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Pasture Supplementation of Beef Cattle Followed by Drylot Finishing with High-concentrate Rations and Antibiotic Supplement

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PASTURE SUPPLEMENTATION OF BEEF CATTLE FOLLOWED BY DRYLOT FINISHING WITH HIGH-CONCENTRATE RATIONS AND ANTIBIOTIC SUPPLEMENT

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

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INTRODUCTION

Meat animals contribute major portions of the protein and other nutrients to the human diet. A large proportion of the nutritional deficiencies found in the world population is caused by a diet lacking proper levels and quality of protein. The addition of protein to the diet in the form of meat could greatly reduce the occurrence of these nutritional deficiencies.

The major factor limiting the amount of meat in the human diet is the cost. Therefore, a continuing effort must be devoted toward making meat available at a price which more people can afford to pay. Since feed costs make up such a large part of the total cost of meat production, major efforts should be devoted to ways of improving efficiency of feed utilization. Of even greater potential is more emphasis on utilization of forage crops grown on land where yield in digestible nutrients from these crops can exceed yield in digestible nutrients from grain crops.

Forages from range and pasture lands as well as harvested forage crops make up most of the diet for the cattle breeding herds. These may also contribute a substantial part of the total diet for growing and fattening of slaughter cattle. More recently, high-concentrate diets have received considerable attention in finishing cattle. Many experiments have shown these high-concentrate diets to produce fast rates of gain with relatively small amounts of feed. They offer many advantages in large feeding operations, and it is a rather common opinion that high-concentrate diets are more economical than

high-roughage diets under these conditions. Utilization of high-roughage rations is generally not as well suited to many large feeding operations as are high-concentrate rations. On the other hand, high-roughage feeding systems may be very desirable for smaller operations by farmer-feeders.

A livestock feeding operation offers a means of increasing farm income and of making more efficient use of the total land area. Feeding systems of this type increase labor needs and may require expensive facilities. Use of pasture with supplemental grain feeding provides a means of reducing labor needs as well as reducing the feedlot period. Pasture feeding offers several possibilities for the production of beef. Producers can sell their cattle as feeders, they may market partly finished cattle or they may market finished cattle from pasture. In addition, cattle may be placed in drylot for final finishing after a period on pasture. With a minimum of facilities required for pasture feeding, the smaller producer can adjust his operation yearly according to market conditions and sell cattle at the weights which would produce the highest income.

Many pasture feeding programs will be followed by drylot finishing with the likely use of high-grain rations. One way in which feed costs may be reduced is by shortening the time required to get cattle on full feed. Being able to get cattle on full feed quickly means less time in the feedlot with some reduction in feed quantities which can mean more profit for the producer. Getting cattle on feed is most generally accomplished by a gradual increase in grain

accompanied by a reduction in roughage. This practice not only causes feed handling inconveniences but results in less than optimum gains during the ration changeover. Some research has been conducted to test other ways in which cattle may be raised to a full feed of concentrate in a relatively short time. None of these methods have proved to be as satisfactory as a gradual change of the ration.

The objectives of the research reported in this thesis were to determine the effects of various levels of pasture grain feeding on pasture weight gains as well as on subsequent gains and feed requirements in drylot. The value of an antibiotic was tested at various levels to determine the effects in rapidly getting cattle on full feed of a high-concentrate ration. The effects of the various levels of the antibiotic were also studied when administered for five consecutive days at monthly intervals throughout the experiment.

REVIEW OF LITERATURE

Grain Feeding Cattle on Pasture

Grazing young cattle on pasture is a popular method of utilizing roughage with a minimum of labor involved. Cattle fed in this manner make good growth but fat deposition is insufficient to produce finished, market cattle. Grain feeding on pasture or a period of drylot finishing is necessary to obtain the degree of finish considered desirable for high quality beef. This is necessary because while pasture may contain sufficient quantities of protein, carotene and minerals, energy is the limiting factor in producing finished cattle from pasture grazing. Usually, full feeding grain on pasture produces the best overall gains, but the most economical gains may be produced by a somewhat lower level of grain feeding.

Black and Clark (1938) and Savage and Heller (1947) reported the increased cost of gain resulting from feeding a supplement to cattle on pasture was more than offset by the increase in gain and sales value of the cattle. Steers fed either corn or cottonseed cake on pasture gained slightly more, were fatter and sold for a higher price according to Stephens et al. (1949). The corn-fed cattle, however, returned more profit per head than the cottonseed cake-fed cattle because of cheaper feed costs.

Huber, Mott and McVey (1963) reported that steers full-fed ground ear corn on pasture gained 2.63 lb. daily which was twice the rate of gain obtained from pasture alone. When grain was fed at several levels (none, 5.7 lb., 11.7 lb and 17.0 lb. per head daily),

stepwise increases of about 0.44 lb. per head daily in gain were noted with each increment increase in grain. The several levels of grain feeding amounted to none, one-third full feed, two-thirds full feed and full feed. A strong complementary relationship between pasture forage and grain was noted early in the season. As the grazing season progressed, this relationship decreased which appeared to indicate grain was substituted for forage. The change in the relationship between pasture forage and grain as noted by the authors would vary depending on the state of growth and finish of the animal. Early in the grazing season, the cattle may have been making a compensatory gain because of a previous limited wintering program. Also, early pasture gains may be good because the animal is still growing fairly rapidly and these gains are relatively efficient; but as the grazing season progresses, the cattle become fatter and more energy is required to produce a pound of gain.

Under certain conditions, marked improvements in weight gains have been reported from limited grain feeding. Haines et al. (1965) reported that feeding 4 lb. of a concentrate mixture per head daily resulted in a considerable increase in gain over unsupplemented controls. Significant improvements in rates of gain from feeding 6 lb. of a concentrate mixture were reported by Sullivan et al. (1959). On the other hand, some workers have obtained only small increases in weight from grain supplementation to pasture for growing and finishing steers (Singletary and Peevy, 1964). In an experiment conducted by Duncan (1958), cattle receiving 10 lb. of corn, cob and shuck meal

gained 1.71 lb. daily, while 5 lb. of the meal produced gains of 1.60 lb. daily. Cattle grazing pasture only gained 1.40 lb. daily. The increased gain from grain feeding did not offset the additional expense of the grain, consequently the return per head over feed costs was higher than from steers receiving pasture only.

The addition of extra protein to the rations of cattle receiving a full feed of corn on pasture apparently does not increase gains. Wise et al. (1965) reported that the addition of protein as soybean meal in the ration or in the forage by seeding clover did not significantly increase the gains of cattle.

While type and quality of pasture have been shown to affect rate of gain, the effect is greater on carrying capacity and thus gain per acre of pasture. Heinemann and Van Keuren (1958) reported that feeding grain during the last 103 days to cattle on irrigated grass pastures significantly increased total beef production over cattle that did not receive grain. The addition of grain to a mixture of orchardgrass-alfalfa did not significantly increase total beef production over orchardgrass-alfalfa pasture alone; nevertheless, the highest per acre return came from cattle fed grain on orchardgrass-alfalfa. In an experiment conducted by Spooner and Ray (1966), it was reported for that particular experiment that a stocking rate above one steer per acre had a detrimental effect on forage quality. This was thought to be due to excessive trampling and manure droppings from the heavier stocking rate which limited intake of the available forage by the steers.

Nitrogen fertilization of grass pastures generally increases the per acre production of beef, although the rate of fertilization as well as grain supplementation can influence production per acre. Also, legume-grass mixtures may produce as much or more beef per acre than nitrogen fertilized grasses. Spooner and Ray (1966) experimented with several levels of fertilization (none, low, medium and high). Daily steer gains were highest for the medium level of fertilization and lowest for the high level of fertilization. Wise et al. (1965) reported that the addition of extra nitrogen to growing forage did not significantly increase gains of cattle receiving a full feed of corn on pasture. Grass-legume pastures produced higher beef yields per acre according to Sullivan et al. (1959). In addition, grass-legume pasturage tended to produce slightly higher gains per animal than nitrogen fertilized grass pasturage under the rotational grazing conditions of one steer per two acres of pasture.

Cattle Finishing Systems

Many cattle are marketed at the end of the summer grazing season. Some of these cattle may be slaughtered, but most of the cattle are purchased as feeders and placed in feedlots for final finishing. Grain fed to cattle on pasture usually results in increased gains and reduces the time required for final finishing in the feedlot. In most instances, total feed requirements will be less for cattle fed grain on pasture and finished in drylot as compared to cattle which are in the feedlot for the entire feeding period.

Comparisons have been made between cattle which were placed directly in drylot after wintering and cattle which were pastured and then finished in drylot. Embry and Dittman (1967) reported gains of steers during finishing following pasture were lower than for those finished in drylot following wintering. After wintering the steers were divided into two equal groups. One group was placed in drylot and the other group was turned on native prairie pasture. The drylot group received a ration composed of 20% ground hay and 80% concentrate, gained 2.75 lb. daily and required an average of 789 lb. of feed per 100 lb. of gain. This group was marketed after 188 days. The pasture group spent 196 days on pasture and received no additional feed except for the last 25 days when 1 lb. per head daily of a protein supplement was fed. These cattle gained at the average rate of 1.13 lb. per head daily. The pasture period was followed by a 161-day feedlot period. When fed the same way as the nonpasture group, they averaged 2.13 lb. of gain daily in drylot and required an average of 1095 lb. of feed per 100 lb. of gain. This group averaged 48 lb. heavier at marketing and spent 27 days less in drylot than the nonpasture group. Costs of gains were considerably higher than for the nonpasture group.

In a related experiment conducted by Embry and Dittman (1969), three groups of cattle were involved. One group was full-fed a high-concentrate ration in drylot, another group was self-fed corn on native prairie pasture and the third group grazed native prairie pasture until fall and was then full-fed a high-concentrate ration in drylot until finished for slaughter market. The cattle full-fed in

drylot gained at the fastest rate (3.24 lb. daily vs. 2.53 lb. daily) and were marketed 50 days earlier (183 days vs. 233 days) than those self-fed grain on pasture. Corn required per 100 lb. of gain under this pasture system was greater than for the drylot cattle. They required 121 lb. more corn per 100 lb. of gain. Forty pasture days were required per 100 lb. of gain, but there was a saving of 143 lb. of hay in comparison to that consumed by the drylot cattle. The cattle on pasture for 164 days and then finished in drylot made the greatest rate of gain when on full feed. However, they made the lowest total average daily gain. While they required more feed during the drylot period, the total requirement per 100 lb. of gain was 60 lb. of hay, 216 lb. of corn and 12 lb. of protein supplement less than for the drylot group. The 164 days on pasture reduced the drylot feeding period by 73 days and the cattle averaged 71 lb. more in final weight. These results indicate that self-feeding grain to growing and finishing cattle on native prairie pasture did not appear to produce an efficient return for pasture on the basis of savings in concentrates and roughages per unit of gain in comparison to full-fed high-concentrate rations in drylot. Pasture grazing for one season followed by drylot finishing appeared to be more efficient in terms of roughages and concentrates saved per unit of total gain than did self-feeding grain on pasture. These results essentially agree with those reported by Whetzal and Minyard (1968). In their experiment, one group of steers was placed in drylot and another group of steers was grazed on native grass pastures. The nonpasture group was fed a ration of

rolled barley, hay and supplement until marketed for slaughter. This group gained an average of 2.39 lb. per head daily for the 214-day experiment and required 884 lb. of feed per 100 lb. of gain. The pasture group gained an average of 1.48 lb. per head daily during the 140-day grazing period. During the drylot period which followed the cattle gained an average of 2.10 lb. per head daily and required 1069 lb. of feed per 100 lb. of gain. Pasturing cattle for 140 days reduced the time required in the feedlot by 69 days but increased the time the cattle were on hand by 71 days when compared to those going directly to the feedlot. Even so, the pasture group showed a greater return per head over initial costs of the cattle and feed costs.

The highest returns per head were realized from pasture plus a full feed of grain in results reported by Telkamp et al. (1967). The experiment consisted of a drylot or pasture phase with and without self-fed grain. Thereafter, all cattle were finished in drylot with free access to grain and roughage. The drylot cattle were either full-fed alfalfa-brome haylage or were given free access to alfalfa-brome haylage and rolled shelled corn. The cattle were allowed to choose according to appetite. The pasture cattle were either grazed on alfalfa-grass pasture or self-fed rolled shelled corn in addition to grazing alfalfa-grass pasture. When the pasture cattle were moved to drylot, those self-fed grain were given free access to alfalfa-brome forage and rolled shelled corn as were the lots initially self-fed grain in drylot. The drylot and pasture lots not fed grain up to this time were gradually raised to a full feed and fed in the same manner

as the full-fed grain lots. On the basis of feed required per 100 lb. of gain, each pasture day saved 16.3 lb. of haylage. Steers self-fed haylage and corn in drylot gained slightly faster than those self-fed corn on pasture. However, grain consumption was 5.2 lb. more per head daily for the drylot group. Each pasture day saved about 5.1 lb. each of air-dry haylage and corn in feed consumed daily. On basis of feed per 100 lb. of gain, each pasture day saved an average of 4.9 lb. of hay and 4.5 lb. of corn. During the final finishing phase those cattle self-fed grain during the previous period also gained faster than those on pasture or fed haylage without grain. Steers from pasture gained faster during this phase than comparable lots in drylot during the previous phase. These results agree with Baker and Baker (1952) who found that steers full-fed grain on pasture equalled or surpassed steers full-fed grain plus alfalfa hay and corn silage in drylot on the basis of rate of gain and corn required per 100 lb. of gain.

Age as well as breed of cattle may influence utilization of grain fed with pasture as well as later performance in the feedlot. Bryant et al. (1965) found that corn fed at the rate of 1 lb. of ground shelled corn per 100 lb. of body weight to calves and yearlings on pasture increased daily pasture gains of yearlings slightly more than those of calves. During the drylot finishing phase calves fed corn on pasture gained more than those cattle not fed corn on pasture. Peacock et al. (1965) reported that gains were significantly higher for pasture-fed steers over those in drylot for Brahman steers.

Differences between pasture and feedlot were not significant when steers of British breeding were used. These results would indicate a breed difference in performance on pasture. It was noted that over a 7-year period concentrates required per 100 lb. of gain were less for pasture-fed steers.

Adaptation of Cattle to High-Concentrate Rations

When cattle are to receive high- or all-concentrate rations, it is customary to change the diet gradually from roughages to concentrates. Such gradual changes may require from 2 to 4 weeks for completion. If a sudden change is made from roughage to high-concentrate diets, cattle may ingest large quantities of grain which can cause digestive disturbances such as going off feed, diarrhea, bloat, lethargy and other overeating symptoms. Extreme cases may even result in death for animals involved.

The theory that the microbial population must undergo a change to accommodate a ration change is supported by Allison, Bucklin and Dougherty (1964). It was found that lambs, which had been inoculated with rumen contents from lambs adapted to wheat-containing rations, did not become sick when fed a diet containing wheat.

Several theories have been proposed attempting to account for the symptoms which develop after sudden ingestion of large quantities of grain by ruminants. Hungate et al. (1952) reported that the presence of large quantities of starch in the rumen usually leads to the production of lactic acid and causes a profound modification in rumen fermentation. Evidence indicates Streptococcus bovis grows

extremely rapid in the presence of large amounts of glucose or starch with lactic acid being the end result. Rumen pH may fall as low as 4 and partially or completely inhibit rumen motility. This condition is generally referred to as acidosis.

Disturbing the normal feeding habits of sheep by suddenly changing the diet followed by overeating may cause enterotoxemia according to Bullen and Battey (1957). Undigested or partially digested food particles escape into the intestine from the rumen. This undigested food provides an ideal substrate for the rapid multiplication of Clostridium welchii. This organism is normally present in the intestine, but organism growth is inhibited unless a source of readily fermentable substrate is available. The rapid growth of this organism is accompanied by the production of large quantities of epsilon toxin. High concentrations of the toxin result in increased permeability of the intestinal wall and consequent absorption of the toxin results in death from acute enterotoxemia. The explanation by the above authors as to what causes the rapid multiplication of the Clostridium welchii organism is not entirely satisfactory because there are always undigested feed particles in the intestine. It is probably not the sudden changes in the diet but rather the kind of changes and the kind of undigested food particles in the intestine which encourage rapid organism growth. In this respect incidence of enterotoxemia is increased when high-concentrate diets are fed.

Dain, Neal and Dougherty (1955) identified histamine and tyramine as toxic constituents in the rumen contents of experimentally over-fed sheep. The illness of the sheep was directly correlated with the level of histamine in the rumen contents. As the acidity of the rumen dropped lower than approximately pH 5, histamine production was observed to increase. Below pH 4.5 the histamine concentration increased above 70 mcg. per ml. of rumen contents and the animals became fatally ill.

Experiments have been conducted exploring ways of introducing cattle to all- or high-concentrate rations in a relatively short time without the accompanying digestive disturbances. Beeson, Perry and Mohler (1957) conducted an experiment whereby cattle which had never received corn prior to the experiment were turned into lots which contained feed bunks filled with concentrates. Those cattle self-fed at high amounts of protein showed no signs of scouring or going off feed. Cattle which did scour were fed the least amount of protein supplement. According to these researchers the important factor is the nutritional balancing effect of a good protein supplement. Slightly different results were reported by Uhart and Carroll (1967). Eight steers were changed from alfalfa hay to a ration containing 90% grain without adaptation and with unlimited access. All steers except one went off feed after consumption of the high-grain ration. Within 2 to 6 days steers resumed eating and were still eating 5 days later when the experiment was terminated. The steers became adapted to the high-grain ration as evidenced by normal values for rumen, blood and

urine pH; blood pCO_2; ruminal lactic acid and ruminal VFA concentrations. Garrigus et al. (1967) suggested that a full feed of roughage prior to exposing finishing cattle to all-concentrate diets would decrease the problems associated with adaptation.

A special starter ration was used by Hironaka (1969) to adapt cattle to free-choice finishing rations. The starter ration was composed of beet pulp, dried brewers grain and ground hay to control the digestive energy content of the total ration. A gradual decrease in the ratio of starter to finishing rations occurred during a 10-day period, after which the cattle were on full feed. This researcher expressed the opinion that controlling the digestible energy concentration appears to be the major factor in getting cattle on feed.

Buffers

In an effort to reduce the acid effects of certain types of feedstuffs as well as offset increased ruminal acid production from all-concentrate rations, alkaline compounds have been added to diets conducive to a low pH in the rumen. Various studies have been conducted to determine the effects of buffers on the rate of gain and feed efficiency of feedlot cattle.

In an experiment conducted by Wise et al. (1961) it was concluded that sodium and potassium bicarbonate added at the rate of 11% of the total ration was excessive. In a second experiment sodium and potassium acetate added at 5% of the total ration showed no advantage over the basal ration. An intermediate level of buffer supplementation (5% of sodium bicarbonate and 2.5% of calcium

carbonate) in soybean meal showed increased daily gains and decreased feed requirements per pound of gain when compared to a urea basal and soybean meal basal rations (Wise et al., 1962).

In a later experiment Wise et al. (1965) found the addition of 5% sodium bicarbonate or a combination of 2% sodium bicarbonate and 3% potassium bicarbonate to the soybean meal basal diet slightly increased feed intake and rate of gain. However, the increases were not significant. No response from similar buffer levels was reported by Nicholson, Cunningham and Friend (1963).

Alkaline compounds do not appear to produce the same results as hay when buffers replace hay in a ration. Nicholson and Cunningham (1961) removed the hay from a basal ration which significantly reduced weight gains and TDN consumption. Feed consumption improved significantly while gains and feed efficiency tended to improve when 7.2% of a mixture of ground limestone and sodium bicarbonate was added to the all-concentrate ration. However, the results did not equal those obtained when feeding hay. The addition of potassium carbonate to make a total of 9% buffers in the ration produced results intermediate between the 7.2% level of buffers and the control all-concentrate ration.

A different method of buffer administration was attempted by Lassiter, Hamdy and Buranamanas (1963). Sodium bicarbonate at the rate of 0.5% was incorporated into the drinking water of fistulated steers fed a pelleted ration. The sodium bicarbonate produced a highly significant effect on the anaerobic counts in the rumen juice

and on the regression of anaerobic counts with time. However, there was no significant effect on the pH of the rumen juice.

Negative results using buffers were reported by Oltjen, Davis and Hiner (1965) and Oltjen and Davis (1965). Addition of buffers at a level of 4.6% of the total ration in the first experiment did not significantly affect gains, but buffer addition significantly depressed carcass grade and fat over the rib eye. In the latter experiment, buffers significantly increased the level of ruminal bicarbonate as well as the incidence of bloat. Perhaps the reason why none of the above buffer levels were very effective was because all of them were too high.

The addition of relatively low buffer concentrations to feedstuffs which are acid by nature has been done and the results have been positive. Embry et al. (1969a) reported that two parts of calcium hydroxide and one part of sodium bicarbonate fed at the level of 10% of the protein supplement fed at 2 lb. daily with corn silage resulted in 17.8% more gain over the control group with approximately 11.2% less feed during a 160-day experiment. In a previous experiment, Embry, Luther and Dye (1968) found when steers were full-fed corn silage and 2 lb. of a 40% protein supplement with sodium bicarbonate added at the rate of 10% of the supplement they gained 10.2% more daily with 5.7% less feed than control steers. However, the same levels of calcium carbonate or calcium hydroxide did not improve weight gains during this time and resulted in only small differences in feed efficiency.

Antibiotics

Considerable research has been conducted to test the effects of antibiotics on cattle when these antibiotics are incorporated into cattle rations and fed on a regular or intermittent basis. It has been found that not only do antibiotics aid in disease prevention but also they may actually stimulate growth and improve feed efficiency by affecting the ruminal microbial population. Perry et al. (1954) found that yearling steers receiving 75 mg. of chlortetracycline per animal daily gained 43 lb. more than control animals on a ground corn cobs-supplement A type ration. The chlortetracycline-fed steers also required 18% less feed per unit of gain. Chlortetracycline added at the rate of 70 to 100 mg. daily resulted in some increase in daily gain and a slightly higher degree of finish as measured by slaughter and carcass grades, percentage of fat in the rib section, rind thickness and objectively measured marbling (Barrick et al., 1961). Although these differences were small, they were apparent in all trials. Beeson et al. (1957) also reported that steers utilized feed more efficiently when fed chlortetracycline.

According to Maynard and Loosli (1962), it has been estimated that approximately 4% faster gain on about 3% less feed per unit of gain can be expected from feeding chlortetracycline and oxytetracycline to growing-finishing beef cattle. This response, although small, is enough to favor the use of these antibiotics in commercial feedlots.

Feeding antibiotics to calves during the first month after their arrival in drylot can aid their adaptation to feedlot conditions. Several experiments conducted by Embry et al. (1969b) whereby two levels of chlortetracycline (350 mg. and 700 mg. per head daily) and a combination of 350 mg. of chlortetracycline and 350 mg. of sulfamethazine per head daily were fed to newly arrived calves in drylot. Gains of the calves receiving the antibacterials exceeded that of the controls which gained 0.37 lb. daily by 0.31, 0.38 and 0.42 lb. daily, respectively. In another experiment gains for the respective treatments exceeded the controls by 0.17, 0.31 and 0.15 lb. daily when the controls gained 2.24 lb. daily. Two experiments conducted a year earlier by Embry et al. (1968) utilized treatments consisting of 350 mg. sulfamethazine, 350 mg. chlortetracycline and 350 mg. of each drug per head daily fed to newly arrived calves. In the first experiment the treatment groups exceeded the gains made by the controls (2.55 lb. daily) by 0.45, 0.54 and 0.43 lb. daily for the respective treatments. Calves receiving the sulfamethazine gained 0.10 lb. less than the control calves in the second experiment. Those fed chlortetracycline gained 0.10 lb. and those fed the combination gained 0.16 lb. more than the control group. Controls gained 1.73 lb. daily. While these results may appear to be quite variable, stress conditions are also quite variable. Research has indicated that the benefits obtained are related to the severity of stress conditions encountered.

Another significant advantage for the feeding of chlortetracycline is the reduction of liver abscesses when fed to cattle

receiving high-concentrate rations. Bohman, Wade and Hunter (1957) and Flint and Jensen (1958) reported 70 mg. per head daily decreased the incidence of liver abscesses in cattle. This reduction in liver abscesses is important in that cattle may gain more on less feed if the incidence of abscessed livers is reduced (Jensen et al., 1954; Garrigus et al., 1967).

Experimental results utilizing bacitracin have been inconclusive. Haskins et al. (1967) reported an apparent but non-significant increase in growth response from feeding 75 mg. per head daily of bacitracin. Various higher levels of bacitracin fed for varying periods of time had no effect on feedlot performance, carcass attributes or incidence of liver abscesses among treatments (Durham and Pruett, 1966).

EXPERIMENTAL PROCEDURES

The research reported here consisted of a two-phase experiment. The first consisted of a pasture phase combined with various levels of corn supplementation. During this phase of the experiment, the treatments were administered to yearling steers averaging about 640 lb. The second phase of the experiment was a drylot finishing period with rapid adaptation to high-concentrate rations. Bacitracin (bacitracin methylene disalicylate) was fed at various levels to each pasture group to determine its effects on adaptation of the cattle to high-concentrate rations and on feedlot performance throughout the feeding period. Experimental treatments were administered during a finishing phase to steers from weights of about 800 lb. to market weights.

One hundred twenty-eight steer calves were purchased from a single herd in South Dakota. They were trucked to the Cottonwood Substation and wintered on rations of prairie hay and protein supplements which contained various levels of urea. The calves were wintered in two experiments which produced an average weight differential between groups of approximately 50 lb. One steer died during the wintering trial.

The 127 steers were trucked to Brookings upon termination of the wintering experiment and held in drylot for 26 days until construction of pasture facilities was finished. During the drylot holding period the steers were fed alfalfa-bromegrass hay to appetite.

Pasture Phase

The experiment consisted of four treatments, each with four replications--control or no grain, 3 lb. of rolled corn grain per head daily, 6 lb. of corn per head daily and a full feed of corn.

A filled weight was taken initially and at 4-week intervals to observe the progress of the experiment. After an overnight stand without feed and water, an initial shrunk weight was obtained for determining weight gains for the experiment on the basis of shrunk weights. The steers were randomly allotted into 15 groups of 8 and one group of 7 after stratifying according to weights. The two wintering groups were allotted separately and each pasture group was assigned 4 steers from each with the exception that one group was assigned 4 steers from the heavier weight group and 3 from the lighter weight group.

The pasture area consisted of three plot sizes. Five acre plots were used for the control and 3 lb. grain treatments, 3.75 acre plots were used for the 6 lb. grain treatments and 2.50 acre plots were used for the full-fed treatments. All those lots receiving grain were started at 3 lb. per head daily of rolled shelled corn and raised a pound per head daily until the various treatment levels were reached. All steers receiving grain were fed once daily. Salt and dicalcium phosphate were supplied in each plot on a free-choice basis. The pasturage consisted of a mixture of approximately 50% bromegrass and 50% alfalfa which had been fertilized earlier in the spring (125 lb. of 18-46-0 per acre). Water from a well was piped to a tank in each

plot with each tank equipped with a float controlled valve to maintain the tank water level.

One steer on the full-fed treatment died 35 days after initiation of the experiment. The steer exhibited symptoms of overeating but appeared to be improving when it suddenly died.

After 80 days on experiment it became necessary to remove some of the steers to prevent overgrazing of some of the pasture plots. Four steers were removed from each of the no grain plots as well as from 3 of the 3 lb. grain plots. Two steers were removed from one plot receiving 3 lb. of grain and from all the plots receiving 6 lb. of grain except one plot where only one steer was removed. No steers were removed from any of the full-fed lots. These steers were moved to drylot where they were given a full feed of alfalfa-bromegrass hay and their respective pasture grain levels until the finishing phase of the experiment was begun.

Ample forage was available for all pasture treatments with a large surplus being present during the early stages. Grazing pressure was not sufficient to measure carrying capacity of the pasture as affected by grain supplementation. Data which are reported for the pasture phase are represented by the tester animals which remained on pasture throughout the entire 99-day grazing period. Feed data were calculated on a steer basis which involved total amounts of feed offered divided by steer days.

After 99 days the pasture phase was terminated and the cattle trucked 5 miles to drylot and weighed. Following an overnight stand without feed and water a final shrunk weight was obtained.

Finishing Phase

After obtaining the final shrunk weight the cattle were allotted according to previous pasture treatment. The cattle were allotted into 14 pens of 8 each and 2 pens of 7 each. The pens were paved but without shelter. They were equipped with a fence-line feed bunk and a water bowl connected to a continuous water flow system.

Four levels of bacitracin feeding were superimposed upon the previous grain feeding treatments and replicated four times with each pasture feeding level represented in each bacitracin treatment. These levels consisted of 0, 250, 500 and 1000 mg. per head fed daily for 5-day periods at initiation of the experiment and at 4-week intervals thereafter.

The cattle were fed 2 lb. per head daily of a 40% protein supplement in 3/16 inch pellet form (table 1). The bacitracin treatments were obtained by substituting the antibiotic supplement for the control supplement at rates of 0.25, 0.50 and 1.0 lb. daily for the 5-day periods.

Three pounds per head of whole corn were fed the first day followed by a 3 lb. per head daily increase until the cattle were on full feed. This rather rapid increase of feed was used in order to provide a more critical test of the antibiotic as related to adaptation

TABLE 1. PERCENTAGE COMPOSITION OF PROTEIN SUPPLEMENTS

Ingredients	Control supplement	Bacitracin supplement
Soybean meal (44%)	41.25	31.25
Fortracin-10	--	10.00
Dehy. alf. meal (17%)	35.00	35.00
Urea (281%)	5.50	5.50
Ground limestone	6.00	6.00
T. M. salt (regular)	6.00	6.00
Dicalcium phosphate	3.00	3.00
Potassium chloride	3.00	3.00
DES premix (5 mg./lb.)	0.25	0.25
Vitamin A premix[a]	33.3 g.	33.3 g.
Vitamin E premix[b]	45.0 g.	45.0 g.

[a] 10,000 I.U. vitamin A per pound of supplement.
[b] 100 I.U. vitamin E per pound of supplement.

to high-concentrate rations. Cattle were fed once daily with the 2 lb. of protein supplement being hand mixed with the whole corn grain.

Adverse weather conditions necessitated bedding the steers with straw 57 days after initiation of the experiment. In order to reduce or eliminate the consumption of bedding, 3 lb. per head daily of alfalfa-bromegrass haylage was fed until termination of the experiment.

The steers were slaughtered in a packing plant about 75 miles distant as each pasture grain level group attained a weight of 1150 lb. This procedure resulted in a feeding period of 83 days for those steers full-fed on pasture, 117 days for those steers receiving 6 lb. of grain on pasture and 146 days for those steers fed no grain and 3 lb. of grain on pasture. A filled weight was obtained before the steers were trucked to the packing plant and a shrunk weight was

obtained at the plant. Carcass data were obtained about 24 hours after slaughter.

RESULTS AND DISCUSSION

Pasture Phase

The results of the 99-day pasture phase of this experiment are presented in table 2. Even though the cattle were fed 3 lb. and 6 lb. of corn throughout the greater portion of the experiment, the average daily ration for the entire experiment was 2.5 lb. daily for the 3 lb. corn treatment, 5.0 lb. for the 6 lb. treatment and 13.7 lb. daily for the full-fed treatment. The cattle did not receive any corn during the first 14 days of the experiment because construction of feed bunks was not finished until 2 weeks after initiation of the experiment. This accounts for the lower average daily ration.

Rate of gain on basis of shrunk weights amounted to 0.82 lb. daily for the steers fed no corn while on pasture. Weight gains increased with increasing levels of corn offered, amounting to 0.32, 0.57 and 1.22 lb. daily, respectively, for the 3 lb., 6 lb. and full-fed (13.7 lb.) corn treatments over the controls. Response in gain over the control no corn supplemented group amounted to 0.130, 0.115 and 0.093 lb. per pound of corn consumed for the 3 lb., 6 lb. and full-fed groups.

Feed efficiency calculated on basis of corn required per 100 lb. of additional gain over the nonsupplemented group was rather high and increased with increasing levels of corn consumed. These values indicate rather inefficient utilization of corn in producing weight gains in comparison to pasture alone or to usual feed requirements obtained in drylot. However, the value of the various levels of corn

TABLE 2. WEIGHT GAINS AND FEED DATA (PASTURE PHASE - 99 DAYS)

Item	Pasture grain feeding			
	0	3 lb.	6 lb.	Full-fed
Number of steers	16	18	24	31
Avg. init. wt., lb.	633	632	624	613
Avg. final wt., lb.	714	744	762	818
Avg. daily gain, lb.	0.82	1.14	1.39	2.07
Avg. daily ration, lb.				
Rolled shelled corn	--	2.5	5.0	13.7
Corn/cwt. of additional gain over no grain group	--	772	870	1082

feeding during the pasture phase depends primarily on the effects on weight gains during drylot finishing and on total feed requirements and time required to produce finished cattle.

Finishing Phase

The results for weight gain and feed and carcass data of the finishing phase of the experiment tabulated according to pasture-corn treatments are shown in table 3. Cattle full-fed corn on pasture gained an average of 3.32 lb. daily during the finishing phase. The other pasture treatment groups gained at lower rates and had higher feed requirements. The lowest rate of gain (2.80 lb. daily) was made by the steers fed 3 lb. of corn on pasture, and they required the most feed per 100 lb. of gain. The steers full-fed corn on pasture were fed in drylot for only 83 days. This is in comparison to 117 days for the 6 lb. corn group and 146 days for the 3 lb. corn and no corn groups. However, the full-fed pasture group was sold at a somewhat lighter weight than the other three pasture groups.

TABLE 3. WEIGHT GAINS AND FEED AND CARCASS DATA
(FINISHING PHASE - 83-146 DAYS)

Item	Pasture grain treatment			
	0	3 lb.	6 lb.	Full-fed
Number of steers	32	32	31	31
Days fed	146	146	117	83
Avg. init. wt., lb.	714	744	762	818
Avg. final wt., lb.	1163	1155	1125	1094
Avg. daily gain, lb.	3.08	2.80	3.10	3.32
Avg. daily ration, lb.				
Alfalfa-brome haylage	1.79	1.79	1.49	0.87
Whole shelled corn	19.47	18.81	19.23	18.42
Control supplement	1.86	1.87	1.89	1.91
Bacitracin supplement	0.09	0.09	0.09	0.08
Total	23.21	22.56	22.70	21.28
Feed/cwt. gain, lb.				
Alfalfa-brome haylage	58.2	63.9	48.1	26.2
Whole shelled corn	634	671	621	554
Control supplement	60.8	66.8	61.0	57.7
Bacitracin supplement	2.8	3.1	3.1	2.4
Total	756	805	733	640
Hot carcass wt., lb.	726	720	698	672
Dressing percent[a]	62.4	62.3	62.0	61.4
Conformation[b]	22.0	21.8	20.6	21.1
Marbling[c]	7.3	7.0	6.1	6.0
Final grade[b]	20.8	20.6	20.1	19.7
Percent kidney fat	3.6	3.7	2.8	3.5
Color[d]	4.7	4.6	4.9	5.0
Firmness[e]	5.2	5.5	5.3	5.2
Maturity[f]	21.8	22.0	22.4	22.5
Rib-eye area, sq. in.	12.35	11.85	12.09	11.87
Fat thickness, in.	0.72	0.67	0.75	0.58

[a] Hot carcass wt. ÷ shrunk live wt.
[b] Prime = 23, Choice = 20, Good = 17.
[c] Moderate = 7, Modest = 6.
[d] Light cherry red = 5, cherry red = 4.
[e] Firm = 6, moderately firm = 5.
[f] 21 = C, 22 = B, 23 = A.

Cattle fed grain on pasture and gaining at a faster rate have been shown on a number of occasions to gain at a lower rate during drylot finishing. However, the effect of pasture gains on later feedlot performance has been shown to be influenced by the amount of pasture gain, weight and condition of the cattle when put in the feedlot and amount of change in energy level of rations from pasture or drylot. The more rapid and more efficient drylot gains made by the pasture full-fed cattle is not in agreement with much of the reported research. However, they would be favored by the shorter feeding period and lighter market weights. At the time they were marketed (83 days), there was very little difference between pasture treatment groups on basis of gain and feed efficiency except that the 3 lb. corn group was somewhat lower in performance. These results would indicate that level of grain feeding and rate of pasture gain may not cause a reduction in gains and an increase in feed requirements during drylot finishing when full-fed high-concentrate rations. The group fed 3 lb. of corn on pasture appears to offer an exception. They showed the greatest response in gain during the period on pasture per unit of corn consumed. Whether this may have been a factor in the apparent difference in drylot performance needs further investigation.

Differences in the carcass characteristics measured were small. Steers fed no corn and 3 lb. of corn per head daily on pasture had a slightly higher dressing percent, more marbling, graded slightly higher and had more fat cover than those steers receiving a full feed of corn on pasture. These differences can probably be attributed to

the heavier market weight. Generally, heavier cattle have a higher dressing percent, more marbling and greater fat thickness, especially when the greater weight is accompanied by a longer period of drylot finishing.

Combined Pasture and Finishing Phases

The results for the combined pasture and finishing phases were calculated and are presented in table 4. The data in this table represent the steers which were on pasture throughout the entire 99-day experiment and do not include data from those steers which were removed before termination of the experiment. The results from the finishing phase, however, represent all the steers including those which were removed from pasture earlier and fed in drylot as outlined in the Procedures section.

Those cattle which received no corn or 3 lb. of corn on pasture gained at about the same rate during the two phases of the experiment. Those fed 3 lb. of corn during the pasture phase had slightly higher feed requirements during drylot finishing (table 3). This along with the corn fed on pasture resulted in more total concentrates required per 100 lb. of gain than for the cattle fed no corn during the pasture phase. The 3 lb. of corn fed during the pasture phase was not an economical rate of supplementation in the experiment since it resulted in no savings in pasture days or forage required per 100 lb. of gain and no reduction in total days to finish the cattle to about the same weight and grade as the nonsupplemented pasture group.

TABLE 4. COMBINED PASTURE AND FINISHING PHASES

Item	Pasture grain treatment			
	0	3 lb.	6 lb.	Full-fed
Days fed				
Pasture	99	99	99	99
Drylot	146	146	117	83
Total	245	245	216	182
Avg. init. wt., lb.	633	632	624	613
Gain/head, lb.				
Pasture	81	113	138	205
Drylot	449	411	363	276
Total	530	524	501	481
Avg. daily gain, lb.	2.16	2.14	2.32	2.64
Feed fed/head, lb.				
Pasture				
Corn	--	247	495	1356
Drylot				
Alfalfa-brome haylage	261	261	174	72
Concentrate mix	3127	3032	2482	1694
Total	3388	3540	3151	3122
Days/100 lb. of total gain				
Pasture	19	19	20	21
Drylot	28	28	23	17
Feed/100 lb. of total gain, lb.				
Alfalfa-brome haylage	50	50	35	15
Concentrates	590	626	594	634

While steers fed 6 lb. corn daily during the pasture phase gained at about the same rate in drylot as the unsupplemented cattle, the faster gain on pasture resulted in a faster rate of gain for both phases. This system of feeding resulted in about the same amount of concentrates required per 100 lb. of gain as when no corn was fed on pasture. The most important advantage for the 6 lb. corn treatment on pasture was a reduction of 29 days in time required to finish the cattle. This amounted to a saving of 4 days per 100 lb. of total gain and a slight lowering in amount of the alfalfa-brome forage required.

The steers full-fed corn on pasture gained at a faster total rate than those fed under the other systems. While they had the most efficient gains in drylot (table 3), the larger amount of corn fed while on pasture resulted in more concentrates required per 100 lb. of total gain than for the other groups. However, the differences between this group and those fed 3 lb. of corn were very slight. These cattle were fed for 63 days less than the nonsupplemented pasture group and 34 days less than the steers fed 6 lb. corn on pasture. This amounted to 9 and 5 days, respectively, per 100 lb. of total gain. In determining the economy of the systems, the saving in nonfeed cost for the few days would have to be weighed against the higher feed requirements per 100 lb. of total gain.

Finishing Phase

Bacitracin Treatments. The results of the finishing phase arranged according to bacitracin treatments are presented in table 5. There were no large differences in rates of gain or feed efficiencies between bacitracin treatments. However, all groups which received the antibiotic gained less than the control group, consumed slightly less feed and were slightly less efficient in converting feed to gain. The apparent negative results from feeding bacitracin deviate from the expected and cannot be explained. Haskins et al. (1967) and Durham and Pruett (1966) reported either slight improvement or no effect on feedlot performance from feeding bacitracin but no negative results were reported.

TABLE 5. WEIGHT GAINS AND FEED DATA
(FINISHING PHASE - 83-146 DAYS)

Item	Bacitracin treatment			
	0	250 mg.	500 mg.	1000 mg.
Number of steers	32	32	30	32
Avg. init. wt., lb.	758	762	758	757
Avg. final wt., lb.	1149	1136	1125	1128
Avg. daily gain, lb.	3.20	3.09	2.98	3.04
Avg. daily ration, lb.				
Alfalfa-brome haylage	1.48	1.48	1.48	1.48
Whole shelled corn	19.26	19.10	18.60	18.93
Protein supplement	1.96	1.92	1.87	1.77
Bacitracin supplement	--	0.05	0.40	0.20
Feed/cwt. gain, lb.				
Alfalfa-brome haylage	47.1	49.6	49.9	49.8
Whole shelled corn	604	624	626	626
Protein supplement	61.6	62.7	63.0	58.9
Bacitracin supplement	--	1.6	3.3	6.6
Liver condemnations, head	0	5	6	2

lots. None of the cattle required treatment for bloat, diarrhea or any of the other conditions frequently associated with a rapid increase to a full feed of concentrates.

Carcass characteristics for the various bacitracin treatments were essentially the same so these data are not reported here.

The incidence of abscessed livers was rather low considering the high-concentrate diet which was fed. Liver abscess incidence amounted to 0, 5, 6 and 2 for the no bacitracin, 250 mg., 500 mg. and 1000 mg. bacitracin treatment groups, respectively. According to pasture levels of corn feeding, 1, 0, 6 and 6 abscessed livers were found in the no corn, 3 lb. corn, 6 lb. and full-fed treatment groups, respectively. No apparent benefit was derived from the feeding of bacitracin on the reduction of the incidence of liver abscesses in this experiment.

SUMMARY

A two-phase experiment was conducted involving a pasture phase and a drylot finishing phase. The pasture phase consisted of several levels of corn supplementation (0, 3 lb., 6 lb. and full-fed) to yearling steers averaging about 640 lb. grazing alfalfa-bromegrass pastures. The second phase of the experiment was a drylot finishing period involving the same steers after about 800 lb. Bacitracin was fed at various levels (0, 250 mg., 500 mg. and 1000 mg. per head) for 5 days initially and once a month thereafter to determine its effects on adaptation of the cattle to high-concentrate rations in a short period and on feedlot performance throughout the feeding period.

During the pasture phase rate of gain amounted to 0.82 lb. for the no corn group. Weight gains increased with increasing levels of corn offered amounting to 0.32, 0.57 and 1.22 lb. daily, respectively, for the 3 lb., 6 lb. and full-fed (13.7) corn treatments over the controls. Feed efficiency calculated on the basis of corn required per 100 lb. of additional gain over the nonsupplemented group was rather high and increased with increasing levels of corn consumed. The results indicated a rather inefficient utilization of corn in producing weight gains in comparison to pasture alone at this stage of the experiment.

Gains during the finishing phase amounted to 3.08 lb., 2.80 lb., 3.10 lb. and 3.32 lb. daily for the no corn, 3 lb. corn, 6 lb. corn and full-fed treatment groups, respectively. Feed requirements per 100 lb. of gain for the respective treatments were 756 lb., 805 lb.,

733 lb. and 640 lb. This does not agree with the inverse relationship of pasture gains to subsequent drylot gains which has been reported frequently by others. However, there are several factors which may affect drylot gains following pasture such as amount of pasture gain, weight and condition of cattle entering drylot and the energy intake in drylot. The results of the experiment do show that grain feeding on pasture may not necessarily reduce drylot gain when a high energy ration is fed during the drylot phase.

While the differences in the carcass characteristics measured were small, steers fed no corn and 3 lb. of corn per head daily on pasture had a slightly higher dressing percent, more marbling, graded slightly higher and had more fat cover than those steers receiving a full feed of corn on pasture. These differences can probably be attributed to a heavier market weight for these groups.

The pasture and finishing phases combined showed that the cattle which received no corn or 3 lb. of corn on pasture gained at about the same rate but the 3 lb. group had slightly higher feed requirements during drylot finishing. The 3 lb. of corn fed during the pasture phase was not an economical rate of supplementation in the experiment since it resulted in no saving in pasture days or forage required per 100 lb. of gain and no reduction in total days to finish the cattle to about the same weight and grade as the nonsupplemented pasture group. The most important advantage for the 6 lb. corn treatment on pasture was a reduction of 29 days in time required to finish the cattle. Steers full-fed corn on pasture gained at a faster total rate

than those fed under the other systems. While they had the most efficient gains in drylot, the larger amount of corn fed while on pasture resulted in more concentrates required per 100 lb. of total gain than for the other groups. However, there was only a slight difference between this group and the 3 lb. group. These cattle were fed for 63 days less than the nonsupplemented pasture group and 34 days less than the steers fed 6 lb. corn on pasture. The savings in nonfeed cost for less days in drylot would have to be weighed against the higher feed requirements per 100 lb. of total gain in determining the economy of the various systems.

Results for the bacitracin treatments were negative in that the groups receiving the antibiotic gained less than the control group, consumed slightly less feed and were slightly less efficient in converting feed to gain. In addition, no effect on feed consumption from the bacitracin treatments was noted during initial adaptation to the high-concentrate diet when the feed was increased rapidly to a full feed. None of the cattle required treatment for any of the conditions frequently associated with a rapid increase to full feed. No apparent benefit was derived from the feeding of bacitracin on the reduction of liver abscesses.

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