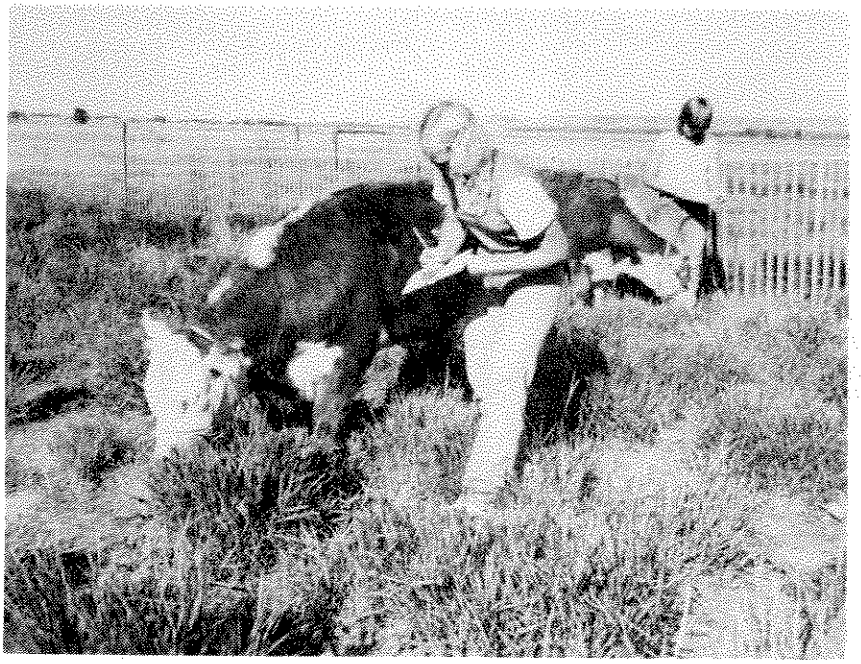
LIVESTOCK AND RANGE RESEARCH STATION

Miles City, Montana

1981
FIELD DAY

RESEARCH IN ACTION



RESEARCH IN ACTION

Agricultural Research Service
United States Department of Agriculture
in cooperation with
Montana Agricultural Experiment Station

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THE LIVESTOCK AND RANGE RESEARCH STATION

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United States Department of Agriculture and
Montana Agricultural Experiment Station,
Cooperating

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 developing 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In 1907, all infantry troops were withdrawn and in 1912 Fort Keogh became a Remount Station for the U. S. Army.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 animal research in cooperation with the Montana Agricultural Experiment Station. Since that time, the U. S. Range Livestock Experiment Station has been under the direction of six 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 to present. The Station name was changed to the Livestock and Range Research Station (LARRS) in March, 1977.

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. Approximately 2,000 acres are under irrigation in the Yellowstone River Valley west of the LARRS 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 breeding herd consists of 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 is the largest cattle inventory in the history of the Station. Replacement heifers, young bulls and steers, herd bulls and cattle on reproduction and range nutrition experiments make up the remainder of the inventory. In addition, about 50 acres are set aside for 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 Agriculture Experiment Station.

Studies on Station animals involve a total of 51 permanent employees. Thirteen of these are employed by the U. S. Department of Agriculture and 38 are employed by the Montana Agricultural Experiment Station. The temporary force will vary between 2 and 15 depending on time of year.

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 studies and wool experiments. 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 still 30 horses on the Station that are used in cattle moving operations.

Turkeys were also an experimental subject 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 Experiement 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 established. Additional breeding has involved the Montana No. 1 and the Yorkshire breeds. This work was terminated in 1971 and a crossbred herd was established to supply animals for nutrition studies directed by staff members in the Animal and Range Science Department at Montana State University.

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 base rations supplemented with soybean meal. A study was also conducted to evaluate the protein from mustard meal 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 and vitamin 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. Mineral and vitamin work presently underway is designed to study the effect of supplemental manganese and biotin on the incidence of spraddle or splay legged pigs. Current studies also include synchronization of estrus and artifical insemination of females in the nutrition studies.

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 and improvement. In addition, some 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 are underway to determine methods for control of eye cancer and the effects of vaginal and uterine prolapse on cow productivity

CATTLE BREEDING RESEARCH

Beginning in 1930, the Station pioneered in the development of methods for evaluating 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 in 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 or are being 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 either bulls or cows since 1934. Animals from this line are now widely used in purebred and commercial beef herds throughout the United States. Station scientists recently received a Superior Service Award from the USDA for development of this line and the impact it has had on the Hereford breed. Animals surplus to the research program are sold at an annual production sale.

One of the first findings in the line breeding 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 line breeding and had to be discarded. However, the success of several lines, notably Lines 1, 12 and 14, has proved that a linebreeding program based upon strict selection for performance is an economically feasible method of improvement for beef cattle.

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. It is believed that 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.

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 for high weaning weights or yearling weights, respectively. Cattle have also been involved in a study to determine what effect selecting herd sires with 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 and involves a Hereford herd of randomly selected males and females. The objective of this study is to determine the relationships among measures of growth, fertility and nutrient requirements in bulls, heifers and cows managed under range conditions in order to identify alternative selection criteria that can maximize total production.

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 type environment should be obtained from a similar type environment if optimum production is to be realized.

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 revealed 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 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 than steers. 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. The crossbred males produced are evaluated for growth performance and carcass characteristics.

A new selection-crossbreeding study was initiated in 1979 to determine if selection within a single breed base is as effective and response is as rapid as obtained 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 will result in development of a polled, medium weight animal with high fertility and rapid early growth.

REPRODUCTION RESEARCH

The objective of research in reproductive physiology is to increase reproductive efficiency of range cattle. Areas of work are directed toward increasing the percent calf crop to optimum levels and increasing the pounds of calf produced per cow exposed to breeding. This work was initiated in 1962. 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 largest loss occurs because cows lose calves at or shortly after birth. These areas are receiving major emphasis in reproduction research studies.

Approximately 15% of the beef breeding herd is replaced yearly. Thus, replacement heifers make up about one in every seven females in the breeding herd. Assuring a high pregnancy rate in the replacement heifer is the objective of puberty research at LARRS and has shown that proper nutritional and genetic management of the heifer can increase conception rates by 20%. Simply breeding 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. LARRS 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 growth 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. These findings are important, not only in terms of increased calf crop, but also because early puberty means potential early conception and calving. Heifers that calve early their first calving season have greater lifetime productivity than heifers that calve late. Research in this area expands the flexibility producers have in selecting programs for managing replacement heifers.

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. Research at LARRS 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. Data have shown 60% of these losses could be prevented by giving timely and proper assistance to dams experiencing difficulty during calving. In addition, LARRS 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 LARRS research indicate 70% of the identified variations in calving difficulty are either present or are established at conception. 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.

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 release of luteinizing hormone from the pituitary gland. This work is important because results are showing means whereby we can assure a high percentage of lactating dams will rebred.

LARRS 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 calves 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 LARRS. 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. But what can be done with twin and triplet calves since many of today's beef cows barely produce enough milk to raise a single calf? LARRS 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 very early following calving. Superovulated cows experience high rates of embryonic and fetal loss. This appears to be due, in part, to a deficiency of progesterone in early gestation. Losses later in gestation may be partly a result of problems associated with metabolite exchange between dam and fetus since multiple fetuses are associated with lower placental weights than are single fetuses.

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

RANGE NUTRITION RESEARCH

Nutrition studies were initiated at LARRS in 1971 and 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 producers of yearling and cow-calf producers. More recent research has shown that a 10% savings in cost of winter supplement can be realized by gearing supplementation to the amount and kind of range forage available. This type of supplemental feeding can reduce the amount of feed required and also increase the efficiency of use of available forages.

Range nutrition studies throughout the Northern Great Plains have shown that optimum animal performance is entirely dependent on adequate forage. Cooperative studies between LARRS 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 lb. per acre to 1100 lb. per acre. Nitrogen fertilization of native range areas resulted in increased beef production roughly equivalent to 1 lb. of beef for each 1 lb. of available nitrogen added per acre. These two procedures could potentially result in an additional $15 million added income for Montana producers alone.

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 both kinds of 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 1978-80.

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 LARRS, 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. Studies at LARRS have shown a 17% increase in pounds of calf produced per cow in herds grazing three 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 LARRS and Logan, Utah, on new hybrid grass species and use of improved forage plants 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 Montana 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. Current range studies are designed to evaluate critically the range forage supply and determine methods of effectively increasing the quantity and quality of forages. Work is in progress on evaluating genetically superior grass hybrid selections for adaptability, viability and forage suitability. 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.

Work is also in progress to control or modify undesirable plant communities on potentially productive range sites through burning, mechanical and herbicide treatments. The objective is to increase productivity of desirable plant species by either introducing new species or increasing the growth and yield of established plants. A better understanding of how plants respond to varied management treatments is basic to this research.

Findings of research studies have immediate application to the beef industry. Results will be beneficial to beef producers for improving production efficiency through yearlong forage supply and management. Consumers will benefit too by having a good supply of beef available at affordable prices.

CURRENT SWINE NUTRITION

Livestock and Range Reseach Station
Miles City, Montana

C. W. Newman and D. O. Elliott[1]

The swine nutrition research at the Livestock and Range Research Station (LARRS) is an effort to reduce ration cost by replacing soybean meal (soy) with alternate and cheaper sources of protein and/or amino acides without reducing animal performance and feed efficiency. Three separate approaches are currently under study:

1. Replace all or a portion of the soy in barley based rations with free lysine and/or free methionine.

2. Replace all or a portion of the soy in barley based rations with faba beans (horse beans).

3. Replace a portion of the soy in barley or corn based rations with a probiotic mixture (a mixture of desirable microorganisms).

A total of 752 pigs are included in three experiments this year. This report will summarize an experiment completed last year with a probiotic mixture replacing a portion of soy in barley and corn rations.

The means by which the nutritional status of an animal may be altered are numerous and complex. Many organisms, including animals, are dependent upon microorganisms for essential nutrients, and it has been suggested that an important relationship exists between the host animal and microbes in the utilization of nitrogen. Microorganisms that produce lactic acid, especially lactobacilli, have long been considered desirable inhabitants in the digestive tract of animals. Numerous experiments have shown the benefits of such microbes in maintaining the health of pigs when challenged with disease producing bacteria. Some reports indicate that growth and feed efficiency of swine, as well as poultry, are improved by lactobacilli feed supplements. More recently, a mutant lactobacillus organism, (L. elaotarum), has been developed at MSU that excretes lysine in much greater quantities than the "wild" type organism. Earlier studies showed that the lysine of cereal and other food sources can be increased when inoculated with this organism.

[1] Animal and Range Science Department, Montana State University, Bozeman, and Livestock and Range Research Station, Miles City, Montana, respectively

The probiotic mixture use in the experiment reported here contained the lysine-excreting lactobacillus mutant, as well as other microbes.

EXPERIMENTAL METHODS

Control rations were prepared with either barley or corn and soy to contain .70% lysine in growers and .57% in finishers, which are the recommended levels of the National Research Council (NRC) for 44 to 132 lb and 132 to 120 lb pigs, respectively. Two grower and two finisher rations with increment decreases of 2.5 and 5.0% soy, as compared to control diets, were prepared with either barley or corn, resulting in a reduction of lysine levels by about 10% and 20%, respectively, in grower rations, and about 12% and 23%, respectively, in finisher rations. The soy was replaced with the respective cereal grain. The remaining nine essential amino acid levels met or exceeded NRC recommendations, with the exception of tryptophan in the corn-finisher ration prepared with 5.0% less soy. Lacto-cil, a probiotic mixture of freeze-dried viable lactobacillus organisms L. elaotarum and L. acidoabilus was added at a rate of .25% in the diets with reduced levels of soy at the expense of the respective cereal grain. Minerals, vitamins, and zinc bacitracin were added at the same levels in all diets.

Weanling crossbred pigs, weighing about 53 lb, were allotted to the six rations by litter, sex, and initial weight. Each ration was fed to 32 pigs in four replications, having eight pigs per replicate. Concreted-floored open front sheds were provided for housing in dirt-sand lots, equipped with self-feeders and nipple waterers.

Pig weights were taken initially and at pen-group averages of about 120 and 220 lb. Feed consumption was measured from start to a pen-group average of about 120 lb (grower period), and from that point to termination (finisher period). Average daily gains were computed for individual pigs from 53 to 220 lb (overall). Average daily feed and average feed/gain ratios were calculated for pen-groups in these periods.

RESULTS

Protein and lysine content of the rations by analysis were an average 1.6 and .07 percentage units higher, respectively, than calculated levels. Thus, by analysis, the control grower and finisher diets exceeded NRC requirements for lysine the diets prepared with 2.5% less soy contained the recommended lysine levels, and those with 5.0% less soy were deficient in lysine.

Analysis of gain data revealed that there were no significant lysine x grain interactions. There were no differences in rate of gain of pigs fed control diets and those fed diets with 2.5% of the soy replaced by cereal grain and the probiotic mixture (Table 1). Removal of the 5.0% of the soy reduced gain in the grower and finisher periods ($P<.05$) of the corn-fed pigs and in the overall comparison ($P<.01$) of both corn-fed pigs and barley-fed pigs. Feed consumption was not different between treatment groups within periods. Pigs fed the corn ration less 5% soy appeared to consume less feed in each period, but the difference was not significant. As a result of similar feed intakes, feed/gain calculations resemble the gain comparisons, although all differences were not significant (Table 1). In the grower period, pigs fed the barley rations less 5% soy were less ($P<.05$) efficient than pigs fed the barley control or barley diet less 2.5% soy. Differences in feed/gain were not significant in the corn-

fed pigs in the grower period. In the finisher period, feed/gain ratios were not different in barley-fed pigs, but pigs fed the corn diet less 5% soy were less ($P<.05$) efficient than those fed the corn control or corn diet less 2.5% soy. Overall feed/gain averages were not different between the control diets or diets less 2.5% soy for either barley-fed or corn-fed pigs, but pigs fed the corn or barley diets less 5.0% soy were less ($P<.05$) efficient.

On the average, corn-fed pigs gained faster ($P<.01$) in the growing period and overall comparison than did barley-fed pigs, but gains were not different between grains in the finisher period (Table 2). Cereal grain had no effect on feed consumption in the grower period, but corn-fed pigs ate less ($P<.01$) feed in the finisher and overall periods. Corn rations were utilized more ($P<.05$) efficiently than barley diets in all periods.

DISCUSSION

In that the protein and amino acid analyses of the ration were higher than calculated levels, the true effect of the probiotic mixture as a replacement for soy is difficult to interpret. Similar performance on control rations, and those with 2.5% less soy plus the probiotic, could have been due to the higher levels of protein and lysine as well as the presence of the probiotic. It is unlikely that the ration samples analyzed were not representative, since care was taken to prevent this, and the protein-lysine increment differences were as expected, only higher. However, the barley-control and the corn-control ration with the higher levels of soy protein and consequently, higher lysine, were no more effective in improving pig performance than the ration with 2.5% less soy plus the probiotic.

These data suggest that further studies with better control of ration protein and lysine levels, and the inclusion of negative control rations, are necessary to determine if this probiotic mixture can effectively replace a portion of the soy in pig rations.

ACKNOWLEDGEMENT

The probiotic mixture was furnished by Creative Research Laboratories, Freemont, Nebraska.

TABLE 1. EFFECT OF REPLACING 2.5 AND 5.0% SOY IN GROWER AND FINISHER SWINE RATIONS WITH GRAIN AND A PROBIOTIC MIXTURE.

	Ration Treatments[a]					
	Barley			Corn		
Period	1	2	3	4	5	6
	Average daily gains (lb)					
Grower	1.46^{d}	1.46^{d}	1.39^{e}	1.63^{c}	1.65^{c}	1.54^{d}
Finisher	1.81^{cd}	1.79^{cd}	1.76^{d}	1.87^{c}	1.83^{c}	1.63^{e}
Overall	1.65^{d}	1.63^{d}	1.59^{e}	1.76^{c}	1.74^{c}	1.61^{de}
	Average daily feed (lb)					
Grower	4.37	4.37	4.43	4.63	4.52	4.37
Finisher	6.83	6.94	6.86	6.15	6.11	5.93
Overall	5.71	5.80	5.75	5.47	5.47	5.29
	Average feed/gain (lb)					
Grower	2.99^{d}	2.99^{d}	3.19^{c}	2.84^{de}	2.74^{e}	2.84^{de}
Finisher	3.77^{cd}	3.88^{c}	3.90^{c}	3.29^{e}	3.34^{e}	3.64^{de}
Overall	3.46^{de}	3.56^{cd}	3.62^{c}	3.11^{f}	3.14^{f}	3.29^{e}

[a] Ration treatments were as follows: Rations 1 and 4, barley and corn controls rations 2 and 5, barley and corn less 2.5% soy; and rations 3 and 6, barley and corn less 5% soy. There were 32 pigs in each ration treatment with four replications of eight pigs per replicate. Probiotic added .25% in diets with reduced soy.

[b] Average initial and final weights for grower, finisher, and overall periods were, respectively, 53 to 120 lb, 120 to 220 lb, and 53 to 220 lb.

c,d,e,f Means in the same line bearing different superscript letters are significantly different, $P<.05$.

TABLE 2. COMPARISON OF BARLEY AND CORN AS BASAL CEREAL GRAINS IN GROWER AND FINISHER SWINE RATIONS.

Period	Cereal grain[a]	
	Barley	Corn
	Average daily gains (lb)	
Grower	1.43[d]	1.61[c]
Finisher	1.79[c]	1.79[c]
Overall	1.63[d]	1.72[c]
	Average daily feed (lb)	
Grower	4.39	4.52
Finisher	6.88	4.52
Overall	5.75	5.45
	Average feed/gain (lb)	
Grower	3.07[c]	2.81[d]
Finisher	3.84[c]	3.39[d]
Overall	3.53[e]	3.17[f]

[a] There were 96 pigs per cereal grain.

[b] Average initial and final weights for the grower, finisher, and overall periods were, respectively, 53 to 120 lb, 120 to 220 lb and 53 to 220 lb.

[c,d,e,f] Means in the same line bearing different superscript letters are significantly different; $P<.01$; $P<.05$.

RESEARCH WITH FROZEN BOAR SEMEN AND SYNCHRONIZATION OF ESTRUS IN GILTS

by

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In 1978 the Montana State University and the USDA initiated cooperative research in reproductive physiology in the Miles City swine herd. The general objectives of this research were to (1) introduce superior genetic material into the swine herd, (2) test new procedures for artificial insemination (AI) of swine with frozen semen, and (3) evaluate the potential of Regu-Mate[1] for synchronization of estrus in gilts.

The successful use of frozen boar semen for AI was first reported in 1971. Since then, a number of improvements have been made, and the freezing and thawing procedure developed by the USDA at Beltsville is used commercially in the U.S. and Canada. At present, frozen boar semen is only used on a limited scale because the pregnancy rate and litter size are usually considerably lower than those following natural service. Thus, additional research is greatly needed to find ways of improving fertility.

An effective method of synchronizing estrus in gilts would provide producers with a highly useful management tool to reduce the number of days that heat checks need to be made, facilitate use of AI, and assist in batch farrowing. Recently, a synthetic hormone, called Regu-Mate, has been found to be useful for synchronizing estrus in gilts. However, considerable further experimentation under many environmental and management conditions is necessary to prove that it is both safe and effective before the Food and Drug Administration will permit general use by producers.

Experiments with Frozen Semen

I. Insemination Volume

Frozen semen used in these studies was purchased from International Boar Semen, Eldora, Iowa. Commercially available frozen semen from either 6 or 7 boars was obtained each year. Most gilts were inseminated twice per estrus using a disposable bent-tip insemination rod.

Some of our preliminary results indicated that fertility could be improved by increasing the insemination volume from 55 ml to 80 ml. Therefore, we alternately assigned gilts to receive one of these insemination volumes during the 1978 experimental period. The farrowing results are summarized in the following table.

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[1] Regu-Mate was supplied by Roussel-Uclaf, Paris, France; not available commercially.

Insemination Volume	Number of Gilts		%	Litter Size	
	Inseminated	Farrowed	Farrowing	Total	Live
55 ml	29	13	45	7.7	7.3
80 ml	30	18	60	8.4	7.9

These farrowing results substantiated our preliminary findings and clearly indicate that fertility was improved by using an 80-ml insemination volume in comparison to the 55-ml insemination volume.

2. Mating with a Vasectomized Boar after AI

The purpose of this experiment was to determine whether mating with a vasectomized boar after AI with frozen semen would improve the pregnancy rate or litter size. Immediately after AI, gilts were alternately assigned either to be bred by a vasectomized boar or not to be bred.

The farrowing results are summarized in the following table.

Group	Number of Gilts		%	Litter Size	
	Inseminated	Farrowing	Farrowing	Total	Live
Bred	78	29	37.2	7.2	6.8
Not Bred	86	33	38.4	7.5	6.9

These results clearly indicate that the additional stimulation provided by the natural mating was not effective in improving the pregnancy rate or litter size of gilts inseminated with frozen semen.

Synchronization of Estrus

The compound under study, Regu-Mate, is a synthetic progestin similar to that produced by the corpora lutea of the ovaries. Regu-Mate prevents estrus and ovulation while animals are consuming it. We mixed Regu-Mate into the feed and fed it at the rate of 15 mg per gilt per day for 18 days. Gilts in groups of 12 to 16 were fed together. When gilts came into estrus, they were either bred by a boar or by AI with frozen semen. Gilts used as controls were those coming into estrus within the same week as the synchronized gilts. The number of days from last feeding of Regu-Mate to estrus averaged 5.7 days with the distribution by day as follows:

	Day of Onset of Estrus after Last Feeding					Not in Estrus
	4	5	6	7	8	
Number of Gilts	8	64	81	28	2	18
Percent of Total	4	32	40	14	1	9

Probably, most of the 18 gilts that did not come into estrus after treatment were reproductively inactive at the time Regu-Mate was fed.

The farrowing rate and litter size of the synchronized and control gilts were as follows:

Item	Synchronized		Controls	
	Natural Breeding	Frozen Semen-AI	Natural Breeding	Frozen Semen-AI
Bred (no.)	91	90	183	108
Farrowed (no.)	73	30	140	38
Farrowing rate (%)	80.2	33.3	76.5	35.2
Total litter size	11.0	8.2	10.3	6.4
Live litter size	10.4	7.9	9.7	5.8
Weaned litter size	9.0	7.1	8.6	5.2

The farrowing rate and litter size of the synchronized gilts were slightly higher than for control gilts.

For the synchronized gilts bred by a boar, both litter size and farrowing rate were slightly higher than for the control gilts bred by a boar. For synchronized gilts inseminated with frozen semen, litter size was considerably higher than for control gilts inseminated with frozen semen. Synchronization of estrus with Regu-Mate is known to cause a slight increase in the number of ovulations per gilt, and this apparently is the cause of the slight increase in litter size.

The fact that synchronization had no harmful effect on either farrowing rate or litter size is extremely encouraging. These findings put the swine industry one step closer to the time when a useful tool for managing the reproduction of gilts is available to producers.

BIOLOGICAL TYPES OF BEEF CATTLE UNDER RANGE ENVIRONMENTS

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This study involves the cooperation of the Livestock and Range Research Station, Miles City, Montana, the Meat and Animal Research Center, Clay Center, Nebraska and the State Experiment Stations of Montana and Nebraska. This report contains only results from studies in progress at the Livestock and Range Research Station.

Biological types of beef cattle differing in size and milk production need to be evaluated under Western range conditions to provide guidelines to selection and management practices for optimum beef production. An objective is 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 and these were the Angus x Hereford, Red Poll x Hereford, Pinzgauer x Hereford and 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 Angus, Pinzgauer, Red Poll and Simmental bulls 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. Existing information suggest that the Simmental and Pinzgauer should be among the larger sire breeds in mature size and the Angus, Red Poll, and Tarentaise among the smaller sire breeds. The Simmental are expected to have higher milk production than the Pinzgauer and the Red Poll and Tarentaise to have higher milk production than the Angus.

The first-cross heifers were kept to form a herd of breeding females and were fed to gain about 1.25 lb. daily during the winter after weaning. The first-cross steers were individually fed a silage-concentrate ration after weaning. When 70% of the Angus x Hereford steers were considered to grade choice, one-third of all the steer progeny were slaughtered. One-third were slaughtered at each of two 28-day intervals thereafter. Carcass data were obtained at slaughter.

Yearling crossbred heifers were exposed to Shorthorn bulls in multiple sire breeding herds while the 2-year-old and older crossbred cows are 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.

Table 1 shows the pregnancy rate of the 18-month-old heifers and the lactating 2- and 4-year-old cows of each breed group. Pregnancy rates of the Simmental x Hereford appears to be lower than the other groups in this environment. Table 2 shows calf death loss. Death losses of calves from the 2-year-old heifers were higher from the Angus x Hereford heifers than the other breed groups and lowest from the Red Poll x Hereford and Angus x Hereford cows. Calves from 3- to 4-year-old Pinzgauer x Hereford cows had a higher death loss than the other breed groups which appears to be caused primarily by a heavier birth weight of the calves as shown in table 3. Table 4 shows the 200-day weight of the first-cross calves from the Hereford dams and then the calves from the 2- to 4-year-old crossbred dams. The calves from Tarentaise x Hereford

first-cross dams were heavier at weaning than calves from the other breed groups. The greater weaning weight of these calves was due to greater milk production of the Tarentaise x Hereford cows. Milk production of the 2-year-old heifers was measured at three different periods. The results of these measurements for 1978 are shown in table 5. Table 6 summarizes weights of the heifers at different periods. The Red Poll x Hereford females were lighter in weight at each weigh period than any of the other breed groups. All the other breed groups were similar in weight at each weigh period. But a major difference was found between the weights of lactating and dry cows.

Table 7 summarizes the feedlot performance of the Shorthorn sired 3-breed cross steers. There was little difference in the gains of the steers by breed groups during the growing phase, but steers from Pinzgauer x Hereford and Simmental x Hereford 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 results for the Charolais-sired, 3-breed cross steers and heifers are shown in table 8. Calves from the Simmental x Hereford dams grew slightly faster than the other breed groups. Fewer of the steers from the Red Poll x Hereford and Simmental x Hereford dams attained choice grade. A higher percentage of the heifers from Simmental x Hereford dams attained choice.

TABLE 1. PREGNANCY RATE OF F_1 FEMALES.

Breeds of dam	No.	Yearlings (% preg.)	Lactating cows (% preg.)
Angus x Hereford	66	92	91
Pinzgauer x Hereford	67	88	88
Red Poll x Hereford	72	90	85
Simmental x Hereford	72	79	79
Tarentaise x Hereford	57	86	87

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

Breed of dam	Calf death loss %		Weaning rate %	
	2-yr-old dams	Older cows	2-yr-old dams	Older cows
Angus x Hereford	20.0	5.6	73.6	85.9
Pinzgauer x Hereford	12.1	16.2	77.3	73.7
Red Poll x Hereford	6.2	4.1	84.4	81.5
Simmental x Hereford	6.9	10.8	73.5	70.5
Tarentaise x Hereford	14.3	10.0	73.7	78.3

TABLE 3. BIRTH WEIGHT (lb) OF CALVES

Breed of dam	First cross calves	Age of Dam (yr)		
		2[a]	3[b]	4 & 5[b]
Angus x Hereford	77	71	83	92
Pinzgauer x Hereford	89	79	92	99
Red Poll x Hereford	82	74	84	94
Simmental x Hereford	88	75	88	94
Tarentaise x Hereford	80	73	86	89

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

TABLE 4. 200-DAY WEIGHT (lb) OF CALVES FROM F_1 FEMALES

Breed of dam	Age of Dam (yr) 2[a]	3[b]	4 & 5[b]
Angus x Hereford	408	452	523
Pinzgauer x Hereford	421	482	521
Red Poll x Hereford	412	472	518
Simmental x Hereford	420	486	530
Tarentaise x Hereford[c]	451	511	---

[a] Sired by Shorthorn bulls.
[b] Sired by Charolais bulls.
[c] One year's data; these Tarentaise x Herefords heifers were donated to the Station and were not contemporaries of the other four crossbred types of females.

TABLE 5. 12 HOUR MILK PRODUCTION OF FIRST-CROSS 2-YEAR-OLD HEIFERS (lb) (1978)

Breed	June 3	August 15	October 13	Avg.
Angus x Hereford	6.6	6.7	2.9	5.4
Pinzgauer x Hereford	7.2	5.8	2.5	5.5
Red Poll x Hereford	6.3	5.0	2.7	4.7
Simmental x Hereford	6.7	5.3	2.4	4.8
Tarentaise x Hereford	7.8	7.8	3.6	6.4

TABLE 6. FALL WEIGHTS (lb) OF FIRST CROSS COWS

Breed	18 mo	Lactating 2 yr	3 yr	4 yr	Dry 2- or 3-yr-olds
Angus x Hereford	833	939	1017	1122	1133
Pinzgauer x Hereford	852	936	1038	1171	1119
Red Poll x Hereford	798	880	954	1070	1104
Simmental x Hereford	862	960	1047	1170	1232
Tarentaise x Hereford	836	950	1017	----	1139

TABLE 7. FEEDLOT PERFORMANCE OF SHORTHORN SIRED STEERS AND HEIFERS (4-Year data)

Breed of Dam	No. fed	Initial wt (lb)	Average Daily Gain (lb) Growing phase[1]	Finishing phase[2]	Entire period	Final wt (lb)	Carcass wt (lb)	Dressing[3] %	% choice
Steers									
Angus x Hereford	25	439	2.01	2.33	2.16	995	572	57.5	92
Pinzgauer x Hereford	26	438	2.04	2.41	2.21	1008	578	57.3	73
Red Poll x Hereford	32	432	2.02	2.32	2.16	988	561	56.8	84
Simmental x Hereford	21	433	2.00	2.40	2.18	997	575	57.7	67
Tarentaise x Hereford	23	444	2.08	2.34	2.20	1009	583	57.8	96
Heifers									
Angus x Hereford	22	413	1.94	2.13	2.03	925	526	56.9	100
Pinzgauer x Hereford	21	442	1.92	2.20	2.04	959	551	57.5	81
Red Poll x Hereford	25	397	1.83	1.88	1.85	865	494	57.1	96
Simmental x Hereford	30	429	1.94	2.12	2.02	940	538	57.2	83
Tarentaise x Hereford	18	450	2.00	2.20	2.08	981	560	57.1	83

[1] Growing phase - 140 days, corn silage and protein supplement.
[2] Finishing phase - steers, average 118 days, corn silage, protein supplement and 4 lb of cracked barley. Heifers, average 111.3 days, same rations as steers.
[3] Calculated from final weight off test (no shrink).

TABLE 8. FEEDLOT PERFORMANCE OF CHAROLAIS SIRED THREE-BREED CROSS STEERS AND HEIFERS FOR YEARS 1979-80 and 1980-81.[1]

Breed of Dam	No. fed	Final wt (lb)	daily gain (lb)	Carcass wt (lb)	Dressing[2] % (lb)	% choice
Steers						
Angus x Hereford	39	1163	2.63	704	60.5	80
Pinzgauer x Hereford	31	1161	2.58	700	60.2	73
Red Poll x Hereford	50	1173	2.65	711	60.6	63
Simmental x Hereford	28	1199	2.71	719	60.0	54
Heifers						
Angus x Hereford	33	1016	2.39	598	58.8	70
Pinzgauer x Hereford	33	1031	2.45	610	59.1	64
Red Poll x Hereford	39	1014	2.41	603	59.6	67
Simmental x Hereford	27	1060	2.50	631	59.6	77

[1] Average length of steer feedlot periods was 270 days; for heifers 242 days.
[2] Calculated from final weight off test (no shrink).

A SELECTION EXPERIMENT TO CONTROL BIRTH WEIGHT IN BEEF CATTLE

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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 weights. 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. It was originally planned that after the first two years, sires for Y would be selected from Y progeny on the basis of age and age-of-dam adjusted yearling weight and soundness. Sires for YB would be selected from among the top half of the YB progeny. Acceptable color patterns have been given consideration in both herds. It was, however, necessary to select across Y and YB herds for replacement bulls before breeding for the 1980 calf crop because of the number of limitations and selection considerations other than weights. In 1981, all sire replacements were selected from within their respective herds and this procedure will continue in following years.

Replacement heifers for Y and YB have been and will continue to be selected annually from those born within their respective herds. Selection is based on adjusted 18 month weight plus structural soundness for the Y group, with birth weight as an added criterion for the YB group.

Progress made through selection will be evaluated by continuous comparison of the Y and YB herds over time and by periodic estimates of within herd changes and herd differences through tests with semen from herd bulls produced at about one-generation intervals.

Results

The performance in these herds to date is based largely on sire selection. There has not been an important contribution yet on performance due to the female selection. The average ratios for the sires used to produce calves in 1978, 1979, and 1980 in Y and YB herds, respectively, for these traits were: birth weight 109 and 96; 205-day weaning weight 114 and 115; 365-day final weight 113 and 112 (table 1). The average actual birth weight difference between Y and YB sires amounted to 8 lb, but for weaning and yearling weights the two sets of sires were essentially the same.

Combined calf data for 3 years (1978-1980) are shown in table 1. The Y calves were heavier for birth weight (2.8 lb) but were essentially the same for weaning weight. The 205-day weaning weight and postweaning performance of the bulls and heifers are shown in table 2. Within sex classes the Y heifers were 12.1 lb heavier at 365 days of age than YB heifers, but the Y bulls were 9.0 lb lighter than the YB bulls. The responses within sex classes, have been consistently different each year. Additional data will help verify if presently observed differences are real. When data from both sexes are combined as they were for preweaning traits, there was little difference between herds for yearling weight performance.

The data are limited for drawing detailed conclusions from this selection study. It does appear, however, that there is a possibility of controlling birth weight while improving postnatal growth. Reproductive data from the 1978-81 calf crops, through calving, are not easily interpreted at this point. Evidence is lacking which would indicate that selection for comparatively light birth weight has improved calving ease or calf survival.

TABLE 1. BIRTH WEIGHT, 205-DAY WEIGHT AND 365-DAY WEIGHT RATIOS OF Y AND YB SIRES SELECTED TO PRODUCE CALVES IN 1973, 1979, and 1980.

Herd[a]	Number of sires	Average Ratios[b] Birth wt	205-day wt	Final wt
		Sires of 1978 Calves		
Y Sires	4	104	113	113
YB Sires	4	98	115	112
		Sires of 1979 Calves		
Y Sires	4	111	116	114
YB Sires	4	94	116	113
		Sires of 1980 Calves		
Y Sires	4	111	113	111
YB Sires	4	96	113	110

[a] Herd Y - Bulls selected for adjusted weight aft ROP test.
Herd YB - Bulls selected for same trait but with age-of-dam adjusted birth weight no higher than herd average.

[b] Weights expressed as percentages of averages for all Line 1 bulls within year of selection.

Table 2. Means of Adjusted Birth and 205-day Weights (bulls and heifers) combined) of Line 1 Hereford Herds in Birth Weight Selection Project (1978-1980)

Item[1]	N	Adjusted weights and gains (lb)[2] Birth wt	Total gain	205-day wt
Herd Y	127	76.9	359.0	436.1
Herd YB	127	74.1	362.9	437.0
Y minus YB		2.8	-3.9	-.9

[1] Herd Y selected for adjusted weight at end of ROP test (bulls) and adjusted fall yearling weight (heifers). Herd YB selected for same traits plus birth weight no higher than herd average.

[2] Adjusted to constant age as applicable, mature age-of-dam basis and heifer calf basis.

Table 3. Means of Adjusted 205-day and 365-day Weights of Line 1 Progeny Born 1978-80 Within Herds in Birth Weight Selection Project.

Item[1]	N	Adjusted weights and gains (lb)[2] 205-day wt	Total gain	365-day wt
		Heifers		
Herd Y	66	439.0	222.9	662.2
Herd YB	65	427.1	222.9	650.1
Y minus YB		11.9	0	12.1
		Bulls		
Herd Y	61	461.1	426.0	887.1
Herd YB	62	471.0	425.1	896.1
Y minus YB		-9.9	.9	-9.0

[1] Herd Y selected for adjusted weight at end of ROP test (bulls) and adjusted fall yearling weight (heifers). Herd YB selected for same traits plus birth weight no higher than herd average.

[2] Adjusted to constant age as applicable and to mature age-of-dam basis.

THE POSTPARTUM COW - CALVING TO REBREEDING

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The failure of cows to rebreed or to be bred late after calving can be a serious economic problem for ranchers. A cow is pregnant for 280-285 days so in order for her to maintain a 365-day calving interval, she has to be rebred within 80 days after calving. This sometimes does not happen and a cow will wind up being a late calver or open - both possibilities being undesirable because cows with a light calf or no calf to market will result in decreased income.

Whether or not a cow can be rebred within the 80-day period after calving is mainly controlled by whether or not she is back in heat within that 80-day period. In fact, she really needs to be in heat within 60 days so she will have 20 days (one heat cycle) to get pregnant. Other factors that affect fertility may also delay or prevent pregnancy, but the first obstacle to successful rebreeding is to get the cow back in heat.

Many factors can affect the interval from calving to heat for cows that are nursing calves, and I will list some in their approximate order of importance.

1. Condition or fatness at calving, mainly determined by precalving feed level.
2. Postcalving weight changes.
3. Age.
4. Level of milk production.
5. Genetic differences (for example, Herefords vs Holsteins).

Other people have made different lists, and you may have heard the statement that the three most important factors determining whether or when a cow will be rebred are feed, feed and feed. There certainly is some validity to this statement and the only quarrel I would have is that it may actually be condition, condition and condition! Basically, what we have found is that if cows are in moderate to good body condition (fatness) at calving, they will have a good chance of rebreeding within 80 days. If cows are thin at calving time, they will have a much longer interval from calving to rebreeding. How long will depend on how much they gain after calving - the more they gain, the quicker they will rebreed. An experiment showing these relationships is summarized in table 1.

Of the factors cited earlier, you have the most control over 1 and 2 and whatever control you have over 3, 4 and 5, its effect or change would be rather slow depending on your breeding program. There is another factor that drastically affects rebreeding; one which you can directly control. That factor is whether or not a cow is nursing a calf. The five factors mentioned earlier were for cows nursing calves. By simply weaning calves (either completely or temporarily), you can start your cows cycling. Early weaning may be a drastic measure, but it may have a place in some management systems.

TABLE 1. EFFECT OF PRECALVING FEED LEVEL AND EARLY WEANING ON INTERVAL TO FIRST HEAT, CONDITION SCORE AND POSTCALVING WEIGHT CHANGES

	Early weaned[a]		Suckled	
	High[b]	Low	High	Low
Interval from calving to first heat (days)	15	27	42	70
Condition score at calving[c]	6.8	5.0	6.8	5.0
Importance of postcalving weight gain and condition score	Low	Low	Moderate	High

[a] Calves weaned when 10 days old.
[b] High or low feed level for 90 days before calving.
[c] Based on a score from 1 (thin) to 10 (fat).

You may now be asking the question - why the big fuss about postpartum cows, since it seems like we pretty well know how to get cows rebred? To a certain extent this is true - if you don't have any restrictions on resources available! With the right cows (breed and age) on adequate feed levels or with about any cow and early weaning, you can come up with reasonable rebreeding performance. However with $100 hay, 20% interest, $50,000 tractors and 60-70¢ calves, you may not be able to afford the luxury of high pregnancy rates. Alternately, you also can't afford low pregnancy rates. What I'm leading up to is that we need more research to fine tune our knowledge about all of the factors that affect the postpartum cow. What are

optimum feed levels and/or body conditions for various breeds, ages and management situations? Some answers to these question are being developed, but progress is slow because we know very little about how all of these factors affect the postpartum cow.

Our approach at this time is to try to gain some understanding and basic knowledge about how suckling and feed level are so drastically affecting the reproductive process in the cow. As we gain more knowledge in this area, we will be able to devise management systems, treatments, feed levels, etc. that will optimize rebreeding performance. In order to pursue this aproach, we have a unique cooperative project between scientists here at LARRS, the University of Wyoming (Drs. Kaltenbach and Dunn) and Michigan State University (Dr. Convey). This is an intensive effort to understand some of the very basic mechanisms controlling reproduction in the postpartum cow. It involves cattle and personnel (graduate students, technicians and scientists) from all three locations, although most of the actual cattle work has been done here at LARRS. It also involves taking hundreds of tissue samples (hypothalamus, pituitaries, ovaries, follicles, etc.) and thousands of blood samples. These samples are analyzed for the hormones that regulate reproduction and even the receptors in the tissue that allow these hormones to exert their effect. Some of the hormones that are being studied are:

Hormone	Where produced
GnRH (gonadotrophin releasing hormone)	brain (hypothalamus)
LH (luteinizing hormone)	pituitary
FSH (follicle stimulating hormone)	pituitary
Prolactin	pituitary
Oxytocin	pituitary
Estrogen	ovary
Progesterone	ovary

Some really interesting results have come from these studies. Prolactin and oxytocin are both released by the suckling stimulus, but we can't find any connection between their release and suckling inhibition of heat. The release of these is probably in response to a nerve stimulus but the suckling block seems to be more than just a neural block. As heat approaches in a postpartum cow, several changes occur: (1) LH and FSH start being released into the blood in small pulses at about 2-hour intervals, probably induced by GnRH; (2) ovarian follicle receptors to LH and FSH increase; (3) estrogen production by the follicle increases; (4) an ovulatory surge of LH and FSH is released; (5) ovulation occurs; (6) if this ovulation is early postpartum, the first cycle is short; (7) a short period of progesterone production occurs before a heat that is late postpartum but not if it is early; (8) small (500 ng) injections of GnRH every 2 hours induce LH and FSH release and ovulation in fat cows but not thin cows. These changes are very similar to those that precede heat in a normal cycling cow, and both suckling and low body condition somehow prevent the succession of events from proceeding.

The status of this research could be likened to a jigsaw puzzle. Some of the pieces are turned over so we can see what they look like. We even have some of the pieces together, mainly the easy border pieces. Now, we need to turn the rest of the pieces over, find the missing ones dropped on the floor and finish putting them together. The completed puzzle will show the blueprint for the control of reproduction in the postpartum cow with a detailed drawing of how body condition, feed level, suckling, etc. modify the machinery. As a result, we will be able to devise those management systems to optimize postpartum reproduction - even with the $100 hay and 60-70¢ calves!

THE EFFECTS OF RALGRO ON REPRODUCTION

R. B. Staigmiller

The use of growth promoting implants have been a part of the beef industry for about three decades. They have been widely used in the feedlot industry and are gaining popularity in cow-calf operations for increasing weaning weight of suckling calves. However, most studies conducted on these growth stimulants have looked only at growth traits and not extensively at effects on reproduction. We have conducted studies at LARRS on how one of these stimulants, Ralgro, affects reproduction in both female and male beef animals.

Ralgro has not been cleared by FDA for use in breeding animals except in experimental herds. We conducted research on the use of Ralgro in our replacement heifer program.

It is desirable to have all replacement heifers reach puberty prior to the breeding season so they can be bred early, and calve early in the calving season. It is also desirable to have them as large as possible to reduce the stress of first calving. At the same time, we want to minimize the winter feed costs. Ralgro implants were used to see if growth rates could be increased without having an adverse effect on reproduction.

The first year, 98 heifers were wintered in a feedlot on corn silage to gain about one pound per day over a 205-day feeding period. Half of the heifers were given a 36 mg Ralgro implant at the start of the feed period and again 84 days later. The second year, 108 heifers were fed to gain about 1.5 pounds per day over a 150-day feeding period, and half were implanted as in the first year. Results of the 2 years of study are shown in table 1.

TABLE 1. EFFECT OF RALGRO ON REPLACEMENT BEEF HEIFERS

Trait	Year 1		Year 2	
	Ralgro	Control	Ralgro	Control
On test weight (lbs.)	435	435	528	523
Off test weight (lbs.)	672	648	753	733
Rate of gain on test (lbs./day)	1.16	1.03	1.5	1.4
Off test pelvic area ($in.^2$)	27.2	24.5	25.3	27.3
Puberty by June 1[a] (%)	69.4	77.6	98	98
October pregnancy (%)	63.3	77.6	89	87

[a] June 1 = start of 60-day AI breeding season.

The results indicate that Ralgro increased the rate of gain and appeared to have a beneficial effect on skeletal growth. This is shown by the larger pelvic area in both years of study. A larger pelvic area should help reduce calving difficulty in first calf heifers.

The effects of Ralgro on breeding performance were not consistant in the 2 years of the study. In the first year, the percentage of females reaching puberty by the start of the breeding season and the percentage pregnant in the fall were lower in implanted heifers than in the nonimplanted control heifers.

In the second year, there were no differences in these traits. The difference between years is hard to explain, and it is not possible to determine if the difference was due to a greater growth rate the second year. Studies are underway at other research stations to look at the effect of nutrition on reproduction in Ralgro-implanted heifers. Until more information is available, it is best to heed the warning on the Ralgro carton and not use Ralgro implants in breeding females.

A Ralgro study was also conducted on young male calves. Ralgro implants have been reported to cause a slow rate of testicular development in bull calves. Some evidence indicates the implants may even induce sterility in male cattle.

While this may be detrimental to breeding stock, it may be useful to the stocker-feeder industry. Intact males grow faster and more economically than steers; but in the past, bulls have been less desirable than steers in slaughter markets. Because of their greater growth ability and because bulls lay down less fat than steers, the idea of leaving male calves intact has been of considerable interest to the cow-calf and feedlot industries. If Ralgro implants can cause permanent infertility, the testicles can be left intact to produce testosterone that causes increased growth and feed efficiency. A study at the Livestock and Range Research Station at Miles City and Southern Montana Agricultural Research Center at Huntley was designed to examine the possible ways of inducing permanent infertility in male calves with Ralgro implants. The study was specifically designed to gain information related to growth rate, feed efficiency, carcass characteristics and sexual development.

One hundred head of uncastrated male calves were divided into five groups of 20 head each. The treatment groups were: Group 1 - nonimplanted controls; Group 2 - 72 mg Ralgro implant at branding; Group 3 - 72 mg Ralgro implant at weaning; Group 4 - 72 mg Ralgro implant at both branding and weaning; Group 5 - 36 mg Ralgro implant at weaning, and 36 mg implant at 80-day intervals throughout the feedlot period.

The calves were obtained from cow herds at the Livestock and Range Research Station at Miles City. They were weaned at about 50-60 days of age and raised in drylot on corn silage and cracked corn with a salt and mineral supplement. Weaning calves at this age is not a normal practice; but due to extreme drought in southeastern Montana, the dams were sold to reduce the herd inventory, and the calves were weaned for use in this study. Past research has shown that beef calves can be weaned and raised very satisfactorily on a roughage and grain diet from 35 days of age. Therefore, it is not likely that the early weaning had a significant influence on the results of the study. "Weaning" in this report refers to the fall of the year when beef calves are normally weaned. At weaning (about 7 months of age), the calves were hauled to the Southern Montana Agricultural Research Center at Huntley and were kept in the feedlot until they were slaughtered in May, 1981. The bull calves were full fed corn silage and rolled barley at a daily rate of about two pounds of barley per 100 pounds of body weight. Mineral supplement was provided to balance the mineral needs. The feed energy in the ration was increased with the bulls' growth rate or weight.

Weight gains, blood samples and scrotal circumference measurements were taken periodically throughout the feeding period. Sexual behavioral was scored and semen collections were made midway through the feeding program. At the completion of the feeding period, the calves were slaughtered at the Midland Empire Packing Company in Billings. Just prior to slaughter, final body weights, hip height, semen collections and blood samples were again taken. The carcasses were measured for fat thickness, percent of kidney fat, ribeye area, marbling score and carcass weight. A number of reproductive organ measurements were made, pituitaries were weighed, testicles paired and weighed and abnormalities of the penis determined.

A summary of gain and feed consumption dated in the feedlot is shown in table 1. The implanted bull calves tended to have a greater average daily gain than the nonimplanted bulls. However, this difference was not significant. The average daily consumption of barley was greater for implanted bulls, but there was no significant difference in the amount of feed per pound of gain.

As can be seen from table 3, Ralgro implants did not significantly affect scrotal circumference and testicular weight when measured at slaughter. Abnormalities of the reproductive system were not increased by the use of these implants.

TABLE 2

Gain and consumption data	Groups 1	2	3	4	5
Average daily gain (lb.)	2.67	2.62	2.80	2.43	2.82
Average daily barley consumption (lb.)	8.76	9.45	8.89	8.42	9.53
Pounds barley/pound gain	3.28	3.60	3.17	3.46	3.38

While there were no obvious effects of implanting with Ralgro on testicle development when measured at slaughter, this may not be true for earlier stages of testicular development. Scrotal circumference was measured at weaning, and the bulls implanted at branding were smaller than nonimplanted bulls. These results indicate that early implanting restricts growth of the testicles but the bulls appear to outgrow this restriction. Further, it indicates that implanting at the later age, approximately 7 months old, does not cause restricted testicle growth. Behavior scores and semen traits have not been fully analyzed so no judgment can be made on how Ralgro affects them.

The results show that possibly some increased growth can be obtained through the use of Ralgro implants in intact bull calves. A reduction in the growth of the reproductive organs will be obtained by implanting them very young, but most of this reduction in reproductive organs will be recovered if bulls are not reimplanted. As in the heifers, this single study does not provide us with complete answers to all our questions about the use of Ralgro. While more information is being gathered, it is not recommended that Ralgro be used in breeding animals, male or female.

TABLE 3

Slaughter data	Groups 1	2	3	4	5
Body weight (lb.)	1032	1057	1063	1000	1063
Hip height (cm)	122.5	120.9	122.8	120.0	121.9
Pituitary weight (g)	1.33	1.31	1.44	1.35	1.44
Testicle weight (paired, g)	535	432	618	406	532
Scrotal circumference (cm)	34.8	32.2	35.2	31.9	33.6
Hot carcass weight (lb.)	611.4	632.0	623.7	595.0	625.9
Ribeye area (In^2)	12.5	12.5	12.7	12.5	12.8
Fat 12th rib (in)	.22	.24	.24	.21	.25
Kidney fat (%)	1.75	1.70	1.50	1.52	1.69
Marbling score	4.2	4.5	4.7	3.8	4.8

SOME NUTRITION EFFECTS ON BIRTH WEIGHT AND CALVING DIFFICULTY AND RELATIONSHIPS OF FEEDING TIME AND CALVING

R. A. Bellows[a]

Calving is one of the most important times for the beef producer. In a sense, it represents the harvest of a year's effort of making both breeding and management decisions. If those decisions have been reasonably accurate, the harvest will be a good one. If they have not, unfortunately we pay the consequences.

Regardless of the wisdom of our decisions, the calving season is a physically exhausting time. The weather seldom really cooperates, the calves are too large or the heifers always have their calving problems between midnight and 5 a.m.

The two areas, calf birth weight and time of calving, are being studied at Miles City, and these will be the subject of this presentation.

Birth Weights

Stating that calf losses at or shortly after birth cause a major reduction in the net calf crop of beef cattle is nothing new. We all know that. The majority of these losses result from dystocia, and the dystocia is caused by a disproportion between the size of the dam and the calf. High birth weights have been identified as the most important factor contributing to this disproportion.

Birth weight results from the genetic growth potential of the calf responding to the uterine environment furnished by the dam. Studies to date indicate carefully selecting and controlling the genetic composition of the calf is the most effective way of controlling calving difficulties.

[a] Location-Research Leader, Livestock and Range Research Station, Miles City, Montana, USDA, SEA-AR and Montana Agricultural Experiment Station, Cooperating.

Studies to date indicate some interesting points. Studies reported account for 25 to 48% of the variation in calving difficulty, and birth weight alone accounts for 10 to 30% of this variation. Other work shows the heritability of birth weight is about 48%. Putting all this information together leads us to an interesting conclusion. We are far from having identified all the factors controlling birth weight and calving difficulty. There are obviously genetic, environmental and genetic X environmental effects that need careful study. Table 1 shows some very interesting data from a genetic X environmental interaction study where cattle were exchanged between Miles City and Brooksville, Florida. The genetics of the respective cattle groups were the same at both locations, but birth weights of calves in the Line 1 herd averaged 17 pounds less in Florida. Birth weights in the Florida herd averaged 11 pounds heavier in Miles City. Why, is the interesting question.

TABLE 1. GENETIC X ENVIRONMENTAL INTERACTION EFFECTS ON BIRTH WEIGHT IN HEREFORD CATTLE[a]

Breeding	Herd location	No. calves	Birth weight (lb.)
Line 1	Montana	727	81
	Florida	677	64
Florida	Montana	405	77
	Florida	363	66

[a] Burns et al., 1979.

Our work has shown that gestation feed level can affect birth weights. Other studies in the U.S. and other countries have also shown this. Some work has indicated that calving difficulty can be affected by the feed level of the dam prior to calving but our studies do not confirm this (table 2).

TABLE 2. EFFECTS OF GESTATION FEED LEVEL

Sire breeds[a]	Gestation feed level[b]	Postcalve body wt. (lb.)	Calf birth wt. (lb.)	Dystocia (%)	Pregnancy rate[c] (%)
Charolais, Hereford and Angus	Low	694	68	61	65
	High	794	71	56	83
Diff.		100	3	5	18

[a] Results of three studies combined; 133 head assigned.
[b] Low = 7.0 to 8.0 lb. TDN; High = 13.8 to 15.0 lb. TDN last 90 days of gestation.
[c] 45-day AI period.

We are now examining the relationships between calf birth weight and the level of crude protein in the gestation ration of the pregnant heifer. Eighty-two days prior to the average calving date, 38 pregnant crossbred heifers were divided into two groups of 19 each and placed in an individual feeding barn. The two groups were individually fed isocaloric rations (identical energy

content) daily that had been formulated to contain either a low or high level of crude protein. Ration analyses indicated the rations contained either 86% or 145% of the NRC crude protein recommendations while all other nutrients met or exceeded NRC recommendations. Heifers remained in the barn during calving and were observed 24 hours daily by experienced herdsmen. Need for obstetrical assistance at calving was based on their judgment.

Following calving, all lactating dams received supplemental feed and pasture with feed levels exceeding NRC standards. Heifers were bred by artificial insemination for a 45-day period. Results are summarized in table 3.

TABLE 3. EFFECTS OF CRUDE PROTEIN ON CALVING DIFFICULTY IN HEIFERS

Item	Protein level[a]	
	Low	High
Precalving dam:		
Body weight (pounds)	913	1005
ADG (pounds)	.9	1.6
Calving difficulty:		
Score	1.6	2.2
Incidence (%)	42	58
Calf:		
Birth weight (pounds)	73	84
Wean weight (pounds)	439	463
Pregnancy rate of dam (%)	78	73

[a] Isocaloric rations: low = 86%; high = 145% NRC crude protein.

Now, let's assume we have a 900-pound heifer gaining 1 pound per day before calving. The NRC recommended crude protein requirement is 2.27 pounds daily. This 2.27-pound requirement can be met by feeding 12.3 pounds of excellent quality or 14.3 pounds of average quality alfalfa hay. But, assume that instead of feeding 12.3 or 14.3 pounds of hay that we feed 20 pounds of hay. This feed level would result in supplying 3.68 pounds or 3.18 pounds or crude protein depending on whether the hay was excellent or average quality. These amounts of crude protein are 62 and 40% above the NRC recommended allowances

Compare these excesses with the study in table 3. The difference between the protein levels was 59% and the high crude protein was above the NRC recommended level. So, I believe this is a realistic example and is something producers must be aware of.

Remember, the study just discussed was conducted on heifers in an individual feeding barn. The rations were formulated using supplemental soybean meal not alfalfa hay. There are probably many other differences such as protein solubility and digestibility differences between the experiment and the example I have shown. Please don't interpret these figures as saying we can circumvent all our calving problems by feeding low levels of protein. Don't forget the

Idaho data on weak-calf syndrome. These studies suggest pregnant dams fed low levels of protein produce calves subject to weak calf syndrome. The point is that we must have balanced rations when we winter pregnant heifers. The heifer definitely has a crude protein requirement that must be met daily, but our data suggest very strongly that we can overfeed crude protein.

Time of Feeding and Time of Calving

The subject I mentioned at the beginning of this presentation regarding heifers calving between midnight and 5 a.m. has been receiving some research attention in recent years. The work did not originate at the Miles City Station. In fact, we started looking at this because we were receiving so many inquiries from producers--"Can I change the time of calving by feeding in the evening?"

Research into the subject reveals that a veterinarian, J. V. Moloney at Moxee City, Washington, was recommending that his clients feed cows in the evening to help them maintain body temperature during cold winter nights. He observed that in cow herds on this feeding regime, the majority of calvings were during the daylight hours. Further checking indicated that cows fed both morning and evening had almost the same incidence of daytime calving as those fed only in the evening. However when cows were fed only in the morning, calving did not occur until late afternoon or evening through about midnight with the more difficult calvings occurring in the early morning hours.

About this same time, Gus Konefal, a purebred Hereford producer from Arborg, Manitoba, was noticing that feeding his cow herd in the late afternoon and early evening resulted in calving during the daylight hours. He documented this for several years and then contacted Dr. Andy Boston of the Canadian Department of Agriculture and Dr. Gunther Rahnefeld at the Brandon, Manitoba, Research Station. An article in the Cattleman magazine on the Konefal Method of daytime calving started the ball rolling and interest mushroomed.

The Konefal Method involves feeding twice daily, once at 11 a.m. to 12 noon and again at 9:30 to 10:00 p.m. This feeding regime starts about 1 month before the first calf is born and continues throughout the calving season. Gus states the objective is to keep the cows busy (eating, walking, etc.) during the early morning hours.

The Konefal Method was experimentally tested on 83 cows. Group 1 (44 head) was fed at 11 a.m. to noon and again from 9 to 10 p.m. Group 2 (39 head) was fed at 8 to 9 a.m. and again at 3 to 4 p.m. The results are summarized in table 4.

TABLE 4. INFLUENCE OF FEEDING TIME ON CALVING TIME[a]

Group	No. calvings	Time of calving (%) 7 a.m. to 7 p.m.	7 p.m. to 7 a.m.
1. Fed 11 a.m. to noon and again 9-10 p.m.	44	80	20
2. Fed 8-9 a.m. and again 3-4 p.m.	39	38	62

[a] Gus Konefal, Arborg, Manitoba. X^2, $P<.01$.

Table 5 shows a summary of a survey conducted by Cliff Iverson, Iowa State University, of 15 Iowa producers. You will note that this was not exactly the same as the Konefal Method since the herds were fed once daily. However, the effect appears to be the same.

TABLE 5. TIME OF FEEDING-TIME OF CALVING, Iowa[a]

Feeding time	No. calvings	Calving time (%)	6 a.m. to 6 p.m.	6 p.m. to 6 a.m.
Morning feed only	695	x	49.8	50.2
		range	16.7-70.0	30.0-83.3
Evening feed only (5 p.m. to 10 p.m.)	1331	x	85.1	14.9
		range	71.4-100.0	0-28.6

[a] C. Iverson; X^2, $P<.01$.

Table 6 shows a combined summary of recent studies at the Brandon Research Station and at Miles City. Scientists at Brandon (Yarney and Rahnefeld) summarized time-of-calving for the crossbred herd from 1975 to 1978. This summary included 1151 calvings, and it is interesting to note that 52% of the calvings occurred from 7 a.m. to 7 p.m. and 48% from 7 p.m. to midnight. These percentages are identical to the percentages noted in the morning-fed groups at Miles City, 52% from 6 a.m. to 6 p.m. and 48% from 6 p.m. to 6 a.m.

TABLE 6. PERCENTAGES OF CALVINGS DURING 24-HOUR PERIOD AND SOME EFFECTS OF FEEDING TIMES, BRANDON, MANITOBA, AND MILES CITY

Location	Group and feeding	No. calvings	Time of calving: 7 a.m. to 7 p.m.	7 p.m. to midnight	Midnight to 7 a.m.
Brandon[a]	Silage, 8-9 a.m. + hay 3-4 p.m.	1151	51.5	19.6	28.9
	Silage only, 10-11 p.m.	280	56.3	28.3	15.4
			6 a.m. to 6 p.m.	6 p.m. to midnight	midnight to 6 a.m.
Miles City[b]	Silage + barley, 8-9 a.m.	21	52	19	29
	Silage + barley, 8-9 p.m.	22	67	21	12
	Hay + barley 7-9 a.m.	193	52	23	25
	Hay + barley 5-6 p.m.	193	62	21	16

[a] Yarney and Rahnefeld; X^2, $P<.01$.
[b] X^2, $P<.01$.

The feeding regime at Brandon at that time was silage fed in the morning and hay in the afternoon. In 1980, feeding was switched to a silage-only ration fed from 10 to 11 p.m. They report 13.5% more calvings between 7 a.m. and midnight occurring in 1980.

The Miles City studies were conducted in 1979 and 1980. The 1979 study involved 43 heifers held in feedlots during the entire calving season and fed all the corn silage that would be consumed in 8 to 10 hours plus 2 pounds ground barley. The morning-fed group was fed between 8 and 9 a.m. daily and the evening-fed group was fed between 8 and 9 p.m. This regime was started 1 week before calving started.

The second Miles City study involved 386 heifers that were divided into two groups 1 week before calving started. The morning-fed group was fed between 7 and 9 a.m. daily and the evening-fed group was fed between 5 and 6 p.m. daily. The daily ration for both groups was 20 to 23 pounds of alfalfa hay plus 3 pounds pelleted barley. Results indicate an increase in number of calvings from 6 a.m. to 6 p.m. which resulted from shifting calvings out of the midnight to 6 a.m. group.

This summary must be considered preliminary, but results certainly suggest a relationship between time of feeding and time of calving.

In summary, I would simply state: (1) feed gestation rations that contain adequate but not excessive amounts of protein; (2) try evening feeding but don't eliminate your night calving crew!

NUTRITION RESEARCH

Livestock and Range Research Station
R. J. Kartchner and D. C. Adams

Gaining an understanding of the nutrient requirements of range livestock and how best to provide these nutrients are the goals of the nutrition program at this Station. This involves, among other things, measuring the intake and digestibility of range forages, determining how these relate to the animals' needs and performance, and how we can manipulate animals and forages through management, supplementation and other means to make better use of our range forages to produce more beef.

We have concluded two projects that involved attempts to manipulate the forages available to the animal:

(1) Range Fertilization

Application of nitrogen fertilizer to native grasses has been shown to increase the protein content of these grasses. A study was made to determine whether animal response such as weight gains and reproductive performance could be improved by grazing fertilized forages. Over a 6-year period, an average of 50 lb of nitrogen per acre, per year, was applied to 455 acres of native rangeland and grazed by cow-calf pairs. Cow and calf weight changes on fertilized range were slightly higher than on non-fertilized range during the months of May

and June, but differences were negligible when projected across the grazing season from May through September or October. Conception rates and calving percentages were not affected by the fertilizer treatment. The primary benefit of fertilizer application came from increased forage production which increased the carrying capacity by 60-70% compared to untreated range.

(2) Introducing Alfalfa Into Native Forage

An effort was made to improve the diet of grazing cattle by introducing alfalfa into a stand of native grasses and forbs. This was done using a shallow (3-5 inches deep), flat-bottomed furrow approximately 2 feet wide and plowed on the contour. Furrows were established 2-3 feet apart and Ladak or Ranger alfalfa was broadcast in the bottoms of the furrows. The furrows served a two-fold purpose: (1) to provide a seedbed for the alfalfa seed and (2) to retain precipitation that would otherwise run off.

Very good stands of alfalfa were established in the furrow bottoms and native species continued to flourish in the areas between the furrows. Total production was increased 2 to 3 times over that on untreated range (table 1). As a consequence, we were able to more than double the number of animals carried per acre of land. However, the alfalfa in the diet did not make any difference in the rate of gain in yearling cattle.

TABLE 1. CONTOUR FURROWING - BN STUDY

	Average annual forage production (lb./A)	Average animal numbers per year	Average annual rate of gain (lb./day)	Total beef production, 5-yr total (lb./A)
Check	573	6	2.43	101
CF + alfalfa	1160	13.2	2.06	193
CF + alfalfa + 100 lb. N/A	1475	14.2	2.10	210

Other work has examined the role of protein and energy supplements in winter grazing programs. Supplemental protein or grain gave no beneficial response during one winter when forage availability was adequate (table 2). In fact, both protein and grain appeared to replace forage in the diet so the net energy intake was the same for those receiving protein meal or barley and for those receiving no supplement. A study of the diet of these animals indicated that the protein level in the forages consumed was adequate or only slightly deficient for meeting the needs of a dry cow. The experiment was repeated the following winter, a year of early heavy snowfall and prolonged cold weather. Forage availability was limited and considerable browsing of sagebrush, rosebush and other shrubs was observed. In contrast to the first year, protein supplementation was beneficial (table 3). Forage intake was increased by 16% compared to unsupplemented cows and the digestibility of the forage was increased by 7%. However, supplementing with as little as 1 lb. of barley per day depressed forage intake by 4% and forage digestibility by 16% when compared to those cows receiving no supplement.

TABLE 2. EFFECTS OF SUPPLEMENTS ON INTAKE AND DIGESTIBILITY OF WINTER RANGE FORAGE, 1976

	Treatment		
	Control	Protein meal	Barley
Supplement fed, lb./day	--	1.6	1.6
Forage intake, lb./day	19.0	18.0	17.3
Forage digestion, %	54.9	52.9	51.7
Total intake, lb./day	19.0	19.6	18.8
Total digestion, %	54.9	53.2	54.2

TABLE 3. EFFECTS OF SUPPLEMENTS ON INTAKE AND DIGESTIBILITY OF WINTER RANGE FORAGE, 1977

	Treatment		
	Control	Protein meal	Barley
Supplement fed, lb./day	--	1.6	1.6
Forage intake, lb./day	15.0	17.6	13.9
Forage digestion, %	40.6	43.6	34.3
Total intake, lb./day	15.0	19.1	15.3
Total digestion, %	40.6	46.4	38.8

These results have led us to investigate further the relationship between forage intake and digestibility and supplemental grain. Several studies have either recently been concluded or are currently underway to look at grain-forage relationships as related to (a) level of grain supplementation, (b) quality of forage and (c) interval of grain supplementation (daily vs every other day).

Another area of interest in our program is the effects that different management programs (such as supplementation) have on the behavior of cattle. We know that grazing behavior and grazing patterns are not haphazard but are quite predictable. We suspect that some of our management programs may affect these grazing patterns to the detriment of the animal. It is common for many stockmen to supplement range cows in the morning. However, this disrupts one of the prime grazing times of cattle; thus forage utilization, intake and animal performance may be altered. Because there are no data available to support this conclusion, we have initiated a trial to begin this fall to evaluate the effects of time of feeding of grain supplements on behavior and forage intake of grazing cattle. We feel that a better understanding of grazing behavior offers potential for improving animal performance.

And then there are times when we just can't get enough feed into the cow to meet her needs. This is especially true for low quality forages such as straw or mature grass. We are trying to determine to what extent a cow can increase consumption in response to conditions that cause her energy requirements to increase, such as cold stress, late gestation or lactation. We would like to know just what her limitations are on forages of differing quality.

At the beginning of this year, the nutrition program took on new strength with the addition to our staff of Dr. Don Adams, whose specialty is the internal

workings of the ruminant digestive system. As you may know, ruminant (multi-stomached) animals such as the cow have a unique relationship with bacteria. The cow provides a home (the rumen) for the bacteria, and the bacteria provide digestive services for the cow. This allows the cow to digest forages and to utilize poor quality protein and non protein nitrogen such as urea. Because of this relationship, to fully understand nutrient requirements of the cow we must also understand the role of bacteria in meeting these requirements. With this in mind, we recently have initiated a study to examine relationships of forage maturity on digestive processes and products in the rumen of grazing cattle. While basic in nature, this study will provide information to improve forage utilization and beef production, while increasing our knowledge of the grazing cow.

Measuring forage intake of grazing animals has been a major problem facing animal scientists for years. The techniques currently being used are very time consuming and require considerable manpower or they are variable in the results they produce. Currently, we are testing application of a simple technique of measuring forage intake by measuring the by-products of protein digestion by the rumen bacteria. The quantity of these by-products (e.g., ammonia) produced is directly related to the amount of protein consumed and, therefore, indirectly related to the feed consumed.

ANIMAL PREFERENCE AND FACTORS INFLUENCING PLANT SELECTION OF A HYBRID GRASS

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Recent development of hybrid forage grasses shows promise for advancing grassland agriculture. Previous selections within these hybrids have been based on morphological, reproductive and adaptive attributes with only limited testing of animal acceptability. Testing of animal preference and selectivity was the primary purpose of the present study. Yearling cattle were tamed and observed for their selectivity in grazing individual plants and genetic lines of F_6 crosses between quackgrass (Agropyron repens) X bluebunch wheatgrass (Agropyron spicatum) designated as ARS hybrids. Animals showed definite preference for individual plants within the genetic lines and for different genetic lines. Different animals frequently preferred the same plant or lines with identical genetic backgrounds. Preferences were exhibited even though animals were provided access at different times or different locations to a large array of hybrid plants or given a choice between the ARS hybrids and other palatable species (table 1). Selectivity was not necessarily associated with observed agronomic or morphological traits. Animals preferred plants rated as caespitose (bunchy) to those ranked rhizomatous (spreading). They also selected plants which had a profusion of soft leaves as well as plants with stiff, erect leaves. The most significant feature was the consistency in selection for certain plants and genetic lines.

Since palatability can limit the value of a particular grass for a range improvement program, it is desirable to develop a method, whether chemical or

biological, to provide for the rapid, reliable screening of new varieties of grass for their relative acceptability to livestock. Objectives of the current studies are to:

(1) Determine if differences exist between genomic lines of A. spicatum X A. repens hybrids in their acceptability to cattle.

(2) Examine the influence of the phenological state and morphological characteristics of hybrids on their acceptability to cattle.

(3) Examine the chemical parameters affecting succulence and digestibility of grasses and their relationship to palatability to determine if these parameters can be used to predict palatability of new hybrid grasses.

Tests are being conducted on two study areas. These areas both have light alluvial soils, good drainage, and medium to high fertility. One area, the Nursery, is on unirrigated dryland. The other, Field 8, is irrigated by a center pivot sprinkler.

The Nursery has replicated plots of 46 specific genomic lines of the hybrids. On this area, grazing trials using eight gentled steers and two esophogeal fistulated steers were conducted at weekly intervals throughout the summer season from May through August. Measurements were made of each plant prior to grazing to establish plant size, stage of growth, leaf type and growth type Plant moisture status as an index of succulence was measured for the 10 most preferred and least preferred hybrid lines. Samples were also collected from all plants for use in chemical analysis. After plant measurements were made, pairs of steers were allowed to graze the plot. The number and size of bites taken from each plant by each animal was recorded. From the data, relative palatability ranking of individual grass plants was established.

Highly significant differences in bite count preference were exhibited by the steers. The mean number of bites taken was 228 from the preferred plants compared with only 53 from the less preferred group. There was also a significant difference in the moisture percentage between preferred and unpreferred plants. The total moisture percentage averaged 72% for the preferred group and 68% for the least preferred plants. There was no detectable differences between groups using pressure bomb measurements as an index of succulence. Neither the older or newer leaves showed significantly different measurements in total water potential on plants selected or not selected by the animals.

Correlations between the number of bites taken (x) and the y variables of percent moisture or total water potential of leaves was low. Also, correlations between percent moisture (x) and water potentials of either old or new leaves was low. These results suggested that moisture may be important in the animal selection process but are not sufficiently definitive for describing critical differences between genomic hybrid lines for making plant selections. The significant preference and moisture differences, however, show that an index of succulence in combination with other chemical or digestibility attributes should be further evaluated in the animal selection process.

Chemical analyses will include total soluble carbohydrates, individual sugar composition, in vitro digestibilities, moistures, soluble nitrogen,

crude proteins, and silica content. The chemical analysis will then be compared to actual bite count data to establish if any relationship exists between the two. Similar comparisons will be made between the physical measurements and palatability rank.

Studies at the Field 8 site involve comparisons between the hybrids and six other species of grasses (Sherman's Big Bluegrass, a pasture mix of meadow brome and cicer milkvetch, Crested Wheatgrass, Pubescent Wheatgrass, Russian wild ryegrass, and Altai wild ryegrass). The influence of regrowth on what animals select is the primary evaluation in this study. This site was strip-mowed on a 3:1 ratio, unmowed to mowed. The same steers used at the Nursery were also used here to evaluate species preference in relation to plant growth. The time they spent grazing each species in the mowed versus unmowed area was recorded during a 1- to 2-hour trial. From this trial, we hope to be able to further evaluate how the hybrid rates in palatability compared to other palatable grasses and determine how large an influence regrowth has on what animals choose to eat.

TABLE 1. PERCENT OF TIME SPENT GRAZING HYBRID PLANTS AND OTHER SPECIES BY YEARLING STEERS. AVERAGE TIME FOR 4 DAYS OF TRIALS DURING FOUR TIME PERIODS.

Grazing period	ARS hybrids	Altai wild ryegrass	Sherman Big Bluegrass	Pasture mix	Crested Wheatgrass
			%		
June	39	4	14	40	3
July	25	15	21	18	21
August	7	6	6	70	11
October	16	36	18	20	10
Average	22	15	15	37	11

PRESCRIBED BURNING IN NORTHERN MIXED GRASS PRAIRIES

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Fire has played an important historical role in the development of grassland communities. Nevertheless, negative attitudes toward burning have frequently limited application of fire as a management tool. Factors such as fire escaping the boundaries of a prescribed burn, temporary elimination of potentially usable forage, and the destructive effects of wildfires have all contributed to such attitudes. Because fire represents a relatively inexpensive method of modifying plant communities, however, it provides several management

opportunities to livestock producers in the Northern Great Plains. The primary thrust of our fire research has been to examine the potential forage benefits that can be realized by burning.

Our study was designed to evaluate the effects of prescribed burning in the mixed grass prairie of eastern Montana. The primary objectives were: (1) to examine post-burn herbage production of three species throughout the growing season, (2) to compare the effects of both fall and spring burning and (3) to determine whether burning would be an effective method of controlling silver sagebrush.

Prescribed burning was conducted in the fall and spring to evaluate the effects of fire on productivity of three forage species. Yield measurements were obtained throughout the growing season at biweekly intervals on western wheatgrass, blue grama, and threadleaf sedge. We found that herbage yield depended upon individual species, sampling date, and treatment as shown in Table 1. Spring burning of western wheatgrass and blue grama stimulated production by mid- and late-June, whereas fall burning also stimulated productivity but to a lesser degree. Production of threadleaf sedge was relatively unaffected by spring burning and reduced by fall burning. Our results show that fire can be used as a management practice to increase forage yield in the Northern Great Plains, but timing of utilization by livestock must receive careful consideration to assure maximum benefit. Some additional factors merit consideration depending upon individual circumstances.

The decision to burn should depend upon when forage needs are anticipated and also on what plant species are predominant. If grazing on a given site is needed in early June, our results indicate that burning should not be undertaken. At that time, plants on burn treatments never out-yielded those on the control. Conversely, if grazing can be deferred until mid- or late-June, burning may be effective in stimulating forage production. At that time, we found that all three species subjected to fall or spring burning out-produced the untreated control. Spring burning, however, usually resulted in higher productivity than fall burning. If grazing is postponed until summer, our results indicate that the decision to burn should depend upon species composition. If western wheatgrass is dominant, burning may not increase forage production. Plants on burned plots tended to dry out more rapidly and provided less standing forage after early July. Blue grama and threadleaf sedge, in contrast, exhibited the opposite trend and had lower yields on the control than on burned plots. Consequently, there may be merit in burning ranges dominated by these species when late utilization is anticipated. Another key factor to consider is available moisture. Burning should not be conducted during the droughts that periodically occur in the Northern Great Plains.

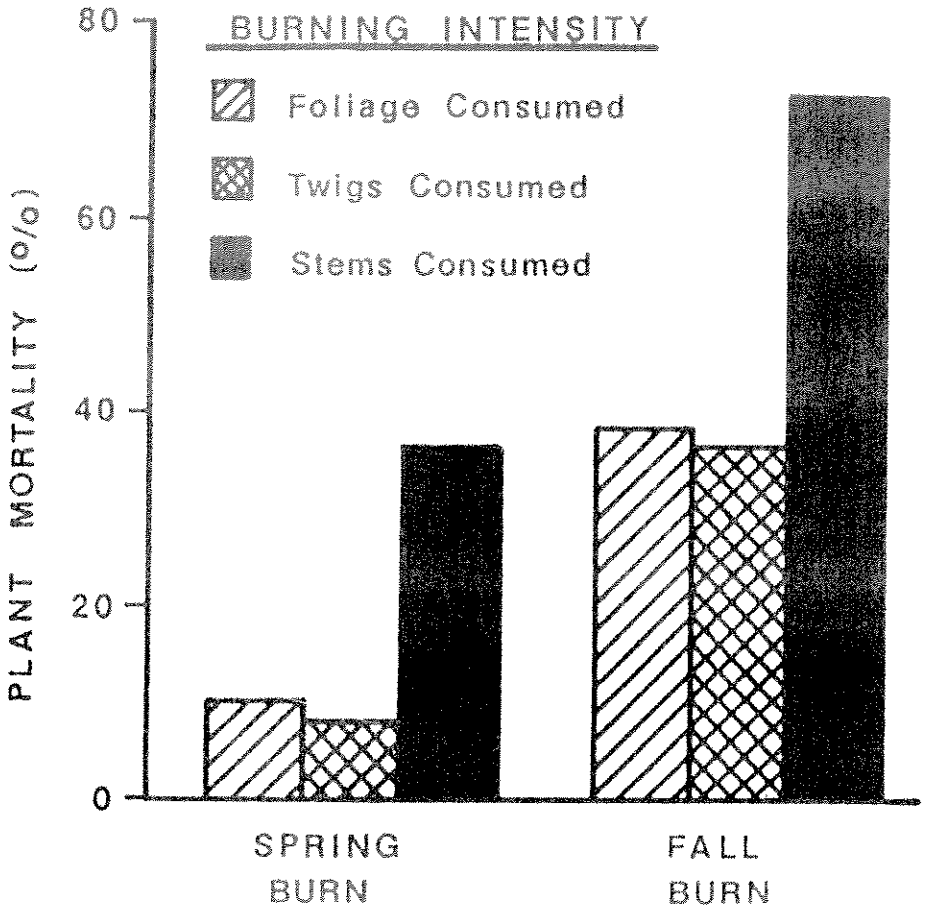
Prescribed burning was also conducted in the spring and fall to evaluate the effects of fire on silver sagebrush. Silver sagebrush survival depended upon fire intensity and the time of year when burning was undertaken (Figure 1). In the spring, soil moisture was high, and sagebrush plants were just becoming active after winter dormancy. At this time about one-third of the plants that were completely burned were killed by fire. Plants that were less thoroughly burned, however, sustained mortalities of less than 10%. Considerably higher plant mortality was achieved by burning under dry fall conditions after sagebrush plants had completed growth and reproductive activity. After fall burning, about three-fourths of the plants that were burned to the stump died,

and almost 40% of the rest were killed by fire. Mortality differences between burning periods were highly significant. This demonstrated that good silver sagebrush control could be achieved by burning under dry conditions in the fall. Better control can probably also be obtained by proper fuel management. Because there was a two- to three-fold increase in kill when plants were completely burned, it is more advantageous to have a more intense burn. One way of achieving this would be to defer grazing before a planned burn. This would serve to provide more fuel and contribute to a more intense fire.

Table 1. FORAGE GROWTH RESPONSE OF DOMINANT SPECIES ON THREE VEGETATION TYPES AT DIFFERNT TIMES OF GROWING SEASON

	Standing Biomass (lb/ac)		
Date	Fall burn	Spring burn	Control
		Western Wheatgrass	
4/27	485	139	461
5/8	736	542	800
5/21	1499	1466	1819
6/4	1973	2062	2174
6/18	3175	3250	2952
7/2	3411	3411	3590
7/30	2811	2922	3442
		Blue Grama	
5/25	673	655	913
6/5	986	1072	1394
6/18	1643	2119	1583
7/2	1579	1610	1383
8/13	1297	1171	814
		Threadleaf Sedge	
4/25	185	161	174
5/8	300	388	395
5/21	688	763	719
6/4	814	1043	1069
6/18	1290	1321	1259
7/2	1222	1162	1069
7/30	1025	1142	----

Figure 1. MORTALITY OF SILVER SAGEBRUSH EXPRESSED AS A FUNCTION OF BURNING INTENSITY AND TIME OF BURNING.



STAND ESTABLISHMENT OF SEEDED GRASS SPECIES

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The economic advantages of using introduced forage species to complement grazing of native range have been well established in the Northern Great Plains. Nevertheless, stand establishment of seeded species can present formidable problems that may discourage the most effective utilization of range resources. Our efforts have been directed toward achieving a better understanding of seedling characteristics that may ultimately affect stand establishment. Such knowledge should facilitate stand establishment so that seedling mortality can be reduced and grazing deferment can be shortened.

Research work was performed using field plantings. Three perennial forage species--crested wheatgrass, pubescent wheatgrass, and Russian wild ryegrass--were seeded in late summer and early fall to obtain seedlings with diverse morphological characteristics. Individual plants of each species were measured and relationships established between seedling size and subsequent seedling development. Specifically, objectives were to: (1) define and quantify relationships between morphological development and winter injury, survival, and growth; and (2) develop a management strategy for stand establishment that considers early seedling growth and development.

Our data showed that winter damage was inversely related to the number of leaves that a seedling had at the time of fall dormancy regardless of planting date (Table 1). Those plants that had only one leaf were most severely injured, but they varied considerabley between the three grasses in amount of damage sustained. As seedlings became larger, tissue damage declined, and more than 70% of the plants with three leaves and more than 90% of the plants with four or more leaves showed either no effects or only light damage.

These results are important from a management standpoint. In our study, no seedlings with more than two leaves died during the winter, and no seedlings with more than three leaves showed heavy or severe damage.

Seedling survival during the first full growing season was closely related to seedling size at the beginning of spring and varied according to individual species (Table 2). During the spring growing period, there was little mortality in any species. Soil moisture and growing conditions were favorable during this time. By late October, however, spring seedling size had a more profound effect. Seedlings that emerged in the spring and those which had one spring leaf had much higher mortality than larger seedlings. This was apparently related to higher soil moisture stresses that occurred later in the summer.

Growth during the first full growing season was directly related to both initial seedling size and winter injury. Seedlings with three or more leaves suffered little winter injury, grew vigorously, and were ready to be grazed after less than a full year of deferment. We were therefore able to effectively shorten the normal deferment period by a full year by having seedlings in a three to five leaf growth stage at the time of fall dormancy.

In the Northern Great Plains, our results suggest late-summer planting in a seedbed that has been summer fallowed to obtain good subsurface moisture is a good management practice. If intermittent late-summer rains occur, seeds will germinate and roots can reach the fallowed moisture. Favorable temperatures would then allow seedlings to develop three or more leaves before fall dormancy. If late-summer rain does not occur, seeds will not germinate, and the planting would be analogous to a late autumn seeding. Although this planting strategy is contrary to the more common practice of seeding in late autumn, it provides additional opportunity to shorten the grazing deferment period. If spring and summer rains are inadequate to provide favorable subsurface moisture by fallowing, seed should be planted in late autumn. This will delay germination until the following spring when moisture conditions will be more favorable.

Table 1. PERCENT OF DAMAGED PLANTS CLASSIFIED ACCORDING TO THE PERCENT OF TISSUE KILLED AND THE NUMBER LEAVES OBSERVED IN THE PRECEDING FALL.

Number of leaves	Winter damage category					
	None	Light	Moderate	Heavy	Severe	Dead
			CRESTED WHEATGRASS			
1	11.1	25.0	27.8	19.5	12.0	4.6
2	12.7	32.0	44.0	5.3	2.0	4.0
3	35.9	41.0	18.0	5.1	0.0	0.0
4+	71.5	25.2	3.3	0.0	0.0	0.0
			RUSSIAN WILD RYEGRASS			
1	2.1	14.7	48.2	25.9	6.3	2.8
2	1.9	32.7	56.1	5.6	2.8	0.9
3	17.4	56.5	26.1	0.0	0.0	0.0
4+	43.9	51.2	4.9	0.0	0.0	0.0
			PUBESCENT WHEATGRASS			
1	0.7	15.9	53.6	19.2	6.0	4.6
2	14.9	45.6	37.4	0.7	0.0	1.4
3	21.2	60.6	18.2	0.0	0.0	0.0
4+	39.2	55.4	5.4	0.0	0.0	0.0

[a] Data were from 1440 individually marked plants.

TABLE 2. RELATIONSHIP BETWEEN SEEDLING SURVIVAL AND PLANT SIZE DURING THE FIRST FULL GROWING SEASON AFTER PLANTING.[a]

Species	Number of leaves in early spring			
	0	1	2	3+
	Survival after Spring (%)			
Crested wheatgrass	93	88	94	100
Pubescent wheatgrass	99	89	99	97
Russian wild ryegrass	93	89	87	94
	Survival after Summer (%)			
Crested wheatgrass	91	84	91	97
Pubescent wheatgrass	75	74	96	96
Russian wild ryegrass	43	66	78	96

[a] Plants with 0 spring leaves were seeded in late October and were marked shortly after emergence in the spring.

EFFECT OF PRECIPITATION ON MIXED GRASS PLANT COMMUNITIES OF SOUTHEASTERN MONTANA AND ITS IMPLICATIONS TO GRAZING INTENSITY

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Data were compiled for a grazing study over a 24 year period between 1932 and 1956 at the Livestock and Range Research Station, Miles City, Montana. The data were collected on two sets of research ranges located on the Station. One set, called Hogback, was used for summer grazing. The other set, called Lone Pine, was used for winter grazing. Each set was used for approximately 6 months of the year. Within each set, there were six pastures of varying sizes. The grazing intensity was varied by putting the same amount of cattle on each pasture. Pairs of pastures in each set were approximately the same size, so that three grazing intensities, with two replicates of each, were represented. These were matched between the summer and winter sets so that cattle from one heavily grazed pasture were always moved to the corresponding heavily grazed pasture as the season changed. The stocking rates were 1.9 acres per AUM (animal unit month) for heavy grazing, 2.6 acres per AUM for moderate grazing, and 3.25 acres per AUM for light grazing.

The data contains two major studies, plus several smaller studies. One of the two major studies is basal area cover data including pantograph charts. The pantograph charts are from 57 one meter chart quadrats that were scattered over both the summer and winter ranges. The other major study is utilization surveys based on height-weight response data. The smaller studies include sagebrush utilization and control studies, cactus measurement studies, SCS soil and range surveys, and various soil studies, including determination of bulk density, organic matter content, and water infiltration. It also contains climatic data and records of livestock used in the study. The original intent of the study was to study the effects of different grazing intensities on range and livestock. However, because of the wide variation in climate during the period of time of the study, it integrates the effects of climate into the study.

The purpose of our project is to determine changes in plant communities due to changes in the amount of precipitation, under the influence of different grazing intensities. Specific objectives are: (1) to investigate the relationship between plant community composition and precipitation, (2) to examine the variation in such relationships with respect to grazing intensity, and (3) to examine management alternatives that maximize desirable plant communities under variable climatic conditions.

The data are being used to develop equations that can be used to predict the response of the plant species to the level of precipitation. Herbage utilization data are being used to determine proper grazing intensity under fluctuating precipitation levels. The level of utilization that is least damaging to the plant community at a given level of precipitation can then be recommended.