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# The effects of pre- and post-transit potassium levels, feedlot receiving diets, and levamisole injection on stressed bull and steer calves

Frank K. Brazle

To the Graduate Council:

I am submitting herewith a dissertation written by Frank K. Brazle entitled "The effects of pre- and post-transit potassium levels, feedlot receiving diets, and levamisole injection on stressed bull and steer calves." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Animal Science.

J.B. McLaren, Major Professor

We have read this dissertation and recommend its acceptance:

K.M. Barth, R.R. Shrode, D.O. Richardson, J.H. Reynolds

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

Karl M. Barth

Jack G. Riley

Don D. Richardson

Robert R. Shrode

John H. Reynolds

Accepted for the Council:

Vice Provost
and Dean of The Graduate School

# THE EFFECTS OF PRE- AND POST-TRANSIT POTASSIUM LEVELS, FEEDLOT RECEIVING DIETS, AND LEVAMISOLE INJECTION ON STRESSED BULL AND STEER CALVES

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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Frank K. Brazle

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## ABSTRACT

In a March 1983 trial, 125 bulls and 139 steer calves were used to compare bulls castrated at feedlot (FL) arrival (BULLS) with steers, to evaluate feeding supplemental potassium (K) at the order-buyer barn (OBB) for three days before shipment or at FL, to compare a 40% concentrate (CONC) receiving diet with a hay (HAY) diet, and to evaluate the effect of injection with levamisole (LEV) at OBB and FL arrival. Mortality was higher ($P<.05$) in BULLS (13.2%) than in steers (7.7%) and higher in CONC bulls than in HAY bulls.

Steers gained more ($P<.10$) (12.1 kg) from purchase to FL-28, had higher ($P<.10$) antibody titers for Bovine Viral Diarrhea (BVD) at OBB, and greater ($P<.10$) change in serum lymphocyte blastogenesis from OBB to FL-28 than BULLS. Calves fed a 1.5% K diet at OBB had less shrink during the 24-hour transit than those fed a 1.1% K diet. FL gains of calves fed a 1.1% K and a 1.7% K receiving diet were similar ($P>.10$).

Calf breed type affected mortality. Mortality of white-faced, feather-necked, red, medium-frame calves (WF) (18.3%) was higher ($P<.10$) than that of black, medium-frame calves (BL) (2.8%). WF calves required 30% more clinical treatments and had higher temperatures than did BL and large-frame calves. Injection of LEV at OBB or FL reduced mortality 6.6% and increased BVD and IBR antibody titers. Gains during the 28-day receiving period were similar for the CONC and HAY calves but the CONC calves gained more ($P<.05$) during the

subsequent silage period. Mortality tended to be higher in CONC calves (12.3%) than in HAY calves (8.5%).

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# CHAPTER I

## INTRODUCTION

The beef cattle industry of the Southeastern United States is composed mainly of small cow herds. Most of the calves are weaned in the fall and they are marketed as feeder calves and shipped to western or cornbelt feedlots for finishing or western wheat pastures for grazing. Many spring-marketed calves are shipped to western states for grazing of "native" grass. For example, in 1979, .8 million calves, representing about 90% of the production from the 1.1 million Tennessee beef cows, were shipped out of Tennessee for grazing and/or finishing (Rawls, 1979).

During the process of marketing and transporting, calves are subjected to a variety of stresses. These stresses include weaning, crowding, starvation, dust, drastic changes in temperatures, precipitation, humidity, castration, and adaptation to new rations (Crenshaw, 1967; Pierson, 1968; Lofgreen et al., 1975; Lofgreen et al., 1978; McKercher, 1978; McLaren, 1978; Wiseman, 1978; Zweiacher et al., 1979; Gill et al., 1980; Lofgreen, 1983a and 1983b; Lofgreen and Kiesling, 1983). During the market-transit process, calves are often frightened, fatigued, fasted, and become dehydrated. Self (1972) suggested that animals may lose 10% or more of their body weight in the form of tissue water and digestive tract contents. Nutritional stress is particularly evident since the calves are subjected to periods of intermittent starvation and re-feeding during marketing and transporting.

Hutcheson et al. (1984) found that increasing the potassium level of the receiving diet from .7% to 1.4% decreased the number of days required for long-hauled calves to regain purchase weight. McLaren et al. (1983) and Hamlett et al. (1983) suggested an advantage for a potassium chloride (KCL) supplemented pre-transit diet with respect to the time required for calves to regain purchase weight.

Gill et al. (1980) and Lofgreen (1983a) reported that the stress associated with adaptation to higher energy receiving diets increased the incidence of Bovine Respiratory Disease. In growing and finishing programs, the relationship of energy levels in the receiving diet to calf performance after the first 28 days is not completely documented. Lofgreen et al. (1981) showed that, in some cases, such as grazing winter wheat pasture, calves on a low energy receiving diet did not compensate during later phases for the lower gain during the receiving period. However, Lofgreen (1983a) and Lofgreen and Kiesling (1983) observed some compensatory gain in calves during a silage program or a finishing program following restricted energy intake during earlier phases, but the higher gains of the calves during these periods did not fully compensate for deficiency in gain during the receiving phase.

Irwin et al. (1980) found that levamisole phosphate reduces the incidence of sickness in calves. It was shown by Symoens and Rosenthal (1977), Soppi et al. (1979), Hogarth-Scott et al. (1980), and Babiuk and Misra (1981, 1982) that levamisole has immunity stimulating properties when the immune system is stressed.

Addis et al. (1973, 1974) and Zweiacher et al. (1979) reported that calves transported as steers gained more during the feedlot phase than did calves transported as bulls and castrated upon arrival. They found also a higher incidence of health problems in castrated bull calves than in steers. There is little research information available with respect to the performance of bull calves castrated upon feedlot arrival after the 28-day receiving period.

The effects of normal transit factors believed by Camp et al. (1981) to affect shrinkage and shipping fever in steers may be different in castrated bull calves because of the differences in disposition and behavorial patterns plus the fact that the additional stress associated with castration may be considerably more severe than is currently recognized.

The objectives of this study were:

1. to evaluate the effects of increasing the potassium content of the pre-shipment and feedlot receiving diets; and

2. to study the effects of varying energy levels in the receiving diet on the performance and health of calves purchased and shipped as steers and in calves purchased and shipped as bulls but castrated upon feedlot arrival.

An additional objective was to evaluate the efficacy of levamisole injection with respect to cell-mediated immune response stimulation.

# CHAPTER II

# REVIEW OF LITERATURE

## 1. THE EFFECT OF CASTRATING BULLS UPON FEEDLOT ARRIVAL AS COMPARED TO EARLIER CASTRATION

Calves purchased and transported as steers gained faster ($P<.05$) than calves purchased and transported as bulls and castrated upon or after arrival at the feedlot (Addis et al., 1973, 1974; Zweiacher et al., 1979). Castration of bull calves upon arrival at the feedlot resulted in higher ($P<.05$) average daily gain than when castration was delayed for one or two weeks (Addis et al., 1973; Zweiacher et al., 1979). However, one exception was that bulls castrated by the elastrator-ligation method upon arrival at the feedlot gained faster than did steers (Zweiacher et al., 1979). The ligation process included exposures of the testes by removal of three-fourths of the scrotum. An elastrator band was then placed around each spermatic cord as far proximal to the major convolutions of the spermatic artery as possible. The testes were removed by severing the cord 2 to 4 cm below each elastrator band.

Delaying processing (castration, vaccination, etc.) for 14 to 21 days resulted in calves regaining their purchase weight 2 and 3 days earlier, respectively, than calves processed at the origin of the transport phase or upon arrival at the feedlot (Lofgreen et al., 1978). Some negative effects of delayed processing were: (1) an

increase in the number of calves requiring treatment; (2) extended time during which sick calves had to be treated; (3) an increase in the number of calves requiring additional treatments after an earlier series of treatments were completed; and (4) an increase in death loss and number of culls. It appears that allowing the calves to rehydrate prior to castration may increase the chances of hemorrhaging from castration (Lofgreen et al., 1978). Therefore, the disadvantages of delayed processing outweighs the advantages. Although processing at transit origin or upon feedlot arrival does not increase the number of calves requiring treatment, it did result in an increase in the number of calves requiring earlier treatment while delayed processing was accompanied by a delay in the onset of sickness in some calves.

The percentage of steers that were diagnosed sick and required clinical treatment was considerably less than those transported as bulls and castrated upon arrival or later. Only 17.5% of the calves transported as steers required treatment for sickness during feedlot adaptation as compared to an average of 38.4% of the bulls from all castration treatments in one trial and 12.9% of steers and 22.0% of castrated bulls in another trial (Zweiacher et al., 1979). This indicates that castration is a stress factor and implies that after castration, calves are more susceptible to infections because of this additional stress. More castrated bull calves may be treated for scrotal infection, or simply because of the stress may be treated for respiratory infections.

From the data, it appears that delaying the processing for two to three weeks allows the calves to recover faster from the stresses

of marketing and shipping, but the stress of processing causes a greater depression of performance than if done either at the transit origin or upon arrival at the feedlot. This suggests that, in most cases, animals have the ability to undergo extreme stress imposed at one time and can satisfactorily recover provided no additional stress is imposed on them immediately or if they are allowed time for complete recovery from the initial stress before subsequent exposure to additional stressors.

## 2. THE EFFECT OF BREED ON THE IMMUNE SYSTEM OF CALVES

The breed of the calf's sire and (or) the breed of the calf's dam were important sources of variation in immunoglobulin concentrations. Norman and Hohenboken (1981) and Baumwart et al. (1977) found that Holstein calves were more efficient than Ayrshire calves in absorbing total gamma globulins from colostrum. Tennant et al. (1969) reported that immunoglobin concentrations in Jersey calves were twice those in Holsteins. Selman et al. (1971) determined that Friesian X Ayrshire calves absorbed more immunoglobulins than did Ayrshires. Bradley et al. (1979) reported higher immunoglobulin concentrations in Hereford calves than in Simmental calves. Norman et al. (1981) reported that Simmental and Pinzgauer-sired calves tended to have lower ($P<.07$) immunoglobulin levels than calves sired by Hereford, Hereford X Angus, and Tarentaise bulls. Calves of Hereford X Angus dams had higher ($P<.1$) immunoglobulin concentrations than did calves of Hereford dams. Muggli et al. (1984) found that serum immunoglobulin

$G_1$ was highest at 24 and 48 hours of age in Angus calves, intermediate in Red Poll and lowest in Herefords. Calves from Hereford lines selected on the basis of higher weaning weight, yearling weight, or an index based on yearling weight and muscling score were lower in serum immunoglobulin $G_1$ concentration than were calves from the randomly selected control lines.

Blecha et al. (1983) found that Brahman X Angus steers subjected to the stressors associated with shipping had lower ($P<.01$) monocyte phagocytic capability than did Brahman X Angus control animals. Angus steers, regardless of pre- or post-shipping treatment, had similar ($P<.05$) monocyte phagocytic function. These data suggest that there are differences between breeds of cattle with respect to their immune response to various stressors. Also, the immune system or disposition of some breeds may make them more able to cope with stress or marketing and transit than that of others.

## 3. RECEIVING RATIONS

The feeding and care of newly arrived feedlot cattle affected by the stresses of marketing and shipping are major problems associated with the cattle feeding industry. The receiving diet can be very important in meeting the animal's nutritional needs, but it must not add additional stress to the animal because of problems associated with adaptation of the diet. Lofgreen (1983a) found that the incidence of respiratory diseases in newly arrived, highly stressed calves increased with increasing energy level in the receiving diet. Including

long stem native grass hay in high energy diets tended to reduce the incidence of respiratory diseases. Similar results were also reported by Gill et al. (1980). Despite a higher incidence of respiratory diseases, calves fed a high energy receiving diet attained an average of 26.4 kg per calf above purchase weight during the 28 day receiving period, while those receiving grass hay alone lacked .5 kg of regaining their purchase weight during this period (Lofgreen, 1983b).

By comparing receiving diets containing different energy levels, Lofgreen et al. (1975) found that the feed intake of calves fed a 55%-concentrate diet was more than for calves fed a 72%-concentrate diet during the first 14 days in the feedlot. However, there was little difference in consumption between the diets during the first 28 days, and both were consumed in larger amounts than was the 20%-concentrate diet.

In another study with feedlot steers, Lofgreen et al. (1980) found lower consumption of the higher concentrate diet compared to lower concentrate levels. Calves fed a 72%-concentrate diet consumed the most energy (T.D.N.), and those fed the 20%-concentrate diet consumed the least. Weight gains of calves fed the receiving diets were a reflection of the energy level in the diet. Calves fed a 72%-concentrate diet regained purchase weight two and five days sooner than those fed the 55%- and 20%-concentrate diets, respectively (Lofgreen et al., 1975). In a cafeteria-type system, stressed calves selected a diet relatively high in energy (Lofgreen et al., 1975).

It was suggested by Gill et al. (1980) that stocker cattle purchased for subsequent grazing programs will compensate for low weight gain during the receiving period during the grazing phase. Therefore, gain during the first 28 days may not always be of economic importance if cattle compensate for that weight loss in a later production phase.

Lofgreen and Kiesling (1983) found that calves fed native grass hay free choice plus .90 kg of protein supplement daily during a 28-day receiving period gained 15 kg less than did those fed ad libitum a 75%-concentrate milled feed during that period. Although calves fed hay during the receiving period made 10 kg of compensatory gain during the finishing period, their final weight was 5 kg less than that of the calves fed high-energy rations during the receiving period. Feeding a growing diet during the first part of the finishing period will promote greater compensatory gains than will feeding a high energy finishing diet throughout. However, research conducted by Lofgreen et al. (1981) showed that calves fed a 75%-concentrate receiving ration had an 8.6 kg gain advantage over those fed hay plus .9 kg of 40%-protein supplement at the end of the receiving period. Following 73 days on wheat pasture, this weight advantage for the calves fed 75%-concentrate receiving diet increased to 13.6 kg. The high-energy fed calves each gained .92 kg daily, while the low-energy fed calves only gained .85 kg per day on wheat pasture. This study confirms the hypothesis that the higher rates of gain promoted by the high-energy receiving diets are maintained during subsequent grazing and (or) finishing phases.

Transported calves tend to be slow in adapting to new feeds and environments. Bond et al. (1976) found that the feeding and drinking patterns of non-transported steers were similar before and after deprivation of feed, water, or both. Results showed that when feed, water, or both were withheld from cattle for up to two days and then the same feed re-introduced there were minimal changes in intake patterns.

Sudweeks (1977) found that chewing time was reduced with each increased increment in concentrate content of the feed. Normally, chewing time is an indication of saliva production. Greater buffering of the rumen resulting from increased salivation, reduced the ratio of acetate to propionate (Harrison et al., 1975).

Diets which increased chewing time and saliva flow produced lower concentrations of volatile fatty acids (VFA's) in the rumen. The acetate-to-propionate ratio increased with chewing time for each concentrate level, but the relationship of chewing time to VFA level was not constant over all concentrate levels (Sudweeks, 1977). Since increased saliva flow has a dilution effect and increases rate of passage in the ruminant, this might explain differences in VFA concentrations.

## 4. EFFECT OF FASTING AND TRANSPORT ON CALVES

Calves in the normal marketing and transit channels are deprived of feed for long periods of time. Fasting steers for 32 hours resulted in a loss of 59 kg in weight and steers fasted and transported

simultaneously lost 55 kg (Galyean et al., 1981). Cole and Hutcheson (1979) reported similar weight-loss patterns in steers fasted for 24 and 48 hours. Steers that were fasted only, but not transported, regained the weight lost during fasting in 4 hours, whereas, steers fasted and transported required 24 hours to recover the weight loss. Rectal temperature did not differ among treatment groups at any sampling time (Galyean et al., 1981). Cole and Hutcheson (1981) found that fasting rumen-fistulated steers for 24 and 48 hours resulted in lower in vitro rumen fermentation activity and fermentative capacity, and the decreases persisted for more than 5 days after re-feeding. During periods of deprivation, the ruminal molar proportions of acetate increased, and the molar proportions of propionate and butyrate tended to decline. Rumen pH increased significantly during deprivation. Three to five days were required for rumen VFA to return to pre-fast levels.

Cole and Hutcheson (1981) found that total rumen VFA concentrations declined significantly during deprivation, but increased rapidly upon re-feeding. This agrees with results reported by Galyean et al. (1981); however, fasting plus transporting of steers resulted in even greater declines in VFA level. Lee et al. (1980) observed inconsistent results during short fasts of 18 and 32 hours, but calves fasted and transported for 32 hours had lower VFA concentration than calves fasted only. This suggests that the stresses associated with transporting calves exerted an additional influence on fermentation beyond that imposed by fasting. However, VFA concentrations throughout

the re-feeding period tended to be higher in fasted and transported steers compared to fasted steers without transporting. In general, total VFA production was reduced when antibiotics were added to the diet (Beede and Farlin, 1977). This may reflect reduced rumen motility and lower absorption and passage rather than increased production. Reduced rumen volume from dehydration and differential absorption of VFA's and water could result in an apparently higher VFA level in fasted and transported steers. Atterbery and Johnson (1969) reported that the frequency and amplitude of ruminal contractions were reduced in fasted Holstein cows. Welch and Smith (1968) reported a rapid decline in normal rumination activity during a 36-hour fast in sheep. The effect of transit and market stress on an animal may induce an even greater reduction in motility than does fasting alone and this may result in reduced absorption and passage of VFA.

During the adaptation of steers from a forage diet of an all-concentrate diet, Lyle et al. (1981) found that total VFA concentration tends to increase over a 28-day period. The molar proportion of acetate decreased, and an increase in propionate and butyrate occurred during the same period. Molar proportions increased for 14 days and then tended to stabilize.

According to Cole and Hutcheson (1981), blood packed-cell volume (PCV) increased during the receiving period when animals were deprived of water and feed, and more than seven days were required for PCV to return to its normal level. Similar trends were observed

by Rumsey and Bond (1976). Cole et al. (1982) found that calves fed a 50%-concentrate diet for 30 days before marketing and transporting showed lower PCV levels than did control calves fed a hay diet. However, serum sodium (Na), potassium (K), and Na-to-K ratios were not appreciably affected by either deprivation or re-feeding (Rumsey and Bond, 1976; Cole and Hutcheson, 1981).

## 5. POTASSIUM

Hutcheson (1980), in a detailed review of potassium, discussed the following points. Potassium is the third most abundant mineral element in the animal's body. Potassium comprises about .3% of adult cattle body dry matter whereas Na makes up .15%. Potassium is present primarily inside the cells, while Na is present in plasma and extracellular fluids. Potassium deficiency has not been an apparent problem in animal nutrition. However, cattle fed high-concentrate diets might have suboptimal K levels. The deficiency of K is manifested by slow growth, depressed energy utilization, muscular weakness, stiffness, decreased feed intake, intracellular acidosis, and nervous disorders. Diarrhea is a common cause of acute K deficiency. Potassium is a dietary essential that should be supplied daily since very little or no reserve is maintained in the soft tissues of the body. There is some storage of K in bones; however, this amount is less than 10% of the total bone composition.

Potassium has many functions and is essential for life. It is a major factor in cellular osmotic balance and acts as an available

base to neutralize acids. If K is not available and Na replaces K, there is an alteration of cellular metabolism and persistent alkalosis occurs. An ionic balance exists among $K^+$, $Na^+$, calcium ($Ca^{++}$), and magnesium ($Mg^{++}$). These ions affect capillary and cell function as well as the excitability of nerves and muscles. Proper water balance in the body is associated with K.

The kidneys play an important role in maintenance and control of K level in an animal's body. Hormones secreted by the adrenal cortex indirectly control the electrolyte balance through their influence on the kidneys. The hormone aldosterone has the important effect of controlling reabsorption of Na and excretion of K. Insufficient production of aldosterone results in excessive loss of Na and retention of K. However, hyperactivity of the adrenal cortex with increased production of aldosterone results in excessive reabsorption of Na and urinary excretion of K. When stress conditions occur, the activity of the adrenal gland tends to increase, which causes the adrenal cortex to increase secretion of aldosterone; therefore, K excretion is increased.

Normal body water distribution is 33% extracellular and 67% intracellular. When dehydration occurs, water leaves the extracellular compartment and then moves from the intracellular to the extracellular compartment. When this occurs, the K concentration increases in the extracellular space and aldosterone is activated to excrete this excess of extracellular K. Thus, when stress occurs to an extent beyond gut water loss, the resulting dehydration shrink will very likely result in a K deficiency.

Hutcheson et al. (1984) found that when calves that had consumed a pre-transit hay diet were fed supplemental K, ranging from 1.3% to 2.1% of the receiving diet, they gained faster than did calves fed either lower or higher K levels (.7 or 3.1% K). However, when a 55%-concentrate diet was fed pre-transit, the calves did not respond to additional K in the receiving ration. Phillips and McLaren (1983) reported similar results. The increased potassium level in the receiving diet had no appreciable affect on morbidity; however, calves fed diets containing 1.3% and 2.2% K had lower ($P<.05$) mortality than those fed diets containing .7% or 3.1% K (Hutcheson et al., 1984). Increases in serum K, whole blood K and decreases in serum osmolality in calves fed diets containing higher K levels were small. These combined changes suggest that a more rapid rehydration occurred in the calves fed higher K levels. The effect of feeding supplemental K (23 g KCL daily) during pre-transit phases was studied by Hamlett et al. (1983). The group of steers fed supplemental KCL during the pre-transit phase regained purchase weight earlier than did the control animals. Rumen concentrations of acetate and butyrate were higher on days three and seven in treated calves than in control calves; however, the propionate concentrations of these calves were lower than in the controls. Post-transit K supplementation resulted in higher acetate, butyrate and propionate levels on feedlot days three and seven than in the non-supplemented control calves.

The K content of tall fescue is normally around 2.0% to 3.0% in the spring, but drops to 1% to 2% as the plants mature (Reid et al.,

1970; Baker, 1977; Steen et al., 1979; Ech et al., 1981). Similar conditions exist in orchardgrass (Reid et al., 1970; Baker, 1977). Therefore, the K intake of calves grazing pastures in the Southeast would vary greatly during different seasons of the year. The K level in the pastures could cause a difference in response of stressed calves to supplemental K at either the orderbuyer barn or the feedlot.

## 6. LEVAMISOLE

### General

Levamisole, first introduced as a broad spectrum anthelminthic, is an immunotherapeutic compound with anti-anergic properties. Symoens and Rosenthal (1977) reviewed this topic in great detail. The structural formula of levamisole is S-2,3,5,6 tetrahydro-6-phenylimidazo-[2,1-b] thiazole hydrochloride. The accumulated evidence from studies in isolated cells, in experimental animals, in healthy volunteers, and in patients strongly suggests that levamisole restores to normal the functions of phagocytes and T lymphocytes from compromised hosts. Therapeutic doses of levamisole appear not to increase the immune response above the normal level. The β cells appear not to be directly influenced by this agent. Levamisole has been shown to be effective in stimulating immune responses in both in vitro and in vivo studies. In experimental animals, levamisole does not consistently suppress the primary invasion of virulent bacteria, viruses, or tumor cells. It may, however, increase the protective effect of certain vaccines and stabilize tumor remission. It has a favorable effect on the course

of certain spontaneous immune deficiency diseases in animals. Levamisole is capable of restoring impaired immune responses, preferentially of the cell mediated type, in a wide variety of clinical disorders.

Effect on Virus and Vaccine

The effects of levamisole on bovine immune responses to infectious bovine rhinotracheitis (IBR) virus were assessed under laboratory and commercial feedlot situations by Babiuk and Misra (1982). They found that levamisole stimulated antibody responses of cattle after IBR vaccination. In smaller pilot trials, levamisole appeared to be more beneficial when given seven days after vaccination, presumably when a large amount of viral antigen was present as a result of viral replication. In larger feedlot trials, administration of levamisole at the time of vaccination appeared to elicit a slightly greater immune response than when it was given seven days later.

Calves were stressed and then inoculated with a cytophatic strain of bovine viral diarrhea (BVD) in conjunction with a levamisole injection (Saperstein et al., 1983). There was no difference in severity of infection or speed of recovery between the levamisole-treated calves and control calves. Concentration of antibody titers for BVD were comparable in both groups and attained the highest level at day 33. However, lymphocyte counts of the levamisole-treated calves were higher ($P<.05$) than that of the control calves.

Levamisole and a clostridial vaccine were used in factorial experiments to determine vaccine efficacy in sheep by Hogarth-Scott

et al. (1980). A higher ($P<.05$) antibody response occurred when the vaccine was given in combination with levamisole. Evidence was presented that the distribution curve of the titers at week eight had shifted to the right, suggesting improved immunocompetence.

## Immune Response

Levamisole has immunomodulatory properties (Anderson, 1984). Oral administration of levamisole (10% levamisole hydrochloride at 7.5 mg/kg) in subclinical mastitis resulted in a 60%-decline in somatic cell count in the treated group and only 25.6% in the untreated group by day 28.

Soppi et al. (1979) showed that levamisole enhanced both humoral and cellular immune responses in normal chickens. Levamisole probably stimulates the activation of the T cell function and affects antibody response.

Levamisole sometimes increases resistance to bacterial and viral infections, particularly in previously immunized hosts (Brunner and Muscoplat, 1980). When persistence of the infective agent produces a chronic infection, levamisole may act by increasing the rate of clearance of the agent and by enhancing cell-mediated immune reactions. Marked clinical improvement was demonstrated with levamisole in the treatment of chronic brucellosis in man, recurrent upper respiratory tract infections, leprosy, recurrent genital tract herpes virus and staphylococcal infections (Brunner and Muscoplat, 1980). In in vitro studies, levamisole corrected T lymphocyte deficiencies associated

with chronic brucellosis, malignancy, surgery, and aging. It has been proposed that aging may be due to a shortage of functional T cells and that levamisole reverses aging by promoting the maturation of precursor T cells into fully functional lymphocytes. Levamisole induced the production of interferon by normal human leukocyte cultures (Symoens and Rosenthal, 1977). Levamisole is not strictly an immunostimulant, but it modulates immunity by altering cell function according to the system's own control mechanisms (Brunner and Muscoplat, 1980).

Effect on Morbidity in Stressed Calves

Irwin et al. (1980) found different immune responses associated with various forms of levamisole. A single treatment with levamisole phosphate reduced ($P<.05$) the incidence of shipping fever in calves. This beneficial side effect of levamisole phosphate was observed between days 8 and 30 when fewer calves required clinical treatment. The levamisole phosphate treatment resulted in 30% less morbidity in calves than did levamisole HCl or thiabendazole.

# CHAPTER III

# EXPERIMENTAL PROCEDURES

## 1. GENERAL

Most Southeastern United States cow herds which produce feeder calves are small (28 cows per herd in Tennessee). Because of the small herds, marketing has taken the form of calves being sold at auction barns and transported to orderbuyer barns (OBB). The calves are usually without feed and water for a period of time at the auction barns. Then they are normally moved to an OBB for a period of time ranging from one to seven days with an average of 72 hours. During some times of the year, the period of OBB is longer. At the OBB the calves are sorted into groups for shipment and normally receive grass hay and water once they are sorted into the truckload shipment groups weighing 20,000 to 21,000 kg. The calves may have been purchased from 6 to 10 auction barns and may have originated from 40 to 60 farms. Many of these calves are shipped to Texas, Oklahoma, or Kansas, which requires 20- to 30-hours transport of calves.

## 2. PRE-TRANSIT PROCEDURES

For this study, three loads of calves were purchased in late March of 1983. The calves averaged 238 kg in weight and were purchased in auctions in East Tennessee and Western North Carolina. The three loads consisted of 139 steers and 125 bulls for a total of 264 calves.

At the OBB, the calves were allotted to treatments. The experimental design was a 2 x 2 x 2 x 3 factorial arrangement. Bulls and steers were allotted to a randomized complete block design and the other effects were factorialized across blocks (Table 1). Other effects studied were site of lavamisole injection (none, at OBB, and upon arrival at FL), potassium supplementation at OBB (1.0% vs 1.5% of the diet dry matter), potassium supplementation during the FL receiving period (1.1% vs 1.7% of the diet dry matter), and receiving diet (hay + .9 kg protein supplement for calf per day vs a 40% concentrate-60% hay diet). The calves were held at the OBB for 24 to 96 hours.

## 3. ORDERBUYER BARN TREATMENTS

The calves were fed .9 kg per calf per day of cracked corn (IFN 4-02-931) supplemented with 45 kg of propylene glycol per 909 kg of feed. Potassium chloride was added to the corn fed 50% of the calves so that they consumed a diet containing 1.5% potassium compared to 1.0% diet consumed by the control calves. The calves were fed .9 kg of cracked corn with 50% of the calves receiving the supplemental K. The calves were allotted to pens so that 50% of each truckload of calves received supplemental K. The calves also received mixed grass hay (mixed grass hay: tall fescue IFN 1-01-912, orchard grass IFN 1-03-438, timothy IFN 1-04-883). The estimated intake of hay used to calculate the required amount of supplemental K was 3.6 kg per calf per day.

TABLE 1. Diagram of the Factorial Arrangement of Treatments

| Pre-Shipment Treatments | | Post-Shipment Treatments<br>Feedlot Receiving Diets | | | |
|---|---|---|---|---|---|
| | | 40% Conc. | | .9 Kg Protein Sup. | |
| Diets | Levamisole | Control | +K | Control | +K |
| Control | Control | " | " | " | " |
| | OBB | " | " | " | " |
| | AFL | " | " | " | " |
| Control + KCL | Control | " | " | " | " |
| | OBB | " | " | " | " |
| | AFL | " | " | " | " |

The calves were allotted to the factorial design so that one-third of the calves received 10 ml of injectable levamisole at the OBB, one-third of them received levamisole during processing at feedlot arrival, and one-third were controls.

## 4. TRANSIT AND POST-TRANSIT TREATMENTS

At the end of the OBB phase, the steers and bulls were loaded on to trucks and transported to Manhattan, Kansas. They were on the trucks for 24 hours. Upon arrival at the feedlot, the calves were vaccinated against Infectious Bovine Rhinotracheitis (IBR) with modified live virus, Bovine Virus Diarrhea (BVD), Parainfluenza$_3$ ($PI_3$), Blackleg, malignant edema, black disease, and Clostridium sordellii. The bulls were castrated with a knife, and the cords were stapled with steel staples. All calves with rectal temperatures over 40°C were administered antibiotic as prescribed by the veterinarian.

After the calves were processed, they were allotted to one of two receiving diets. Fifty percent of the calves in each receiving-diet group received supplemental K so that those calves were consuming a diet containing 1.7% potassium compared to 1.1% K diet for the control. The composition of the receiving diets is shown in Table 2. The calves received .9 kg of 32% crude protein supplement per day and ad libitum intake of native grass hay (IFN 1-07-956).

After the 28-day receiving period, all calves consumed a silage diet for 17 days and subsequently grazed native grass for 60 days

TABLE 2. Receiving Rations

| | Diet | | | |
|---|---|---|---|---|
| | 40% Concentrate | | Protein[a] Supplement + Hay | |
| | +K | Control | +K | Control |
| Native grass hay (IFN 1-07-956) | 60.0 | 60.0 | --[b] | --[b] |
| Grain sorghum (IFN 4-08-138) | 27.6 | 29.6 | 11.25 | 24.0 |
| Soybean meal (IFN 4-04-604) | 8.4 | 8.1 | 65.0 | 63.0 |
| Dical phos. (KFN 6-01-080) | 1.44 | 1.44 | 7.63 | 7.63 |
| Salt | .4 | .4 | 2.5 | 2.5 |
| Fat | .2 | .2 | 1.25 | 1.25 |
| Aureomycin 10 | .2 | .2 | 1.25 | 1.25 |
| Trace mineral[c] | .04 | .04 | .25 | .25 |
| Potassium chloride | 1.7 | -- | 10.75 | -- |
| Vitamin A premix[d] | .02 | .02 | .12 | .12 |
| | 100 | | | |
| Crude protein percent (90% D.M.) | 11.37 | | 32.0 | |

[a]The protein supplement was fed at the rate of .90 kg per animal per day.

[b]Native grass hay was fed free choice with .90 kg of protein supplement listed below.

[c]Calcium Carbonate Co. Z10.

[d]Premix contains 30,000 I.U./gram of vitamin A.

from May 15 to July 14. The calves were stocked at twice the normal stocking rate but they grazed the pastures for a time much shorter than normal.

## 5. MANAGEMENT OF CALVES

The calves were weighed, bled, and rumen sample were taken at the OBB. Blood samples were taken upon arrival at the feedlot, as well as on days 7, 14, 21, and 28. Additional rumen samples were taken on days 14 and 28. Weights were taken again on day 28 and at the beginning and end of the 60 day grazing period.

## 6. LABORATORY PROCEDURES

Blood packed-cell volumes (PCV) were determined on whole blood with Wintrobe microhematocrit tubes. Serum samples were frozen for transport to the University of Tennessee Laboratory where serum Na, K, and Mg were determined using atomic absorption spectrophotometry. Whole blood samples were frozen and whole blood K determined by the atomic absorption spectrophotometer.

Isolated bovine lymphocytes were obtained from heparinized blood samples by density gradient centrifugation for lymphocyte blastogenesis determinations. Five milliliters of heparinized blood diluted (1:2) with Rosswell Park Memorial Institute (RPMI) 1640 culture medium (Grand Island Biological Co., Grand Island, NY) supplemented with sodium bicarbonate (24mM), Hepes buffer (25mM), glutamine (6mM), and gentamicin sulfate (Schering Laboratories,

Union, NJ) (100 μg/mL) was layered onto 4 ml of Histopaque-1077 (Sigma Chemical Co., St. Louis, MO). After centrifugation at 400 x g for 40 minutes at 25°C, the lymphocyte layer at the interface of the plasma and Histopaque-1077 was collected. Lymphocytes were washed twice in RPMI 1640 medium and suspended at either 5 x $10^6$ or 2 x $10^6$ cells/ml and in supplemented RPMI 1640 medium containing 10% bovine fetal serum (BFS) (Grand Island Biological Co., Grand Island, NY). Viability of cells isolated by this procedure was determined by trypan blue dye exclusion and was greater than 98%. Two variations of the lymphocyte blastogenesis assay are used in research. However, only the serum evaluation was used in this trial. Serum from stressed calves was tested for its ability to influence lymphocyte blastogenesis. Lymphocytes were isolated from a control nonstressed calf as described earlier and suspended in RPMI 1640 culture medium (without BFS) at 2 x $10^6$ cells/ml. Then, 50 ml of heat-inactivated serum from stressed calves was added to 100 ml of the control lymphocytes (Blecha and Minocha, 1983).

The BVD and IBR antibody titers were assayed by the College of Veterinary Medicine Laboratory at Kansas State University. The serum neutralization assay used requires heating the serum at 56°C for 30 minutes and then mixing dilutions of the serum with a constant dose of virus. The mixtures were allowed to stand for 60 minutes and then assayed for residual infectivity by inoculation into culture cells. The end point of the titration was taken as the highest dilution of antiserum that inhibits the development of cytophatic effects in the

cultured cells. The antibody titers were converted to log 2 for comparison and statistical analysis (Table 3).

Rumen samples were taken by inserting via the animals' mouths a stainless steel strainer attached to tygon tubing (Raun and Burroughs, 1962) directly into the reticulo-rumens of the intact calves. Suction was applied with a 60-cc syringe, and approximately 60 ml of rumen fluid was drawn and discarded before collecting 100 ml for experimental use. Samples which were thick and serous were considered to be contaminated by saliva and were discarded. The position of the strainer was altered until a satisfactory sample was obtained. The fluid was immediately frozen for VFA (Bendix gas chromatograph 2600) analyses.

## 7. STATISTICAL ANALYSIS

The statistical analyses were conducted in two stages. The preliminary analyses of variance were conducted to assess interactions between treatments. Evaluation of the preliminary analyses suggested that there was an interaction between potassium and feedlot diet in the case of some variables. The model used for the final analyses of variance included a term for interaction of potassium and feedlot diet. Orthogonal contrasts were used for mean separation in some treatments to better explain biological significance where differences between treatments occurred. The means are reported as least-squares means because of unequal sub-class numbers.

TABLE 3. Conversion of IBR and BVD Antibody Titers to Log 2 Values

| Antibody Titers | Converted to Log 2 |
|---|---|
| 1/2 | 1 |
| 1/4 | 2 |
| 1/8 | 3 |
| 1/16 | 4 |
| 1/32 | 5 |
| 1/64 | 6 |
| 1/128 | 7 |
| 1/256 | 8 |

# CHAPTER IV

# THE EFFECTS OF LEVAMISOLE AND RECEIVING DIETS ON GAIN AND HEALTH OF STRESSED CALVES

## 1. SUMMARY

A study involving 264 calves (125 bulls and 139 steers) purchased in Tennessee and transported to Kansas was conducted to evaluate the effects of levamisole injections, before and after transit, and feedlot diets on calf performance and health. The calves were held for 48 to 96 hours in the orderbuyer barn (OBB), transported for 24 hours, and fed either a 40% concentrate or hay plus protein-supplement receiving diet for 28 days followed by 17 days on a silage diet. Subsequently, they grazed native grass pasture for 60 days.

Levamisole reduced ($P<.10$) feedlot (FL) mortality in the stressed calves. Evaluation of the response in steers and bulls (castrated upon arrival at the feedlot) suggested a greater response ($P<.05$) in castrated bull calves than in steer calves. Mortality was 4.8% in castrated bull calves injected with levamisole upon arrival at the FL and 12.2% in those injected with levamisole at the OBB compared to 19.0% in the non-injected controls. Due to severe environmental stress caused by low ambient temperature and a cold blowing rain, all calves were diagnosed as morbid and were mass medicated on FL on days three and four. The severe stress resulted in no detectable difference in morbidity among treatment groups.

Serum lymphocyte blastogenesis was higher ($P<.5$) in control calves than in either of the levamisole groups. Levamisole injection resulted also in a trend toward higher IBR antibody titers and greater change in BVD titers during stress. Calves fed the 40%-concentrate diet tended to have higher mortality (12.3%) than those fed hay and protein supplement (8.5%). More ($P<.10$) clinical treatments per calf were required in the concentrate-fed calves than in the hay-fed calves. Due to the super-stress condition during the first week in the FL, the calves required most of the 28-day receiving period to recover purchase weight. Gains during the 28-day period were similar ($P>.05$) in all groups. Calves fed the 40%-concentrate receiving diet gained more ($P<.10$) during the 17-day silage period. There was no appreciable difference in pasture gains between ration groups; however, calves treated with levamisole gained faster ($P<.05$) during the pasture phase than did the control calves.

## 2. INTRODUCTION

Feeder calves undergo numerous stresses during the processes of marketing, transporting, and adapting to FL environments. The adverse effects of these stressors, in combination with viral and bacterial pathogens, can result in an increased incidence of bovine respiratory disease (BRD) (Hoerlein and Marsh, 1957). The two major problems encountered by feedlot operators are the increased incidence of BRD in shipped feeder calves and the difficulty in adaptation of these stressed calves to the FL environment and the

receiving diet. Frequently, the lack of adequate intake of the receiving diet and the failure of the diet to supply nutrient requirements may add to the stress and increase the incidences of BRD.

Lofgreen et al. (1975) found higher average daily gain (ADG) and a higher incidence of BRD in stressed calves fed high-concentrate receiving diets than in calves fed low-concentrate diets. Normally, calves maintained on low-concentrate diets, which result in low ADG during the receiving period, compensate for those low gains with higher than expected gains during subsequent phases. However, Lofgreen et al. (1981) found that calves fed a 75%-concentrate diet gained 13.6 kg more than did calves fed a hay diet supplemented with .9 kg of 40% protein supplement during the receiving period. The calves fed the concentrate diet continued to gain faster (5.4 kg) than the calves fed the hay diet during the subsequent 77-day grazing period on wheat pasture.

Levamisole has been shown to have immunostimulation properties when administered to stressed animals (Soppi et al., 1979; Hogarth-Scott et al., 1980; Confer and Adldinger, 1981; Babiuk and Misra, 1982; Anderson, 1984). Hogarth-Scott et al. (1980) found that the presence of levamisole increased ($P<.05$) the antibody response. Although in some cases it was trivial in degree, this may be qualitatively critical in that it seems generally to eliminate the very low or non-responders to clinical treatment. Irwin et al. (1980) observed a reduction in morbidity in stressed calves when levamisole phosphate was administered as compared to the use of levamisole HCl or thiabendazole.

The objectives of this trial were:

1. to evaluate the effects of time of administration of levamisole in stressed calves on mortality, morbidity, IBR and BVD titers; and

2. to evaluate a 40% concentrate receiving ration as compared to a hay diet supplemented with .9 kg of a 32% crude protein supplement in terms of mortality, morbidity, 28-day gains, and pasture gains.

## 3. MATERIALS AND METHODS

In March 1983, three loads of calves were purchased at auction markets in Eastern Tennessee and Western North Carolina. The 264 mixed-breed calves consisted of 125 bull and 139 steer calves which were randomly assigned to treatment groups within sex at an OBB in Newport, Tennessee. The calves were processed at the OBB and 33% of them were injected with 10 ml of levamisole phosphate (13.65% active ingredient). The calves were allotted in a factorial arrangement with the bulls and steers being allotted into a randomized complete block design within the factorial arrangement.

The calves were held at the OBB for 48 and 96 hours, depending on when they were purchased. The load from North Carolina was purchased first and was in the OBB for the longest period. All calves received .9 kg of cracked corn (IFN 4-02-931) per day plus ad libitum intake of mixed grass hay (IFN 1-01-912, 1-03-438, 1-04-883). The calves were mainly medium-frame, number one muscled calves that were black or red in color. Each load of calves was penned separately at the orderbuyer barn. The three loads of calves traveled together and

were in transit for 24 hours. After their arrival at their destination in Kansas, the calves were immediately processed with another 33% of the calves being injected with levamisole phosphate. All calves were vaccinated for Infectious Bovine Rhinotracheitis (IBR), Bovine Virus Diarrhea (BVD), Parainfluenza$_3$ ($PI_3$) and Blackleg (4 way: malignant edema, blackleg, black disease, and Clostridium sordellii). The bull calves were castrated with a knife, and the cords were stapled with steel staples to reduce bleeding. The calves remained in the FL and consumed the receiving diet for 28 days. The concentrate diet and protein supplement composition is shown in Table 4. This was followed by a holding period of 17 days during which the calves were fed silage. The subsequent pasture phase consisted of 60 days during which the calves grazed native grass from May 15 to July 14.

The calves were weighed, bled, and rumen samples were taken at the OBB. Blood samples were taken upon arrival at the FL, and on FL days 7, 14, 21, and 28. Additional rumen samples were taken on days 14 and 28. Weights were taken again on day 28 and at the beginning and end of the 60-day grazing period.

Packed cell volumes (PCV) were determined on whole blood using Wintrobe microhematocrit tubes. Serum K, serum mg and whole blood K were determined using an atomic absorption spectrophotometry.

Isolated bovine lymphocytes were obtained for lymphocyte blastogenesis from heparinized blood by density-gradient centrifugation. Five milliliters of heparinized blood diluted (1:2) with Rosswell Park Memorial Institute (RPMI) 1640 culture medium (Grand Island Biological

TABLE 4. Receiving Diets

| | IFN | 40% Concentrate % | Protein Supplement + Hay % |
|---|---|---|---|
| Native grass hay | 1-07-956 | 60.0 | --[a] |
| Grain sorghum | 4-08-138 | 29.6 | 24.0 |
| Soybean meal | 4-04-604 | 8.1 | 63.0 |
| Dical Phos. | 6-01-080 | 1.44 | 7.63 |
| Salt | | .4 | 2.5 |
| Fat | | .2 | 1.25 |
| Aureo 10 | | .2 | 1.25 |
| Trace mineral[b] | | .04 | .25 |
| Vitamin A premix[c] | | .02 | .12 |
| | | 100 | 100 |
| Crude protein percent | | 11.37 | 32.0 |

[a]Native grass hay was fed free choice with .90 kg of protein supplement listed below.

[b]Calcium Carbonate Co. 210.

[c]Contains 30,000 I.U./gram of vitamin A.

Co., Grand Island, NY) supplemented with sodium bicarbonate (24mM), Hepes buffer (25mM), glutamine (6mM), and gentamicin sulfate (Schering Laboratories, Union, NJ) (100 μg/ml) was layered onto 4 ml of Histopaque-1077 (Sigma Chemical Co., St. Louis, MO). After centrifugation at 400 x g (gravity) for 40 minutes at 25°C, the lymphocyte layer at the interface of the plasma and Histopaque-1077 was collected. Lymphocytes were washed twice in RPMI 1640 medium and suspended at either $5 \times 10^6$ or $2 \times 10^6$ cells/ml in supplemented RPMI 1640 medium containing 10% bovine fetal serum (BFS) (Grand Island Biological Co., Grand Island, NY). Viability of cells isolated by this procedure was determined by trypan blue dye exclusion and was greater than 98%. Two variations of the lymphocyte blastogenesis assay have been used in research similar to this study. However, only the serum evaluation was used in this trial. Serum from stressed calves was tested for its ability to influence lymphocyte blastogenesis. Lymphocytes was isolated from a control nonstressed calf as described earlier and suspended in RPMI 1640 culture medium (without BFS) at $2 \times 10^6$ cells/ml. Then, 50 ml of heat-inactivated serum from stressed calves was added to 100 ml of the control lymphocytes. All other aspects of the lymphocyte blastogenesis assay were conducted as described earlier (Blecha and Minocha, 1983).

The BVD and IBR antibody titers were assayed by the College of Veterinary Medicine Diagnostic Laboratory at Kansas State University. A serum neutralization assay which required heating the serum at 56°C for 30 minutes and mixing varying dilutions of the serum with a

constant dose of virus was used. The mixtures of diluted serum and virus were allowed to stand for 60 minutes and were then assayed for residual infectivity by inoculation into culture cells. The end point of the titration was taken as the highest dilution of antiserum that inhibited the development of cytophatic effects in the cultured cells. The antibody titers were converted to log base 2 for comparison and statistical analysis.

Calves were examined daily for visual signs of morbidity and treated when they were subjectively determined to be sick. All calves had their temperatures taken with a digital thermometer at the OBB, on arrival at the feedlot (AFL), and on days 7 and 14. If an animal's temperature was over 40°C, it was treated. The calves were mass medicated on days three and four when a high percentage of the calves were visually sick after 16 hours of exposure to cold driving rain followed by cold temperatures. This exposure resulted in an inordinate percentage of the calves becoming sick followed by a subsequent high death loss. A wide range of antibiotics, indicated by the practicing veterinarian, were used in treating sick calves.

Rumen samples were taken by inserting via the animals' mouths a stainless steel strainer attached to tygon tubing (Raun and Burroughs, 1962) directly into the reticulo-rumens of the intact calves. Suction was applied with a 60 cc syringe, and approximately 60 ml of rumen fluid were drawn and discarded before collecting 100 ml for experimental use. Samples which were thick and serous were considered to be contaminated by saliva and were discarded. The

position of the strainer was altered until a satisfactory sample was obtained. The fluid was immediately frozen for VFA (Bendix gas chromatograph 2600) analyses.

The statistical analysis was conducted in two stages. In preliminary analyses of variance all main effects and their interactions were included in the model to assess interactions among main effects. Evaluation of the preliminary analyses suggested that there was an interaction between potassium and feedlot diet in the case of some variables. The model used for the final analyses of variance included all main effects and terms for significant interactions found in the preliminary analyses. Orthogonal contrasts were used for mean separation in some factors with more than two levels. Because of unequal sub-class numbers, least-squares procedures were used and the results were reported as least squares means.

## 4. RESULTS AND DISCUSSION

Injection with levamisole at the OBB before transit or upon arrival at the feedlot decreased ($P<.10$) mortality in injected calves compared to that of non-injected control calves. The percentages of calves in each group that died were 14.8, 9.6, and 6.8 in control calves, calves injected with levamisole at OBB, and calves injected with levamisole upon FL arrival, respectively (Table 5). However, the analysis of variance suggested a sex by levamisole interaction with respect to feedlot mortality. In steer calves, there was a trend toward a slight reduction in mortality in calves injected with

TABLE 5. Effects of Levamisole and Receiving Diets on Gain and Health of Stressed Feeder Calves

| | Levamisole | | | | Feedlot diet | | |
|---|---|---|---|---|---|---|---|
| | Control | Inject. OBB[f] | Inject. AFL[e] | SE[g] | Hay .9 Kg 32% Protein | 40% Conc. | SE[g] |
| Weight and gain, Kg | | | | | | | |
| Market-Transit Shrink Receiving period (28 days) | 27.1 | 25.1 | 25.9 | 3.94 | 24.8 | 27.3 | 3.21 |
| Purchase to FL[e] day 28 | 5.2 | .64 | 2.6 | 4.46 | 1.95 | 9.7 | 3.64 |
| Silage gain (17 days) | 5.9 | 5.7 | 3.9 | 3.30 | 3.5[b] | 6.8[c] | 2.68 |
| Pasture gain (60 days) | 53.4[b] | 58.9[c] | 59[c] | 4.78 | 58.2 | 56.0 | 3.87 |
| Purchase to end pasture period | 64.1 | 67.7 | 69.3 | 5.51 | 66.2 | 67.9 | 4.53 |
| Health | | | | | | | |
| Mortality, % | 14.8[b] | 9.6[c] | 6.8[c] | .034 | 8.5 | 12.3 | .028 |
| No treatments per animal FI day 7-FL day 28 | .84 | 1.07 | 1.03 | .150 | .84[b] | 1.12[c] | .091 |
| Temperature (°C) FL day 17 | 39.3 | 39.3 | 39.2 | .152 | 39.2[b] | 39.4[c] | .124 |
| No. Lymphocyte[h] blastogenesis FL day 28 | 28.80[b] | 26.50[c] | 29.68[b] | .30 | 29.15[b] | 27.49[c] | .78 |
| Changes OBB[f] to FL day 28 | 3.52 | 1.10[c] | .93[c] | .85 | 2.40 | 1.30 | .71 |
| Changes in BVD antibody titers, Log 2 OBB[f] to FL day 28 | 2.8 | 3.0 | 3.0 | .589 | 3.3 | 2.6 | .481 |
| IBR FL day 28 antibody titers Log 2 | 2.88 | 2.96 | 3.04 | .0247 | 2.95 | 2.97 | .0166 |

[a]Least squares means from model Y = Levamisole, sex, potassium, feedlot-diet, feedlot diet* potassium.

[b,c,d]Means within each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]AFL = Arrival at Feedlot.

[f]OBB = Orderbuyer barn.

[g]SE = Standard Error.

[h]Actual values = tabled values x $10^4$

levamisole at OBB. The main effect of levamisole occurred in calves shipped as bulls and castrated upon AFL. The percentages of mortality in castrated bulls were 19.0, 12.2, and 4.8, for the control calves, those injected with levamisole at OBB, and those injected with levamisole at AFL, respectively. If the effect of levamisole were evaluated from the performance of the steers in this study, one could conclude that vaccination at OBB is preferable. However, in super-stressed calves such as those purchased and transported as bulls and castrated upon AFL, levamisole injected at the time of castration resulted in a lower percentage mortality. This is in agreement with Irwin et al. (1980) who found a lower percent mortality in calves treated with levamisole phosphate following transit stress. The effect of levamisole on morbidity in this study may have been reduced by the mass medication of calves on feedlot days three and four because of the effect of the unusual degree of stress to which they were exposed. From the standpoint of reduced mortality, it appears that the best results would be obtained by administering levamisole to calves after they are subjected to stress. This hypothesis was supported by Symoens and Rosenthal (1977) who stated that levamisole restored immune function in compromised hosts but had little or no effect in normal hosts.

The mean change in serum lymphocyte blastogenesis based on the OBB and FL-day-28 determinations were higher ($P<.05$) in the control calves than in calves treated with levamisole at either OBB or AFL (Tables 5 and 6). However, the level of lymphocyte blastogenesis

TABLE 6. Analysis of Variance of the Effects of Levamisole and Receiving Diets on Gain and Health of Stressed Feeder Calves

| Source | df | Mean Square (gain) During Receiving Period | Purchase to FL 28 | Silage Gain (17 d) | Pasture Gain (60 d) | Purchase to End Pasture Period | % Mortal. | No. Treat. Per Animal FL 7 FL 28 | Temperature FL 14 | Serum Lymphocyte Blasto. FL 28[a] | Changes in Serum Lymphocyte Blasto. No. OBB/FL 28[a] | Changes in BVD Antibody Titers Log 2 | IBR FL Day 28 Antibody Titers Log 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levamisole | 2 | 329.5 | 1794 | 401.4 | 3474† | 2489.2 | .13† | 1.34 | .93 | 1921.12* | 1386.7 | .306 | .411 |
| Sex | 1 | 37761.1*** | 27224*** | 1089.4 | 8355** | 61460.5*** | .18† | 2.69 | 1.79 | 3831.01** | 4784.12** | 1.02 | .259 |
| Potassium | 3 | 235.1 | 342.6 | 904.7 | 369 | 2892.87 | .11 | .60 | .92 | 651.1 | 308.91 | .60 | 1.452 |
| Feedlot diet | 1 | 1652.1 | 801.9 | 2736.5* | 1182 | 734.8 | .08 | 4.8† | 5.71* | 1422.34† | 621.4 | 6.78 | .045 |
| Feedlot diet *potassium interaction | 3 | 72.9 | 146.2 | 668.5 | 2404 | 643.4 | .05 | .379 | 3.62† | 1382.12† | 678.67 | 5.16 | .896 |
| Residual | | 1104.1 | 1432 | 731.7 | 1529.8 | 2280.5 | .0918 | 1.84 | 1.69 | 60.4 | 506.12 | 6.25 | 1.709 |
| Residual df | | 204 | 206 | 204 | 205 | 212 | 233 | 233 | 212 | 207 | 207 | 45 | 207 |

†P<.10, *P<.05, **P<.01, ***P<.001.

[a]Actual values = Table values x $10^7$.

was higher in calves injected with levamisole AFL than in the other groups at both OBB and FL day 28. Even though these differences appear real (low probabilities of chance occurrence), the magnitude of the difference was small. The observed lower lymphocyte blastogenesis change in the levamisole group may be an artifact partly due to the higher survival rate in the levamisole-injected calves following the severe stress to which the calves were subjected to during the first week in the FL. This could have resulted in a larger percentage of the calves in the injected groups exhibiting a lower immune response because of the earlier effect of levamisole on the immune system.

Levamisole has been shown to increase antibody titers when administered with a vaccine (Hogarth-Scott et al., 1980; Babiuk and Misra, 1981). The levamisole-injected calves in this study had been vaccinated against BVD and IBR which resulted in a trend toward a large change in BVD antibody titers and also a higher IBR antibody titer at FL day 28. The degree of stress in this trial may have reduced the ability of the IBR and BVD vaccines to produce high IBR and BVD titers.

Propionate was higher ($P<.10$) in both levamisole groups than in the control group at FL day 28 (Tables 7 and 8). This may simply reflect the effects of levamisole on the health of the calves. Numerous reports have suggested that increased feed intake resulted in increased propionate production. It can be assumed that healthy calves had higher intake. However, differences in intake could not be determined in this study, which may aid in explaining the higher propionate production (Table 7).

TABLE 7. Effects of Levamisole and Receiving Diets on Rumen Parameters of Stressed Feeder Calves

| | Least squares mean[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| | Levamisole | | | | Feedlot diet | | |
| | Control | Injected OBB[e] | Injected AFL[f] | SE[g] | Hay .9 kg 32% Protein | 40% Conc. | SE[g] |
| Rumen | | | | | | | |
| VFA's mm/L. | | | | | | | |
| OBB | 113.6 | 113.1 | 102.4 | 10.37 | 113.7 | 105.7 | 8.47 |
| FL[e] day 14 | 86.4 | 82.0 | 72.9 | 6.01 | 70.3[b] | 90.3[c] | 4.97 |
| FL day 28 | 74.5 | 74.9 | 72.5 | 4.79 | 77.3[b] | 70.6[c] | 3.9 |
| Propionate, Molar % | | | | | | | |
| FL day 14 | 12.7[b] | 12.4[b] | 11.2[c] | .0053 | 11.6[c] | 12.6[c] | .0044 |
| FL day 28 | 12.2[c] | 13.2[b] | 13.5[b] | .0039 | 12.8 | 13.1 | .0033 |
| Acetate, Molar % | | | | | | | |
| FL day 14 | 71.8 | 74.4 | 74.4 | .0093 | 75.9[b] | 71.8[c] | .0075 |
| FL day 28 | 74.6 | 74.2 | 74.1 | .00073 | 77.9[b] | 71.7[c] | .0059 |

[a]Least squares means from model Y = Levamisole, SEX, Potassium, Feedlot diet, Feedlot diet* Potassium.

[b,c,d]Means within each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]OBB = Orderbuyer barn.

[f]AFL = Arrival at Feedlot.

[g]SE = Standard Error.

TABLE 8. Analysis of Variance of the Effects of Levamisole and Receiving Diets on Stressed Feeder Calves

| | | Mean Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | VFA's | | | Propionate | | Acetate | |
| Source | df | OBB | FL 14 | FL 28 | FL 14 | FL 28 | FL 14 | FL 28 |
| Levamisole | 2 | 538 | 620 | 17.8 | .0008≠ | .00055≠ | .00126 | .000084 |
| Sex | 1 | 1345 | 480 | 15.8 | .0001 | .00002 | .00095 | .000016 |
| Potassium | 3 | 2822 | 838 | 912.2* | .0003 | .0003 | .00022 | .00013 |
| Feedlot diet | 1 | 679 | 3762≠ | 375≠ | .00089≠ | .000079 | .0156*** | .0229*** |
| Feedlot diet *Potassium interaction | 3 | 1231 | 60 | 793* | .00023 | .00019 | .0026* | .0009 |
| Residual | | 1506 | 470 | 276 | .0003 | .00019 | .001 | .0064 |
| Residual df | | 33 | 29 | 26 | 29 | 26 | 29 | 26 |

≠P<.10, *P<.05, **P<.01, ***P<.001.

The receiving diets (hay vs concentrate) did not appreciably affect gain during the 28-day receiving period. This may have resulted from the super-stressed calves requiring most of the 28 days to recover purchase weight. The castrated bull calves had not recovered purchase weight after 28 days. This is not in complete agreement with results from Lofgreen et al. (1975) who reported that calves fed concentrate diets gained more than those fed hay plus protein supplement during the 28 day receiving period. However, the amount of stress to which these calves were subjected may have nullified the ration effect with respect to performance, since little gain was made except recovery of rumen fill and tissue shrink during this 28-day period.

Lofgreen et al. (1981) reported a higher ADG on wheat pasture following a 75% concentrate receiving diet compared to a hay-plus-protein supplement diet. In this study, calves fed the 40% concentrate receiving diet gained more ($P<.05$) during the 17-day silage period than calves fed the hay receiving diet (Table 5). However, pasture gains were similar in calves fed both rations. There was a trend toward a higher mortality in the concentrate fed calves with 12.3% of those calves dying as compared to 8.5% of the hay fed calves.

The main receiving diet effects were observed in the castrated bulls. Morbidity was 14.3% in those fed the concentrate receiving diet as compared to 9.7% of those fed the hay diet. Little difference in mortality was observed between the steers fed the two diets (7.2 vs 8.7% for hay and 40%-concentrate diets, respectively). Calves fed the 40%-concentrate diet required more ($P<.10$) medical treatments

per calf from FL day 7 to FL day 28 than did those fed hay. This is in agreement with Lofgreen et al. (1975) and Gill et al. (1980) who suggested that a higher-energy receiving ration resulted in a higher incidence of sickness.

The calves fed the 40%-concentrate diet had higher ($P<.05$) body temperature at FL day 14 than did the calves fed the hay diet. Also, there was a trend toward a greater change in lymphocyte blastogenesis and BVD antibody titers in the hay fed calves compared to the concentrate fed calves (Table 5). All health parameters favored the hay plus protein supplement diet in super-stressed calves as compared to a 40%-concentrate diet. The hay diet was even more favorable when evaluated with respect to the health of stressed castrated bull calves. The 40%-concentrate diet resulted in a higher ($P<.10$) level of total VFA and molar percent of propionate at FL day 14 than did the hay diet (Tables 7 and 8) (Figures 1 and 2) but a higher ($P<.10$) molar percentage of acetate was found in calves fed the hay diet. The calves consumed slightly more of the 40%-concentrate diet than of the hay-plus-protein-supplement diet (Table 9).

In super-stressed calves, a hay-plus-protein-supplement diet may be the most desirable receiving ration. However, in calves subjected to a lesser degree of stress a higher-energy ration may be prefered because of the increase in gains on such a ration.

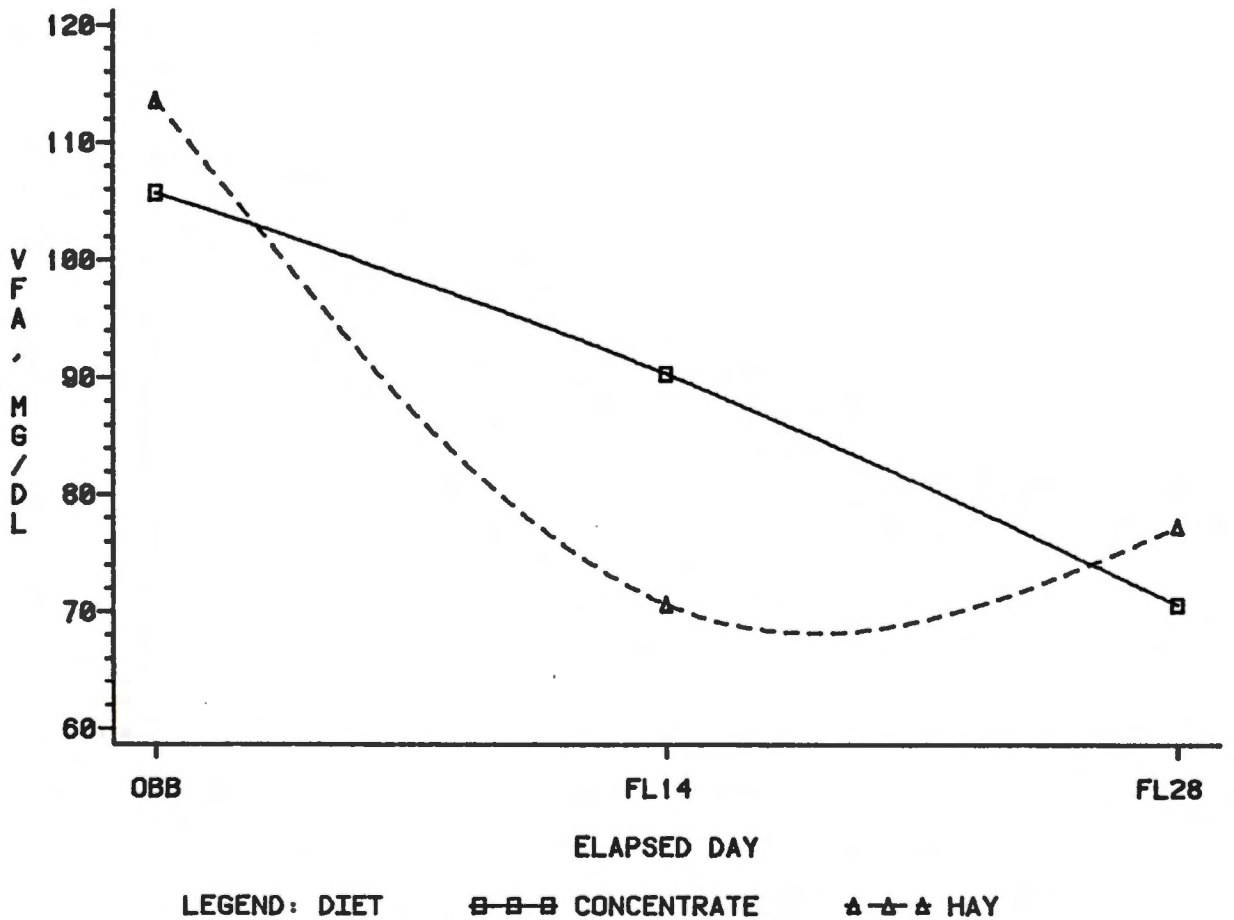


FIGURE 1. Effect of feedlot diet on VFA.

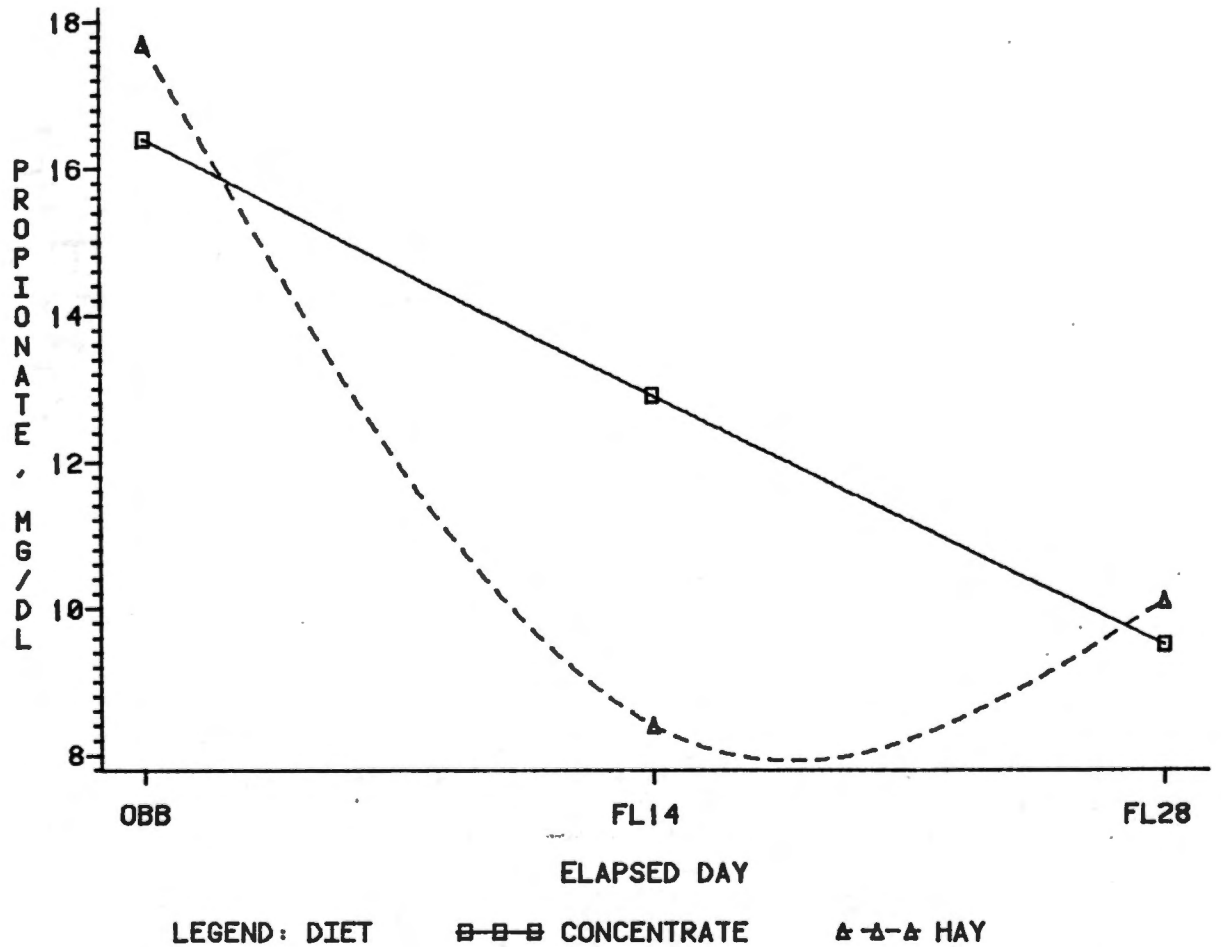


FIGURE 2. Effect of feedlot diet on propionate level.

TABLE 9. The Effects of Receiving Diet on Intake of Stressed Calves

| Feed Intake | Hay+.9 Kg. 32% Protein | 40% Concentrate |
|---|---|---|
| | --------Kg. Dry Matter Intake/Animal/Day------- | |
| Day 1-7 | 3.85 | 4.01 |
| Day 8-14 | 5.15 | 5.63 |
| Day 15-28 | 6.40 | 6.50 |
| Day 1-28 | 5.45 | 5.67 |
| Total Digestible Nutrients (TDN) Intake per day | 6.21 | 7.41 |
| Crude Protein Intake per day | 1.42 | 1.57 |

# CHAPTER V

# PRE- AND POST-TRANSIT POTASSIUM ON THE PERFORMANCE OF STRESSED CALVES

## 1. SUMMARY

A study involving 264 calves purchased in Tennessee and transported to Kansas was conducted to evaluate the effects of pre-transit and post-transit potassium (K) on the performance, health, and blood chemistry of stressed feeder calves. The control pre-transit diet consisted of .9 kg of cracked corn and grass hay which contained 1.0% K. One group of calves was fed the control diet supplemented plus potassium chloride (KCL) to provide 1.5% dietary K which was compared to the 1.0%-K control diet.

The post-transit diets were formulated to contain 1.1% or 1.7% potassium. The two pre-transit diets and the two post-transit diets were arranged as a 2 x 2 factorial layout to produce four treatment combinations. The pre-transit diet was fed for four days at the order-buyer barn (OBB) with all calves receiving their allotted diet for a minimum of three days before shipment. Feeding calves the 1.5%-K pre-transit diet resulted in a lower weight loss (2.85 kg) due to transit than did feeding the control diet. No appreciable difference in weight gains during the receiving period were observed in calves fed the different diets.

Fewer of the calves fed the 1.5%-K pre-transit diet died during the first three days in the feedlot than of those fed the control diet.

The post-transit K (1.7%-K) diet resulted in a trend toward higher percent mortality during the receiving period.

## 2. INTRODUCTION

Nutritional practices to which calves are subjected before and after transit have a major influence on subsequent performance and health of those feeder calves. Therefore, different diets and management systems may be required for different groups of calves.

Potassium has been recognized as a nutritionally important mineral for many years and is a major factor in cellular osmotic balance. When body dehydration occurs, water is lost from the extracellular compartment and is replaced by intracellular water (Hutcheson et al., 1984). Stress of calves during shipment has been reported to result in an increase in plasma corticoid level (Phillips et al., 1982) which causes excretion of K and retention of sodium (Na). Thus, when stress occurs during periods when calves are deprived of feed and water, cellular and gut dehydration result. In severe cases, cellular K deficiency occurs and this deficiency prolongs the period required for re-hydration.

Preliminary information regarding the effects of increasing the K level of feedlot (FL) receiving diets was presented by Hutcheson et al. (1984) in the Fall of the year (October, November). The effect of supplementing the pre-transit diet with K was also studied in a small pilot trial by Hamlett et al. (1983). However, no conclusive evidence was reported with respect to the effect of

adequate K intake before transit or transit shrink and feedlot performance.

The objectives of this experiment were to determine effects of: (1) additional K in pre-transit diets; (2) addition of K in post-transit diets; and (3) addition of K in both pre-transit and post-transit diets on the performance, health and blood chemistry of transported calves.

## 3. MATERIALS AND METHODS

In March 1983, three truckloads of calves were purchased at auction markets in Eastern Tennessee and Western North Carolina. The 264 mixed-breed calves, consisting of 125 bulls and 139 steers, were assembled at an orderbuyer barn (OBB) in Newport, Tennessee. The calves were allotted in a factorial arrangement with the bulls and steers being allotted into a randomized completed block design. The calves were fed .9 kg of cracked corn at the OBB with half of the calves receiving potassium chloride added to the cracked corn to increase the K level from 1.0% to 1.5%. The calves were held at the OBB for 48 to 96 hours, depending on when they were purchased. All calves received at least three days of supplemental corn or corn and potassium at the OBB. The load of calves from North Carolina was purchased first and remained at the OBB for the longest time. The calves received an ad libitum intake of grass hay. Each load of calves was penned separately at the OBB. The calves were in transit for 24 hours. At the feedlot they were fed four receiving

diets of hay or concentrate with and without increased potassium levels (Table 10).

After arrival at their destination in Kansas, the calves were immediately processed. All calves received vaccinations for Infectious Bovine Rhinotracheitis (IBR), Bovine Virus Diarrhea (BVD), Parainfluenza$_3$ ($PI_3$), and Blackleg (malignant edema, blackleg, black disease and Clostridium sordellii). The bull calves were castrated with a knife and the cords were stapled with steel staples to reduce bleeding.

The calves were weighed, bled, and rumen samples were taken at the OBB. Additional blood samples were taken upon arrival at the feedlot, and on feedlot days 7, 14, 21, and 28. Additional weights were taken at the start and at the end of the 60-day grazing period.

Packed cell volumes (PCV) were determined on whole blood with Wintrobe microhematocrit tubes. Serum Na, serum K, and serum Mg and whole blood K were determined in the laboratory using atomic absorption spectrophotometry.

Serum samples from stressed calves were evaluated for ability to influence lymphocyte blastogenesis using methods described by Blecha and Minocha (1983). The BVD and IBR antibody titers were determined by the Department of Veterinary Medicine Diagnostic Laboratory at Kansas State University. A serum neutralization assay was used that requires heating the serum at 56°C for 30 minutes and then mixing various dilutions of the serum with a constant dose of virus. The mixtures are allowed to stand for 60 minutes and then were assayed for residual infectivity by inoculation into culture

TABLE 10. Receiving Rations

| | Diet | | | |
|---|---|---|---|---|
| | 40% Concentrate | | Protein[a] Supplement + Hay | |
| | +K | Control | +K | Control |
| Native grass hay (IFN 1-07-956) | 60.0 | 60.0 | --[b] | --[b] |
| Grain sorghum (IFN 4-08-138) | 27.6 | 29.6 | 11.25 | 24.0 |
| Soybean meal (IFN 4-04-604) | 8.4 | 8.1 | 65.0 | 63.0 |
| Dical phos. (KFN 6-01-080) | 1.44 | 1.44 | 7.63 | 7.63 |
| Salt | .4 | .4 | 2.5 | 2.5 |
| Fat | .2 | .2 | 1.25 | 1.25 |
| Aureomycin 10 | .2 | .2 | 1.25 | 1.25 |
| Trace mineral[c] | .04 | .04 | .25 | .25 |
| Potassium chloride | 1.7 | -- | 10.75 | -- |
| Vitamin A premix | .02 | .02 | .12 | .12 |
| | 100 | | 100 | |
| Crude protein % (90% D.M.) | 11.37 | | 32.0 | |

[a]The protein supplement was fed at the rate of .90 kg per animal per day.

[b]Native grass hay was fed free choice with .90 kg of protein supplement listed below.

[c]Calcium Carbonate Co. Z10

[d]Premix contains 30,000 I.U./gram of vitamin A.

cells. The end point of the titration was taken as the highest dilution of antiserum that inhibited the development of cytophatic effects in the cultured cells.

Calves were examined daily for visual signs of morbidity. All calves had their temperature taken with an electrical thermometer upon arrival at the feedlot and on feedlot days 7 and 14. Animals with temperatures over 40°C were treated. After standing in 16 hours of driving rain, all calves were treated with antibiotics on feedlot days three and four. A wide range of antibiotics was suggested and used by a practicing veterinarian.

Preliminary analyses of variance were conducted to determine differences among main affects and to determine if any interaction existed. Evaluation of the preliminary analyses suggested that interaction in the case of some variables occurred between feedlot diets and potassium level. Therefore, these interactions were included in the model for the final analyses of variance. Due to unequal subgroup numbers, the results were expressed as least-squares means.

## 4. RESULTS AND DISCUSSION

Calves fed the 1.5%-K diet at the OBB lost ($P<.10$) 2.85 kg less weight during the 24-hour transit than did calves fed the 1.0%-potassium diet (Table 11). During the receiving period, weight gains of the calves fed the K control diet at both the OBB and the feedlot and those fed diets containing higher levels of K at the

TABLE 11. Effects of Potassium on Gain and Health of Stressed Feeder Calves

| | Least-squares means[a] | | | | |
|---|---|---|---|---|---|
| | Control | Feedlot K | OBB K | Feedlot and OBB K | SE[e] |
| **Gain, kg** | | | | | |
| Market-transit shrink | -25.1[bd] | -23.6[cd] | -19.9[c] | -23.1[c] | 2.35 |
| Receiving period (28 days) | 26.5 | 26.2 | 24.7 | 26.8 | 4.52 |
| Purchase to FL day 28 | 1.18 | 2.91 | 3.64 | 3.56 | 5.15 |
| Silage gain (17 days) | 7.9 | 3.27 | 4.6 | 4.86 | 3.79 |
| **Health** | | | | | |
| Mortality % | 7.3[b] | 16.6[c] | 7.9[b] | 9.9[b] | .0388 |
| **No. treatments per animal** | | | | | |
| FL day 7 to FL day 28 | 1.00 | 1.09 | .98 | .85 | .175 |
| AFL to FL day 28 | 3.34 | 3.73 | 3.47 | 3.25 | .246 |
| **Temperature (°C)** | | | | | |
| AFL | 39.9 | 40.0 | 39.82 | 39.85 | .186 |
| FL day 7 | 39.64 | 39.68 | 39.75 | 39.54 | .191 |
| FL day 14 | 39.1 | 39.3 | 39.3 | 39.3 | .174 |
| **Changes in BVD antibody titers log 2** | | | | | |
| OBB, FL day 28 | 2.80 | 2.97 | 3.14 | 2.78 | .668 |
| IBR, FL day 28 | 3.02[b] | 2.71[c] | 3.08[b] | 3.04[b] | .181 |
| Changes in serum lymphocyte blastogeneses no. OBB to FL day 28 | 28094 | 16080 | 9870 | 19881 | 31817 |

[a]Least-squares means from model Y = Levamisole, Potassium, Feedlot diet, Feedlot diet Potassium.

[bcd]Means with each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]SE = Standard Error.

feedlot, at the OBB, or at both the OBB and the feedlot were similar (Table 11). This is in partial agreement with results from Hutcheson et al. (1984) who reported that when a high energy diet was fed three days prior to shipping, additions of K during the receiving period did not affect performance of the animals. In this case, the improved OBB diet which was supplemented with K resulted in less shrink during transit, and the calves arrived at the feedlot in less nutritional stress. The failure of the calves fed the higher K diet at the OBB to respond to the higher K diets at the feedlot was similar to results of Cole et al. (1979) and Hamlett et al. (1983). In both studies, an interaction ($P<.10$) between pre- and post-transit diet with respect to calf health and performance was observed.

When a 1.7%-potassium diet was fed at the feedlot, there was a trend toward a higher percent mortality than when the 1.1%-potassium diet was fed. In calves fed the control (1.0%-K) diet at the OBB, mortality was higher ($P<.10$) when the supplemental potassium was added to the receiving diet (Tables 11 and 12). Hutcheson et al. (1984) found an increase ($P<.05$) in mortality in calves fed a diet supplemented at a low level (.7%-K) and a high level (3.1%-K). The 1.7%-K diet fed the highly stressed calves in this study may have produced a condition similar to that produced by the higher K diets (3.1%-K) Hutcheson et al. (1984) fed to calves that were subjected to less stress. The depressed gains and increased morbidity associated with calves fed additional K at both the OBB and the feedlot which were reported by Hamlett et al. (1983) were not observed

TABLE 12. Analysis of Variance of the Effects of Potassium on Gain and Health of Stressed Feeder Calves

| Source | df | Mean Square (gain) Market Transit Shrink | Receiving Period 28 Days | Purchase to FL 28 | Silage Gain 17 Days | Percent Mortality | No. Treat. per Animal FL 7-FL 28 | AFL-FL 28 | Temperaure °C AFL | FL 7 | FL 14 | Changes in BVD Antibody Titers Log 2 OBB-FL 28 | IBR Antibody Titers Log FL d 28 | Changes in Serum Lymphocyte Blastogenesis No. OOB-FL 28[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levamisole | 2 | 572 | 329 | 1794 | 402 | .13† | 1.34 | 3.45 | .99 | .01 | .93 | .306 | .411 | 1.4* |
| Sex | 1 | 1269† | 37761*** | 27224*** | 1089 | .18† | 2.69 | 23.87*** | 16.6** | 3.9† | 1.79 | 1.02 | .259 | 4784.2* |
| Potassium | 3 | 1498† | 235 | 343 | 9714 | .11† | .60 | 2.57 | 2.15 | 1.44 | .92 | .60 | 1.452† | 308.9 |
| Feedlot diet | 1 | 3.2 | 1652 | 801 | 2736* | .08 | 4.8† | 6.49 | 6.5† | 3.0 | 5.71* | 6.78 | .045 | 621.4 |
| Feedlot diet Potassium | 3 | 344 | 72.7 | 146 | 668 | .05 | .379 | 1.15 | 1.8 | 2.47 | 3.62† | 5.16 | .896 | 678.7 |
| Residual | | 374 | 1104 | 1432 | 731 | .0918 | 1.84 | 3.68 | 2.15 | 2.01 | 1.69 | 6.25 | 1.709 | 5.1 |
| Residual df | | 245 | 204 | 206 | 194 | 233 | 233 | 233 | 247 | 215 | 212 | 45 | 207 | 207 |

†P<.10, *P<.05, **P<.01, ***P<.001.

[a]Actual values = table values x $10^7$.

in the present study. The degree of stress that results from shipment may influence the optimum level of potassium that should be included in a receiving diet.

One calf fed supplemental potassium at the OBB died during the first three days at the feedlot compared to three calves in the control group. It appears that the effect of K at the OBB may be short-lived if the calves are subjected to severe stress at the feedlot. Calves in this study were subjected to 16 hours of driving rain, chilling temperatures and castration upon arrival at feedlot. The benefit of feeding K at the OBB may have been greater if the calves were exposed to less feedlot stress.

The number of clinical treatments required per animal, rectal temperature on various feedlot days, and BVD antibody titers changes were similar ($P>.05$) in calves fed diets containing the different K levels at the OBB or feedlot (Tables 11 and 12). However, trends in IBR antibody titers at feedlot day 28 were similar to the trends with respect to mortality in calves fed K only at the feedlot. These calves had lower IBR titers than those in the other groups.

Rumen VFA concentration at feedlot day 28 was lower ($P<.10$) in the control calves than in the calves fed supplemental K (Tables 13 and 14). Rumen K concentrations were higher ($P<.01$) at feedlot day 14 in calves fed the 1.7%-K diet at the feedlot (Tables 13 and 14).

Mean packed cell volume (PCV) of the various groups ranged from 41.8 to 43.3 at orderbuyer barn. This agrees with Phillips

TABLE 13. Effects of Potassium on Rumen and Blood Parameters

| | Least-squares means[a] | | | | |
|---|---|---|---|---|---|
| | Control | Feedlot K | OBB K | Feedlot and OBB K | SE[g] |
| **Rumen** | | | | | |
| VFA's, mm/L | | | | | |
| FL[e] day 14 | 80.3 | 76.7 | 72.0 | 92.8 | 6.86 |
| FL day 28 | 58.9[c] | 75.3[b] | 80.8[b] | 80.9[b] | 5.54 |
| Propionate, molar % | | | | | |
| FL day 28 | 12.6 | 12.3 | 13.3 | 13.6 | .00465 |
| Acetate molar % | | | | | |
| FL day 28 | 74.4 | 74.8 | 73.9 | 73.9 | .0084 |
| Potassium mg/DL | | | | | |
| FL day 14 | 77.4[b] | 127.2[c] | 85.0[b] | 114.6[c] | 11.97 |
| FL day 28 | 61.9 | 68.0 | 59.3 | 76.6 | 10.26 |
| **Blood** | | | | | |
| Pack cell volume % | | | | | |
| OBB[f] | 43.2 | 42.6 | 43.3 | 41.8 | .867 |
| FL day 14 | 32.1 | 31.9 | 33.1 | 31.7 | 1.28 |
| FL day 28 | 33.9 | 33.9 | 34.4 | 33.8 | .645 |
| **Potassium** | | | | | |
| Whole blood, mg/100 ml | | | | | |
| OBB | 34.9 | 34.7 | 34.4 | 33.9 | 1.06 |
| FL day 14 | 20.9 | 25.0 | 26.7 | 24.8 | 3.02 |
| FL day 21 | 25.5 | 27.5 | 25.4 | 26.5 | 2.87 |
| FL day 28 | 26.3 | 26.2 | 25.9 | 25.8 | 1.61 |
| Serum mg/100 ml | | | | | |
| OBB | 21.7 | 21.6 | 20.7 | 20.8 | .355 |
| FL day 14 | 24.9 | 22.5 | 25.8 | 23.8 | 1.320 |
| FL day 21 | 19.1[bd] | 17.2[d] | 18.6[b] | 18.0 | .36 |
| FL day 28 | 19.6 | 19.8 | 19.7 | 20.5 | .396 |
| **Magnesium** | | | | | |
| Serum mg/100 ml | | | | | |
| OBB | 2.292 | 2.36 | 2.296 | 2.287 | .041 |
| FL day 14 | 2.114 | 1.957 | 2.091 | 2.050 | .067 |
| FL day 21 | 2.352 | 2.229 | 2.275 | 2.228 | .072 |
| FL day 28 | 2.247[b] | 2.198[c] | 2.222[bc] | 2.210[c] | .036 |

[a]Least-squares means from modely = Levamisole, SEX, Potassium, Feedlot diet, Feedlot diet* Potassium.

[b,c,d]Means with each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]FL = Feedlot

[f]OBB = Orderbuyer barn.

[g]SE = Standard Error.

TABLE 14. Analysis of Variance of the Effects of Potassium on Rumen and Blood Parameters

| | | Mean Square | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VFA | | | | | | Blood | | | | | | | | | | | | | |
| | | Total | | Propionate | Acetate | Rumen potassium | | Packed cell volume | | | Whole blood potassium | | | | Serum Potassium | | | | Serum Magnesium | | | |
| Source | df | FL 14 | FL 28 | FL 28 | FL 28 | FL 14 | FL 28 | OBS | FL 14 | FL 28 | OBS | FL 14 | FL 21 | FL 28 | OBS | FL 14 | FL 21 | FL 28 | OBS | FL 14 | FL 21 | FL 28 |
| Levamisole | 2 | 620 | 17.8 | .00056† | .000083 | 55.2 | 974 | 51.5 | 9.7 | 34.5 | 4.7 | 314.4 | 149 | 13.1 | 9.3 | 76.6 | 2.31 | .92 | .048 | .009 | .015 | .125 |
| Sex | 1 | 480 | 15.8 | .00002 | .000006 | 2772 | 4439* | 1.43 | 23.1 | 104 | 2.12 | .54 | 14.3 | 101.4† | .79 | 7.3 | 9.17* | 3.08 | .241 | .243 | .233 | .248 |
| Potassium | 3 | 838 | 912.2* | .000304 | .00013 | 5677.5** | 616 | 29.9 | 6.83 | 3.03 | 10.2 | 94 | 13.7 | 1.37 | 15.15 | 31.45 | 9.33* | 8.6 | .333 | .075 | .047 | .149 |
| Feed-diet | 1 | 3726† | 37.5 | .000079 | .02291*** | 1119.7 | 2661† | 17.7 | .197 | 0.11 | 16.7 | 10.2 | 4.1 | .075 | 6.45 | .478 | 5.43 | 7.7 | .114 | .048 | .016 | .126 |
| Feed-diet potassium interaction | 3 | 60 | 793* | .000192 | .00096 | 835.9 | 1833† | 19.2 | 9.6 | 37.5 | 57.3 | 98.7 | 166.8 | 32.0 | 1.33 | 25.6 | 1.89 | 8.27 | .089 | .022 | .049 | .037 |
| Residual | | 470 | 276 | .00019 | .00064 | 1434.9 | 948.3 | 45.0 | 24.5 | 22.5 | 68 | 137 | 123.5 | 39.1 | 7.59 | 27.9 | 1.95 | 8.15 | .1 | .061 | .077 | .068 |
| Residual df | | 29 | 26 | 26 | 26 | 32 | 27 | 229 | 51 | 204 | 233 | 53 | 50 | 119 | 232 | 54 | 51 | 199 | 232 | 54 | 51 | 199 |

†P<.10, *P<.05, **P<.01, ***P<.001.

and Eischen (1983) who reported that assembly and transit resulted in packed cell volume in the 41.2 to 43.7 range. Feeding of supplemental potassium at the OBB or at the feedlot had no affect (P>.10) on packed cell volume (Tables 13 and 14) (Figure 3). In addition, whole blood potassium levels were not affected by K treatments (Tables 13 and 14) (Figures 4 and 5). This does not agree with Hutcheson et al. (1984) who observed that an increase in dietary K level resulted in an increase in PCV.

A dietary K level of 1.7% in the receiving ration resulted in a higher (P<.10) serum magnesium (mg) level at feedlot day 28 (Tables 13 and 14) (Figure 6). Greene et al. (1983) found that increased dietary potassium level resulted in a lower absorption of mg. Therefore, supplementing receiving diets with potassium chloride should result in lower mg absorption.

The results of this trial are not in total agreement with the results reported by Hutcheson et al. (1984) with respect to the benefit of supplemental potassium in a receiving ration. Most of the research reported by Hutcheson et al. (1984) was conducted in the fall of the year when most of the forage would be lower in potassium. The present trial was conducted in the spring when most of the forage that the calves consumed in Tennessee prior to transit was probably high in potassium content. Ech et al. (1981), Reid et al. (1970), Baker (1977), and Steen et al. (1979) found that the potassium levels in tall fescue during the spring ranged from 2.7% to 3.64%. The higher potassium level of the forage consumed

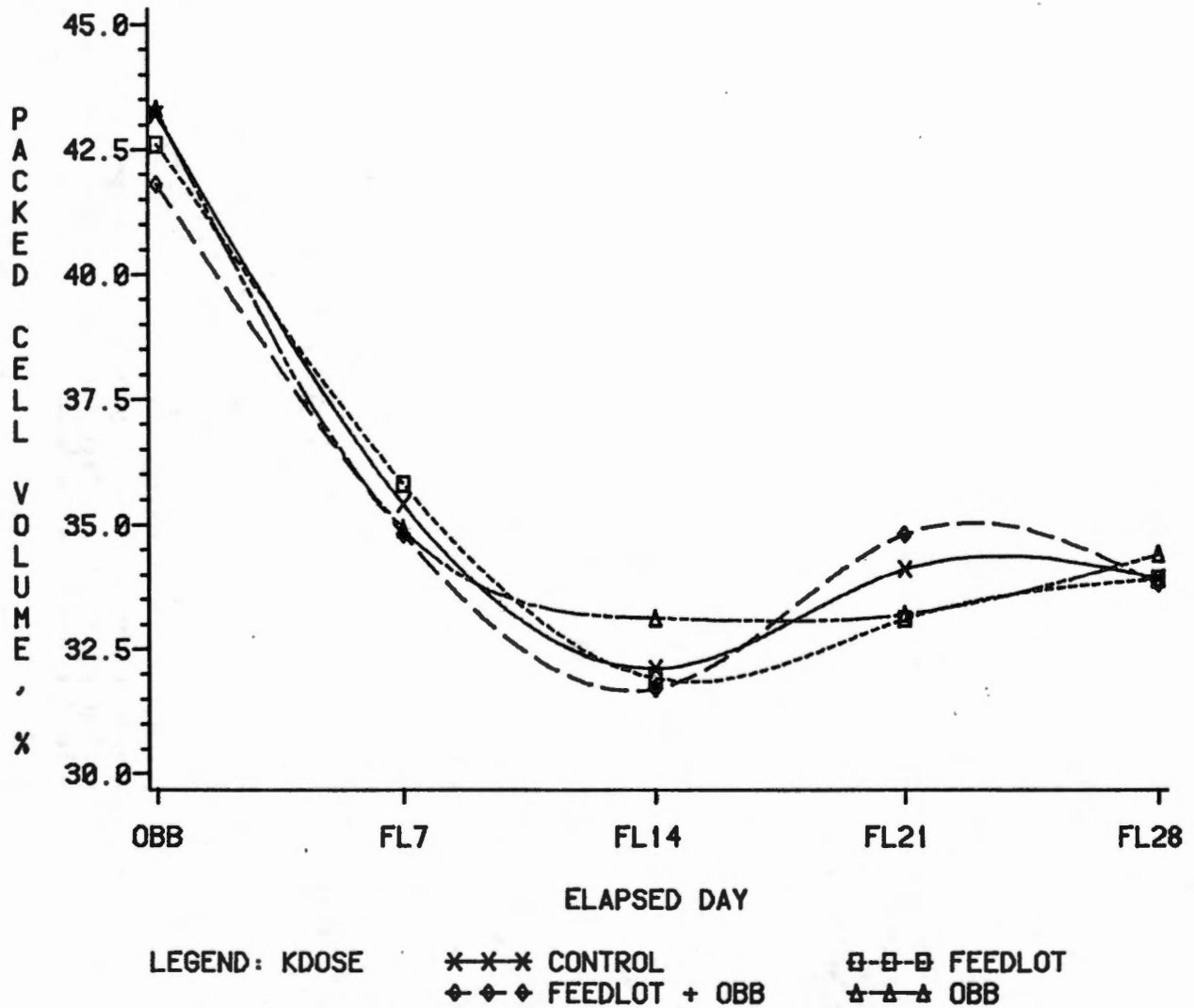


FIGURE 3. Effect of potassium level on packed cell volume.

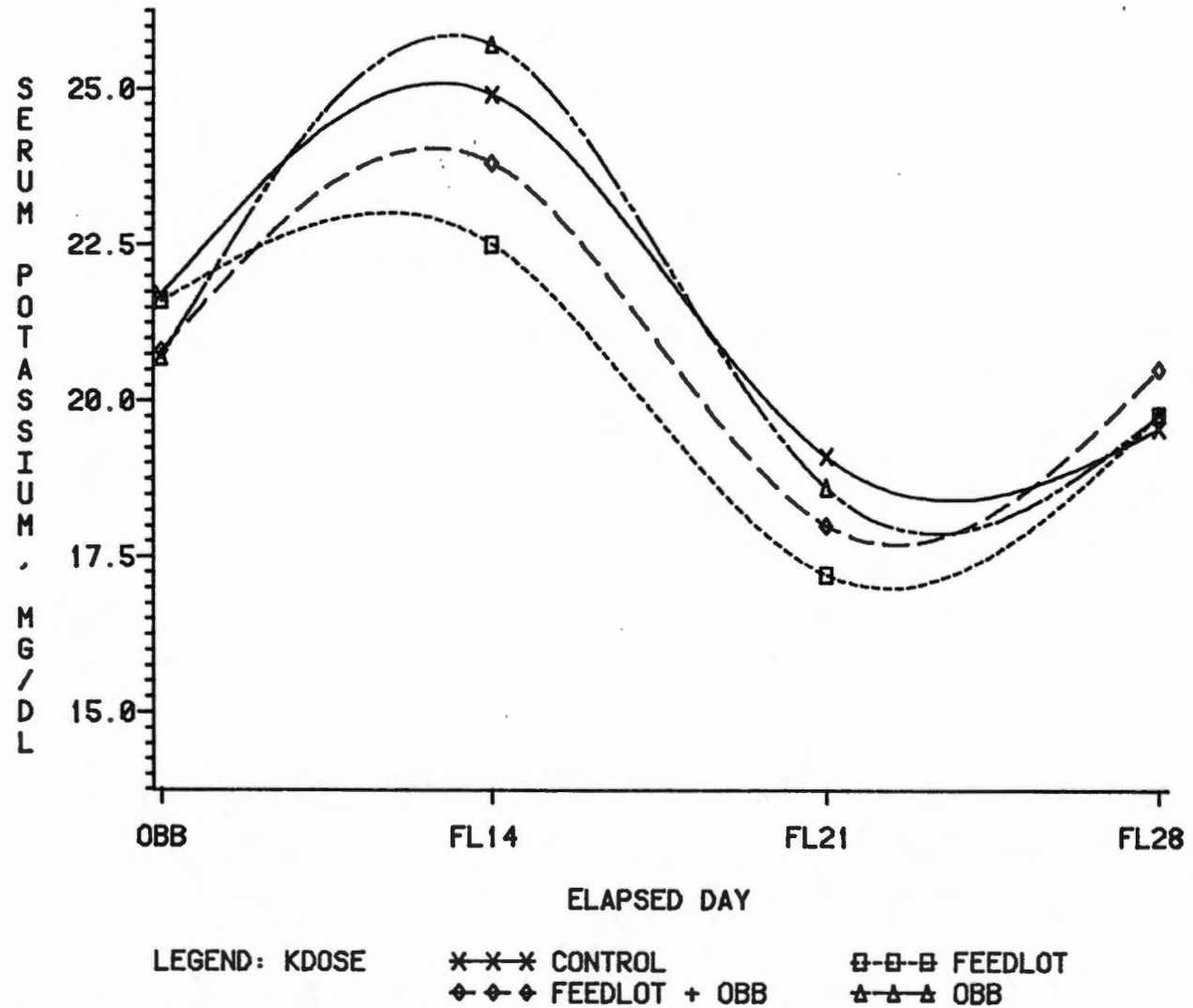


FIGURE 4. Effect of potassium level on serum potassium.

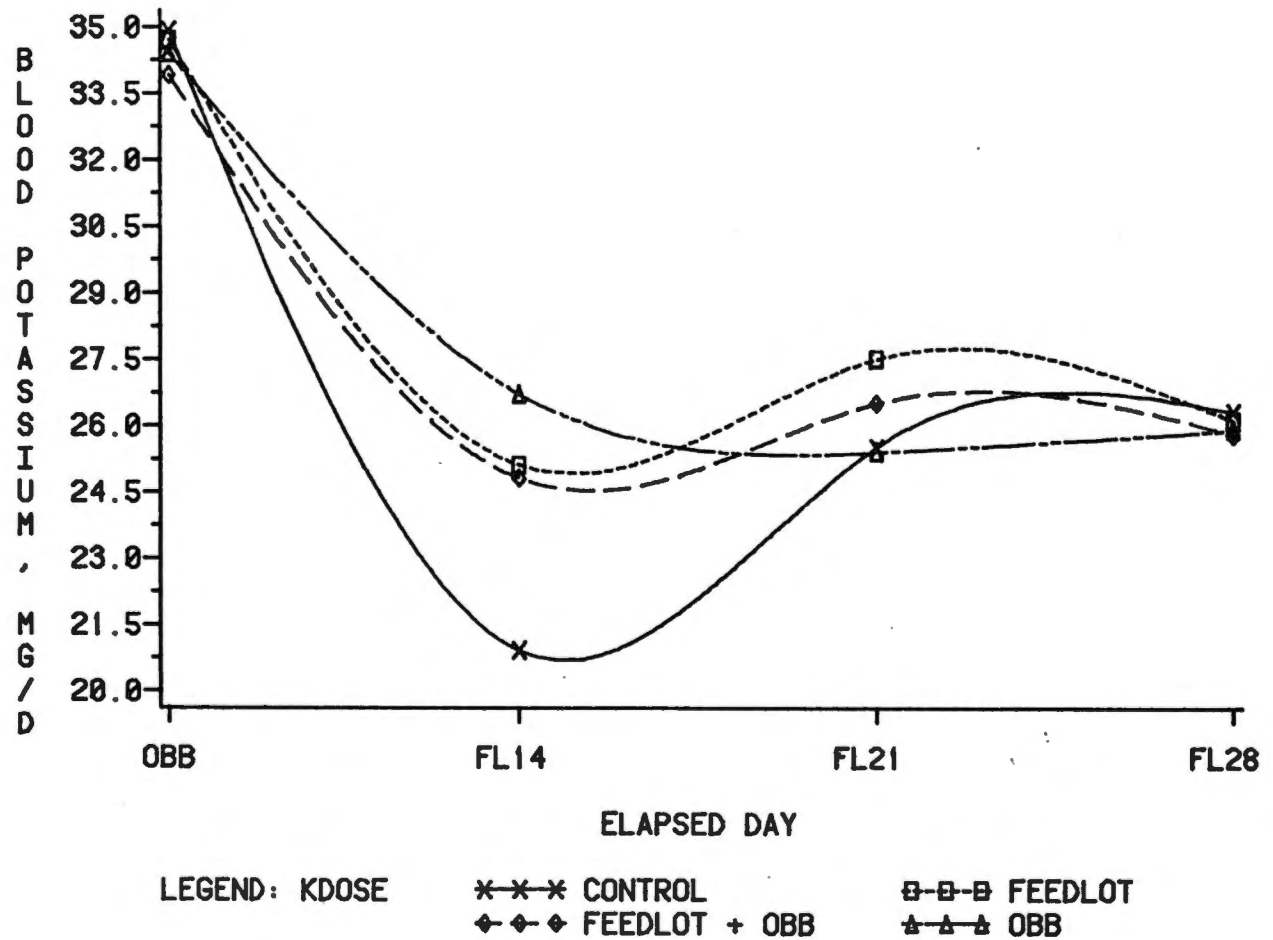


FIGURE 5. Effect of potassium level on blood potassium.

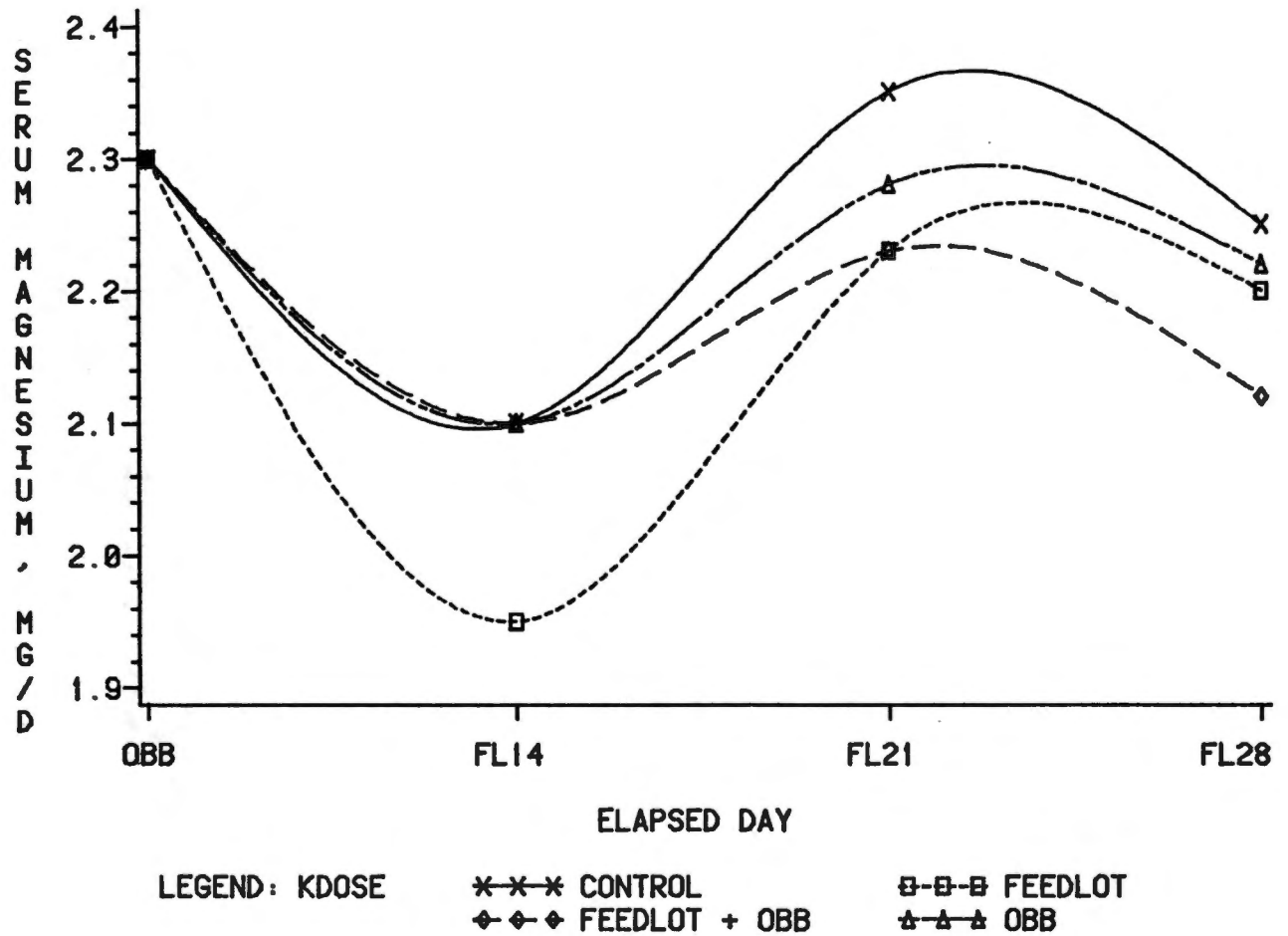


FIGURE 6. Effect of potassium level on serum magnesium.

by calves prior to shipment could affect the response of the calves to increased potassium in a receiving diet. This may explain, in part, the failure of calves to respond to higher dietary K at the feedlot. Although there was an interaction ($P<.10$) between potassium level and the feedlot diets with regard to some of the health parameters (lymphocyte blastogenesis and body temperature on feedlot day 14), the severe interaction similar to that reported by Hamlett et al. (1983) was not observed. The interactions reported by Hamlett et al. (1983) suggested an inherent danger of depressed feedlot gains (from arrival to feedlot day 28) when calves received higher than normal K diets at both the OBB and in the receiving diets. However, results of the present study suggest that this danger is negligible and that no depression in performance or health resulted when calves fed 1.5%-K diets prior to shipment were fed receiving diets high in K. Rumen fluid of calves fed the 1.7%-K receiving diets contained higher ($P<.05$) concentration of K than that of calves fed the control receiving diets. Although a similar trend was observed at feedlot day 28, the differences ($P>.10$) were small.

# CHAPTER VI

# BULL, STEER AND CALF TYPE AS RELATED TO STRESS

## 1. SUMMARY

Bull and steer calves of mixed calf type were shipped from Newport, Tennessee, to Manhattan, Kansas. Bull calves were castrated on arrival at Manhattan. The majority of the calves were classified into four calf types as follows: (1) black, polled medium-frame, number one muscling; (2) white-faced, feather-necked, medium-frame, number one muscling; (3) black or red with white-face, medium-frame, number one muscling; and (4) large-frame mixed-color calves. The calves were in transit for 24 hours. Calves purchased and transported as steers outgained ($P<.001$) the calves purchased as bulls and castrated upon feedlot arrival during both the receiving and pasture phase. Fewer ($P<.10$) steer calves died than castrated bull calves. Steer calves had higher ($P<.10$) BVD antibody titers than did bulls. Medium-frame, number one muscling, white-faced calves had a higher ($P<.10$) mortality rate than did other calf types. The large-frame, number one muscling, mixed-color calves had the highest total gain.

## 2. INTRODUCTION

A large majority of the calves moving into western feedlots originated in the Southeastern United States. Many of these calves are bulls when they enter the market chain. The effects of the

numerous stresses during marketing, transporting and adapting to feedlots are increased by the additional stress of castration. Addis et al. (1973) and Zweiacher et al. (1979) found that castration of bull calves upon arrival at the feedlot resulted in higher ($P<.05$) ADG than those whose castration was delayed for one or two weeks. During the first 21 days in the feedlot, calves purchased and transported as steers gained faster ($P<.05$) than did those purchased and transported as bulls and castrated upon feedlot arrival (Addis et al., 1973; Zweiacher et al., 1979).

The objectives of this trial were:

1. to evaluate the effect of stresses of marketing, transit, and castration upon arrival at the feedlot on the performance of bull calves during the 28-day receiving period and during a grazing period;

2. to determine the magnitude of health problems associated with castration of bull calves upon feedlot arrival; and

3. to evaluate the effect of stress on rumen parameters and immune antibody titers in castrated bull and steer calves.

## 3. MATERIALS AND METHODS

In March 1983, three truckloads of calves were purchased at auction markets in Eastern Tennessee and Western North Carolina for this study. The 264 mixed breed calves consisted of 125 bulls and 139 steers and were grouped at an orderbuyer barn (OBB) in Newport, Tennessee. The calves were held at the OBB for 48 to 96 hours, depending on when they were purchased. All calves received .9 kg

of cracked corn per day plus grass hay fed free choice. Most calves were either: (1) medium-frame, number one muscling, black, polled calves; (2) medium-frame, number one muscling, white-faced feather-necked calves; or (3) medium-frame, number one muscling, black or red, white-faced calves without white on the neck. There was a small percentage of large-frame, number one muscling, crossbred calves of mixed colors. Each load of calves was held separately at the OBB. The bull and steer calves were randomly loaded on each truck. The three trucks traveled together and were in transit for 24 hours.

Upon arrival at the destination in Kansas, the calves were immediately processed. All calves were vaccinated for Infectious Bovine Rhinotracheitis (IBR), Bovine Virus Diarrhea (BVD), Parainfluenza$_3$ ($PI_3$), and Blackleg (4-way: malignant edema, blackleg, black disease and Clostridium sordellii). The bull calves were castrated with a knife, and the cords were stapled with steel staples to reduce bleeding.

In order to obtain information on the effect of stress on the calves, they were weighed, bled, and rumen samples were taken at the OBB. Additional blood samples were taken upon arrival at feedlot and on feedlot days 7, 14, 21, and 28. Purchase weight, OBB weight, feedlot arrival weight, 28-day weight, weight at the end of silage period, and weight at the end of a 60-day grazing period were recorded. Condition scores were recorded for the calves at the orderbuyer barn.

Packed cell volumes (PCV) were determined on whole-blood samples using Wintrobe microhematocrit tubes. Serum Na, serum K,

and serum Mg, and whole blood K were determined with atomic absorption spectrophotometry.

Serum samples from stressed calves were tested for their ability to influence lymphocyte blastogenesis by the Blecha and Minocha (1983) methods. The BVD and IBR antibody titers were assayed by the College of Veterinary Medicine Diagnostic Laboratory at Kansas State University. A serum neutralization assay was used that requires heating the serum at 56°C for 30 minutes and then mixing dilutions of the serum with a constant dose of virus. The mixtures were allowed to stand for 60 minutes and then assayed for residual infectivity by inoculation into culture cells. The end point of the titration was taken as the highest dilution of antiserum that inhibited the development of cytophathic effects in the cultured cells.

Calves were examined daily for visual signs of morbidity. All calves had their temperature taken with an electric thermometer upon arrival at the feedlot and on feedlot days 7 and 14. Animals with temperatures over 40°C were treated. After standing in 16 hours of driving rain, all calves were treated with antibiotics on days three and four. A wide range of antibiotics were used as indicated by a practicing veterinarian.

Preliminary analyses of variance were conducted to determine if any interaction existed. Evaluation of the preliminary analyses suggested that interaction in the case of some variables occurred between feedlot diet and potassium and between calf type and sex.

Therefore, both of these interactions were included in the model for the final analyses of variance. Because of unequal subgroup numbers, the results were expressed as least-squares means.

## 4. RESULTS AND DISCUSSION

Calves purchased and transported as steers gained significantly ($P<.001$) more in all phases of the study than did calves purchased and transported as bulls and castrated upon arrival at the feedlot. This is in agreement with findings of Zweiacher et al. (1979). However, bull calves shrank significantly less than did steer calves during the marketing and transit period (Table 15).

Steers gained significantly more ($P<.05$) (12.1 kg) from purchase weight to feedlot day 28 (Tables 15 and 16). Castrated bull calves had not regained purchase weight by the end of the 28-day receiving period. This may be due to the excess amount of stress to which these calves were subjected. Steers gained significantly more ($P<.1$) (15.1 kg) from purchase to the end of the pasture period than did the castrated bulls. If allowances were made for the difference in mortality and chronically ill steer calves, each steer had 30 kg more saleable weight at the end of the pasture period than did calves purchased as bulls and castrated upon arrival at the feedlot. When the calf type term was not included in the statistical model, steers gained significantly more than castrated bulls. In the pasture phase analysis for which the model included calf type, the differences in gain on pasture were not appreciable.

TABLE 15. Effects of Sex and Calf Type on Gain of Stressed Feeder Calves

| | Least squares means[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sex | | Calf type | | | | |
| | Steers | Castrated Bulls | Black, Medium-frame | White faced, Medium-frame | Black, White-faced, Medium-frame | Large-Frame, Mixed Color | SE[e] |
| Weight and Gain, kg | | | | | | | |
| Market-transit shrink | -24.0[b] | -20.1[c] | -21.6[b] | -24.2[c] | -23.1[c] | -23.9[c] | 1.21[c] |
| Receiving period (28 days) | 32.1[b] | 20.0[c] | 24.4 | 26.8 | 26.3 | 26.3 | 2.21 |
| Purchase to FL[d] 28 | 8.0[b] | -2.3[c] | 3.4 | 2.9 | 2.8 | .95 | 2.47 |
| Silage gain (17 days) | 6.7 | 4.1 | 8.4[b] | 2.1[c] | 4.1[c] | 3.1[c] | 1.79 |
| Pasture gain (60 days) | 60.0 | 54.2 | 52.5[bd] | 60.1[c] | 55.4[b] | 65.8[d] | 2.54 |
| Gain, purchase to end of pasture period | 74.6[b] | 59.5[c] | 64.6[b] | 67.7[b] | 64.6[b] | 71.2[c] | 3.12 |
| Purchase wt. | 236.1 | 239.5 | 237.6 | 238.6 | 237.3 | 289.3 | 6.13 |

[a]Least square means from model Y = Levamisole, calf type, potassium level, feedlot diet, sex, feedlot diet potassium, and calf type x sex.

[b,c,d]Means within each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]SE = Standard Error.

TABLE 16. Analysis of Variance of the Effects of Sex and Calf Type on Gain

| Source | df | Mean Squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | Market Transit Shrink | Gain During Receiving Period | Gain Purchase to FL 28 | Silage Gain (17 Days) | Pasture Gain (60 Days) | Gain From Purchase to End of Pasture Period |
| Levamisole | 2 | 496.3 | 211.8 | 1486.5 | 260.3 | 4230.8* | 1723.4 |
| Calf type | 6 | 592.0+ | 592.0+ | 652.6 | 1825.3** | 3679.4** | 5704.9** |
| Potassium | 3 | 959.6* | 272.9 | 521.7 | 805.2 | 733.3 | 1600.4 |
| Feedlot diet | 1 | 1.9 | 1123.7 | 701.7 | 1217.9 | 769.8 | 1353.4 |
| Feedlot diet x potassium | 3 | 360.6 | 235.7 | 142.6 | 513.6 | 1390.0 | 801.9 |
| Sex | 1 | 737.3+ | 11289.6*** | 7514.0* | 182.6 | 57.0 | 6176.6+ |
| Calf type x sex | 6 | 200.5 | 1080.5 | 1720.4 | 1027.4 | 1893.0+ | 7316.3* |
| Residual | | 371.4 | 1114.9 | 1409.0 | 702.3 | 1422.8 | 2165.9 |
| Residual df | | 233 | 208 | 210 | 198 | 199 | 201 |

+P<.10, *P<.05, **P<.01, and ***P<.001.

There was a calf type x sex interaction (P<.10) which explains why the pasture gains were not appreciably different because black castrated calves had low gains and white-faced castrated calves had good gains. More studies involving differential stress levels are needed to determine if calves purchased and transported as bulls and then castrated upon arrival gain less after the 28-day receiving period, or if this occurs only in super-stressed calves.

Black, polled medium-frame, number one muscled calves shrank less (P<.10) than calves of other types (Tables 15 and 16). Pasture and silage gains were affected (P<.10) by calf type. Black, polled, medium-frame, number one muscling calves gained more (P<.01) than did calves of the other types during the 17-day silage period. However, large-frame, number one muscling, mixed-color calves gained more (P<.01) than any other type during the pasture period. Gains of calves of the various types are shown in Table 15.

More (P<.10) castrated bull calves (13.2%) died than that of steer calves (7.6%) (Tables 17 and 18). This would be expected because of the extreme stress of castration on the calves which arrived as bulls. However, the surprising fact was that a difference in mortality occurred within calf type. The white-faced, medium-frame, number one muscling calves had more (P<.10) calves dying (18.39%) than did the other calf types (Tables 17 and 18). Fewer (P<.10) of the black, medium-frame, number one muscling calves died (2.79%). Approximately one-fourth of the white-faced, medium-frame, number one muscling bull calves died. There was about the same ratio

TABLE 17. Effects of Sex and Calf Type on Health

| | Least squares means[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sex | | | Calf type | | | | |
| | Steers | Castrated Bulls | SE | Black Medium Frame | White Face Medium Frame | Black White-face Medium Frame | Large Frame Color Mixed | SE[g] |
| Health | | | | | | | | |
| Mortality, % | 7.68[b] | 13.22[c] | .025 | 2.79[b] | 18.39[c] | 12.93[c] | 6.34[b] | .036 |
| Antibody titers log 2, BVD orderbuyer barn | 4.02[b] | 2.96[c] | .221 | 3.37 | 3.27 | 2.87 | 3.41 | .314 |
| Arrival feedlot | 4.14[b] | 3.05[c] | .236 | 3.62 | 3.48 | 3.09 | 3.57 | .336 |
| Feedlot day 7 | 4.68 | 3.52 | .427 | 4.84 | 4.15[c] | 2.88[cd] | 6.54[bd] | .613 |
| Feedlot day 14 | 5.48[b] | 4.01[c] | .494 | 5.46 | 4.84 | 4.05 | 3.53 | .710 |
| Feedlot day 21 | 7.39[b] | 5.55[c] | .392 | 7.16 | 5.87 | 6.25 | 9.07 | .666 |
| Feedlot day 28 | 6.8 | 6.05 | .201 | 6.62 | 5.99 | 6.81 | 6.24 | .285 |
| Antibody titers log 2, IBR | 2.99 | 2.93 | .129 | 2.73 | 3.22 | 2.97 | 2.99 | .183 |
| No treatments per animal AFL[e] to FL[f] d/7 | 2.26 | 2.68 | .007 | 2.38[b] | 2.60[c] | 2.53[c] | 2.38[b] | .123 |
| FL d/7 to FL d/28 | .87[c] | 1.08[b] | .119 | .84 | 1.23 | .86 | 1.06 | .169 |
| AFL to FL d/28 | 3.13[c] | 3.76[b] | .167 | 3.22[b] | 3.82[c] | 3.40[d] | 3.44[d] | .238 |
| Changes in serum lymphocyte blastogenesis OBB to FL d/28 | 33761[b] | 3201[c] | 5031 | 17499 | 29630 | 11205 | 14408 | 9142 |
| Temperature (°C) | | | | | | | | |
| Orderbuyer barn | 39.43 | 39.61 | .094 | .406 | 39.67[c] | 39.47[b] | 39.44[b] | .135 |
| Arrival feedlot | 40.06 | 40.08 | .128 | 39.85[b] | 40.11[c] | 39.74[b] | 40.07[c] | .184 |
| Feedlot d/7 | 39.59 | 39.74 | .134 | 39.57 | 39.73 | 39.55 | 39.56 | .190 |
| Feedlot d/14 | 39.18 | 39.29 | .118 | 39.22 | 39.23 | 39.35 | 39.13 | .168 |

[a]Least-squares means from model Y = Levamisole, calf type, potassium feedlot diet, sex, feedlot diet potassium, and calf type x sex.

[b,c,d]Means within each treatment class classification and in the same row superscripted with different letters are different (P<.10).

[e]AFL = Arrival at feedlot.

[f]FL = Feedlot.

[g]SE = Standard Error.

TABLE 18. Analysis of Variance of the Effects of Sex and Calf Type on Health

| | | | Mean squares | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | BVD Antibody Titers Log 2 | | | | IBR Antibody Log 2 | No. Treatments per Animal | | | Changes in Serum Lymphocytes Blastogenesis[a] | | Temperature | | |
| Source | df | % Mortality | OBB | AFL | FL 7 | FL 14 | FL 21 | FL 28 | FL 28 | AFL-FL 7 | FL 7-FL 28 | AFL-FL 28 | OBB-FL 28 | OBB | AFL | FL d 7 | FL d 14 |
| Levamisole | 2 | .099 | 1.16 | 2.63 | 1.94 | 2.24 | 2.25 | 1.14 | .268 | .51 | 1.77 | 3.99 | 1.3 | .085 | .65 | .0005 | .7 |
| Calf-type | 6 | .2601[b] | 5.78 | 7.21 | 9.59[b] | 3.18 | 7.09 | 6.65 | .255 | 1.83[b] | 3.18 | 8.66* | .33 | 1.92[b] | 3.52[b] | 1.3 | 1.0 |
| Potassium | 3 | .1229 | 16.99 | 16.79 | 1.91 | 2.33 | 2.11 | 7.4 | 1.39 | .775 | .65 | 2.19 | 2.8 | 1.24 | 1.7 | 2.1 | 1.63 |
| Feedlot diet | 1 | .1774 | 8.48 | 14.96 | 0.22 | 7.19 | 4.15 | 1.36 | .095 | .34 | 5.4[b] | 8.50[b] | 506.7 | 1.36 | 6.12[b] | 2.89 | 6.13 |
| Feedlot diet potassium | 3 | .0390 | 10.63 | 8.43 | 0.81 | 3.68 | 3.58 | 12.4* | .543 | .57 | .369 | .59 | .83 | .003 | .89 | 1.93 | 3.2 |
| Sex | 1 | .1678[b] | 18.57[b] | 19.12[b] | 1.27 | 36.7* | 17.87* | 6.86 | 1.42 | .103 | 6.96* | 8.75[b] | 2247.2 | 1.26 | .029 | 4.06 | .74 |
| Calf type x sex | 6 | .2489[b] | 1.89 | 1.68 | 1.92 | 3.97 | 1.94 | 3.93 | .834 | 1.54 | 3.74[b] | 7.64* | 3.3 | 2.99** | 1.61 | .26 | .31 |
| Residual | | .0845 | 6.42 | 7.34 | 6.01 | 8.07 | 4.92 | 4.39 | 1.67 | .9614 | 1.87 | 3.68 | 501.4 | 1.158 | 2.13 | 2.03 | 1.69 |
| Residual df | | 238 | 228 | 225 | 47 | 47 | 45 | 197 | 201 | 238 | 238 | 201 | 201 | 238 | 236 | 208 | 217 |

[b]P<.10, *P<.05, **P<.01, and P<.001.

[a]Actual - table value x $10^7$

of bulls to steers within each calf type as there was in the whole trial. This suggests that there are some differences in live-ability between calf types in relation to stress.

Blecha et al. (1983) found that Brahman X Angus steers had a lower ($P<.01$) monocyte phagocytic capability than did Brahman X Angus control steers. However, shipped Angus calves had similar ($P>.05$) monocyte phagocytic function to that of non-stressed control Angus steers. This supports the results of the present study indicating differences among breeds of calves with respect to their response to the stresses of marketing and transit from an immune-function standpoint.

Norman and Hohenboken (1981) found that calves of Hereford X Angus dams had consistently higher immunoglobulin concentrations than did calves of Hereford dams. This indicates that differences exist also between breeds with respect to many aspects of the immune system.

Steers had a higher ($P<.1$) antibody titers for BVD at the OBB than did bulls. The changes in antibody titers for BVD during the 28-day receiving period were similar in bulls and steers as shown in Table 17 and Figure 7. Steers had higher BVD antibody titers at the end of the receiving period. The higher antibody titers indicate that the calves purchased as steers would have more protection than the castrated bulls even though both groups were vaccinated against BVD. There was no difference between bulls and steers with respect to IBR titers after 28 days in the feedlot.

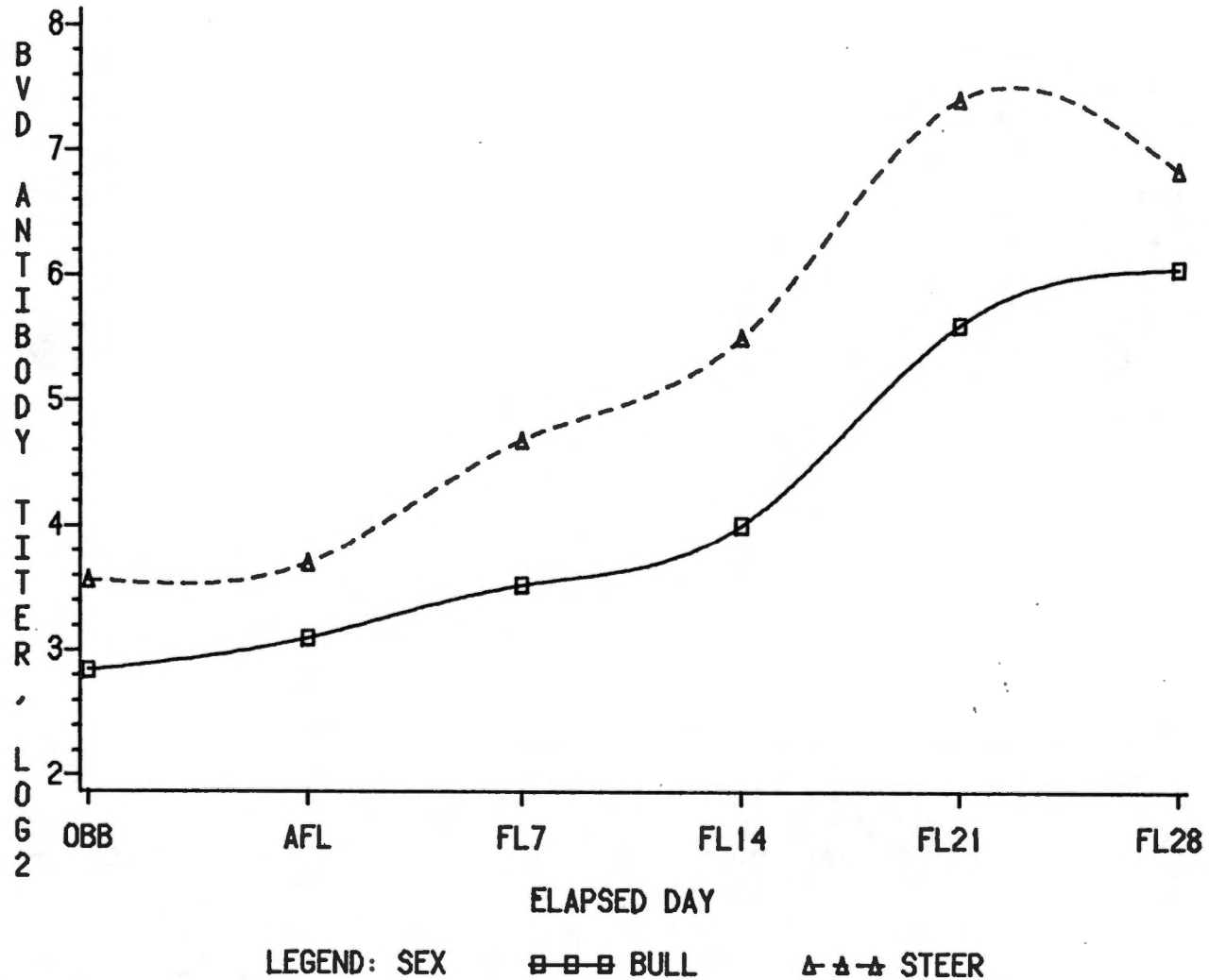


FIGURE 7. Effect of sex on BVD antibody titer change.

The black, white-faced, medium-frame, number one muscling calves had lower (P<.10) BVD titers at the OBB, and this titer was lower (P<.10) on feedlot day seven than in the other calf types. The trend with respect to IBR antibody titers at feedlot day 28 was for black, medium-frame, number one muscling calves to have the lowest titer and white-faced, feather-necked, medium-frame, number muscling calves to have the highest level.

More (P<.05) treatments per animal were required in castrated bulls (3.76 treatments/animal) than in steers (3.13 treatments/animal) during the 28-day receiving period. More (P<.05) treatments per animal were required in the white-faced, medium-frame, number one muscling calves than in the other group with the fewest (P<.05) treatments per animal required in the black, medium-frame, number one muscling group (Tables 17 and 18). These results may be misleading because all cattle were treated on days three and four. However, an indication of the real difference was observed from feedlot day 7 to feedlot day 28. During this period, the castrated bulls required 19.5% more treatments than did the steers, and the white-faced, medium-frame, number one muscling calves required 30% more treatments than did calves of all other calf types. This is in agreement with results reported by Zweiacher et al. (1979) who found that 34.4% of castrated bulls required treatments as compared to 17.5% of steers. Steers had a greater (P<.10) change in serum lymphocyte blastogenesis from OBB to feedlot day 28 than did bulls (Tables 17 and 18). This indicates that steers had a higher immune potential at the end of the 28-day receiving period than did castrated bulls.

There was a tendency for bulls to have higher rectal temperatures than steers had during the first two weeks (Table 17 and Figure 8). White-faced, medium-frame, number one muscling calves had higher ($P<.10$) rectal temperatures at the orderbuyer barn and upon arrival at the feedlot than did calves of other types. This may indicate that the white-faced calves are more susceptible to early stress than are calves of the other types.

Therefore, calf types and sex must be considered in the experimental design of studies involving stress of 240 kg calves due to sex and calf-type difference in ability to cope with high degrees of stress.

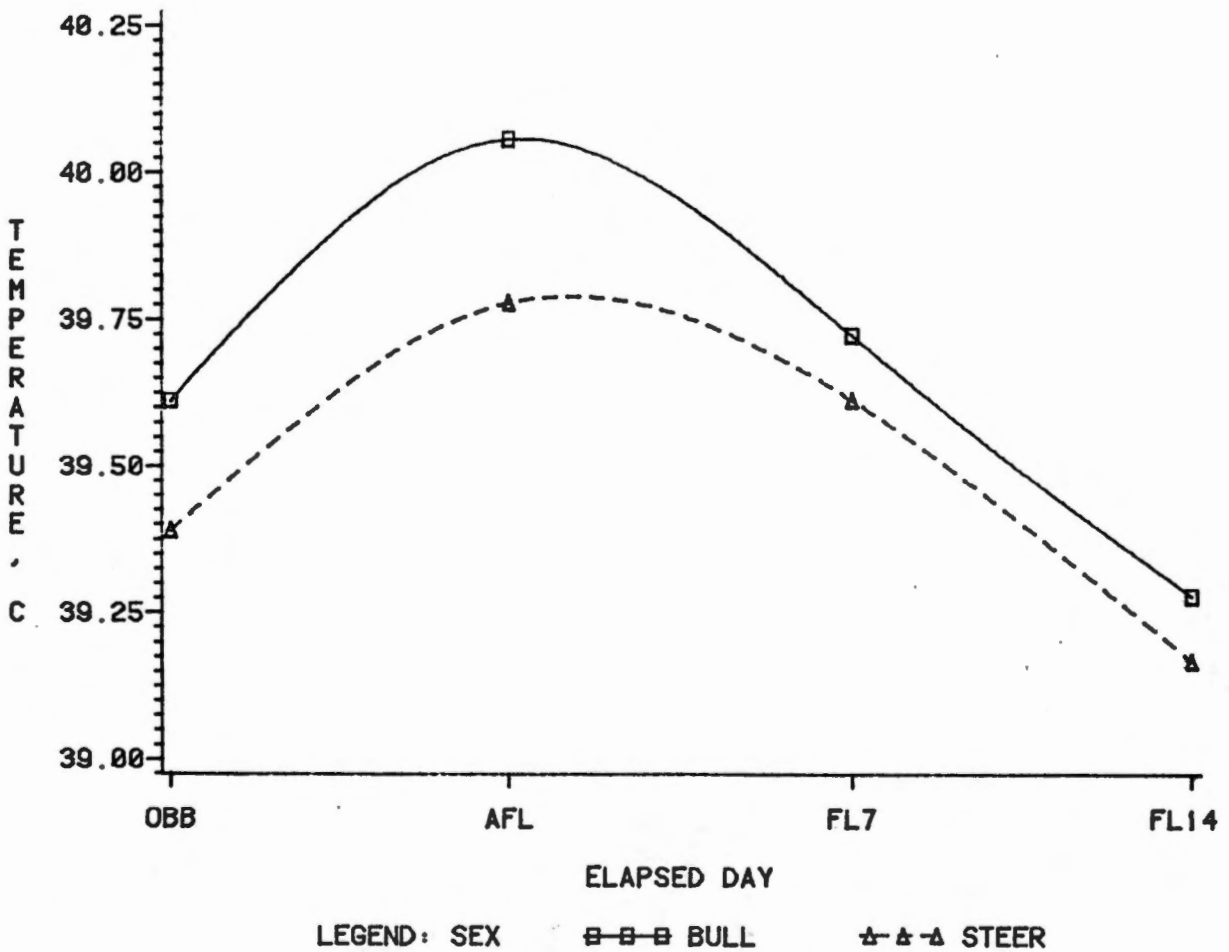


FIGURE 8. Effect of sex on temperature change.

# CHAPTER VII

## SUMMARY

Most feeder calves in the Southeast are exposed to the stresses of marketing and transporting which may alter rumen metabolism and delay feedlot adaptation. Castrating bull calves upon receipt subjects them to even greater stress as evidenced by a higher percentage death loss for bull calves (13.22%) than steer calves (7.68%) in a March 1983 trial involving 125 bull and 139 steer calves. Steer calves adapted to a higher energy receiving ration without changing percent mortality as compared to bulls. However, the receiving ration had an effect on percent mortality of castrated bull calves with the lowest mortality occurring when a hay diet was fed.

Steers gained more ($P<.10$) (12.1 kg) from purchase weight to 28-day weight. Castrated bull calves did not regain purchase weight by the end of the 28-day receiving period and steers gained more ($P<.10$) (15.1 kg) from purchase to the end of the pasture period than did the bulls. Steers had higher ($P<.10$) antibody titer for Bovine Virus Diarrhea (BVD) at the orderbuyer barn (OBB) than bulls. Steers experienced greater ($P<.10$) change in serum lymphocyte blastogenesis from OBB to day 28 than bulls.

Feeding of supplemental potassium (K) before shipment resulted in fewer calves dying during the first three days (1 vs 3 out of groups of 132 calves). Calves fed 1.5% K diet at the OBB lost 2.85 kg less weight during the 24 hour transit than did calves fed a 1.1% K

diet. Weight gains were similar of cattle on the two K levels at the feedlot (FL). However, rumen K concentrations were higher ($P<.10$) at feedlot day 14 in calves fed the 1.7% K diet at the feedlot.

There were large differences between calf types in terms of percent mortality. The highest mortality (18.3%) was in the white-faced, feather-necked, red medium-frame calves as compared to the black, medium-frame calves (2.79%). White-faced calves required 30% more clinical treatments than did black, white-faced black and large-frame calves from FL 7 to FL day 28. They also had higher rectal temperatures at the OBB.

Levamisole injection at FL and OBB resulted in 6.8% and 9.6% mortality, respectively, compared to 14.8% in the control groups. Most of this difference occurred within the bull calves in each group. Levamisole injected calves showed a trend toward higher BVD and Infectious Bovine Rhiontracheitis antibody titers.

The receiving diets (hay vs 40% concentrate) did not affect gain appreciably during the 28-day receiving period. However, the 40%-concentrate diet resulted in more ($P<.05$) gain during a subsequent 17 day silage period, but pasture gains were similar. There was a trend toward higher mortality in calves fed the 40%-concentrate diet (12.3%) compared to 8.5% of the hay-fed group. Calves fed the 40%-concentrate diet had higher ($P<.05$) rectal temperatures at FL day 14 than did calves fed the hay diet.

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## LITERATURE CITED


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# APPENDIX

TABLE A1. Analysis of Variance for the Effects of Sex and Calf Type on Health and Gain

| Source | df | % Mortality | No. Treatments OBB to FL 28 | BVD Antibody Log 2 OBB | BVD Antibody Log 2 FL 28 | IBR Antibody Titers FL 28 | Changes Lymphocyte Blastogenesis OBB to FL 28 | Receiving Period | Purchase to End Pasture Period |
|---|---|---|---|---|---|---|---|---|---|
| Levamisole | 2 | .103 | 2.44 | 1.41 | 1.60 | .40 | 13315098522† | 302.0 | 1083.3 |
| Calf type *sex | 7 | .214* | 5.75† | 6.81 | 9.4† | 1.36 | 10103402321† | 5783*** | 11219.0*** |
| Potassium | 3 | .125 | 2.23 | 19.1* | 6.3 | 1.2 | 2788517732 | 142 | 1287.1 |
| Feedlot diet | 1 | .166 | 7.09† | 8.2 | 2.6 | .059 | 437400492 | 1681 | 1863.9 |
| Feedlot diet * potassium | 3 | .042 | 1.51 | 6.21 | 10.67† | .51 | 3291790424 | 107 | 294.0 |
| Residual | | .0885 | 3.707 | 6.45 | 4.493 | 1.714 | 5111495326 | 1123.7 | 2194.0 |
| Residual df | | 227 | 227 | 217 | 187 | 191 | 191 | 198 | 191 |

†P<.10, *P<.05, **P<.01, ***P<.001.

TABLE A2. Effects of Sex and Calf Type on Health and Gain

| | Least squares means[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Black Steers | Black Bulls | White-face Steers | White-face Bulls | Large Frame Steers | Large Frame Bulls | Black WF Steers | Black WF Bulls | SE |
| Health | | | | | | | | | |
| Mortality % | 6.4[d] | .9[e] | 12.4[c] | 24.3[b] | 2.4[e] | 15.0[c] | 7.1[d] | 18.9[b] | .051 |
| No treatments OBB[e] to FL/d/28[f] | 2.89[d] | 3.54[c] | 3.32[c] | 4.35[b] | 3.29[c] | 3.56[c] | 3.13 | 3.63[c] | .375 |
| BVD antibody titers Log 2 | | | | | | | | | |
| Orderbuyer barn | 3.96 | 2.78 | 3.37 | 3.17 | 3.99 | 2.96 | 3.25 | 2.49 | .43 |
| Feedlot day 28 | 7.20[b] | 6.01 | 6.63 | 5.32 | 6.59[b] | 5.87 | 6.71 | 6.93[b] | .36 |
| IBR antibody titers feedlot day 28 | 2.62 | 2.82 | 3.30 | 3.14 | 3.01 | 2.96 | 3.09 | 2.86 | .220 |
| Change in lymphocyte blastogenesis OBB to feedlot day 28 | 425121[b] | 7207[d] | 42932[b] | 15177[c] | 25748[b] | 3148[d] | 17014[c] | 7550[d] | 4127.5 |
| Gain Kg | | | | | | | | | |
| Receiving period to 28 days | 29.7[b] | 19.3[c] | 33.0[b] | 20.3[c] | 30.1[b] | 22.5[c] | 34.3[b] | 19.2[c] | 5.66 |
| Purchase to end of pasture period | 72.1[b] | 57.6[c] | 76.9[b] | 58.1[c] | 78.8[b] | 64.2[c] | 75.5[b] | 54.1[c] | 8.03 |

[a]Least square means from model Y = Levamisole, potassium, feedlot diet, calf type *sex, and feedlot diet *potassium.

[b,c,d]Means within each treatment classification and in the same row superscripted with different letters are different (P<.10).

[e]OBB = Orderbuyer barn.

[f]FL = Feedlot.

# VITA

The author, Frank K. Brazle, son of Clarence T. Brazle and Helen Radcliff Brazle, was born February 11, 1947 in Winfield, Kansas, which is in Cowley County. He attended elementary and secondary schools at Dexter, Kansas. He graduated as president of the 1965 high school class. He entered Kansas State University and received the Bachelor of Science degree in Agriculture in 1970. He was employed as County Extension 4-H Agent and then County Extension Director and Agricultural Agent in Crawford County, Kansas until November 1974. He purchased one-third of the Winfield Livestock Auction at that time. In June of 1975, he sold his interest in the livestock auction to his brother John and entered Kansas State University graduate program. In June of 1975 he received the Master of Science degree. He was then employed by Kansas State University as an Extension Livestock specialist. In December 1984 he received the degree of Doctor of Philosophy in Animal Science from The University of Tennessee, Knoxville.

He was married to the former Kathleen M. Requa on December 18, 1977. He has two children, Andy, age seven, and Amber, age three.