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Feeding Protein, Phosphorus and Energy Supplements to Beef Cows on Utah Desert Ranges

Robert Hyrum Olsen
Utah State University

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FEEDING PROTEIN, PHOSPHORUS AND ENERGY SUPPLEMENTS
TO BEEF COWS ON UTAH DESERT RANGES
by
ROBERT RYRUM OLSEN

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in
Animal Nutrition

UTAH STATE UNIVERSITY
Logan, Utah

1959
ACKNOWLEDGMENT

This research was financed in part by the U.S.D.A. Regional Research W-34 and the phosphorus supplements were provided by Monsanto Chemical Company.

My sincere appreciation is extended to Dr. John E. Butcher for assisting in the planning of this experiment and for the advice and assistance given in carrying out the project, and for the aid in the statistical analysis of the data and preparation of this thesis; to James and Carl Dearden for furnishing the cattle and range for this experiment, and for their assistance in carrying it out; to Dr. Lorin E. Harris for his suggestions in the preparation of this thesis; to Clifford Bellander for his aid in carrying out this project; and to my parents who have always encouraged me to obtain an education.

Robert H. Olsen
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INTRODUCTION

Many of the beef cattle in the Great Basin area are maintained part or all of the year on range lands. Most of those going on to desert ranges for only part of the year go on during the late fall, winter, and early spring. It is estimated that 50-60 percent of the 600,000 beef cattle grazing on range lands in Utah graze on the one-fourth million acres of desert or semi-desert sometime during the year.

The desert ranges of the Great Basin are composed primarily of browse species, and are intermixed with various grasses of the area at different intensities. These areas furnish about five months forage each year, although certain areas are grazed year long.

There are great variations of temperature, rainfall, elevation, topography, soil type, and site. These differences account for the variations in species, forage quality, and nutritive content of the plants grown.

Previous studies on range forage plants have indicated that there may be a deficiency in phosphorus and protein on desert winter ranges. Because of a lack of protein and phosphorus in the diet, cattle may not be able to consume an adequate ration, therefore, an energy deficiency may occur. Work which has been done with sheep shows that maintenance requirements are met but that protein and phosphorus are too low for most efficient production of wool and lambs. The data obtained from a range research experiment conducted in previous years on Utah desert ranges indicated that protein and phosphorus may be too low for most efficient production of beef cattle.
An experiment was set up in 1957 to continue the study of the previous year and note the effects of supplementing cattle to offset these deficiencies. The objectives of this experiment were:

1. To note the effect on the cattle weights, calf crop, and weaning weight of calves due to supplementation.
   a. A group feeding trial was conducted to determine effects of protein and phosphorus supplementation.
   b. An individual feeding trial was conducted to determine effects of protein, phosphorus and energy supplementation.

2. To develop equipment that can be used to feed animals individually on the range.

3. To develop techniques of handling cattle for range nutrition research.
REVIEW OF LITERATURE

A careful study of the literature review presented in a thesis by James (1957) "Supplementing cattle with protein and phosphorus on desert ranges" has been completed. This current thesis is based on information that was collected as a continuation of the previous study. Therefore, the literature review presented here has been summarized with a minimum of repetition of the previous work. New information from more recent studies has been added along with information regarding energy supplementation which was a new phase of the work.

The standards and requirements referred to throughout this thesis are those of the National Research Council, Morrison's "Feeds and Feeding", and Maynard and Loosli's "Animal Nutrition". The latest edition of each of the above named sources was used in compiling the following table.

Table 1. Wintering mature pregnant beef cows. 1/

<table>
<thead>
<tr>
<th></th>
<th>Wt. of cow</th>
<th>Total feed</th>
<th>Dig. prot.</th>
<th>TDN</th>
<th>Phos.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs.</td>
<td>lbs.</td>
<td>lbs.</td>
<td>lbs.</td>
<td>grams</td>
</tr>
<tr>
<td>N.R.C. - 1958</td>
<td>800</td>
<td>22</td>
<td>1.0</td>
<td>11.0</td>
<td>15</td>
</tr>
<tr>
<td>Morrison - 1957</td>
<td>900</td>
<td>14.5 - 20.5</td>
<td>.65 - .70</td>
<td>6.9 - 9.7</td>
<td>17</td>
</tr>
<tr>
<td>Maynard and Loosli - 1956</td>
<td></td>
<td>(uses N.R.C. standards)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ N.R.C. requirements allow for 1.5 lbs. daily gain and Morrison allows for a slight gain.

Nutritional deficiencies

The value of a feed depends upon the nutrients contained in it. Animals that eat the feed have certain minimum nutritional requirements
which must be met in order to produce efficiently. Therefore, in order to balance diets on the range, it sometimes is necessary to feed supplements (Cook and Harris, 1950).

In a study of Utah's winter range Esplin et al. (1937) analyzed 16 dominant desert plants. They found that energy provided by winter range forage was adequate, but that a severe deficiency of phosphorus and a slight deficiency of protein existed according to chemical analyses. Experimental work in New Mexico and surrounding states has shown that many of the semi-desert grasses are too low in phosphorus to properly meet range livestock needs (Knox et al., 1946).

The season or stage of maturity at which a plant is grazed has a profound influence on its nutritive value. Young plants are high in protein and phosphorus but almost all range plants are deficient in these constituents when mature (Harris et al., 1956).

Chemical analysis of the entire plant compared to that portion of the plant which cattle or sheep graze shows that animals tend to select and eat the most nutritious portions. This selectivity becomes greater with increased maturity (Cook et al., 1954).

Browse plants of the Great Basin area are known to contain a much higher content of protein than the grasses of the area. They also contain a high level of carotene which will meet the needs of most grazing livestock (Cook et al., 1954).

Sheep tend to graze a diet containing more browse and less grass than do cattle. The selectivity of grazing by sheep is greater than with cattle and the sheep's diet may be more nearly balanced (Harris et al., 1956).
Cook et al. (1954) found that the chemical content of ungrazed desert range plants did not change appreciably after the cattle reached the range late in the fall. Most of the chemical change and losses due to maturity and leaching come earlier in the late summer and fall of the year. In a study by Knox and Watkins (1942) some plants were chemically analyzed for nutrient losses. Seventy-five percent loss of phosphorus and 25 percent loss in calcium occurred between April and September on New Mexico ranges. Ninety-eight percent of the plants analyzed in February and March were low in phosphorus. In ordinary years this deficiency becomes acute from January until new growth starts.

Some of the principal range grasses on the college ranch in southern New Mexico were observed to show losses of 37 to 73 percent between October and March (Watkins, 1943). During this same period phosphorus losses of from 49 to 83 percent were observed, depending on the amount of late fall and winter leaching losses. Except at the peak of the growing season, phosphorus requirements of cattle were not met according to blood analyses using four milligrams of inorganic phosphorus per 100 cc. of plasma as the minimum requirement. Carotene levels of the forage grasses were borderline or deficient during the winter months. Sagebrush (Artemisia filifolia) and shadscale (Atriplex canescens), the main browse plants, were adequate in protein, phosphorus, and calcium.

Harris et al. (1956) found that supplementation with phosphorus, protein, and energy increased weight gains of pregnant ewes. Clean wool and grease wool were significantly increased by phosphorus and protein supplements.
Knox and Watkins (1942), Lantow (1930), and Nelson et al. (1955) all found advantages in feeding protein and phosphorus supplements to range cattle.

**Phosphorus**

The mineral matter of the body is composed of many minerals. Chief among these are calcium and phosphorus. Despite their small amounts, they are absolutely essential to life (Maynard and Loosli, 1956). The phosphorus, which is combined with calcium to form the skeleton, accounts for approximately 80 percent of the body supply. The remainder is widely distributed in combination with certain proteins and fats and as inorganic salts. Phosphate ions are found in the blood cells. Phosphorus is essential for energy transfer in the muscle tissue.

Phosphorus deficiency is likely to occur in cattle or sheep grazing semi-arid areas in which phosphorus is lacking in the forage.

There is usually no correlation between calcium and phosphorus in the soil and plants grown on that soil; however, some species are more efficient than others in obtaining phosphorus from the soil and showed a high content even on soils low in available phosphorus. (Cook and Harris, 1950). In this same study it was found that there was a significant decrease in percent phosphorus as the season advanced in nearly all species and in their various plantpart.

The National Research Council (1958) listed the symptoms of phosphorus deficiency as a decrease in blood phosphorus, a depraved appetite, and decreased weight gains. These symptoms are followed by pica and a craving for bones, sticks, etc. Irregularities in the estrous cycle may also occur. As the deficiency becomes more pronounced, the efficiency of feed utilization decreases, especially in regard to protein.
There is indication from blood data that the availability of phosphorus may be associated with protein in the diet (James, 1957).

The amount of inorganic phosphorus in blood plasma has been found to be a good measure of the adequacy of phosphorus consumed by cattle. Work with dairy cows shows that 4 to 6 milligrams of inorganic phosphorus in 100 cubic centimeters of blood plasma are normal for mature cows. This is in agreement with Stanley (1938), Watkins (1948), and Knox et al. (1941).

Lonn et al. (1957) conducted feeding trials with grade Hereford steers to compare the effects of different percentages of supplemental phosphorus on feed consumption, weight gain, and inorganic phosphorus in the plasma as measures of phosphorus nutrition. He fed steers monosodium phosphate to raise the base level of (.07 -.09%) phosphorus in the ration to various levels between 0.11 and 0.19 percent of the total diet. Feed intake, weight gain, and plasma phosphorus increased with increased phosphorus from .07 to .11 percent. Plasma phosphorus was especially sensitive to change in phosphorus intake but showed periodic variation. Heifers calving at two years of age had lower inorganic phosphorus levels than open heifers wintered at the same level (Thomas 1948).

Nelson et al. (1955), in his work with cows on the range in Oklahoma, found that a daily phosphorus intake of 7 grams per head in winter, 9 grams in early summer, and 6 grams during late summer was required. This requirement was met by 16 to 20 pounds of prairie hay and 1.25 pounds of protein supplement. In years of poor grass growth a phosphorus supplement should be provided as a margin of safety, and also when two pounds or more of a protein supplement is fed.
Types of phosphorus supplements

In areas where soils and forage are deficient in phosphorus, it is a common practice to feed a mineral phosphorus supplement. Many methods of feeding the supplements on the market have proven quite satisfactory.

Minerals have been successfully and conveniently fed mixed with salt at a level of 6.5 percent phosphorus (Knox and Watkins, 1942).

James (1957) found monosodium phosphate mixed into the water to be a satisfactory method of administration in cases where the water is supplied by hauling to troughs located on the range.

Steers and lambs were used to ascertain the relative availability of various inorganic phosphatic materials for ruminants, using phosphorus balance and inorganic blood phosphorus levels as criteria when 80 percent of the phosphorus of the diet came from inorganic sources (Ammerman et al., 1957). It was found that no difference existed between two commercial electrothermically produced dicalcium phosphates, two calcined defluorinated phosphates, and one sample each of bone meal, soft phosphate with colloidal clay, and Curacao Island phosphate were of equal value in promoting phosphate retention and maintaining blood phosphorus levels in yearling steers, but only dicalcium phosphate and Curacao Island phosphate was utilized by lambs.

Long et al. (1957), in feeding trials conducted with heifers using steamed bonemeal, Curacao Island phosphate and dicalcium phosphate, showed no statistical difference between the phosphorus types studied.

Mineral supplements of dicalcium phosphate, steamed bonemeal, or defluorinated rock phosphate proved to be satisfactory supplements when mixed with two parts ground rock salt and one part phosphorus supplement.
In a study conducted with Hereford beef steers, Tillman and Brethour (1958) showed that there was no statistical difference between reagent grade phosphoric acid and di-calcium phosphate as phosphorus supplements when 60 percent of the phosphorus of the diet was supplied by the supplement.

The requirement for phosphorus by calves weighing from 200-275 pounds was shown to be about 0.22 percent of the air dried ration by Wise et al. (1958). Adding a factor of safety, calves from 12-18 weeks of age should receive about 0.30 percent phosphorus in the diet.

**Protein**

Proteins are present in every cell, and as such, are the principal constituent, other than water, of the organs and soft structure of the body such as the muscles, tendons, and connective tissues. The body is composed of about 20 percent protein from these various tissues according to Maynard and Loosli (1956) and Morrison (1957).

A deficiency of protein causes a decrease in the digestibility of the ration, retards growth in young animals and slows the rate of gain in fattening animals. Milk production drops off, and the animals become unthrifty in appearance. A prolonged deficiency can result in permanent injury (Morrison, 1957).

The National Research Council requirements are based on farm conditions and allow for 1.5 pounds gain in weight each day. Cattle can be wintered at a lower level of protein and still produce normal calves according to Butcher (1958). Heifers and ewes were wintered at three levels of protein, five percent, seven percent, and nine percent of the diet. This equals a level at maintenance as derived by Kliber's formula,
one 30 percent above, and one 30 percent below. All heifers and ewes produced normal offspring, although, those on the two lower levels lost weight while the high level gained weight during the test period. This suggests that National Research Council levels may be too high for practical application to range livestock although this is supported by only one years data and provides no evidence on carry over effect.

On the basis of data collected by Thomas (1948), it would appear that the practice of wintering heifers bred to calve at two years of age at a high level of nutrition is not as economical as wintering at a low level. This was verified by records of their future production.

In this same study, it was noted that the plasma-protein level tended to be lower for heifers wintered at a low level than for heifers from the higher levels.

In digestion and nitrogen balance trials with lambs, soybean oil meal, sesame oil meal, and cottonseed meal were compared as protein supplements in semi-purified rations containing 4, 6, and 9 percent protein. The digestibility of protein at each protein level was significantly lower in the cottonseed meal ration than in either of the other two rations. Also, average nitrogen retention at each protein level was lowest with the cottonseed oil meal ration and highest with the sesame oil meal ration (Woods et al., 1958).

Energy

The feeding value of forage depends primarily on the magnitude of its contribution toward the daily energy need of an animal. The difference between forages in respect to their contribution is due to the amounts in which they are consumed (Crampton, 1957). Also, the extent of voluntary consumption of a forage is limited mainly by the role of
digestion of its cellulose and hemicellulose rather than by the contained nutrients or the completeness of their utilization.

This is further explained by Moir (1958) who states that the rate of digestion determines the amount of a nutrient made ready for body use. The total capacity cannot influence digestible nutrients any faster than digested materials are removed to make room for new feed. Rate of digestion is more important than capacity and becomes slower as feed intake goes higher. With limited feed intake the rate of digestion and completeness of digestion is increased. The digestibility was raised from 68 to 72 percent of the dry matter ingested by sheep.

The rate of digestion may be retarded by any one of numerous circumstances which interfere with the numbers or activity of rumen microflora. These include: excessive lignification from advanced maturity of forages, partial starvation of flora from nitrogen or specific mineral deficiency, or from the presence in excess of bacteriostatic agents (Crampton, 1957).

According to Cook et al. (1954) total digestible nutrients or digestible energy are inaccurate measures of energy values for range forage due to the consumption of browse plants which contain essential oils and are lost to the animal consuming them via the urine. Therefore, metabolizable energy is a much more accurate measure of a range diet's energy worth.

The digestibility of nitrogen-free-extract, crude fiber, cellulose, and other carbohydrates decreases as the lignin values increase within a single species of plant in its different stages of growth (Phillips and Loughlin, 1949). Most species of plants on Utah ranges showed a steady decrease in digestible protein, cellulose, gross energy, and other
carbohydrates as maturity increased (Cook et al., 1954).

Studies conducted by Skipitaris (1957) with pigs to determine the influence of added sugar upon the digestibility of crude protein and crude fiber of barley showed that addition of 16 percent sucrose to the ration decreased crude fiber digestion by 38 percent. This is in agreement with ruminant studies.

Heifers wintered on a low level of nutrients successfully produced two calf crops when bred to calf at two years and three years of age, but required longer to reach their mature weights than similar heifers which were on liberal rations (Thomas, 1958).

**Water**

Water, because of its abundance and universal use, is seldom regarded as a feed, and yet it is one of the most essential nutrients for all animal life (Snapp, 1952). The vital role of water in the body was shown by Rubner who observed that the body can lose practically all of its fat and over one-half of its protein and yet live while a loss of one-tenth of its water causes death (Maynard and Loosli, 1957).

All living plant or animal tissues are composed to a large extent of water. In the case of cattle, the water content is approximately 95 percent for the embryo shortly after conception, 75 to 80 percent at birth, 66 to 72 percent at five months, and 50 to 60 percent in the mature animal (Maynard and Loosli, 1956).

Water dissolves and transports nutrients, acts in chemical reactions of digestion, aids in control of the body temperature and gives shape to plants and animals (Morrison, 1957). Water varies between tissues of the body. Blood plasma contains 90 to 92 percent, muscle, 72 to 78 percent, bone, approximately 45 percent, and the enamel of the teeth 5 percent.
Water is excreted in the urine as a solvent for metabolic products which leave the body through this channel. It is also lost to the body through respiration, perspiration, and with the feces (Maynard and Locali, 1957).

Cattle obtain about one-third of a gallon of water per day through the ingestion of dry feeds which contain about 10 percent moisture. In contrast to this, a very large portion of the daily water requirement may be obtained from green succulent feeds (Winchester and Morris, 1956). In this same study it was found that the level of nutrition or amount of feed eaten did not influence the ratio between dry matter and water required. Water intake and urine excretion rates were shown to be related to temperature, protein, and dry matter intake by Winchester and Morris (1956). Steers on high protein allowances consumed 26 percent more water than did similar animals on low protein rations.

Protein supplements fed with salt as a regulator of consumption increased water intake from 22 percent or less up to 100 percent (Riggs et al., 1953). Winchester and Morris (1956) were able to increase water consumption 40 to 60 percent by increased feeding of salt.

The influence of the ratio of energy to dry matter on water consumption of cattle is still unknown.

Ragsdale et al. (1953) found that at temperatures below 75 degrees Fahrenheit, the effect of humidity was found to be negligible. The frequency of drinking was greater above than below 75 degrees and at temperatures above 75 degrees water consumption was somewhat less at high than at low levels of relative humidity.

Winchester and Morris (1956) found that until the ambient temperature exceeds 80 degrees Fahrenheit, cattle tend to do most of their drinking in the late forenoon or in the early afternoon. The least drinking occurred
in the night and morning hours. Ragsdale *et al.* (1950) found that cattle drink oftener, about every two hours, at temperatures above 90 degrees Fahrenheit.

Winchester and Morris (1956) showed water intake to be a function of dry matter consumed, and ambient temperature. Little influence was noted between 10 to 40 degrees ambient temperature, but as the ambient temperature rose above this value, the water consumption rose very sharply to a high near 100 degrees Fahrenheit.

Water hauling is becoming an increasingly important part of desert range management. Where natural water supplies can not be developed, water hauling to livestock offers the following advantages (Costello and Driscoll, 1957):

1. Hauling provides a dependable water supply in dry seasons.
2. It helps the cattle owners obtain a more even use of forage.
3. It places water where forage is available.
4. It reduces trailing damage to the range.
5. It permits grazing at the most appropriate time of the season.
6. Animal weight gains are more easily maintained with the reduced travel.

Successful water hauling requires an adequate source of water within 15 miles, and storage space for one week's supply of water. Also, a tank truck and troughs for about 1,000 gallons of water is required for an economical unit according to the Costello and Driscoll (1957).

As a rule of thumb, the average cow requires 10 gallons of water per day. The actual amount an animal will consume depends on the weather, kind of forage, and size of animal.

According to the Agricultural Research Service (1957), a 1,000 pound steer or heifer on southwestern ranges will consume 7 gallons of
water daily at 40 degrees Fahrenheit; 10 gallons at 70 degrees, and 17 gallons at 90 degrees.

Salt should be placed about one quarter mile from the water because the average time lapse between salting and watering for cattle is seven hours (Costello and Driscoll, 1957).

Salt as a regulator of protein consumption

The need for salt in livestock feeding has long been recognized. Salt or its constituents, sodium and chlorine, are closely associated with the functions of respiration, blood circulation, and digestion, as is also the enzyme system of the body. When salt is excluded from the diet of animals definite deficiency symptoms appear. The amount of salt eaten by animals varies with diet and tends to be higher on high roughage rations and in the feedlot. The digestibility of feeds is influenced by the addition of salt to a diet, and it was found that animals on a low salt diet are retarded in growth and make reduced gains in the feedlot (Cox et al., 1957).

One of the recent findings in range research was the use of salt mixed with protein concentrate to regulate consumption when self fed to cattle on pasture.

The amount of salt in the salt protein meal mix regulates the daily consumption. McIlvain (1955) lists the following advantages and disadvantages of the self feeding of a protein meal salt mixture.

Advantages of the self feeding system are:

1. Saving of labor since the protein supplement can be put out weekly or biweekly instead of daily.
2. Less disturbance of animals because they do not need to be rounded up to be fed.
3. More uniform consumption of meal. After the more aggressive cattle have eaten their fill, there is still plenty of supplement for the more timid and weaker cattle.

4. More uniform grazing because the feeding bunks can be moved to ungrazed portions of the range.

5. No apparent ills results from the feeding of the salt meal mixture.

Disadvantages:

1. Slight reduction in per head gains during the winter.

2. The cost of the salt and of mixing it with the protein meal.

The general practice has been to use cottonseed oil meal, soybean oil meal, and in some cases, a meal comprised of small grains and a protein supplement.

Since absorption of salt is almost quantitative into the blood stream, water must be available because it is used by the animal to produce urine and eliminate the salt. The maximum concentration of salt in the urine is 2.3 percent. For every pound of salt eaten, about five gallons of urine must be produced for its elimination (Cardon et al., 1951).

Riggs et al. (1953) and James (1957) reported a periodic scouring in cows getting self fed salt meal mixtures. No ill effects on the health of the cattle were noted, however.

Salt meal mixtures have been successfully fed in Arizona by Cardon et al. (1951), in Oklahoma by Nelson et al. (1954), in Washington by Galgan and Ensminger (1956), in Texas by Riggs et al. (1950), in Utah by James (1957), and in Alabama by Brown et al. (1958).
Birth and weaning weights of calves

Nelms and Bogart (1956) found that breeding lines, time of birth, and birth weight all affected rate of gain during the suckling period. A difference of 0.115 pounds per day in rate of suckling gains was noted for age of dam although there was a large difference between two year old and older cows. No direct effect of sex on rate of suckling gain was found, therefore, when birth weight effect was removed the females approached the males in suckling gains.

In a study by Marlowe and Gaines (1958) the influence of age, sex and season of birth of calf and age of dam on the preweaning growth rate and type score of Virginia beef calves was evaluated. This study included all three major beef breeds from many different herds, and extended from 1953 through 1956. About one-third of the calves were creep fed before weaning.

Type scores were not influenced by age of calf. Sex of calf influenced growth rate significantly but had little effect on type scores. Bull calves grew approximately 5 percent faster than steer calves and steer calves grew approximately 8 percent faster than heifer calves. Season of birth had a significant influence on growth of non-creep-fed calves, but was of no practical importance on growth of creep-fed-calves or type score in either group.

Age of dam was the most important source of variation with the largest differences occurring in the younger age groups. Maximum production came from the cows between six and ten years of age.

According to the National Research Council (1958) a weight of not less than 1,050 pounds before calving is usually necessary in beef cows to support consistently regular rebreeding and maximum lactation and to
produce optimum weaning weights of the calves they produce.

In a study by Knapp and Black (1941) milk consumption had the greatest influence of all contributing factors on the weaning weight of calves. This is closely correlated with milk production of the dam and her level of nutrition.
METHOD AND PROCEDURE FOR GROUP TRIAL

The method and procedure used for this experiment was very much like that of James the previous year.

Three hundred head of grade Hereford cows and desert range in Pine Valley located west of Milford, Utah, was obtained from the Dearden Land and Water Company of Garrison, Utah.

Description of area

This area was thoroughly discussed by James (1957). The four pastures used for the experiment were revised from the previous year and a group trial was conducted in the northernmost three of the pastures while an individual feeding trial, to be discussed later, was conducted in the southernmost pasture.

Water

As in the preceding year, all water was hauled to the cattle on a truck fitted with water tanks (figure 1).

Experimental design

The three pastures used were about equal in grazing capacity and size and were separated by two wire electric fences.

Three hundred and three Hereford cattle were stratified according to age and allotted at random in 1955. The same cattle were used in 1956-57, but some had been lost and there was some reallocation.

Groups were assigned at random to the pastures as follows: Soybean oil meal and monosodium phosphate (1), Control (2), and Monosodium phosphate (3). The ages listed below were the ages attained by the cattle in the spring of 1957.
Figure 1. Cattle being watered on the range.
Table 2. Numbers of cattle on experiment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Age of cattle in years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Soybean oil meal and monosodium phosphate</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>Monosodium phosphate</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>Control</td>
<td>34</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>102</td>
<td>69</td>
</tr>
</tbody>
</table>

Monosodium phosphate was added to the drinking water to increase the phosphorus content of the diet by approximately 8 grams of phosphorus per cow per day. The soybean oil meal was mixed with coarse ground salt to regulate the intake of the soybean oil meal to approximately one pound per cow per day.

The soybean oil meal and monosodium phosphate and salt mixture was fed in 55 gallon drums which had been split lengthwise and set in log frames.

The monododium phosphate was thoroughly dissolved in a five gallon glass bottle of water and then poured into the watering troughs when they were filled each day.

The feeding period extended from December 7, 1956 to May 25, 1957, for the phosphorus group and until May 6, 1957 for the soybean oil meal and phosphorus group.

The cows were identified by duplicate black enamel lettered ear tags. Three digits were used for identification. The first digit was the last digit of the year in which the cow was born and the other two digits identified the group and individual within the treatment group.
Different shaped ear tags were used on each group of cattle. The cattle were further identified by putting daubs of scourable sheep branding paint on the back or withers. A different color was used for each group.

The cattle were rotated among pastures (table 3). The rotations were to reduce the effects of natural variations among pastures.

Table 3. Rotations

<table>
<thead>
<tr>
<th>Rotation period</th>
<th>Pasture 1 treatment</th>
<th>Pasture 2 treatment</th>
<th>Pasture 3 treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 5 - Jan. 12</td>
<td>SBOM &amp; P</td>
<td>Phos.</td>
<td>Control</td>
</tr>
<tr>
<td>Jan. 13 - Feb. 15</td>
<td>Control</td>
<td>SBOM &amp; P</td>
<td>Phos.</td>
</tr>
<tr>
<td>Feb. 16 - Mar. 29</td>
<td>Phos.</td>
<td>Control</td>
<td>SBOM &amp; P</td>
</tr>
<tr>
<td>Mar. 30 - May 27</td>
<td>SBOM &amp; P</td>
<td>Phos.</td>
<td>Control</td>
</tr>
</tbody>
</table>

The cattle were brought to a central corral at the well to be weighed. The well was located in about the center of pasture 2 and was near the west side of the allotment. The cattle were watered on arrival at the corral and held overnight without feed or water before weighing. All groups were mixed and the cattle were weighed at random.

Cattle movement

Saddle horses were used to move the cattle during rotations and weighing. A trailer was provided to haul a horse behind the water truck if needed. A two-ton truck with a stock rack was also available for transporting cattle and the hauling of a saddle horse.

Condition scores

At the January, March and May weighing all cattle were scored for condition. The score and condition scale used was as follows:

**Observations**

The cattle were observed daily at the time of watering for condition, fill, contentment and general response to their treatment. Sick, lame or otherwise incapacitated animals were noted.

Temperature was recorded at the well along with a general statement of weather each day.

**Birth weights and weaning weights**

During calving time, the cattle were inspected on horseback as often as possible and not over two or three days apart. The new-born calves were roped, weighed, and ear-tagged. The calves were weighed with a 100 pound capacity spring scale that was carried on the saddle while checking through the cattle. Ear tags in the 7100 series were used in the SBOM & P group, the 7200 series in the phosphorus group, and the 7300 series in the control group.

The small calvy cows were taken out at the March weighing and fed from May 8, 1957 until a cow from each treatment group could be returned to pasture after calving, whenever possible.

The calves were identified with their dams when the cattle were moved from the winter range. At the same time they were weighed and tags that had been placed too deep in the ear were replaced.

The calves were weaned October 10, 1957, at that time they were weighed individually. The cows were weighed individually at the same time.

These same cattle were maintained in common during the summer pasture period. The cows were weighed in February, 1958 and the calves
and cows in May, 1958 and October, 1958. During the winter grazing period the cattle were maintained in one group and rotated over the experimental area of the previous year. They received no supplementation after May of 1957.
METHOD AND PROCEDURE FOR
THE INDIVIDUAL TRIAL

During the winter of 1956-57 a supplemental feeding program was also carried on with two-year-old Hereford heifers in Pine Valley. The heifers were fed supplements of phosphorus, protein, and energy from December until March. During the summer they were grazed on meadow pasture near Garrison, Utah.

Description of area

The range area used was divided into four pastures. The northernmost three of these pastures were used for the group feeding trial which has already been discussed. The fourth or southernmost pasture was used for the individual feeding trial. This pasture was about three miles wide and six miles long.

Water

There is no natural source of water within the pasture limits. Water was supplied to the cattle by snow or hauled by truck from a drilled well near the hardpan on the allotment. The water was hauled on a two-ton truck to the watering trough which held about 900 gallons. The trough was moved periodically to control the grazing area of the heifers.

Experimental design

Ninety-nine head of two-year-old Hereford heifers were stratified according to weight and allotted at random to the treatments outlined in table 4.
Table 4. Experimental design, showing daily allowance of feed
(animals were fed every second day twice these amounts)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Amount of phosphorus</th>
<th>Number of animals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gms.</td>
<td>no.</td>
</tr>
<tr>
<td>9 Control</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>1 6 grams phosphorus</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>4 12 grams phosphorus</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>7 .8 lbs. sugar plus 6 grams phosphorus</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>8 1.6 lbs. sugar plus 6 grams phosphorus</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>2 1 lb. soybean oil meal plus 3 grams phosphorus</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>3 2 lbs. soybean oil meal</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>5 1 lb. soybean oil meal plus 9 grams phosphorus</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>6 2 lbs. soybean oil meal plus 6 grams phosphorus</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

To obtain the phosphorus level in treatment 1, 140 grams of mixture 1, and 100 grams of mixture 2 (table 5) were mixed and fed each second day. For treatment 4, 280 grams of mixture 1 was fed each second day. Mixtures 1 and 2 (table 5) were pelleted into three-fourths inch pellets.

Table 5. Phosphorus supplement fed to heifers

<table>
<thead>
<tr>
<th>Feed</th>
<th>Mixture No.</th>
<th>Mixture No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Molasses, cane</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Monosodium phosphate</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Straw, oat</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>Meadow hay</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Condition scores

Every second weigh period the heifers were scored for condition. The score and condition scale used was as follows: 1. Fat; 2. Medium flesh; 3. Thin; 4. Poor; 5. Very poor (Appendix table 18).

The heifers were also scored for lameness at the March 13 rotation. The scale used was as follows; 1. No lameness; 2. Slight lameness; 3. Moderately lame; 4. Marked lameness; 5. Very lame. At this same weighing the heifers were scored for haircoat and general appearance using the following scale; 1. Glossy haircoat with heifers licking themselves; 2. Moderate licking of haircoat - glossy; 3. Average haircoat - some sheen; 4. No licking of haircoat and lack of sheen; 5. Rough - shaggy haircoat.

Blood samples were taken in February to check on the phosphorus content.

Observations

The heifers were observed daily at watering or feeding time for condition, fill, contentment, and general response to treatment. Sick, lame or otherwise incapacitated animals were noted and treated when it was necessary.

A daily statement of general weather conditions and temperature was recorded.

Methods of feeding and handling

The diets used for this trial were prepared on the Utah State University campus at Logan, Utah, and were transported from there to Pine Valley where they were stored in a small portable feed shed near the well which was the base of the experiment operation. This shed was made of a wooden frame covered with corrugated metal roofing. It served to store about five tons of feed.
Feed was secured from this stockpile one sack at a time as it was required. A sack of each ration was maintained in the feed storage area between the chutes. A measured amount of feed was removed from these sacks and placed in the feeding boxes as the heifers were fed.

Weight measurements were used in the determination of the size of the container used to measure each ration into daily portions. A can was then provided for measurement of each diet into daily allotments and was used throughout the experiment (figure 2). Treatments 1 and 4 were weighed to the nearest gram on a small portable scale.

Due to the wildness of the heifers and the difficulty of getting them to eat in individual stalls they were fed one pound of soybean oil meal per head for about three weeks before the actual trial began. The heifers were forced to walk through the chutes to obtain feed until they became accustomed to eating the soybean oil meal and being in the chutes.

Monosodium phosphate was added to the lower soybean oil meal levels to increase its phosphorus content. Sugar (sucrose) and phosphorus were fed at a level to duplicate the energy of the soybean oil meal and phosphorus mixtures.

The heifers were identified by duplicate black enamel lettered ear tags. Three digits in the 500-599 series were used. Daubs of black, scourable sheep branding paint on the withers were used for further identification.

The heifers were moved periodically to reduce the effects of over-grazing small areas and to provide range forage nearer the supply of water. The shorter distance to water aided rounding the heifers into the corral to be fed and helped keep the heifers from getting too tender-footed to graze normally.
Figure 2. Daily rations fed to the heifers on the individual trial.
Cattle weights and blood samples

The heifers were brought to a central corral at the well to be weighed. They were watered on arrival at the corral and held overnight without feed or water before weighing. They were weighed and moved to a new area of feed on the following dates (table 6).

Table 6. Weight and movement dates of individual trial

<table>
<thead>
<tr>
<th>Weighed</th>
<th>Moved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 2, 1956</td>
<td>Dec. 7, 1956 Moved to desert</td>
</tr>
<tr>
<td>Jan. 10, 1957</td>
<td>Jan. 25, 1957</td>
</tr>
<tr>
<td>Feb. 9, 1957</td>
<td>No Rotation</td>
</tr>
<tr>
<td>Mar. 12, 1957</td>
<td>Mar. 19, 1957 No Rotation</td>
</tr>
<tr>
<td>April 9, 1957</td>
<td>No Rotation To meadow pasture for summer</td>
</tr>
<tr>
<td>May 28, 1957</td>
<td></td>
</tr>
</tbody>
</table>

Supplemental feeding began December 9, 1956 and extended to March 8, 1957. The heifers were fed every day until January 18, 1957 at which time every other day feeding began.

The heifers were gathered by a man on horseback and herded toward the corral at a very leisurely gait on every second day. During January and February of 1957 the heifers were on rather rocky ground at the base of the Wah-Wah Mountains and they became quite tenderfooted. They were disturbed as little as possible during this period.

Upon reaching the corral all of the heifers were allowed to water. After watering they were crowded into the holding corral and crowding pen preparatory to feeding. They were fed and allowed twenty to thirty minutes to eat their ration. They were turned loose after eating and allowed to water again if they desired or return to grazing. They usually laid down outside the corral for an hour or two after eating before they again moved out to graze.
A check sheet was kept on each heifer to see whether she ate all, part, or none of her feed. The cows were identified to treatment by ear-tag number and were fed accordingly. They were allowed to enter the feeding chutes at random. After a routine had been worked out the entire herd could be fed in about four hours.

**Birth and weaning weight of calves**

At the April 9, 1957 weighing all heifers which looked like they would calve were removed from the group. As near equal numbers of heifers from each treatment group as was possible were removed and were fed meadow hay at the central corral until after calving.

As each heifer began to calve she was removed from the group and put into a separate pen where she could be watched and aided if necessary. She remained in the small pen with her calf for a day or two and was then turned out with the other heifers which had calved. Each heifer and her calf was observed in this group for about a week or ten days. If everything proceeded normally and a heifer from each treatment was available, this group was hauled by truck back to the individual feeding corrals and unloaded. After an hour or so when the heifers had located their calves again, they were turned out to graze. These heifers were observed periodically afterward to see that all of the calves were properly mothered.

Many of the heifers required help during calving. Some of them did not clean properly and had trouble with infection. These were given penicillin and sulfa tablets as it was deemed necessary. If they remained sick and weak, they were cared for individually until they could return to the group.

The calves were weighed and ear-taged the day after birth with a
100 pound capacity spring scale. The calves were tagged with a number in the 7,000 series, the last three digits being the same number as that of their mother. The tags used were of a permanent type with small stamped in numbers.

The calves were weaned October 10, 1957, and at that time they were weighed individually as were the heifers.

These cows were pastured in common with the cows of the group experiment for the summer and winter of 1957-58. They received no further supplementation. Weights were obtained on the cows in February, 1958, and on the cows and calves in May, 1958, and October, 1958.
DESIGN OF EQUIPMENT

Corrals, chutes, and gates

The corrals, gates, and chutes were constructed of one inch by six inch rough sawed pine boards. Panels were made five feet high and four, eight, and twelve feet long. The fence of the corrals was constructed of lengths of diamond mesh wire five feet high and fifty-five feet long. Steel posts were driven into the ground approximately sixteen to eighteen feet apart and were arranged in a circular fashion to form two corrals which varied from sixty to seventy feet in diameter (figures 3 and 4). The wire was placed around the perimeter of these posts and was wired securely to them. Lodgepole pine poles approximately 18 feet long were then wired to the outside of the fence about three and one-half feet from the ground and were arranged so that they extended twelve to eighteen inches beyond each post. They were wired securely together at the point of crossing and were then wired to each post and to the net wire between each post.

The gates between the corrals were twelve foot panels for the heifers and a four foot panel which was used as a handgate. The main gate to the corral containing the water trough was made of two eight foot panels which swung together and joined at the center of the gate opening. Two eight foot panels were considered better than a single twelve foot panel because the water truck had the water tanks mounted crosswise of the truck bed and the spouts for removal of the water protruded beyond the truck bed. It was also found that the heifers crowded the gate when they were gathered to be fed and watered, especially if they were thirsty. A four
Feeding Chutes

Materials Required

12 12 in. x 8 in. x 4 in. feed boxes
10 12 ft. panels 5 ft. high
22 8 ft. panels 5 ft. high
10 4 in. panels 5 ft. high
5 55 ft. rolls of 5 ft. high net wire
20 to 30 18 ft. pine poles
12 24 in. chains with snap fasteners
60-70 6 ft. steel posts
Smooth wire to tie fence parts together

Figure 3. Diagram of corral and inventory of materials
Figure 4. Corrals and chutes used to feed the heifers of the individual feeding trial.
A foot panel was used as a handgate at the end of the outside feeding chute to facilitate feeding the three heifers contained in that chute at feeding time. A twelve foot panel was sometimes extended forward to the corner of the larger corral in place of the mesh wire. All of the gates were secured with chains 24 inches long with snap fasteners.

The crowding pen was constructed of board panels. It was two twelve foot panels long and extended from the eight foot opening of the chutes back to a width equal to an eight and twelve foot panel. The gate panel swung outward into the holding corral and made junction with a twelve foot wing. The heifers could be crowded along the corral fence behind the wing and into the feeding chutes. This pen would hold twenty to thirty heifers. The crowding pen was held up by steel posts driven approximately six to eight feet apart to which the panels were securely wired.

The chutes for feeding the heifers were arranged in a V shape. They were adjacent at the point where they left the crowding pen and fanned out to a distance of twelve feet which was the length of a panel placed between the center chutes to form an enclosure in which feed could be stored. Two rows of three chutes, each eight feet long, and two chutes, each twenty-five inches wide, were used. This allowed twelve heifers to be fed at a time.

The chutes were made of eight foot panels five feet high for sides and panels four feet long and five feet high for gates and ends. The eight foot panels were arranged so that an opening about eight inches wide was left between the first and second and between the second and third panels. This allowed a gate to be slid along the ground between the panels to separate the individual animals for feeding. Gates were
attached to both ends of the chute. The individual chutes were approximately twenty-five inches wide. This width was a little narrower at the beginning of the feeding period but as the heifers became accustomed to the system and ceased to struggle to free themselves it was widened. A greater width was necessary due to the increase in size of the pregnant heifers whose sides rubbed a narrower chute excessively. Mesh-wire corrals were used at the well to facilitate weighing the cattle. Sick cattle could be retained and cared for here.

Some small pens constructed of railroad ties and poles were used to hold heifers at calving time.

**Feeders**

The heifers were fed in feed boxes constructed of one inch lumber. These boxes were twelve inches long, eight inches wide and four inches deep by inside measurement. These boxes were slid under the sides of the chutes in a small trench.

Salt was fed free choice in a feeder made of one-half of a fifty-five gallon drum which had been cut lengthwise and was supported in a frame made of small logs.

The trough provided for watering the heifers was approximately twelve feet long and would hold about 900 gallons of water. It was placed in the large corral. The water troughs for the group trials held about 400 gallons each. Two troughs were allowed for each treatment group.

**Scales**

A portable Ranger scale was used to weigh the cattle throughout the experiment (figure 5). The scale was modified to best fit the needs with a more heavily constructed sliding door at the entrance, and with a ply-
Figure 5. Scale, squeeze chute, cutting gates, and corrals used in obtaining the data for this experiment.
wood reinforcement along both sides and high enough to prevent it from coming open when an animal began to struggle while on the scale. A canopy was built of light metal to cover the top and prevent cows from jumping out.

The scale had to be leveled before reliable accuracy could be obtained in the weights recorded.

A two by six inch piece of timber was extended across the floor of the scale and securely fastened to the frame by small bolts whenever the scale was moved. The beam was also removed for transport.

The trailer designed for transporting the Teco squeeze chute was also used for the scale.

This scale weighs to an accuracy of one pound. Five pound accuracy was considered satisfactory for the cow weights, but the May, 1957 and October, 1957 weanling weights of the calves was carried to one pound accuracy.

This scale was quite satisfactory for the type of work for which it was used.

Squeeze chute

A Teco squeeze chute was placed ahead of, and in series with, the scales and cutting gates (figure 5). This allowed any animal to be caught and restrained during the regular weigh periods without extra effort. Any ear tags which had been lost during the preceding period on the range could be replaced. Sick or injured animals could be examined and treated.

At the February weighing, cows were selected at random from the groups and blood samples obtained while the cows were retained in the squeeze. This squeeze chute was very satisfactory for such work because the cows
heads could be securely held and the neck and jugler vein was exposed.

Cutting gates

Three aluminum gates four feet wide and five feet high were mounted on hinges and hung on cedar posts in such a manner that the cattle passing through the scales and squeeze chute could be cut into four separate groups (figure 5). These gates were moved into position by pulling on ropes which ran through pulleys mounted on overhead uprights. This was a very useful and time saving piece of equipment. It operated very smoothly and was a satisfactory method of separating cattle for this range operation.
RESULTS AND DISCUSSION

The distribution of the cattle was controlled by hauling water and locating water and salt in the areas desired. The cattle had become accustomed to the frequent changes which followed the grazing pattern of the previous year. The cattle were quite content at all times, and did not trail along the fences as they had done the first part of the year before.

The cattle were easily rotated and relocated in the new grazing areas. The troughs were moved at each rotation to provide fresh feed. A constant supply of water aided in relocation of the cattle. Those cattle receiving the soybean oil meal supplement were the easiest to relocate and the most content with each move.

The older cows were easier to relocate and more content with each move than were the two-year old heifers. The heifers became easier to move toward spring and seemed more contented after calving.

Two wire electric fences were satisfactory for dividing the pastures. The fences and corrals at the well were adequate and efficient for handling the cattle at weigh periods and for calving out the weak cows and the two-year old heifers.

Care of the cattle and the gathering of the heifers for feeding required at least one saddle horse. After calving started and calves had to be tagged, the use of two saddle horses became necessary.

Water consumption

No natural source of water is available to livestock on the range used in this experiment. All water was hauled to the cattle on a two-ton truck fitted with water tanks (figure 1).
The average water consumption of each group of cattle is shown in table 7.

Table 7. Water consumption of cattle (average gals. per head per day)

<table>
<thead>
<tr>
<th>Date</th>
<th>Treatment</th>
<th>Heifers</th>
<th>Control</th>
<th>Phos</th>
<th>SBOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>To</td>
<td>During time on desert range</td>
<td>gal.</td>
<td>gal.</td>
<td>gal.</td>
</tr>
<tr>
<td>December 9</td>
<td>January 12</td>
<td>5.0</td>
<td>6.3</td>
<td>6.0</td>
<td>7.7</td>
</tr>
<tr>
<td>January 13</td>
<td>February 9</td>
<td>2.8</td>
<td>2.2</td>
<td>3.5</td>
<td>4.7</td>
</tr>
<tr>
<td>February 10</td>
<td>March 8</td>
<td>4.1</td>
<td>4.2</td>
<td>5.4</td>
<td>7.8</td>
</tr>
<tr>
<td>March 9</td>
<td>April 5</td>
<td>4.5</td>
<td>6.4</td>
<td>6.3</td>
<td>7.8</td>
</tr>
<tr>
<td>April 6</td>
<td>May 3</td>
<td>6.6</td>
<td>6.4</td>
<td>5.8</td>
<td>8.8</td>
</tr>
<tr>
<td>May 4</td>
<td>June 1</td>
<td>5.4</td>
<td>7.9</td>
<td>6.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>4.75</td>
<td>5.57</td>
<td>5.53</td>
<td>7.26</td>
</tr>
<tr>
<td>Average during time supplements were being fed on desert range</td>
<td></td>
<td>4.82</td>
<td>5.10</td>
<td>5.43</td>
<td>7.36</td>
</tr>
</tbody>
</table>

The average consumption of the control and phosphorus supplemented groups was 5.5 gallons per head per day. The average consumption of the soybean oil meal and salt fed group was 7.3 gallons per head per day. This is 1.33 times as much water as the groups not receiving salt as a regulator of protein meal consumption. James (1957) found that these same cattle consumed 1.67 times as much water the year prior to this experiment. Much of this difference can be attributed to the great reduction in water consumption from Jan. 12 - Feb. 9. During this period of time, snow covered the ground and the temperature dropped to 10 degrees Fahrenheit and lower. Under these conditions, the cows either could not water due to ice on the water troughs or ate snow and did not come in for water.

The heifers in pasture four consumed much less water as would be
expected due to their smaller size. This group was never rotated to another pasture and hence has no basis for comparison to the other groups. It was found in the experiment of the previous year (James, 1957) that the forage in this pasture contained more saltbush. Water consumption may have been influenced by herding the heifers to the corral and feeding them every second day. Water was available in the corral where they were fed.

Water consumption is shown to be closely related to ambient temperature as is shown in figure 6 (Water and temperature chart).

Dry matter consumption and nutrient balance

Under range conditions where forage for livestock is gathered by grazing animals no method has yet been developed for accurately measuring the quantity of forage ingested. However, Winchester and Morris (1956) have developed a formula for determining the water consumption from the amount of dry matter ingested. This leads to the assumption that working by a reverse process an estimate of dry matter intake can be calculated from water consumption records.

Table 8 shows the estimated values of forage intake as calculated from water consumption records, with due consideration for temperature. One week periods from each month were used as a basis for this estimation.

On the basis of the average diet of the animals as represented by surveys made by the Range Management Department further estimates of total digestible nutrients, digestible energy, metabolizable energy, crude protein, digestible protein, and phosphorus were estimated for the average sized cow or heifer used in this experiment (table 9).
Figure 6. The relationship of water consumption (gal./head/day) to temperature
Table 8. Some estimates of daily dry matter consumption based on water intake

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Temp.</th>
<th>Heifers</th>
<th>Control</th>
<th>Phosphorus</th>
<th>Soy + Phos.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F.</td>
<td>Water DMI</td>
<td>Water DMI</td>
<td>Water DMI</td>
<td>Water DMI</td>
</tr>
<tr>
<td></td>
<td>gal.</td>
<td>lbs.</td>
<td>gal.</td>
<td>lbs.</td>
<td>gal.</td>
</tr>
<tr>
<td>12/23</td>
<td>29</td>
<td>4.0</td>
<td>11.2</td>
<td>4.9</td>
<td>13.7</td>
</tr>
<tr>
<td>1/20</td>
<td>32</td>
<td>3.4</td>
<td>9.5</td>
<td>2.3</td>
<td>6.4</td>
</tr>
<tr>
<td>2/24</td>
<td>48</td>
<td>3.9</td>
<td>9.9</td>
<td>4.9</td>
<td>12.4</td>
</tr>
<tr>
<td>3/23</td>
<td>43</td>
<td>5.5</td>
<td>14.5</td>
<td>5.5</td>
<td>14.5</td>
</tr>
<tr>
<td>4/20</td>
<td>52</td>
<td>6.2</td>
<td>15.1</td>
<td>6.8</td>
<td>16.5</td>
</tr>
<tr>
<td>5/18</td>
<td>58</td>
<td>3.8</td>
<td>8.5</td>
<td>7.9</td>
<td>17.6</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>11.4</td>
<td>13.5</td>
<td>14.9</td>
<td></td>
</tr>
</tbody>
</table>

1/ Interpolated from actual water consumption and data on dry matter-water intake relationships given by Winchester and Morris (1956)

2/ Values reduced by 1/3 to allow for increased water intake because of salt in meal.

Table 9. Estimated average daily intake of nutrients from range forage on the winter range

| DM. Intake TDN DE ME Crude protein Dig. protein Phos. Phos. |
|-----------------|-----------------|-----------------|-----------------|
| lbs. Kcal Kcal lbs. lbs. gms. |
| 550# Heifer 1/ | 11.4 4.67 9,325 7,649 .74 .30 .009 4.1 |
| 700# Cow 1/   | 14.0 5.74 11,452 9,394 .91 .37 .011 5.0 |
| 700# Heifer 2/ | 18.0 10.00 20,000 16,400 1.5 0.9 14.0 |
| 740# Heifer 3/ | 9.3 5.33 10,660 .72 |

1/ Previous study of the area indicated an average nutritive value of the forage to be 671 Kcal. metab. energy/lb., 2.64% digestible protein and 0.06% phosphorus. This is approximately equivalent to 6.5% protein crude basis and 818 Kcal. digestible energy/lb. or 41% TDN. On the basis of these estimations the following values may be derived.

2/ These values were based on the National Research Council requirements and allow for 1.5 lbs. average daily gain.

3/ These values were obtained from the maintenance level for beef cattle as determined by Butcher (1958).

These data indicated that the quantity of dry matter ingested was below that level suggested for beef cattle by the accepted standards.

Because these cattle were maintained on a desert range area where feed
was scarce and grazing difficult it is reasonable to believe that they
did not obtain more feed than is indicated by this estimation. Weight
gains and losses are quite closely correlated to these feed consumption
values. The cattle tended to gain for the first part of the winter than
lost weight during the coldest period and gained again after the weather
warmed and the forage plants began to grow.

As the forage became green and the early growth was succulent the
water consumption was supplemented from the feed eaten. Calving and
lactation was a further drain on the cows and may have had a greater
influence on the feed consumed than is indicated.

According to the generally accepted standards not only dry matter
but also digestible protein, total digestible nutrients, digestible
energy, and phosphorus were below requirement levels.

Metabolizable energy is considered to be a better estimate of the
true energy value of this desert forage due to the adjustment for essential
oil losses via the urine. Therefore, digestible energy was calculated
from metabolizable energy standards for comparative purposes. Two
thousand Kcal. of digestible energy was considered equal to one pound
of total digestible nutrients. Due to the multiple estimates involved
in obtaining these values the error may be greater than is apparent.
However, these values compare quite closely to those values obtained
by Butcher (1956) in which the feeding was carefully controlled.
According to these data an apparent deficiency of phosphorus should
have eventually appeared in the control cattle.
Blood phosphorus analysis

Blood data obtained from a random sample of cows and heifers at the February and March 1957 weighings did not statistically confirm a phosphorus deficiency or a differential among treatments. Most of the samples showed an analysis for phosphorus between 4 and 6 mg/100 cc. of blood. Some individuals were near the 4 mg minimum level. However, cows from the control group were observed to chew bones and sticks to a great degree. Some animals walked up to three miles a day to revisit a bone pile and spent hours chewing on bones.

Supplements

It was planned to feed the soybean oil meal and phosphorus group one pound of soybean oil meal per head per day. The consumption was to be limited by the use of salt used as a regulator. Figure 7 shows the supplement and salt consumption actually obtained.

During the period of coldest weather when snow covered much of the forage, the cattle were found to consume much more meal. During the first week of this weather, the cattle did not water regularly and consumption dropped off, but thereafter and for the rest of the cold weather period consumption was increased greatly. During this period the salt meal ratio was never greatly changed from two parts of meal to one part salt. As the spring feed became better, the consumption of meal dropped off rapidly. The salt meal ratio was reduced slightly, but consumption was held under one pound per day to obtain the overall average of one pound per head per day. The amount of meal consumed varied greatly with forage type, availability, time of season and weather conditions. Adjustments in the ratio of salt to protein meal can be made to level out the average consumption.
Figure 7. The consumption of soybean oil meal supplement and salt. Salt was used as a regulator of soybean oil meal consumption.
Cows on a high level of salt meal consumption tend to scour regularly. The cattle from the other groups did not scour. At no point during the period of supplemental feeding did the scouring become serious or cause digestive upsets or sickness in the group.

Phosphorus was fed by mixing monosodium phosphate in the drinking water. Phosphorus consumption varied with water consumption during the entire period. Figure 8 shows the variation in phosphorus consumption of the group being supplemented. This is a very satisfactory method of supplementation where water consumption is the same from day to day, but may limit the results where consumption is varied as was the case in this experiment.

Monosodium phosphate was corrosive to the metal tanks, especially if it become somewhat concentrated. Leaks will occur in the troughs if they are not observed frequently and treated with tar or welded.

Weights of heifers and cows

The heifers were weighed in October prior to movement to the winter range. They were weighed again on December 2, 1956 and moved to the desert. Periodical weighings occurred on January 7, 1957, February 9, 1957, March 12, 1957, April 9, 1957, and May 28, 1957. The period from May until the next October was spent in summer pastures. The heifers were weighed again in the following sequence, October 10, 1957, February 19, 1958, May 19, 1958, and October 10, 1958.

During the period from October 1956 to March 1957 the entire group showed a significant gain (P .01) by covariance analysis using the October 19, 1956 weight as a base (table 10).
Figure 8. Graph showing phosphorus consumption (grams/head/day)
Table 10. Covariance analysis of the cumulative weight changes of heifers in the individual trial

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean Square Oct.56-Mar.57</th>
<th>Mean Square Oct.56-Oct.57</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>8</td>
<td>7165**</td>
<td>6410</td>
</tr>
<tr>
<td>Error</td>
<td>89</td>
<td>619</td>
<td>7274</td>
</tr>
</tbody>
</table>

** Significant at the .01 level.

Supplements were being fed for the duration of this period. This variation must have been due to treatment alone because all of the heifers were in the same group and were treated exactly alike.

Covariance analysis from October 1956 to October 1957 shows no significant effect due to treatment. Treatment ended in March of 1957 which shows that the carry-over effect of treatment on these growing heifers had no significant effect. The residual effect of treatment was lost during the summer grazing period following the treatment of the winter before (table 11).

Table 11. Average weight of heifers by periods.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>560</td>
<td>543</td>
<td>601</td>
<td>633</td>
<td>787</td>
</tr>
<tr>
<td>6 grams phosphorus</td>
<td>550</td>
<td>561</td>
<td>615</td>
<td>654</td>
<td>749</td>
</tr>
<tr>
<td>12 grams phosphorus</td>
<td>537</td>
<td>545</td>
<td>546</td>
<td>618</td>
<td>788</td>
</tr>
<tr>
<td>.8 lbs. sugar + 6 grams Phos.</td>
<td>545</td>
<td>561</td>
<td>600</td>
<td>621</td>
<td>780</td>
</tr>
<tr>
<td>1.6 lbs. sugar + 6 grams phos.</td>
<td>548</td>
<td>553</td>
<td>581</td>
<td>611</td>
<td>841</td>
</tr>
<tr>
<td>1 lb. soybean oil meal plus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 grams Phosphorus</td>
<td>545</td>
<td>584</td>
<td>642</td>
<td>669</td>
<td>800</td>
</tr>
<tr>
<td>2 lbs. soybean oil meal</td>
<td>553</td>
<td>609</td>
<td>620</td>
<td>644</td>
<td>784</td>
</tr>
<tr>
<td>1 lb. soybean oil meal plus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 grams phosphorus</td>
<td>552</td>
<td>587</td>
<td>656</td>
<td>675</td>
<td>750</td>
</tr>
<tr>
<td>2 lbs. soybean oil meal plus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 grams phosphorus</td>
<td>547</td>
<td>607</td>
<td>602</td>
<td>625</td>
<td>833</td>
</tr>
</tbody>
</table>
Heifer weights were related to body condition, lameness, and haircoat scores (Appendix table 18).

Because all of the treatment groups were maintained in common and handled exactly alike no variation could have occurred through pasture or physical handling differences.

The cows weights obtained from the group feeding trial were not statistically analyzed because they followed a pattern quite similar to that of James (1957) and because it was thought that production factors such as calf crop and weaning weights were more important measures of the worth of the experiment. The cow weights were closely related to condition scores.

**Calf weights and production values**

Birth weights were obtained on all calves within one or two days after birth. The birth weights followed a pattern very similar to that of the previous year (James, 1958). The calves were heaviest in the treatment group receiving the protein supplement and lighter in the control and phosphorus groups.

No difference could be shown in the experiment with the two-year-old heifers because the number of calves born was too small. However, trends indicated that additional protein supplement produced heavier calves in these growing heifers. The heifers on the highest protein levels with or without an additional supplement of phosphorus had difficulty calving.

The following table for the group trial shows the number of calves present in October at weaning time for each age group of cows, and includes the three year period of this experiment.
Table 12. Cow numbers and calves born for each age group of cows

<table>
<thead>
<tr>
<th>Year cows were born</th>
<th>Number of calves</th>
<th>Number of cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>47</td>
<td>51</td>
</tr>
<tr>
<td>1953</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>1954</td>
<td>6</td>
<td>48</td>
</tr>
<tr>
<td>1949</td>
<td>43</td>
<td>46</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>174</td>
</tr>
</tbody>
</table>

The number of calves weaned in 1956 and 1957 is based on the 1956-1957 number of cows. In 1958 some of the cows were replaced for production reasons and it is from those remaining cows that the 1958 calf crop was produced.

The cows born in 1952 were quite mature when this experiment started and their production of calves has been maintained at a constant rate. The drain of calving apparently did not affect these cows to the extent where reproduction was affected. The cows born in 1953 have maintained a reasonably constant production of calves although the production tended to rise as they approached maturity. The cows born in 1954 were bred to calf as two-year-old heifers on the first year of this experiment. These growing heifers did not conceive and were unable to produce a satisfactory calf crop the first year. As three-year-old heifers the majority of the group calved. As four-year-old heifers the production of calves again went down. The drain of calving the year before was evidently so great that this age group did not breed and many of them spent the winter grazing period as dry cows (figure 9). Cows born in 1949 were mature and produced satisfactorily for the entire experiment, although the tendency was slightly downward as would be expected with old cows.

The heifers bred to calf at two years of age gave birth to about a 65 percent calf crop. This can be accomplished when the heifers have
Figure 9. Weights of cows and pounds of calf weaned for cows born in 1954.
been well fed and reach a weight near 600 pounds before going on the desert range.

When such a program is carried out the drain of lactation may be so great on these heifers that they will not breed again and produce calves in the following year (table 13).

Table 13. Calving record of the heifers on individual feeding in 1956-57.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of calves weaned 1957</th>
<th>No. of calves weaned 1957</th>
<th>No. of cows calving 1957 &amp; 1958</th>
<th>No. of cows per treatment 1957</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>6 grams phosphorus</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>12 grams phosphorus</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>.8 lbs. sugar + 6 grms. phos.</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>1.6 lbs. sugar + 6 grms. phos.</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>1 lb. SBOM + 3 grms. phos.</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>2 lb. SBOM</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>1 lb. SBOM + 9 grms. phos.</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>2 lb. SBOM + 6 grms. phos.</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>29</td>
<td>6</td>
<td>99</td>
</tr>
</tbody>
</table>

Most of those heifers which did not calf at two years of age calved at three years of age. Only six of the heifers calved both years. This supports the findings of the group trial in relation to those cows born in 1954.

Table 14 shows the annual calf crop production of each treatment group for the three year duration of the experiment.
Table 14. Number of calves weaned each year for each treatment group of cows

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of calves weaned</th>
<th>No. of cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean oil meal plus phosphorus</td>
<td>46</td>
<td>59</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>44</td>
<td>58</td>
</tr>
<tr>
<td>Control</td>
<td>40</td>
<td>57</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>174</td>
</tr>
</tbody>
</table>

1/ October 1956 and 1957 calf crops were produced from the number of cows listed for those years. In 1958 some cows were culled or replaced and the 1958 calf crop is based on the remaining number.

This table shows that the feeding of a protein supplement raised the overall average number of calves weaned. The greatest fluctuation occurred in the phosphorus group and was largely due to variation in the age group born in 1954.

The final production analysis for the group trial was based on the calves from the 235 cows which remained in the experiment for all three years and is presented in tables 15 and 16.

Table 15. Pounds of calf weaned per cow (all cows) by age group.

<table>
<thead>
<tr>
<th>Year of experiment</th>
<th>1949</th>
<th>1952</th>
<th>1953</th>
<th>1954</th>
<th>Single year average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>190</td>
<td>151</td>
<td>120</td>
<td>17</td>
<td>115</td>
</tr>
<tr>
<td>1957</td>
<td>239</td>
<td>182</td>
<td>120</td>
<td>152</td>
<td>173</td>
</tr>
<tr>
<td>1958</td>
<td>174</td>
<td>178</td>
<td>228</td>
<td>99</td>
<td>166</td>
</tr>
<tr>
<td>Three year average</td>
<td>201</td>
<td>170</td>
<td>156</td>
<td>89</td>
<td>151</td>
</tr>
<tr>
<td>Number of cows</td>
<td>53</td>
<td>64</td>
<td>51</td>
<td>67</td>
<td>---</td>
</tr>
</tbody>
</table>
Table 16. Pounds of calf weaned per cow (all cows) by treatment group

<table>
<thead>
<tr>
<th>Year of experiment</th>
<th>SBOM + P</th>
<th>Treatment</th>
<th>Control</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>127</td>
<td>112</td>
<td>104</td>
<td>115</td>
</tr>
<tr>
<td>1957</td>
<td>191</td>
<td>164</td>
<td>161</td>
<td>173</td>
</tr>
<tr>
<td>1958</td>
<td>192</td>
<td>138</td>
<td>163</td>
<td>166</td>
</tr>
<tr>
<td>Average</td>
<td>170</td>
<td>138</td>
<td>143</td>
<td>151</td>
</tr>
<tr>
<td>Number of cows</td>
<td>83</td>
<td>75</td>
<td>77</td>
<td>---</td>
</tr>
</tbody>
</table>

This is further illustrated by figure 10 which shows the changes in body weight of all cows of the group trial for the duration of the experiment. The pounds of calf weaned for each of the three years is represented on this same figure and shows some advantage for the protein supplemented group each year. This is in agreement with James (1957).

The phosphorus and control groups remained about equal as was also shown by James (1957).

This is further explained by table 17.

Table 17. The analysis of variance table for weaning weights.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean square weaning wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>575</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>2</td>
<td>38,838**</td>
</tr>
<tr>
<td>Age</td>
<td>3</td>
<td>351,849**</td>
</tr>
<tr>
<td>Treatment X age</td>
<td>6</td>
<td>9,083</td>
</tr>
<tr>
<td>Error a</td>
<td>180</td>
<td>8,728</td>
</tr>
<tr>
<td>Year</td>
<td>2</td>
<td>156,348**</td>
</tr>
<tr>
<td>Year X treatment</td>
<td>4</td>
<td>9,678</td>
</tr>
<tr>
<td>Year X age</td>
<td>6</td>
<td>99,727**</td>
</tr>
<tr>
<td>Error b</td>
<td>372</td>
<td>14,949</td>
</tr>
</tbody>
</table>

** Significant at the .01 level.
Figure 10. Weights of cows (235 present for whole of experiment) and pounds of calf weaned.
Statistical analysis shows that the effects of treatment and age are highly significant. The effect of year is also significant as is the interaction of year and age. It is to be expected that year and age would be significant. The significance attached to age has been previously discussed. The variation due to year is understandable because in 1955-56 the average annual precipitation of the area was below normal which reduced the forage growth the following year. Precipitation for the other years was near normal. Winter temperatures varied during these years as did the periods of time that snow covered the ground. Advancing age of cows also increased production levels.

Appendix table 19 shows a breakdown of birth and death losses. Of the seven cows in the group trial which died, two died of prolapsed uteruses, and two died from getting on their backs in small depressions of the ground while calving. Of the remaining three, two died of causes incidental to calving, and one died from unknown causes. The deaths were not associated with treatments. Two of the five heifers which died calving were on the highest protein level. One heifer from the low protein level also died. They all had such large calves that birth was difficult. One rather weak, thin heifer from the high phosphorus level died calving. One heifer died from a prolapsed uterus and one from unknown causes.

Several of the remaining heifers on the high level and on the lower level of protein had difficulty calving and of the calves lost at birth four were from these heifers. Calves which were lost at birth in the non-protein treatments were lost from causes other than difficulty in the calving process. Such causes included thin weak calves which died
from exposure or suffocated in the birth process. These losses did not appear to be associated with any one treatment. However, trends indicated that additional protein supplement produced heavier calves in these growing heifers. The heifers on the highest protein levels with or without an additional supplement of phosphorus had difficulty calving.
SUMMARY AND CONCLUSIONS

1. In 1957 three hundred and three Hereford cows were stratified into three treatment groups containing cows 3, 4, 5, and 6 to 9 years of age, and allotted to the same treatment groups as in the experiment of the previous year. These treatments included, (1) soybean oil meal plus monosodium phosphate (SBOM & P), (2) phosphorus (P) and (3) range forage only (control). For the purpose of analysis, those cattle remaining on experiment for the three year duration of the experiment were used.

In addition to this experiment, 99 head of two-year-old Hereford heifers were stratified by weight and assigned to nine treatments which included supplementation with protein (3 levels), phosphorus (2 levels), sugar (2 levels), which was used as an energy supplement, and a control group which received range forage only.

2. The protein meal was fed to the cows in the group trial free choice with salt used to regulate consumption to approximately one pound per head per day. Monosodium phosphate was fed mixed with the drinking water at the rate of approximately eight grams per head per day. All cows were maintained in common and fed in groups. The consumption of these supplements varied somewhat from day to day as they were affected by temperature and precipitation.

The heifers were fed their rations individually, every other day. This was accomplished by herding them to a central corral for feeding.

3. A portable system of corrals was devised which could be set up or taken down and moved to a new location on the range with a minimum of effort. Twelve heifers could be fed at once with the entire group
requiring about four hours feeding time. A portable scale was used for weighing the cows and calves. A portable squeeze chute was placed in series with the scales and a four way cutting gate at the central corrals was used at each rotation.

4. The cattle were grazed on the desert winter range from early December, 1956, to late May, 1957, and on meadow pasture from the first of June to late October, 1957.

5. The winter range was divided by two wire electric fences into four pastures. The northernmost three of these was used for the group feeding trial. The south pasture was used for the individual feeding trial. The groups were rotated among the three northernmost pastures to reduce variation due to pasture differences.

6. Water was pumped from a central well and hauled to the cattle in tanks placed on a truck. Water consumption was affected by temperature, precipitation and the salt used as a regulator. The cattle receiving the salt as a regulator consumed 1.33 times as much water as those not receiving the salt.

7. The cattle were weighed before going on to the desert range and at periodic intervals thereafter. Rotations between pastures were made at the time of weighing. The cattle supplemented with protein showed significantly heavier body weights for the supplementary period. The group supplemented with phosphorus showed no advantage over the control group, in fact, weaning weights of calves showed a slight disadvantage. At the October, 1958 weigh period all three groups had approached a common weight and the residual advantage of supplementation had been lost.
No advantage appeared in the heifer weights for the group on the highest level of protein supplementation, (2 lbs. per day). Extra difficulty at calving time may have been due to this extra protein in the diet. Some cows scoured slightly on the high protein diets. Sugar did not increase the body weight of calf. The heifers supplemented with sugar scoured regularly and in some cases digestive upsets resulted from the highest level of supplementation (1.6 lbs. per day).

Regardless of the winter supplementation used when heifers of this age and size calve under conditions like those of this experiment they are unable to breed back and produce a satisfactory calf crop the following year. This was further verified by the production data of the cows born in 1954. The strain of producing a calf at two years of age may be so great that under desert range conditions a cow will not breed the following year. This suggests that further supplementation, or supplementation at a different season of the year may be needed.

8. Weight analysis of the cows is confounded with calf production or weaning weight of calves but the analysis of calf production does show a significant advantage for the protein supplemented group for the three year group. These data indicates that phosphorus supplementation as determined by this experiment is not worthwhile.

9. A method for estimating dry matter consumption was worked out using the formula of Winchester and Morris (1956). Using this as a base value, estimates were made for all diet constituents. These estimates indicated that the cattle received less nutrients than is recommended by the accepted standards, however, a winter maintenance level was approached.

10. Blood samples were taken at the February and March, 1957 weigh
periods and were analyzed for plasma inorganic phosphorus. All groups were above the minimum level of 4.0 mg P/100 plasma. There was no difference among treatment groups.

11. Analysis shows a significant effect on calf production due to age of dam. Cows must be mature and healthy in order to produce a satisfactory calf crop each succeeding year. When cows calve at two years of age, the strain usually restricts production in the following year. This was evident from the production data of the two-year-old heifers.

12. Calf production among years was significantly different. This was due to many factors, which include, increasing age of dam, climatic changes between years, supplements fed, and length of the period supplements were fed.
LITERATURE CITED

Agricultural Research Service Leaflet. 1957. No. 419, U.S.D.A.


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Condition Mar. 57</th>
<th>Lameness Mar. 57</th>
<th>Haircoat Mar. 57</th>
<th>Condition Apr. 57</th>
<th>Condition May 57</th>
<th>Condition Octr. 57</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.25</td>
<td>1.39</td>
<td>3.27</td>
<td>3.54</td>
<td>3.09</td>
<td>3.10</td>
</tr>
<tr>
<td>6 grams phosphorus</td>
<td>3.26</td>
<td>1.27</td>
<td>3.21</td>
<td>3.41</td>
<td>3.13</td>
<td>3.30</td>
</tr>
<tr>
<td>12 grams phosphorus</td>
<td>3.09</td>
<td>1.48</td>
<td>3.33</td>
<td>3.59</td>
<td>2.88</td>
<td>3.40</td>
</tr>
<tr>
<td>.8 lbs. sugar + 6 grms. phos.</td>
<td>3.15</td>
<td>1.64</td>
<td>3.12</td>
<td>3.22</td>
<td>3.04</td>
<td>3.10</td>
</tr>
<tr>
<td>1.6 lbs. sugar + 6 grams phos.</td>
<td>2.96</td>
<td>1.55</td>
<td>2.91</td>
<td>3.31</td>
<td>2.80</td>
<td>3.30</td>
</tr>
<tr>
<td>1 lb. SBOM + 3 grms. phos.</td>
<td>3.12</td>
<td>1.58</td>
<td>3.36</td>
<td>3.22</td>
<td>2.82</td>
<td>3.00</td>
</tr>
<tr>
<td>2 lb. Soybean oil meal</td>
<td>2.78</td>
<td>1.45</td>
<td>3.33</td>
<td>3.18</td>
<td>2.66</td>
<td>3.30</td>
</tr>
<tr>
<td>1 lb. SBOM + 9 grms phos.</td>
<td>2.90</td>
<td>1.73</td>
<td>3.15</td>
<td>3.45</td>
<td>2.81</td>
<td>2.80</td>
</tr>
<tr>
<td>2 lb. SBOM + 6 grams phos.</td>
<td>3.29</td>
<td>1.33</td>
<td>3.46</td>
<td>3.04</td>
<td>2.64</td>
<td>3.50</td>
</tr>
</tbody>
</table>
## Appendix Table 19. Summary of birth and death losses.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total cows 1957</th>
<th>Calves born 1957</th>
<th>Born dead shortly after birth</th>
<th>Died after birth</th>
<th>1957 Calves unaccounted weaned for</th>
<th>Cows died naturally calving</th>
<th>Cows died naturally calving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>89</td>
<td>58</td>
<td>1</td>
<td>0</td>
<td>57</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>SBOM + Phos.</strong></td>
<td>89</td>
<td>63</td>
<td>2</td>
<td>0</td>
<td>59</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Phosphorus</strong></td>
<td>92</td>
<td>65</td>
<td>4</td>
<td>0</td>
<td>58</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Heifers</strong></td>
<td>99</td>
<td>64</td>
<td>11</td>
<td>1</td>
<td>52</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Control</td>
<td>11</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>6 grm. Phos.</strong></td>
<td>11</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>12 grm. Phos.</strong></td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>.8 lbs. sugar+6 grms Phos.</td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>1.6 lbs. sugar+6 grms Phos.</strong></td>
<td>11</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 lb. SBOM + 3 gms. Phos.</td>
<td>11</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 lb. SBOM</td>
<td>11</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 lb. SBOM + 9 gms. Phos.</td>
<td>11</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 lb. SBOM + 6 gms. Phos.</td>
<td>11</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1/ Calves unaccounted for had lost their ear tags before weaning time.