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RESPONSE OF YOUNG DAIRY CALVES
TO AUREOMYCIN FEEDING

by

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TABLE OF CONTENTS

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I. INTRODUCTION

With the discovery and isolation of various antibiotics, and the development of procedures for their mass production, a new field in animal nutrition was uncovered. Bacterial infections among farm animals, especially the young, have long been a serious problem to the livestock and dairy farmers. Losses range from inefficient weight gains to death of the animal. Thus, effective methods of reducing these losses would pave the way for great advances in the livestock and dairy industries.

Antibiotics are classified as drugs and are produced by fermentation procedures with microorganisms. These drugs have been extremely useful in the treatment of various human and animal diseases. The antibiotics are not classed as nutrients; nevertheless some have been found to have a growth-stimulating effect when fed to poultry (67), swine (39) and young dairy calves (3). Moreover, a reduction of the incidence and severity of diarrhea was observed in swine (30) and in dairy calves (3).

Several theories have been proposed as to how the antibiotics exert their influence, but no reports have appeared which unquestionably demonstrate the exact mode of action.

Very little is known about the effect of the antibiotics when fed to ruminants. Since antibiotics inhibit the growth and multiplication of microorganisms, harmful effects might be expected if an antibiotic is fed to ruminants inasmuch as rumen function is dependent upon microorganisms. Early work with lambs (18) and steers (5) supported this postulate. Contrary to expectation, however, dairy calves that were fed hay and grain in addition to milk exhibited growth responses when supplemented with aureomycin (3).

Aureomycin was selected for the present investigational work because preliminary work indicated that it was non-toxic and stimulated growth responses in young dairy calves. Also it is an antibiotic exhibiting a wide bacterial spectrum.

The present investigation was designed (a) to determine the effect of aureomycin feeding on the growth and health of dairy calves in various practical dietary regimes during the age period of rumen functional development, and (b) to determine the effect of aureomycin supplementation on the efficiency of utilization of various nutrients by dairy calves fed restricted diets.

II. REVIEW OF LITERATURE

A. History of Aureomycin

A new antibiotic active against certain viruses and rickettsia and against gram-positive and gram-negative microorganisms was isolated in 1948 by B. M. Duggar and associates of the Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y. (7, 10, 17, 51). The new microorganism *Streptomyces aureofaciens*, the antibiotic producer, was discovered during the course of screening thousands of soil samples. The antibiotic was named "aureomycin" from the yellow color of the parent actinomycete and the golden color of the crystalline antibiotic.

Chemically, aureomycin is a weakly basic compound containing both nitrogen and nonionic chlorine and having a molecular weight of 508 (10, 17). In the form of the crystalline hydrochloride, aureomycin is a stable preparation, and in the dried state maintains its potency at 22° C. for at least 6 months. High concentrations in distilled water are stable at room temperature for periods up to 2 or 3 weeks, but aureomycin loses its potency rapidly in broth, serum or low agueous concentrations (17, 51). Stability is also a function of the pH; solutions above pH 7 are unstable (17).

Welch (69) reported that aureomycin was readily absorbed from the gastro-intestinal tract of rabbits. A significant continuous blood level was maintained with doses as low as 0.25 gm. every 6 hours. Furthermore, the drug was widely distributed throughout the body. Of three drugs tested by Welch (69), the kidneys, liver and lungs exhibited higher concentrations of aureomycin than of terramycin or chloramphenicol. Harrell (34) reported that aureomycin was concentrated in the liver and excreted in the bile. Large amounts also were excreted at a rather constant rate in the urine, and there appeared to be no "piling up" of the antibiotic in the serum of the patient.

Aureomycin apparently is non-toxic to laboratory animals even when administered in large doses, since Harned et al. (33) found that mice, rats, cats, dogs, rabbits and guinea pigs were able to tolerate oral doses of 100 to 200 mg. per kilo. body weight per day for periods of 12 weeks with no evidence of toxicity. The criteria were growth, general appearance, hematology, clotting time of blood, liver function, blood sugar, blood pressure and kidney function.

The bacterial spectrum of aureomycin is quite wide inasmuch as it has been shown to have an inhibitive action against both gram-positive and gram-negative organisms (7) as well as against clostridia which are commonly found in the intestinal tract (34). Its greatest activity appears to be against the gram-positive, spore-bearing organisms (7).

Loomis (43) reported that aureomycin inhibits aerobic phosphorylation, and suggested that this mode of action was the cause of the toxic effect of aureomycin on microorganisms. It was suggested that actively multiplying and invading microorganisms might be more susceptible to a lower level of phosphate bond energy than mature and undividing cells.

Carter and Ford (11), in a review of the biochemistry of antibiotics, suggested that the development of bacterial resistance to aureomycin was not as important as in the case of streptomycin. Resistance develops slowly, and when developed, the resistant forms of bacteria rapidly revert to sensitive ones. Harrell (34) reports that no aureomycin-resistant mutants were selected from several strains of Brucella.

B. Experimental Feeding

The recent work of Stokstad et al. (67) with chicks provided the first indication that the so-called "animal protein factor" (APF) was multiple in nature and that a whole fermented mash resulting from the growth of Streptomyces aureofaciens in deep aerobic culture contained an unidentified chick growth factor(s). These fermentation products were capable of producing growth increments in chicks greater than those obtained with vitamin B_{12} alone.

Subsequent reports indicate that the inclusion of crystalline aureomycin (15, 32, 65, 70) or streptomycin (32, 45) in the diets of chicks and pigs produced growth stimulation greater than that obtained by supplementation with vitamin B_{12} alone. Whitehill et al. (70) and Groschke and Evans (32) suggested that the effect of these compounds was related in some way to their antibiotic activity in the intestinal tract, since these drugs, administered intravenously, failed to exhibit the growth-stimulating effect. Furthermore, reports by Moore et al. (48) and by Smith and Robinson (61) indicated that orally administered streptomycin brought about a marked reduction in the coliform bacteria of the feces of chicks, and Sieburth et al. (59) demonstrated similar activity when chick diets were supplemented with penicillin and terramycin.

Jukes and Stokstad (38) studied the effect of adding small amounts of aureomycin to the diet of various species. At suboptimal levels of vitamin B_{12} feeding the growth response was enhanced more markedly by the aureomycin than was the case at higher levels of B_{12} supplementation.

Stokstad and Jukes (66), in an attempt to determine the vitamin B_{12} requirements for growth of chicks, noted a "sparing effect" of aureomycin upon vitamin B_{12}. A growth-promoting effect for aureomycin was noted, however, both in the presence and absence of the added B_{12}. The mortality of chicks on the diet containing no added B_{12} was markedly reduced by aureomycin. Slinger et al. (60) found that certain APF concentrates, containing penicillin and aureomycin, increased the lysine requirement of turkey poults as measured by normal feather pigmentation. These workers suggested the possibility that these compounds also increase the requirements of poults for other amino acids.

Pyridoxal and pyridoxamine, when incorporated into the diet, were inferior to pyridoxine for the growth of rats and chicks, but all three forms of vitamin B_6 were approximately equal in growth-promoting activity when aureomycin was added to the diet (42). The investigators suggested that aureomycin may prevent utilization or destruction of pyridoxal or pyridoxamine by intestinal microorganisms, thus increasing the amount of vitamin B_6 available to the animal.

Jukes et al. (39) and Edwards et al. (24) showed that aureomycin when added to diets containing vitamin B_{12} would stimulate the growth of pigs. The increase in rate of growth was approximately equal to that obtained from supplementation with an aureomycin fermentation product designated as "animal protein factor" (Lederle APF). Lepley et al. (41) found that the addition of dried whole aureomycin mash to the diets of growing-fattening pigs increased average daily gains significantly in both dry lot and pasture. Moreover, no diarrhea occurred in the pigs which were fed the aureomycin mash while there was diarrhea in other experimental lots of pigs. Luecke et al. (45) demonstrated that the addition of streptomycin or APF to diets of pigs resulted in an increase in weight gains of 40 per cent over those of the pigs on the basal ration while the addition of vitamin B_{12} alone produced only a 10 per cent rise above the basal.

Speer et al. (64), working with healthy, well-fed pigs under relatively disease-free conditions, were unable to show either an increase in daily gains or an improvement in feed efficiency by the addition of 5 to 10 mg. of aureomycin per pound of total ration. These workers concluded that the response of the pigs to antibiotic feeding depends upon the "disease level" as described by Catron (12). The "disease level" is defined as the degree or amount of feedlot contamination with bacterial or virus infection which causes pigs to scour.

Catron et al. (15, 16) fed aureomycin at various levels to pigs and found that those receiving 5, 10, 20 or 40 mg. of aureomycin hydrochloride per pound of feed exhibited significantly higher average daily gains and greater feed efficiency than did similar non-supplemented animals. The incidence of scouring after the first week subsided for those pigs receiving aureomycin, whereas diarrhea continued in the lots of pigs fed the basal diet.

Rusoff and Haq (58) fed Merck APF, a vitamin B_{12} supplement, by adding it to a grain mixture which was fed to dairy calves during the period from 4 to 63 days of age. No apparent differences were observed in weight gains, heights at withers or feed efficiency of the calves. The decrease in growth rate which normally occurs after weaning calves from milk at an early age was not prevented by the feeding of the APF. Williams and Knodt (73) reported that APF (Merck) when added to a milk replacement that was fed to young Holstein male calves did not appear to improve the rates of growth of these animals.

On the other hand when Lederle's APF, containing aureomycin, was fed to young dairy calves, increased weight gains, improved appearance and a reduction in incidence and severity of diarrhea were observed (3, 50, 57).

Bartley et al. (3) fed an APF concentrate (Lederle), containing 5 mg. of aureomycin per gram, to dairy calves from birth to 42 days of age. The APF concentrate was administered daily by capsule at the rate of 3 gm. per 100 pounds body weight. The weight gains of the aureomycin-fed calves were no greater than the expected average gain according to the Ragsdale growth standard for dairy calves (52) but the controls were considerably below the growth standard. A much lower incidence of scouring was noted in the antibiotic-supplemented calves which were thriftier and in better condition than the controls. It was suggested that the APF concentrate containing aureomycin appeared to have enhanced growth by preventing diarrhea.

Rusoff (55, 56) noted a greater increase in body weight gains of 14-week-old Jersey male calves fed a grain mixture supplemented with an APF concentrate containing aureomycin than in those of the control calves. The daily rates of gain were 1.36 and 1.11 for the supplemented and control calves, respectively, during the first 6 weeks of the experiment, whereas no difference was observed beyond this period. The outstanding contrasting features between the groups were the smooth haircoats and the sleek, solid, muscular appearance of the APF-supplemented calves, and the rougher appearance and larger barrels of the control animals. Further work by Rusoff and Davis (57) with dairy calves from birth to 90 days of age demonstrated that aureomycin produced a growth stimulation. Jersey calves receiving a calf starter supplemented with 2 per cent aureomycin feeding supplement, containing 2.5 gm. aureomycin per pound of supplement, and those receiving the calf starter supplemented daily with 75-150 mg. of crystalline aureomycin fed by capsule showed a rate of gain approximately 25 per cent above Jersey control calves. Holstein calves similarly fed and supplemented exhibited body weight gains approximately 15 per cent greater than those of the Holstein control group. The antibiotic supplementation appeared to lower the incidence of diarrhea.

Loosli _et al_. (44) fed various milk replacements to 39 pairs of Holstein calves to 8 weeks of age. One member of each pair received an antibiotic feed supplement (Lederle) mixed either in whole milk or in milk replacement at a level of 2 per cent. The average daily gain in body weights was

1.16 pounds for those fed the antibiotic supplement and 0.95 pound for the control calves, a highly significant difference, statistically. There were no significant differences in the amounts of hay consumed, but the antibiotic-supplemented calves consumed approximately 40 per cent more concentrate than the controls and required less T.D.N. per pound of weight gain. Control calves exhibited a greater incidence and severity of scours than those fed the antibiotic supplement. Studies on total bacterial counts and morphological types of bacteria, using the stained slide method, were made on the rumen contents of the calves, but no differences were apparent between the antibiotic-supplemented and the control calves.

A preliminary report of the work to be reported herein (50) indicated improved weight gains and physical appearance and greater efficiency of feed utilization when the diets of young dairy calves were supplemented with 80 mg. per calf daily of crystalline aureomycin hydrochloride fed in the milk via nipple pail.

In contrast to the aforementioned favorable responses of ruminants to antibiotic feeding, other research workers have reported deleterious effects. Colby et al. (18) fed a group of weaning-age lambs a basal ration consisting of oats, milo, bran, cottonseed meal and alfalfa hay supplemented at a 1 per cent level with an APF feed supplement (Lederle) which contained 0.6 mcg. vitamin B_{12} and 4 mg. aureomycin per gm. Since the APF adversely affected the palatability of the ration, the supplementation rate was reduced to 0.5 per cent of the total ration after the first 2 weeks of feeding. During the last half of the 28-day experimental period, the lambs receiving the ration containing the APF practically ceased eating the concentrate mixture, and gained only 0.22 pound per day as compared to 0.38 pound for the control lambs. Also, the APF supplement had a slightly depressing effect upon both the diameter and the length of wool fiber. Further experimentation with lambs by these investigators (19, 20) indicated that the feeding of crystalline aureomycin hydrochloride at the daily rate of 100 mg. per lamb orally by capsule resulted in a marked decrease in feed consumption and in weight loss. Bacterial counts were made on the rumen contents of the lambs fed aureomycin and were found to be much higher than in the control animals, indicating that perhaps the aureomycin had destroyed certain strains of bacteria, thereby eliminating a normal competitive environment and permitting less desirable strains of bacteria to multiply (19).

Bell, Whitehair and Gallup (5) observed that feeding crystalline aureomycin hydrochloride orally by capsule, at the daily rate per animal of 0.6 gm., to beef steers produced anorexia and diarrhea within 48 to 72 hours. In further studies with steers fed a basal ration of corn, soybean oil meal and prairie hay, aureomycin was added at the daily rate of 0.2 gm. and digestion coefficients, nitrogen retention and blood urea values were obtained. The aureomycin decreased the apparent digestibility of dry matter and of crude fiber by as much as 15 per cent and 50 per cent, respectively. A subsequent report by these investigators (6) indicated that continued feeding of 0.2 gm. of aureomycin daily produced somewhat milder digestive disturbances than did 0.6 gm.

C. Lactose Feeding to Animals

Since the restricted diet employed in this investigation was composed largely of reconstituted skimmilk and thus involved a high lactose intake, a review of the literature on lactose feeding seemed desirable. An excellent review on the effect of lactose in the diet of various species of animals has been made by Fischer and Sutton (25). A lactose feeding level of 20 per cent of the diet often induces diarrhea in weanling rats. Ten to 15 per cent similarly adversely affects puppies. If lactose constitutes more than 20 per cent of the diet of chicks, diarrhea results, as well as a lowering of the pH of the cecum which becomes distended by a frothy liquid material.

Couch *et al.* (22) fed laying hens a purified diet with lactose as the carbohydrate and found that the hens ceased laying in one to two weeks. Adding 30 per cent fat to the diet eliminated the deleterious effect of lactose on egg production.

Rojas _et al_. (54) reported the occurrence of diarrhea in dairy calves fed separated milk with sufficient extra lactose added to make the total lactose content twice that of separated milk. The scouring was observed within a few hours after feeding of the lactose-enriched separated milk began and decreased when the extra lactose was omitted.

An animal may adapt to lactose feeding; i.e., the diarrhea may become less severe, may occur less frequently or may cease if the animal continues to ingest rather large amounts of lactose over an extended period of time. Riggs and Beaty (53) indicated that the capacity of the rat to utilize lactose without suffering from diarrhea can be increased through a continued daily intake of rations containing lactose. Fischer and Sutton (26) recently reported that previous lactose feeding increases the ability of the rat intestine to hydrolyze and absorb lactose. Softer fecal pellets continued after the diarrheal condition of young rats fed a 70 per cent lactose diet had subsided (47).

Fischer and Sutton (25) postulated that the mechanism of adaptation of animals to lactose feeding is an increased production of the enzyme, lactase, in the intestinal mucosa. Lactase occurs in the mucosal cells of the intestines of mammals, but not to any appreciable extent in the intestinal juice. Therefore, these workers suggest that lactose hydrolysis must be mainly an intracellular process, occurring during absorption. Since lactose diarrhea may be caused by the absence of extensive lactose hydrolysis and the resulting hydragogue effect, the species, strain, age and individual differences in the severity of lactose-feeding symptoms might be due to differences in intestinal lactase activity.

Fischer and Sutton (25) suggested several possible ways in which lactose might act to produce diarrhea: (a) direct stimulation of intestinal muscles; (b) hydragogue action, i.e., interfering with absorption of water and organic nutrients; (c) alteration of intestinal flora to an aciduric type; (d) alteration of pH to a degree sufficient to stimulate the intestinal musculature; (e) maintenance of a positive oxidation-reduction potential; and (f) stimulation of intestinal muscle through its nerve supply, by small amounts of unhydrolyzed lactose in the blood. The writers favored the second possibility, that of a hydragogue type of action, as the most plausible.

Flipse *et al.* (27, 28, 29, 30) in attempting to develop a synthetic milk for young dairy calves, have made an extensive comparison of various types of carbohydrates as the source of energy. Young calves fed, from birth to 28 days of age, various synthetic diets of equal caloric value but varying in content of lactose from 5 to 30 per cent gained at a greater rate than other calves receiving either glucose or corn syrup as the carbohydrate source. The level of lactose feeding apparently made little difference in body weight gains which were 16.0, 20.5, and 19.5 pounds for calves receiving levels of 5, 10 and 30 per cent lactose, respectively. This gain was in contrast to 9.33 pounds for glucose-fed calves and 8.66 pounds for corn syrup-fed calves. Subsequent work (27) indicated that calves receiving lactose plus corn syrup gained an average of 28.33 pounds, those receiving lactose plus starch gained an average of 24.67 pounds, while calves fed starch as the only dietary carbohydrate gained only 14 pounds in 31 days. These workers (30) suggested that much of the beneficial action of lactose may be credited to its stability and to its low solubility which permit it to pass unchanged into the intestinal tract where it promotes the growth of beneficial lactic acid-producing bacteria and inhibits scatologic putrefaction. This view is not universally accepted, however, since Whittier and co-workers (71) could not attribute improved growth of lactose-fed rats to the production of acidophilic organisms in the lower intestine.

In an attempt to explain the more favorable effect of lactose as compared to other forms of carbohydrates, Flipse et al. (27, 28) studied blood glucose tolerance curves of calves, between the ages of 28 and 35 days, which were fed various types of carbohydrates. The blood samples were obtained from the jugular vein just prior to feeding and at 0.25, 0.5, 1, 2, 4, 6 and 8 hours following feeding and were analyzed for reducing sugars. The blood sugar level rose rapidly after the ingestion of glucose, of lactose, and of corn syrup with maximum concentrations at 4, 4 and 1 hours, respectively, after feeding. Following starch ingestion, there was no change in blood sugar the first 4 hours and only a moderate increase at 6 to 8 hours. The curve for glucose decended more rapidly than did that for lactose. It was suggested that this continued high level of blood sugar for the lactose-fed calves might indicate that the hydrolysis of lactose continued over a longer period of time, and this might be considered advantageous in that energy was made available over an extended period and thus absorption and utilization were permitted to take place more efficiently. However, these workers (28) cautioned that blood sugar levels can be considered only as a rough index of the utilization of a carbohydrate, since the concentration of sugar in the blood at any specified time depends upon the rate of absorption of the sugar into the blood stream and the rate at which it is removed from the blood. The investigators stated that the latter may be accomplished through excretion in the urine or through utilization by the tissues and the rate of removal, whether by excretion or utilization, varies with the sugar concerned.

McCandless and Dye (46) determined blood glucose tolerance curves on several species of ruminants, both young and adult animals. Non-ruminating animals of four species exhibited much higher blood sugar levels than ruminating animals of the same species. The workers explained the difference as resulting from metabolic changes incident to bacterial fermentation of carbohydrates in the rumen, i.e., a shift from a milk diet to hay and grain.

Derse _et al_. (23), in studying the urinary excretion of galactose in young and adult rats on a skimmilk diet, discovered that the amount of galactose excreted by the weanling rat was lower than that for the adult animal. It was suggested that in the young animal more efficient utilization of galactose may be necessary for the more adequate utilization of the high lactose diet during early life.

III. EXPERIMENTAL AND RESULTS

The procedures and results of this investigation will be presented as two separate trials because of the differences in dietary regimes and the nature of measurements that were made. Trial I was designed to study the effect of aureomycin on the growth and well-being of young dairy calves.

The second phase of the investigation (Trial II) was designed to investigate the more fundamental aspects of the response of calves to aureomycin supplementation.

A. Trial I

1. Procedure

a. Dietary groups: Four-day old dairy calves of the Ayrshire, Guernsey, Holstein and Jersey breeds from the Iowa State College herd were divided into four comparable groups, based upon breed and sex, and were fed various experimental diets over a period of 16 weeks. Each calf received hay *ad libitum* and a concentrate mixture[1] free choice up to a maximum of 4 pounds daily. Calves in Groups I and II received whole milk whereas those in Groups III and IV were fed a reconstituted skimmilk (Table 1). Each calf in Groups II and

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[1]The concentrate mixture consisted of 40 per cent ground corn, 30 per cent cracked oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

IV received, in addition, 80 mg. daily of crystalline aureomycin hydrochloride[1] fed in the milk via nipple pail. Data relative to the calves and dietary groups are presented in Table 2.

Table 1. Milk Feeding Plan Used in Trial I

Age (days)	Rate of feeding milk (All groups)	Composition of reconstituted skimmilk (Groups III and IV)
	(lbs. daily /100 lbs. body wt.)	(Ratio of non-fat dry milk solids to water)
4 - 6	10	1 : 9
7 - 9	10	1 : 7
10 - 12	10	1 : 5
13 - 18	10	1 : 4
19 - 25	9	1 : 4
26 - 32	8	1 : 4
33 - 39	7	1 : 4
40 - 46	6	1 : 4
47 - 53	5	1 : 4
54 - 60	4	1 : 4
61 - 67	3	1 : 4
68 - 74	2	1 : 4
75 - 116	1 lb./feeding	1 : 4

b. Preparation of the rations: The whole milk was obtained immediately prior to each feeding from specified Holstein cows (producing milk containing approximately 3.5 per cent fat) in the Iowa State College dairy herd. Analysis of

[1]Supplied through the courtesy of Dr. T. H. Jukes, Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y.

weighted composite samples of the milk fed indicated an average of 3.45 per cent fat.

Spray dried non-fat dry milk solids[1] (dried skimmilk) was reconstituted immediately prior to each feeding in the ratios shown in Table 1. The ratio of non-fat dry milk solids to water was calculated to yield approximately the same calories during the milk feeding period as that supplied by the whole milk.

The crystalline aureomycin hydrochloride was mixed with dry skimmilk in proper proportions to deliver 40 mg of aureomycin per tablespoon of mixture. Just prior to each of the two daily feedings one tablespoon of the mixture was dissolved, by stirring, in the milk for each calf.

c. Management of the calves: The calves were allowed to remain with their respective dams for 3 days following birth, after which they were removed to a different barn and placed in individual calf pens. The barn had no artificial heat in winter but 15 dairy cows were housed in the same building. Later, as space became available, the calves were moved to the main calf barn maintained at a minimum temperature of about 65°F. by a thermostatically controlled oil-burning furnace.

The milks, at a temperature of approximately 100°F., were

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[1]Purchased from the Des Moines Cooperative Creamery, Des Moines, Iowa.

fed twice daily from nipple pails. The rate of feeding both the whole milk and the reconstituted skimmilk (Table 1), was adjusted, for each calf, at weekly intervals after the initial 2 weeks during which they were fed at the rate of 10 pounds of milk per 100 pounds of body weight. Also, the composition of the reconstituted skimmilk was changed during the first 2 weeks as indicated in Table 1. The amount of milk fed was reduced to one-half when digestive disturbances were noticed. The decrease level was maintained until the diarrhea subsided, after which the quantity was increased gradually to the regular amount. In severe cases of diarrhea "Kaopectate" or a scour medicine prepared by the Veterinary Clinic, Iowa State College, was administered with warm water.

The hay was weighed and placed in individual hay racks, and the uneaten portions were weighed back periodically and replaced with fresh hay. The concentrate mixture was fed at the rate of 2 pounds twice daily if the individual calves had consumed the previous feeding, otherwise the previously fed grain mixture was allowed to remain in the feed box until either consumed by the calf or until it became contaminated with excreta or other debris, at which time it was weighed back and discarded.

Each calf that received reconstituted skimmilk was fed a daily supplement[1] of approximately 15,000 USP units of

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[1]"Natola" capsules purchased from Parke, Davis and Co.

vitamin A and 3000 USP units of vitamin D during the first 4 weeks of the experimental period. At this age it was assumed that the calves were eating sufficient hay and concentrate mixture to supply adequate amounts of vitamins A and D.

d. Records: The recorded data included body weight changes, incidence of diarrhea and general appearance of the calves and the amounts of milk, hay and concentrate mixture consumed. The calves were weighed at 4 days of age and once each week throughout the trial. Each calf was examined for signs of scouring at each feeding. The general appearance and state of health of each calf were recorded periodically and whenever abnormalities were noted, and a series of colored pictures (2" x 2" slides) were made of most of the calves.

2. Results

a. Growth: Body weight changes of calves are presented in Table 2. The range of the mean initial weights for the groups of calves was only 7 pounds, which was considerably smaller than the variations among calves within each group. The mean weight changes for each group of calves are shown graphically in Figure 1. These trends indicate approximately equal weight gains in calves fed aureomycin with whole milk (group II) and with skimmilk (group IV). A similar relationship was exhibited in the calves that were not supplemented with the antibiotic, (groups I and III), and it appeared that

Table 2. Effect of Aureomycin and of Type of Milk on Changes in Body Weights

Dietary Group[a]	Calf No.	Breed	Sex	Age, days 4	11	18	25	32	39	46	53	60	67	74	81	88	95	102	109	116	Total Gain
				(lbs.)																	
	3449	J	M	60	60	65	69	74	82	84	96	110	127	142	147	161	168	181	196	214	154
	3470	J	F	55	56	60	65	72	79	84	88	97	108	116	123	132	143	157	167	179	124
	3480	G	F	54	51	57	61	62	68	76	80	88	94	106	111	118	128	133	142	150	96
I	3528	H	M	95	101	108	105	119	130	142	155	165	179	194	210	218	231	245	260	287	192
(Whole	3554	H	F	98	105	111	119	128	139	146	157	169	177	190	205	219	229	248	260	276	178
milk)	3521	A	F	68	70	77	82	90	97	108	114	126	129	138	150	160	168	181	192	207	139
	3569	H	M	110	117	127	134	145	152	168	180	192	200	213	228	236	254	268	277	288	178
	3504	J	F	57	51	55	61	66	73	80	85	88	89	92	96	100	107	111	118	121	64
	3543	G	M	78	74	76	82	88	94	100	104	109	116	124	137	148	150	158	169	180	102
	Average			75	76	82	86	94	102	110	118	127	135	146	156	166	175	187	198	211	136
	3503	J	M	64	64	68	73	80	91	99	111	121	126	141	153	164	185	190	207	225	161
II	3463	J	F	60	63	75	75	84	94	103	111	116	133	140	152	160	166	185	194	197	137
(Whole	3530	G	F	70	73	79	88	98	109	116	125	131	138	152	155	168	182	194	194	218	148
milk	3539	H	M	95	98	105	112	121	132	143	157	172	185	196	206	232	249	255	275	296	201
plus	3550	H	F	91	98	103	112	125	136	152	165	173	190	203	215	226	240	250	262	282	191
aureo-	3520	A	F	64	67	74	78	89	101	111	121	132	146	158	172	187	201	209	222	242	178
mycin[b])	3570	H	M	84	85	90	102	113	123	132	143	154	169	187	198	214	230	241	252	266	182
	3472	J	F	41	43	45	52	58	66	74	80	90	102	113	124	137	146	151	158	171	130
	3505	G	M	63	65	75	84	93	104	116	129	137	151	161	172	185	195	210	228	235	172
	Average			70	73	78	86	96	106	116	127	136	149	161	172	186	199	209	221	237	167

[a] All calves received alfalfa hay ad libitum, and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b] 80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 2. (Continued)

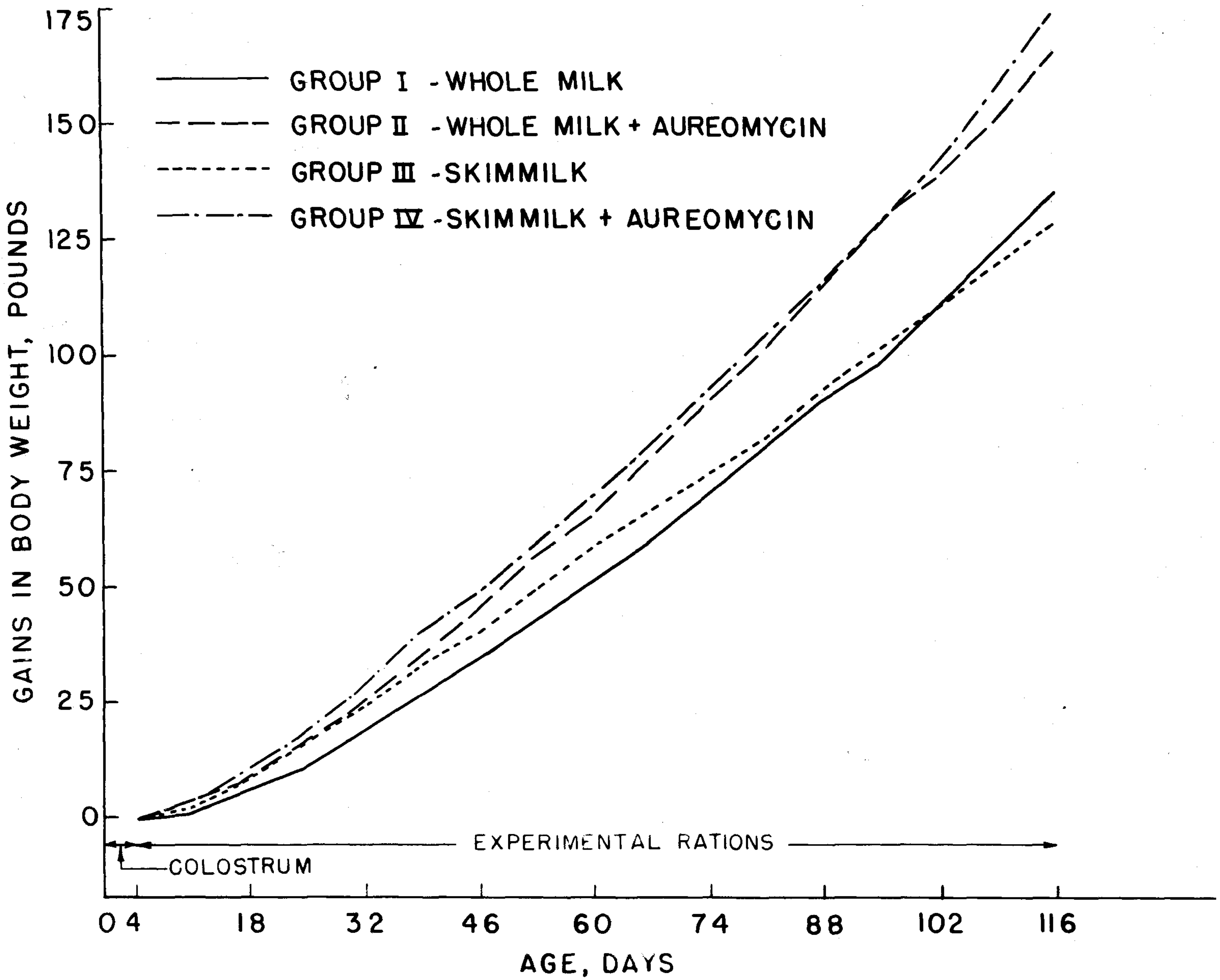
Dietary Group[a]	Calf No.	Breed	Sex	Age, days 4	11	18	25	32	39	46	53	60	67	74	81	88	95	102	109	116	Total Gain
				(lbs.)																	
	3511	J	M	53	54	57	60	67	73	81	86	94	102	109	112	125	134	139	147	151	98
III	3542	J	F	55	61	68	75	84	92	100	110	117	130	139	148	160	168	176	189	197	142
(Recon-	3532	G	F	59	60	57	62	69	72	78	83	88	92	94	102	104	111	118	121	128	69
sti-	3531	H	M	90	92	100	108	120	136	146	160	172	185	190	204	214	220	235	246	259	169
tuted	3557	H	F	90	88	93	106	114	124	133	141	152	156	164	176	179	189	203	218	226	136
skim-	3522	A	M	86	86	91	101	112	125	138	150	160	174	186	192	208	226	228	245	253	167
milk[c])	3564	H	F	94	103	114	126	133	139	142	152	158	171	178	184	191	202	220	222	238	144
	3534	J	M	65	65	72	80	88	97	105	118	124	125	130	135	151	156	164	165	179	114
	Average			74	76	82	90	98	107	115	125	133	142	149	157	167	176	185	194	204	130
IV	3489	J	M	66	64	66	76	87	104	111	120	132	141	153	168	180	194	210	224	244	178
(Recon-	3499	J	F	63	60	68	76	89	97	108	117	126	133	140	154	164	173	183	192	203	140
sti-	3525	G	F	71	70	75	84	93	107	114	123	131	143	153	163	176	187	201	217	229	158
tuted	3537	H	M	81	88	100	109	121	129	138	146	162	175	187	197	205	227	241	259	276	195
skim-	3552	H-	F	88	89	97	103	112	122	132	142	155	170	179	192	201	207	215	227	252	164
milk[c]	3495	A	M	83	86	99	100	114	123	131	147	158	173	187	200	217	229	254	272	297	214
plus	3565	H	F	92	100	107	119	133	146	152	165	170	186	196	206	222	242	240	262	278	186
aureo-	3498	J	M	71	72	86	90	99	107	117	123	133	146	155	167	177	190	205	225	235	164
mycin[b])	Average			77	79	87	95	106	117	125	135	146	158	169	181	193	206	219	235	252	175

[a]All calves received alfalfa hay *ad libitum*, and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[c]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

Figure 1. Effect of aureomycin and type of milk on changes in group mean weights of calves.


GROUP I -WHOLE MILK
GROUP II -WHOLE MILK + AUREOMYCIN
GROUP III -SKIMMILK
GROUP IV -SKIMMILK + AUREOMYCIN
GAINS IN BODY WEIGHT, POUNDS
175
150
125
100
75
50
25
0
EXPERIMENTAL RATIONS
COLOSTRUM
0 4
18
32
46
60
74
88
102
116
AGE, DAYS

in both the antibiotic-supplemented and non-supplemented calves the type of milk made little difference in the rate of growth from 4 to 116 days of age. After the initial 2 to 3 weeks of the experiment, however, the aureomycin-fed calves (groups II and IV) gained weight at a more rapid rate than the controls, and the difference between the mean weights became increasingly greater throughout the trial.

The aureomycin-fed calves (groups II and IV) showed a 27 per cent greater body weight gain during the 16-week trial than the control animals (groups I and III). The Ayrshire, Guernsey and Jersey calves of Groups II and IV exhibited a 41 per cent increase in gain over their controls in Groups I and III, whereas the Holsteins of the supplemented groups had only a 12 per cent greater growth than the Holstein control calves. This difference between breed groups is similar to that reproted by Rusoff and Davis (57) who found that the weight gain of aureomycin-supplemented Jersey calves exceeded that of their controls by 25 per cent, while the gain of supplemented Holstein calves was 15 per cent greater than that of the Holstein controls.

The differences in gain exhibited between calves that were supplemented with aureomycin (groups II and IV) and the non-supplemented animals (groups I and III) were significant statistically as indicated in Table 3. Only the first eight calves of each dietary group (Table 2) were used in the

Table 3. Analysis of Variance of Body Weight Gains Data

Source of Variation	Degrees of Freedom		Sums of Squares	Mean Square
Groups	7		361,925	51,703
Rations	3		29,856	9,952
Whole milk vs. Skim-milk (M)		1	2,603	2,603
Aureomycin vs. Non-aureomycin (A)		1	24,463	24,463*
Interaction M x A		1	2,790	2,790
Groups x Rations (Experimental error)	21		97,459	4,640
Weeks	16		1,256,709	78,544**
Weeks x Rations	48		17,666	368**
Weeks x Groups	112		32,074	286**
Weeks x Rations x Groups	326		20,240	60
Total	543		1,815,933	

F (Aureomycin vs. Non-aureomycin) = 5.27
F (Weeks) = 274.63
F (Weeks x Rations) = 6.10
F (Weeks x Groups) = 4.75

*P = .05

**P = .01

statistical analysis in order to simplify the calculations involved, since there were nine calves in each of Groups I and II and only eight in each of Groups III and IV.

The differences in weight changes of the calves by weeks were significant at the .01 probability level. The interpretation might be, as can be noted also by studying weight increases by weeks for individual calves, that the calves gained at varying rates during different weeks.

The interaction of weeks by rations also was statistically significant at the .01 probability level. This results, in the main, from the fact that the difference in gain in favor of the calves fed aureomycin became greater as the feeding period progressed.

The interaction of weeks by groups, also statistically significant at the .01 probability level, may be interpreted as an indication that the groups of calves varied in the magnitude of their rates of gain by weeks. The calves were grouped according to breed and sex with four breeds represented. Therefore, these two factors also would influence the rate of gain by weeks among groups.

Table 4. Analysis of Variance of Total Weight Gain Data

Source of Variation	Degrees of Freedom		Sums of Squares	Mean Square
Groups	4		12,297	3,074
Rations	3		6,652	2,217
Aureomycin vs. Non-aureomycin (A)		1	4,961	4,961**
Whole milk vs. Skimmilk (M)		1	884	884
Interaction A x M		1	807	807
Experimental error	12		4,790	399
Total	19		23,739	

F (Aureomycin vs. Non-aureomycin) = 12.43
F (Whole milk vs. Skimmilk) = 2.22

**P = .01

Since the groups of calves were not equally balanced with respect to sex, an analysis of variance was made using the total body weight gains of only the first five calves of each dietary group (similar breed and sex distribution in each group) Table 4. This analysis revealed a statistically significant difference at the .01 probability level in the total body weight gains in favor of the supplemented animals. This statistical test, applied to the data to double check the differences, if any, between the whole and the skimmilk groups, indicated no significant differences in weight gains due to type of milk.

b. Efficiency of feed utilization: The ratio of calculated total TDN consumption (49) to body weight gain (Table 5), reveals that the aureomycin-fed calves (groups II and IV) consumed more feed and utilized it more efficiently than did the control animals (groups I and III). The aureomycin-fed calves required an average of 2.05 pounds of calculated TDN per pound of body weight gain as compared to an average of 2.30 pounds for the non-supplemented calves, a 14 per cent greater efficiency for the former.

Table 6 reveals that the antibiotic-supplemented calves consumed significantly more calculated TDN than the controls. Since the dietary groups of calves were not evenly balanced with respect to sex, only five animals (comparable breed and sex distribution) from each group were used in the statisti-

Table 5. Effect of Aureomycin and Type of Milk on TDN Consumption (Calculated) and on Ratio of TDN Ingested to Body Weight Changes of Dairy Calves

Dietary Group[a]	Calf No.	Br.	Sex	Initial Wt.	TDN[b] consumption (lbs.) Milk	Conc.	Hay	Total	Wt. Gain	TDN/lb. Gain
	3449	J	M	60	72	174	41	287	154	1.9
	3470	J	F	55	66	159	28	253	124	2.0
	3480	G	F	54	58	143	40	241	96	2.5
I	3528	H	M	95	100	169	84	353	192	1.8
(Whole	3554	H	F	98	100	236	69	405	178	2.3
milk)	3521	A	F	68	81	149	66	296	139	2.1
	3569	H	M	110	115	262	133	510	178	2.9
	3504	J	F	57	61	115	41	217	64	3.4
	3543	G	M	78	74	157	51	282	102	2.8
	Average			75	81	174	61	316	136	2.3
	3503	J	M	64	67	168	73	308	161	1.9
II	3463	J	F	60	75	193	29	297	137	2.2
(Whole	3530	G	F	70	82	193	51	326	148	2.2
milk	3539	H	M	95	103	190	106	399	201	2.0
plus	3550	H	F	91	95	233	94	422	191	2.2
aureo-	3520	A	F	64	81	193	91	365	176	2.1
mycin[c])	3570	H	M	84	95	245	136	476	182	2.6
	3472	J	F	41	57	156	41	255	130	2.0
	3505	G	M	63	73	200	65	338	172	2.0
	Average			70	81	197	76	354	167	2.1

[a]All calves received alfalfa hay ad libitum and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]TDN values used in calculations were: Whole milk, 16 per cent; dry skimmilk, 84 per cent; concentrate, 77 per cent; and hay, 50 per cent.

[c]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 5. (Continued)

Dietary Group[a]	Calf No.	Br.	Sex	Initial Wt.	TDN[b] consumption Milk	Conc.	Hay	Total	Gain	TDN/lb. Gain
					(lbs.)					
	3511	J	M	53	71	100	36	207	98	2.1
	3542	J	F	55	68	169	70	307	142	2.2
	3532	G	F	59	57	68	50	175	69	2.5
III	3531	H	M	90	87	166	99	352	169	2.1
(Skim-	3557	H	F	90	93	171	78	342	136	2.5
milk[d])	3522	A	M	86	84	206	85	375	167	2.3
	3564	H	F	94	100	169	93	362	144	2.5
	3534	J	M	65	72	132	45	249	144	2.2
	Average			74	79	148	70	296	130	2.3
	3489	J	M	66	87	151	42	280	178	1.6
IV	3499	J	F	63	71	159	51	281	140	2.0
(Skim-	3525	G	F	71	82	185	77	344	158	2.2
milk[d]	3537	H	M	81	96	148	99	343	195	1.8
plus	3552	H	F	88	97	168	120	385	164	2.4
aureo-	3495	A	M	83	97	173	86	356	214	1.7
mycin[c])	3565	H	F	92	104	200	118	422	186	2.3
	3498	J	M	71	88	164	69	321	164	2.0
	Average			77	90	169	84	342	175	2.0

[a]All calves received alfalfa hay _ad libitum_ and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]TDN values used in calculations were: Whole milk, 16 per cent; dry skimmilk, 84 per cent; concentrate, 77 per cent; and hay, 50 per cent.

[c]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[d]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

Table 6. Analysis of Variance for Calculated TDN Consumption Data

Source of Variation	Degree of Freedom		Sums of Squares	Mean Squares
Group	4		57673	14418
Ration	3		18326	6079
Aureomycin vs. non-aureomycin (A)		1	14525	14525*
Whole milk vs. Skimmilk (M)		1	3618	3618
Interaction A x M		1	93	93
Experimental Error	12		25677	2140
Total	19		101586	

F (Aureomycin vs. Non-aureomycin) = 6.79

*P = .05

cal analysis.

The milk feeding was limited to a definite daily amount based upon individual body weights of the calves, and also, the quantity of milk fed daily was reduced when signs of diarrhea were noted. Table 7 shows that the whole milk-fed calves consumed an average of 505 pounds per calf. The aureomycin-supplemented, whole milk-fed calves grew more rapidly than their controls, but they had a mean initial weight of 5 pounds less than the controls which explains the similar milk consumption. However, the skimmilk-fed, aureomycin-supplemented calves due to a slightly greater mean initial weight,

Table 7. Effect of Aureomycin and Type of Milk on the Mean Quantities of Feed Consumed by Young Dairy Calves

Dietary Group[a]	No. Calves	Period (weeks)	Feed (group av. per calf): Whole Milk (lbs.)	Non-fat dry milk solids[b] (lbs.)	Grain (lbs.)	Hay (lbs.)
I (Whole milk)	9	1- 4 incl.	212		15	5
		5- 8 "	164		42	17
		9-12 "	73		75	39
		13-16 "	56		93	62
		Total	505		225	123
II (Whole milk plus aureomycin[c])	9	1- 4 incl.	203		18	7
		5- 8 "	169		50	20
		9-12 "	78		85	42
		13-16 "	56		103	83
		Total	505		256	152
III (Skim-milk[d])	8	1- 4 incl.		33	11	4
		5- 8 "		34	36	17
		9-12 "		16	63	43
		13-16 "		11	82	75
		Total		94	192	139
IV (Skimmilk[d] plus aureomycin[c])	8	1- 4 incl.		36	8	6
		5- 8 "		40	34	20
		9-12 "		16	75	48
		13-16 "		12	105	92
		Total		104	222	166

[a]All calves received alfalfa hay ad libitum and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]Dried product prior to reconstitution.

[c]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[d]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

greater growth and lower incidence of diarrhea (Table 7), consumed 10.5 per cent more milk than their controls.

The concentrate mixture was fed free choice up to a maximum of 4 pounds daily per calf. The antibiotic-supplemented calves exhibited better appetites, thus consuming their maximum daily allowance at an earlier age than the control animals. Therefore, they consumed 11 per cent more of the concentrate mixture than did the control calves (Table 8). Furthermore, the supplemented animals consumed 21 per cent more hay (fed ad libitum) than did the non-supplemented calves (Table 9).

c. Health: The calves were observed for various abnormalities, particularly diarrhea, at each feeding or a total of 224 times for each calf during the experimental period. Considering the total number of times observations were made, the frequency of scouring among the experimental calves was low. Table 10 indicates a greater incidence of diarrhea during the first 4 weeks of the trial for the calves fed skimmilk (groups II and IV) than for those receiving whole milk (groups I and III). Aureomycin supplementation apparently did not reduce the incidence of diarrhea during this initial period but during the latter stages of the trial, from 5 to 16 weeks, a slight reduction was observed. The difference was not statistically significant, however. The group mean number of times diarrhea was observed throughout

Table 8. Effect of Aureomycin and Type of Milk on Concentrate Consumption

Group[a]	Calf No.	Br.	Sex	Period, weeks 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	Total
				(lbs.)				
I (Whole milk)	3449	J	M	10	34	86	96	226
	3470	J	F	12	31	70	94	206
	3480	G	F	20	38	62	66	186
	3528	H	M	6	27	86	100	219
	3554	H	F	14	88	92	112	306
	3521	A	F	18	34	50	92	194
	3569	H	M	38	82	108	112	340
	3504	J	F	12	32	50	55	149
	3543	G	M	8	14	72	110	204
	Average			15	42	75	93	225
II (Whole milk plus aureomycin[b])	3503	J	M	10	32	70	106	218
	3463	J	F	18	46	84	102	250
	3530	G	F	27	48	76	100	251
	3539	H	M	4	36	93	114	247
	3550	H	F	22	68	100	112	302
	3520	A	F	18	49	82	102	251
	3570	H	M	28	66	112	112	318
	3472	J	F	6	38	66	92	202
	3505	G	M	26	64	84	86	260
	Average			18	50	85	103	256

[a]All calves received alfalfa hay ad libitum and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 8. (Continued)

Group[a]	Calf No.	Br.	Sex	Period, weeks 1-4 incl.	5-8 incl. (lbs.)	9-12 incl.	13-16 incl.	Total
III (Skim-milk[c])	3511	J	M	4	24	40	62	130
	3542	J	F	10	48	68	94	220
	3532	G	F	10	18	24	36	88
	3531	H	M	12	56	70	78	216
	3557	H	F	6	32	78	106	222
	3522	A	M	20	42	96	110	268
	3564	H	F	12	34	74	100	220
	3534	J	M	12	34	55	70	171
	Average			11	36	63	82	192
IV (Skim-milk[c] plus aureo-mycin[b])	3489	J	M	4	20	66	106	196
	3499	J	F	9	42	62	94	207
	3525	G	F	6	34	86	114	240
	3537	H	M	10	18	62	102	192
	3552	H	F	6	38	68	106	218
	3495	A	M	10	36	90	110	246
	3565	H	F	8	46	94	112	260
	3498	J	M	13	36	72	92	213
	Average			8	34	75	105	222

[a]All calves received alfalfa hay _ad libitum_ and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[c]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

Table 9. Effect of Aureomycin and Type of Milk on Hay Consumption

Group[a]	Calf No.	Br.	Sex	Period, weeks 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	Total
				(lbs.)				
I (Whole milk)	3449	J	M	5.7	12.6	24.0	38.8	81.1
	3470	J	F	2.8	10.8	16.2	25.2	55.0
	3480	G	F	8.7	18.4	22.1	31.6	80.8
	3528	H	M	7.6	26.0	53.4	80.1	167.1
	3554	H	F	3.0	12.4	37.1	86.0	138.5
	3521	A	F	6.2	18.6	48.0	59.7	132.5
	3569	H	M	6.0	28.7	97.1	134.2	266.0
	3504	J	F	3.3	9.3	23.2	46.5	82.3
	3543	G	M	4.0	18.2	25.4	53.6	101.2
	Average			5.3	17.2	38.5	61.7	122.7
II (Whole milk plus aureomycin[b])	3503	J	M	4.5	21.3	41.9	78.5	146.2
	3463	J	F	5.8	7.6	20.0	23.6	57.0
	3530	G	F	10.1	11.8	35.2	45.0	102.1
	3539	H	M	4.4	36.6	49.3	120.6	210.9
	3550	H	F	11.2	13.6	38.6	124.0	187.4
	3520	A	F	11.5	26.4	51.1	92.0	181.0
	3570	H	M	6.2	29.1	78.0	157.9	271.2
	3472	J	F	3.2	20.3	26.2	31.9	81.6
	3505	G	M	4.5	16.2	35.0	73.3	129.0
	Average			6.8	20.3	41.7	83.0	151.8

[a]All calves received alfalfa hay ad libitum and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 9. (Continued)

Group[a]	Calf No.	Br.	Sex	Period, weeks 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	Total
					(lbs.)			
III (Skim-milk[c])	3511	J	M	2.0	3.6	19.8	45.6	71.0
	3542	J	F	5.5	25.8	42.8	65.8	139.9
	3532	G	F	2.8	14.9	26.0	56.1	99.8
	3531	H	M	6.0	14.6	63.3	114.4	198.3
	3557	H	F	1.4	23.5	42.7	88.6	156.2
	3522	A	M	5.7	16.8	50.5	97.5	170.5
	3564	H	F	6.2	17.9	65.9	96.5	186.5
	3534	J	M	3.5	17.0	31.9	37.9	90.3
	Average			4.1	16.8	42.9	75.3	139.1
IV (Skim-milk[c] plus aureo-mycin[b])	3489	J	M	2.3	11.6	21.0	49.4	84.3
	3499	J	F	6.0	12.4	39.9	44.4	102.7
	3525	G	F	11.6	18.5	52.6	71.1	153.8
	3537	H	M	5.0	38.6	63.2	90.4	197.2
	3552	H	F	4.0	24.4	70.5	141.4	240.0
	3495	A	M	4.0	13.4	35.1	119.9	172.4
	3565	H	F	10.6	24.8	70.2	129.3	234.9
	3498	J	M	2.0	14.9	33.7	87.8	138.4
	Average			5.7	19.8	48.3	91.7	165.5

[a]All calves received alfalfa hay _ad libitum_ and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[c]See Table 1 for Composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

Table 10. Effect of Aureomycin on Incidence of Diarrhea of Calves in the Various Dietary Groups

Dietary Group[a]	Calf No.	Periodic (wks.) incidence of diarrhea[b] 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	16-week period
I (Whole milk)	3449	8	16	0	0	24
	3470	8	0	0	0	8
	3480	0	0	0	0	0
	3528	0	3	0	0	3
	3554	0	0	0	0	0
	3521	0	0	0	0	0
	3569	0	0	0	0	0
	3504	0	0	0	0	0
	3543	7	0	0	4	11
	Average	2.6	2.1	0	0.4	5.1
II (Whole milk plus aureomycin[c])	3503	2	4	0	0	6
	3463	0	0	0	0	0
	3530	0	0	0	0	0
	3539	0	0	0	0	0
	3550	0	0	0	0	0
	3520	0	0	3	0	3
	3570	0	0	0	0	0
	3472	7	0	0	0	7
	3505	6	0	0	0	6
	Average	1.7	0.4	0.3	0	2.4

[a]All calves received alfalfa hay *ad libitum* and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]Observations made twice daily (a total of 224).

[c]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 10. (Continued)

Dietary Group[a]	Calf No.	Periodic (wks.) incidence of diarrhea[b] 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	16-week period
III (Skim-milk[d])	3511	15	11	0	0	26
	3542	6	0	0	0	6
	3532	22	1	0	0	23
	3531	15	0	0	0	15
	3557	2	0	3	0	5
	3522	33	7	0	0	40
	3564	0	0	0	0	0
	3534	2	0	20	0	22
	Average	11.9	2.4	2.9	0	17.1
IV (Skim-milk[d] plus aureo-mycin[c])	3489	21	0	0	0	21
	3499	34	0	0	0	34
	3525	12	0	0	0	12
	3537	1	0	0	0	1
	3552	12	0	0	0	12
	3495	16	4	0	0	20
	3565	0	0	0	0	0
	3498	3	0	0	0	3
	Average	12.4	0.5	0	0	12.9

[a]All calves received alfalfa hay _ad libitum_ and a concentrate mixture (limited to 4 lbs. per calf daily) consisting of 40 per cent ground corn, 30 per cent crushed oats, 28 per cent soybean oil meal, 1 per cent salt and 1 per cent steamed bone meal.

[b]Observations made twice daily (a total of 224).

[c]80 Mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

[d]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

the trial was slightly lower for the aureomycin-supplemented calves, Groups II and IV (2.4 and 12.9, respectively) than for the control animals, Groups I and III (5.1 and 17.1, respectively).

The differences in the dietary effects of the aureomycin supplementation were manifested not only in body weight changes, in efficiency of feed utilization and, to a slight degree, in the incidence of diarrhea, but also in the general appearance of the calves. Those receiving aureomycin exhibited a smoother haircoat and a better condition (fleshing), noted particularly after about the third or fourth week of the trial. The differences between the supplemented and nonsupplemented calves were greater for the Ayrshires, Guernseys and Jerseys than for the Holsteins.

B. Trial II

1. Procedure

a. Dietary groups: In the second phase of the investigational work ten Holstein male calves were assigned randomly to two groups of five calves each. During the period from 4 to 60 days of age, the calves were restricted to a diet of skimmilk, reconstituted in the same ratios as in Trial I (Table 1), plus supplemental vitamins A and D. The milk, reconstituted immediately prior to each of two daily feedings, was fed at a daily rate of 1 pound per 10 pounds of body weight up to a maximum of 12 pounds per day.

Beginning at 60 and continuing to 116 days of age the calves were fed hay ad libitum, and a concentrate mixture (Table 2) free choice up to a maximum of 4 pounds daily per calf, in addition to a limited quantity of reconstituted skimmilk. The rate of skimmilk feeding was reduced, from the original daily allowance of one pound per ten pounds of body weight (maximum of 12 pounds daily), by two pounds each week until it reached one pound per feeding, a rate which was maintained to the end of the trial.

The two diets differed only in that 80 mg. daily of crystalline aureomycin hydrochloride were fed in the milk via nipple pail to each calf in Group VI, while Group V constituted the control animals.

b. Management of the calves: The calves were managed, housed, fed and treated with respect to digestive disturbances in a manner similar to those animals in Trial I, except that vitamins A and D were supplemented to about 10 weeks of age. Also, the calves were muzzled during the first 8-week feeding period to prevent their consuming feed other than the reconstituted skimmilk and vitamins.

c. Records and techniques: The calves were weighed weekly, observations of digestive disturbances were made twice daily, and the amounts of milk, hay and concentrate mixture consumed were recorded daily. At 16-18, 36-38 and

58-60 days of age, the calves were placed in individual, wire bottomed, elevated collection stalls and three successive 24-hour samples of urine and feces were obtained. The 24-hour samples of urine were collected under toluene in large jars via a plastic funnel beneath the wire floor of the collection stall. Feces samples were obtained in plastic collection bags about six inches in width and eight inches in length secured over the rectum of the calves. A heavy wire was secured around the open end to hold the mouth of the bag open. The open end of the bag was secured over the rectum by three cloth strings, two of which passed downward from the rectum, forward between the rear legs, one passing on each side of the scrotum, and then upward one on each side of the calf immediately in front of the rear legs. Both of these strings were tied at the loin to the third string which extended from the base of the tail forward along the top of the back and was secured around the neck of the calf.

All urine samples were analyzed for reducing sugars and total nitrogen. Because of a high concentration of reducing sugars, the urine was diluted one part to 39 parts of distilled water prior to the addition of barium hydroxide solution and then was analyzed for reducing sugar by the method of Somogyi (62). The sugar was calculated as glucose since the presence of other sugars was not demonstrated positively by 2-dimensional paper chromatograms using the method of

French and associates (31). Urinary nitrogen was determined by the Kjeldahl method (35) using copper selenite as the catalyst.

Feces were analyzed for reducing sugars, total nitrogen, dry matter, ether extract and ash. That portion used for sugar analysis was collected three times daily and preserved by freezing immediately after each collection. The three daily collections were thawed, thoroughly mixed and a 5 gm. sample was weighed and mixed with 75 ml. distilled water prior to the addition of 10 ml. of 3 N barium hydroxide. After the mixture was allowed to stand about 5 minutes, 10 ml. of 5 per cent zinc sulfate was added and the entire contents were thoroughly mixed in a Waring blender for 1 minute. After filtering through a No. 40 Whatman filter paper aliquots of the clear filtrate were analyzed for reducing sugars using the colorimetric method as described by Somogyi (62). Two to 4 gms. of each 24-hour sample of feces were weighed into 5 ml. Pyrex beakers which were then placed in regular Kjeldahl flasks and the nitrogen determined by the method mentioned above. The dry matter was estimated by drying weighed samples to a constant weight in an oven maintained at 105° C. Ether extract and ash analyses of the samples were made by methods described by the Association of Official Agricultural Chemists (2).

One day during each collection period and again at about

84 days of age, venous blood samples were taken from each calf at feeding and at two, four, six, eight and ten hours postprandially. Potassium oxalate, with sodium fluoride added to inhibit glycolysis (63), was used as the anticoagulant. Blood sugar was determined on these samples, using the colorimetric method described by Somogyi (62).

2. Results

a. Growth and feed efficiency: The mean weight gains and the ratios of calculated TDN consumption to body weight gain (Table 11) reveal no difference between the supplemented and non-supplemented animals during the initial 8 weeks. The initial mean body weight was eight pounds less for the supplemented calves, however.

During the subsequent 8-week period, after hay and concentrate feeding had begun, the average daily gain (Tables 11 and 12) and the efficiency of feed utilization (Table 11) were greater for the antibiotic-supplemented animals than for the control calves. The average daily gain during the second 8-week period was 1.7 pounds for the supplemented calves and 1.4 pounds for the non-supplemented animals, or 21 per cent greater for the former. This difference was due largely to the more rapid growth by the supplemented calves during the terminal 2 weeks of the experiment. Considerable variation in growth rate was observed among individuals within groups. Although the control animals consumed more concentrates and

Table 11. Weight Gains and Feed Consumption of Calves on Restricted Skimmilk Diets

Dietary Group	Calf No.[a]	Initial Wt.	Feed efficiency: 1-8 wks. incl.: TDN[b] intake	Wt. gain	TDN/lb. gain	9-16 wks. incl.: TDN[b] intake: Skimmilk	Hay	Conc.	Total	Wt. gain	TDN/lb. gain
			(lbs.)			(lbs.)					
V (Skim-milk[c])	3546	112	90	54	1.7	42	61	124	227	75	3.0
	3548	78	85	48	1.8	44	46	98	188	72	2.6
	3551	106	103	67	1.5	47	18	114	179	82	2.2
	3558	93	93	54	1.7	42	26	111	179	75	2.4
	3567	82	90	60	1.5	42	60	134	236	98	2.4
	Average	94	94	57	1.6	43	42	116	201	80	2.5
VI (Skim-milk[c] plus aureo-mycin[d])	3547	100	101	61	1.7	41	53	126	220	97	2.3
	3555	88	93	55	1.7	44	16	111	171	103	1.7
	3556	62	78	62	1.3	42	18	112	172	116	1.5
	3563	81	78	39	2.0	42	14	97	153	73	2.1
	3568	100	101	66	1.5	42	45	122	209	81	2.6
	Average	86	90	57	1.6	42	29	114	185	94	2.0

[a]All calves were Holstein males.

[b]TDN values used in calculations were: Whole milk, 16 per cent; dry skimmilk, 84 per cent; concentrate, 77 per cent; and hay, 50 per cent.

[c]Calves restricted to reconstituted skimmilk (Table 1) for 8 weeks, after which hay and a concentrate mixture also were fed (see Table 2).

[d]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

hay (Table 13) than the supplemented calves, the efficiency of utilization (TDN per pound of gain) was 25 per cent greater for the latter group of calves.

Table 14 indicates the effect of aureomycin on the incidence of diarrhea of the calves. The antibiotic did not prevent scouring, but the incidence was slightly lower in the supplemented calves. Except for calf number 3563, there was a trend toward less scouring as the trial progressed, particularly during the first 8-week period during which the calves were restricted to a reconstituted skimmilk ration.

b. Utilization of nutrients: Table 15 presents the percentage utilization of various nutrients by antibiotic-supplemented and non-supplemented dairy calves during the period from 4 to 60 days of age. The utilization of carbohydrates and nitrogen by the calves as determined by intake vs. excretion was similar for both groups of calves. The coefficient of digestibility for dry matter was also similar for both groups of calves, whereas the coefficient of digestibility for the ash appeared to be greater for the supplemented animals than for the control calves, 65.2 and 52.9 per cent, respectively, although the difference was not statistically significant (Table 16). Apparently, the calves in both dietary groups made more efficient use of the nitrogen and ash at the early ages (16-18 days) than during the latter periods (36-38 and 58-60 days of age). Over 50 per cent of

Table 12. Effect of Aureomycin on Changes in Body Weight of Calves on Restricted Diets

Dietary Group[a]	Calf No.[b]	Age, days 4	11	18	25	32	39	46	53	60 (lbs.)	67	74	81	88	95	102	109	116	Total Gain
	3546	112	110	123	134	130	142	150	159	166	183	193	213	223	233	236	234	241	129
V	3548	78	81	87	93	101	110	119	129	126	141	151	156	162	169	178	188	198	120
(Skim-	3551	106	109	121	127	135	146	157	169	173	182	193	203	213	222	231	244	255	149
milk[c])	3558	93	95	102	110	117	124	131	138	147	160	168	178	186	196	212	226	222	129
	3567	82	88	95	98	108	110	125	135	142	159	167	179	202	216	230	232	240	158
	Average	94	97	106	112	118	126	136	145	151	165	174	186	197	207	217	225	231	137
VI	3547	100	108	126	133	135	140	150	155	161	172	183	193	212	224	226	242	258	158
(Skim-	3555	88	87	93	100	113	125	137	135	143	153	165	178	194	205	21[illegible]	232	246	158
milk[c]	3556	62	69	73	83	92	99	107	117	124	138	155	171	185	196	211	224	240	178
plus	3563	81	77	80	91	103	107	108	116	120	130	133	139	149	157	171	184	193	112
aureo-	3568	100	109	114	125	136	141	156	161	166	174	187	195	207	213	225	234	247	147
mycin[d])	Average	86	90	97	106	116	122	132	137	143	153	165	175	189	199	210	223	237	151

[a]Calves restricted to a skimmilk diet from 4 to 60 days of age, after which hay and concentrate were fed (Table 2).

[b]All calves were male Holsteins.

[c]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

[d]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 13. Effect of Aureomycin on Hay and Concentrate Consumption of Calves on Restricted Diets

Dietary Group[a]	Calf No.[b]	Hay Period, wks. 9-12 incl. (lbs.)	Hay Period, wks. 13-16 incl. (lbs.)	Hay Total	Concentrate Period, wks. 9-12 incl. (lbs.)	Concentrate Period, wks. 13-16 incl. (lbs.)	Concentrate Total
V (Skim-milk[c])	3546	26	96	122	54	108	162
	3548	11	81	92	31	96	127
	3551	13	22	35	44	104	148
	3558	9	42	51	42	102	144
	3567	21	100	121	62	112	174
	Average	16	68	84	47	104	151
VI (Skim-milk[c] plus aureo-mycin[d])	3547	15	91	106	53	110	163
	3555	6	26	32	40	104	144
	3556	9	27	36	44	101	145
	3563	5	23	28	28	98	126
	3568	7	83	90	56	102	158
	Average	8	50	58	44	103	147

[a]Calves restricted to a skimmilk diet from 4 to 60 days of age after which hay and concentrate were fed.

[b]All calves were Holstein males.

[c]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

[d]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 14. Effect of Aureomycin on Incidence of Diarrhea of Calves on Restricted Diets

Dietary Group[a]	Calf No.[b]	Periodic (wks.) incidence of diarrhea[c] 1-4 incl.	5-8 incl.	9-12 incl.	13-16 incl.	16-week period
V (Skim-milk[d])	3546	12	3	6	2	23
	3548	8	6	0	5	19
	3551	5	4	0	1	10
	3558	11	6	0	4	21
	3567	0	2	0	0	2
	Average	7.2	4.2	1.2	2.4	15
VI (Skim-milk[d] plus aureo-mycin[e])	3547	6	6	0	1	13
	3555	4	0	1	0	5
	3556	3	0	0	1	4
	3563	4	17	0	0	21
	3568	2	4	0	0	6
	Average	3.8	5.4	.2	.4	9.8

[a]Calves restricted to reconstituted skimmilk for first 8-week period, after which hay and concentrate were fed.

[b]Holstein male calves.

[c]Observations made twice daily (a total of 224).

[d]See Table 1 for composition. Each calf received supplementary vitamins A and D during the first 4 weeks of the trial.

[e]80 mg. crystalline aureomycin hydrochloride fed daily in the milk via nipple pail.

Table 15. Nutrient Utilization by Dairy Calves Restricted to Skimmilk Diets

Nutrient	V Skimmilk				VI Skimmilk + Aureomycin			
	Calf	Age, days[a]			Calf	Age, days[a]		
	No.	16-18	36-38	58-60	No.	16-18	36-38	58-60
		(per cent)				(per cent)		
Carbohydrate[b]	3546	94.7	98.8	96.7	3547	93.7	98.8	99.1
	3548	99.3	99.2	98.9	3555	99.3	97.6	97.7
	3551	99.2	95.9	97.3	3556	99.3	99.3	97.6
	3558	98.6	99.0	99.5	3563	99.9	98.3	99.3
	3567	99.3	99.6	99.1	3568	99.7	99.5	99.4
	Av.	98.2	98.6	98.3	Av.	98.4	98.7	98.6
Nitrogen[b]	3546	43.5	40.0	37.5	3547	44.3	32.0	34.0
	3548	44.1	21.9	45.8	3555	54.4	42.1	36.0
	3551	61.7	30.2	38.9	3556	48.7	44.2	46.1
	3558	50.3	38.4	41.4	3563	60.0	38.1	43.6
	3567	51.2	47.8	43.2	3568	46.9	47.6	31.3
	Av.	50.2	35.7	41.4	Av.	51.9	39.0	38.2
Dry matter[c]	3546	96.2	96.9	93.5	3547	97.3	93.3	96.0
	3548	96.3	92.0	96.4	3555	97.4	96.7	96.9
	3551	96.8	96.2	93.1	3556	97.1	97.5	96.5
	3558	97.5	94.9	93.2	3563	97.8	95.1	95.3
	3567	97.1	95.9	94.9	3568	97.4	94.4	96.9
	Av.	96.8	95.2	94.1	Av.	97.4	95.4	96.3
Ash[c]	3546	59.5	68.0	32.7	3547	69.3	25.1	58.7
	3548	62.7	24.6	69.5	3555	70.7	71.3	71.0
	3551	66.9	62.9	29.7	3556	68.4	75.4	65.6
	3558	72.4	51.1	34.4	3563	80.0	62.2	57.9
	3567	71.8	61.3	50.5	3568	73.4	56.9	72.5
	Av.	66.4	54.4	43.3	Av.	72.6	57.9	65.2

[a]Three-day collection: each day's sample analyzed separately and average values presented.

$$^{b}\% = \frac{\text{Intake} - (\text{fecal} + \text{urinary excretions})}{\text{Intake}} \times 100$$

$$^{c}\% = \frac{\text{Intake} - \text{fecal excretion}}{\text{Intake}} \times 100$$

Table 16. Analysis of Variance of Data on Coefficient of Digestibility of Ash[a]

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares
Treatments	1	426	426
Among calves	8	1343	168
Periods	2	1060	530
Periods x Treatments	2	743	371
Calves x Periods (within treatments)	16	3160	198
Total	29	6732	

F (Treatments) = 2.15

F (Periods) = 2.76

[a]Analysis based upon means of each 3-day collection period.

the nitrogen intake was retained by the calves during the former age period while about 40 per cent was retained during the latter. About 70 per cent of the ash was utilized by the calves during the age period of 16-18 days as compared to appreciably lesser amounts for the age periods of 36-38 and 58-60 days.

Data relative to the quantities of urine and feces voided daily by the calves on the restricted diets are presented in Table 17. The mean quantities of urine voided

Table 17. Quantities of Urine and Feces Voided by Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	Urine			Feces		
			Age, days			Age, days		
			16-18	36-38 (ml.)	58-60	16-18	36-38 (gm.)	58-60
	3546	1	2170	1360	2300	250	254	58[a]
		2	2160	1690	3100	229	153	443[b]
		3	2150	2340	3140	138	199	423
	3548	1	2360	1710	3050	151	674[b]	211
		2	1850	2260	2130	132	478[b]	364[b]
		3	1855	2530	2210	101	417[b]	107
V (Skim-milk)	3551	1	1975	2630	2130	137	591[b]	450[b]
		2	1630	1900	1980	181	149	675[b]
		3	2375	2600	2335	235	170	255
	3558	1	1570	2625	2860	184	392[b]	587[b]
		2	1550	2550	2245	155	340[b]	566[b]
		3	1880	2470	2810	189	350[b]	334[b]
	3567	1	1510	2050	1890	198	454[b]	326
		2	1910	1710	2430	151	214	190
		3	1200	--	1980	95	-	253
	Group Av.		1876	2153	2439	168	344	353

[a]Constipated

[b]Scouring

Table 17. (Continued)

Dietary Group	Calf No.	Day	Urine Age, days 16-18	Urine 36-38 (ml.)	Urine 58-60	Feces Age, days 16-18	Feces 36-38 (gm.)	Feces 58-60
	3547	1	1910	1940	2900	159	652[b]	246
		2	1925	2190	3000	150	951[b]	336[b]
		3	1920	2670	2080	172	561[b]	504[b]
VI (Skim-milk plus aureo-mycin)	3555	1	1040	2860	3180	119	189	82
		2	1920	3010	3130	199	90	269
		3	1925	3100	2500	111	130	104
	3556	1	1750	2300	2980	153	64	142
		2	2000	2580	3060	134	138	160
		3	1850	2580	2230	103	119	217
	3563	1	1360	2060	2320	278	203	409[b]
		2	1340	1850	2150	63	216	429[b]
		3	1310	1950	2040	136	345[b]	365[b]
	3568	1	2810	1600	1860	200	421[b]	141
		2	1910	1650	2030	142	376[b]	219
		3	1920	1950	2030	141	306	173
	Group Av.		1792	2286	2500	151	297	253

[b]Scouring

daily by the calves were similar for both dietary groups, and the volume increased as the calves grew older and consumed more milk. There was tremendous variation in the amount of feces excreted daily. This variation probably was due to frequent diarrheal condition of the calves since in severe cases of diarrhea greater quantities of feces were excreted.

Data relative to the intake-output studies of the various nutrients are presented in Tables 18, 19, 20, 21 and 22. Table 22 shows considerable individual variation among calves within groups and among periods relative to the excretion of ether extract in the feces. Although the intake was very small because of the milk solids-not-fat diet, often the excretion was greater than the intake, which would indicate that the fecal fat was largely of endogenous origin (35).

Figure 2 shows the blood sugar tolerance curves which were made at 2, 5, 8 and 12 weeks of age; the three former periods while the calves were restricted to a skimmilk diet, and the latter after hay and concentrate were being fed. The sugar found in the blood was calculated as glucose since the presence of other sugars was not demonstrated positively by 2-dimensional paper chromatograms using the method of French, et al. (31). The shape of the curves were similar at the various ages for both the aureomycin-supplemented animals and the control calves. The mean increase in the blood glucose levels was slightly greater for the supplemented calves but

Table 18. Effect of Aureomycin on Utilization of Carbohydrates by Young Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	16-18 Intake (gm.)	16-18 Output Feces	16-18 Output Urine	36-38 Intake (gm.)	36-38 Output Feces	36-38 Output Urine	58-60 Intake (gm.)	58-60 Output Feces	58-60 Output Urine
V (Skim-milk)	3546	1	500	.05	47.1	545	.09	5.3	545	.01	22.2
		2	500	.06	25.5	545	.06	6.3	545	.06	15.1
		3	500	.05	6.5	545	.05	8.7	545	.07	17.3
	3548	1	363	.04	2.6	463	.70	3.5	545	.09	7.6
		2	363	.04	2.4	463	.21	3.9	545	.07	6.0
		3	363	.02	2.6	463	.13	3.2	545	.04	4.0
	3551	1	500	.04	4.0	545	.34	30.0	545	.06	16.7
		2	500	.06	3.6	545	.06	15.0	545	.03	11.1
		3	500	.04	4.9	545	.06	21.9	545	.06	15.6
	3558	1	427	.07	4.1	527	.19	3.7	545	.40	2.4
		2	427	.04	4.8	527	.17	9.6	545	.40	4.4
		3	427	.05	8.8	527	.14	2.7	545	.14	2.5
	3567	1	427	.12	3.9	490	.22	1.9	545	.14	3.7
		2	427	.09	2.1	490	.13	1.6	545	.09	5.8
		3	427	.05	1.9	-	-	-	545	.09	4.6
	Group Av.		443	.05	8.2	514	.18	7.9	545	.12	9.3

Table 18. (Continued)

Dietary Group	Calf No.	Day	16-18 Intake	16-18 Output Feces	16-18 Output Urine	36-38 Intake	36-38 Output Feces	36-38 Output Urine	58-60 Intake	58-60 Output Feces	58-60 Output Urine
			(gm.)			(gm.)			(gm.)		
	3547	1	490	.11	31.9	477	.28	6.1	545	.09	5.1
		2	490	.08	30.5	545	.38	6.9	545	.17	6.1
		3	490	.08	29.8	545	.19	5.1	545	.28	3.8
VI	3555	1	400	.01	2.8	509	.16	9.8	545	.04	11.5
(Skim-		2	400	.04	3.3	509	.06	12.3	545	.10	12.0
milk		3	400	.03	2.1	509	.08	14.4	545	.04	14.7
plus											
aureo-	3556	1	363	.04	2.6	417	.03	2.5	518	.07	8.0
mycin)		2	363	.06	2.0	417	.15	2.5	518	.06	12.8
		3	363	.04	2.9	417	.07	3.5	518	.06	17.1
	3563	1	445	.18	.6	463	.17	4.6	522	.10	4.1
		2	445	.05	.4	463	.14	11.4	522	.15	2.2
		3	445	.06	.6	463	.17	7.3	522	.16	4.0
	3568	1	500	.14	1.4	545	.17	2.6	545	.08	3.0
		2	500	.05	1.0	545	.08	3.5	545	.10	3.0
		3	500	.07	1.6	545	.11	2.9	545	.09	3.1
	Group Av.		439	.07	7.6	491	.15	6.4	535	.10	7.4

Table 19. Effect of Aureomycin on Utilization of Nitrogen by Young Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	16-18 Intake	16-18 Output Feces	16-18 Output Urine	36-38 Intake	36-38 Output Feces	36-38 Output Urine	58-60 Intake	58-60 Output Feces	58-60 Output Urine
			(gm.)			(gm.)			(gm.)		
V (Skimmilk)	3546	1	57.5	4.0	32.6	62.8	4.0	26.4	62.8	.5	35.7
		2	57.5	-	29.5	62.8	2.2	36.3	62.8	4.2	37.2
		3	57.5	-	23.3	62.8	3.1	41.4	62.8	4.1	36.0
	3548	1	41.8	2.5	20.9	53.4	8.9	29.2	62.8	2.4	31.7
		2	41.8	2.3	19.3	53.4	6.1	33.6	62.8	3.3	27.8
		3	41.8	1.8	23.9	53.4	4.9	42.4	62.8	1.8	35.0
	3551	1	57.5	2.2	18.9	62.8	3.6	28.5	62.8	5.2	36.5
		2	57.5	2.7	16.8	62.8	1.6	32.3	62.8	6.7	36.7
		3	57.5	3.7	21.7	62.8	2.9	38.7	62.8	3.5	38.4
	3558	1	49.2	2.9	21.9	60.7	4.6	32.3	62.8	5.7	29.6
		2	49.2	1.8	22.4	60.7	4.3	31.2	62.8	3.0	31.8
		3	49.2	2.1	22.2	60.7	6.0	33.9	62.8	4.6	35.7
	3567	1	49.2	2.7	18.0	56.5	2.8	30.3	62.8	3.9	30.1
		2	49.2	2.1	28.0	56.5	2.5	23.4	62.8	1.8	35.5
		3	49.2	1.5	19.8	--	-	--	62.8	3.2	32.4
	Group Av.		51.1	2.5	22.6	59.2	4.1	33.6	62.8	3.6	34.0

Table 19. (Continued)

Dietary Group	Calf No.	Day	Age, days: 16-18 Intake	16-18 Output Feces (gm.)	16-18 Output Urine	36-38 Intake	36-38 Output Feces (gm.)	36-38 Output Urine	58-60 Intake	58-60 Output Feces (gm.)	58-60 Output Urine
VI (Skim-milk plus aureo-mycin)	3547	1	56.5	1.5	32.0	54.2	4.2	36.6	62.8	2.5	39.6
		2	56.5	2.6	28.0	62.8	7.0	35.0	62.8	2.9	43.6
		3	56.5		28.0	62.8	4.7	35.3	62.8	4.4	31.6
	3555	1	46.2	1.6	16.8	58.0	2.9	28.1	62.8	.8	36.1
		2	46.2	3.6	21.0	58.0	1.6	32.2	62.8	3.9	37.3
		3	46.2	2.3	17.9	58.0	2.4	33.6	62.8	1.8	40.7
	3556	1	36.6	2.1	19.1	48.1	1.0	21.2	59.6	2.0	22.0
		2	36.6	1.8	15.4	48.1	2.0	26.5	59.6	1.7	34.0
		3	36.6	2.2	15.8	48.1	1.7	28.2	59.6	2.8	34.1
	3563	1	51.3	1.9	20.4	53.4	2.8	33.4	60.7	4.9	32.4
		2	51.3	.8	19.4	53.4	3.2	29.8	60.7	3.9	29.1
		3	51.3	2.0	17.0	53.4	2.6	37.3	60.7	2.3	30.2
	3568	1	57.5	2.9	28.1	62.8	4.2	26.1	62.8	2.2	42.7
		2	57.5	2.3	24.5	62.8	3.8	28.7	62.8	3.0	36.3
		3	57.5	2.4	31.4	62.8	4.5	31.5	62.8	2.0	43.1
	Group Av.		49.6	2.2	22.3	56.5	3.2	30.2	61.7	2.7	35.5

Table 20. Effect of Aureomycin on Digestibility of Dry Matter by Young Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	Age, days 16-18 Intake	Output Feces	36-38 Intake	Output Feces	58-60 Intake	Output Feces
			(gm.)		(gm.)		(gm.)	
V (Skimmilk)	3546	1	999	38.1	1090	44.6	1090	13.6
		2	-	-	1090	29.5	1090	103.2
		3	-	-	1090	36.2	1090	96.0
	3548	1	726	31.7	926	100.5	1090	40.5
		2	726	26.5	926	64.5	1090	48.6
		3	726	21.8	926	57.2	1090	28.0
	3551	1	999	25.9	1090	61.9	1090	100.5
		2	999	31.7	1090	21.2	1090	76.0
		3	999	36.3	1090	40.4	1090	50.1
	3558	1	854	25.8	1053	46.1	1090	105.4
		2	854	17.8	1053	49.1	1090	57.2
		3	854	22.6	1053	67.6	1090	61.4
	3567	1	854	33.5	981	46.4	1090	64.5
		2	854	24.3	981	34.5	1090	43.3
		3	854	15.8	-	-	1090	60.3
	Group Av.		886	27.0	1028	50.0	1090	63.3
VI (Skimmilk plus aureomycin)	3547	1	981	18.8	1044	49.2	1090	37.2
		2	981	34.2	1044	97.6	1090	37.5
		3	-	-	1044	64.7	1090	57.9
	3555	1	800	12.6	1017	46.5	1090	14.1
		2	800	30.2	1017	21.4	1090	60.9
		3	800	19.5	1017	32.1	1090	25.6
	3556	1	636	21.9	835	13.2	1035	28.8
		2	636	20.3	835	27.7	1035	33.1
		3	636	13.5	835	22.5	1035	47.7
	3563	1	-	-	926	42.8	1053	67.2
		2	890	12.7	926	41.5	1053	50.8
		3	890	26.5	926	36.5	1053	29.6
	3568	1	999	29.9	1090	47.5	1090	27.0
		2	999	21.1	1090	45.3	1090	46.6
		3	999	25.7	1090	60.6	1090	27.0
	Group Av.		861	22.2	983	43.3	1071	39.4

Table 21. Effect of Aureomycin on Digestibility of Ash by Young Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	16-18 Intake (gm.)	16-18 Output Feces (gm.)	36-38 Intake (gm.)	36-38 Output Feces (gm.)	58-60 Intake (gm.)	58-60 Output Feces (gm.)
	3546	1	76.3	30.9	83.3	33.3	83.3	11.4
		2	-	-	83.3	20.5	83.3	82.2
		3	-	-	83.3	26.2	83.3	74.7
	3548	1	55.5	25.8	70.8	72.3	83.3	22.6
		2	55.5	19.0	70.8	48.3	83.3	34.2
		3	55.5	17.4	70.8	39.5	83.3	19.4
V (Skim milk)	3551	1	76.3	21.3	83.3	46.5	83.3	80.1
		2	76.3	25.3	83.3	15.8	83.3	58.1
		3	76.3	29.3	83.3	30.4	83.3	37.5
	3558	1	65.3	20.6	80.2	29.6	83.3	78.6
		2	65.3	14.3	80.2	36.4	83.3	40.8
		3	65.3	19.2	80.2	51.7	83.3	44.6
	3567	1	65.3	24.8	74.9	34.8	83.3	44.1
		2	65.3	17.7	74.9	23.2	83.3	33.4
		3	65.3	12.7	-	-	83.3	46.1
	Group Av.		67.7	22.7	78.5	35.8	83.3	47.2

Table 21. (Continued)

Dietary Group	Calf No.	Day	16-18 Intake (gm.)	16-18 Output Feces (gm.)	36-38 Intake (gm.)	36-38 Output Feces (gm.)	58-60 Intake (gm.)	58-60 Output Feces (gm.)
VI (Skim-milk plus aureo-mycin)	3547	1	74.9	16.9	72.8	38.1	83.3	29.1
		2	74.9	29.0	72.8	76.6	83.3	27.6
		3	-	-	72.8	49.0	83.3	46.5
	3555	1	61.0	11.5	77.7	28.4	83.3	10.3
		2	61.0	26.1	77.7	15.4	83.3	43.4
		3	61.0	16.1	77.7	23.1	83.3	18.8
	3556	1	48.6	18.4	63.8	10.1	79.5	21.2
		2	48.6	16.4	63.8	20.3	79.5	24.8
		3	48.6	11.3	63.8	16.7	79.5	35.9
	3563	1	-	-	70.8	26.4	80.2	45.1
		2	68.0	8.8	70.8	27.8	80.2	35.4
		3	68.0	18.4	70.8	25.8	80.2	20.9
	3568	1	76.3	24.1	83.3	35.6	83.3	18.2
		2	76.3	17.5	83.3	32.2	83.3	32.2
		3	76.3	19.3	83.3	39.9	83.3	18.4
	Group Av.		65.8	18.0	73.7	31.0	81.9	28.5

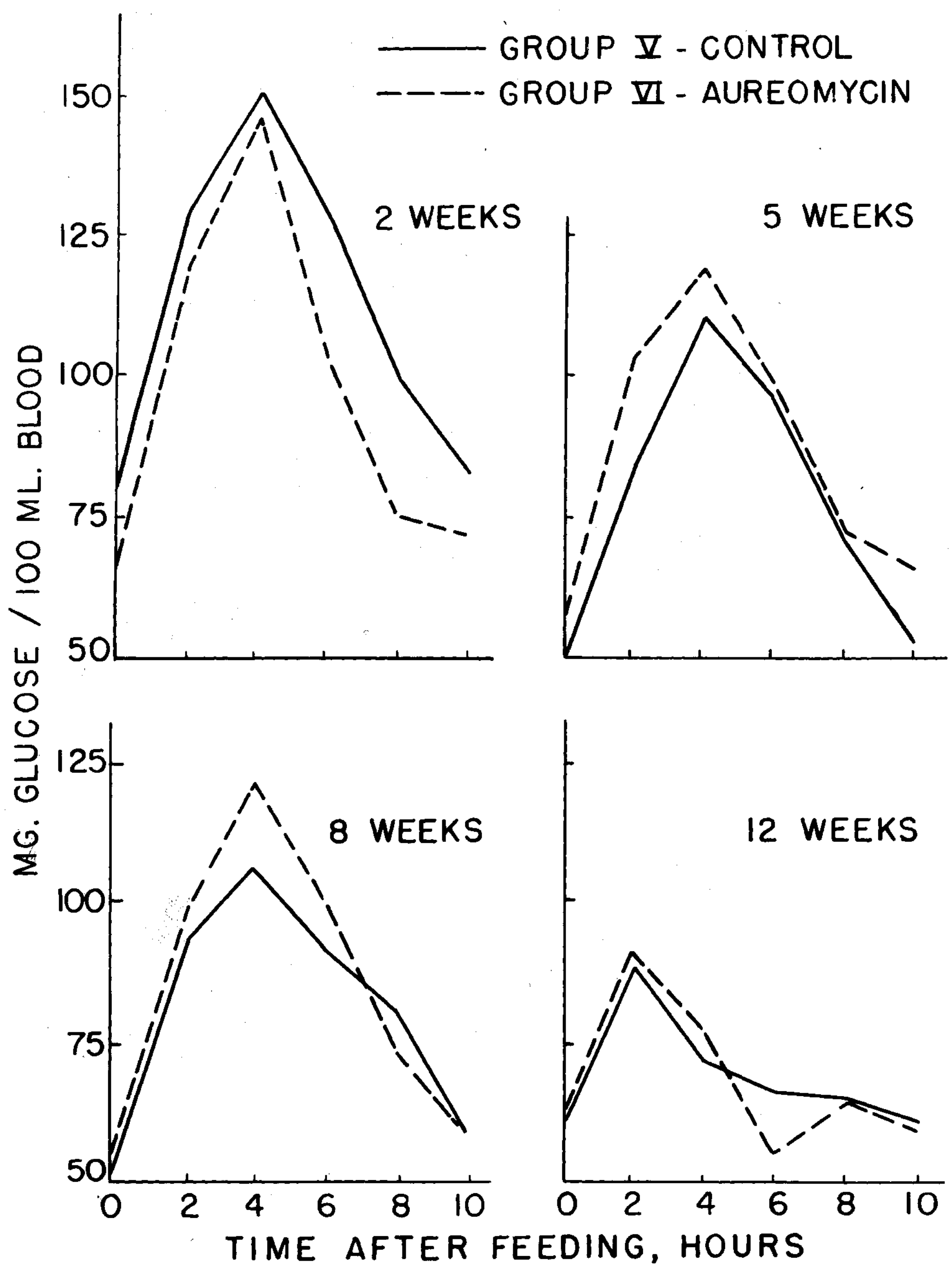
Table 22. Effect of Aureomycin on Digestibility of Fat by Young Dairy Calves Restricted to Skimmilk Diets

Dietary Group	Calf No.	Day	16-18 Intake (gm.)	16-18 Output Feces (gm.)	36-38 Intake (gm.)	36-38 Output Feces (gm.)	58-60 Intake (gm.)	58-60 Output Feces (gm.)
	3546	1	1.2	.73	1.3	.92	1.3	.33
		2	-	-	1.3	.43	1.3	4.00
		3	-	-	1.3	.47	1.3	2.10
	3548	1	.9	.91	1.1	2.41	1.3	1.34
		2	.9	.56	1.1	1.82	1.3	1.41
V (Skim-milk)		3	.9	.62	1.1	2.50	1.3	.64
	3551	1	1.2	.38	1.3	2.09	1.3	3.35
		2	1.2	.72	1.3	.69	1.3	2.84
		3	1.2	1.08	1.3	.66	1.3	1.26
	3558	1	1.0	.50	1.3	2.37	1.3	3.24
		2	1.0	.19	1.3	2.05	1.3	2.21
		3	1.0	.23	1.3	1.42	1.3	2.38
	3567	1	1.0	1.16	1.2	1.81	1.3	1.49
		2	1.0	.83	1.2	1.04	1.3	1.17
		3	1.0	.70	-	-	1.3	1.64
	Group Av.		1.1	.67	1.2	1.49	1.3	1.95

Table 22. (Continued)

Dietary Group	Calf No.	Day	16-18 Intake	16-18 Output Feces	36-38 Intake	36-38 Output Feces	58-60 Intake	58-60 Output Feces
			(gm.)		(gm.)		(gm.)	
VI (Skim-milk plus aureo-mycin)	3547	1	1.2	.31	1.1	2.35	1.3	1.15
		2	1.2	.51	1.1	3.21	1.3	1.60
		3	-	-	1.1	2.49	1.3	1.78
	3555	1	1.0	.23	1.2	1.25	1.3	.20
		2	1.0	.38	1.2	.64	1.3	1.19
		3	1.0	.34	1.2	1.13	1.3	.62
	3556	1	.8	.24	1.0	.36	1.3	.34
		2	.8	.41	1.0	.69	1.3	.63
		3	.8	.31	1.0	.51	1.3	1.07
	3563	1	-	-	1.1	1.21	1.3	2.71
		2	1.1	1.46	1.1	1.14	1.3	1.59
		3	1.1	.73	1.1	1.30	1.3	1.15
	3568	1	1.2	1.28	1.3	1.77	1.3	0.87
		2	1.2	.97	1.3	2.08	1.3	1.29
		3	1.2	1.17	1.3	2.33	1.3	1.17
	Group Av.		1.0	.59	1.2	1.50	1.3	1.15

Figure 2. Effect of aureomycin on blood glucose levels following skimmilk feeding.


GROUP V - CONTROL
GROUP VI - AUREOMYCIN
2 WEEKS
5 WEEKS
8 WEEKS
12 WEEKS
MG. GLUCOSE / 100 ML. BLOOD
150
125
100
75
50
0 2 4 6 8 10
TIME AFTER FEEDING, HOURS

the difference between groups was not significant statistically.

IV. DISCUSSION

The results of the investigational work presented in this manuscript indicate that a growth stimulus is produced in young dairy calves by aureomycin supplementation. The antibiotic-fed calves exhibited more vigorous appetites, consumed more feed, and utilized feed more efficiently (less TDN per pound of gain). The fundamental cause or causes of these effects remain obscure; however, some observations from the investigations reported herein are in order.

The incidence of diarrhea was low for the calves in all experimental groups except those fed restricted diets. There was, however, a slight reduction in scouring among the calves fed aureomycin, which is in agreement with Bartley and co-workers (3) and Loosli *et al.* (44) who demonstrated less diarrhea in antibiotic-fed dairy calves.

The beneficial action of the aureomycin is probably related at least in part to the control of diarrhea or digestive disturbances of the young dairy calf. It is possible to measure digestive upsets of young dairy calves if the severity is sufficiently great to result in diarrhea, but there probably are numerous gradations of digestive disorders present in growing dairy calves that are not outwardly apparent, except possibly in the general unthriftiness and behavior of the animal. Therefore, the aureomycin may act in some undetermined way to reduce or control these digestive disorders, either apparent or non-apparent, thus resulting in a more vigorous calf that is in good health and has a stimulated appetite.

Rusoff and Davis (57) reported a response of young dairy calves to aureomycin supplementation similar to that observed in the trials reported herein. These workers noted, also in accordance with observations made herein, that Jersey calves exhibited a greater growth response than did Holsteins. A possible explanation of the differential responses of these breeds of dairy calves to aureomycin supplementation is that young calves of the Ayrshire, Guernsey and Jersey breeds may be somewhat less vigorous than those of the Holstein breed, thus providing a greater opportunity in the former breeds for the stimulating effect of the antibiotic to be exhibited. Apparently the aureomycin acted in some way to aid the Ayrshire, Guernsey and Jersey calves to combat and partially overcome the unknown factors that inhibit rapid growth and generally retard calves of these breeds. It might be postulated further that the Holstein calves did not respond to the antibiotic supplementation to the same extent as did the other breeds since they were better able to partially overcome the retarding factors and to make normally rapid weight gains without the aid of the aureomycin. Further investigation will be required before it can be determined whether this relationship is general or whether it is peculiar to the herds investigated.

Furthermore, Speer et al. (64) working with healthy well-fed pigs under relatively disease-free conditions were unable to show either an increase in daily gains or an improvement in feed efficiency by the addition of 5 to 10 mg. of aureomycin per pound of total ration. On the other hand, Catron and Cuff (13) fed "runt" pigs, weighing less than 20 pounds at 76 days of age, 20 mg. of aureomycin per pound of ration and the pigs made normal daily gains of 1.3 pounds during a 10-week feeding period, whereas a control lot, receiving only the basal diet, gained only 0.86 pound daily. Higher mortality and highly variable weight gains were observed in the pigs not receiving the antibiotic.

Catron and co-workers (14) demonstrated more rapid intestinal absorption of glucose in swine that were supplemented with aureomycin than in non-supplemented animals. This may mean that the antibiotic eliminates harmful or competitive bacteria from the intestinal tract, thus making more glucose available for absorption by the pig. That glucose is utilized by bacteria was demonstrated by Cole (21) who found that *Trichomonas foetus* organisms consume glucose *in vitro*, especially during the actively increasing phase of the growth cycle of the organism.

Although the blood glucose levels (Figure 2) for the aureomycin supplemented calves in the trials reported herein were not significantly different statistically from the values of the control animals, there was a slightly more rapid rate of uptake of glucose noted following skimmilk feeding, which would tend to support the findings of Catron et al. (14). There was extreme variability among calves within each group and the numbers of calves were small. Also lactose, which is slowly hydrolyzed in the intestinal tract (35), was fed, whereas Catron et al. (14) administered glucose to the swine via stomach tube.

The foregoing discussion relative to the action of aureomycin in reducing digestive disturbances in dairy calves, and, in turn, controlling diarrhea, and the indications that glucose is absorbed more rapidly and in greater quantities from the intestinal tract of antibiotic-fed animals than from the intestines of non-supplemented animals would suggest a bacteriological mode of action.

The foregoing suggestion indicates the need for further investigation, particularly relative to the effect of aureomycin on the rate of absorption of various nutrients from the intestinal tract of dairy calves. More rigid control of method of administration of the nutrients should be followed, more readily available forms of nutrients should be used, and more frequent sampling of the blood for analyses should be made. Furthermore, bacteriological studies of the types of organisms in the intestinal tract of dairy calves and of the possible change resulting from aureomycin administration are suggested.

The calves that received milk, hay and a concentrate mixture and were supplemented with aureomycin consumed an average of 13 per cent more calculated TDN and gained 27 per cent more weight than did similarly fed non-supplemented calves. These observations are in accord with the findings of Loosli et al. (44) in which calves fed various milk substitutes, hay and a concentrate mixture plus aureomycin consumed 40 per cent more of the concentrate mixture and made significantly greater gains than did the control animals. Bartley et al. (4) also found that antibiotic-supplemented dairy calves consumed 22 per cent more grain than control animals. The supplemented calves in the trials reported herein tended to express their increased appetites by consuming their maximum daily allowance (4 pounds) of the concentrate mixture at an earlier age than the control animals (the former consuming 11 per cent more of the concentrate mixture) as well as by consuming 21 per cent more hay (fed ad libitum).

That aureomycin supplementation stimulates the appetites of young dairy calves is further indicated by the lack of a growth response of the calves to aureomycin supplementation during the first 8-week period of Trial II when the calves were restricted to a controlled intake of skimmilk. Since they had access to no other source of nutrients, their stimulated appetites could not be expressed, thus perhaps accounting for the similarity of rate of gain for the supplemented and non-supplemented animals. It is possible, however, that the reason no differences in weight gains were observed during the restricted skimmilk dietary regime may be the nature of the diet itself. In reports by previous workers (4, 44) as well as in Trial I reported herein, the aureomycin supplementation effected a growth and an appetite stimulus in young dairy calves which had access to other types of feed, namely hay and a concentrate or grain mixture. That the type of diet may influence the response exhibited by dairy calves supplemented with aureomycin is further indicated by the lack of differences between supplemented and non-supplemented groups of calves with respect to the efficiency of nutrient utilization as determined by intake-output studies of carbohydrates, total nitrogen, dry matter, ash and ether extract.

On the other hand, the possibility exists that the results obtained from Trial II relative to weight changes, TDN consumption and utilization of various nutrients by calves are inconclusive only because of the small number of calves used. There was considerable variation among calves within groups. Also, only Holstein male calves were used in the fundamental studies of Trial II, and, as mentioned previously, Holstein calves did not respond to aureomycin supplementation to the same extent as did calves of the other breeds studied. Furthermore, if the TDN consumption and the TDN per pound of gain is studied closely among breeds of Trial I, it will be observed that the Holstein calves did not exhibit as great differences relative to these two factors as did calves of the other breeds. Therefore, more confidence should be placed in the results observed in Trial I in which a greater number of calves were used, various breeds were represented and a different dietary regime was employed than in Trial II. During the terminal 8-week period when hay and a concentrate mixture were added to the diet of the calves in Trial II a greater efficiency of feed utilization (less TDN per pound of weight gain) was observed for the supplemented calves. In contrast to the results in Trial I, however, the non-supplemented animals consumed more hay and concentrate than did the antibiotic-fed calves. Since major differences between the two groups in rate of weight gain occurred only during the terminal 2 weeks, it is possible that a period of adjustment to aureomycin feeding was required, this accounting for the contrast in results of Trial II as compared to Trial I. Moreover, the small number of calves per group and the large within-group variations reduce the significance of feed utilization data in Trial II.

The common diet for dairy calves during the first few weeks of age consists of whole milk. Since this practice of feeding young dairy calves often is relatively uneconomical, other methods have been used by dairymen and research workers. Among these methods is the practice of feeding a remade skimmilk; i.e., one reconstituted from the dried solids-not-fat portions of milk. Arrington and Reaves (1) fed 3-day-old Jersey and Holstein calves on a ration consisting of remade skimmilk (one part skimmilk powder to nine parts water), hay and grain, supplemented with vitamins A and D. Growth rates were below normal for the first few weeks for the Holstein calves, but at 16 weeks of age normal weights were attained. Four of the five Jersey calves died within 2 to 4 weeks after being placed on the experimental ration, and the fifth died at 16 weeks of age as a result of bloat. Similarly, Rojas et al. (54) compared a skimmilk diet with a whole milk diet for young dairy calves and observed a slower rate of gain and more severe scouring in the former group than in the latter.

When the fat is removed from milk, the energy content of the milk is reduced considerably. Therefore the absence of normal growth in the previously mentioned trials (1, 54) was probably due to insufficient energy intake. Also, skimmilk per se is quite laxative because of its high content of lactose (25). Thus with a low energy intake and a laxative feed, slow growth and a high mortality rate might be expected among young dairy calves.

Wing (74) attempted to increase the energy intake of calves fed a low-fat diet by feeding reconstituted skimmilk containing either 13, 16, or 18 per cent milk solids-not-fat. Four-day-old dairy calves were restricted to the reconstituted skimmilk and supplemental vitamins A and D. Diarrhea was severe in calves on all three levels of feeding and the growth was below normal standards for young dairy calves (52).

An attempt to eliminate diarrhea when calves were fed remade skimmilk containing a high percentage of milk solids-not-fat was made in the trials reported herein. A 20 per cent milk solids-not-fat product was used because it was approximately calorically equivalent to the Holstein herd milk (3.5 per cent fat) which was the other experimental milk. Instead of changing the calves at 4 days of age to the more concentrated reconstituted milks as was done in the experiments of Wing (74), a series of gradual changes were adopted. To evaluate the effectiveness of the antibiotic in controlling scours due to high dietary milk solids-not-fat, aureomycin was added to the rations of one group of skimmilk-fed calves.

In Trial I, in which hay and concentrates were also fed, normal weight gains were observed in the groups fed skimmilk. Scouring was less than that observed in previous experiments (74) but was greater than that among calves in the whole-milk groups. The aureomycin-supplemented calves exhibited significantly greater gains and, although slightly less scouring was observed in the aureomycin-fed group, the antibiotic failed to control adequately the scouring due to high milk solids-not-fat diets. Even in Trial II, however, in which the calves were restricted to the skimmilk diet, both the non-supplemented and the supplemented calves gained at a normal rate. As in Trial I, slightly less scouring was observed in the antibiotic-fed calves, and scouring became less frequent as the first 8 weeks progressed (Table 14).

It is possible, therefore, that the calves adapted themselves to the high lactose diets (26, 47, 53), thereby being able to utilize the increased energy intake and in the absence of severe diarrhea to make normal body growth.

In the routine feeding of a concentrated skimmilk diet to young dairy calves, certain precautions are indicated. The concentration should be gradually increased whereby the 20 per cent concentration is reached between 14 and 21 days of age, because the most severe scouring observed in the calves was prior to three weeks of age. Also, special care must be used to detect signs of scouring and when this condition is first noticed, the quantity of milk should be reduced until the diarrheal condition subsides.

McCandless and Dye (46) observed that the young of four ruminant species (cattle, sheep, goats and addax antelope), exhibited higher blood glucose levels than did the adult animals of the same species and attributed the differences to dietary changes,the young consuming large quantities of milk, and the adults consuming chiefly feeds that must be acted upon in the developed rumen. The blood glucose levels shown in Figure 2 indicated that under the conditions of this experiment the type of diet was not the determining factor in the level of blood sugar in young dairy calves since the mean levels at 2 weeks of age were considerably higher than those at 5 and at 8 weeks of age, even though composition of the diet was constant. Furthermore, results by Jacobson and coworkers (36) in which rumen development in 45 dairy calves was retarded by restricting the animals to various milk diets indicated that blood glucose values declined steadily during the first four weeks following birth and remained relatively constant thereafter. Thus, it seems that development of rumen function is not the primary cause of the downward trend of blood glucose levels in the young calf.

Two calves in the aureomycin-supplemented groups, (groups IV and VI) exhibited symptoms similar to those reported for thiamine (37) and riboflavin (72) deficiencies, respectively. Calf 3560, Group IV, at about 40 days of age exhibited a reduced appetite for hay and concentrate, appeared dull and listless, and at 51 days of age went into convulsions. There was extreme stiffness in the front legs and the head was retracted posteriorly toward its spine (excessive dorsal flexion). About 20 mg. of thiamine hydrochloride were administered intravenuously and the calf exhibited a marked recovery within two hours, soon regained its appetite and made apparently normal gains throughout the remainder of the trial.

Calf 3563, Group VI, developed a severe alopecia beginning at about 50 days of age, and at 70 days of age had lost most of the hair along the underline, between its front legs and up its rear flank almost to the point of the hip. The calf received no hay or concentrate until 60 days of age and then consumed a very small amount during the next few weeks. Starting at 70 days of age, 5 mg. of riboflavin were administered daily by capsule for a period of about 7 days at the end of which time new hair growth was apparent. It is possible that the calves would have recovered spontaneously without treatment, although the fast recovery that ensued treatment indicated vitamin B-complex deficiencies.

Kesler and Knodt (40) demonstrated that thiamine, riboflavin and nicotinic acid are synthesized by the dairy calf on normal rations at ages from 2 to 14 weeks. Riboflavin and niacin were found in highest concentration in the small intestine while thiamine was more concentrated in the rumen and omasum than in other parts of the gastrointestinal tract. However, a need for a dietary source of thiamine (37) and for riboflavin (72) by the very young calf (on synthetic milk diets deficient in these vitamins) has been demonstrated.

Furthermore, Brisson and Sutton (9) developed a riboflavin deficiency in dairy calves during the period from birth to 8 weeks of age even when feeding up to 35 mcg. of riboflavin per kilo. of body weight daily, but a deficiency was not observed when 45 mcg. were fed. A minimum daily requirement of the male dairy calf up to 8 weeks of age was suggested as being between 35 and 45 mcg. per kilo. of body weight.

The two calves (3560 and 3563), involved in the trials reported herein, ate very little hay and concentrate prior to the appearance of the thiamine and riboflavin deficiency symptoms, therefore, it is possible that normal rumen function, and, in turn, synthesis of B-complex vitamins, was absent in these two calves. This, as well as the marked recovery upon thiamine and riboflavin administration, respectively, would suggest that the dietary source was insufficient to prevent deficiencies from developing.

Whether the synthesis of the B-complex vitamins were inhibited by the antibiotic remains a moot question. Further investigation of the rate of synthesis of the B-complex vitamins by young calves fed aureomycin is suggested.

Although it has been demonstrated that aureomycin feeding stimulates appetite, increases rate of growth (weight gain) and efficiency of feed utilization, improves appearance and reduces incidence of diarrhea, there still remain numerous unanswered questions relative to the long-time effect of this antibiotic. More research is needed to determine if the stimulated growth will continue to maturity, and if so, if the increased size will permit earlier breeding, thus bringing quicker returns from the investment of raising the animal. Furthermore, will there be any impairment of breeding efficiency, and what will be the effect on the level of production of the females? Also of interest, is the effect of feeding a low level of an antibiotic on later efficiency of the antibiotic when used therapeutically. It would seem, however, that if antibiotic feeding to dairy animals is desirable, the greatest advantages may be realized in the young calf where reduction in digestive disorders and stimulation of growth might be expected to decrease mortality and "stunting". Also, although a maximum rate of growth may not be essential in raising calves for dairy purposes, a stimulation of rate of growth of veal calves would seem desirable.

Aureomycin (3, 44, 50, 57) penicillin (8) and terramycin (67) have been used in antibiotic feeding studies with dairy calves, yet no conclusive reports are available that indicate which antibiotic produces the most favorable responses, although aureomycin has been used experimentally more than the latter two. Further investigation of these and other antibiotics is needed. Moreover, although various levels of the antibiotics have been fed, levels required for optimum responses have not been established.

V. SUMMARY

In two feeding trials, 4-day old dairy calves were divided into six groups and were fed various diets over a period of 16 weeks. In Trial I, four groups of calves were fed hay, a concentrate mixture and a limited quantity of milk, two groups receiving whole milk and two groups receiving a reconstituted skimmilk with the dry matter content adjusted to yield a product approximately calorically equivalent to the whole milk. Supplemental vitamins A and D also were fed to the latter two groups. To one group in each dietary regime, crystalline aureomycin hydrochloride, 80 mg. daily per calf, was fed in the milk via nipple pail.

In Trial II ten Holstein male calves were restricted, during the period from 4 to 60 days of age, to a diet of reconstituted skimmilk similar in composition to that fed in Trial I. During the subsequent 8-week period the calves received, in addition to a limited amount of the skimmilk, hay and a concentrate mixture. To half of the calves, aureomycin was fed at the same rate as in Trial I.

The results of Trial I indicated that the aureomycin-supplemented calves, irrespective of the type of milk in the diet, exhibited gains that were significantly greater statistically than those of the non-supplemented animals. The aureomycin apparently stimulated the appetites of the calves,

causing them to eat more feed and to gain weight more efficiently (less TDN per pound of gain). A slightly greater incidence of diarrhea was noted among the non-supplemented animals, although the antibiotic did not completely control scouring. Type of milk had no significant effect on growth response of the calves, although incidence of scouring was slightly higher among calves fed skimmilk.

Ayrshire, Guernsey and Jersey calves exhibited a greater response to the antibiotic feeding than did the Holsteins. Calves of the three former breeds gained 41 per cent more weight than the control animals of those breeds whereas supplemented Holstein calves gained only 12 per cent more than their controls.

During the first 8-week period of Trial II, when the calves were restricted to a skimmilk diet the mean weight gains and the efficiencies of feed utilization (TDN per pound of gain) were similar for the two groups of calves. During the terminal 8-week period, after hay and concentrate feeding had begun, the average daily gain and the efficiency of feed utilization were greater for the antibiotic-fed calves than for the controls.

No major differences were observed in efficiency of nutrient utilization or in blood glucose values between antibiotic-supplemented and non-supplemented calves restricted to skimmilk diets. In most instances, however, the aureomycin-fed calves utilized the nutrients somewhat more efficiently and exhibited slightly greater increases in blood glucose levels following feeding.

Under the conditions of this experiment, aureomycin supplementation produced significantly greater weight gains, more efficient utilization of feed, a smoother hair coat and more condition (fleshing). The type of milk in the diet, whether whole milk or reconstituted skimmilk, apparently made no difference in the response of the calves to antibiotic feeding.

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