The effects of metaphylactic injectable antibiotics on feeding and watering behavior of newly received feedlot calves

by Tanya Keigh Daniels

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science
Montana State University

Abstract:
Three 21-d trials were conducted at a commercial feedlot near Wellton, AZ using 150 (Trial 1), 150 (Trial 2) and 148 (Trial 3) newly received male calves (avg wt 159 kg) to determine the effects of methaphylactic injectable antibiotics on feeding and watering behavior. Calves were randomly assigned to one of four treatments administered at processing 1) No injectable antibiotic (Control), 2) Tilmicosin s.c. (10 mg/kg BW; TIL), 3) Florfenicol i.m. (neck; 20 mg/lcg BW; FIM), and 4) Florfenicol s.c. (30 mg/kg BW; FSC). All calves within a trial were managed together in a single pen. Calves were classified as morbid (medicated for any reason during the 21-d) or healthy. Daily feeding and watering behavior (frequency, duration, and bouts) were collected for Trial 2 and Trial 3. Data were analyzed using the GLM procedures of SAS for a replicated completely randomized design. Animal within trial x treatment was used as the testing term for treatment. A smaller (P = .02) percentage of TIL, FIM, and FSC calves were identified as morbid (32%) compared with Control (47%). Treatment had no effect (P > .10) on watering behavior, feeding bouts/d, or min/feeding bout of healthy calves. Healthy FIM calves spent more (P = .04) time feeding/d (76.0 min) than did healthy Control, TIL, or FSC calves (avg 65.6 min). Treatment had no effect (P > .10) on watering behavior of morbid calves. Feeding bouts were greatest (P = .004) by morbid FIM calves (8.5 bouts/d) and least by morbid Control calves (5.8 bouts/d). In Trial 2, morbid TIL and FSC calves spent more (P = .03) time feeding (avg 48.7 min/d) than did morbid Control calves (34.8 min/d). In Trial 3, morbid FIM calves spent more (P = .03) time feeding (63.5 min/d) than morbid Control, TIL, or FSC calves (avg 32.8 min/d). Healthy calves outweighed (P = .04) the morbid calves by an average of 3.18 kg at the beginning of the study and by 20 kg (P = .0001) at the end of the study, with healthy calves having an ADG of .78 lcg/d compared (P = .0001) to morbid animals with -.03 lcg/d. Calves previously castrated gained an average of 7 kg more (P = .0008) during the 21-d trials than calves castrated at the feedlot. Injectable antibiotics administered at processing increased total time spent feeding by newly received feedlot calves. Metaphylactic injectable antibiotics administered upon arrival to the feedlot decreased the incidence of BRD and did not reduce animal performance.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding contents, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date 12-10-99

This thesis is dedicated to my mom and dad:

Jo and Tooter Rogers,
who never had anything and gave me everything.

Thank you both.

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ABSTRACT

Three 21-d trials were conducted at a commercial feedlot near Wellton, AZ using 150 (Trial 1), 150 (Trial 2) and 148 (Trial 3) newly received male calves (avg wt 159 kg) to determine the effects of methaphylactic injectable antibiotics on feeding and watering behavior. Calves were randomly assigned to one of four treatments administered at processing 1) No injectable antibiotic **(Control)**, 2) Tilmicosin s.c. (10 mg/kg BW; **TIL**), 3) Florfenicol i.m. (neck; 20 mg/kg BW; **FIM**), and 4) Florfenicol s.c. (30 mg/kg BW; **FSC**). All calves within a trial were managed together in a single pen. Calves were classified as morbid (medicated for any reason during the 21-d) or healthy. Daily feeding and watering behavior (frequency, duration, and bouts) were collected for Trial 2 and Trial 3. Data were analyzed using the GLM procedures of SAS for a replicated completely randomized design. Animal within trial x treatment was used as the testing term for treatment. A smaller ($P = .02$) percentage of TIL, FIM, and FSC calves were identified as morbid (32%) compared with Control (47%). Treatment had no effect ($P > .10$) on watering behavior, feeding bouts/d, or min/feeding bout of healthy calves. Healthy FIM calves spent more ($P = .04$) time feeding/d (76.0 min) than did healthy Control, TIL, or FSC calves (avg 65.6 min). Treatment had no effect ($P > .10$) on watering behavior of morbid calves. Feeding bouts were greatest ($P = .004$) by morbid FIM calves (8.5 bouts/d) and least by morbid Control calves (5.8 bouts/d). In Trial 2, morbid TIL and FSC calves spent more ($P = .03$) time feeding (avg 48.7 min/d) than did morbid Control calves (34.8 min/d). In Trial 3, morbid FIM calves spent more ($P = .03$) time feeding (63.5 min/d) than morbid Control, TIL, or FSC calves (avg 32.8 min/d). Healthy calves outweighed ($P = .04$) the morbid calves by an average of 3.18 kg at the beginning of the study and by 20 kg ($P = .0001$) at the end of the study, with healthy calves having an ADG of .78 kg/d compared ($P = .0001$) to morbid animals with -.03 kg/d. Calves previously castrated gained an average of 7 kg more ($P = .0008$) during the 21-d trials than calves castrated at the feedlot. Injectable antibiotics administered at processing increased total time spent feeding by newly received feedlot calves. Metaphylactic injectable antibiotics administered upon arrival to the feedlot decreased the incidence of BRD and did not reduce animal performance.

INTRODUCTION

Agriculture is Montana's leading industry providing one-third of the state's employment, gross income and sales (Mont. Ag. Stat. Serv., 1997). The sale of cows and calves accounts for 32% of the state's cash receipts for all commodities sold (Mont. Ag. Stat. Serv., 1997). The majority of the calves produced in Montana leave the state to be finished in large commercial feedlots. With the current interest in retained ownership and quality assurance programs, cow/calf producers, by necessity, are becoming more interested in what occurs at feedlots. Of particular interest is the prevention of bovine respiratory disease (**BRD**). Feedlot managers want incoming cattle to be healthy and recognize that morbidity suffered by cattle once they reach the feedlot is directly related to their health management history. Producers are becoming more aware that they cannot quit thinking about the production cycle as soon as their cattle leave the ranch.

Bovine respiratory disease is the most economically important health problem facing feedlot managers today (Morck et al., 1993). The disease occurs when pathogenic bacteria are present in combination with a viral infection. When this is combined with the stresses endured by newly received feedlot cattle such as mixing, transportation, and processing, the ability of the immune system to ward off disease is reduced. Prophylactic or preventative treatment of newly arrived calves has been shown to reduce the incidence and severity of BRD (Morck et al., 1993). However, a large number of cattle still require individual treatment for BRD.

Early detection of BRD could increase profitability of cattle. Feed and water consumption are known to decrease rapidly after the onset of respiratory disease (Pijpers et al., 1991). Basarab et al. (1996) used watering behavior for the early detection of BRD. It has been shown that morbid steers spend 30% less time at the feedbunk than healthy steers (Sowell et al., 1998). Medical treatment is more effective the earlier it is administered in the disease. However, identifying animals that need medical treatment is difficult and subjective. Therefore, using changes in feeding or watering patterns of individual animals would be useful in diagnosing animals as morbid before other clinical signs are evident.

Tilmicosin and florfenicol have been shown to be effective treatments for BRD (Morck et al., 1993; Hoar et al., 1998). However, there has been some question as to which drug is most effective in treating BRD.

The objectives of this study were to determine the effects of methaphylactic injectable antibiotics on feeding and watering behavior of newly received feedlot calves and to determine if metaphylactic antibiotics administered upon arrival to the feedlot reduce the incidence of BRD.

LITERATURE REVIEW

Behavior of Cattle

Currently identifying sick animals at the feedlot is a subjective and difficult process. Mass medication (metaphylactic) programs may result in unneeded treatment of healthy animals, increasing the feedlot's expenses. The earlier in the disease the treatment is administered the more effective it has been shown to be (Merck Veterinary Manual, 1998; White et al., 1997). Late detection of a sick animal may mean ineffective treatment or death of the animal. Using changes in feeding and watering behavior may prove to be a useful tool in detecting sick animals (Basarab et al., 1996; Sowell et al., 1999).

Traditional Intake/Behavior Monitoring Systems

There are three commercially available systems, which monitor feed intake or behavior in group-fed animals and have been traditionally used by researchers. These systems allow for monitoring and/or control of feed intake (Cole, 1995). The three systems are the Calan Individual Feeding System, the Pinpointer System, and the Alfa-Laval Rationmaster.

The Calan Individual Feeding System consists of a series of individual feedbunks, each with a gate opened by a unique key worn around the animal's neck. When an animal approaches the proper feeder, the key unlocks the gate so the animal can push the gate open and eat its assigned ration. The advantages of the Calan Gate System include the ability to feed a variety of diets at one time to animals in the same pen, a relatively low initial cost, and animals can be limit-fed (Cole, 1995). According to Pond et al. (1995) additional advantages of the Calan gate system are animals are freed from a restrictive metabolism crate that may alter the animals health and intake, animals can remain socially active, and the potential for experimental error is reduced. The disadvantages of this system are the intense labor required for feeding, a long animal training period (1 to 3 weeks), "stealing" of the diets can occur, in the event of an electrical failure animals are not able to obtain feed, and there is a need for extra animals to be kept because some animals are untrainable to the system (Cole, 1995).

The Pinpointer System consists of one individual stall, a feed bin with a scale, and a microprocessor. Each animal wears a transponder around its neck. When the animal enters the stall, it is identified by the microprocessor which records the time the animal entered the stall, the time it is in the stall, and the amount of feed the animals consumes while in the stall. According to Cole (1995) the advantages of the Pinpointer System are its low labor costs, good accuracy, and animals can still obtain feed in the event of an electrical failure. The major disadvantage of using the Pinpointer system is that it allows only one animal to feed at a time (Pond et al., 1995). Other disadvantages of the Pinpointer System include a high initial cost, the type of diet that can be fed is limited by the diet's ability to flow through the feed hopper, only a limited number of animals can be fed in each Pinpointer, and only one diet can be fed per pen (Cole, 1995).

The Alfa-Laval Rationmaster was designed for use in commercial dairy operations. As animals enter the feeding station, the system feeds a specified amount of the diet to individually identified animals (Cole, 1995). However, this system was not designed for research purposes and feed intakes for individual animals are not as accurate as is preferred by researchers.

Pond et al. (1995) stated that the systems described above alter animal behavior. With only 15 animals/Pinpointer, the stall is occupied 80-100% of the time (Pond et al., 1995). Under these circumstances, some animals may not be consuming their fill. Cole (1995) stated that calves using Pinpointers had only 50% of the DMI of bunk fed calves in the first 1 to 2 weeks of a study. However, Phillips and VonTungeln (1995) compared animal performance, DMI, and carcass characteristics of yearling steers (n = 81) fed by either the Pinpointer System, the Calan Individual Feeding System, or by the Calan Individual Feeding System with the gates left unlocked. The results of this study showed no differences between the three groups for any of the three variables measured.

The Growsafe System is a new system on the market for collecting feeding and watering behavior of animals. This system consists of a black mat that contains an antenna and lays in the back of the feedbunk, a radio frequency ear tag in the ear of each animal, and a personal computer for data collection. Each animal is fitted with a radio frequency ear tag, which contains an individual identification number. Every time an animal comes to the feedbunk the system records the time and duration of the visit as well as the location on the feedbunk. The data collected by the system is sent to a personal computer where it is downloaded for future analysis. A similar mat can also be fitted to the water trough to collect watering behavior. The Growsafe System allows for monitoring of individual animal feeding and watering behavior without any equipment that may modify behavior. The major disadvantage of this system is the initial start up cost. Another disadvantage is there is no measurement of feed intake.

Factors Affecting Feeding and Watering Behavior

The control of feed intake has been shown to be directly related to daily feeding behavior (Chase et al., 1976). Variation in the number of meals/d and the meal size adjusted the daily intake (Chase et al., 1976). Feeding behavior was affected by environmental temperature, age, and feed type (Hafez et al., 1969). Flies, mosquitoes, dogs, interference by herd mates, or any situation which may frighten or disturb the animal may lead to a temporary termination of eating (Hafez et al., 1969).

Putnam et al (1967) used two sets of identical twin Angus steers to determine ration preference and feeding behavior of the steers when given a choice of multiple rations between 25% and 89% hay ration as a coarsely ground mixture or as pellets. The steers averaged 82 min/d at the feeder containing the ground 25% ration but only 4 min/d at the feeder containing the same ration as a pellet. Even though the amount of time spent consuming the different rations varied, the feeding patterns remained the same (Putnam et al., 1967). Putnam et al. (1967; 1968) concluded that time spent at the feeder was a good indicator of feed consumed. Of the time spent at the feeder, 94 to 97% of the time was spent feeding (Putnam et al, 1968). Similarly, validation of the Growsafe System has led researchers to believe that cattle are typically consuming feed when their radio frequency eartag is within reading range of the mat (Sowell et al., 1998; Streeter et al., 1999).

Sickness – Feeding Behavior

Hart (1987) stated the behavior of sick animals is not necessarily a product of debilitation but more of an adaptive strategy. However, if sick behavior occurred for more than a few d it could be counterproductive. In most cases, it appeared the onset of sick behavior and fever were the first lines of defense until the immune system was activated. Most pathogens have an optimum growing temperature that usually corresponds to the normal body temperature of the animal. When an animal has a fever, the growth of disease causing viruses and bacteria is suppressed. However, in order to accommodate a 1° C increase in body temperature, the animal's metabolism must be increased by 10 – 13%. During illness, body temperature may increase by 2 to 3° C (Merck Veterinary Manual, 1998). A sick animal's behavior is related to the high cost of producing a fever. By displaying anorexia and depression, the animal did not expend much needed energy by searching for food. Hart (1987) stated that sick behavior and fever concentrated all the animal's resources on recovering from illness. As the immune system took over, the fever subsided and the animal became interested in its environment and regained its appetite.

Though the relationship between feeding behavior and animal performance and health remains undefined, Sowell et al. (1998) stated that measuring changes in feeding patterns may be useful in detecting morbid animals. In six clinically healthy pigs inoculated with *Actinobacillus pleuropneumonia*, feed intake decreased with the onset of sickness (Pijpers et al., 1991) and differences existed in animal performance between healthy and morbid animals. Hutcheson and Cole (1986) found that weight gain of morbid calves was 29% less than in healthy calves after 56 d in the feedlot. After 7 d at the feedlot only 83% of the morbid calves had eaten compared with 95% of the healthy calves. Feed intake for morbid calves was 11% less than in healthy calves (Hutcheson and Cole, 1986).

Sowell et al. (1998) conducted a study in a commercial feedlot near Wellton, AZ using 108 mixed breed calves (avg weight 139 kg) for 32 d. In this study, health status affected time spent at the feedbunk as well as animal gain performance. Healthy calves spent 47% and 23% more time at the feedbunk than morbid calves during the first 4-d of the study and for the entire 32 d study, respectively. The feeding pattern of the morbid and healthy steers were similar, except total feeding time was 30% less for the morbid steers. Over the entire 32-d trial, healthy steers spent more time at the bunk at both the first and second feeding than the morbid steers, with both groups spending similar amounts of time at the bunk at the third feeding. When comparing healthy to morbid steers, Sowell et al. (1998) found that healthy steers gained 9 kg more and had 28% higher ADG than morbid steers.

Sowell et al. (1999) conducted two trials at a commercial feedlot and found an average of 68% of the animals were identified as morbid and of the morbid animals an average of 97.5% were treated for BRD. Eighty percent of the morbid steers were identified and treated in the first 10 d of the trials. By the fourth d of both trials, 100% of the healthy animals were present at the feedbunk for at least 5 minutes. Ninety-five and 76% of the morbid animals were present by the fouth d in trials 1 and 2 respectively. This agrees with Hutcheson and Cole (1986) who found when animals are transported long distances it may take at least 4 d before all the healthy calves are eating from the feedbunk. This time period may be even longer for morbid calves to begin eating after traveling long distances. In Trial 1 of the study by Sowell et al. (1999), total time spent at the feedbunk was greater for the healthy steers than for the morbid steers. However, there were no differences between the two groups for total time at the feedbunk in trial 2. There were no differences between the morbid and healthy animals in either trial for time spent at the water trough (average 6-8 min/d). Healthy calves had 3.7 and 3 more feeding bouts/d than morbid calves in the first 4-d of Trials 1 and 2, respectively. Healthy calves averaged 1.1 and 1.5 more feeding bouts/d than morbid calves for the entire 32-d of Trial 1 and Trial 2, respectively. Differences in time at the feed bunk and feeding bouts between healthy and morbid steers were most pronounced during the first 4-d in both the trials

Sickness – Watering Behavior

Basarab et al. (1996) used 173 crossbred yearling steers in one pen at a commercial feedlot in Alberta, Canada to relate watering behavior to growth performance and the detection of respiratory disease. Watering behavior was collected hourly using the Growsafe System. Pen riders checked pens daily and pulled any suspect animals. Rectal temperatures were taken to determine sickness. Rectal temperatures higher than 38.9°C were considered morbid and treated. Watering behavior was not related to ADG over the entire period. Therefore, the authors concluded that automatic monitoring of watering behavior could not be used as an indicator of performance. Steers treated for respiratory disease had a 23.7% reduction (2.8 min/d) in watering behavior as compared to healthy animals. This reduction in watering behavior occurred beginning 3 d before and continued through 7 d after the animals were diagnosed and treated for respiratory disease. Basarab et al. (1996) concluded that watering behavior had the potential for use in early detection of respiratory disease with accuracy of 81.5%. Sick animals demonstrated a dramatic decline in watering behavior 3 to 4 d before being observed as sick. This study also implied that mass medication by water likely gives more medication to healthy calves than to sick calves.

In contradiction to Basarab et al. (1996), Sowell et al. (1999) found no differences in time spent at the water trough between healthy and morbid animals. Sowell et al. (1999) contributed the difference in results to the differences in climate, management, and type of cattle used in these two studies.

Pijpers et al. (1991) found a decrease in both feed and water consumption with the onset of disease in pigs challenged with *Actinobacillus pleuropneumoniae* toxins.

Time of Day and Season of the Year

Cattle have been shown to exhibit a highly repeatable diurnal feeding pattern (Stricklin, 1986). Several researchers have demonstrated that the feeding pattern of cattle has two major peaks during the d and a minor peak at night (Hicks et al., 1989; Stricklin, 1986; Gonyou and Stricklin, 1984). Using feedlot steers, Putnam et al. (1967) analyzed time at the feeder in 3 h intervals and found that time at the feeder varied significantly with the time of d, with the major feeding interval occurring from 1500 to 1800. They found that 72% of the feeding occurred between 0600 and 1800. Further research by

Putnam et al. (1968) indicated the number of visits to the feeder are higher from 0600 to 2100 than during the rest of the 24-h period.

Season of the year affects the time of sunrise and sunset, which in turn influenced the time of the daytime feeding peaks (Stricklin, 1986). Gonyou and Stricklin (1984) found that eating, drinking, standing, mounting, and agonistic encounters were closely associated with sunrise and sunset. Ray and Roubicek (1971) also found eating patterns of feedlot cattle to be associated with daylength. They found that feedlot cattle did exhibit diurnal feeding patterns with two major peaks of activity occurring around sunrise and in the afternoon and early evening, with the second peak being more intense (having a higher frequency of eating activity). The research by Ray and Roubicek (1971) showed the morning peak of feeding activity occurred about 2 h earlier in the summer than during the winter, probably due to the difference in time of sunrise between the two seasons. Also the afternoon peak of feeding activity occurred 2 h later in the summer as compared to the winter. The amount of time spent eating at night was greater during the winter when the day length was shorter (Gonyou and Stricklin 1984). This agrees with Ray and Roubicek (1971) who found that steers ate more frequently in the summer from 1800 to 2400 than in winter.

Basarab et al. (1996) found three peaks in watering behavior at: 1) 1100 – 1300 h, 2) 1800 – 2000 h, and 3) 0100 h. These patterns were similar to the diurnal feeding patterns found by Stricklin (1986). Basarab et al. (1996) concluded that the feedlot cattle divided their days into three 8-h periods of feeding. The two daylight peaks were affected by the time of sunrise and sunset, with the time of sunset having the biggest effect.

Gonyou and Stricklin (1984) used 342 bulls and found that eating and drinking were at a minimum in the early morning hours. The bulls spent an average of 145 minutes/d eating (range of 32 - 279 min/d) and drank an average of 5.4 times/d. Gonyou and Stricklin (1984) determined that the time spent eating did not change with daylength. Eating and standing activities were not influenced by daylength but were influenced by inclement weather. Eating decreased on windy days, while standing increased. Gonyou and Stricklin (1984) concluded that cattle behavior patterns varied in a predictable but dramatic manner with the seasons.

Gonyou and Stricklin (1981) found that the diurnal feeding pattern of stall-fed cattle differed from trough-fed cattle, and the stall-fed cattle ate faster. However, the two groups did not differ in rates of gain. The majority of eating for both groups occurred between 0800 and 2000. The trough-fed animals had two major eating peaks at 0900 and 1900, which coincided with the time feed was added to the trough. Gonyou and Stricklin (1981) found no differences between stall-fed bulls and steers in the total time spent eating, and consumption rate did not differ between bulls and steers, however, the steers had more meals shorter in length than the bulls.

Hoffman and Self (1973) found that very little eating occurred between 2400 and 0600 in three groups of Iowa feedlot steers. Cattle tended to do most of their eating during the warm hours of the day in the winter and during the cooler hours of the day in the summer. Cattle spent more time drinking in the summer than in the winter and cattle drank more rapidly in the summer than in the winter. Most of the drinking activity occurred during the daylight hours, regardless of season. The greatest amount of watering activity occurred between 1200 and 2100 during the summer and between 1200 and 1800 during the winter.

Feeding Frequency

Feeding frequency and time of day of feeding may affect feeding behavior and animal performance. Researchers have found that animals fed once in the afternoon have increased ADG and improved feed to gain ratios compared to animals fed once in the morning (Reinhardt and Brandt, 1994; Pritchard and Knutsen, 1995). Furthermore, once daily feeding increased the proportion of feed consumed in the evening hours (Pritchard and Knutsen, 1995). By measuring fill as the differences in body weight within a day, Pritchard and Knutsen (1995) found that feeding schedule did alter feed intake patterns. These authors hypothesized that "eating behavior may be manipulated to enhance performance by altering the feeding schedule".

Hicks et al. (1989) reported that the greatest percentage of cattle at the feedbunk coincided with feed delivery times. If feeding schedules were expanded to include an afternoon feeding, the presence of fresh feed stimulated eating (Hicks et al. 1989). Hicks et al. (1989) found that as animals increased the percentage of their time spent eating, ADG also increased. Reinhardt and Brandt (1994) reported that animals fed once in the evening had 18% greater (P<.02) ADG compared with animals fed once in the morning, despite diets balanced for equal caloric intake. They stated that ruminal fermentation of high-grain diets peaked during the first 12 h after consumption. Therefore, cattle fed in the morning were digesting the bulk of their feed during the hottest times of the day. Cattle being fed once/d in the summer months may benefit from afternoon feeding rather than morning feeding.

Goonewardene et al. (1995) found no effect of feeding once, twice, or three times/d on ADG, FI, or FE of growing and finishing steers. The authors concluded that feeding animals one time/d was effective and less costly for the feedlot manager, as long as feed was available to the animals at all times. The twice and three times/d feedings were found to be less economical compared with feeding once/d.

Gibb et al. (1998) found that delivery of a second meal significantly affected feeding behavior when cattle were limit fed. Steers being limit fed twice/d spent more time at the feed bunk and visited the feedbunk more often than steers being limit fed once/d at 0900. This suggested the steers being fed twice/d had slower average eating rates than the steers being fed once/d. Bunk attendance during daylight hours by cattle being limit fed twice/d more closely resembled the pattern seen by animals being fed ad libitum. Total daily attendance by steers in this study was less than half that observed in commercial feedlots. However, Gibb et al. (1998) postulated this may be due to the restrictive design of the bunks used in this study. The results of Gibb et al. (1998) disagree with Stricklin (1986) who found afternoon feeding only slightly impacted feeding behavior of full fed cattle.

Environmental Stress

Changes in environmental conditions may be related to changes in an individual animal's overall behavior, including feeding behavior (Hafez et al. 1969; Streeter et al., 1999). Changes in conditions such as wind speed, barometric pressure, and extremes in temperature, heat load, and day length all appear to have an effect on feeding behavior (Hafez et al., 1969; Streeter et al., 1999). Streeter et al. (1999) discussed unpublished data by Whitley and McCollum who reported spikes in temperature seemed to have a corresponding negative spike in feeding duration early in the feeding period. In addition, average wind speeds above 14 mph resulted in a reduction in feeding duration during the first 50 to 60 days on feed.

Pritchard and Knutsen (1995) also found that environmental stress altered feeding behavior. In the summer, animals must contend with the heat from the environment, as well as the heat produced by fermentation. In the winter, when the coldest temperatures are at night, cattle may benefit from the heat produced by fermentation of feed that was consumed in the afternoon. This led Pritchard and Knutsen (1995) to conclude that overall energetic efficiency may be improved with night feeding in both the summer and winter.

Similarly, Mader et al. (1997b) found that cattle fed in the afternoon under hot conditions had lower DMI than cattle fed in the morning or split fed (one-third of the diet was fed from a 30% roughage ration at 0800 with the remaining dietary intake provided from a 6% roughage diet fed at 1600) under hot temperature conditions. Under thermoneutral conditions, body temperature was lower for morning fed cattle and higher for split fed cattle. “Steers fed in the afternoon may not experience a reduction in body temperature that is normally associated with the natural overnight cooling process” (Mader et al., 1997b). Mader et al. (1997a) also found significant declines in intake by cattle when exposed to increasing levels of heat, and when roughage content of the diet was changed from 55% to 10%.

Interestingly, environment may affect performance more in morbid calves than in healthy calves (Hutcheson and Cole, 1986). Hutcheson and Cole (1986) found that weather conditions had a greater effect on the weight gains of morbid calves than on healthy calves, with increasing temperatures increasing weight gain by morbid calves and decreasing weight gain by healthy calves.

Bovine Respiratory Disease

Bovine respiratory disease (BRD) is the greatest single disease loss the beef cattle industry suffers (Johnson, 1985; Pharmacia & Upjohn Animal Health, 1998a) and the most economically important health problem facing feedlot managers today (Morck et al., 1993). Bovine respiratory disease has been reported as the most common cause of morbidity and mortality in feedlots (Perino, 1992). Approximately 20% of the 25 million cattle in feedlots annually contract BRD and the mortality rate of BRD has been reported to be 10-15% (Pharmacia & Upjohn Animal Health, 1998a; Perino and Apley, 1999).

Bovine respiratory disease can be encountered year round, but the majority of cases occur in the fall and winter months (Johnson, 1985). Griffin (1998) stated that respiratory disease was most often diagnosed in cattle during the first four weeks of the feeding period. A greater incidence of BRD was encountered in calves than in yearlings (Johnson, 1985). Morbidity rates in calves ranged from 30 to 50 percent (Johnson, 1985) but reached rates exceeding 50% in severe outbreaks occuring in high risk animals

(Perino and Apley, 1999). Perino and Apley (1999) stated that it was not uncommon for respiratory disease to account for 75% of the morbidity in feedlots. Mortality rates in yearling cattle diagnosed with BRD ranged from .5 to 10 percent (Johnson, 1985)

Early detection of BRD could increase profitability of feedlot cattle as medical treatment is more effective the earlier it is administered in the disease (Merck Veterinary Manual, 1998; White et al., 1997). It has been shown that morbid steers spent 30% less time at the feedbunk than healthy steers (Sowell et al., 1998) and that this decrease in feeding time occurred 4 d before physical signs of sickness were observed (Basarab et al., 1996; Sowell et al., 1998). Feed intake decreased by more than 50% in cattle with respiratory disease and fever, and it took 10-14 days before feed intake was back to normal (NRC, 1996). Therefore, using changes in feeding and watering behavior to detect sickness could mean earlier treatment, less time off feed and increased profitability of feedlot cattle.

Economics behind BRD

Feedlots are increasingly concerned with controlling the health of their cattle. Medical costs have been shown to be the most important factor affecting profitability and can be as high as $353/head (Gardner et al. 1996). Bovine respiratory disease is the most economically important health problem facing feedlot managers today (Kelling, 1993; Morck et al., 1993). Sick animals mean extra labor costs, medication, and loss in production. In 1991, BRD cost the U.S. cattle industry $624 million in treatment costs, production losses, and death losses (Hansen, 1998). Morbidity may cost more than mortality when considering expenses associated with medications, labor for treatments, premature culling because of chronic conditions, and expense of reduced performance during and after an illness (Smith, 1999). In a survey of nineteen feeder companies, Northcutt et al. (1996) found health was listed in the top four cattle traits important to feeders.

Perino (1992) divided the cost of disease into three categories: 1) the cost of treatment, 2) the cost of lost productivity and/or salvage (chronics), and 3) the cost of death loss. Bovine respiratory disease was economically significant because it resulted in losses in all three categories. Regardless of the management scheme or treatment regimen, there are often cattle that become chronic or die of BRD. This is what makes BRD one of the most costly diseases. As the number of BRD cases increased, the cost of each case also increased, magnifying the impact of the disease. Perino (1992) estimated the cost of BRD for 100 head of cattle to be $1700 or $85/sick calf or $17/calf fed.

Griffin et al. (1995) stated that health costs accounted for 8% of the production cost in a feedlot. In a study of the Texas ranch to rail study Griffin et al. (1995) found that 26% of the cattle incurred no medical cost but 22% of the cattle incurred a medical cost of $10/head or more. This study also found that sick cattle not only incurred more expenses but also generally gained less, had poorer feed efficiency, and graded lower than cattle that did not get sick. Griffin et al. (1995) found that morbid cattle gained 3% less and had an 18% higher total cost of gain compared with cattle that did not get sick. The cost for morbid cattle as reported by Griffin et al. (1995) was $111.38/sick animal.

Etiology and Clinical Signs

Bovine respiratory disease is a complex multifactorial disease that develops as a result of interactions between the environment, individual animal, and pathogens (Merck Veterinary Manual, 1998). Environmental, viral and bacterial factors occur in various combinations to produce symptoms ranging from subclinical infections to acute bronchopneumonia (Johnson, 1985; Perino and Apley, 1999). Bovine respiratory disease occurs when there is the presence of a viral infection and/or a stressor with a pathogenic bacteria (Perino, 1992; Merck Veterinary Manual, 1998). When viral infection and/or pathogenic bacteria are combined with the stresses endured by newly received feedlot cattle such as weaning, mixing, transportation, and processing, the ability of the immune system to ward off disease is reduced (Merck Veterinary Manual, 1998). In addition, environmental factors such as crowding and poor ventilation may also serve to enhance transmission of BRD among animals (Merck Veterinary Manual, 1998). Added to this is the exposure to many bacterial pathogens when cattle are comingled with cattle from other origins at the stockyards, auction barns and on trucks. Immunizations against bacteria and viruses have historically been only partially successful (Pharmacia & Upjohn Animal Health, 1998a).

Bovine respiratory disease typically has occurred soon after environmental, physiologic, or psychological stress or exposure (Perino and Apley, 1999). Stress has been defined as a nonspecific response of the body to any demand from the environment (NRC, 1996). "Stress alters the steady state of the body and challenges the physiological capabilities of the animal" (NRC, 1996). The major stresses endured by beef cattle are feed and water deprivation while in market, weaning, crowding, and disease exposure (NRC, 1996). Other stresses include weather changes, castration, dehorning, vaccination, dipping, deworming and other processing procedures (NRC, 1996). Cattle that spend more than 24 h in transit and/or have greater than 7 percent shrink in body weight have a greater chance of contracting BRD (Johnson, 1985). Furthermore, cattle may have subclinical symptoms of BRD due to the stress of a longer shipping time (Montague et al., 1996). Diesel fumes have also contributed to lung disease (Johnson, 1985). Once the stressors have disarmed the defense mechanisms, bacterial pathogens that normally reside in the respiratory tract can gain access to the lungs (Griffin, 1998).

Usually bacteria did not serve as the primary pathogens in causing BRD in healthy unstressed cattle (Griffin, 1998). Bacteria shown to cause BRD include *Pasteurella haemolytica, Pasteurella multocida, hemophilus somnus, Mycoplasma* spp., and *Chlamydia* spp. (Griffin, 1998). Viruses shown to cause BRD include *Infectious Bovine Rhinotracheitis (*IBR*), Bovine Virus Diarrhea (*BVD*), Parainfluenza 3 (*PI_3*)*, and *Bovine Respiratory Synctial Virus (*BRSV; Albin and Thompson, 1996). These viruses caused respiratory disease without interacting with other pathogens (Griffin, 1998). However, these pathogens (viral and bacterial) were not capable of causing BRD in healthy, unstressed cattle (Griffin, 1998). Respiratory disease has been shown to be the most severe when bacterial infections are superimposed upon viral infections (Kelling, 1993).

Bovine respiratory disease begins in the upper respiratory tract, progresses down through the trachea and settles in the lungs (Pharmacia & Upjohn Animal Health, 1998c). Death has resulted as quickly as 24 to 36 h (Pharmacia & Upjohn Animal Health, 1998c). If death did not occur, the infection could become chronic and cause widespread permanent lung damage (Pharmacia & Upjohn Animal Health, 1998c). If the animal survived, it had residual lung problems that impacted performance (Pharmacia & Upjohn Animal Health, 1998b). Most animals that died of BRD didn't die of the clinical signs and processes, they died of terminal bacterial infection in almost all cases (Pharmacia & Upjohn Animal Health, 1998b).

Clinical signs of BRD include nasal and eye discharge, bloody nasal discharge, depression, fever (rectal temperature > 40° C), loss of appetite, stiff gait, crusty muzzle, salivation, diarrhea, rapid shallow breathing, and soft coughing (Merck Veterinary Manual, 1998). Perino and Apley (1999) listed the primary sign of BRD as depression, with other symptoms including a decreased flight zone, glazed look, and respiratory character (outstretched head or labored breathing). Perino and Apley (1999) stated that nasal and ocular discharge along with increased respiratory rate were unreliable signs of BRD when there was the absence of depression. The genetics of the individual animal may affect the degree which they show clinical signs of the disease (Perino and Apley, 1999).

Sick animals will usually reduce their intake gradually, not immediately (Pharmacia & Upjohn Animal Health, 1998c) and sick cattle may still go to the feedbunk with their penmates (Perino and Apley, 1999). Griffin et al. (1993) stated the most important early symptom of pneumonia is appetite depression. Research has shown that feed consumption in cattle exposed to viral respiratory disease began to decline 48 h before a rise in body temperature could be detected and that this drop in consumption could be as much as 50 percent 24 h before the animal's temperature began to rise (Griffin et al., 1993).

Hutcheson (1990) measured antibody titers to PI3, BVD, RSV, and IBR in cattle shipped from the Southeast to the Texas Agricultural Experiment Station. Results showed at least 45% of the calves did not have antibodies to any one of these diseases. Therefore, these calves had not been exposed to these diseases prior to shipping.

Management Strategies

The main management tool feedlot managers have to reduce the incidence of BRD is to minimize the number and severity of stressors the cattle experience to prevent compromising the defense system (Perino, 1992; Perino and Apley, 1999). Usually it is not a single stressor that reduces the immune system, but a cumulative effect of mild to moderate stressors over a short period of time (Perino and Apley, 1999). "Not only does each animal have a unique immunologic history but each animal varies in response to stressors, resulting in the wide spectrum of morbidity and response to vaccination frequently seen in cattle" (Perino and Apley, 1999). Other important host factors determining an animal's ability to respond to vaccine and fight infections are age, previous nutritional status and parasite burden (Perino and Apley, 1999).

Lofgreen (1988) stated that calves should be processed upon arrival. Increasing the time between arrival and processing resulted in reduced feed intake, increased stress, and lower weight gains. However, if calves cannot be processed upon arrival, processing may be delayed up to 3 d without any negative effects on the calves. Johnson (1985) advised waiting even longer (14 d after arrival) to vaccinate and process severely stressed cattle.

The feedlot manager may want to buy preconditioned calves. Preconditioned calves were 19.5 times less likely to be sick in the feedlot (Perino and Apley, 1999). In a study comparing the performance of preconditioned to non-preconditioned calves, Lofgreen (1988) found that the preconditioned calves gained better than non-preconditioned calves during a 28-d receiving period. However, by the finishing period there were no differences in ADG between the two groups. Furthermore, cattle shipped directly from the ranch to the feedlot were 5.7 times less likely to be sick in the feedlot than cattle that went to auction and were mixed before going the feedlot (Perino and Apley, 1999).

Griffin et al. (1993) stated that one of the most important factors influencing the outcome of a disease in cattle was finding the sick cattle and starting treatment early. Appropriate therapy started within 48 h of the onset of sickness drastically improved an animal's chance of survival. However, identifying sick animals was both difficult and subjective. In most feedlots, pen riders have relied on subjective signs of BRD to identify and pull possible sick animals. Once the calf was pulled and taken to the hospital pen, the objective signs of BRD, such as rectal temperature, were assessed. However, in surveys of cattle packing plants, Perino and Apley (1999) found that well over half the cattle that were not detected as clinically ill during the feeding period displayed pulmonary lesions. Cattle with these lesions gained approximately .05 kg/d less than cattle without lesions.

In an attempt to design a more objective diagnostic tool, researchers have used rectal temperatures (Galyean et al., 1995), bodyweight change (Blood et al., 1996), feeding behavior (Sowell et al., 1998), and watering behavior (Basarab et al., 1996) to identify cattle with BRD. Rectal temperature at processing can be used as a diagnostic tool as long as one considers that rectal temperature was affected by ambient temperature and management practices (Lofgreen, 1983; Galyean et al., 1995; Perino and Apley, 1999). Lofgreen (1983) agreed that rectal temperature was a good indicator of sickness. However, rectal temperature at receiving was not indicative of expected morbidity later on (Lofgreen, 1983). Blood et al. (1996) found that calves gaining weight in the feedlot were 3.4 times less likely to be pulled as sick than calves losing weight. Body weight change could also be used as a tool to assess the response to treatment. Feed and water consumption was shown to decrease rapidly with the onset of respiratory disease (Pijpers et al., 1991). It has been shown that morbid steers spend 30% less time at the feedbunk than healthy steers (Sowell et al., 1998). Basarab et al. (1996) used watering behavior for the early detection of BRD and found that morbid steers spent 23.7% less time at the waterer than healthy steers.

Perino and Apley (1999) stated the environment the animals were kept in was an important factor in disease control. Environmental factors to consider in disease control were bunk space (45.72 – 60.96 cm linear bunk space/hd), pen space (6.10 sq m/animal), pen surface, water space, pen layout, wind breaks, sanitation, pen size, and shade. Water was the most important nutrient for an animal recovering from respiratory disease (Perino and Apley, 1999).

Identifying and pulling sick cattle has often been described as an art. This technique has been difficult to perfect. Animals have often been pulled too late, resulting in chronics, or too early, which has wasted time and drugs. If drugs are used too early they mask the normal signs of disease and contribute to prolonged outbreaks and the development of chronics (Johnson, 1985). Johnson (1985) recommended a checklist of symptoms to use for pulling cattle. His recommendations included cattle not pulled until they showed all the clinical signs listed on the checklist.

Treatments for BRD

Effective BRD treatment has been a series of judgment calls (Pharmacia & Upjohn Animal Health, 1998b). In many feedyards, 25 to 50% of respiratory deaths occurred in the pen, before treatment could be initiated (Perino and Apley, 1999). Perino and Apley (1999) stated the farther along in the incubation period the cattle were, the less likely they were to respond to treatment. Johnson (1985) stated that vaccination must be done within the first 72 h after arrival to be effective in preventing sickness but ideally cattle should be vaccinated at least 10 d prior to shipping. In contrast, Wittum et al. (1994) concluded that therapeutic antibiotic treatment did not modify the negative effect of BRD on rate of gain in the feedlot.

Timing and route of administration were very important when using antibiotics and sulfa drugs in the prevention of respiratory disease (Johnson 1985; Galyean et al., 1995). If the animal was already incubating the disease or had been exposed soon after treatment, some animals still got sick, making the treatment seem ineffective, contributing to prolonged outbreaks and the development of chronics (Johnson 1985; Galyean et al., 1995). Treatment that was administered too late in the disease was ineffective (Johnson, 1985). Galyean et al. (1995) advised to remember it takes several days for a vaccine to elicit a response from the animal's immune system and for the animal to be protected. Vaccines and injectable antibiotics may be administered intramuscularly or subcutaneously. However, there is the threat of injection site lesions at slaughter when administering drugs intramuscularly.

Hjerpe (1983) stated that cattle that traveled long distances to the feedlot may still have responded unsatisfactorily to treatment for respiratory disease. It should be considered that several weeks might have passed between weaning and arrival to the feedlot. Often cattle arrived exhausted, too tired and weak to eat for several days. If cattle were sick upon arrival or became sick before recovering from the stresses of shipping, they may not have responded to treatment (Hjerpe, 1983). Long acting antibiotics were preferred when treating respiratory disease because the animals were handled less often (Laven and Andrews, 1991).

Metaphylactic treatment or mass medication has been defined as "treatment given to animals with a viral or bacterial disease before overt signs of disease are evident" (Vogel et al., 1998). There is some controversy over mass medication of animals upon arrival to the feedlot. Administration of an antibiotic upon arrival to the feedlot can reduce the incidence of BRD and extend the time before the first treatment has to be administered, giving the animals more time to acclimate to the stressful environment

(Morck et al., 1993). Morck et al. (1993) concluded that the administration of long-acting antibiotics upon arrival to the feedlot was an effective control measure for the incidence and severity of pneumonia. However, mass medication increased the feedlot owner's medical costs and reduced profit and a large number of cattle still required individual treatment (Morck et al., 1993; Vogel et al., 1998). Treating animals based on rectal temperature versus mass medication reduced medical costs and identified sick animals better than visual observation alone (Klemesrud et al., 1997). Mass medication programs were best used in highly stressed groups of cattle where a large percentage of the cattle would be treated anyway (Hjerpe, 1983). Vogel et al. (1998) stated that treatment based on high rectal temperatures at processing was not as effective in reducing mortality rates as metaphylactic treatment.

Traditionally, treatments for BRD included long-acting oxytetracycline, penicillin, feed additives, and tilmicosin either alone or in combination with sulfamethazine boluses. These drugs may not only be used to treat BRD, but also to prevent BRD in a mass medication program.

Tilmicosin has been found to be an effective treatment for BRD (Schumann et al., 1991; Galyean et al., 1995; Scott et al., 1996). Tilmicosin has been found to be more effective in treating BRD than long acting oxytetracycline (Laven and Andrews, 1991; Morck et al., 1993; Musser et al., 1996). Klemesrud et al. (1997) and Morck et al. (1993) found that mass treatment with Micotil decreased the incidence of BRD, and improved ADG and DMI. Reece and Smith (1999) found no differences in morbidity rates in animals treated with tilmicosin at receiving compared with animals receiving no antibiotic treatment upon arrival. However, calves receiving no antibiotic were 3.18 times more likely to die of BRD during the first 30 d than the calves receiving tilmicosin. Vogel et al. (1997) concluded that Micotil was effective in controlling BRD in high-risk cattle. Using Micotil in a metaphylactic program resulted in decreased morbidity and mortality and increased animal performance. Metaphylactic use of Micotil at processing was more effective (Vogel et al., 1997) or as effective (Galyean et al, 1995) in preventing respiratory disease as temperature based therapy at processing.

Florfenicol has also been found to be effective in treating and preventing BRD (Booker et al., 1997; Hoar et al., 1998). Cattle that received florfenicol had significantly higher weight gains and lower rectal temperatures when compared to cattle receiving no antibiotic treatment (Booker et al., 1997; Hoar et al., 1998). With the recent introduction of florfenicol to the market, many questions have been raised as to which treatment is more effective. There has been limited research comparing the two antibiotics. Hoar et al. (1998) concluded that both antibiotics were equivalent in limiting death loss and reducing clinical signs of BRD. Florfenicol was more effective in preventing relapses when compared to tilmicosin, with 57% of the tilmicosin treated calves suffering relapse and only 27% of the florfenicol treated calves relapsing (Hoar et al., 1998). However, the calves receiving florfenicol were treated twice as many times as the tilmicosin calves, as specified by the label of the drug. Jim et al. (1999) found lower rates of chronicity, wastage, mortality, and BRD mortality rates and no differences in relapse rates, in calves treated with florfenicol compared to calves treated with tilmicosin. Jim et al. (1999) also found it to be more cost effective to use florfenicol to treat BRD compared to tilmicosin.

This contradicts Griffin et al. (1996) who found no differences between the two injectable antibiotics in cost effectiveness.

Castration

Castration is one of the stressors often endured by newly received feedlot cattle. Typically cattle that arrive to the feedlot as bulls are castrated during the receiving process. Even though bulls have a higher feed efficiency, improved growth rates and better carcass characteristics compared to steers, they are castrated to reduce their aggressive and sexual behavior (Cohen et al., 1990). However, questions about the ideal method and timing of castration, and the effects of castration on feed intake and health status are common among feedlot managers. Both weaning and castration cause stress and it is often recommended that both of these practices are not done simultaneously. Peterson et al. (1989) found that the timing of castration, dehorning, and vaccination influenced ADG. If these practices occured at sale time, the rate of feedlot gain was reduced. The animals with the highest ADG were those that were castrated, dehorned, and vaccinated at the same time, four weeks prior to being sold and prior to weaning. Peterson et al. (1989) concluded that animals that were stressed less frequently performed better than animals that underwent management practices that caused stress at different times.

The release of acute phase proteins, such as haptoglobin and fibrinogen, have been associated with immunosuppression (Fisher et al., 1997). Researchers have measured levels of these proteins to indicate stress levels of castrated cattle.

Age at Castration

Lyons-Johnson (1998a; 1998b) cites unpublished data from Dr. Julie Morrow-Tesch that states calves castrated shortly after birth suffered less stress and recovered faster than those castrated around weaning time. Stress was measured by assessing the haptoglobin levels, a protein the liver makes when an animal is injured. Haptoglobin levels were higher in calves castrated at 36 weeks than in calves castrated at 33 weeks or at birth, implying the earlier in life that castration occurs the less stress the animal undergoes. Brazle (1995) found that calves castrated at birth to 3 months of age reached slaughter 11.6 d earlier than calves castrated at weaning. The size of the animal and the degree of stress it had been exposed to were factors determining the appropriate time for castration to occur (Brazle, 1995). If castration is delayed, it should be delayed long enough for the calves to overcome the stress of shipping and be in good health at the time of castration (up to 21-28 d). In contrast to Brazle (1995) and findings by Dr. Julie Morrow-Tesch, Cohen et al. (1991) found that age at castration did not affect feedlot performance or carcass characteristics. Furthermore, King et al. (1991) found that calves castrated at a younger age suffered no physiologically detectable stress up to 30 h postcastration, while physiological stress was detectable in older calves up to 30 h postcastration.

Method of Castration and Effects on Performance

There are many methods currently available to use when castrating bulls. Surgical castration is actually removing the testicles from the scrotum, usually without the use of any anesthetic. Chemical castration utilizes a compound administered to the animal that interrupts the spermatogenic process, however the effectiveness of this method has been questioned. Burdizzo castration uses special clamps that crush the spermatic cord through the intact skin. It is thought when using the Burdizzo method animals endure pain that is more intense compared to other castration methods but of shorter duration (Robertson et al., 1994). The banding method involves applying a rubber ring at the top of the testicles that slowly cuts off the blood supply to the testicles and results in infertility.

Robertson et al. (1994) used 12 head of calves randomly assigned to one of four treatments: 1) Handling (Control), 2) surgical castration, 3)Burdizzo castration, and 4) rubber ring castration. Plasma cortisol concentrations (PCC) were measured as an indicator of stress and behaviors were recorded for a 3 h period following the castration. Robertson et al. (1994) observed higher frequencies of restlessness, tail wagging, foot stamping, and head turning for the rubber ring group than for the other three groups. The castrated calves ate and sucked less time than the control calves. The surgical castration group's peak levels of PCC were significantly greater than the other three groups' indicating that surgical castration was more stressful than the other three methods.

It has been shown that that both surgical castration and banding cause some stress, however, surgical castration is more stressful than banding (Lyons-Johnson, 1998a; 1998b; Cohen et al., 1990). This is an interesting fact when considering that Brazle (1995) reported a trend of less health problems and better gain in bulls that were surgically castrated upon arrival compared to banded bull calves. Brazle (1992) found that animals purchased as steers gained better than bulls castrated surgically or castrated using bands upon arrival to the feedlot. However there were no differences seen between animals purchased as steers and animals castrated at the feedlot in morbidity rates. Band castration did not improve gain, morbidity, medications required, or cost of medication over surgically castrated animals. Castrated animals (surgical or banded) required more medications than steers (Brazle, 1992). The differences in morbidity and performance between bulls and steers may have been due to the stocker bulls not receiving vaccinations to build up their immunity, the increased stress endured by young bulls due to their social activity (Brazle, 1992), and the conversion of muscle to fat tissue that occured in the change from a bull to a steer (Brazle, 1995).

The manager must remember that a castrated animal must undergo body changes that will have a temporary negative effect on weight gain (Brazle, 1995). Smith et al. (1999) found that cattle castrated at the feedlot tended to gain .07 $kg \cdot animal^{-1} \cdot d^{-1}$ ($P<.10$) less than cattle purchased as steers. Brazle (1995) cites research by Zinn et al., (1985) that showed a reduction in gain the first 28-d of .22 kg and an increase in sickness in 227 kg calves bought as bulls and castrated upon arrival compared to steers. Research also shows that this reduction in gain can occur for up to 100 d past the time of castration (Brazle, 1995). In contrast, Cohen et al. (1991) concluded that the method of castration (surgical or chemical) had no effect on carcass characteristics and had little effect on ADG, liveweight and carcass weight. King et al. (1991) found ADG between bulls and steers did not differ, nor did method of castration have an effect on liveweight or ADG.

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MATERIALS AND METHODS

This study was conducted at a commercial feedlot near Wellton, Arizona beginning August 19, 1997 and ending October 22, 1997. We conducted three 21-d trials using 150 (Trial 1; August 19 to September 9), 150 (Trial 2; September 9 to September 30), and 148 (Trial 3; October 1 to October 22) newly received Brahman cross-bred male calves (avg wt 158 kg). Calves traveled approximately 27 h from Texas sale barns to the feedlot. General practices followed by the feedlot for managing, handling, and feeding animals were observed during all three trials. Weather data was collected by an on-site system, with daily high and low environmental temperatures being recorded.

Processing and Treatments

Upon arrival to the feedlot, calves were uniformly processed according to feedlot procedures. During processing rectal temperature was measured and calves were individually weighed. If necessary, horn tipping was done at processing. Animals were individually examined for the presence of intact testicles and if present, were surgically castrated. Each animal was fitted with an ear tag displaying an individual feedlot identification number and an Allflex® radio frequency (**RF**) ear tag with an individual RF identification number. All animals received a predetermined specified preventative drug and biological regimen at processing (Table 1). Animals were also visually appraised for health status and status was recorded.

Calves were randomly assigned to one of four treatments administered at processing. The treatment groups were: 1) No injectable antibiotic at processing with chlortetracycline in the feed to provide approximately 350 mg^{-1}•hd^{-1}•d^{-1}; served as a control (**CON**), 2) Tilmicosin administered subcutaneously (10 mg/kg BW; Micotil® 300, Elanco Animal Health, Indianapolis, IN; **TIL**) at processing with chlortetracycline in the feed to provide approximately 350 mg^{-1}•hd^{-1}•d^{-1}, 3) Florfenicol administered intramuscularly (neck; 20 mg/kg BW; Nuflor® Schering-Plough, Union, NJ; **FIM**) at processing with chlortetracycline in the feed to provide approximately 350 mg·hd^{-1}·d^{-1}, and 4) Florfenicol administered subcutaneously at processing (30 mg/kg BW; Nuflor® Schering-Plough, Union, NJ; **FSC**) with chlortetracycline in the feed to provide approximately 350 mg·hd^{-1}·d^{-1}. Animals were classified by treatment, castration status, and health status (Figures 4, 5, and 6). The first classification used was treatment where animals were divided into Control, TIL, FIM, and FSC. The next classification level was castration status where animals within each treatment were separated into those castrated at the feedlot (CF) and animals that had been castrated prior to arrival to the feedlot (PC). Health status was the next level of classification. Animals within treatment and castration status were divided into morbid (M) and healthy (H). The final stage of classification was morbidity, showing animals within treatment, castration status and health status that died during the study.

Health Management

Pen riders subjectively evaluated calves on a daily basis for sickness. Clinical signs used for evaluation were nasal discharge, coughing, depression, and inappetence. Calves that were diagnosed as sick or injured by the pen riders were removed from the study pen and taken to the hospital pen. At the hospital pen, each animal's rectal temperature was taken. If rectal temperature was greater than 40° C, the animal was treated for BRD. If rectal temperature was less than 40° C, the animal was not treated and was returned to the study pen. Medical treatment of sick animals was under the guidance of the feedlot veterinarian. Calves that were treated for BRD received their respective assigned experimental antibiotic treatment. Calves were returned to the study pen when confirmed to be healthy according to the veterinary protocol. Dates and times animals were removed and returned to the study pen were recorded. If therapeutic drugs were required for treatment of sickness, the name of the drug, dosage, date administered, and reason for administration were recorded. Any animals that died were necropsied by a veterinarian to determine the cause of death. Calves that were removed from the pen at any time were considered to be morbid (M) and those calves not removed from the pen were considered to be healthy (H) for experimental classification purposes.

Housing, Diet and Feed Management

Within each trial, cattle were managed in a single pen. Animals were fed three times/d with 30 % of the day's total ration being delivered at 0600, 30% at 0800, and 40% at 1100. The pen was 30 x 36 m with 30 m of feedbunk space located at the south end (Figure 1). A maximum of 120 animals could feed at the bunk at one time. The water trough was located opposite the feed bunk, at the north end of the pen, and was 4.5 m in length. A coccidiostat was in the ration for the first 4 d of each trial at the rate of .06 $kg \cdot hd^{-1} \cdot d^{-1}$. Loose hay, in addition to a 50% concentrate diet, was fed for the first 4 d of each trial. After the first 4 d, the loose hay was eliminated from the diet and the cattle continued on the 50% concentrate diet (Table 2). The diet was formulated to contain

13.02% CP, .35 Mcal/kg NE_m, and .22 Mcal/kg NE_g. Water was available on an ad libitum basis at all times.

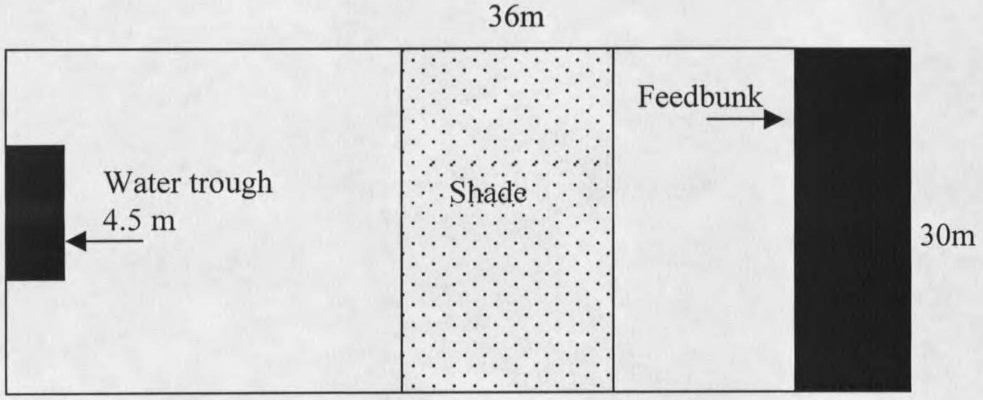

Figure 1. Experimental pen layout at a commercial feedlot near Wellton, Arizona.

Behavior Data Collection

The Growsafe® system was used to collect daily individual feeding and watering behavior. The system consists of 4 components: 1) a black mat that lays in back of the feedbunk and contains an antenna (Figure 2), 2) a reader panel, 3) a personal computer that collects the data, and 4) a RF ear tag (passive transponder) in the ear of each animal.

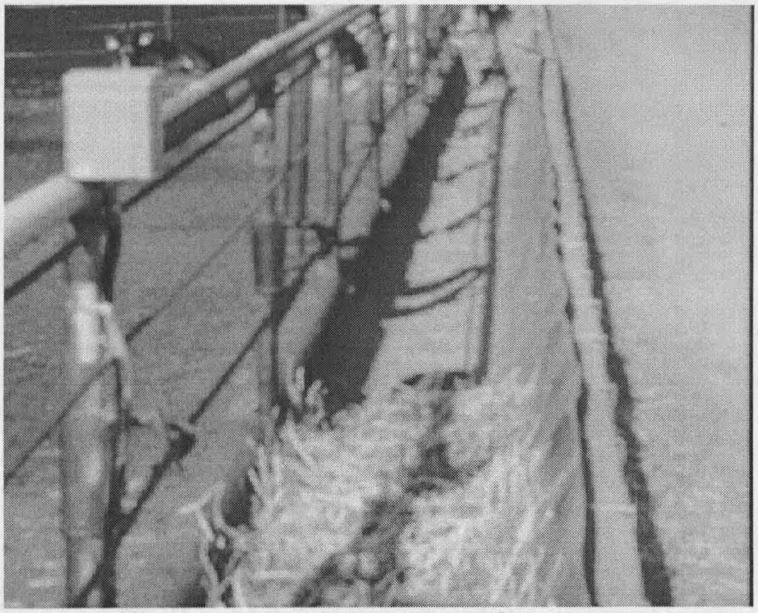

Figure 2. Feedbunk equipped with the Growsafe® System.

Each RF ear tag had a unique identification number (Figure 3). Before the RF ear tags were inserted into the ear of each animal, they were scanned into the system to ensure they were working properly and to create a file. The Growsafe® System queried every 5.25 seconds and animals wearing RF ear tags that were within 50 cm of the bunk were recorded. Every time the animal came to the bunk, the system recorded the time and the duration of the visit as well as the location at the bunk. This data was electronically sent to a computer approximately 200 m from the pen where it was downloaded for future analysis. A sync chip was also within the system and was queried constantly. The sync chip provided information of the times the system was down or working improperly. If the system was down for more than one h of a 24-h d, the records for that date were deleted from the behavior analysis. Behavior data for Trial 1 was not collected due to system failure. Animals were required to be present in the study pen for the entire 24-h period for that day's data to be included in the analysis. Therefore, behavior data from the first and the last day of Trial 2 and Trial 3 were deleted due to animals not being present in the study pen for the entire 24-h period. The water tank was equipped with a similar Growsafe® System mat containing an antenna. Every 5.25 s, an animal was recorded as absent or present at the feedbunk or water tank. The behavioral variables collected for daily feeding and watering activity were frequency of visits, duration of visits, and number of bouts. A bout was defined as a feeding or watering event with at least five minutes of inactivity between bouts (Rook and Huckle, 1997; Sowell et al., 1999).

Figure 3. A steer wearing the small round radio frequency ear tag.

Study Termination

The exact time the animals were removed from the study pen at the end of each trial was recorded. Ear tag identifications were verified and any missing tags were noted. At termination of the study all animals were individually weighed and RF ear tags removed. Each RF ear tag was held to the Growsafe® mat to verify it was still functioning at the time of study termination.

Statistical Analysis

Comparisons between treatments were made for the number of healthy vs morbid animals for the three trials using contrast statements in the Chi-Square procedure of SAS (Steel and Torrie, 1980). First, the Control group was compared to the other three groups that received injectable antibiotics to test if injectable antibiotics reduced the incidence of sickness. Second, the TIL group was compared to the FSC group to test for differences in morbidity. This comparison was made because both antibiotics were administered subcutaneously for each of these treatments. Finally, the FIM group was compared to the FSC group to see if route of administration affected incidence of morbidity. Column percents, frequencies, and Chi-Square probabilities are reported.

Performance data were analyzed by combining the data from all three trials. Data were analyzed using the GLM procedure of SAS (1993) for a completely randomized design with individual animal as the experimental unit. The model used for the performance data analysis is shown in Table 3. Comparisons were made between trials, treatments, health status, and castration status for beginning and ending weights and

ADG. Interactions that were tested were trial*treatment, treatment*health status, treatment*castration status, trial*health status, and trial*casatration status. Significant interactions are reported. Animals that died during the study were deleted from the behavior and the performance data analysis (n = 15). Means were separated using the LSD tests when significant F-values were detected (P < .10). Least square means and P-values are reported.

Comparisons between castration status and health status were made to test for differences in morbidity using the Chi-Square procedure of SAS (Steel and Torrie, 1980). Column percents, frequencies, and the Chi-Square probability are reported.

Behavior data were analyzed by combining the data from the two behavior trials. Data were analyzed using the GLM procedure of SAS (1993) for a completely randomized design with individual animal as the experimental unit. The testing term for the behavior analysis was animal within trial by treatment. Animals were sorted by health status (healthy and morbid) and comparisons were made between trials and treatments for feeding and watering bouts/d, total min/d, and daily min/bout. The model used for the behavior analysis is shown in Table 4. Castration status was not included in the model due to the absence of an observation for certain blocks. For example, in Trial 2, in the FSC group, there were 0 animals that were recorded as morbid in the previously castrated animals (Figures 4, 5, and 6); resulting in SAS reporting non-estimable means when castration status was included in the model. The trial*treatment interaction was tested. Significant interactions are reported.

Table 1. Specified drug regimen administered to all animals at the time of processing.

Drug	Purpose	Dosage and Route of Administration
Pyramid MLV[1]	Vaccine for IBR, BVD, BRSV, and PI_3	2 cc/hd - SC
Ivomec Plus[2]	Anthelmintic parasite control	1 cc/hd - topical
Ralgro[3]	Increase weight gain and improve weight gain	1/hd – ear implant
Autogenous bacterin,[4] "Brew"	Prevention of pneumonias caused by *Haemophilus Somnus, Pasturella Haemolytica,* and *Pasturella Multocida*	2 cc/hd – IM, neck
Safeguard[5]	Anthelmintic - parasite control	9 cc/hd – oral
Vision 7[6]	Control of some types of *Clostridium*	2 cc/hd – SC[7]

[1]Fort Dodge Animal Health, Overland Park, KS
[2]Merck & Company, Inc., Whithouse Station, NJ
[3]Schering-Plough Animal Health Corporation, Kenilworth, NJ
[4] American Animal Health
[5]Hoechst Roussel Vet, Clinton NJ
[6]Bayer Corporation, Shawnee Mission, KS
[7]SC = subcutaneous

Table 2. Description of the diet fed to newly received feedlot calves over three 21-d trials.

Ingredient	% DM	Percent of Diet
Milo, steam flaked	78.00	37.83
Cotton seed w/ lint	90.00	10.00
Alfalfa	90.00	7.50
Fat added w/ alfalfa	98.00	.23
Cottonseed hulls	90.00	27.81
Conditioned corn distiller solubles (liquid protein)	48.50	14.00
Liquid urea (23% N)	50.00	1.00
Calcium carbonate	100.00	1.00
Salt	100.00	.22
Chlortetracycline, 90 g/lb	100.00	.2778
Vitamin A, 400,000 IU/g	100.00	.00069
Trace mineral premix	98.96	.13

Table 3. The analysis of variance table used for analyzing the performance data collected on newly received feedlot calves over three 21-d trials.

Source	df
Trial	2
Treatment	3
Health Status	1
Castration Status	1
Trial*Treatment	6
Treatment*Health Status	3
Treatment*Castration Status	3
Trial*Health Status	2
Trial*Castration Status	2
Error	409

Table 4. The analysis of variance table used for analyzing the behavior data collected on newly received feedlot calves for two 21-d trials[a].

Source	df
Trial	1
Treatment	3
Date(Trial)	35
Trial*Treatment	3
Animal(Trial*Treatment)	183
Error	3245

[a]The model shown here is for the healthy calves for minutes/day watering.

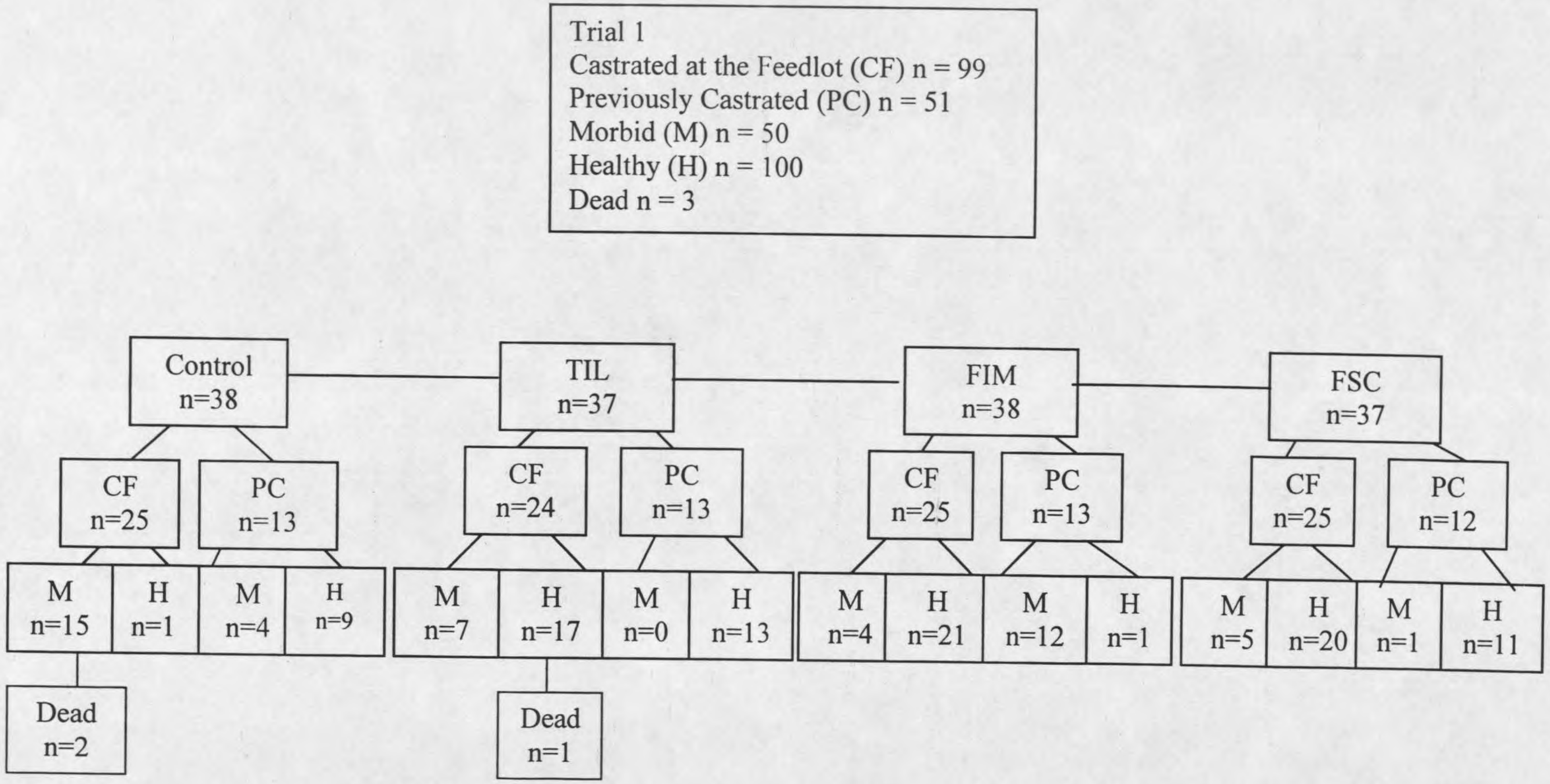

Figure 4. Diagram of animal classification according to treatment, castration status, health status, and mortality status in Trial 1.

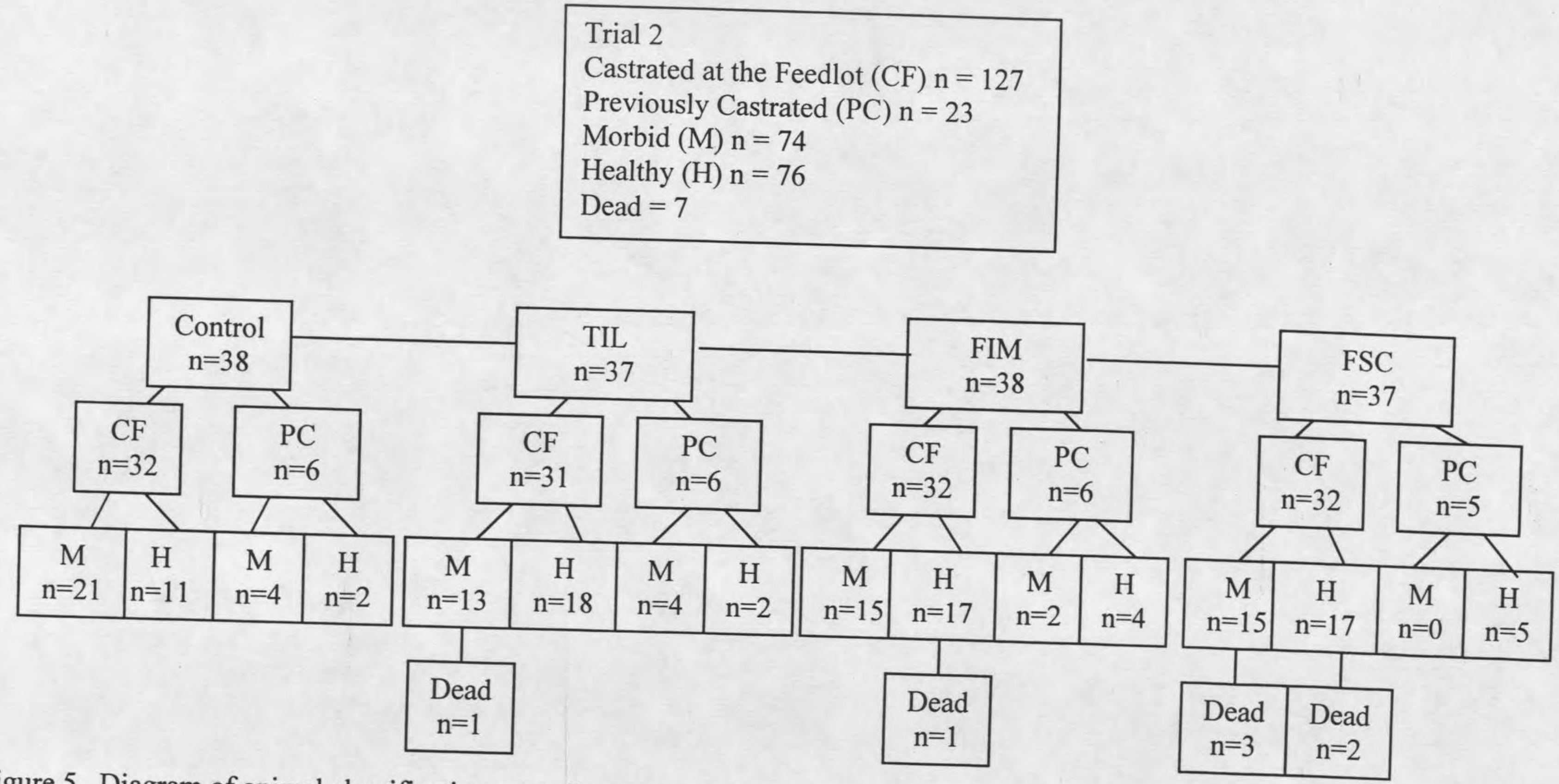

Figure 5. Diagram of animal classification according to treatment, castration status, health status, and mortality status in Trial 2.

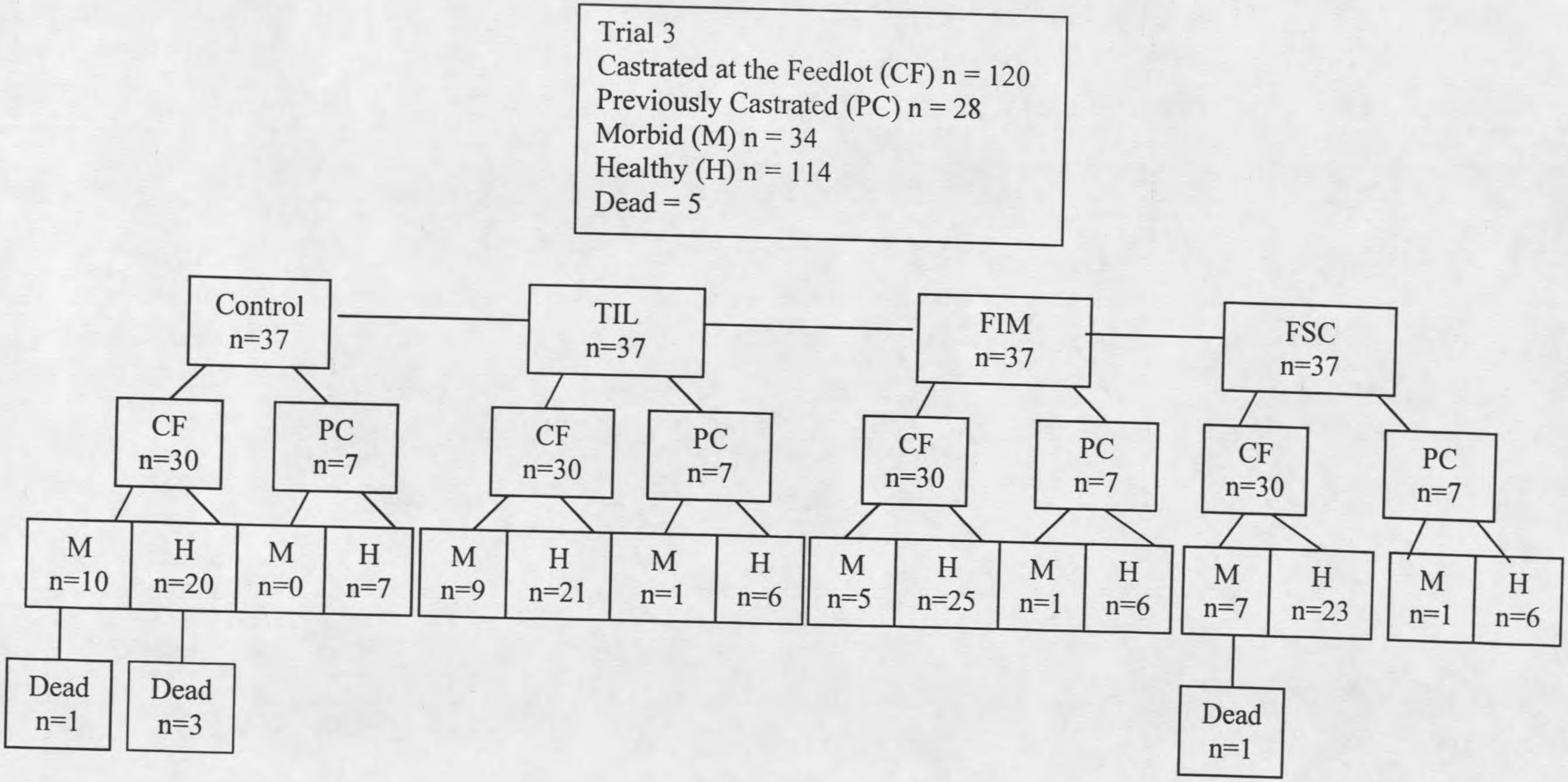

Figure 6. Diagram of animal classification according to treatment, castration status, health status, and mortality status in Trial 3.

RESULTS AND DISCUSSION

The maximum, minimum and mean environmental temperatures for each day of Trials 1, 2, and 3 are presented in Figures 7, 8, and 9. Mean daily temperature averaged 36.7 °C for Trial 1, 33.0 °C for Trial 2, and 26.0 °C for Trial 3. The high daily temperature for Trial 1 was 50.6 °C occurred on d 8 of the trial, for Trial 2 was 47.2 °C and occurred on d 2, and for Trial 3 was 45.8 °C and occurred on d 1. The minimum daily temperature for Trial 1 was 22.8 °C and occurred on d 15, for Trial 2 was 17.8 °C and occurred on d 14, and for Trial 3 was 11.11 °C and occurred on d 11 and 12. The differences in daily temperature between the trials may have affected the performance and the behavior of the animals and may account for some of the differences in the results between trials. Hutcheson and Cole (1986) found that environmental factors affected performance of morbid calves more than healthy calves.

The number of calves that became morbid and the day they were removed from the pen for treatment during each trial is presented in Figures 10, 11, and 12. Calves from the Control group were the first to be pulled and treated in all three trials. This trend continued throughout the three trials with Control having the most numerous sick animals of the three groups. Morbidity rates seen in Trial 1, 2, and 3 were 33%, 49%, and 23% respectively. In Trial 1, Control calves had a morbidity rate of 50%, FIM of 42%, TIL of 19%, and FSC of 16%. In Trial 2, Control calves had a morbidity rate of 66%, followed by TIL (46%), FIM (45%), and FSC (41%). In Trial 3, Control and TIL calves had morbidity rates of 27%, followed by FSC (22%), and FIM (16%). During the first 4-d of each trial, the Control group had an average of 4 calves that were morbid, while the antibiotic treated groups had an average of .56 calves that were morbid (Tables 5,6, and 7). This trend continued through the first 7-d of each trial with the Control group having an average of 9.67 morbid animals and the antibiotics treated groups having an average of 1.67 morbid animals. Sowell et al. (1999) found that the first 4 d on feed are the most important in establishing an animal's feeding pattern. In our study, metaphylactic antibiotics given at receiving decreased morbidity in the first 4 d on feed and may have enabled the animals to establish strong feeding patterns.

The percent of healthy and morbid animals were compared between Control and all injectable antibiotics, TIL was compared to FSC, and FIM and FSC were compared (Table 8). A smaller (P = .001) percentage of TIL, FIM, and FSC calves were identified as morbid (27%) compared with Control (47%). Injectable antibiotics given at arrival to the feedlot reduced the incidence of morbidity by 42.6% (Table 8). There were no differences in the percentage of healthy and morbid animals when contrasting TIL and FSC (P = .46) or FSC and FIM (P = .70). Hoar et al. (1998) used 220 feedlot calves diagnosed with BRD to compare tilmicosin and florfenicol in their efficacy to treat the disease. Hoar et al. (1998) found that tilmicosin and florfenicol were equivalent in reducing mortality and decreasing clinical signs of BRD.

A total of 6 head died on the Control treatment, 6 head on the FSC treatment, 2 head on the TIL treatment, and 1 head on the FIM treatment for all trials (Table 9). The number one cause of death was pneumonia/respiratory disease (n = 11), with other causes being liver dysfunction (n = 1), coccidiosis (n = 1), peritonitis (n = 1) and bleeding due to castration (n = 1). Control had 29 calves that were treated once, 16 treated twice, 3 treated three times and 3 treated four times for sickness (Table 9). This is compared to an average of first, second, third, and fourth treatments for the antibiotic treated groups of 18, 6, 4, and 1 calf, respectively. Morck et al. (1993) concluded that the administration of long-acting antibiotics upon arrival to the feedlot was an effective control measure for the incidence and severity of pneumonia.

Calves that were castrated at the feedlot had a higher (P = .001) chance of becoming morbid than those calves previously castrated (Table 10). Thirty-six percent of the calves castrated at the feedlot became morbid compared to only 19% of the calves that had been previously castrated. The stress of castration contributes to morbidity especially when occurring simultaneously with weaning, processing, and other stressors endured by feedlot cattle.

Animal performance was affected by the health status of the calves (Table 11). Healthy calves had heavier (P = .04) initial weights than did morbid calves. This may indicate that lighter weight calves are more susceptible to disease or that some calves are morbid upon arrival. Healthy calves also had heavier (P = .0001) ending weights than did morbid calves. This difference was expected, however, this large a difference was not expected after only 21-d. Morbid calves weighed an average of 20 kg less (P = .0001) than healthy calves at the end of the 21-d trials. In a review of performance data from 18 studies, Hutcheson and Cole (1986) found that the weight gain of morbid calves was 29% less than in healthy calves after 56 d in the feedlot. Griffin et al. (1995) found that morbid cattle gained 3% less and had an 18% higher total cost of gain. Health status affected (P = .0001) ADG as well, with healthy animals gaining .78 kg/d and morbid animals losing .03 kg/d.

No differences (P = .14) were seen between treatments for ADG (Table 12). Average daily gains were .23 kg for control, .38 kg for TIL, .37 kg for FIM, and .51 kg for FSC. Though these differences are not statistically different, they might be economically important. When contrasting Control to all antibiotic treatments, the Control group had lower (P = .04) ADG than the three groups receiving an antibiotic at receiving. The difference seen between the control group and the FSC group is .27 kg/d. When using local current market prices of $2.38/kg for 136 – 159 kg feeder steers, this equals a reduction in value of $9.50/calf in the Control group for the three 21-d trials. This reduction in value includes only the decreased weight gain and does not include the cost of treatment, labor and death loss. The cost for morbid cattle as reported by Griffin et al. (1995) was $111.38/sick animal in the Texas Ranch to Rail program. In the Texas Ranch to Rail study, sick cattle not only gained less, they also incurred more medicine costs, had poorer feed efficiency, and graded lower than cattle that were not morbid (Griffin et al., 1995).

There were no differences (P = .69) in initial weights between the previously castrated calves and the calves castrated upon arrival to the feedlot (Table 13). However, calves previously castrated gained an average of 7 kg more (P = .0008) than those calves castrated upon arrival to the feedlot. Calves castrated upon arrival to the feedlot gained an average of .32 kg less (P = .0001) per d than the previously castrated calves.

Healthy FIM calves spent 15.9% more ($P = .04$) min feeding/d (76.0 min) than did healthy Control, TIL, or FSC calves (avg 65.6 min). Research has shown that time at the feedbunk is a good indicator of feed intake (Sowell et al., 1999; Putnam et al, 1967; 1968). This result was not expected, as florfenicol is thought to temporarily reduce feed intake. In fact, reduced feed intake is listed on the package insert as an adverse effect of florfenicol. Treatment had no effect ($P > .10$) on feeding bouts/d or min/feeding bout of healthy calves (Table 14).

Treatment had no effect ($P > .10$) on watering behavior of healthy (Table 14) or morbid calves (Table 15). This contradicts Basarab et al. (1996) who found watering behavior had potential for use in early detection of respiratory disease. These differences may be due to the difference in environmental conditions and location of this study. Feeding bouts were greatest ($P = .004$) by morbid FIM calves (8.5 bouts/d) and least by morbid Control calves (5.8 bouts/d; Table 15). One of the first clinical signs of BRD is appetite depression (Griffin et al., 1993; Merck Veterinary Manual, 1998). Administration of an antibiotic upon arrival to the feedlot can reduce the incidence of BRD and extend the time before the first treatment has to be administered, giving the animals more time to acclimate to the stressful environment (Morck et al., 1993). The administration of an antibiotic increased the time the morbid FIM calves spent at the feedbunk when compared to the Control calves.

An interaction was found ($P < .05$) between treatment and trial for the number of feeding bouts/d of the healthy calves (Table 16). There were no differences between treatments for the number of feeding bouts/d in trial 2. In trial 3, healthy calves receiving any injectable antibiotic treatment had more feeding bouts/d than the healthy control group. An interaction between treatment and trial was also found for min feeding/d (P = .04) and min/feeding bout (P = .01) for morbid calves. Morbid TIL and FSC calves in trial 2 spent more (P = .03) time feeding (avg 48.7 min/d) than did morbid Control calves (34.8 min/d). In trial 3, morbid FIM calves spent more (P = .03) time feeding (63.5 min/d) than morbid Control, TIL, or FSC calves (avg 32.8 min/d). This means that during trial 3, FIM animals were present at the bunk for twice as long as the Control animals. In trial 2, animals receiving FSC spent more (P = .01) min/bout at the feedbunk than the florfenicol or control groups. In trial 3, animals receiving FIM had the most (P = .01) min/bout feeding (7.9 min/bout) compared with the Control, TIL, and FSC calves (avg 4.4 min/bout). The length of stay in a holding facility prior to shipment, length of transportation from the auction barn to the feedlot, environmental conditions during transport and after arrival, and level of initial morbidity are factors which may have contributed to the variation between trials.

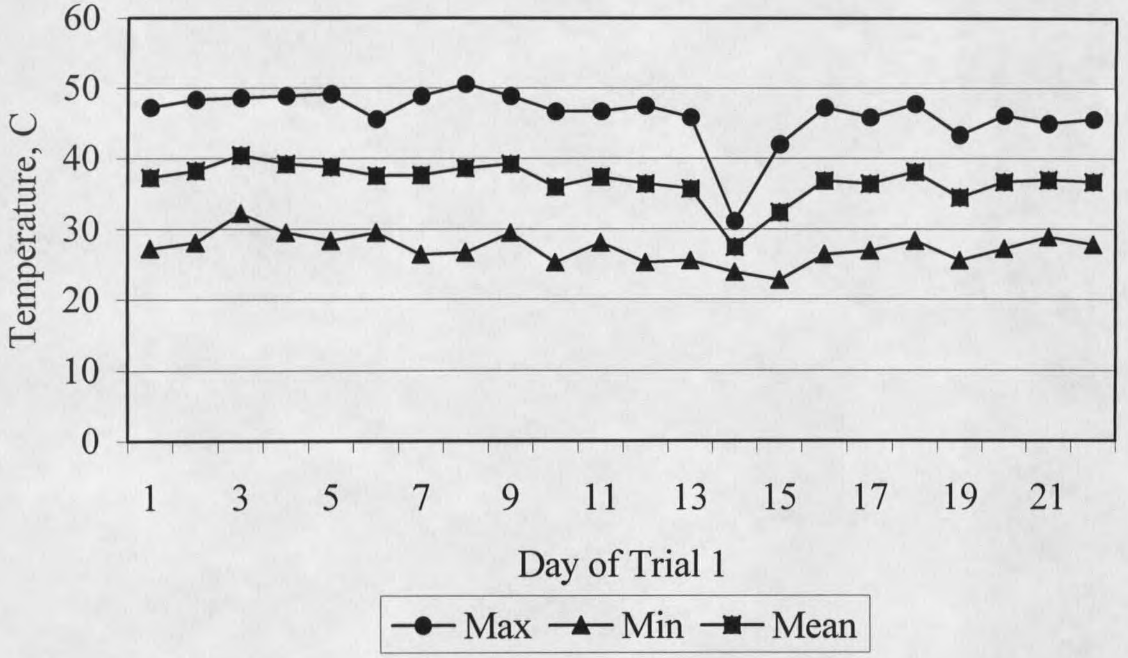

Figure 7. Maximum (•), mean (■), and minimum (▲) daily environmental temperatures (°C) at Wellton, Arizona during Trial 1 (August 19 to September 9, 1997).

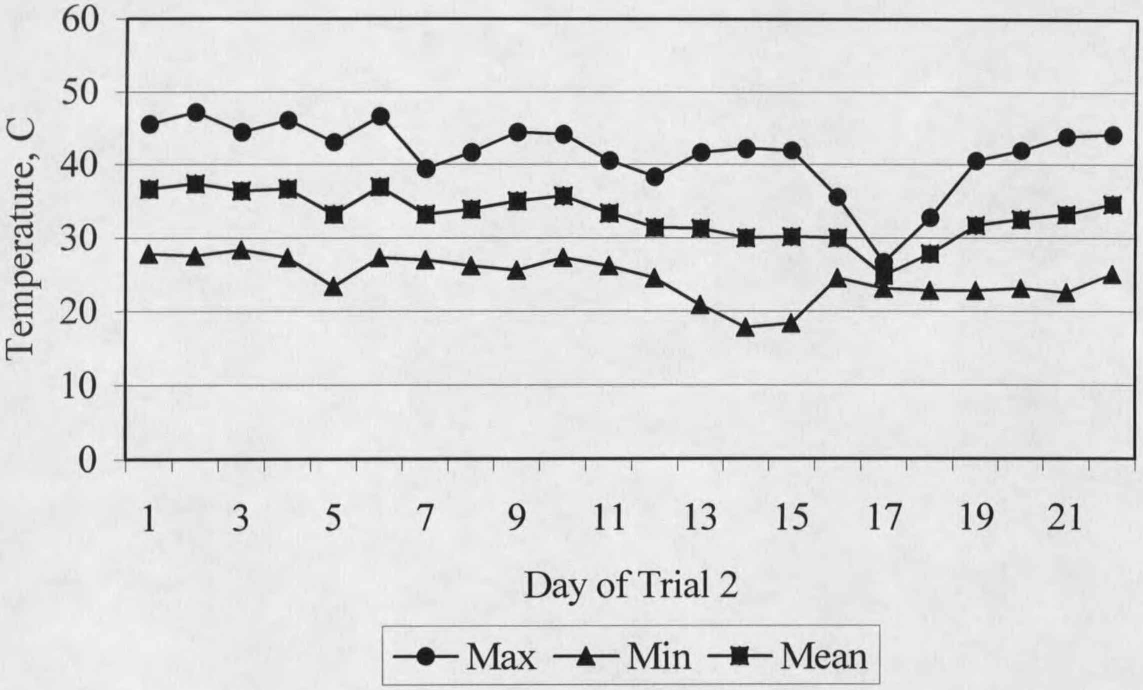

Figure 8. Maximum (•), mean (■), and minimum (▲) daily environmental temperatures (°C) at Wellton, Arizona during Trial 2 (September 9 to September 30, 1997).

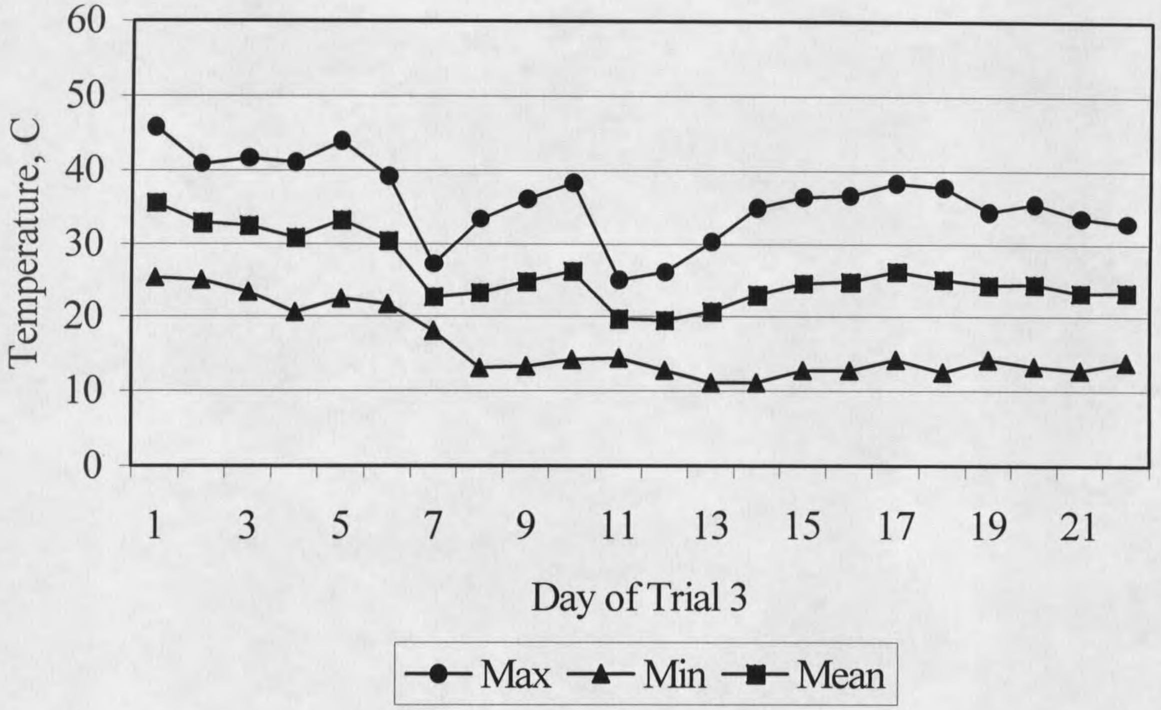

Figure 9. Maximum (•), mean (■), and minimum (▲) daily environmental temperatures (°C) at Wellton, Arizona during Trial 3 (October 1 to October 22, 1997).

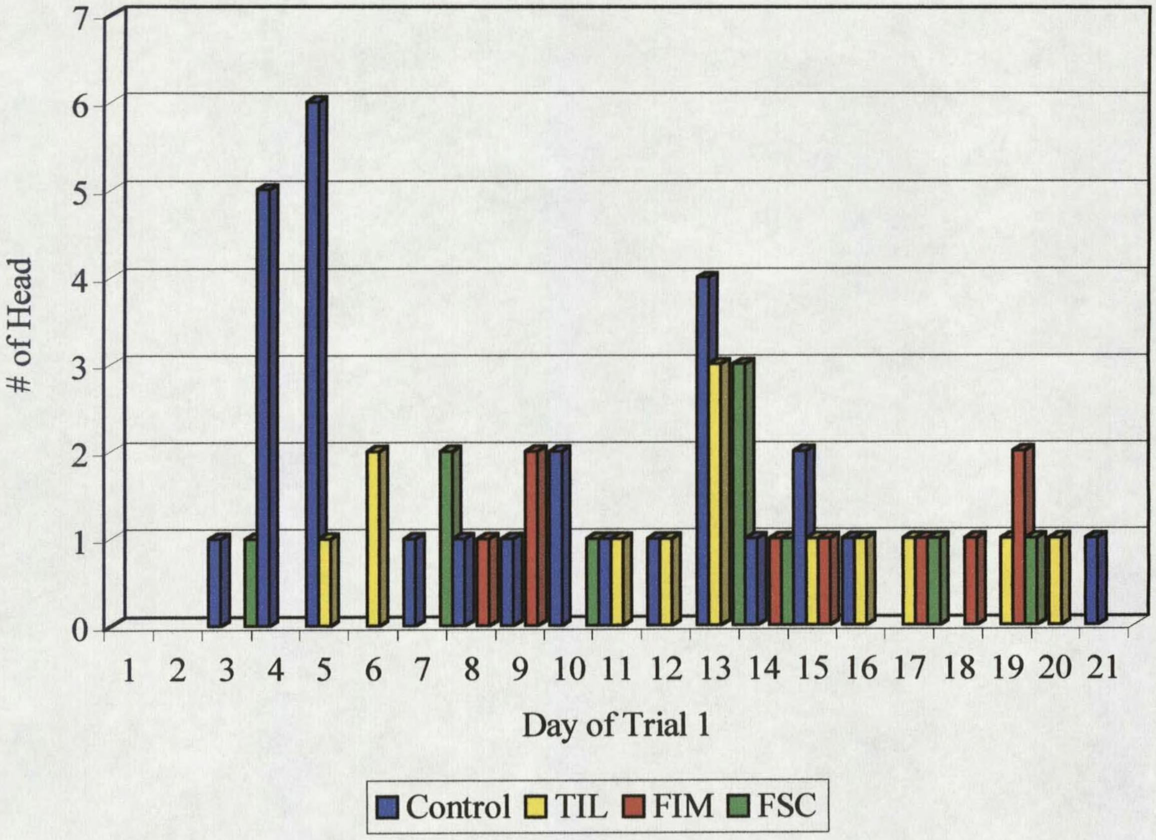

Figure 10. The number of calves that became sick during Trial 1 (August 19 to September 9, 1997) and the day they were removed from the pen when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Table 5. A comparison of the number of calves that became sick during Trial 1 (August 19 to September 9, 1997) when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Time Period	Control	TIL	FIM	FSC
n	38	37	38	37
First 4-d	6	0	0	1
First 7-d	13	3	0	3
Second 7-d	11	5	4	5
Third 7-d	4	5	5	2

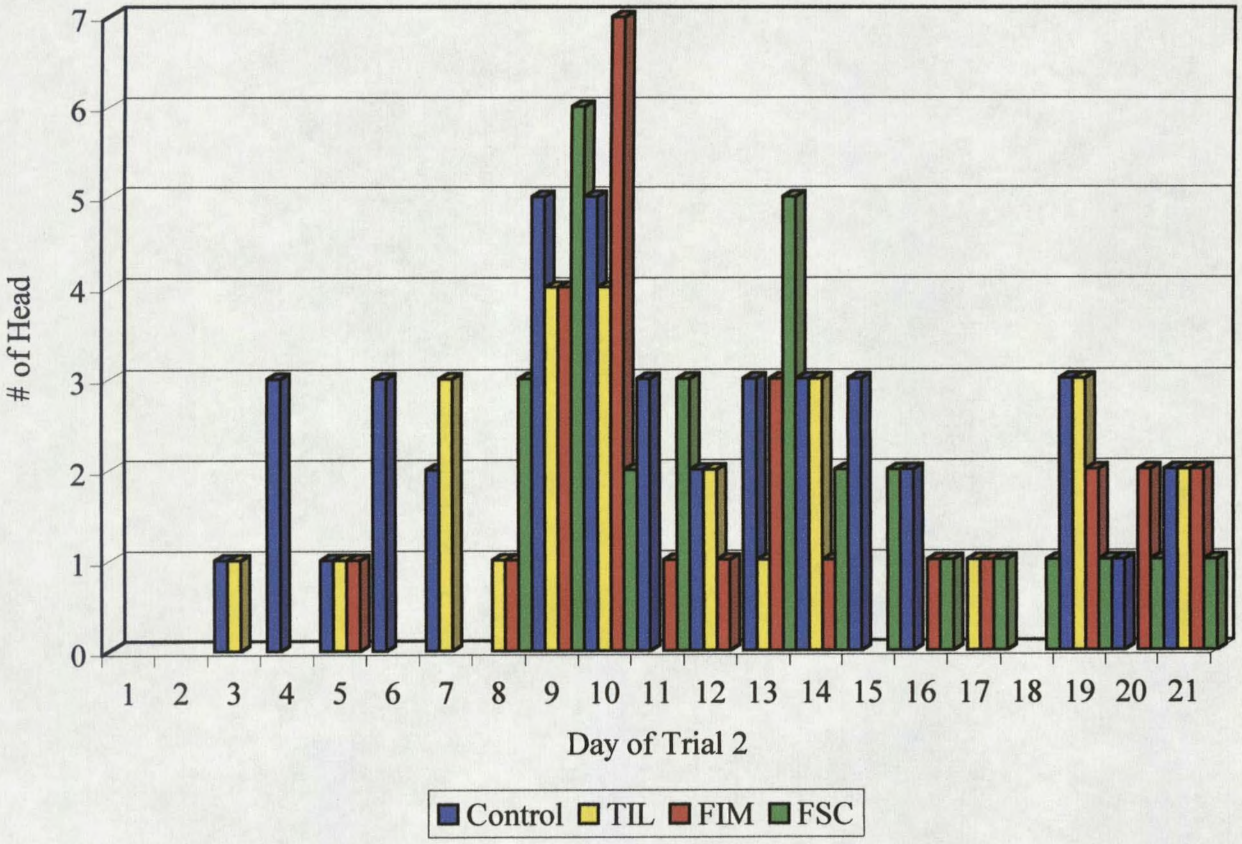

Figure 11. The number of calves that became sick during Trial 2 (September 9 to September 30, 1997) and the day they were removed from the pen when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Table 6. A comparison of the number of calves that became sick during Trial 2 (September 9 to September 30, 1997) when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Time Period	Control	TIL	FIM	FSC
n	38	37	38	37
First 4-d	4	1	1	0
First 7-d	10	5	1	0
Second 7-d	21	15	18	21
Third 7-d	11	6	8	8

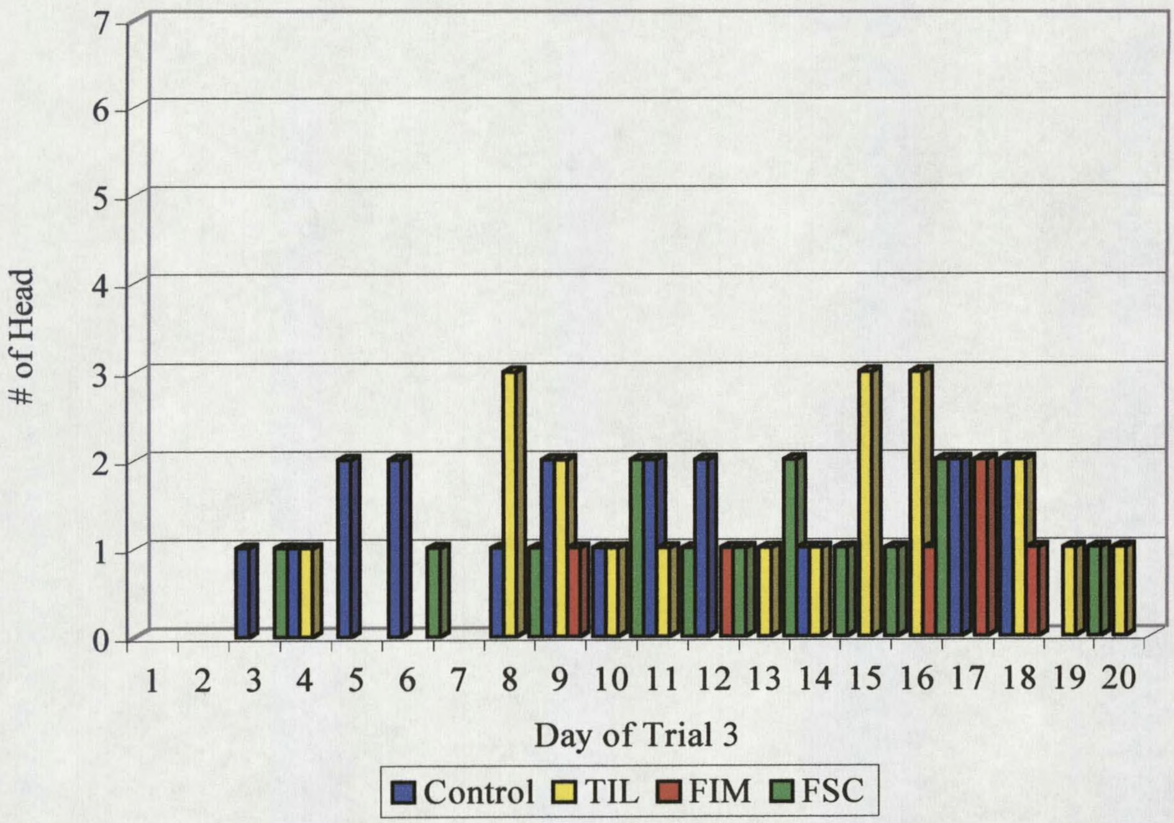

Figure 12. The number of calves that became sick during Trial 3 (October 1 to October 22, 1997) and the day they were removed from the pen when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

Table 7. A comparison of the number of calves that became sick during Trial 3 (October 1 to October 22, 1997) when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Time Period	Control	TIL	FIM	FSC
n	37	37	37	37
First 4-d	2	1	0	1
First 7-d	6	1	0	2
Second 7-d	9	9	2	8
Third 7-d	4	10	4	4

Table 8. Percent of calves that remained healthy or became morbid in three 21-day trials when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

Treatment	Control[a]	TIL	FIM	FSC	*P*
n	113	111	113	111	
Healthy, %	53.10	69.37	76.11	73.87	
Morbid, %	46.90	30.63	23.89	26.13	.001[b]

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.
[b]Chi-square analysis using contrasts to compare Control to all injectable antibiotic treatments, TIL to FSC (P = .457), and FIM to FSC (P = .700).

Table 9. Animal mortality and treatment incidence in three 21-d trials when not treated or treated with one of three metaphylactic antibiotics upon arrival to the feedlot.

Variable	Control[a]	TIL	FIM	FSC
n	113	111	113	111
Mortality, # of animals	6	2	1	6
Treated once				
# of animals	29	18	19	16
percentage	27.10	16.51	17.12	15.24
Treated twice				
# of animals	16	9	2	7
percentage	14.95	8.26	1.80	6.67
Treated three times				
# of animals	3	4	5	2
percentage	2.80	3.67	4.50	1.90
Treated four times				
# of animals	3	2	1	1
percentage	2.80	1.83	0.90	0.95

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.

Table 10. Calves that were morbid or healthy after being castrated upon arrival to the feedlot or being castrated prior to arrival to the feedlot during three 21-d trials.

Variable	Previously Castrated	Castrated at Arrival	*P*
n	102	346	---
Healthy,			
n	83	222	---
%	81.37	64.16	---
Morbid,			
n	19	124	---
%	18.63	35.84	.001[a]

[a]Chi-square analysis

Table 11. Gain performance by healthy and morbid calves when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot during three 21-d trials.

Variable	Healthy	Morbid	SEM	*P*
n	290	158	---	---
Initial weight, kg	160	157	2.612	.04
Ending weight, kg	176	156	3.519	.0001
Average daily gain, kg	.78	-.03	.125	.0001

Table 12. Gain performance by calves during three 21-d trials when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

Variable	Control[a]	TIL	FIM	FSC	SEM	*P* Trt[b]	*P* Control vs treated
n	109	109	112	105	---	---	---
Initial weight, kg	159	156	157	161	3.896	.31	.63
Ending weight, kg	164	165	165	171	5.249	.11	.24
Average daily gain, kg	.23	.38	.37	.51	.1866	.14	.0410

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.
[b]Trt = Treatment

Table 13. Gain performance by calves during three 21-d trials when previously castrated or castrated upon arrival to the feedlot.

Variable	Previously Castrated	Castrated at Arrival	SEM	*P*
n	102	333	---	---
Initial weight, kg	159	158	2.615	.69
Ending weight, kg	170	163	3.524	.0008
Average daily gain, kg	.53	.21	.125	.0001

Table 14. Daily watering and feeding behavior of healthy feedlot calves during two 21-d trials when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

Variable	Control[a]	TIL	FIM	FSC	SEM	*P* Trt[d]	*P* T	*P* Trt*T
n	40	47	47	49	---	---	---	---
Feeding								
Min/d	65.37[b]	64.36[b]	75.98[c]	67.18[b]	3.44	.04	.0001	.43
Bouts/d	10.44	10.89	10.85	10.74	.369	.83	.0001	.03
Min/bout	6.22	6.56	7.20	6.40	.376	.26	.0001	.98
Watering								
Min/d	10.63	10.53	11.10	12.08	.834	.53	.0001	.94
Bouts/d	5.29	5.51	5.32	5.84	.226	.28	.0001	.21
Min/bout	1.96	1.84	2.04	2.06	.148	.69	.0001	.66

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.

[b,c] Within a row, means lacking a common superscript differ ($P < .05$).

[d]Trt = treatment, T = Trial

Table 15. Daily watering and feeding behavior of morbid feedlot calves during two 21-d trials when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

						P		
Variable	Control[a]	TIL	FIM	FSC	SEM	Trt[e]	T	Trt*T
n	33	26	23	19	---	---	---	---
Feeding								
Min/d	31.85	43.70	53.14	39.80	4.86	.0129	.0718	.0354
Bouts/d	5.77[b]	7.30[cd]	8.49[d]	6.80[bc]	.548	.004	.0025	.99
Min/bout	4.25	5.54	6.29	5.25	.602	.1091	.44	.0102
Watering								
Min/d	8.97	9.68	9.97	11.04	1.361	.74	.0306	.94
Bouts/d	3.67	3.56	4.18	3.88	.282	.41	.0008	.55
Min/bout	2.49	2.57	2.27	2.80	.339	.77	.2525	.91

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.

[b,c,d] Within a row, means lacking a common superscript differ ($P < .05$).

[e]Trt = Treatment, T = Trial

Table 16. Treatment x Trial interaction for daily watering and feeding behavior of morbid and healthy feedlot calves during two 21-d trials when not treated or treated with one of three methaphylactic antibiotics upon arrival to the feedlot.

	Trial 2				Trial 3					
Variable	CON[a]	TIL	FIM	FSC	CON	TIL	FIM	FSC	SEM	*P*
n	38	36	37	32	35	37	37	36	---	---
Healthy, feeding										
Bouts/d	11.21[b]	10.13[b]	10.34[b]	10.16[b]	9.68[b]	11.66[c]	11.37[c]	11.32[c]	.519	.03
Morbid, feeding										
Min/d	34.80[b]	47.83[c]	42.78[bc]	49.59[cd]	28.90[b]	39.57[bc]	63.49[d]	30.01[b]	6.706	.04
Min/bout	4.74[b]	5.56[bc]	4.70[b]	6.66[c]	3.77[b]	5.53[b]	7.88[c]	3.84[b]	.833	.01

[a]Control = no injectable antibiotic received, TIL = tilmicosin administered s.c., FIM = florfenicol administered i.m., FSC = florfenicol administered s.c.
[b,c,d] Within a row, means lacking a common superscript differ ($P < .05$).

CONCLUSIONS

The results of this study agree with those findings of other researchers (Kee Jim et al., 1999; Hoar et al., 1998) conducted in different locations. Tilmicosin and florfenicol were found to be comparable treatments for BRD when used in combination with chlortetracycline in the feed, reducing morbidity (P = .001) compared to the Control. Injectable antibiotic treatment increased (P = .04) ADG compared to those animals not receiving an injectable antibiotic at receiving. As expected, healthy calves had greater (P = .0001) ADG than morbid calves during the first 21-d in the feedlot. For metaphylactic treatment to be economically viable there must be increased growth rates and reduced rates of morbidity and mortality of the cattle to overcome the increased cost of antimicrobials. Both of these stipulations were met in this study. Though there was not any economical analysis done in this study, given the weight differences seen between the Control and the treated animals and the similar costs between the antibiotics, there is an obvious economic advantage to using metaphylactic antibiotics at receiving in high stress animals.

There were no differences seen between FIM and FSC for morbidity (P = .700) or ADG (P = .14). Therefore, the chosen route of administration should be s.c. to avoid any threat of muscle damage for slaughter purposes.

Castration upon arrival to the feedlot reduced weight gain when compared to calves previously castrated. Research shows that castration induces stress in the animal. Animals should be castrated prior to the producer shipping them, to reduce stress suffered by the animal once it reaches the feedlot and to minimize the negative impact on ADG caused by stress.

Metaphylactic injectable antibiotics given at receiving did not reduce feeding time. This was an unexpected result for it is common belief that antibiotics temporarily reduce feed intake. Sowell et al. (1999) found that the animals with the higher feeding time had increase performance and that the first 4 d on feed are the most important in establishing an animal's feeding pattern. Considering that metaphylactic injectable antibiotics did not reduce feeding time, this is a practice that can be used without the risk of reduced feed intake and performance.

No differences were seen between those animals not receiving any antibiotic or receiving one of three antibiotic treatments in min/d ($P = .94$), bouts/d ($P = .21$), or min/bout ($P = .66$) for watering behavior. There were also no differences ($P > .10$) seen between healthy and morbid animals for watering behavior.

The implications of my research are: 1) injectable antibiotics administered at arrival to the feedlot decreased the incidence of BRD and 2) the use of metaphylactic injectable antibiotics did not reduce animal performance or feeding behavior.

Future research should include economic analysis comparing the four treatments in their respective benefits of labor, cost, and effectiveness. Another direction for future research should be following the calves through all the way to slaughter to check for lung lesions in possible chronic cases of BRD, muscle damage from i.m. drug administration, and gain performance, morbidity, and mortality throughout the entire time the animals are in the feedlot.

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APPENDIX

Code Used for Statistical Analysis Using SAS

1. To determine difference for feeding and watering bouts/d (See Table 17 for a complete description of the terms used in the SAS code).

```
Proc sort; by status;
Class trial trt date an_no;
Model feedbout waterbt = trial trt date(trial) trial*trt an_no(trial*trt);
Test h=trt e=an_no(trial*trt);
***Contrast 'Control vs Antibiotics' trt 3 –1 –1 –1;
***Contrast 'FIM vs FSC' trt 0 0 1 –1;
***Contrast 'TIL vs FSC' trt 0 1 0 –1;
lsmeans trt/e=an_no(trial*trt) s p;
lsmeans trial*trt/e = an_no(trial*trt) s p;
Run;
Quit;
```

2. To determine differences for total time feeding and watering/d.

```
Minutes = (act hits * 5.25)/60;
Proc sort; by status;
Proc glm; by status;
Class trial trt date an_no;
Model minutes = trial trt date(trial) trial*trt an_no(trial*trt);
Test h= trt e = an_no(trial*trt);
Test h = trial*trt e=an_no(trial*trt);
Lsmeans trt/ e=an _no(trial*trt) s p;
Lsmeans trial*trt/ e = an_no(trial*trt) s p;
Run;
Quit;
```

3. To determine differences for minutes/bout for feeding and watering.

```
Minboutf = hitbtf*5.25/60;
Minboutw = hitbtw*5.25/60;
Proc sort; by status;
Proc glm; by status;
Class trial trt date an_no;
Model minboutf minboutw = trial trt date(trial) trial*trt an_no(trial*trt);
Test h = trt e = an_no(trial*trt);
Test h = trial*trt e = an_no(trial*trt);
Lsmeans trt / e = an_no(trial*trt);
Lsmeans trial*trt / e = an_no(trial*trt);
Run;
Quit;
```

4. Differences in initial and ending weights and ADG.
```
Adg = (outwt – inwt)/21;
Proc sort; by trt;
Proc glm;
Classes trial trt status sex;
Model inwt - - adg = trial trt status sex trt*status trt*sex trial*status trial*sex;
Lsmeans trial trt status sex trt*status trt*sex trial*status trial*sex/ s p;
Contrast 'Control vs Antibiotics' trt 3 –1 –1 –1;
Contrast ' TIL vs FSC' trt 0 1 0 –1;
Contrast ' TIL vs florfenicol' trt 0 2 –1 –1;
Contrast 'FIM vs FSC' trt 0 0 –1 –1;
Lsmeans trial trt status sex trt*status trt*sex trial*status trial*sex / s p;
Run;
Quit;
```

5. To determine treatment differences for morbidity using Chi-Square.
   a. To compare Control to Antibiotics
   ```
   If trt = '2' then trt = '5';
   If trt = '3' then trt = '5';
   If trt = '4' then trt = '5';
   ```
   b. To compare TIL to FSC
   ```
   If trt = 1 then delete;
   If trt = 3 then delete;
   ```
   c. To compare FSC to FIM
   ```
   If trt = 1 then delete;
   If trt = 2 then delete;
   ```

```
Proc sort; by trt;
Proc freq;
Tables status*trt / chisq;
Run;
Quit;
```

6. To determine treatment the morbidity differences between previously castrated and castrated at the feedlot.
```
Proc sort; by trt;
Proc freq;
Tables status*sex / chisq;
Run;
Quit;
```

Table 17. Key for terms used in SAS code to analyze feeding and watering behavior and performance data collected on newly received feedlot calves for three 21-d trials.

Term	Meaning
Status	health status 1=healthy 2 = morbid
Sex	castration status 1 = previously castrated 2 = castrated at the feedlot
Trial	Trial 1, Trial 2, or Trial 3
Trt	treatment 1 = Control, 2 = TIL, 3 = FIM, and 4 = FSC
An_no	Animal number (individual animal)
Feedbout	feeding bouts/d with at least 5 min separation between feeding bouts
Waterbt	watering bouts/d with at least 5 min separation between watering bouts
Act hits	activity hits = the daily cumulative number of 5.25 sec hits the computer registered for each animal.
Minboutf	Minutes/feeding bout
Minboutw	Minutes/watering bout