I. The effect of Aureomycin in pelleted or whole grain creep rations fed to suckling lambs II. The effect of Thyroprotein, Thiouracil, and Stilbestrol on gains of fattening lambs

by Charles A Daley

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Montana State University

Abstract:
I. The first portion of the thesis presents the results of a study to determine the effect of Aureomycin in pelleted and whole grain creep rations fed to suckling lambs. ' Thirty-two ewes of three breeds, all with twin lambs, were randomly divided by breed into four equal groups. Variables consisted of four creep feeds which were offered free choice to the month-old lambs in a fifty-day feeding trial. Rate of gain, feed efficiency, and general health of the lambs were observed to determine (l) the effect of pelleting a simple oat-beet pulp ration, (2) the effect of adding Aureomycin at 20 mg. per pound of a simple oat-beet pulp pellet, and (3) the effect of using a commercial type creep pellet containing Aureo-mycin at 20 mg. per pound of ration. Addition of Aureomycin apparently increased rate of gain during the first two weeks of the trial. Lambs on a whole grain ration (without Aureomycin) had the lowest rate of gain and feed consumption per lamb during this period. At the end of the fifty-day trial, feed cost and feed cost per hundredweight of gain were lowest for the whole grain group (without Aureomycin), and highest for the group on the commercial type pellet (with Aureomycin. The lambs on the whole grain ration appeared "pot-bellied" which would have adversely affected carcass grades, had the lambs been marketed then. The cost of including Aureomycin at 20 mg. per pound in an oat-beet pulp pellet was more than repaid through increased feed efficiency. Rate of gain was not affected. Incidence of scours was approximately equal among the four groups. Because of the low occurrence of scours, the value of Aureomycin in controlling scours could not be determined.

II. In the second trial, eleven lots of three wether lambs each were hand-fed a grain and alfalfa hay ration; weight gains were observed. Variables included combinations of thyroprotein, thiouracil, or stilbestrol in a soybean meal carrier, and stilbestrol pellets implanted subcutaneously. Lambs showed a marked dislike for thiouracil when it was included in the ration. There was a highly significant difference (($P<0.01$) in gains per lamb among lots. A 12 mg. stilbestrol implant gave the highest rate of gain (0.60 pounds per day), while 0.5 gm. thiouracil orally per head daily gave the lowest (0.23 pounds per day). Addition of 0.3 gm. thiouracil orally per head daily to the ration of lambs already implanted with a 12 mg. stilbestrol pellet lowered daily gains by 0.07 pounds per day. Levels of 0.5, 1.0, and 2.0 mg, stilbestrol orally per head daily resulted in rate of gain increases of 0.14, 0.08, and 0.13 pounds per day respectively over the controls. Feed requirement per hundred pounds of gain was improved by 99, 101, and 68 pounds, respectively. Oral intake of stilbestrol with either thyroprotein or thiouracil increased feed efficiency over that of the controls but did not affect rate of gain. Carcass grades of one animal from each lot showed the lambs were not fat. The control animal graded average choice, the highest of all the eleven lots. The pituitary, adrenal, and thyroid glands were removed and weighed, after which the glands were preserved for future histological study*

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CHARLES A. DALEY

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Approved:

Fred S Willson
Head, Major Department

O O Thomas
Chairman, Examining Committee

Leon H Johnson
Dean, Graduate Division

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ABSTRACT

I. The first portion of the thesis presents the results of a study to determine the effect of Aureomycin in pelleted and whole grain creep rations fed to suckling lambs. Thirty-two ewes of three breeds, all with twin lambs, were randomly divided by breed into four equal groups. Variables consisted of four creep feeds which were offered free choice to the month-old lambs in a fifty-day feeding trial. Rate of gain, feed efficiency, and general health of the lambs were observed to determine (1) the effect of pelleting a simple oat-beet pulp ration, (2) the effect of adding Aureomycin at 20 mg. per pound of a simple oat-beet pulp pellet, and (3) the effect of using a commercial type creep pellet containing Aureomycin at 20 mg. per pound of ration. Addition of Aureomycin apparently increased rate of gain during the first two weeks of the trial. Lambs on a whole grain ration (without Aureomycin) had the lowest rate of gain and feed consumption per lamb during this period. At the end of the fifty-day trial, feed cost and feed cost per hundredweight of gain were lowest for the whole grain group (without Aureomycin), and highest for the group on the commercial type pellet (with Aureomycin). The lambs on the whole grain ration appeared "pot-bellied" which would have adversely affected carcass grades, had the lambs been marketed then. The cost of including Aureomycin at 20 mg. per pound in an oat-beet pulp pellet was more than repaid through increased feed efficiency. Rate of gain was not affected. Incidence of scours was approximately equal among the four groups. Because of the low occurrence of scours, the value of Aureomycin in controlling scours could not be determined.

II. In the second trial, eleven lots of three wether lambs each were hand-fed a grain and alfalfa hay ration; weight gains were observed. Variables included combinations of thyroprotein, thiouracil, or stilbestrol in a soybean meal carrier, and stilbestrol pellets implanted subcutaneously. Lambs showed a marked dislike for thiouracil when it was included in the ration. There was a highly significant difference ($P<0.01$) in gains per lamb among lots. A 12 mg. stilbestrol implant gave the highest rate of gain (0.60 pounds per day), while 0.5 gm. thiouracil orally per head daily gave the lowest (0.25 pounds per day). Addition of 0.5 gm. thiouracil orally per head daily to the ration of lambs already implanted with a 12 mg. stilbestrol pellet lowered daily gains by 0.07 pounds per day. Levels of 0.5, 1.0, and 2.0 mg. stilbestrol orally per head daily resulted in rate of gain increases of 0.14, 0.08, and 0.15 pounds per day respectively over the controls. Feed requirement per hundred pounds of gain was improved by 99, 101, and 68 pounds, respectively. Oral intake of stilbestrol with either thyroprotein or thiouracil increased feed efficiency over that of the controls but did not affect rate of gain. Carcass grades of one animal from each lot showed the lambs were not fat. The control animal graded average choice, the highest of all the eleven lots. The pituitary, adrenal, and thyroid glands were removed and weighed, after which the glands were preserved for future histological study.

INTRODUCTION

The most important feed for the new-born lamb is milk. After two weeks of age the rumen becomes increasingly functional, and the lamb can then consume increasing amounts of other feeds such as grains and hays. Pasture plus a few pounds of milk daily provide an adequate source of nutrients for production of healthy, normal-growing lambs.

Lambs born early in the year, before green grass is available, benefit by having access to creep feed. This feed is placed in an exclosure that permits small lambs to enter, but excludes the ewes.

Ingredients used in a lamb creep feed can vary widely, but the end result should be a ration that is palatable to the lambs. Although good results have been obtained on only oats or corn, a mixture of several feeds is usually recommended. The young lambs should be offered a roughage such as good alfalfa hay as well as a concentrate mixture. Choice alfalfa hay can be chopped, mixed with the concentrate, and offered free choice. Another way is to limit the concentrate and feed the hay free choice in racks which the ewes cannot reach. Feed offered lambs should always be clean and fresh. Lambs will refuse to eat much feed that is old, spoiled, or contaminated.

There is a trend in Montana toward more farm flocks of sheep. Home-grown grains and other feeds are available and cheap on farms; therefore lambs are sometimes creep-fed and sold on the early market.

In the past several years, research workers and commercial feeders have obtained desirable effects on non-ruminants, and to a lesser extent on ruminants, by including antibiotics in the ration. These effects have included more rapid growth, better feed utilization, and healthier animals. The Montana Agricultural Experiment Station conducted a feeding trial during the Spring of 1955 in response to many requests received for specific information on the value of antibiotics in lamb creep rations. Only twin lambs were selected for this experiment, as any potential benefit from the antibiotic would be expressed more readily than with single lambs.

REVIEW OF LITERATURE

Antibiotics

Antibiotics are growth inhibitors or bactericidal agents which are formed by living organisms, and which are active in very low concentrations.

Dr. Fleming discovered the first really effective antibiotic in 1928, when he studied a variation of Staphylococcus, and found that around a large colony of a contaminating organism the Staphylococcus colonies became transparent and underwent lysis. This work was ignored until 1941. Then the demands of World War II stimulated an international project to isolate and purify the active material produced by Fleming's contaminating organism. Today this material is known the world over as Penicillin.

Studies in the antibiotics field expanded greatly following successful work with Penicillin. Duggar (1948) and associates of the Lederle Laboratories announced the discovery of chlortetracycline at a conference held by the New York Academy of Sciences in July, 1948. This antibiotic is produced by an Actinomycetes, Streptomyces aureofaciens, which was first isolated from a sample of soil collected from a timothy field in Missouri. During certain stages of growth this species is characterized by a golden yellow color, and the isolated antibiotic is similarly colored.

The manufacturing process for chlortetracycline is patented by Lederle Laboratories, and the product is sold under the trade name of Aureomycin, or Aurofac in the case of livestock supplements. Little has been reported on the exact manufacturing procedure used. Raper (1952), indicates a fermentation medium used is composed as follows: Corn steep liquor, 1 percent; sucrose, 1 percent; $(NH_4)_2HPO_4$, 0.2 percent; KH_2PO_4, 0.2 percent; $MgSO_4.7H_2O$, 0.025 percent; $OaCO_3$, 0.1 percent; plus several other cations.

Fermentation is conducted in large (10,000 gallon) aerated tanks which are agitated as in the manufacture of other antibiotic drugs. The purified crystalline form is obtained by precipitating the chlortetracycline with calcium ions, and then introducing HCl to form the salt known as Aureomycin HCl.

Stephens _et al._ (1952), gives the structure of chlortetracycline as shown in Figure 1.

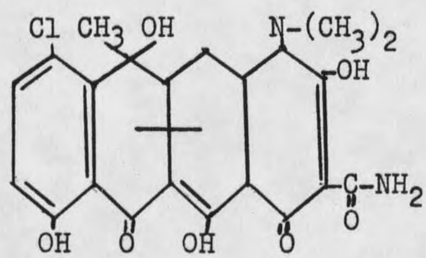

Figure 1. Structure of chlortetracycline.

Aureomycin is highly active against gram-negative rods and displays very low toxicity to higher animals. It is rapidly absorbed, circulated, and excreted. Because of these factors it can cause almost complete sterilization of the intestine, according to Thimann, (1955). In man, bacteria sometimes almost disappear from the feces. Occasionally the sterilized feces becomes infected with a pathoganic yeast species which causes serious secondary infections.

While the trial reported in this thesis used Aureomycin as the antibiotic, other antibiotics are available which are related chemically, and which give somewhat similar results in their effect on the physiology of farm animals. Terramycin is the trade name for oxytetracycline, which is similar to chlortetracycline, and is widely used. Many other antibiotics have been discovered, but only the most promising ones are employed in extensive trials with livestock. Besides the two already mentioned, Bacitracin, Streptomycin, Procaine penicillin, and a recent one, tetracycline, are the more important ones used in supplementation of commercial feeds.

Aureomycin in Chick Rations

Aureomycin was used exclusively as human medication until it was indirectly found beneficial to farm animals as well. Animal nutritionists by 1948 had found a definite growth response in animals, particularly chicks, from feeding liver extracts, fish meal, or cow manure. Also some substance in these materials was found essential for hatchibility of hen eggs. This unknown substance was termed "Animal Protein Factor." Crystalline Vitamin B_{12} was found to be the crude Animal Protein Factor substance that gave such beneficial response in chicks.

Ricks et al. (1948) then discovered Vitamin B_{12} activity in culture broths of various small bacteria and Actinomycetes, including the streptomycin-producing organism. It was shown also that Vitamin B_{12} was produced in other microbial fermentations. Aureomycin and other culture filtrates formerly disposed of as wastes were now concentrated, and became a chief source of Vitamin B_{12} for clinical use, and in the form of A.P.F. supplements were used to satisfy the skyrocketing demands of feed manufacturers. Efforts were successfully made to find strains of micro-organisms capable of giving high yields of Vitamin B_{12}.

Stokstad et al. (1949), at the Lederle Laboratories, fed Aureomycin fermentation A.P.F. supplements and obtained a growth response with chicks that was more than could be expected from Vitamin B_{12} by itself. The supplements were known to contain Aureomycin residue; the investigators therefore theorized that the extra growth was due to Aureomycin.

Stokstad and Jukes (1950) fed chicks a diet with adequate levels of Vitamin B_{12}, and when small amounts of Aureomycin were added to the ration, a significant extra growth response was obtained. This proved conclusively that the antibiotic itself had a beneficial effect on chick growth. With the antibiotic, the amount of Vitamin B_{12} needed was often found to be reduced. The addition of Vitamin B_{12} and antibiotics to a ration does not alter the need for other B-complex vitamins.

Coats et al. (1951), Lillie et. al. (1953) and Hill et al. (1953), indicate chicks reared in new or clean quarter showed no growth responses when fed antibiotics. Hill and Larson (1955) state that workers at the Lobund Institute of Notre Dame first reported germ-free chicks and poults fail to show growth responses when fed antibiotics, but later work showed sporadic growth increases for both germ-free chicks and poults fed antibiotics.

Aureomycin in Swine Rations

Lasley et al. (1954), summarized work of several years from various stations on the response of swine to different antibiotics when basal rations contained protein from plant or plant and animal sources.

The data for normal, healthy pigs from weanling to market weights showed clearly that antibiotics were effective in most trials with an average increase (48 trials) of about 17 percent in daily gains, 11.5 percent in daily feed consumption, and a saving of 3.9 percent in amount of feed required per unit of gain, compared to pigs on the basal rations. There was little difference among Aureomycin, Terramycin, Procaine penicillin, and Streptomycin in ability to increase average daily gains and feed consumption. There was no clear-cut evidence that any one antibiotic tested was superior to any other one in increasing efficiency of feed utilization.

Antibiotics seemed to be slightly more effective when added to an all-plant protein ration than when added to one containing proteins from both plant and animal sources. A level of about 5 milligrams antibiotic per pound of total ration, or 20 to 25 milligrams per pound of protein supplement seemed to give optimum response from normal, healthy pigs. It was suggested that higher levels would be beneficial when pigs are infected with certain types of pathogenic organisms.

Antibiotics in pig rations seem to be effective in controlling certain kinds of bacteria located in the digestive tract which cause scours. Many reports indicate that antibiotics are effective in controlling certain types of scours. Data are presented concerning unthrifty pigs, showing an average of 96.2 percent increase over controls in rate of gain when antibiotics were fed, and an average increase of 22.9 percent in efficiency in gains. The performance of the control groups of these unthrifty pigs was, however, far below normal.

One experiment was reviewed in which a creep ration containing one percent Aureomycin was offered suckling pigs, and 0.5 percent Aureomycin supplied in the sow ration. The average 56-day weaning weight of the pigs was increased 11 pounds. The opinion was that the antibiotic was not transferred through the sows' milk, but was taken in adequate amounts via the creep feed.

Lasley reviewed another trial in which 43 litters of pigs were used to test Procaine penicillin at levels of 5 mg. and 20 mg. per pound of pig starter. Feed consumption and rate of gain of the pigs both increased. Scours were not eliminated, but were markedly reduced. A level of 2.5 mg. per pound of ration showed no significant effect on feed consumption or rate of gain.

Aureomycin was reported to have a sparing action on protein requirements of growing-fattening pigs when rations containing 14 to 20 percent crude protein were compared. In another trial using Terramycin fed with different levels of protein, pigs receiving a 15 percent protein ration (reduced to 12 percent at 100 pounds) did just as well as pigs receiving an 18 percent protein ration (reduced to 15 percent at 100 pounds). It was suggested that the present standards for protein for pigs may be higher than necessary when rations include adequate amount of B vitamins. High levels of B vitamins in a protein supplement seem to increase the efficiency of protein utilization.

Summarizing several reports, Lasley stated that there seemed to be little or no advantage from feeding antibiotics to brood sows during gestation, as measured by litter size, and size and liveability of newborn pigs.

Aureomycin in Young Calf Rations

From abundant research evidence that has accumulated during the past several years, it is evident that swine and poultry respond favorably when antibiotics are included in their rations. The nutrition of the very young ruminant can be expected to be similar to that of mono-gastric animals because of similar physiological functions. Therefore it would be reasonable to expect a favorable reaction of the very young ruminant to antibiotics. This has been brought out regarding the work done with young calves, most of which were of dairy breeding.

Studies by Bartley et al. (1950) (1954), Rusoff et al. (1951), Jacobson et al. (1951), Knodt and Ross (1952), MacKay et al. (1952), Bloom and Knodt (1953) and others, using Aureomycin on young dairy calves have shown benefits through increasing growth rates and decreasing occurrence of scours. Some workers--Bell et al. (1951), Murley et al. (1952), Rusoff et al. (1953)--have found that use of antibiotics results in improved feed efficiency. However, Bartley et al. (1950), Bell et al. (1951), Jacobson et al. (1951), Loosli et al. (1951), Murley et al. (1952), and others found no difference in the amount of feed needed to produce a unit of gain in body weight.

Murley et al. (1952), stated Aureomycin fed to calves resulted in no effect on utilization of dry matter, carbohydrates, nitrogen, or ash. These calves received a restricted diet of non-fat dry milk solids. Rate of gain was not affected. Kesler and Knodt (1952), reported micro-organisms from Terramycin-fed calves digested 22.4 percent less cellulose than the controls, as determined by the artificial rumen method. Raddison et al. (1953), using the artificial rumen also, found Aureomycin added to rumen samples from young calves decreased digestion of filter paper cellulose but had no effect on alfalfa hay digestion.

Lassiter et al. (1953) found Aureomycin did not affect dry matter digestibility in dairy steers, but did significantly depress digestibility of the crude fiber. Lassiter et al. (1955), using new-born dairy calves, reported a boost in gain, improvement in feed efficiency, and lowered incidence of scours with Aureomycin. There was no effect on digestibility of feed nutrients, digestion of crude fiber, and urea nitrogen blood levels. Aureomycin did appear to lower non-protein nitrogen blood levels for the first seven weeks; this depression corresponded closely with stimulation of growth that occurred in this period.

Pritchard, et al. (1955), using Aureomycin on young identical-twin male calves, reports increased growth rate and improved feed efficiency for the first eight weeks of age. A seven-day collection period at the end of the eighth week showed practically no differences in digestibility of dry matter, ash, protein, curde fiber, nitrogen-free extract, or fat.

Mann et al. (1953), studied the changes in concentration of Aureomycin in the digestive tracts of calves of increasing age, and also compared the respective microflora and microfauna of several sets of Aureomycin-fed and control calves. Animals were all of similar age and breeding and were handled to simulate American practices. Aureomycin HCl at 40-60 mg. was fed daily in a gruel from about the twelfth day of age to about the 5th, 8th, and 12th week of age. At these times animals were killed together with a control animal. The treated animals had larger and less acid rumen contents which reached a rumen pH of more than 6.0 (suitable for intensive rumen bacterial action) at a much earlier age than controls. Aureomycin was never detected in the rumen or the caecum, only traces were found in the omasum, and it was definitely found in the abomasum, usually at 2-5 mg. per gram of contents. There was little difference in final development of a typical rumen-viable streptococcal population. These workers concluded that Aureomycin taken by mouth does not act directly on rumen micro-organisms, but probably does affect them by making the animal a better host. Aureomycin was always found in the abomasum where bacterial action is nil, and where the acid pH corresponds to the condition at which Aureomycin possesses a maximum of stability. The statement was made that a complete ciliate microfauna was established at eight weeks of age. If this is always true, the beneficial effects of antibiotics should become evident at an early age.

Hester et al. (1954) studied absorption, distribution, and excretion of Aureomycin in the body of calves which received doses of 50-90 mg. daily orally, or 400 mg. weekly by injection. Compared to the controls, growth was increased 19 percent in 16 weeks. Antibiotic was found present in blood plasma, bile, and urine. The highest concentration was found in urine of injected calves, and the lowest levels in blood plasma. Livers and kidneys of injected animals contain measurable amounts of Aureomycin, while a trace was found in the liver and kidney of one calf orally-fed. The spleen, thymus, pituitary, and muscle showed no antibiotic in any calf. No Aureomycin was found in the rumen of the injected calves. A definite pattern of distribution was established in the intestines. Antibiotic increased in concentration from the upper end to the lower portion of the small intestine, and decreased in concentration between the lower small intestine and the anal end of the large intestine.

Aureomycin in Steer Rumen Studies

Work has also been performed on older cattle. Bell et al. (1951), fed Aureomycin to steers and found a definite decrease in digestibility of all nutrients. Chance et al. (1953) studied the influence of Aureomycin on rumen digestion and rate of passage of nutrients from the rumen. Two rumen-fistulated steers were used. Aureomycin was fed at 0.5 gm. per day for 15 days, and then 1.0 gm. per day for the next 15 days. The period when no antibiotic was given was the control period. Rumen contents were completely evacuated, weighed, sampled, and replaced in the rumen before feeding (zero hour), and again at six and twelve hours after feeding. Rate of removal of dry matter, crude fiber, crude protein and nitrogen-free extract was highest when 0.5 gm. level was fed. Accumulation of dry matter, crude protein, and nitrogen-free extract in the rumen occurred at the zero hour when 1.0 gm. level was fed, suggesting a slight depression in digestibility of the constituents may have taken place. There was a definite accumulation of ether extract in the rumen at the zero hour when either level of Aureomycin was fed.

Hungate et al. (1955) measured total fermentation production of rumen contents of Aureomycin-fed and control steers, both in the presence and absence of additional Aureomycin. Inhibition by added antibiotic was greater in the control animals, indicating that the Aureomycin fed first altered the composition of the microbial population. Methane production was reduced by the added Aureomycin, but this was thought to be a secondary result from inhibition of production of the intermediates hydrogen and formate. The micro-organisms seemed to be more sensitive to Aureomycin than to Streptomycin.

Aureomycin and Penicillin at different levels of intake were studied (Horn et al. 1955)in digestion and nitrogen balance trials with steers. He found Aureomycin had a greater depressing effect than Penicillin on the digestibility of protein and crude fiber. The two antibiotics had an equal effect in decreasing nitrogen retention. At the level of 100 mg. per day, Aureomycin resulted in a less desirable rumen floral composition for roughage digestion, as evidenced by a decreased ability to digest fiber in an artificial rumen.

Aureomycin in Sheep Fattening Rations

Colby et al. (1950) fed Aureomycin at 100 mg. daily, orally by capsule, to fattening lambs, and also the same level plus all known B vitamins. The treated groups went almost entirely off feed. Penicillin and Streptomycin were given at the same levels and by the same methods. These two compounds were less severe in their effects compared to Aureomycin. Weight gains of all treatments were less than that of the controls; some animals (Aureomycin treatment) lost weight.

At South Dakota, Jordan (1952) fed native and western fattening lambs a ration of shelled yellow corn, alfalfa hay and soybean meal. Aureomycin was added to the soybean meal and was fed at levels of 7.2 mg., 10.0 mg., and 14.4 mg. per lamb daily. Results of four separate trials showed that lambs did not go off feed or scour excessively. Feed consumption was not stimulated, but in two trials the lambs were more easily put on full feed. The 14.4 mg. level reduced rate of gain and feed efficiency in both trials where it was employed. Aureomycin did not give complete protection from enterotoxemia, but did reduce it materially in the last trial. Gains were improved in one trial where unthrifty lambs were used.

Jordan and Bell (1951) conducted two trials using 21 and 16 lambs respectively in which they full-fed a standard corn-alfalfa hay ration plus antibiotics. A control group was included. In the first trial, the lambs were supplemented with 6.0 mg. Aureomycin per lamb daily and had an average gain of 0.49 pounds per lamb daily, compared with 0.39 pounds per lamb daily for the controls. Also 22 percent less concentrates per 100 pounds of gain was required. In the second trial, 10.8 mg. Aureomycin per lamb daily was supplied, and the animals gained 0.40 pounds per lamb daily, compared to 0.36 pounds per lamb daily for the controls. The treated lambs in this case required 20 percent less feed.

Turner and Hodgetts (1952), in Australia, fed single 750 mg. doses of Aureomycin HCl orally to adult Merino sheep. This dosage was equivalent to 23.6-27 mg. per kg. of body weight. Rumen flora was reduced 75 percent within two hours. This reduced level persisted for two days, and the surviving bacteria were predominantly Gram-positive rods and cocci. Other effects included marked depression in rumen fermentation, reduction of organic acid production, depressed appetite, and weight loss. The animals responded favorably to administration of rumen fluid and yeast extract.

Elliot and Ellsworth (1953) fed fattening lambs Aureomycin at 10 mg. and 20 mg. per pound of feed, and had three roughage-grain ratios--80-20, 60-40, and 40-60. The 20 mg. level of Aureomycin showed a significant increase in gain with the higher levels of roughage, but showed a loss at the high grain level. Bridges et al. (1953) at Texas fed fattening lambs Aureomycin at 1.1 mg. per pound of feed, 2.2 mg., 3.2 mg., 4.3 mg., 5.0 mg., and 15 mg. The basal ration was milo and alfalfa hay or milo, cottonseed meal, and alfalfa hay. The Aureomycin resulted in relatively small increases in rate of gain, which were not statistically significant. Feed efficiency was apparently improved at the 2.2 and 5.0 mg. levels.

Botkin (1953) at Wyoming fed 30 mg. Aureomycin per lamb daily and stimulated gains to 28 days but produced no advantage over a control group when the 117-day feeding period ended. There was no apparent difference in carcass grades. Dressing percentages were slightly higher for the supplemented lambs.

Keith and Leherer (1954) fed lambs individually, twice a day, a concentrate of equal parts barley and oats with two percent salt, plus pure crystalline Aureomycin HCl at 10 mg. per pound of total feed. Compared to a control group, the lambs consumed from 12 to 30 percent less total feed, made 36 to 53 percent less average gain (0.17 to 0.32 pounds per day), and required 20 to 34 percent more feed per unit of gain.

Thompson and Grainger (1954) of the University of Kentucky conducted a series of three metabolism trials consisting of three groups of two wethers each (I--Control; II--basal plus 10 mg. pure crystalline Aureomycin HCl per pound of ration; III--basal plus Aurofac to furnish 10 mg. Aureomycin HCl per pound of ration). The ration was composed of 640 gm. ground corn cobs; 116.88 gm. soybean meal; 16 gm. alfalfa meal; 16 gm.

molasses; plus minerals (Ca, P, Na, Cl, and Co) and cod liver oil. A 10-day preliminary period was followed by a 10-day collection period. Wethers in Groups II and III showed anorexia within 48 to 72 hours after antibiotics were supplemented. Appetite returned to normal after two or three days. Average apparent digestion coefficients for crude fiber were 71.4, 60.4, and 59.7 for Groups I, II, and III respectively. These differences were statistically significant. There was no difference in nitrogen retention among groups. Apparent digestibility of dry matter, nitrogen-free extract, and energy was lowered for the treated animals, but differences were not significant.

Tillman and MacVicar (1954) studied the effect of 10 mg. crystalline Aureomycin daily on digestibility of ration components fed wether lambs. They found no significant effect on the amount of nitrogen retained or on digestibility of the ration.

Hatfield et al. (1954), at Illinois, ran three trials using western blackfaced wether lambs fed ground corn, soybean meal, and alfalfa, plus Aureomycin as Aurofac or Aureomycin HCl. Levels of the antibiotic were 7.2 mg. per pound of feed and 7.6 mg. Combining results of the three trials, average daily gains are higher by 0.055 - 0.014 pounds, average feed efficiencies were higher, and average carcass grades were higher for the Aureomycin supplemented groups. Aurofac-fed lambs nearly parallelled average performance of the lambs receiving Aureomycin HCl. The authors thought antibiotics have a practical use in growing-fattening rations for lambs by improving rate and efficiency of gains, and by reducing the number of unthrifty lambs.

Kercher and Smith (1955), at Cornell, worked with lambs on cobalt-deficient diets. Aureomycin fed at 10 mg. per day seemed to retard body weight losses and increased hay consumption slightly. The Aureomycin definitely could not substitute for the cobalt that was absent in the diet, however.

Jordan (1954) used four lots of 12 lambs each and fed four different rations--Lot I--long alfalfa hay and corn in equal proportions; Lot II--ground alfalfa hay and corn in equal proportions mixed and pelleted, plus 0.3 pounds long alfalfa per lamb daily; Lot III--same as Lot II plus 10 mg. Aureomycin per pound of pelleted rations; Lot IV--three pounds ground alfalfa hay and one pound ground corn, plus 10 mg. Aureomycin per pound of mix. This last mixture was pelleted and fed along with long alfalfa at 0.3 pounds per lamb daily. Average daily gains were--0.51, 0.54, 0.60, and 0.57 pounds per lamb for Lots I, II, III, and IV respectively. Pelleting or Aureomycin did not increase feed consumption. Total feed consumption per lamb was highest in Lot IV, but corn consumption was lowest here. Pelleting did not increase feed efficiency, but did increase feed costs materially. Lot III lambs (Aureomycin supplemented) required 10 percent less feed per pound of gain than did lambs in Lot II.

Botkin and Paules (1954) at Wyoming fed ratios of roughage-to-concentrate of 1:1, 1.5:1, and 2:1. The concentrate consisted of barley, dried beet pulp, and ground alfalfa hay. Response to Aureomycin was not affected by the different rations. The control group (153 lambs) averaged 0.287 pounds gain per lamb daily, and required 7.50 pounds total digestible nutrients per pound of gain. Those lambs getting 10 mg. Aureomycin per pound of ration gained 0.304 pounds per day, and consumed 7.24 pounds total digestible nutrients per pound of gain.

At Texas, Kunkel (1954), hand-fed lambs a complete ration of hay, cottonseed meal, milo and minerals for 56 days. The control group had an average daily gain of 0.45 pounds per day and required 7.42 pounds feed per pound of gain; a group supplemented with 5 mg. Aureomycin per pound of feed gained 0.44 pounds per lamb daily and consumed 7.17 pounds feed per pound of gain, while a lot receiving 10 mg. Aureomycin per pound of ration gained an average of 0.52 pounds daily and took 7.26 pounds of feed per pound of gain. Carcass grades were about equal among the three groups.

In another 56-day trial, Kinkel self-fed a complete ration of 45 percent cottonseed hulls, 37.5 percent milo, 7.5 percent cottonseed meal, and 10 percent molasses. Again three lots were employed; Lot I was the Control; Lot II received the basal ration plus 7.5 mg. Aureomycin per pound of feed; Lot III got the basal ration plus 15.0 mg. Aureomycin per pound of feed. Average daily gains were 0.30, 0.32, and 0.36 pounds, and feed required per pound of gain was 13.1, 11.2, and 12.0 pounds for Lots I, II, and III, respectively.

The most recent work from Texas (Kunkel and Packett, 1955) was with 20 lambs fed 15 mg. Aureomycin per pound of ration and a control group of 20 lambs fed the same ration without antibiotics. The supplemented group gained 0.46 pounds per head daily on 6.74 pounds feed per pound of gain; the controls gained 0.43 pounds daily on 7.03 pounds feed per pound of gain. The Aureomycin group dressed out about one percentage point higher; there was no difference in carcass grades.

Packett et al. (1955) summarized death losses in four years of the Texas work. Aureomycin at varying levels generally showed a decrease in enterotoxemia. Of 230 lambs in control groups, 10 animals died of enterotoxemia (4.3 percent), and 12 died from all causes (5.2 percent). During this same period 353 lambs were fed rations including Aureomycin at various levels. Here there were no deaths from enterotoxemia, and only six deaths (1.7 percent) from all causes. Lambs fed the antibiotic often started off eating less, and scouring was less intense and of a shorter duration than with the controls. It was suggested that the greatest value of antibiotics in feeder lamb rations was a conditioner allowing greater ease of getting lambs on full feed.

Three trials were reported by Bohman et al. (1955) in which lambs were fed 0.0, 5.0, 10.0, and 20.0 mg. levels of Aureomycin per pound of grain mix, with and without B-Vitamin supplementation. The higher antibiotic levels together with presence of B-Vitamins were slightly more favorable than the controls in rate of gain and feed efficiency, but differences were not statistically significant. No adverse effects were noticed among the treated groups. The authors suggested that either antibiotics do not inhibit action of rumen micro-organisms that normally synthesize B-Vitamins, or that the feeds used in this study meet the B-Vitamin requirements of the fattening lambs, B-Vitamin content of the rations was not determined.

Anglemier and Oldfield (1955) at Oregon found that healthy lambs on a standard grain and legume hay ration apparently did not benefit from the