EFFECTS OF LEVUCELL SB YEAST ON AVERAGE DAILY GAIN, FEED INTAKE, AND MORBIDITY OF NEWLY RECEIVED CATTLE

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ABSTRACT

Three separate loads of beef heifers (n = 277 heifers) were transported to the Texas Tech Burnett Center in New Deal, TX to examine the effects of a yeast supplement (Levucell SB yeast; Lallemand Animal Nutrition, Milwaukee, WI) on health and performance of feedlot cattle. In Load 1, 91 beef heifers (average BW = 223.5 kg) were shipped 1,403 km from an order buyer facility in Meridian, MS. On arrival, cattle were weighed and processed and assigned randomly to one of two treatments (five pens per treatment) during a 35-d receiving period: 1) Control (C) = a 65% concentrate receiving diet; or 2) Yeast (Y) = a 65% concentrate receiving diet with Levucell SB yeast added to supply 0.5 g of yeast/(heifer•d). Diets were changed to 72% concentrate on d 21 to 35. Following processing, cattle were moved to their assigned pens and fed their respective diets ad libitum once daily at 0800. Cattle were observed daily for symptoms of bovine respiratory disease (BRD) and treated as needed when rectal temperature was $\geq$ 39.7 °C. Loads 2 and 3 (93 heifers each; average BW = 223.5 kg and 226.1 kg respectively) were processed and assigned to treatments and pens as described for Load 1. Averaged over the three loads, feeding Levucell SB yeast did not affect the overall ($P \geq 0.12$) dry matter intake (DMI) or average daily gain (ADG) during the 35-d study. Although, numerical advantages in ADG for the Y treatment were evident from d 0 to 14 and 0 to 28, changes in ADG were inconsistent among the three loads. As with ADG, concentrate DMI for the various measurement periods did not differ between treatments, but a trend was evident for a slight increase from d 0 to 35 in concentrate DMI for the Y vs. C treatment for Loads 1 and 3, but not with Load 2. Because treatment effects on ADG and DMI were

not significant, G:F did not differ between treatments. Within loads, no differences (P = 0.21 to 0.28) were noted for the percentage of cattle treated once or more for BRD; however, a consistently smaller proportion of the cattle in the Y treatment group were treated compared with those in the C group. Thus, averaged over the three loads, an increase (P = 0.04) in the percentage of C heifers treated once or more compared with Y heifers (24.0 vs. 13.78% respectively) was observed. An odds ratio of 1.99 for C vs. Y indicated that C heifers were approximately twice as likely to be treated once or more for BRD than were Y heifers.

From the results of the three loads of newly received heifers used in this experiment, the addition of 0.5 g/heifer daily of Levucell SB yeast to the diet of newly received cattle plus oral dosing of approximately 1 g/heifer at the time of arrival processing resulted in fewer heifers being treated for BRD. The feeding of Levucell SB yeast during the receiving period had limited effects on performance of the 277 heifers used in the experiment.

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CHAPTER I

INTRODUCTION

Feedlot nutritionists frequently work to manage feed intake and diet composition to maximize intake of net energy for gain (NEg) in cattle. Lightweight (e.g. < 200 kg) newly received cattle are often a main focus of such management because they are more likely to endure stresses from weaning, marketing, transportation, and processing leading to decreased feed intake. These cattle are more susceptible to bovine respiratory disease (BRD) and they exhibit greater morbidity and death loss than older (e.g., yearling), heavier cattle (Galyean et al., 1999). Thus, proper nutrition is essential to promote a healthy immune system otherwise compromised by stressors before and after weaning. Plans implemented to increase feed intake may decrease morbidity, thereby increasing performance and health of newly received cattle.

In the animal feed industry, direct-fed microbials (DFM) and live, viable yeast cultures may be an alternative to antibiotics and other growth stimulants used to increase feed intake. A trend of "feeding the bugs" in the rumen has become popular among managers and nutritionist alike. Combining adequate nutrition with DFM to repopulate the intestines might decrease changes in the microbial population associated with stress (Krehbiel et al., 2003). Direct-fed microbials have shown to decrease use of antibiotics, to enhance milk production in dairy cows, and to improve feed efficiency and daily gain in beef cattle (Krehbiel et al., 2003; Wohlt et al., 1998; Dawson et al., 1990). Yeast culture also has been shown to have several effects in ruminants. Cole et al. (1992) noted altered ruminal fermentation, increased ruminal turnover rate and increased retention of

K, Cu, and Zn in ruminants fed diets supplemented with yeast culture. A common yeast culture manufactured primarily for human consumption is *Saccharomyces cervevisiae*, which can have beneficial effects on morbid calves (Cole et al., 1992; Krehbiel et al., 2003) noted that morbidity was decreased by 27.7% in cattle receiving a bacterial DFM.

Data are plentiful in experiments pertaining to DFM and yeast culture; however, results of experiments concerning performance and health of feedlot cattle have varied. Krehbiel et al. (2003) summarized reports with no improvement in average daily gain (ADG) as a result of feeding *Lactobacillus* cultures. In contrast, Bechman et al. (1977) reported increased (17%) ADG when *L. acidophilus* was added to milk or milk replacer in the diets of neonatal calves. Similar improvements have been observed in experiments supplementing yeast culture in receiving diets for feedlot cattle (Cole et al., 1992; Oeztuerk et al., 2005).

The problem with varying results among studies is likely attributable to several factors. In unpublished data from a pilot study conducted at Texas Tech University, Galyean and McMeniman (2005) observed lower dry matter intake (DMI; decrease of 15%) in healthy beef steers injected with Nuflor (Schering-Plough Animal Health) compared with those injected with sterile water ($P = 0.092$). This finding suggests that underlying factors (e.g., transfer of a strong antibiotic to the gut) may decrease feed intake other than induced stress on an animal. In the same study, by top dressing feed with Levucell SB (*Saccharomyces cerevisiae* subspecies *boulardii* CNCM I-1079) yeast, Galyean and McMeniman (2005) observed an increase in DMI from d 3 to 4 after injection of Nuflor ($P = 0.197$), with no differences noted between treatments after d 4. These preliminary findings suggested supplementation of dry active yeast may result in a

tendency for cattle treated with a strong antibiotic to return more quickly to baseline DMI than when a control diet is fed.

Based on the results of the pilot study described above, additional research was needed to evaluate the potential benefits of Levucell SB yeast in practical diets for lightweight, newly received cattle. Thus, the objective of this thesis was to study the effects of Levucell SB yeast on ADG, DMI, and BRD morbidity of newly received cattle.

CHAPTER II

REVIEW OF LITERATURE

Bovine Respiratory Disease and Feed Intake

One of the most common diseases in newly received stocker and feedlot cattle is the bovine respiratory disease (BRD) complex, which accounts for approximately 75% of morbidity and more than 50% of mortality in feedlots (Edwards, 1996). As a result of the costs of treatment, lost production, and death loss, economic losses caused by BRD can be substantial. Loerch and Fluharty (1999) indicated that losses from BRD cost the U.S. beef industry approximately $500 million annually. Bovine respiratory disease extends far from the feedlot adversely affecting carcass characteristics, as indicated by respiratory tract lesions observed at slaughter that are correlated with negative effects of BRD on feedlot performance (Gardner et al., 1999). Decreasing the pervasiveness with which BRD occurs will increase economic return to the U.S. beef industry (Stovall et al., 2000).

Bovine respiratory disease complex is a consequence of interactions among stressors, host immunity, pathogenicity of agents, and environmental factors that encourage the probability of pathogen exposure (Spears, 2000). The complexity of the disease is a major reason that BRD continues to be a significant problem in feedlots. Multi-functional causes aggravate this disease at many levels. Figure 2.1 illustrates the common causes of BRD. Primary importance lies with immunity. Maintaining healthy animals requires an immune system that is functioning optimally. When the integrity of the immune system is compromised, disease may result (Larson, 2005; Roth and Perino, 1998). Causes of BRD are associated with interactions among pathogens (viruses,

bacteria), coupled with the suppression of the immune system from environmental, nutritional, and management practices (Swanson and Morrow-Tesch, 2001; Larson, 2005).

Considering that the bacteria known to cause BRD (pneumonia) are found naturally within the nasopharyngeal region of healthy cattle, it is likely that interactions with these bacterial species and other components are the cause of BRD (Roth and Perino, 1998). Native immune responses, in healthy cattle, prevent these bacteria from moving into the lower respiratory tract. When an animal becomes immunosuppressed, small numbers of bacteria can cause a severe case of pneumonia leading to BRD (Roth and Perino, 1998). Smith (1998) analyzed feedlot records concluding that approximately 65 to 80% of the overall morbidity recorded during a feeding period occurred within the first 45 d with 67 to 82% of detected morbidity caused by respiratory disease. Naturally, this early period in the feedlot is when newly received cattle are experiencing the majority of stress attributable to new surroundings, changes in feed composition, and establishment of dominance patterns within the feedlot pen.

Nutrition plays an intricate role in maintaining the integrity of the immune system, but interactions among nutritional status, immunology and disease resistance are extremely complex. Micronutrients such as Cr, Cu, Se, Zn, and vitamins A, E, and B have been shown to stimulate immune reactions in cattle in some cases but not in others (Galyean et al., 1999). The effects of supplementation of such micronutrients on the BRD morbidity response have been variable (Galyean et al., 1999; Spears, 2000), which may partially be a result of differences in feed intake among experiments, differences in

immune response among cattle within the same pen, and discrepancies in changing stages of infection with BRD.

One additional reason for variable responses to nutritional supplementation is an interaction between the environmental and psychological stressors that decrease feed intake by newly received cattle. Results of numerous studies indicate that psychological stress can have profound effects on the immune system (Datnzer and Kelley, 1989). When an animal perceives a situation as stressful, the central nervous system (CNS), endocrine system, and immune system interact, respond to stimuli in a coordinated manner, and influence the behavior of the animal (Figure 2.2). Both physical and psychological stressors have been demonstrated to suppress natural killer cell activity, and cytokine production (von Borell, 2001). Cytokines, although known to be mediators of the immunological and pathological responses to stress, induce fever and decrease feed intake (von Borell, 2001). Physical and psychological stressors also stimulate the hypothalamic-pituitary-adrenocortical (HPA) stress response system, which also can lead to decreased feed intake (von Borell, 2001).

Loerch and Fluharty (1999) summarized a three-step process of response to stress called the general adaptive syndrome proposed by Hans Selye (Selye, 1976). The initial response to a stressor is called the alarm reaction, followed by resistance, leading to exhaustion by an animal. The alarm response is basically characterized by vocalization and catabolism, whereas resistance is described by anabolism and increased feed intake. If resistance is not successful, animals enter the exhaustion stage which occurs before an animal is able to adapt to the stressor (Loerch and Fluharty, 1999). During marketing and transportation, cattle are typically deprived from feed and water for an extended period of

time. For the duration of this period and some time thereafter, ruminal activity is decreased and the animal's reserve of nutrient concentrations is exhausted, leading to decreased feed intake (Loerch and Fluharty, 1999; Galyean et al., 1999). Decreased intake is especially evident on arrival at the feedlot. With many feeds, animals initially eat too little and later eat too much, which can lead to digestive upset and other health problems. Feed intake is low by lightweight, newly received cattle ranging from 0.5 to 1.5 % of their body weight (BW) on a dry matter (DM) basis during the first 2 wk after arrival (Galyean et al., 1995; Larson, 2005). Calves are frequently introduced to unusual surroundings that differ greatly from the pasture they were grazing or from the stream or pond they drank from just days before.

Low feed intake, and associated low nutrient intake, makes correction of nutritional deficiencies difficult; this could further compromise immune function and thereby increase susceptibility to infection (Galyean et al., 1999). As a result, nutritionists employ strategies to increase DMI and/or nutrient intake by newly received cattle, thereby providing adequate protein, energy, and vitamins and minerals to help support the immune system. The aim of these strategies is to decrease morbidity and mortality linked to BRD.

One common way that nutritionists combat the problem of low DMI is by providing cattle with free-choice hay for to 5 to 7 d after arrival at the feedlot. Lofgreen (1978) reported a significant increase in feed intake and ADG when newly received calves were provided free-choice alfalfa during a 27-d receiving period. This practice may not be economically feasible for longer period of time; however, the results of this

experiment illustrate the advantage gained by encouraging stressed cattle to eat, which ultimately should help decrease effects of BRD.

After adjustment to new feedlot surroundings, received cattle are conditioned to "mixed formulated diets." Although dietary concentrate levels change based on desired performance, Lofgreen (1983) suggested that voluntary intake of low-energy (high-roughage) diets by lightweight, stressed calves is less than that of high-energy (> 60% concentrate) diets. Loerch and Fluharty (1999) observed that daily DMI increased ($P <$ 0.02) with increasing concentrate level (in excess of 60%) for a 28-d receiving period. Decreasing the transition from free-choice high-roughage diets to high-energy diets will not only increase DMI more rapidly, but it should aid in the prevention of disease by increasing nutrient supply. Nonetheless, depending on the level of stress cattle endure before arrival, it may not be possible to rapidly decrease the time required for transition to higher-concentrate diets.

Supplementation of probiotics (e.g., DFM) is yet another way nutritionists approach the problem of decreased feed intake by stressed cattle. Direct-fed microbials have been used in studies conducted as far back as 1920. After World War II, antibiotic use has been widespread, but when an increased incidence of "antibiotic diarrhea" and other related side effects occurred, an interest in *Lactobacillus acidophilus* therapy for restoration of normal intestinal microorganisms was renewed (Krehbiel et al., 2003). Since World War II, there has been a slow but steady interest in the use of DFM, as they may have potential to decrease cattle morbidity and increase feed intake by cattle (Krehbiel et al., 2003).

Control of Feed Intake

Beef cattle are almost always fed ad libitum, which usually maximizes growth rate and profitability. Intake control involves energy because changes in energy requirements of the animal and/or in the digestible or metabolizable energy content of the diet cause intake to change (Forbes, 2003). Many factors are implicated in the control of feed intake, including nutrients, disease, and environmental conditions and social pressures, all of which interact in a multifactorial manner (Forbes, 2003). It is important to remember that there are physiological mechanisms involved within an animal that also trigger signals to control feed intake as well.

Information from stress, environmental factors (climate, photoperiod, and water availability), disease (morbidity), and gastrointestinal receptors integrate into the CNS (Forbes, 2003; Forbes, 1996; Johnson, 1997). This information is controlled by positive and negative feedback systems that stimulate an animal to increase or decrease feed intake. It has been suggested that animals experiment with feed intake daily to reach an average intake that minimizes total discomfort (Forbes, 2003). Day-to-day fluctuations in feed intake might provide a means by which animals can assess whether an intake somewhat higher or lower than their current average intake will improve their well-being (Forbes, 2003).

The goal of bunk management practices such as programmed feeding, multiple feed deliveries per day, and consistent timing of feed delivery is to decrease variability in intake (Schwartzkopf-Genswein et al., 2003). The effectiveness of these practices is based on pen average intakes; however, there can be significant differences in the ruminal profiles and feeding behavior among individuals within a pen (Schwartzkopf

Genswein et al., 2003). If calves are fed ad libitum, continuous access to feed is ensured, and many factors (e.g., feeding behavior, dominance, temperament, and motivation) negatively influencing bunk management become insignificant.

Nutritionists can increase feed intake through a variety of strategies. In feedlots mixed, formulated diets are fed to optimize production levels in cattle; however, this practice is not without consequences. Figure 2.3 illustrates the metabolic effects of feed intake in feedlot cattle on ruminal pH and the ruminal microbial population. Schwartzkopf-Genswein et al. (2003) noted that the ruminal pH initially decreases below 6.0 without a significant increase in ruminal lactic acid concentration or in numbers of microorganisms in the rumen. Introduction of highly fermentable starch to the diet increases the availability of free glucose, and stimulates the growth of most ruminal bacteria, which increases production of VFA and lowers ruminal pH. Incorporation of supplements such as yeast cultures and DFM have been shown to increase absorption of viable nutrients by ruminal microbes, thereby increasing microbial fitness, and increasing rate of digestion and feed intake (Malcolm and Kiesling, 1990; Dawson et al., 1990; Cole et al., 1992; Williams et al., 1991). Although acidosis is a practical problem with feedlot cattle, it is not a major concern for this review because lightweight, newly received cattle typically have low intakes and are often fed diets with a fairly high proportion of roughage.

Dietary supplements of yeast cultures release essential enzymes, vitamins, and amino acids during digestion, all of which are thought to have a positive effects on the performance by ruminants (Oeztuerk et al., 2005; Wohlt et al., 1998; Callaway and Martin, 1997). Benefits may arise as a result of the metabolites per se and their

interactions with other ruminal microbes. The uptake of nitrogen sources, such as ammonia, amino acids, and peptides, for use by ruminal microbes is thought to be stimulated by yeast (Wohlt et al., 1998).

Yeast Supplementation and Cattle Production

For many years, ruminant nutritionists and microbiologists have been interested in manipulating the microbial ecosystem of the rumen to improve production efficiency by domestic ruminants. Based on growing concern over the use of antibiotics and other growth stimulants in the animal feed industry (Callaway and Martin, 1997), interest in the effects of microbial feed additives on animal performance has increased during the past 5 to 10 yr. As one example of the potential benefits of yeast, addition of *S. cerevisiae* to ruminant diets has been observed to improve digestibility of DM; increased ruminal bacteria numbers (Oeztuerk et al., 2005; Dawson et al., 1990); decreased ruminal lactate concentrations (Williams et al., 1991; Callaway and Martin, 1997); and increased milk production by cows in early lactation (Cole et al., 1992). Despite these positive findings in some studies, response to fungal or yeast culture supplementation has been variable.

Feed energy converted to methane and lost via eructation in ruminant animals may amount to 12% of the gross energy in the feed (Martin and Nisbet, 1992). Thus, decreasing feed energy losses associated with methanogenesis in the rumen has become an area of extensive research over the past 20 yr. The most widely used group of feed additives that have been shown to decrease methane production is ionophores. In general, ionophores, which are antibiotics, are thought to improve feed utilization by increasing the amount of metabolizable energy available to the animal as propionate,

thereby resulting in improved feed efficiency (Martin and Nisbet, 1992). Propionate-producing bacteria (*Selenomonas ruminantium*) are more resistant to ionophores than other ruminal bacteria, which supports this theory (Callaway and Martin, 1997). As noted previously, growing concern over the use of growth stimulates and antibiotics has increased research involving alternative, natural methods for increasing animal performance. Nonetheless, variable results with "natural" products like viable yeast culture suggests that more research is needed to fully understand the effects yeast supplementation on the physiology of predominant ruminal microorganisms and production by ruminant animals, particularly feedlot cattle.

Little is known concerning the mechanism by which yeast supplementation influences performance by feedlot cattle. In a review article Krehbiel et al. (2003) summarized the possible modes of action for bacterial DFM, which many researchers suggest mirror the path yeast takes within an animal's body. It is known that enterotoxin-producing strains of *Escherichia coli* 0157:H7 rely on attachment to the intestinal wall to induce diarrhea. It seems logical that DFM, such as viable yeast culture, could compete with pathogens for sites of adherence on the intestinal surface with attachment supporting proliferation and a decrease in pathogens (Krehbiel et al., 2003). Adhesion also is thought to be mediated either nonspecifically (physicochemical) or specifically (adhesive bacterial surface molecules and epithelial receptor molecules). Fibrils found on adhering bacteria might reinforce attachment (Krehbiel et al., 2003).

Modulation of host immunity might represent another mechanism by which DFM like viable yeast culture promote intestinal health and overall well-being of the animal. The animal's immune system is capable of mounting both nonspecific (innate) and

specific (adaptive) immune responses against a variety of pathogens (Galyean et al., 1999). The gastrointestinal tract (GIT), in addition to it role of digestion and absorption of nutrients, provides protective defenses against the presence of antigens from food and microorganisms. After infection by an antigen, immune cells are rapidly activated leading to enhanced phagocytosis as well as the production of humoral mediators (T cells; Forbes and Barrio, 1992; Krehbiel et al., 2003). Gill et al. (2000) observed an increase in the population of helper and activated T cells in the blood of elderly people consuming *Bifidobacterium lactis*. In addition, *Lactobacillus johnsonii* favored the induction of tumor necrosis factor-α (TNF-α) in animals (Krehbiel et al., 2003). These data provide evidence that DFM have the potential to protect animals and humans against pathogenic organisms, with several mechanisms likely involved. The ability of DFM to adhere and colonize the GIT seems important.

The effects of live yeast culture on ruminal microbes are important in relation to rate and extent of digestion, as well as the overall health of an animal. Callaway and Martin (1997) conducted an experiment to determine the effects of yeast (*S. cerevisiae*) on lactate utilization and cellulose digestion by ruminal bacteria. Compared with control incubations, yeast culture (containing B-vitamins, amino acids, and organic acids) stimulated growth of *S. ruminantium* as much as 55% and resulted in a 13-fold stimulation of the growth of *Megasphaera elsdenii* ($P < 0.05$) on lactate supplied in the medium. Providing yeast culture provided did not have any effects on the uptake of labeled L-lactate from either *S. ruminantium* or *M. elsdenii*; however, carbon sources (glucose, lactate) in the yeast culture might have prohibited the labeled L-lactate uptake during the assay. Callaway and Martin (1997) suggested that one should not dismiss the

theory that other unidentified components in the yeast might have been involved in the responses noted.

Although widely used throughout the dairy industry for its positive effects on milk production (Williams et al., 1991; Wohlt et al., 1998), yeast supplementation is not often practiced in the beef industry. Williams et al. (1991) observed increased milk production by 1.4 L/d (corrected to 4% butterfat; $P \leq 0.05$) and increased DMI by a mean of 1.2 kg/d ($P \leq 0.062$) in multiparous Friesian dairy cows supplemented with 10 g/d of a yeast culture comprised of *S. cerevisiae* plus growth medium. Despite the positive effects yeast provides for growth of ruminal microbes and utilization of lactate, based on varying data with respect to animal performance (Krehbiel et al., 2003; Cole et al., 1992; Martin and Nisbet, 1992; Wohlt et al., 1998), further research is needed to determine optimal doses, strains used, and proper delivery of the supplement for feedlot cattle.

Saccharomyces cerevisiae Subtype *boulardii*

Saccharomyces cerevisiae is the most common type of yeast used both in culture and feeding applications. More than 1000 strains of *S. cerevisiae* are listed in the American Type Culture Collection catalogue (ATCC, 1990) and it is still unknown how widespread probiotic activity is among these strains of yeast (Oeztuerk et al., 2005). Among the different strains applied in practice, little is known concerning the effects of *S. cerevisiae* subtype *boulardii* (SB) yeast in domestic animals.

Saccharomyces cerevisiae subtype *boulardii* is a non-pathogenic yeast that was originally used in humans to prevent or treat diarrhea of various origins (McFarland and

Bernasconi, 1993; Oeztuerk et al., 2005). Recent studies observed significantly diminished artificially induced secretory response of the jejunal mucosa due to application of theophylline. Theophylline is a compound that increases intracellular cyclic nucleotide concentrations, which can stimulate mucosal Cl^- secretion (Oeztuerk et al., 2005). The ability to differentiate SB from other colonic flora allows pharmacokinetic studies to be performed and thereby study the behavior and fate of the organism (Oeztuerk et al., 2005). Studies indicate that this yeast is well suited as a treatment agent because it can quickly achieve high concentrations in the colon quickly, and maintain a constant concentration thereafter; however, it does not permanently colonize in the colon, and it remains within the intestinal tract without colonizing other parts of the body (McFarland and Bernasconi, 1993).

Human patients infected with HIV and suffering from chronic diarrhea that were given SB yeast for 15 d showed decreased frequency in number of stools per day and gained 3.6 kg of weight during the study (McFarland and Bernasconi, 1993). Focusing on the loss of nutrients, electrolyte imbalances, and dehydration and the severe effects they have to both animals and humans would seem to be logical areas for future research with viable yeast cultures. Oral administration of SB yeast was shown to increase concentrations of mucosal sucrase, lactase, and maltase in the duodenum and jejunum of humans and rats compared with controls (McFarland and Bernasconi, 1993). This increase in disaccharidase activity might improve absorption of carbohydrates, and failure to absorb these carbohydrates has been associated with diarrhea.

In terms of ruminal microbial metabolism, SB yeast has not been extensively evaluated. Only one article, (Oeztuerk et al., 2005) was found that investigated the

effects of SB yeast on short-chain fatty acid (SCFA) production rates, microbial protein synthesis, and digestibility of organic matter. Results indicated that total SCFA production was ($P < 0.05$) increased by SB yeast in a dose-dependent manner. This result was mainly caused by changes in rate of acetate production, with no significant differences in propionate production. Conversely, the addition of yeast increased the production rates of butyrate, isovalerate, and valerate. The stimulatory effects of yeast on SCFA production can best be explained by the relationship to the composition of the cell wall or other cell contents of SB yeast. The cell wall consists of three components; glucans, mannoproteins, and chitin, which are potential substrates for microbial fermentation in the rumen. Application using the rumen simulation technique (RUSITEC) of SB yeast also showed an increase ($P < 0.05$) in values for microbial protein synthesis averaging 425 vs. 325 mg/d for controls, suggesting that SB yeast stimulated ruminal microbial metabolism. Oeztuerk et al. (2005) also stated that based on comparisons of autoclaved and live yeast, yeasts act through prebiotic rather than probiotic effects that other researchers have suggested. The term "probiotic" has been defined as a live microbial feed supplement, which affects the host animal by improving its intestinal microbial balance. Prebiotics can be defined as a killed (autoclaved) microbial feed supplement, which stimulates microbial metabolism rather than improving microbial balance as observed with probiotics (Krehbiel et al., 2003; Oeztuerk et al., 2005). Because of the limited data currently available, further research is needed with SB yeast, particularly with respect to its mode of action, possible performance effects, and overall effects on animal health.

Conclusions from the Literature

Multiple interacting factors contribute to bovine respiratory disease. Adequate nutrition is essential to maintaining healthy animals that have an immune system that is functioning optimally. Low feed (nutrient) intake by lightweight, stressed cattle makes it difficult to correct nutritional deficiencies, which can further compromise immune function and potentially increase susceptibility to infection. Control of feed intake in cattle is complex, and it involves positive and negative feedback from both physiological and metabolic systems. Interest in the effects of microbial feed additives on animal performance has increased during the past 5 to 10 yr because of growing concern over the use of antibiotics and other growth stimulants by the animal feed industry. The addition of viable yeast culture to diets of both humans and animals has increased feed intake, improved digestibility of DM, and in the case of ruminants, has increased bacterial numbers in the rumen, decreased ruminal lactate concentrations, and increased milk production by cows in early lactation. Nonetheless, because of variable results, further research is needed to test the efficacy of direct-fed microbials like viable yeast culture in practical diets for beef cattle.

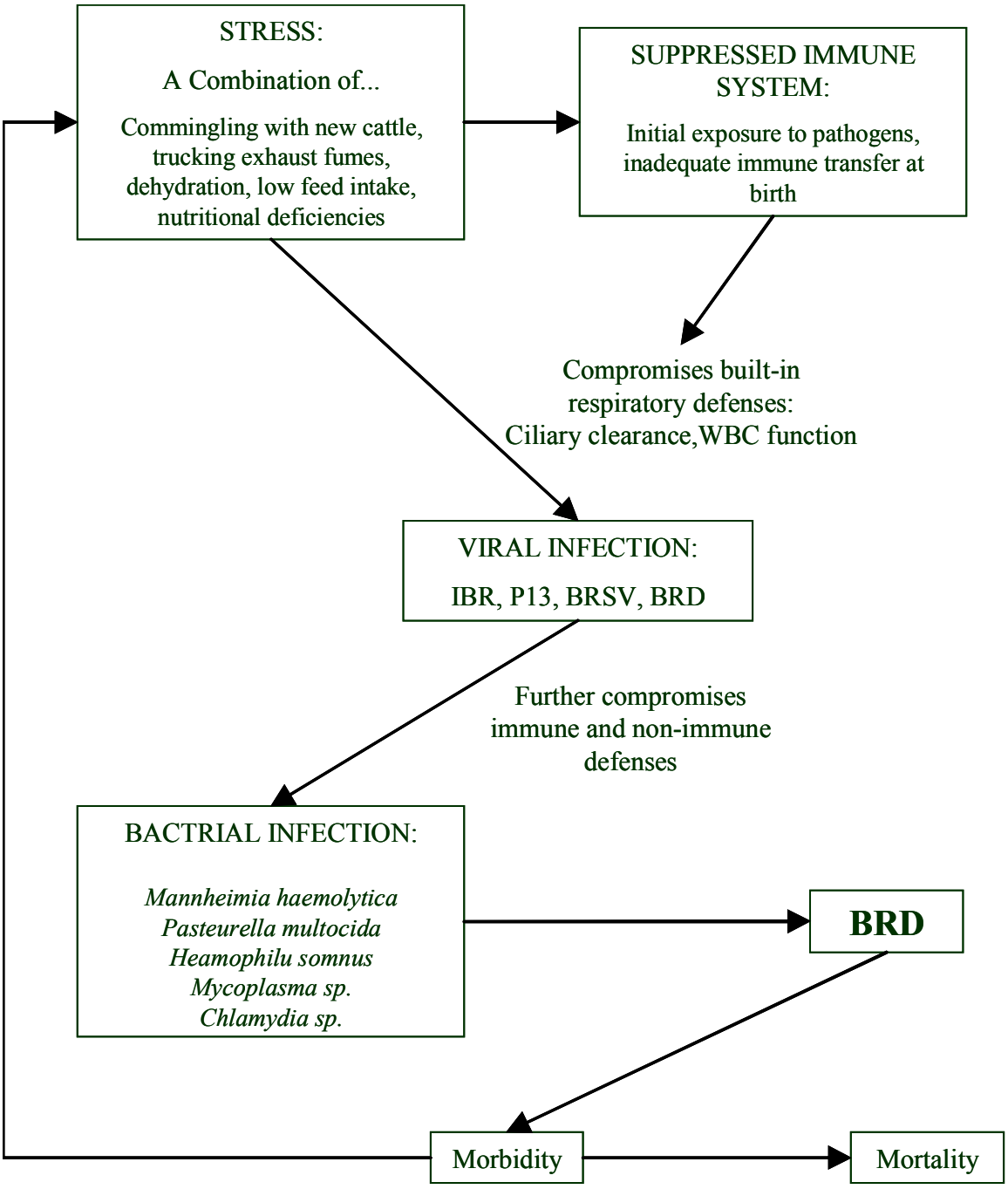

Figure 2.1. Path for causes of Bovine respiratory disease (adapted from: Larson, 2005). IBR = infectious bovine rhinotracheitis virus; PI3 = parainfluenza-3 virus; BRSV = bovine respiratory syncytial virus ; BVD = bovine viral diarrhea virus; BRD = Bovine respiratory disease.

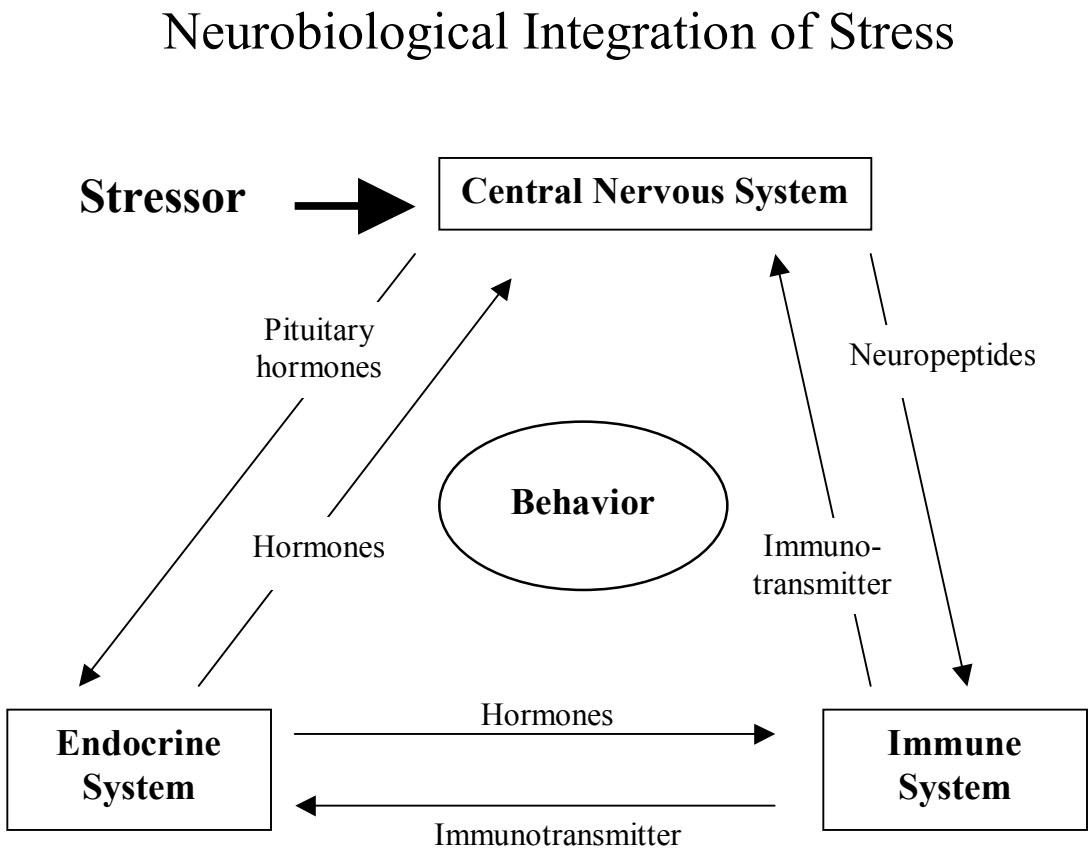

Figure 2.2. Communication between central nervous system (CNS), endocrine system, and immune system (adapted from: von Borell, 2001).

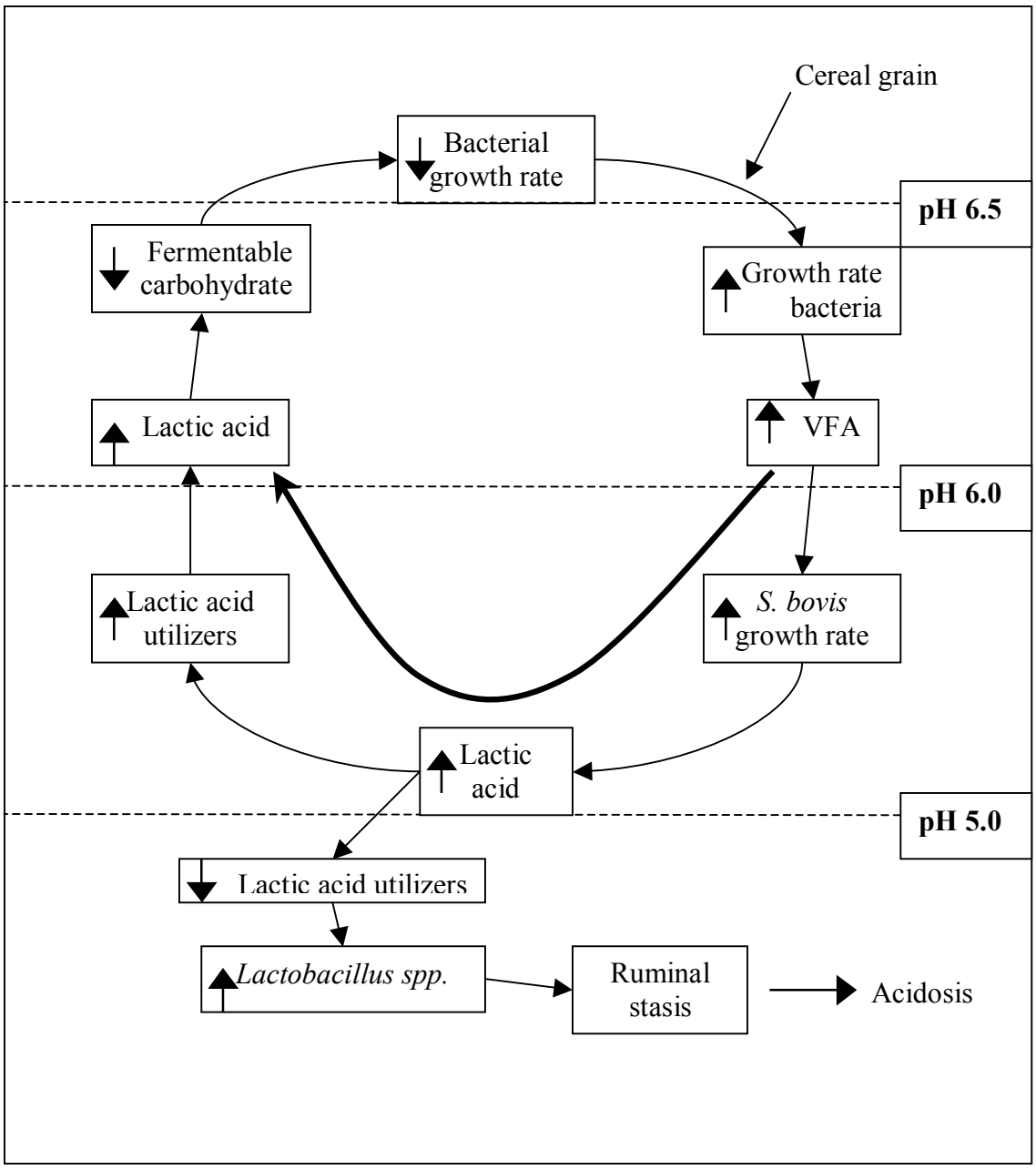

Figure 2.3. Metabolic effects of feed intake in feedlot cattle on ruminal pH and microbial populations (adapted from: Schwartzkopt-Genswein et al., 2003).

CHAPTER III

MATERIALS AND METHODS

Receipt of and Processing of Cattle

Three separate loads of beef heifers were purchased for Cactus Feeders Ltd., Amarillo, TX by Meridian Order Buyers, Meridian, MS from auction markets in Mississippi. Loads 1, 2, and 3 were shipped from Meridian, MS on the evenings of July 13, August 10, and September 8, 2005, respectively, arriving at the Texas Tech University Burnett Center the next morning. Load 1 (91 heifers) was 14.5 h in transit, with a 3.07% shrink from a pay weight of 240.7 kg (average arrival BW = 233.3 kg). Cattle in Load 1 were allowed access to water after unloading. Load 2 (93 heifers) was 13.75 h in transit, with a 6.08% shrink from a pay weight of 238 kg (average arrival BW = 223.5 kg). As with Load 1, the cattle were allowed access to water after unloading. Load 3 (93 heifers) was 17 h in transit, with a 4.7% shrink from a pay weight 237.2 kg (average arrival BW = 226.1 kg). Heifers in Load 3 were processed immediately after unloading (no access to water). Processing procedures and method of assignment to treatment that are described in the subsequent sections were consistent across the three loads.

Within 1 h of unloading, the heifers in each load were processed in the Burnett Center working facilities for initial processing. Processing included: 1) placement of a ear tag (uniquely numbered) in the left ear; 2) an individual body weight (BW); 3) vaccination (s.c.) with IBR, BVD, PI3, RSV modified live virus vaccine (Titanium 5,

Agri-Labs, Des Moines, IA) and clostridium chauvoei septicum novyi sordelli perf. Types C and D bacterin toxoid (Vision 7 with SPUR, Intervet, Millsboro, DE; 4) injection (i.m.) with 2 mL of Vitamin A/D_3 solution (Phoenix Pharmaceuticals, St. Joseph, MO; 500,000 IU of vitamin A and 75,000 IU of vitamin D_3/mL); 5) deworming with 25 mL of moxidectin down the back line (Cydectin; Ft. Dodge Anim. Health, Overland Park, KS); 6) injection (s.c.) with Nuflor (Schering-Plough Anim. Health, Union, NJ; given to the nearest 4.5 kg of BW); and 7) assignment of cattle to treatment. The time required to process each load was approximately 2.5 to 3 h.

Procedures for Assignment of Cattle to Treatments

Two treatments were applied at the time of processing: Control (C) or Levucell SB yeast (Y). Treatments were assigned by a coin toss before processing to establish the treatment for the first calf, after which the treatments were alternated between C and Y. Yeast calves received an oral dose of a paste containing Levucell SB yeast (to supply approximately 1 g of Levucell SB yeast per heifer; one click from a caulking gun placed in the corner of the heifer's mouth, which, based on preliminary measurements in the laboratory, delivered approximately 14 g of product exceeding the target delivery of 10 g. Control calves received 15 mL of water from one depression of a fluid dosing gun (a dosing gun used to give anthelmintics was used) placed in the corner of the heifer's mouth. After processing, C and Y heifers were housed in separate sorting pens until a sufficient number of each group (9 to 10 heifers per pen depending on the total number in the load) had been processed to fill two Burnett Center soil-surfaced receiving pens (approximately 5.5 m x 30.5 m; 4.57 m of linear bunk space). After processing each pair

of pens (C and Y as pairs) was moved to soil-surfaced pens (Pens 3 through 12, starting with Pens 11 and 12 as the first pair to Pens 3 and 4 as the last pair). Each pair of pens within a load was considered a block, with blocking accounting for processing order and location in the feedlot.

Application of Treatments and Routine Feeding Procedures

After completion of processing and movement of the heifers to their assigned soil-surfaced pens, heifers in each load were offered approximately 1.4 kg/heifer of long-stemmed sorghum sudangrass hay and 1.4 kg/heifer of the 65% concentrate receiving diet (Tables 1 and 2). The 65% diet was formulated to contain approximately 14% CP and to meet or exceed the NRC (1996) nutrient requirements for the heifers. Heifers in the Y treatment pens were fed 0.5 g/(heifer•d) of Levucell SB yeast mixed in the receiving diet.

The procedure to apply the treatment was to weigh the required quantity of yeast (to the nearest 0.1 g using an electronic balance; Ohaus, Pine Brook, NJ), place the weighed yeast into a plastic sprinkler can, add 2 L of warm tap water, mix until dissolved, and sprinkle the contents over the feed (delivered by a drag chain conveyor) in a Rotomix 84-8 mixer/delivery unit (Rotomix, Dodge City, KS) while the diet was mixing. The sprinkler can was then flushed with 500 mL of water which also was sprinkled over the feed. After approximately 3 min of mixing, feed was delivered to the pens. Control pens received water only in the receiving diet, using the same procedures and another sprinkler can. On d 21 after arrival, heifers in each load were switched to a 75% concentrate diet (Tables 3.1 and 3.2; formulated to contain 13.5% CP).

Additional BW measurements were collected for each load of heifers on d 14, 28, and 35 (end of the experimental period) after arrival. On d 14, heifers in each load were revaccinated with Titanium 5 (Agri-Labs) and implanted in the right ear with Ralgro (Schering-Plough Anim. Health). All BW measurements were taken using a C & S Single-Animal Squeeze Chute (Garden City, KS) set on four Rice Lake Weighing Systems (Rice Lake, WI) load cells. The scale was calibrated with 453.5 kg of certified weights on the day before or day of use. Average daily gain was calculated (change in unshrunk BW divided by days in period) for the periods of d 0 to 14, d 0 to 28, and d 0 to 35.

Estimates of the approximate quantity of unconsumed feed and orts remaining in the feed bunk were made in each of the 10 pens per load from 0700 to 0730 daily. Adjustments to the feed delivery for each pen were made to ensure ad libitum access to feed. As noted previously, sorghum sudangrass hay was fed after the cattle were processed, and hay feeding was continued at the rate of 0.91 to 1.4 kg (as-fed basis) per heifer for the first 6 (Load 1) to 7 d (Loads 2 and 3) after processing. Diet samples (and hay samples during the first week) were taken twice weekly from the feed bunks to determine the DM content (dried in a forced-air oven at 100°C for approximately 24 h) for each load. Weights for DM determination were taken on an Ohaus electronic balance (readability = ± 0.1 g). Feed bunks were cleaned on d 7, 14, 21, 28 and 35, and orts were weighed using an Ohaus electronic scale (readability = ± 0.045 kg). The DM content of feed weighed back from the bunks was determined as described for weekly diet samples. The DMI by each pen during various periods of the study was calculated by subtracting the quantity of dry feed refusal at the end of each period from the total dietary DM

delivered to each pen during that period. The number of animals housed per pen was multiplied by number of days in the weigh period to determine animal days, which were then divided into the corrected total DM delivered to the pen to obtain average DMI per heifer. Diet samples were ground to pass a 2-mm screen in a Wiley mill and analyzed for DM, crude protein, acid detergent fiber, Ca, and P in the Texas Tech University Ruminant Nutrition Laboratory; Table 3.3).

Assessment and Treatment of Morbid Cattle

Heifers in each load were monitored daily (0700) for signs of morbidity from BRD. Signs included lethargy, anorexia, nasal and ocular discharge, and labored breathing. Heifers showing these signs were removed from their pen for a more thorough evaluation. Antimicrobial therapy was given when the rectal temperature of a heifer that had been "pulled" from the pen was $\geq$39.4^{o}C, and returned to its assigned pen. Antimicrobial therapy schedule was based on the number of times an animal was pulled for treatment. The first time an animal was treated, it received Excede (ceftiofur crystalline-free acid sterile suspension; 1.5 mL/45.4 kg of BW given s.c. in the middle third of the posterior aspect of the ear; Pfizer, Eaton, PA). In addition to antibiotic treatment, heifers in the Y treatment group were given an oral dose of a paste containing Levucell SB yeast, whereas C heifers received an oral dose of 15 mL of water (same method as described for arrival processing). Heifers that required a second treatment received tilmicosin phosphate (1.5 mL/45.4 kg of BW given s.c.; Micotil; Elanco Animal Health, Indianapolis, IN) plus 2 mL/45.4 kg of BW [s.c.] of Penicillin G Benzathine and Penicillin Procaine G (150,000 units of each/mL; Aspen Veterinary

Resources, Kansas City, MO). As for the first treatment, Y and C heifers received either the oral paste or water at the time of treatment. Heifers requiring a third treatment were considered "chronics" and were removed from the experiment, after which they received treatment with long-acting oxytetracycline (Maxim 200; 200 mg of oxytetracycline/mL; Phoenix Pharmaceutical, Inc., St. Joseph, MO) plus sulfamethazine boluses (Albon SR; Pfizer, Exton, PA).

Statistical Analyses

Performance data were analyzed using the Mixed procedure of SAS (SAS Inst., Inc., Cary, NC) with a model that included the fixed effect of treatment and the random effects of load, load x treatment, and block nested within load. Preliminary analyses of the data with load and load x treatment considered as fixed effects revealed no indication of load x treatment interactions ($P = 0.12$ to 0.97). For descriptive purposes, performance data also were analyzed by load, with a Mixed model that included the fixed effect of treatment and the random effect of block.

Morbidity data were analyzed with the Glimmix procedure of SAS. The proportion of cattle in each pen that were treated one or more times for BRD was the dependent variable, with a model that included the fixed effect of treatment and the random effects of load, load x treatment, and block nested within load. A default logit link function with a binomial distribution was assumed. Percentages of morbidity by treatment were calculated with the Means procedures of SAS, and these values along with the odds ratio (odds of BRD for C vs. Y) are reported. Because cattle with two or more treatments were very infrequent (12.7% of total heifers treated) in the data set, the

proportion of cattle treated twice or more was not analyzed statistically. Morbidity data also were analyzed by load using a Glimmix model that included the fixed effect of treatment and the random effect of block.

Weather Data

A summary of weather data for the experimental period is provided in Appendix Table A-1. Data for this summary were obtained from the USDA-ARS weather station located approximately 9.65 km southwest of the Burnett Center.

Table 3.1. Ingredient composition (%, DM basis) of the experimental diets

	Dietary concentrate, %	
Ingredient	65	75
Steam-flaked corn	48.24	59.78
Cottonseed hulls	14.67	12.14
Alfalfa hay, ground	19.84	12.32
Urea	0.54	0.81
Cottonseed meal	8.07	5.85
Fat	2.03	2.54
Molasses	4.07	4.04
Supplement[a]	2.54	2.52

[a]Composition of the supplement is shown in Table 3.2.

Table 3.2. Composition of the supplement used in the experimental diets

Ingredient	% of DM
Cottonseed meal	23.36763
Endox (antioxidant)[a]	0.50000
Limestone	42.10526
Dicalcium phosphate	1.03627
Potassium chloride	8.00000
Magnesium oxide	3.55872
Ammonium sulfate	6.66667
Salt	12.00000
Cobalt carbonate	0.00174
Copper sulfate	0.15717
Iron sulfate	0.13333
EDDI	0.00252
Manganese oxide	0.26667
Selenium premix, 0.2% Se	0.10000
Zinc sulfate	0.84507
Vitamin A, 1,000,000 IU/g[b]	0.00792
Vitamin E, 500 IU/g[b]	0.12600
Rumensin, 176.4 mg/kg[b]	0.67499
Tylan, 88.2 mg/kg[b]	0.45005

[a]Kemin Industries, Des Moines, IA.
[b]Concentrations noted by ingredients are on a 90% DM basis.

Table 3.3. Chemical composition of (%, DM basis) of 65 and 75% concentrate diets with or without 0.5 g/(heifer•d) of Levucell SB yeast fed to newly received beef heifers

		Treatment[a]			
		Control		Levucell SB yeast	
Item[b]	Hay	65%	75%	65%	75%
DM	86.22	82.43	82.34	82.03	82.46
Ash	10.99	6.30	5.37	6.48	5.40
CP	12.76	13.81	13.00	14.04	13.31
ADF	32.81	25.53	20.78	26.54	22.23
Ca	0.44	0.70	0.60	0.71	0.62
P	0.20	0.27	0.27	0.28	0.26

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Values are the mean of composite samples obtained during each week of study for each of three loads of heifers. CP = crude protein; ADF = acid detergent fiber.

CHAPTER IV

RESULTS AND DISCUSSION

Performance

As noted previously, preliminary statistical analyses of the data were conducted with load considered as a fixed effect, which allowed testing the load x treatment interaction. Because these analyses revealed no indication of load x treatment interactions ($P = 0.12$ to 0.97), data were analyzed with load assumed to be a random effect, and results are presented averaged over the three loads. For descriptive purposes, performance data analyzed for each load are shown in Appendix Tables A.1 through A.3. Body weight, ADG, DMI, and gain:feed ratio (**G:F**) data averaged over the three loads are shown in Table 4.1. With the exception of hay DMI ($P = 0.01$), no differences ($P \geq 0.12$) were noted between treatments for performance. In addition, the small difference in hay DMI (0.980 vs. 0.925 kg/(heifer•d) for the C and Y treatments, respectively) is difficult to explain and likely not of importance practically. Hay was limit-fed, so this difference was probably a result of a chance, associated with very low variation in the measurement. Average daily gain did not differ between treatments, although numerical advantages for the Y treatment were evident from d 0 to 14 (1.06 kg) and 0 to 28 (1.19 kg); however, changes in ADG were inconsistent among the three loads (Appendix Tables A.1 through A.3). Short-term changes in BW, like those measured in this experiment, for which changes in gut fill from one measurement to another can have substantial effects on ADG, should be viewed cautiously. As with ADG, concentrate DMI for the various measurement periods did not differ between treatments, but a trend

was evident for a slight increase from d 0 to 35 in concentrate DMI for the Y (4.59 kg) vs. C (4.47 kg) treatment. For the by-load analyses, this trend in concentrate DMI from d 0 to 35 was evident with Loads 1 and 3, but not with Load 2 (Appendix Tables A.1 through A.3). Because treatment effects on ADG and DMI were not significant, G:F also was not expected to differ between treatments. Similar to the present results, Krehbiel et al. (2001) noted no differences in ADG by calves fed a DFM that contained yeast plus various digestive enzymes during the receiving period. This finding is consistent with previous studies (Adams et at., 1981; Cole et al., 1992; Zinn et al., 1999) in which no influence ($P > 0.10$) of yeast supplementation on ADG or feed efficiency was noted with the introduction of yeast supplementation into a receiving diet. Nonetheless, present results contradict a previous study summarized by Krehbiel et al. (2003), in which ADG, DMI, and G:F were increased (13.2, 2.5, and 6.3% respectively) when newly received beef calves were fed DFM containing live cultures of *L. acidophilus, L. plantarum, L. casei, and S. faecium* at processing and throughout the receiving period (average = 30 d). Further research is needed to fully understand the effect of Levucell SB yeast on performance during and within the receiving period of feedlot cattle, but present results suggest that feeding Levucell SB yeast would not have major effects on receiving period performance.

Galyean and McMeniman (2005) previously evaluated the effects of Levucell SB yeast on feed intake by healthy beef steers (average BW = 382.8 kg) injected with the strong antibiotic Nuflor. In that study, DMI during the 5-d period before the injection of Nuflor was essentially the same ($P = 0.544$) for the Control and Levucell SB yeast groups, and DMI decreased substantially from d 0 to 1 after Nuflor injection compared

with the average of the 5-d period before injection. By d 2 to 3 after injection, DMI began to increase for steers fed Levucell SB yeast, but it remained essentially unchanged for Control cattle, with the difference between treatments approaching statistical significance ($P = 0.107$). Similarly, for d 3 to 4, DMI tended ($P = 0.197$) to be greater for cattle fed Levucell SB yeast compared with controls, but DMI did not differ from d 4 through the remainder of the 7-d period. Perhaps the numerically greater concentrate DMI ($P = 0.12$ and 0.24 for d 0 to 28 and 0 to 35, respectively) by heifers fed Levucell SB yeast in the present study reflects effects of this treatment on intake similar to those noted in the Galyean and McMeniman (2005). Healthy beef steers that were fully accustomed to their diet and surroundings were used in the Galyean and McMeniman (2005) study. Thus, it is likely that the marketing, transport, and processing stressors to which the heifers in the present experiment were subjected would have negatively affected the overall intake by the heifers, thereby decreasing possible negative effects of Nuflor on feed intake and decreasing the magnitude of any potential response on top feeding Levucell SB yeast. Cole et al. (1992) reported that in feeder steers challenged intranasally with infectious bovine rhinotracheitis virus, feeding diets with 0.75% yeast culture (XP yeast culture; Diamond V, Cedar Rapids, IA) tended to allow the calves to maintain a greater DMI and BW after the challenge compared with a control diet. Thus, the trends in the present data support the findings of Galyean and McMeniman (2005) and Cole et al. (1992) and suggest that Levucell SB yeast might be beneficial for stimulating intake by newly received cattle, particularly when they are given a strong antibiotic as a prophylactic measure at the time of arrival processing.

Morbidity

Within loads, no differences ($P = 0.21$ to 0.28) were noted for the percentage of cattle treated once or more for BRD (Table 4.2); however, a consistently smaller proportion of the cattle in the Y treatment group were treated compared with those in the C group. Thus, when the data were analyzed across the three loads, the consistent response and the lack of load and load x treatment variance resulted in an ($P = 0.04$) increase in the percentage of C heifers treated once or more for BRD compared with Y heifers (24 vs. 13.78%). The odds ratio for C vs. Y was 1.99, indicating that C heifers were approximately twice as likely to be treated for BRD as were Y heifers. Reasons for the effect of Levucell SB yeast on BRD morbidity are unknown; however, the trends for increased concentrate intake by the Y heifers discussed previously may have contributed to (or perhaps reflected) their lower BRD morbidity compared with C heifers. A decrease in morbidity (48%) as well as a decrease in sick days (44%) was observed when 24.8 g/d of Diamond V XP yeast was supplemented to stressed calves by Zinn et al. (1999). In addition, Cole et al. (1992) reported that morbid stressed calves supplemented with XP yeast required fewer days of antibiotic treatment than controls. Krehbiel et al. (2003), as noted previously, observed decreased morbidity by 27.7% in cattle receiving bacterial DFM compared with controls. McFarland and Bernasconi (1993) noted immunological responses to an oral ingestion of *S. boulardii* in humans and in rats, with an increase in the mean number of erythrocytes, hemoglobin, leukocytes, and phagocytes (indicative of an inflammatory process), as well as an increase disaccharidase activity within the intestinal mucosa. These observations may explain the precursors by which SB yeast affects morbidity in newly received calves. Further research is needed to

determine veracity the present findings and to understand more fully the mechanism of action of yeast on BRD morbidity..

Although weather data were not analyzed statistically for interactions between weather and morbidity, weather may have had a negative effect on morbidity data with Load 3 (9/8 to 10/13/2005) based on decreased average air temperature compared with Loads 1 and 2 (7/14/05 to 9/15/05). This decrease was observed (Appendix Tables B.1 through B.3) from the beginning of the experiment in late summer to the end of the experiment in the early fall months. The cooler temperatures (along with light precipitation), may have prevented immuno-suppressed cattle from warding off effects of BRD leading to slightly increased morbidity rates and treatment with Load 3 compared with the other two loads. Nonetheless, changes in morbidity among the three loads were not large, and the response to treatment was very consistent among loads, so it is very unlikely that changing weather conditions interacted with treatment.

Table 4.1. Effects of Levucell SB yeast on body weights, average daily gain (ADG), dry matter intake (DMI), and gain:feed ratio (G:F) by newly received beef heifers (averaged over three separate loads)

	Treatment[a]			
Item	Control	Levucell SB yeast	SE[b]	*P*-value[c]
d 0 BW, kg	229.6	230.9	3.41	0.63
d 35 BW, kg	271.1	272.3	2.73	0.67
ADG, kg				
d 0 to 14	1.04	1.06	0.192	0.89
d 0 to 28	1.11	1.19	0.162	0.21
d 0 to 35	1.18	1.18	0.136	0.99
DMI, kg/(heifer•d)				
Hay				
d 0 to 7	0.980	0.925	0.032	0.01
Concentrate				
d 0 to 7	1.21	1.22	0.059	0.65
d 0 to 14	2.73	2.80	0.092	0.37
d 0 to 28	4.05	4.18	0.190	0.12
d 0 to 35	4.47	4.59	0.198	0.24
G:F[d]				
d 0 to 14	0.320	0.326	0.0515	0.87
d 0 to 28	0.257	0.267	0.0268	0.36
d 0 to 35	0.252	0.247	0.0198	0.75

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Standard error of the treatment means, n = 15 pens per treatment averaged over three loads of heifers.

[c]Observed significance level for the difference between treatments.

[d]Gain:feed data include intakes of hay.

Table 4.2. Effects of Levucell SB yeast on bovine respiratory disease (BRD) morbidity in newly received beef heifers

	Treatment[a]			
Item	Control	Levucell SB yeast	Odd ratio[b]	*P*-value[c]
Load 1				
Treated for BRD, %[d]	22.22	13.11	1.93	0.28
Load 2				
Treated for BRD, %	24.00	13.11	2.15	0.21
Load 3				
Treated for BRD, %	25.78	15.11	1.93	0.25
All loads				
Treated for BRD, %	24.00	13.78	1.99	0.04

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Odds ratio for Control vs. Levucell SB yeast; n – five pens per treatment within a load of heifers, and n = 15 pens per treatment averaged over three loads of heifers.

[c]Observed significance level for the difference between treatments; analyzed assuming a binomial distribution using the Glimmix procedure of SAS.

[d]Heifers treated one or more times for BRD.

CHAPTER V

CONCLUSIONS

Results from the present study suggest that the addition of 0.5 g/(heifer•d) of Luvecell SB Yeast to the diet of newly received heifers plus 1 g/heifer at arrival processing decreased morbidity, resulting in fewer antibiotic treatments for animals to recover from bovine respiratory disease. These effects might be associated with greater DMI during the second half of the receiving period for heifers fed Levucell SB yeast, thereby resulting in enhanced nutritional and/or immune status of the heifers. In addition, feeding yeast might have direct effects on the immune system that resulted in decreased morbidity.

Heifers fed Levucell SB yeast showed less signs of the onset of bovine respiratory disease; thus, treatment decreased by nearly half that of the control heifers. Although body weight gain and gain efficiency did not differ between treatments, based on the experimental protocol used in the present study, it seems that supplemental Levucell SB yeast might increase DMI by newly received heifers, particularly when they are treated with a strong antibiotic like the one used in the present study (Nuflor). Depending on the level and severity of morbidity of newly received calves, and the physical and chemical characteristics of the diet consumed, Levucell SB yeast may be of benefit in feedlots. Previous reports (Cole et al., 1992; Zinn et al., 1999) also have suggested positive effects of supplemental live yeast culture on morbidity in newly received cattle. Further research is needed to verify the present findings and to understand the mechanism(s) by which

supplemental yeast affects health of newly received cattle and to test the efficacy of this product in practical settings.

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APPENDIX A

PERFORMANCE DATA BY LOAD

Table A.1. Effects of Levucell SB yeast on body weights, average daily gain (ADG), dry matter intake (DMI), and gain:feed ratio (G:F) by newly received beef heifers (Load 1)

	Treatment[a]			
Item	Control	Levucell SB yeast	SE[b]	*P*-value[c]
d 0 BW, kg	236.4	233.8	2.50	0.49
d 35 BW, kg	266.5	268.8	3.80	0.69
ADG, kg				
d 0 to 14	0.58	0.85	0.098	0.11
d 0 to 28	0.79	0.94	0.071	0.20
d 0 to 35	0.86	1.00	0.072	0.21
DMI, kg/(heifer•d)				
Hay				
d 0 to 7	0.984	0.957	0.024	0.35
Concentrate				
d 0 to 7	1.23	1.26	0.052	0.63
d 0 to 14	2.54	2.73	0.093	0.16
d 0 to 28	3.68	3.83	0.138	0.41
d 0 to 35	4.06	4.06	0.148	0.42
G:F[d]				
d 0 to 14	0.193	0.271	0.0278	0.08
d 0 to 28	0.206	0.232	0.0156	0.27
d 0 to 35	0.203	0.226	0.0106	0.17

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Standard error of the treatment means, n = 5 pens per treatment.

[c]Observed significance level for the difference between treatments.

[d]Gain:feed data include intakes of hay.

Table A.2. Effects of Levucell SB yeast on body weights, average daily gain (ADG), dry matter intake (DMI), and gain:feed ratio (G:F) by newly received beef heifers (Load 2)

	Treatment[a]			
Item	Control	Levucell SB yeast	SE[b]	*P*-value[c]
d 0 BW, kg	229.0	234.2	2.85	0.23
d 35 BW, kg	275.2	276.1	2.47	0.79
ADG, kg				
d 0 to 14	1.14	1.07	0.118	0.71
d 0 to 28	1.18	1.14	0.063	0.64
d 0 to 35	1.32	1.20	0.085	0.33
DMI, kg/(heifer•d)				
Hay				
d 0 to 7	1.039	0.948	0.026	0.04
Concentrate				
d 0 to 7	1.12	1.09	0.045	0.59
d 0 to 14	2.73	2.73	0.035	0.88
d 0 to 28	4.21	4.24	0.088	0.72
d 0 to 35	4.73	4.71	0.107	0.80
G:F[d]				
d 0 to 14	0.349	0.334	0.0352	0.76
d 0 to 28	0.262	0.253	0.0100	0.55
d 0 to 35	0.267	0.244	0.0141	0.27

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Standard error of the treatment means, n = 5 pens per treatment.

[c]Observed significance level for the difference between treatments.

[d]Gain:feed data include intakes of hay.

Table A.3. Effects of Levucell SB yeast on body weights, average daily gain (ADG), dry matter intake (DMI), and gain:feed ratio (G:F) by newly received beef heifers (Load 3)

	Treatment[a]			
Item	Control	Levucell SB yeast	SE[b]	*P*-value[c]
d 0 BW, kg	223.5	224.8	2.16	0.48
d 35 BW, kg	271.6	272.1	4.39	0.94
ADG, kg				
d 0 to 14	1.41	1.26	0.093	0.30
d 0 to 28	1.37	1.48	0.079	0.31
d 0 to 35	1.37	1.35	0.077	0.86
DMI, kg/(heifer•d)				
Hay				
d 0 to 7	0.921	0.866	0.024	0.15
Concentrate				
d 0 to 7	1.27	1.33	0.059	0.27
d 0 to 14	2.93	2.94	0.067	0.93
d 0 to 28	4.25	4.48	0.097	0.14
d 0 to 35	4.61	4.83	0.122	0.23
G:F[d]				
d 0 to 14	0.417	0.374	0.0275	0.31
d 0 to 28	0.303	0.316	0.0146	0.55
d 0 to 35	0.285	0.270	0.0107	0.34

[a]Treatments (Control or Levucell SB yeast) were applied at the time of feeding by mixing the required quantity of Levucell SB yeast with 2.5 L of warm tap water (tap water only for the Control), adding the water to the mixer via a sprinkling can, and mixing for approximately 3 min before delivery to the pens.

[b]Standard error of the treatment means, n = 5 pens per treatment.

[c]Observed significance level for the difference between treatments.

[d]Gain:feed data include intakes of hay.

APPENDIX B

WEATHER DATA

Table B.1. USDA - Agricultural Research Service North Lubbock Meteorological Tower, Lubbock, TX[A] (7/14/06 to 8/13/06)

Date	Daily rain, mm	Avg wind speed, m/s	Resultant wind dir deg.	Max gust, m/s	Min RH, %	Max RH, %	Avg RH, %	Min air temp, C	Max air temp, C	Avg air temp, C	Min soil temp, C	Max soil temp, C	Avg soil temp, C	Max solar rad., W/m^2	Avg solar rad., W/m^2	Avg sta. press., mb
7/14/05	0	2.87	144	10.9	24	80	50	19.3	41.0	28.1	27.5	32.2	29.7	1061	355	901
7/15/05	0	3.01	59	10.1	30	88	56	19.3	35.8	26.7	28.5	32.2	30.4	1157	320	903
7/16/05	0	1.94	112	11.0	28	82	54	19.2	39.2	27.4	28.5	32.7	30.6	1140	322	903
7/17/05	0	4.42	181	12.1	28	75	51	21.2	35.1	27.7	29.0	33.0	31.0	1027	357	901
7/18/05	0	3.78	165	11.9	32	81	56	21.1	35.5	27.7	29.4	33.3	31.3	1076	323	902
7/19/05	0	4.56	177	12.3	32	72	50	22.5	35.6	28.5	29.9	33.4	31.7	1118	336	903
7/20/05	0	4.32	173	12.3	24	63	46	22.6	36.2	28.4	29.9	34.0	31.9	1017	355	904
7/21/05	0	3.85	188	9.6	33	80	56	21.5	33.9	27.1	30.4	33.3	32.0	1105	305	907
7/22/05	0	2.70	187	8.0	30	77	50	21.8	37.8	28.4	30.1	33.4	31.8	1061	295	907
7/23/05	0	2.59	160	12.2	25	68	45	20.7	39.7	28.9	30.2	34.2	32.2	1089	336	906
7/24/05	0	3.59	171	11.2	25	87	54	19.3	36.8	27.7	30.5	34.0	32.4	1170	335	903
7/25/05	0	5.49	176	14.1	25	80	48	21.4	36.5	28.7	30.7	34.2	32.5	1036	345	901
7/26/05	3.3	5.71	46	16.5	47	93	68	18.0	28.5	23.8	30.1	33.2	31.4	890	145	902
7/27/05	15.1	4.46	34	15.2	56	97	77	15.0	23.8	17.9	26.2	30.2	27.4	613	140	908
7/28/05	0	1.99	98	9.2	32	92	62	12.3	32.0	21.6	23.9	27.8	25.9	1036	361	908
7/29/05	0	2.03	186	7.5	45	97	71	16.5	32.3	23.5	24.9	27.9	26.5	1261	294	908
7/30/05	0	1.96	154	7.0	32	94	63	18.7	36.9	26.4	25.6	29.1	27.3	1100	317	908
7/31/05	0	2.22	102	8.5	24	83	54	19.9	37.2	27.4	26.3	30.2	28.2	1040	348	907
8/1/05	0	1.99	142	8.4	28	75	50	17.6	36.0	26.4	26.7	30.5	28.6	1032	338	906
8/2/05	0	1.93	200	7.6	24	71	44	17.4	36.1	26.4	27.0	30.9	28.9	1074	319	905
8/3/05	0	2.81	181	11.8	29	73	50	19.1	36.2	26.6	27.6	30.8	29.3	1068	284	903
8/4/05	3.5	3.12	103	17.6	31	94	57	19.4	37.6	26.2	27.8	31.8	29.8	1081	324	906
8/5/05	1.1	3.48	26	9.3	62	95	83	18.0	28.1	21.3	27.1	30.9	28.3	991	156	909
8/6/05	0	1.88	135	7.4	48	97	74	16.9	33.6	23.7	25.6	28.3	27.1	1200	244	907
8/7/05	0	2.89	179	12.0	37	92	66	18.9	34.8	25.1	25.9	29.3	27.6	1262	286	905
8/8/05	0	3.21	145	9.7	49	94	74	18.3	32.3	24.2	26.7	30.1	28.3	1036	314	904
8/9/05	0	2.77	150	10.0	49	96	74	17.9	34.0	25.0	27.2	31.0	29.0	1028	324	903

8/10/05	0	2.57	114	8.3	41	95	70	16.9	35.0	25.0	27.7	31.1	29.5	1054	321	903
8/11/05	0	2.95	158	9.6	34	96	66	18.7	34.1	25.6	27.9	31.4	29.7	1020	321	902
8/12/05	0	3.71	161	12.0	40	88	68	19.5	33.0	25.3	28.3	31.1	29.8	1156	287	900
8/13/05	10.9	2.58	139	13.4	51	95	77	19.0	33.2	23.1	28.2	30.3	29.3	1098	204	900

TABLE B.2. USDA - AGRICULTURAL RESEARCH SERVICE NORTH LUBBOCK METEOROLOGICAL TOWER, LUBBOCK, TX^ (8/14/06 TO 9/13/06)

8/14/05	15.2	3.17	54	8.1	89	97	95	18.1	22.6	19.5	25.9	29.1	26.9	518	70	902
8/15/05	0.9	2.82	84	7.3	78	98	91	17.4	26.2	20.2	24.4	25.9	25.2	932	140	906
8/16/05	0	1.62	154	7.5	52	97	80	19.1	33.7	24.0	24.3	27.3	25.6	1160	243	906
8/17/05	0	3.44	187	9.8	48	94	71	19.0	33.4	25.6	24.8	28.2	26.4	1020	321	902
8/18/05	0	4.03	191	9.6	40	84	62	20.7	35.9	27.2	25.5	28.6	27.0	975	308	900
8/19/05	0	3.81	180	11.4	42	84	62	19.8	33.4	26.6	25.9	28.6	27.3	989	314	902
8/20/05	0	3.15	184	12.4	41	84	63	19.8	33.6	26.2	26.1	28.7	27.4	1125	311	905
8/21/05	0.4	2.62	41	10.3	45	94	76	19.0	32.4	23.6	26.1	28.0	27.1	1170	181	906
8/22/05	0	2.69	178	9.8	36	95	63	18.6	33.6	25.6	25.7	28.2	27.0	1108	275	903
8/23/05	0	3.57	191	10.6	28	83	54	19.8	35.0	26.8	26.0	29.1	27.5	1038	316	901
8/24/05	0	3.41	170	14.6	32	82	58	19.3	34.6	26.4	26.5	29.6	28.0	1126	308	901
8/25/05	0	3.53	181	10.0	33	83	57	20.5	35.2	27.1	27.0	30.3	28.6	1052	303	904
8/26/05	0	3.18	187	9.5	30	81	55	20.5	38.5	27.6	27.5	31.3	29.3	964	313	902
8/27/05	18.7	3.89	80	23.2	35	93	67	18.5	35.7	24.1	27.4	30.4	28.8	1226	188	901
8/28/05	0	3.02	39	13.1	50	95	72	16.7	31.9	23.4	24.9	28.0	26.6	964	310	900
8/29/05	0	2.70	14	8.3	34	94	64	16.2	31.9	22.9	24.7	27.6	26.3	1108	292	901
8/30/05	0	2.44	193	7.8	27	83	53	15.6	35.4	24.0	24.2	27.8	26.0	969	313	899
8/31/05	0	3.49	144	9.9	29	83	53	16.2	34.1	24.9	24.6	28.2	26.3	961	307	901
9/1/05	0	2.43	128	8.1	32	79	57	15.6	34.5	24.4	24.9	28.3	26.6	1060	286	905
9/2/05	0	2.72	123	11.1	25	89	59	15.3	33.6	23.7	25.2	28.7	27.0	1062	286	907
9/3/05	0	2.12	141	11.6	33	82	61	16.0	33.4	23.9	25.5	28.8	27.2	1010	264	908
9/4/05	0	3.04	145	10.9	41	90	68	16.8	31.1	23.5	25.8	29.0	27.4	1065	278	907
9/5/05	0	3.17	148	11.0	50	90	75	18.5	28.4	22.8	26.3	28.2	27.2	897	180	906
9/6/05	0	2.97	168	10.1	34	84	60	18.1	31.7	24.0	25.4	28.7	27.0	944	238	907
9/7/05	0	2.74	168	9.3	35	78	56	17.6	32.4	23.8	25.8	29.4	27.6	1002	277	908
9/8/05	0	3.08	177	9.7	30	74	52	17.7	33.4	23.5	26.0	29.5	27.8	991	277	907
9/9/05	0	3.90	180	12.3	32	68	51	14.5	30.6	23.0	25.8	28.9	27.6	1017	254	903

9/10/05	0	4.25	160	11.7	34	86	58	16.7	32.5	24.7	26.1	29.4	27.8	948	265	901
9/11/05	0	4.00	159	11.4	36	87	67	17.8	33.5	23.8	26.6	30.0	28.3	907	261	903
9/12/05	0	4.76	176	12.3	36	92	68	20.0	32.9	25.1	27.2	30.9	28.9	913	252	902
9/13/05	5.6	3.95	188	18.3	33	88	67	20.2	35.1	24.5	27.8	30.2	29.0	1140	225	900

TABLE B.3. USDA - AGRICULTURAL RESEARCH SERVICE NORTH LUBBOCK METEOROLOGICAL TOWER, LUBBOCK, TX^ (9/14/06 TO 10/14/06)

9/14/05	0	3.37	210	11.6	24	95	61	19.1	37.5	25.3	25.7	29.0	27.5	1004	261	899
9/15/05	0	3.84	58	10.4	37	97	71	16.7	30.9	22.5	26.0	29.3	27.6	933	272	903
9/16/05	0	2.69	129	8.6	40	97	73	13.3	29.4	20.8	25.3	28.9	27.2	917	280	907
9/17/05	0.2	4.66	174	22.5	29	95	67	17.0	36.4	24.9	26.1	29.5	27.6	1179	215	902
9/18/05	0	4.65	188	15.1	22	62	43	22.4	37.3	28.1	26.4	30.4	28.2	996	272	901
9/19/05	0	4.25	187	11.4	28	69	51	20.8	36.2	26.8	27.1	30.9	28.9	947	265	905
9/20/05	0	2.79	187	11.1	28	75	50	18.0	37.6	26.4	27.3	31.2	29.3	902	275	908
9/21/05	0	3.36	203	12.7	22	75	46	16.3	34.1	24.8	27.2	31.2	29.3	923	282	905
9/22/05	0	2.72	189	7.7	19	72	44	15.7	38.7	25.9	27.3	31.5	29.4	909	276	901
9/23/05	0	2.78	105	9.0	23	83	49	15.5	34.1	24.1	27.3	31.1	29.4	900	267	901
9/24/05	0	2.07	130	6.6	28	81	52	15.2	35.9	24.8	27.2	31.2	29.3	869	259	899
9/25/05	0	3.98	258	12.8	11	72	35	16.8	36.9	27.0	27.3	31.3	29.3	910	276	899
9/26/05	0	4.26	27	14.1	32	75	51	14.5	31.9	22.0	27.1	30.9	29.1	884	268	905
9/27/05	0	2.53	197	8.7	29	86	58	12.6	34.6	23.4	26.7	30.8	28.8	859	258	905
9/28/05	0	6.60	7	22.2	22	69	49	14.3	35.4	23.5	27.4	30.7	29.1	919	250	903
9/29/05	0	3.23	64	12.9	29	74	52	8.9	25.0	15.1	25.8	29.5	27.2	797	151	908
9/30/05	0.7	4.32	214	12.8	24	83	55	13.3	29.1	19.8	24.3	27.3	25.9	921	214	900
10/1/05	0	3.87	216	12.4	14	76	38	13.5	33.9	23.9	24.3	28.6	26.4	883	264	899
10/2/05	0	4.89	171	12.4	34	79	56	19.5	31.5	24.2	26.0	28.4	27.2	947	196	902
10/3/05	0	4.54	170	13.0	40	83	62	17.6	30.4	23.8	25.9	28.6	27.3	944	216	903
10/4/05	0	5.09	172	13.7	38	86	64	19.1	29.8	23.8	26.2	28.3	27.3	1010	171	902
10/5/05	32.6	5.41	98	19.3	44	96	77	8.8	31.7	18.9	24.4	28.6	26.8	989	170	903
10/6/05	4.5	4.22	29	11.9	49	87	71	7.6	10.4	8.8	19.4	24.3	21.2	288	63	909
10/7/05	0	2.11	63	6.8	39	81	62	6.7	20.8	12.1	17.7	21.0	19.3	845	205	906
10/8/05	0	3.21	159	10.2	54	90	73	6.7	21.7	14.0	17.7	20.7	19.3	826	239	900
10/9/05	17.2	3.15	173	13.8	73	96	90	10.3	17.9	13.4	18.2	20.2	18.8	625	52	895
10/10/05	3.3	3.28	239	18.7	48	98	82	8.7	22.4	14.2	17.5	20.0	18.6	979	166	897

10/11/05	0	2.16	245	7.6	41	95	70	5.5	21.7	13.1	16.3	19.9	18.2	820	228	902
10/12/05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10/13/05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10/14/05	0	2.36	236	8.2	38	93	66	9.5	27.5	17.0	17.4	21.0	19.2	802	228	910

[a]Abbreviations: Avg = average: dir = direction; Max = maximum; Min = minimum; RH = relative humidity; temp = temperature; rad. = radiation; and sta. = station.

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