that were planted, very few seedlings emerged in the field (1.2%), and of these only 11 percent survived the summer.

The degree to which plains silver sagebrush relies on vegetative reproduction was etablished by root excavations. Plains silver sagebrush in almost all cases showed some degree of rhizomatous growth even among small seedlings. However, most excavated individuals turned out to be sprouts from an already established plant. Ages of aboveground shoots were younger than any belowground roots or rhizomes, while the oldest plant segments were parent rhizomes to which individual plants were connected. Most growth was belowground and was represented by subsurface lateral extension of rhizomes and rhizome systems. On average, this lateral spread was 3 1/2 times that of the shoot height. The largest proportion of rhizomatous connections to parent plants or larger rhizomes were 50 (20 inches) to 100 cm (40 inches) in distance. No differences could be found between disturbed or undisturbed sites. This was most likely due to drought conditions overriding any effect of disturbance.

In excavations of large, isolated plants, the large degree to which sprouts arise from rhizomes was evident. These "individual" plants were composed not of one, but an aggregate of clonal systems indicating a great potential for vegetative reproduction.

RANGELAND IMPROVEMENT MACHINE (RIM)

P. O. Currie, R. S. White, and L. R. Erickson[1]

A prototype Rangeland Improvement Machine (RIM) was developed for interseeding rangeland or renovating problem marginal farmland. The unit tills the soil, forms a vee-trough seedbed and plants in a single-pass operation. Soil tillage is accomplished with a rototiller. A packing wheel assembly forms continuous, packed furrows on farmland. On rangeland, the furrows have intermittent check dams for water retention and control. Furrows are large enough to retain water and remain intact for a number of years but small enough to minimize field traffic problems. Various types and combinations of seed and fertilizer can be planted and applied with the modified all purpose drill.

A first and second generation RIM has received field testing. Figure 1 shows a side view of the current RIM showing its component mechanisms. On both generation machines, the rototiller operates from the PTO of the tractor. A tractor rated at 80 - 120 KW (100 - 150 drawbar horsepower) has been used for the power source. Rototiller tines and packing wheels are selectively added or removed to create tilled strips for the drill unit. The packing wheel frame is mounted directly behind the rototiller and the drill immediately behind the packing unit which provides for good drill tracking in the packing wheel furrows. The main frame has transport wheels that are retracted for field work (figure 2). A weight box was added to ensure sufficient down pressure on the packing wheels. Packing wheels are individually attached to a common axle to allow for row spacing adjustments. A 5" (13 cm)-deep vee trench with check dams every 7.6' (2.3 m) is formed by each packing wheel during seedbed preparations on rangeland. A removable insert for the wheel notch is put in place so that continuous furrows can be made on irrigated farmland (figure 3).

A modified commercial drill is attached to the rototiller-packing wheel frame. A "float" position is provided on the hydraulics for the tiller and drill so that the tiller can creep over rocks and the drill will follow ground contours and not be forced into the soil. All meters on the drill are driven by an end-wheel ground-drive system. Provisions have been made to close off unneeded meters in each hopper on an individual basis. The end wheels are necessary to support the drill, since the opener springs do not provide down pressure. The end wheel is spaced so it can ride in a furrow from the previous pass during full-width tillage on irrigated land. Narrow single-rib tires are used to prevent damage to the furrow. On rangeland with intermittent furrows, this is not a consideration.

Double-disc openers with specially-developed depth bands on both sides of the openers are used to control seed placement. The depth bands ensure a seeding depth of 1/2 - 3/4" (1 - 2 cm) which is essential for good grass stand establishment. Seeds are fed through drop tubes from each of three boxes into the disc openers through a specially-developed drop tube manifold that merges

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the three separate tubes. To prevent destruction of the intermittent check dams, the opener springs are not used on rangeland. Shallower-than-normal seeding depth caused by low down pressure on the openers has not been a problem because some natural erosion in the furrow tends to cover the seed, and a shallow planting depth is usually desired. The openers are followed by standard 2 x 13" or 1 x 10" (5 x 33 cm or 3 x 25 cm) rubber-tired seed packing wheels.

There are four boxes on the drill, and drive sprocket ratios are changed to vary application rates from each of the boxes. The front box on the drill is for granular fertilizer which is independently metered and top dressed in front of the double disc openers. The second box is for grass seeds. This unit uses a picker-wheel metering assembly on which the seeding rate is adjusted by varying the drive sprocket gear ratios. Drop tubes are directly over the double-disc openers to ensure uniform grass seed flow, accurate placement and to avoid bridging by light or fluffy seed. The third box is for small seeds or legumes and has a fully adjustable fluted metering system. These seeds are also fed through the double-disc openers. The fourth box is for small grains. Drop tubes from this box travel at a considerable angle to reach the openers. This has not been a problem, since the weight and geometry of small grains seeds ensures transit through the tubes.

Rangeland Use:

The RIM was primarily designed for seeding native and introduced species into semi-arid rangeland of the Northern Great Plains. This type of work would normally be done on the contour with row spacings 20 - 60 inches (50 - 150 cm) apart, depending on species, land form or other conditions. Rototiller tines, packing wheels, seeding meters, and drill openers in rows that are not being used are removed or deactivated.

The tractor operator follows previously established contours with the unit, creating a seeded and/or fertilized contour furrow with intermittent check dams. Some operator discretion is required to maintain the machine on contour, and to make layout decisions where contours come together or diverge because of landform or field irregularity.

Farmland Use:

The RIM can be used to establish continuous furrows for irrigation purposes by filling the notch in the packing wheel. For establishing completely new pastureland, all 10 furrows would normally be used, creating a fully tilled field. Opener spring down pressure can be increased if desired, as there are no check dams to preserve.

RIM FIELD TRIALS AND EXPERIMENTAL PLOT ESTABLISHMENT:

The units developed and described have been effective for renovation of semi-arid rangeland and marginal pastureland. Modifications are being made as needed to improve machine performance. Test plots established with the first generation machine in 1981 on irrigated saline soils and plots established in 1982 on upland rangeland sites have both been successful. Additional plot

work, testing, and evaluation is in progress or was made on some rockier soils in western Montana in 1983 using the second generation machine.

A problem, saline bottomland pasture at the Fort Keogh Livestock and Range Research Laboratory at Miles City, Montana was treated in September 1981 to evaluate the RIM's potential for reclaiming marginal pastures. The unit was used to till this field on tests for plant establishment at different times of the year. A well-tilled soil with a firm seedbed was accomplished under good moisture conditions. No power train or rototiller clutch-related problems were encountered during stand establishment when soil moisture levels were optimum and averaged 20 - 25 percent. However, the rototiller clutch was overloaded when the full-width unit was worked on this heavy clay sod when moisture was limited and the soil dry. Also, "gumming" of the clay into large balls around the tines occurred if the RIM was used when soils were wet.

Planting in the bottom of the furrow was most beneficial under the existing saline conditions. Soil moisture in furrow bottoms remained high, which improved seed germination and establishment. Also, evaporation tends to be more rapid and occur at the ridge crests between rows, which results in a saline crust frequently being developed at the ridge crests. Furrows established in the gently-sloping, unleveled field showed some signs of moderate washing at the lower end of the quarter-mile-long field. However, these individual furrows held up reasonably well for two years under irrigation and showed a vee profile with 10" (25 cm) between ridge crests and a furrow depth of about 3 - 4" (7 - 10 cm). Excellent grass and grass-legume stands were established from all of the RIM tests made.

On rangeland, the unit was not used until the spring of 1982 because of severe drought conditions at the test sites. Eight blocks of 30 acres (12 ha) each were established at two separate test sites to test seven different treatments and a control. The renovated range sites are typical of many areas in southeastern Montana. They were in poor to fair condition, typified by presence of sagebrush, low-growing cactus, blue gramma grass, and other drought-tolerant species of low forage value. One site is on a well-drained silty clay loam with rolling contours. The other site is on a heavy clay panspot area.

Treatments established included the following: 1) control (no treatment); 2) contour furrowed and seeded to alfalfa and cicer milkvetch; 3) RIM treated, seeded to the legumes, and chopped or sprayed with herbicide for brush control; 4) RIM treated and seeded to the legumes; 5) RIM treated and fertilized; 6) RIM intertilled, and packed only; and 7) & 8) RIM treated, seeded to legumes, sprayed with herbicide for brush control, and grazed on an alternate season basis. The entire experiment covers approximately 480 acres (190 ha) of rangeland. Again, good to excellent two-year-old stands of alfalfa and cicer milkvetch have been interseeded and established within native range plant communities.

CONCLUSIONS

To date, field work has been an effective test of machine concept and machine components. The machine performs according to the initial concept when soil

moisture conditions are good. A number of rototiller tines have been worn out but breakage has generally not been a problem even on the rockier test site in western Montana. A firm vee-shaped seedbed with relatively solid check dams is created by the packing wheels. As the soil moisture level drops, the furrows and check dams become softer. Scrapers are required on the packing wheels and the double disc drill openers to prevent soil accumulation when soils are moist and ideal for planting. Also, soil bodies build up in the packing wheel notches and must be removed periodically, particularly on moister areas with heavier clay soils.

Mechanical components of the first generation prototype machine were rigorously tested in establishing the research treatments. Several structural components were damaged or failed during field tests, and have been modified, strengthened, or replaced in the current RIM. The wear and fatigue problems were attributable to stresses imposed by severe operating conditions.

The present machine weighs approximately five tons and each main component is relatively heavy. The drill weighs about 2500 lb (1100 kg) when fully loaded, and is normally lifted to make sharp turns at the ends of the field. The packing wheels and frame weighs over 1500 lb (680 kg) and the weight box adds another ton, to the unit. All of these components plus the tiller are raised and supported by the transport wheels during turns and road transport. Modification of some of these items on the second generation machine has alleviated earlier stress problems. Testing will continue with this second generation research machine.

Figure 1: Overview of RIM in transport position showing component configuration

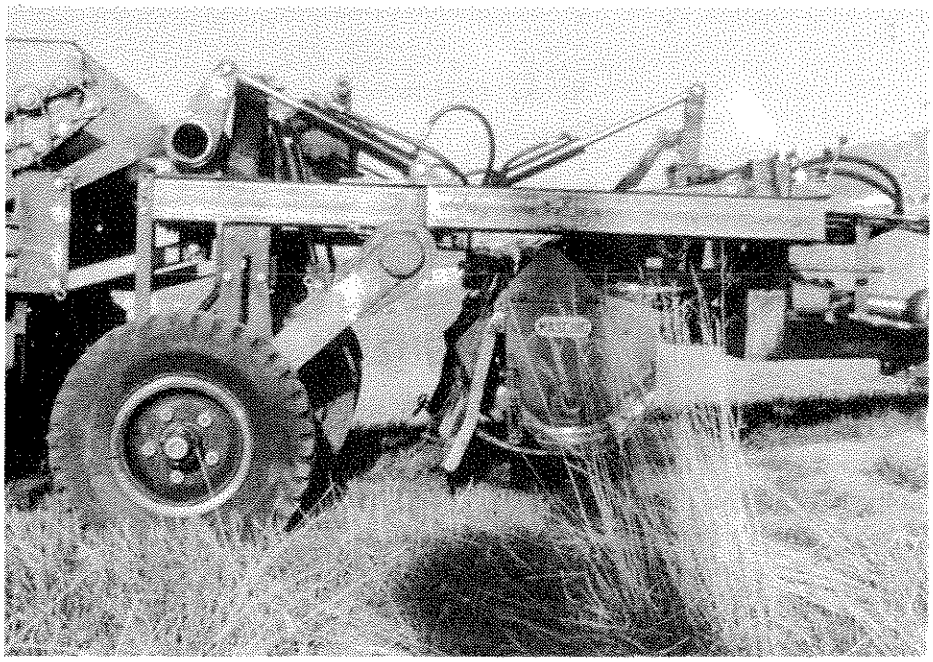

Figure 2: Closeup of main frame configuration showing hydraulics and lift configurations for tiller, transport wheel and drill.

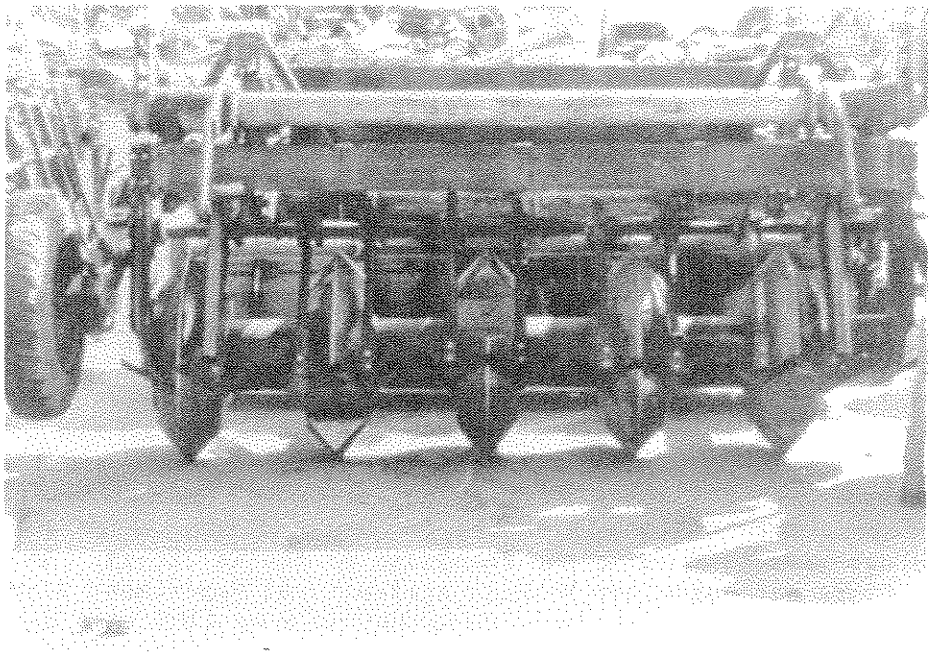

Figure 3: Packing wheel unit with arrangement for alternate row tillage with "cutouts" removed to form check dams on contour tilled native range.

FORT KEOGH LIVESTOCK AND RANGE RESEARCH STATION

R. A. Bellows

Congress established the Fort Keogh Military Reservation, July 22, 1876. This followed the massacre of Custer's 7th Cavalry in the Battle of the Little Big Horn on June 24, 1876. Fort Keogh was named after Captain Myles Keogh, an adjutant to General George Custer, killed in the Battle of the Little Big Horn. Establishing and early development of Fort Keogh was under the direction of General Nelson A. Miles. This was a colorful historical era and the town of Miles City was named after General Miles.

In 1907, all infantry troops were withdrawn and in 1910 Fort Keogh became a Remount Station for the U. S. Army. This Remount Station was very active in World War I and during this period more horses were processed here than at any other army post in the United States. Horses were shipped worldwide. In 1922, the Army relinquished control and in 1924 the U. S. Range Livestock Experiment Station was founded by an act of Congress. Fort Keogh Military Reservation was transferred to the Department of Agriculture making it possible to undertake agricultural research in cooperation with the Montana Agricultural Experiment Station. Since that time, the Station has been under the direction of seven superintendents: Mr. J. W. Swartz, 1924-1926; Mr. J. R. Quesenberry, 1926-1962; Dr. N. M. Kieffer, 1962-1964; Dr. O. F. Pahnish, 1964-1976; Dr. R. R. Woodward, 1976-1979; Dr. R. A. Bellows, 1979-1984; Dr. P. O. Currie, 1984 to present. The Station name was changed to the Livestock and Range Research Station (LARRS) in 1977 and to Fort Keogh Livestock and Range Research Station in 1983.

The size of the original Station was 100 square miles or 64,000 acres. The Station now consists of 55,300 acres. In 1878, a large piece of land east of the Tongue River was released by the Army and is now the present site of the City of Miles City. Since that time, additional land has been released for the Miles City industrial sites, Custer County fairgrounds, the warm-water fish hatchery and Spotted Eagle Recreation Area. Approximately 1,600 acres are under irrigation in the Yellowstone River Valley west of the Station headquarters. The remainder of the Station is rough, broken badlands typical of range cattle producing areas of the Northern Great Plains. All land areas are used for research studies or for production of feed for research animals.

The beef breeding herd ranges from 1100-1650 cows yearly, maintained in 30 to 50 breeding herds. In 1979, there were 3250 head of cattle on the Station and there were 1681 cows bred in 72 separate sire groups. This was the largest cattle inventory in the history of the Station. Replacement heifers, young bulls and steers, herd bulls and cattle on reproduction, range nutrition or range forage experiments make up the remainder of the inventory. In addition, about 50 acres are set aside for Montana Agricultural Experiment Station swine research. The number of swine range from 200 to over 1700 head depending on the time of year. Approximately 150 females are bred yearly. All animals on the Station are owned by the Montana Agricultural Experiment Station.

Station research studies involve a total of 50 permanent, full-time employees. Twelve of these positions are with the U. S. Department of Agriculture, which includes 10 professional scientists, and 38 positions are with the Montana Agricultural Experiment Station. An additional 10 to 20 temporary positions are used to support research studies depending on time of year and project needs.

The early Station was a widely diversified unit. There were 1200 Rambouillet ewes on experiment during the early days. Ewes and lambs were on breeding and feeding experiments and wool studies. All sheep were transferred to the U. S. Sheep Experiment Station, Dubois, Idaho, in 1941.

There was also a Milking Shorthorn dairy herd maintained on the Station. The milk was sold to the employees, but the animals were not used extensively for research purposes. The herd was dispersed in the late 1930's.

There have also been many horses on experiments. In 1934, the inventory showed 250 head on breeding, feeding and reproduction studies involving pure-bred Belgian, Morgan and Thoroughbred sires. Some of the early work to develop successful semen collection and artificial insemination techniques in horses was conducted at this Station. The Thoroughbred breeding herd was maintained until 1964. There are now 30 to 40 horses on the Station that are used entirely in cattle-moving operations.

Research on turkeys has also been conducted at the Station. Studies with Bronze turkeys started in 1929 and involved approximately 1500 young turkeys and 350 breeding hens. Studies consisted of feeding, breeding and rearing experiments, and the original crosses and the early work leading to the development of the Beltsville White breed were made here.

SWINE RESEARCH

The early swine work was directed largely toward production of Wiltshire Sides for the European pork market. In 1930, pork from the U. S. Range Livestock Experiment Station was reported to be the best American Wiltshire Sides on the London market. The swine work is most famous for the development of the Montana No. 1 breed. This was produced by crossing the Danish Landrace and the Black Hampshire breed. The crosses were inbred and through selection, one of the first meat-type breeds was developed. Federal funding for Station swine research was terminated in 1968 and, since that time, swine work has been directed by staff members in the Animal and Range Sciences Department at Montana State University. Work involving the Montana No. 1 and the Yorkshire breeds was terminated in 1971 and a crossbred herd was established to supply animals for studies directed by Montana State University nutritionists.

Swine nutrition research deals largely with questions or problems faced by Montana swine producers. Studies have been completed on determining the feeding value of six varieties of barley commonly produced in the State. All appeared to be essentially of equal value. Other studies have been conducted to evaluate the effects of various antibacterial drugs and agents on rate of gain and feed efficiency. Work has also shown that barley-based rations supplemented with safflower or linseed meal can be used to produce pork at an

equal or lower cost than corn-based rations supplemented with soybean meal. Studies have also been conducted to evaluate alternate sources of protein such as mustard meal or faba beans in barley-based meal rations. Results indicated that mustard meal could be used to replace up to 5% of the protein supplement without reducing gain and feed efficiency. Amino acid supplementation has also been studied and indicates lysine or methionine fed either separately or in combination can replace up to 5% of the soybean meal in growing rations and all the soybean meal in finishing rations.

Recent work has involved effects of mineral, vitamin and amino acid supplementation on efficiency of pork production. Rations containing 0.6 to 0.8% supplemental phosphorus gave higher gains than when no phosphorus was added. However, there appeared to be no difference among four phosphorus sources investigated. Additional mineral and vitamin work was designed to study the effect of supplemental manganese and biotin on the incidence of spraddle- or splay-legged pigs. Current research is evaluating protein requirements for barrows and gilts fed separately or in mixed groups. Current studies also include synchronization of estrus and artifical insemination. This work is cooperative with USDA scientists at Beltsville, MD. A new phase of genetics work is now evaluating if selection of boars for productivity in a purebred population results in maximum productivity of the boar's crossbred offspring.

BEEF CATTLE RESEARCH

The broad goal of the beef research program at this Station is to increase the efficiency of beef production from cattle maintained in a range environment. The work involves research studies in the areas of animal breeding, physiology of reproduction, animal nutrition and range pasture development, improvement and management. In addition, studies on various diseases have also been conducted. It is believed that scientists at this Station were the first to investigate methods for control of brucellosis that were applicable to range and semi-arid conditions. Other studies have involved determining methods for control of eye cancer and the effects of vaginal and uterine prolapse on cow productivity.

CATTLE BREEDING

Beginning in 1930, Station scientists pioneered in the development of methods for evaluating individual performance in beef cattle. All beef performance testing programs now active in the United States and much of the remainder of the world trace to these pioneering activities. Perhaps the most important contribution of these experiments was the determination of heritability estimates for economically important traits in beef cattle. This gave knowledge of the comparative influences of heredity and environment on performance and has greatly improved selection techniques.

The first large-scale linebreeding studies in beef cattle in the United States were initiated at the Station. A number of lines of purebred Hereford cattle have been developed and have been tested for production potential. These studies have resulted in the development of highly productive lines of cattle, Line 1 being the most famous. The objective of these experiments is to determine the improvement that can be made in a closed population of beef cattle

starting from a superior genetic base. The oldest line (Line 1) has not had an introduction of outside bulls or cows since 1934. Animals surplus to the research program are sold at an annual production sale, and animals from this line are now widely used in purebred and commercial beef herds throughout the United States. In 1980, Station scientists received a Superior Service Award from the USDA for development of this Line and the impact it has had on the Hereford breed.

One of the first findings in the linebreeding study was that linebreeding is profitable only when practiced with cattle that exceed the breed average for most production traits. Despite the fact that the original lines in the studies were selected from presumed top herds, many did not respond to linebreeding and had to be discarded. However, the success of several lines, notably Lines 1, 12 and 14, has proved that a linebreeding program, coupled with strict selection for performance, is an economically feasible method of improvement for beef cattle.

Semen was collected from Line 1 bulls in 1955, 1965 and 1975 and used for breeding within a common group of females. This work was conducted to determine the permanent genetic progress or change established through selection. Results indicated that selection permanently improved all economically important traits, and the improvements actually observed agreed closely with the predicted values based on heritabilities of the various traits.

The long-term linebreeding research involving Line 1 was modified in 1977 to include selection for low birth weights. Calving difficulty problems are increasing nationwide and high birth weights have been identified as the main contributing factor. This work is designed to determine if selection of replacement sires with below average birth weight offers promise in alleviating this problem. Thus, Line 1 has been sublined with one-half of the Line being maintained with low birth weight as an added selection criterion. To date, this selection has resulted in a 5% decrease in birth weight of bull calves, but this was accompanied by lower weaning weights and gains on test.

Several of the lines have been crossed in a study to determine if hybrid vigor or heterosis would result. This work has shown that the linecross animals excelled the average production of the parents for all economically important traits studied. The greatest increases were realized from crossing of the highest producing lines. Additional work has indicated that continued crossing of lines within the breed can result in increased production. However, results show that topcrossing a linebred sire on unrelated females is the most practical method of realizing increased production.

Other work with inbred lines of cattle indicates that the maximum improvement in weaning weight or yearling weight, for example, can be obtained by selecting replacements with high weaning weights or yearling weights, respectively. Cattle have also been involved in a study to determine what effect selecting herd sires with superior muscling and low back fat thickness might have on subsequent fat and lean composition in their progeny. Results indicated sires with lower back fat thickness produced offspring with a higher proportion of lean in the carcass.

A new selection study has been initiated and is designated the Selection Criteria Study. The work involves a Hereford herd of randomly selected males and females. The objective of this study is to determine the relationships among measures of growth and fertility in bulls, heifers and cows managed under range conditions in order to identify alternative selection criteria that can maximize total production by maintaining rapid growth rate accompanied by high fertility in both males and females.

A genetic-environmental interaction study started in 1961 involved exchange of cattle between Miles City and Brooksville, Florida. Results showed both herds performed best at their place of origin. These results suggest that seedstock for a specific environment should be obtained from a similar environment if optimum production is to be realized. This work further indicated that animals transferred to a new location go through an adjustment or adaptation period and that selection within the new environment will result in adapted, high-producing animals.

Several crossbreeding studies have been conducted at this location. The early work, started in 1935, involved Hereford, Angus and Shorthorn breeds with later studies, started in 1961, involving Hereford, Angus, Charolais and Brown Swiss breeds. These studies have shown breed crossing increased the number of calves produced, calf birth and weaning weights, yearling weights and a slight improvement in feedlot performance. Later work has shown increased production can be realized from three-breed crossing schemes but the increase is not as great as realized in the initial two-breed cross. The total production advantage over straightbreds for this two-breed cross averaged 12.6%, and 14.3% for the three-breed cross. Comparison of beef x beef crossbreds with beef x Brown Swiss crossbreds indicated the beef x Brown Swiss dams produced calves that were 10% heavier at weaning than calves from the beef crossbreds. Fertility in the beef x Brown Swiss crossbred cows was equal to the beef crossbreds. Carcass cutability was slightly higher in the beef x Brown Swiss steers but carcass grades were slightly lower.

Puberty information has indicated crossbred bulls and heifers are potentially fertile at younger ages than are straightbreds. Comparisons have also been made of feedlot performance of bulls and steers. Bulls had heavier weaning weights and continued to grow faster in the feedlot. Bulls required less time in the feedlot, were more efficient gainers, had a higher percentage of lean in the carcass, but produced lower grading carcasses than steers. Marketing and consumer acceptance problems must be overcome, however, before bull feeding can prove profitable.

The most recent crossbreeding study is designed to evaluate the crossbred female for performance as a brood cow under range conditions. The crossbred females being evaluated resulted from crossing Angus, Red Poll, Simmental, Pinzgauer and Tarentaise sires on Hereford cows. These females have been mated to Shorthorn sires as heifers and Charolais sires as cows. Results suggest that the forage available from ranges in semiarid areas is not adequate to permit large, high milk-producing breeds to perform at an acceptable level. The crossbred offspring produced are evaluated for growth performance in the feedlot and carcass characteristics but maternal breed effects have been small.

A new selection-crossbreeding study was initiated in 1979 to determine rate of progress when selection is made within a multibreed population. Three breeds are involved in this study, Red Angus, Polled Charolais and Tarentaise. The breeds were selected to compliment each other in terms of total productivity and results will be evaluated by determining effects on fertility and growth rate.

REPRODUCTION

The objective of research in reproductive physiology is to increase reproductive efficiency of range beef cattle. Areas of work are directed toward increasing the percent calf crop to optimum levels and in conjunction with the other disciplines at the Station, increasing the pounds of calf produced per acre and per cow exposed to breeding. It has been found that the largest single reason that cows do not wean calves is because they fail to become pregnant during the breeding season. The second most important reason is that cows lose calves at or shortly after birth. These areas are receiving major emphasis in reproduction research studies.

Approximately 15% to 20% of the beef breeding herd is replaced yearly. Thus, replacement heifers make up about one in every five to seven females in the breeding herd. Assuring a high pregnancy rate in replacement heifers is the objective of puberty research at the Station, and this work has shown that proper nutritional and genetic management of the heifer can increase conception rates by 20%. Simply feeding heifers in separate groups based on heavy or light weaning weights resulted in a 19% increase in pregnancy rate during the first breeding season with no increase in total feed costs. Station research has shown that feeding heifer calves monensin during the first winter following weaning hastens puberty. Additional work has shown heifers must be on a nutritional plane that will allow maximum skeletal growth so development of the pelvic opening will not be reduced and result in increased calving problems. Recent studies have shown puberty and conception can be induced in young heifers by hormonal treatments but altering day length (photoperiod) had no effect. Implanting heifers with zeranol (Ralgro®) increased gain but pregnancy rates were reduced. Use of Ralgro® in young bull calves reduced testicle size, thus use of this compound in potential breeding animals is not recommended. These findings are important, not only in terms of increased calf crop, but also because early puberty means potential early conception and calving. Research in this area expands the flexibility producers have in selecting programs for managing replacement animals.

Failure of cows to rebreed or rebreeding late in the breeding season results in a 15-25% reduction in potential pounds of calf weaned per cow exposed to the bull. Station research has shown that the major cause of this reduction is a result of poor nutrition during one or both of two critical periods. The first critical period is during the last 3 months of pregnancy. Inadequate energy intake during this period in pregnant heifers can result in a 20% reduction in calf crop with little effect on calf birth weight and no benefit in reducing calf losses due to calving difficulty. The second critical period is during the time after calving until adequate grass is available on native range (usually from March through May). Unless adequate nutrition is supplied

by proper supplementation or by providing pastures with early-season introduced grasses, cows will lose weight and have lower calf crops.

Calf losses at birth result in a major reduction in the net calf crop. Station data have shown 60% of these losses could be prevented by giving timely and proper assistance to dams experiencing difficulty during calving. In addition, Station research has shown that proper, early obstetrical assistance will reduce the rebreeding problems often encountered in dams that experience calving difficulty. Other studies have shown that the feed level during gestation or exercise of the pregnant dam have little predictable effect on calving difficulty. Calf birth weight is the most important causative factor associated with calving difficulty. But, results of Station research indicate 70% of the identified variation in calving difficulty are either present or are established at conception and that ranking of birth weight differences exist prior to day 200 of gestation. This is why little can be done to alter calving difficulty by changing factors during gestation and emphasizes the importance of adequate heifer development and wise selection of sires for breeding to first-calf heifers. Other Station studies indicate feeding pregnant dams in the evening resulted in 17% fewer calvings from midnight to 6 a.m. than when dams were fed at 8 a.m.

Suckling has a major delaying effect on the interval from calving to first postpartum estrus. The postpartum interval can be shortened by high levels of feeding, weaning the calf or by removal of the mammary gland. Additional data indicate suckling can alter the pulsatile release of luteinizing hormone from the pituitary gland and that these effects are quite different, depending on whether the cow is fat or thin. Extensive studies are underway to develop methods for determining body fat content in the live animal. This work is important because results are showing methods whereby we can assure a high percentage of lactating dams will rebreed.

Station research has shown that conception rates following artificial insemination can be increased over 6% by massage of the reproductive tract (specifically the clitoris) following routine A.I. Benefits resulting include more pregnancies and less semen used because of fewer services per conception. Estimates indicate benefits could increase annual income over $200,000 in Montana and over $4 million nationally.

Successful production of twins and triplets from beef cows has been accomplished at the Station. This research was among the first to successfully combine synchronization of estrus and drug treatments for superovulation (increased production of ova or eggs). Calf crops of up to 119% were produced following a single breeding compared to 70% in untreated cows. This work has the potential of increasing the calf crop without an increase in the number of brood cows in the herd. Station research has shown that if twin or triplet calves receive colostrum and are weaned at birth they can be successfully artificially reared on cold milk or cold milk replacer plus grain and hay. This practice results in the added bonus that the dams will return to breeding condition and become pregnant quickly following calving. Recent work is designed to develop methods to produce twins through use of embryo transfer. Superovulation is a critical part of any successful embryo transfer program, but results are often unpredictable. Research is underway to determine why

and to investigate mechanisms controlling growth of ovarian follicles and determine their response to hormonal stimulation.

Effective methods for synchronization of estrus with a high conception rate are definite possibilities. Recent Station results show a combination of a progestogen implant plus injected prostaglandin is the most promising. To date, studies attempting to synchronize ovulation so insemination can be made at a predetermined time, have been only partially successful.

RANGE NUTRITION

Nutrition studies have shown the importance of proper winter supplementation as measured by improved conception rates, calf survival and cow and calf growth. Studies on protein, energy, vitamin A and phosphorus supplementation have been of importance to yearling and cow-calf producers. Research has shown the importance of gearing supplementation to the amount and kind of range forage available. This type of supplemental feeding can reduce the amount of supplement required and also increase the efficiency of use of available forages. Recent studies show low levels of cubed alfalfa hay to be a promising alternative protein supplement for wintering beef cows.

Station research has shown daily feeding of winter energy supplements resulted in greater gains in pregnant cows than did feeding the supplement on alternate days. Station studies on grazing behavior of cattle show definable grazing and rest periods. Feeding supplement during a normal grazing period (7:30 a.m.) tended to disrupt grazing patterns and depress daily gain by 0.5 pounds when compared to animals supplemented during a normal rest period (1:30 p.m.). Studies on winter grazing behavior of pregnant cows showed low temperatures reduced grazing time with the greatest reduction occurring in young cows.

Range nutrition studies throughout the Northern Great Plains have shown that optimum animal performance is entirely dependent on adequate forage. Cooperative studies between this Station and the Northern Great Plains Soil and Water Research Center at Sidney, Montana, have shown important methods of increasing forage production. Contour furrowing of panspot areas increased forage production from only 350 pounds per acre to 1100 pounds per acre. Nitrogen fertilization of native range areas resulted in increased beef production roughly equivalent to 1 pound of beef for each 1 pound of available nitrogen added per acre.

Basic research studies on feed intake, rumen fermentation and rate of passage of feed through the digestive tract are currently underway. Results of this work will be used to develop better supplements and to improve utilization efficiency of range forages.

RANGE RESEARCH

Research in range improvement and management was initiated at this Station by the U. S. Forest Service in 1932. Early studies were designed to determine optimum stocking rates for cattle and sheep on Northern Great Plains rangelands. Recommendations were developed for proper use by animals on different range sites and during different seasons. Also, the long- and short-term

changes and effects of drought on vegetation and livestock performance were determined for these rangelands. The 30 acres per cow average stocking rate figure established in this work is used extensively by both ranchers and Federal agencies to establish proper stocking rates. Use of this stocking rate plus forage utilization standards of 50% use, took the Plains out of an era of exploitation into one of grazing management. Use of these standards reduced soil loss, increased plant growth and increased production of both domestic livestock and wild animals. Value to the livestock industry and Montana agriculture on a sustained yield basis is conservatively estimated at over $1 billion. The research has also provided a foundation for making adjustments to drought such as that experienced in 1979-1984.

Other studies were made to determine the most effective methods of increasing forage production. These early studies included adaptability studies which tested more than 100 different plant species under various range conditions. Crested wheatgrass was found to be an outstanding species for seeding many range sites. Later research at this Station, other Northern Great Plains institutions and in Canada has been instrumental in developing and promoting use of crested wheatgrass and Russian wildrye as introduced forage species. These species have been planted on several million acres of Northern Great Plains rangelands. Station studies have shown a 17% increase in pounds of calf produced per cow in herds grazing introduced, cool-season forage species during the critical postpartum-rebreeding period.

Beginning in 1936, water spreading systems were developed by building diversion dams and contour dikes. These studies were among the first in the Nation to demonstrate that water normally lost to run-off could be used effectively to increase growth of native and introduced grasses. Over the years, studies have also been made of other methods of range improvements including furrowing, range pitting, and application of various kinds and amounts of mineral fertilizers.

Recent cooperative research between scientists at this Station and Logan, Utah, on new hybrid grass species and use of improved forage plants show these forages hold promise of increasing rangeland productivity as much or more than that experienced in the past. More than 10 years of research by plant geneticists, plant breeders and range scientists have gone into plant development work. The promise of benefits to individuals and agriculture in the Northern Great Plains are enormous. Plants are being tested for growing in saline soils and restoring rangelands subject to saline seep. Hybrids are being developed and tested for increasing livestock production and growth. Other varieties are being evaluated for increasing productivity through more efficient use of limited water resources. Detailed studies are underway to evaluate adaptability, productivity and animal acceptance of a cross between quackgrass and bluebunch wheatgrass. The hybrid forages under study are designated ARS I and ARS II, and both cultivars show promise of being welcome additions to the list of recommended, introduced forage species.

A number of forage species are being analyzed for their ability to contribute high quality grazeable forage at such critical times as very early spring, late fall and winter. Evaluations include seedling establishment, yield, post-harvest regrowth and vigor in relation to morphological and physiological

attributes of both native and introduced plant species. Other studies involve evaluation of various species for drought tolerance. Cultivars of the intermediate-pubescent wheatgrass complex were killed or most severely damaged by recent drought. Damage was also severe on seeded stands of the native green needlegrass, western and thickspike wheatgrasses and big bluegrass. Crested wheatgrass was only moderately drought tolerant, but two cultivars of Russian wild ryegrass established well even with adverse moisture conditions in the seeding year. Altai wild ryegrass seedlings established well but did not survive the drought. An established stand of Vinall Russian wild ryegrass increased in basal area and produced leaf growth and seedstalks during the most severe drought periods. These periodic droughts are sporadic in occurrence but need to be considered in reference to species recommendations for range seedings in the Northern Great Plains.

Work is also in progress to control or modify undesirable plant communities on potentially productive range sites through burning or mechanical and herbicide treatments. The control of silver sagebrush is an example of reducing competition to increase desirable forage. Mechanical top removal was effective in achieving control, and time of treatment was critical. Most sagebrush plants cut in April and May, 60% of those cut in June, but only 40% of plants cut in July and August resprouted 8 weeks after treatment. Surviving plants showed cutting date and original plant size were important in determining subsequent sprouting and regrowth.

A prototype Rangeland Improvement Machine (RIM) has been developed for renovating rangelands. The unit prepares the soil, forms a vee-trough seedbed, and plants in a single-pass operation. A packing wheel forms check dams for water retention. Legumes and grasses may both be planted with this specialized drill. Stands established in heavy clay soils and various range sites are being evaluated.

Many findings of Station research are of basic scientific value, while others have immediate application to the beef industry. Both types of results are beneficial to producers for improving production efficiency in their beef herd. Consumers benefit by being assured of a good supply of beef available at affordable prices.