BOVINE RESPIRATORY DISEASE COMPLEX: EFFECTS OF NUTRITION, MANAGEMENT AND MEDICAL TREATMENT OF NEWLY RECEIVED STOCKER CATTLE

By

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CHAPTER I

INTRODUCTION

Respiratory diseases continue to be the major cause of economic loss in beef cattle. From a year-long study of diseases in 407,000 yearling feedlot cattle, Jensen and others (1976) reported that respiratory tract diseases accounted for about three fourths of the clinical diagnoses and about two thirds of the necropsy diagnoses. Annual losses from bovine respiratory disease in the United States have been estimated at about 500 million dollars or about 100 million kg of carcass beef (James, 1987). These figures represent those losses directly related to mortality and exclude losses associated with reduced animal performance and increased labor and medical costs.

Bovine respiratory disease complex (BRDC), commonly known as "shipping fever", is used to describe the respiratory disease observed in cattle 6 months of age or older after shipment either into feedlots or onto pasture. The stresses of weaning, castration, dehorning, fasting, overcrowding, exposure to infectious agents, diet changes, environmental temperature extremes, and other stressors combined with viral, bacterial, mycoplasmal, and or chlamydial infections contribute to the complex. During

times of stress, viruses, mycoplasma, and/or clamydia are believed to damage the respiratory tract which predisposes it to other severe bacterial and/or viral infections (Hoerlein and Marsh, 1957).

A clinical outbreak of respiratory disease in cattle usually occurs from hours to a few days following arrival at the destination. Recently shipped cattle in the 300 to 500 pound weight range commonly have a 20 to 80% morbidity and 1 to 10% mortality (Cummins, 1983). The symptoms associated with BRDC are subtle and typically go unnoticed during the early, viral stage of the disease. As secondary infections occur, cattle begin to exibit the following signs of shipping fever: 1) calves appear sluggish and exhibit signs of depression, standing alone with their heads down and ears drooping; 2) calves often have a gaunt appearance from anorexia; 3) the nasal mucous membranes may be either dry or a copious nasal exudate may be present; 4) calves exhibit a soft cough, increased respiratory rate; and 5) diarrhea may be present (Hoerlein, 1964). If symptoms go untreated, cattle become weaker and death ensues. Necropsy examinations and tissue cultures typically reveal pneumonia due to one or a combination of the BRDC organisms as the cause of death.

Because BRDC is recognized as the major health problem in feedlot and stocker cattle operations (Cummins, 1983), it is important to conduct research on the prevention, treatment and control of this disease. It was the

objectives of this research project to investigate the effects on health and performance of newly arrived stressed cattle of the following factors: 1) vitamin E supplementation, 2) zinc supplementation, 3) respiratory syncytial virus vaccine, and 4) lead steers (steers that had learned to eat from a bunk and drink from the water fountains) as a management tool.

CHAPTER II

REVIEW OF LITERATURE

Etiology of the Bovine Respiratory Disease Complex

Hoerlein and Marsh (1957) hypothesized that BRDC involved the combination of three factors: stress, nonbacterial infection and bacterial infection. Hamby et al. (1963) supported this hypothesis by exposing calves to various viral and bacterial antigens and physical stress. They found that subjecting calves to any single factor or two factors in combination did not produce shipping fever symptoms. However, symptoms of BRDC were observed in calves subjected to stress in combination with parainfluenza-3 and Pasteurella haemolytica. Because of the earlier work of Hamby et al. (1983) and supportive work by others, the three factor hypothesis generally has been accepted; six bacterial pathogens and eleven non-bacterial pathogens have since been associated with BRDC (Hoerlein, 1973).

The pathogenisis hypothesized for BRDC (Collier, 1968b; Carter, 1973; Henry, 1984) is as follows: 1) Many

potentially pathogenic organisms are found in the upper respiratory tract of cattle. Different pathogens are found in different herds and among different individuals. 2) The mixing of cattle from various origins results in an exchange of these organisms. 3) Subacute viral infections occur continually in cattle; when environmental stress such as mixing of cattle from different origins occurs, these infections become more acute. 4) As the infections become more severe, these agents move into the lower respiratory tract and offer more favorable conditions for invasion by secondary bacteria.

Viruses

The viruses associated with BRDC are normal inhabitants of the respiratory tracts of healthy cattle; they are typically controlled by the animals immune system. However, when the immune system is suppressed by stress, these potentially pathogenic organisms multiply and predispose the animal to bacterial infection and respiratory disease.

Bovine parainfluenza-3 virus. Bovine parainfluenza-3 (PI-3), a ribonucleic acid virus, was originally isolated from cattle with shipping fever by Reisinger et al. (1959) and later was recovered from normal cattle as well as calves with enzootic pneumonia (Betts et al., 1964). The virus is shed in nasal and occular secretions and enters

cattle via nasal passages and mouth. PI-3 is distributed worldwide. This topic has been reviewed extensively (Woods, 1968; Gale, 1970; Frank and Marshal, 1973).

Dawson and others (1965) experimentally infected calves with PI-3 and observed fever, coughing, excess nasal and occular discharge, and increased respiratory and pulmonary rates. They found that, despite damage to the epithelial mucosa in the respiratory tract, the observed signs of infection frequently were mild. PI-3 associated disease is most severe when other bacterial infections occur simultaneously (Dawson et al., 1964; Baldwin et al., 1967; Marshall and Frank, 1975); thus lessions found in BRDC cannot be attributed totally to PI-3 even if the virus played a role in its development.

An antibody survey by Woods (1968) showed that buffalo, deer, horses and monkeys could be infected with PI-3, but they hypothesized that cattle are the principal reservoir with 53-85% of the beef cattle tested possessing serum antibodies. Antibody prevalence appeared to increase with increasing age but, differences among sexes or breeds of cattle surveyed were not significant .

Bovine respiratory syncytial virus. Bovine respiratory syncytial virus (BRSV), a ribonucleic acid virus, was isolated from nasal or ocular secretions following outbreaks of respiratory disease in adult cattle (Inaba et al., 1970; Paccaud and Jacquier, 1970) and calves

(Jacobs and Eddington, 1971; Rosenquist, 1974; Lehmkuhl et al., 1979b). Clinical and experimental observations indicate that BRSV is a primary pathogen even though it is commonly associated with bovine viral diarrhea (BVD), parainfluenza-3 (Inaba et al., 1972), Pasteurella and/or bovine adenoviruses (Lehmkuhl et al., 1979a).

BRSV is widely distributed and reported to be a rapidly spreading, usually mild respiratory disease found in Japan (Inaba et al., 1972), the United Kingdom (Jacobs and Eddington, 1971), Switzerland (Paccaud and Jacquier, 1970) and the United States (Lehmkuhl et al., 1979b). All studies reported a rapid onset, an increased respiratory rate, a watery nasal and ocular discharge, coughing and in some cases, depression. Pneumonia, determined by auscultation with a stethoscope, occurs in a very small percentage of cases (Inaba et al., 1972). Mortality is rare. No lesions of diagnostic value are evident in live animals infected with BRSV.

Necropsy conclusions typically are confounded by a secondary infection; however, one calf experimentally infected and slaughtered had lymphadenitis and hyperplasia of bronchial lymph nodes and pneumonia characterized by small consolidated areas in the cranial and accessory lobes of the lung (Mohanty et al., 1975).

In individual cattle, the BRSV disease runs its course in 2 to 10 days. A few cattle develop pneumonia and a small percentage of these succumb. Cattle are probably the

principle reservoir. Lehmkuhl and Cutlip (1979) sucessfully infected sheep; but, their role in the epidemiology is unknown. Antibody prevalance was reported by Mohanty and co-workers (1975) at 38% in Maryland, 76% in Oklahoma (Potgieter and Aldridge, 1977b) and 69% in Alabama (Rossi and Kiesel, 1974). Though the method of transmission is uncertain, it appears that BRSV occurs in the air and route of entry into susceptible cattle probably is via the respiratory tract or by ingestion. The viral infection attack and fatality rates do not appear to be affected by age, sex or breed.

Infectious bovine rhinotracheitis virus. Infectious bovine rhinotracheitis (IBR), a herpes virus, was first described in 1955 as a respiratory tract disease of feedlot cattle in the western United States (Miller, 1955). Shortly thereafter it was isolated (Madin et al., 1956) and recognized in dairy cattle (Kendrick et al., 1958). IBR has been extensively reviewed by McKercher (1959), Gibbs and Reyemamu (1977) and Kahrs (1977).

As there are many forms of IBR. The respiratory form is manifested by fever, rapid respiration, dyspnea associated with mucopurulent material in the nasal passages and trachea and dilated nostrils. Occasionally, partial blockage of these airways results in open-mouthed breathing (Kahrs and Smith, 1965). The hyperemia and reddening of the nasal turbinates and muzzle has resulted in the common

reference to the disease as "red nose". Ferris et al. (1964) observed conjunctivitis and excess occular secretions in certain herds that changed from clear to mucopurulent as the disease progressed.

After surveying feedlot and dairy cattle, Rosner (1968) reported that the fatality rate due to the respiratory form of IBR was low unless it was complicated by secondary bacterial infections. Infections leading to death were more common in feedlot cattle than dairy herds and were attributed to the additional environmental stress associated with shipping, aggregation, social acclimatization and exposure to multiple pathogens typically found in feedlots. Upon necropsy, animals had lesions on mucosal surfaces, especially in the trachea and nasal passages (Baker et al., 1960). Pasteurellosis is often confounded necropsy reports.

Cattle are believed to be the principal reservoir of IBR virus. Many antibody studies suggest that this virus is widespread; it is considered to be ubiquitous in the United States (Kahrs, 1974). Davies and Duncan (1974) hypothesized that transmission probably occurs by direct contact between infected cattle. Latent infections are occasionally reactivated which is accompanied by virus shedding.

Bovine viral diarrhea virus. Bovine viral diarrhea (BVD) is a disease caused by bovine viral diarrhea virus, a

ribonucleic acid virus. Olafson et al. (1946) were the first to report BVD. Acute systemic BVD is characterized by fever, leukopenia, diarrhea, coughing, rapid respiration, nasal and ocular discharges, and death, frequently due to dehydration. The most noted lesion is erosion and ulceration of the oral mucosa. BVD can be diagnosed easily as a respiratory disease based upon an increased respiratory rate, increased rectal temperature, nasal discharge and coughing. BVD infection usually is not accompanied by pneumonia unless other infective agents are present. BVD is considered to be widespread (Kahrs, 1981).

Adenoviruses. The first bovine adenovirus (BAV), a DNA virus, was found in feces of cattle (Klein et al., 1959). BAV isolates have been reported worldwide. Isolations have been acquired from sick cattle and from apparently healthy cattle (Burki, 1973). Seroconversion among healthy cattle has been observed (Lehmkuhl et al., 1979a). Thus inapparent infections can occur.

BAV has been isolated from calves with pneumonia (Cole, 1970; Reed et al., 1978) and by serologic studies (Cole, 1970; Lehmkuhl et al., 1979a). Mild pneumonia has been produced experimentally (Darbyshire, 1968; Mattson, 1973b; Lehmkuhl et al., 1975).

Data suggest that BAV should be considered among the many etiologic agents that contribute to the multifactor etiology of bovine respiratory disease (Kahrs, 1981).

Several BAV isolates were recovered by Lehmkuhl et al. (1979a) from calves with concomitant bacterial infections and some calves have had multiple viral infections. Serologic studies indicate widespread BAV infections. For example, 75% of adult slaughter cows tested had antibody to BAV-3 (Mattson, 1973b). The BAV have been reviewed by Mattson (1973a) and Mohanty (1978).

Mycoplasma and Chlamydia. Mycoplasma and chlamydia organisms play a predisposing role in BRDC (Cummins, 1983). Mycoplasma bovis and M. dispar and the M. ureplasma species are the more significant mycoplasma species in North American cattle. Mycoplasma infections commonly cause arthritis in feedlot cattle following an outbreak of respiratory disease. Mycoplasmas frequently are isolated from pneumonic lungs of sick cattle and respiratory tracts of healthy cattle (Hjerpe and Routen, 1976; Jensen et al., 1976). The role of mycoplasma organisms in the shipping fever complex is undetermined (Stalheim, 1983).

Many strains of Chlamydia psittaci exist. These organisms undergo an intracellular life cycle terminating in the infectious particle, elementary body (Cummins, 1983). Most chlamydia infections result in, or are associated with, mild signs of respiratory tract and arthritic infections; and, it is unlikely that they alone cause BRDC.

Other viruses. Bovine herpes virus strain DN599 is antigenetically unrelated to IBR virus. Mohanty et al. (1972) produced respiratory disease symptoms in calves by innoculating them with DN599. Potgieter and Aldridge (1977a) found by serological techniques that the DN599 virus had infected 2% of Oklahoma cattle tested. The virus is apparently widespread in North America, but it is not believed to be as prevalent a pathogen as PI-3, BRSV, IBR, BAV or BVD.

Other viruses suspected to be associated with BRDC are rhinoviruses, reoviruses, bovine parvovirus and bovine enteroviruses. They have been isolated in cattle exhibiting signs of shipping fever. The importance of these antigens in BRDC is undetermined (Cummins, 1983).

Bacteria

Bacteria are one of the infectious components associated with BRDC. The role of bacteria in shipping fever complex has been reviewed extensively (Collier, 1968a, 1968b; Carter, 1973; Lillie, 1974). The bacteria most commonly found in calves exibiting shipping fever (Lillie, 1974) are: Pasteurella multocida, Pasteurella haemolytica, Hemophilus somnus and Corynebacterium pyogenes.

Pasteurella haemolytica. Pasteurella haemolytica is the primary end-stage organism responsible for severe

pneumonic morbidity and mortality in cattle under stress (Thompson, 1975; Wilkie, 1982; Shewen and Wilkie, 1983; Frank, 1986b; Ames et al., 1987). The rod-shaped gram-negative bacteria has at least 15 serotypes of which type-A1 is the type most frequently isolated from pneumonic lungs and nasal passages of cattle with acute respiratory disease (Frank, 1986a). In an epidemiological study of P. hameolytica, Frank and Smith (1983) reported that prior to shipment of calves to a feedyard, very few calves carried detectable numbers of serotype 1. Shortly after arrival at the feedyard, however, the frequency of serotype 1 isolates increased; they were found in both sick and healthy calves.

Experimental attempts to reproduce pasteurella pnuemonia in healthy, unstressed calves by aerosol or intratracheal inoculation have been unsuccessful (Frank, 1979). However, when calves were stressed by transport, cold, or exercise and subjected to IBR or PI-3 virus, P. haemolytica pneumonia was easily produced experimentally (Frank, 1979; Yates, 1983). Henry (1984) proposed the following thesis for the pathogenisis of P. haemolytica pnuemonia. Frank (1986b) put forth essentially the same thesis.

1) P. haemolytica normally exists in a balance with resistance factors and nonspecific immune factors in healthy animals.

2) When stresses of a physical or infectious nature are introduced, this balance is disrupted and bacterial numbers increase on the nasal epithelium.

3) As bacterial numbers increase in the upper respiratory tract, physical and infectious stressors concurrently inactivate other resistance mechanisms in the lower respiratory tract (Dyer, 1982).

4) The net result is proliferation and colonization of P. haemolytica in the lungs of the stressed animal. Severe fibrinous pneumonia as seen on necropsy is the final result of this infection and diagnosed as the cause of death.

Pasteurella multocida. Pasteurilla multocida was associated with BRDC long before P. haemolytica (Farley, 1932). Since then, P. multocida isolates have become less frequent and P. haemolytica isolates more frequent from the pneumonic lungs of feedlot cattle (Jensen et al, 1976; Hjerpe and Routen, 1976; Reggiardo, 1979; Martin et al., 1980).

Other Bacteria. Other bacteria associated with BRDC are Corynebacterium pyogenes and Haemophilus somnus. C. pyogenes have been isolated from the upper respiratory tract in healthy cattle and from the lower tract in pneumonic calves (Hjerpe and Routen, 1976; Brown, 1979; Frank and Smith, 1983). H. somnus has been isolated from calves with bronchial and fibrinous pneumonia. However,

their relative significance remains to be demonstrated (Brown, 1979; Frank and Smith, 1983; Stephens et al., 1981).

Stress

Stress is the final component hypothesized to be involved in BRDC by Hoerlein and Marsh (1957). As mentioned earlier, symptoms of shipping fever were not produced in animals when subjected to viral and/or bacterial antigens unless various stressors also were applied to the animals (Hamby et al, 1963; Frank, 1979; Yates, 1983).

Phillips (1982) divided the various stressors of shipped calves into five major types: nutritional, physiological, physical, environmental and productive. He proposed that, to the young calf, all experiences are new and perceived as stressful. As the calf matures, it experiences fewer new situations and thus is subjected to fewer stressful situations. Stress lowers the resistance of the calf to viral and bacterial agents and BRDC can result.

Nutritional stress. Nutrition-health interactions have recently been reviewed by (Williams and Mahoney 1984; Hicks, 1985). They suggested that feed and water deprivation, sudden dietary changes, protein deficiency and mineral imbalances are prevalent nutritional stressors.

Vitamin- and mineral-health interactions will be discussed later in this review.

Physiological stress. Physiological stresses include transit, weaning, changes in location, social order, feeding pattern and space allowance. Cole et al. (1982) reported that in a group of 186 kg steers, those preweaned thirty days prior to marketing and shipping consumed more ($P<.05$) feed dry matter during the first thirty days in the feedlot than calves weaned on the day of shipment. Packed blood cell volumes were lower ($p<.05$) for preweaned calves upon arrival at the feed yard suggesting that preweaned calves became less dehydrated than calves weaned the day of shipment. However, Cole et al. (1982) reported that preweaning calves did not reduce stress or improve feedlot adaptation. Crookshank et al. (1979) reported that preweaned calves gained approximately five times more during the 16-d test period than calves immediately weaned and put into the feedlot and nine times more weight than calves weaned and trucked for 12 hours and then placed into the feedlot. Wieringa et al. (1976) concluded that weaning is one of the most severe stresses of feeder calves.

In a Canadian feedlot survey, it was observed that mixing groups of cattle after arrival in the feedlot resulted in higher morbidity and mortality rates (Martin et al., 1982). Henry (1984) suggested that mixing herds or individuals introduces new infectious organisms to

susceptible animals. However, the stress of a change in social order also may increase an animal's susceptibility to the new pathogens.

Physical stress. Physical stresses include restraining, castrating, branding, dehorning, transporting and assembly. A ten year feeder cattle survey reporting on 53 shipments of calves indicated an average shrink of 7.2 and 9.1% ($p<.05$) for cattle purchased from a ranch or a salebarn, respectively (Self and Gay, 1972). Ten additional shipments of individually identified feeder steers averaged 8.8 and 8.9% shrink for the two shipping procedures. When sixty steers were slaughtered it was found that slightly less than half of the weight loss was due to loss of digestive tract contents.

Addis et al. (1974) reported that males purchased as steers gained 18.5 lbs. more during a 28 day test period, consumed 12% more feed and gained 22% more efficiently than did calves castrated at the feedlot. Davis et al. (1975) concluded that castration was a major stress because castrated animals had perfomance inferior to either steers or bulls.

Although castration had no significant effect on morbidity and mortality, Zinn et al. (1985) reported that castration reduced gains and feed efficiency of calves averaging 198 kg by 20 and 9.8% respectively in a 45-day receiving period (trial 1). Similar results were observed

in a second trial, with 148 kg calves, although effects were somewhat smaller. In the third trial, using 227 kg calves, castration depressed weight gains by 22% during the initial 29 day receiving period and by 10% during the subsequent 140 day finishing period. As weight of the calf increases, the stress of castration appears to increase. Similar results have been reported by Brazle et al. (1985), Brazle (1986), Zinn et al. (1986) and Zinn (1987).

Davis et al. (1975) compared surgical castration with the "Burdizzo" method and observed that morbidity was lower, number of health treatments necessary were fewer and mortality was lower for surgically castrated animals than for "Burdizzo" castrated calves.

Environmental stress. Temperature, humidity, solar intensity and length of daylight are considered environmental stresses. Self (1972) noted seasonal variations in transit shrink. Loads shipped during summer months (June, July and August) lost 1.9% more weight than those shipped during the months of October, November and December. In summarizing the performance of some 150,000 West Texas calves, Schake et al. (1971) also noted that mortality in the feedlot varied seasonally.

Vaccines

Research in the past 50 years has been conducted with vaccines for different viral and bacterial pathogens

associated with BRDC. Yet today, controversy remains regarding the efficacy of vaccination. Martin (1983) adressed this issue. After reviewing several studies, he concluded that little published data supports the use of virus vaccines (PI-3, IBR, IBR/PI-3 and BVD) to protect against BRDC under feedlot conditions.

Despite this ongoing controversy, vaccines are used frequently. Although they do not prevent BRDC, vaccines are thought to be helpful in controlling certain components of BRDC. As many vaccines are available, discussion of each one is beyond the scope of this manuscript. However, it seems desirable to discuss vaccines in general and IBR, PI-3 and BVD vaccines specifically.

Most vaccines are available in two forms: inactivated (killed) and modified live virus (MLV) vaccines. Killed vaccines do not replicate in vaccinated cattle; thus the entire antigenic mass must be provided by the vaccine. In contrast, with MLV the virus replicates so that vaccinated individuals produce new virus (antigen). This replication stops when an adequate immune response level occurs. In general, killed vaccines require a larger dose and a longer time to engender an antibody response than do MLV vaccines. Kahrs (1981) suggested that two inoculations of inactivated vaccine are required to accomplish what one dose of MLV vaccine can achieve. However, the immunologic inferiority of inactivated vaccines can be partly compensated by their greater safety over MLV vaccines.

The inactivation process eliminates many contaminants. The preservatives used in killed vaccines also help protect against growth of bacteria introduced after the vial has been opened. Conversely, MLV vaccines provide greater efficacy and immunogenicity at the expense of safety. Most MLV vaccine strains probably remain in vaccinated cattle and are reactivated occasionally, producing additional antigenic stimulation. Such a recurrent stimulation was observed by Davies and Duncan (1974) with MLV-IBR vaccine in calves.

A small percentage of cattle develop clinical disease from infection with MLV vaccines. Peter et al. (1967) observed post-vaccination disease in BVD vaccinated cattle. Some post-vaccination disease actually is the result of a natural infection present at the time of vaccination (McKercher et al., 1968). This is especially frequent when BVD vaccine is used in combination with MLV-IBR vaccines (Fuller, 1967).

Live vaccines as well as the animal restraint required for their administration induce added stress. Even vaccines regarded as avirulent occasionally cause reactions (Kahrs et al., 1973), and post-vaccination reactions to both IBR and BVD vaccines are frequently of multifactorial etiology (Peter et al., 1967).

IBR

Numerous IBR vaccines studies have been reported since the 1950's. Antibody prevalence studies indicate that 10 to 96% of cattle (Bruner and Gillespie, 1973; Sheffy and Krinsky, 1973; Magwood, 1974) are IBR infectioned. Because of the widespread geographic distribution of IBR (Dennett et al., 1976), most control efforts are based on use of IBR vaccines (Kahrs, 1981). The history of IBR vaccines has been reviewed by Lupton and Reed (1980).

The first IBR vaccine developed was an MLV vaccine for intramuscular inoculation (Schwarz et al., 1957). It is still in use and has the advantages of administration ease and of availability in combination with the PI-3 and BVD vaccines.

Aside from abortion, minimal post-vaccination problems have been associated with intramuscular IBR-MLV vaccines. Vaccination of calves with intramuscular vaccine suckling pregnant cows is contraindicated; this warning appears on most package inserts.

While controversy remains concerning the efficacy of the intramuscularly administered IBR vaccines (Rosner, 1968; Kelling et al., 1973), their general acceptance and use is widespread (House, 1978). The need for revaccination is the subject of varying opinion (Bartholomew, 1973; Studer, 1973). A single successful vaccination should provide partial protection from serious

clinical disease for the lifetime of most cattle (Kahrs et al., 1976). Studies on the duration of humoral antibody following intramuscular vaccination (Kahrs and Smith, 1965) or infections of field strains of virus (Chow, 1972) indicate that humoral immune responsiveness persists for 2 to 6 years. Recognizing the importance of cell-mediated immunity in combating IBR virus infection, however, others (Rosner, 1968; Studer, 1973; House, 1978) have recommended occasional or annual revaccination.

Intranasally administered MLV-IBR vaccine was introduced in 1969 (Todd et al., 1971) and has gained widespread acceptance. Unlike vaccines for intramuscular injection, the intranasal vaccines are reportedly safe for use on pregnant cattle (Kahrs et al., 1973; Todd, 1976). Additional advantages ascribed to these products are rapid protection attributable to interferon production and rapid induction of secretory antibody at mucosal surfaces (Todd, 1972). Currently, all intranasal IBR virus vaccines are combined with PI-3 and the duration of protection following intranasal vaccination is unknown (Kahrs, 1981).

Inactivated IBR vaccine has been available intermittently in combination with a bacterin containing two Pasteurella species and inactivated PI-3 vaccine. There is disagreement regarding its efficacy (Matsuoka et al., 1972; Schipper and Kelling, 1975; Koonse and Overpeck, 1977).

Subunit vaccines consisting of viral proteins preparations derived by detergent treatment of infected cell cultures have shown promise in protecting cattle from IBR virus infection (Lupton and Reed, 1980). They supposedly replicate but contain no live virus and thus have the potential for solving many problems associated with MLV vaccines.

PI-3

Woods et al. (1964) found that formalin-inactivated PI-3 vaccine, with various adjuvants, stimulated HI antibody more efficiently than aqueous suspensions; subsequently the inactivated PI-3 vaccine was released for marketing in the U.S. in combination with bacterins for *P. multocida* and *P. hemolytica* in the late 1960's. In the early 1970's it was combined with inactivated IBR vaccine. Consistent production of PI-3 antibody following infection from the use of this inactivated vaccine was reported by Gossett et al. (1970) and Matsukoa et al. (1972).

Intranasal application of PI-3 vaccines was proposed by Gutekunst et al. (1969). Because PI-3 vaccines are available only in combination vaccines and tend to lose their identity to the more fashionable viruses like IBR and BVD, few studies have been reported on their use alone. The intranasal route of vaccination is viewed as being closer to the natural route of infection (Kahrs, 1981). It is thought to stimulate locally deployed components of the

cell-mediated immune system as well as humoral immunity, and to invoke interferon production which provides more immediate protection than intramuscular vaccination.

BVD

There has been considerable investigation of inactivated BVD vaccines (McClurkin et al., 1975). Their practical usage may be delayed until the technology evolves to permit production of acceptable dosage forms for delivery of required antigenic masses in an economically acceptable fashion.

Modified live virus vaccines for BVD were first introduced in the late 1950's. The available MLV vaccines are widely used both singly and in combination with MLV vaccines for IBR and PI-3.

BVD infections may be immunosuppressive (Johnson and Mucoplat, 1973; Hueschele, 1978). Until it is shown that each MLV strain does not possess immunosuppressive capabilities, a cautious approach to MLV vaccination is suggested. The applicability of MLV-BVD in sick, exposed, recently assembled or stressed cattle needs to be evaluated.

Nutrition and Health

Adequate nutrition is important for growth as well as for the immune system. Specific vitamin and/or mineral deficiencies not only reduce growth and efficiency of feed

conversion but may also cause an immunologic deficit. The detrimental effects of a deficiency of calories, proteins, minerals or vitamins on immunocompetency have been well reviewed (Scrimshaw, Taylor and Gordon, 1968; Chandra and Mewberne, 1977; Beisel, 1982; Miller, 1985).

Vitamins

Several vitamins (A, E, C) have been linked with the immune system. The importance of B vitamins in ruminants has been reviewed recently by Brent and Bartley (1984) and Hicks (1985).

Vitamin E was discovered by Evans and Bishop (1922) as an unidentified factor in vegetable oils required for reproduction in female rats. In 1924, Sure concluded that this fat-soluble reproductive factor was a new vitamin and named it vitamin E. Vitamin E was isolated in its pure form (Evans et al., 1936) and synthesized by Karrer et al. (1938). The role of vitamin E in nutritional deficiency diseases, interrelationships with other nutrients, as well as the biochemical functions, forms of the vitamin and hypervitaminosis have been reviewed by Mason and Horwitt (1972), Scott (1978), Combs (1981) and Machlin (1980, 1984).

More recently, research has demonstrated that supplemental vitamin E may enhance an animal's immune response. Tengerdy et al. (1972) observed that, in chicks immunized with sheep red blood cells, supplemental vitamin

E elevated hemagglutin titers. Mice were used next to determine whether supplemental vitamin E would alter their immune response when sheep red blood cells and tetanus toxoid were used as antigenic stimuli (Tengerdy et al., 1973). Supplemental vitamin E increased spleen weight, the number of plaque-forming cells in the spleen and hemagglutinin titers of class M and class G immunoglobins (IgM and IgG). These results suggest that vitamin E stimulated humoral immunity in chicks and mice. Marsh et al. (1981) reported that vitamin E may be required in the development of the humoral immune system.

An investigation with young pigs was conducted to determine if the addition of vitamin E to an otherwise nutritionally complete diet would stimulate a primary and secondary antibody response to an injection of E. coli bacterin (Ellis and Vorhies, 1976). Titers rose significantly throughout the 56 day sampling period and were at least 150 percent higher than controls. Using lambs vaccinated with Clostridium perfringens type C and D toxoids, Tengerdy et al. (1983) observed enhanced blood antibody titers in groups supplemented with vitamin E.

While these studies suggest that vitamin E can effectively increase humoral immunity, they do not prove that the animal has an increased disease resistance. Recent research has involved challenging animals with pathogenic organisms. The first of these studies was conducted by Heinzerling et al. (1974) using chicks

infected with a pathogenic E. coli strain. Supplemental vitamin E increased antibody titers and significantly reduced mortality. Similar results were observed when the study was repeated using turkeys infected with the pathogenic E. coli.

Sheep were used in one study to determine if vitamin E supplementation would increase protection from chlamydia-induced pneumonia (Stephens et al., 1979). Vitamin E supplemented lambs had higher weight gains than the non-supplemented controls. Necropsy observations revealed fewer infected lungs. No chlamydia were isolated from E-supplemented lambs whereas chlamydia were isolated from 40% of control lambs.

Effects of vitamin E supplementation in feedlot cattle are highly variable and appear to be dependent upon previous nutrition, vitamin E content of the diet and supplementation method. Work in the 1960's showed little or no response to feeding supplemental vitamin E to yearling cattle (Perry et al., 1968). Studies by Newland et al. (1966), Lyford and Colby (1967) and Totusek et al. (1968) indicated that vitamin E injections would not improve the performance of feedlot cattle. In contrast, Davis (1982b) reported an improvement in yearling steer performance during the first 66 days of a growing trial but no differences were seen between vitamin E supplemented and non-supplemented groups at the end of the 110-d study.

In a three trial study (Lee et al., 1985), dietary vitamin E supplementation increased calf weight gain, reduced feed intake and subsequently improved gain to feed ratios. In contrast, George et al. (1986) reported that yearling steers fed or injected with selenium, vitamin E or combinations performed similarly throughout the study.

Hicks (1985) supplemented diets of stressed calves with vitamin E and concluded that it reduced morbidity and sick days while improving average daily gain and feed conversion. However, in a similar 28-d receiving trial with stressed feeder calves, Brandt and Elliot (1987) reported that performance of vitamin E supplemented cattle was similar to that of the non-supplemented groups. Brazle (1987) observed that vitamin E injection had no apparent effect on stressed calves during a 29-d receiving study.

Many unanswered questions remain concerning inconsistent results with vitamin E, especially with respect to the form of supplementation and to ruminal effects. However, vitamin E does appear to be immunostimulatory; under certain conditions it improves growth and health of stressed cattle.

Minerals

Several minerals play immunologic roles. These include zinc, copper, iron, manganeese, cobalt and selenium. Their effects on the immune system have been summarized by Hutcheson and Cummins (1987) and Beisel

(1982). The following discusses the role of zinc on the immune system and its effects on respiratory disease.

Zinc is redistributed in response to viral, bacterial, spirochetal and parasitic infections. Pekarek et al. (1973) found that zinc is removed from the blood and enters the liver in response to LEM released from phagocytic cells. The role of zinc in the immune system has been reviewed by Sugarman (1983).

Hutcheson and Cummins (1987) reported that serum zinc levels decreased after calves were challenged with virulent IBR virus. They reported also that peak morbidity occurred simultaneously with reduced serum Zn concentrations during a natural outbreak of BRDC in feedlot cattle. On arrival, serum Zn concentrations were significantly lower than at the farm of origin or at the auction barn. Therefore, it appears that the stress of marketing and shipping reduces serum Zn.

There is some evidence that in certain animal species zinc administered at levels above that required for optimum growth and reproduction is immunostimulatory. Snyder and Walker (1976) observed that an injection of zinc chloride into mice one hour before challenge with Salmonella typhosa reduced mortality by 97%. A level of 0.4 mg of zinc chloride per mouse gave optimum results. Sobocinski et al. (1977a, 1977b) found similar results when rats were pretreated with 0.4 to 2.0 mg zinc chloride before they were challenged with Salmonella typhimurium, Francisella

tularensis and Streptococcus pneumonia but not with Salmonella typhimurium.

Tocco-Bradley and Kluger (1984) also found that rat mortality was reduced if zinc was given before rather than after S. typhimurium challenge. This suggests that the normal reduction in plasma zinc is associated with the survival response in infected mammals.

C. Albicans susceptible mice exhibited increased disease resistance and released higher titers of migration inhibitory factor after four weeks of zinc supplementation. Hill and Smith (1974) presented evidence that the addition of 200 ppm Zn to a diet reduced morbidity when chicks were inoculated with S. gallinarum.

Southern and Baker (1983) observed that adding 50 ppm zinc to a diet containing 40 ppm Zn increased gain and feed efficiency in cockerels infected with E. acervulina.

Results have been variable when zinc sulfate has been used to control foot rot in sheep. In dry conditions, sheep consuming 0.5 to 0.75 mg Zn sulfate per head per day had fewer cases of foot rot than controls not supplemented with Zn sulfate (Cross and Parker, 1981a,b). However, added zinc was ineffective when conditions were wet.

An early zinc supplementation study investigated the effect of supplemental zinc oxide (250 mg Zn per head per day) on dehorning stress (Brethour and Duitsman, 1972). They found that zinc supplemented for a period of 43 days (24 days before to 19 days after dehorning) increased the

percent of calves healed by one week after dehorning and tended to improve gains throughout the feeding period. Hence, it appeared that increased dietary zinc reduced the stress of dehorning and increased the rate of healing.

Brandt and Elliot (1987) added zinc (350 mg per head per day) to the diets of newly received steers to evaluate its effect on stressed feeder calves. They reported that zinc supplementation increased feed consumption, improved daily gains of morbid steers, reduced the number of sick days per calf and decreased the number of reoccuring illnesses in that Zn enhanced immunocompetence. It also appears that zinc supplementation can partially alleviate deficiency induced diseases. On the other hand, Heinricks et al. (1984) reported that the addition of zinc-methionine to the diet had no effect on plasma zinc levels, wound healing, mammary health and the immune responses in dairy cattle.

More research needs to be conducted on the effects of zinc nutritional status, zinc supplementation on respiratory disease in stressed cattle as well as the immunostimulatory effects of zinc.

Antibiotics

Several antibiotics have been included in receiving diets to improve health and performance. Growth benefits have been well established. However, the effectiveness of

antibiotics on reducing secondary bacterial infections associated with BRDC is still under evaluation.

Embry (1977) reported that calves weaned at an average weight of 173 kg in the fall and fed prairie hay and protein supplement or corn silage and protein supplement with 300 to 350 mg chlortetracycline (CTC) daily consistently gained at a faster rate than calves not receiving CTC in 11 experiments. Their improvement in rate of gain during the first month in the feedlot averaged 18.6%. Feed intake also tended to be greater for the calves fed the antibiotic.

In seven experiments, calves fed a combination of CTC and sulfamethazine, each at 350 mg daily, following weaning and shipping gained weight faster (27.5%) as compared with controls during the first month in the feedlot (Kercher et al., 1977). No improvements in morbidity or mortality were reported. In another study, feeding 350 mg of CTC and 350 mg of sulfamethazine for 28 days following weaning improved gains by 16% and feed efficiency by 13%.

Two feedlot adaptation trials reported by Theix et al. (1971) showed that bull and heifer calf weights and feed intake were improved when their feed supplements contained CTC-sulfamethazine (350 mg each). Bull calves gained .97 kg vs .76 kg for controls and consumed .86 kg more feed per day. Treated heifers gained .63 kg daily, 0.29 kg more than the control group. Feed intake by the treated heifers was only slightly greater than for the control group; thus,

there was a considerable improvement in feed efficiency. Only minor health problems were encountered in either trial. On the other hand, Luther (1986) reported no benefits from feeding the CTC-sulfamethazine combination or oxytetracycline.

During a 31-d feedlot adaptation period, Prouty et al. (1983) reported that CTC-sulfamethazine (350 mg each) fed to calves averaging 173 kg initially, improved daily weight gains (.99 vs .76 kg), slightly increased feed intake and improved feed efficiency. Fewer cattle receiving CTC-sulfamethazine required treatment. Brethour et al. (1972) reported that 350 mg each of CTC and sulfamethazine fed to calves for 7 days after arrival tended to improve daily gains over CTC controls and over calves fed CTC-sulfamethazine for the entire 30-d receiving period (.29, .05 and .11 kg, respectively).

In two shipping fever studies of 28 days each, Beeson et al. (1966) compared 350 mg each of CTC and sulfamethazine alone or in combination, they reported that in one trial CTC treated calves gained 28% faster than the controls. Those fed the combination gained 74% more rapidly than the controls and 36% more rapidly than those receiving only CTC. Administration of sulfamethazine alone had no effect on gain. No differences in health were noted among the various treatment groups. In the second trial, CTC alone was as effective as a combination of CTC and

sulfamethazine in stimulating rate of gain. Sulfamethazine alone gave no response in gain.

Coccidiosis

Coccidiosis is caused by the protozoan species Eimeria. Subclinical coccidiosis weakens cattle, inviting secondary infection, while chronic coccidiosis causes an acute contagious diarrhea in cattle resulting in large economic losses due to reduced performance, morbidity, treatment costs and death. Part of the life cycle takes place in the small and large intestine and at times can result in bloody fluid feces. Coccidiosis is most common when calves are overcrowded and ambient temperature and soil moisture conditions are suitable for survival and development of coccidia. Infected cattle shed oocytes in their feces, reinfecting themselves and transmitting the disease to other cattle that consume contaminated soil, feed and water.

Fox (1983) from a survey found that coccidiosis ranked third in prevalence of cattle health problems; medication with a coccidiostat reduced stress associated with disease in cattle (Fox, 1984).

Several recent studies have evaluated the effectiveness of decoquinate as a coccidiostat. Including decoquinate in the receiving diet of transit stressed calves for 28 days increased gains (10%), improved feed

efficiency (24%) and reduced morbidity and mortality by 6% and 37% respectively (Hutcheson and Cummins, 1982).

Barnes et al. (1984) reported that heifers grazing native range and supplemented with decoquinate (30 mg/45.35 kg body weight) gained 20% more weight than non-supplemented controls. In a similar trial, however, decoquinate fed heifers gained 5% less weight per day than did their respective controls. Barnes et al. (1985) fed heifers consuming grass hay plus two pounds of a 38%-protein supplement containing decoquinate to provide 23 mg/45.35 kg of body weight in two trials. In both trials, decoquinate increased daily gains and reduced morbidity. Lusby et al. (1985) also found that decoquinate-fed heifers consuming wheat and crabgrass hay plus two pounds of a 38%-protein supplement daily gained more (.61 vs .48 kg/day) weight and had less (34.7 vs 49.0%) morbidity than non-decoquinate fed controls.

Decoquinate increased calf daily gains by 12% (.5 vs .56 kg/day), improved feed efficiency by 26%, reduced morbidity by 6% and reduced mortality by 37% over controls in a 28-d field study (Fox, 1984). In a similar field trial, decoquinate reduced morbidity and mortality by 18% and 29% respectively. Brazle (1986) summarizing three trials reported that decoquinate significantly improved daily gains and feed efficiency and reduced the number of treatments required per animal (trial I). In trials two and three, decoquinate did not affect weight gains or feed

efficiency, but significantly reduced the number of medical treatments needed per calf.

In a 28-d receiving trial, Hicks et al. (1985) reported that calf gains were not altered by decoquinate. Gains of healthy cattle fed decoquinate were reduced by 6.5% (.72 vs .77 kg/head/day). Other studies have reported no improvement in cattle performance or apparent health when decoquinate was fed (Prouty et al., 1981; Rust et al., 1981; Williams and Mahoney, 1984).

Harmon (1986) measured the influence of decoquinate on rumen and plasma metabolites, diet digestibility and volatile fatty acid production; he concluded that it had no metabolic effects that would suggest a role for decoquinate in altering rumen fermentation and feed efficiency of ruminants.

The effectiveness of ionophores in controlling coccidiosis has been tested recently. Horton (1982) reported that lasalocid at sufficiently high levels is an effective coccidiostat in cattle. Wray et al. (1984) reported that monensin reduced clinical signs of coccidiosis.

Lusby et al. (1984) compared the effects of decoquinate and monensin (100 mg/day) on the performance of calves grazing native grass pastures and receiving 0.36 kg of soybean meal per head per day. On day seven of the 63 day trial, both drugs had reduced the number of fecal coccidia. Calves receiving monensin gained 14% faster

than the decoquinate-fed calves. The decoquinate-treated calves gained 1% faster than did the non-treated calves. No clinical signs of coccidiosis were detected for any of the groups.

Davis (1982a) reported that lasalocid fed at a level of 30 g per ton of feed improved feed efficiency by 16.8% in newly received feedlot cattle. Gill et al. (1982) reported that adding 110.25 mg of lasalocid per kg of a 10% protein supplement and fed at .9 kg per head per day increased weight gain by 7.8% in steers grazing native grass. No clinical signs of coccidiosis were reported in this study.

Foreyt et al. (1986) reported that monensin, lasalocid and decoquinate were equally effective at preventing experimentally induced coccidiosis. All three treatments effectively reduced oocysts in the feces of Holstein calves and prevented clinical coccidiosis during the 90-d study. No significant differences were found in calf performance among the treatment groups.

CHAPTER III

VITAMIN E SUPPLEMENTATION FOR NEWLY RECEIVED STOCKER CATTLE

Summary

Two loads of calves consisting of 131 newly received steer and bull calves and yearlings averaging 242 pounds were used to study the effects of supplemental vitamin E on the health and performance during a 28-d receiving period. All cattle had ad libitum access to prairie hay and were fed a soybean meal-based pellet at the rate of .91 kg/day for the first 21 days and .45 kg/day during days 22-28. Upon arrival, half of the cattle received an injection of 3,000 IU of vitamin E as DL-alpha-tocopherol. Half of each group (injected and non-injected) also received vitamin E in the feed at a rate of 882 IU kg^{-1} of supplement. Daily gains tended to be improved ($p=.15$) from .75 kg to 1.03 kg by adding vitamin E to the feed. Vitamin E supplementation of the feed increased ($p<.01$) feed intake 3.7% (6.92 vs 7.17 kg $head^{-1}$ d^{-1}). Serum vitamin E concentrations decreased throughout the 28-d receiving period and were not altered by either dietary or injected source of vitamin E.

Introduction

Vitamin E is an essential fat soluble nutrient. It has been shown to prevent several animal diseases including muscular dystrophies in lambs and calves (Machlin, 1980). Along with selenium (via glutathione peroxidase), vitamin E is believed to function as a part of the antioxidant defense system (Chow, 1979). Vitamin E also may be required for development of the humoral immune system (Marsh et al., 1981).

Supplementing vitamin E above nutritionally required levels has been shown to effectively increase humoral immunity in chicks, mice, pigs and lambs (Tengerdy et al.,1972; Tengerdy et al., 1973; Ellis and Vorhies, 1976; Tengerdy et al., 1983), and to increase disease resistance and weight gains in the chick, the turkey (Heinzerling et al., 1974) and the lamb (Stephens et al., 1979).

Although the role of vitamin E on the immune system of ruminants has yet to be fully established, recent studies have shown that vitamin E supplementation in diets of newly received cattle may improve rate and efficiency of gain, and reduce morbidity during a 28-d receiving period (Lee et al., 1985; Gill et al., 1986). These results contrast with results of earlier studies in which vitamin E supplementation or injection had no effect on performance of feedlot calves (Newland et al., 1966; Lyford and Colby, 1967; Perry et al., 1968; Totusek et al., 1968).

The objective of this study was to examine the health and performance response of newly received, stressed cattle to either dietary supplementation of vitamin E (882 IU/kg supplement) or injection of vitamin E (3,000 IU/head).

Experimental Procedure

Two truck loads of cattle (designated as trials) consisting of 131 steer and bull calves and yearlings, were assembled by order buyers and shipped to Pawhuska, Oklahoma in September, 1985. The origin, arrival date and weight, number of head, and transit shrink for each load is summarized in Table I. Cattle had free access to prairie hay and were fed .91 kg head^{-1} day^{-1} of a pelleted feed supplement (Table II) for the first 21 days. Supplement was decreased to .45 kg head^{-1} day^{-1} during days 22-28. This supplement contained either no supplemental vitamin E, or had 882 IU DL-alpha tocopherol acetate[1] added per kg of supplement. Two hospital pens were maintained so that sick animals received their assigned feed while in their hospital pen.

Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of four pens holding 24 to 39 animals each. Pens were randomly assigned to vitamin

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[1]Rovimix E 50% SD, Hoffmann-La Roche, Inc., Nutley, NJ 07110.

TABLE I

ORIGIN, ARRIVAL DATE, NUMBER OF HEAD, ARRIVAL WEIGHT AND INTRANSIT SHRINK FOR EACH LOAD OF CATTLE

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	Shrink %
Trial 4	KY	9-09-1985	55	611	5.8
Trial 5	KY	9-11-1985	76	485	NA[a]

[a]NA=not available.

TABLE II

COMPOSITION OF FEED SUPPLEMENT

Ingredient	IFN[a]	As Fed %
Soybean meal	5-20-637	88.90
Cottonseed meal	5-01-621	5.00
Salt	6-04-152	3.00
Vitamin A-30,000 IU/g		.11
Premix[b]		.18
Dicalcium phosphate	6-01-080	2.75
Bovatec 68[c]		.15

[a]International Feed Number.
[b]To provide: 0 for control, or 882 IU vitamin E per kg.
[c]To provide 33 mg of lasalocid per kg.

E supplement and control supplement groups. On the morning following arrival, individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded.

2. Cattle were vaccinated with IBR-PI3 (MLV) intermuscularly, Leptospira pomona bacterin, and Clostridia chavoei, septicum, novyi and sordellii bacterin and dewormed with Ivomec[2].

3. Cattle with odd numbered ear tags received an intramuscular injection of vitamin E (3,000 IU DL-alpha tocopherol[3]/animal).

4. Nine to fourteen head from each treatment were randomly chosen, jugular blood samples were collected and later assayed for serum vitamin E concentration.

5. Cattle with clinical signs of illness or a body temperature of 40 C or above received antibiotic treatment and were placed in the hospital pen; healthy animals were returned to their home pen.

Cattle were checked twice daily for signs of illness. If the body temperature exceeded 40 C the animal was considered sick. The animal also could be classified as sick based on clinical signs. Sick animals were moved to the processing area, body temperature was measured and severity of illness was clinically appraised.

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[2]MSD Agvet, Rahway, NJ 07065.
[3]Vitamin E Alcohol, Hoffmann-La Roche, Inc., Nutley, NJ 07110.

TABLE III

SEQUENCE OF DRUGS USED FOR TREATMENT OF BRDC

Treatment No.1:	Oxytetracycline (Biomycin-C)[a] subcutaneously-5mg/lb. Plus Sulfamethazine Boluses (Sulmet-15gm)[b] 1 bolus/150 lb on day 1. 1 bolus/300 lb on subsequent days.
Treatment No.2:[c]	Erythromycin (Gallamycin)[d] deep in the muscle-10 mg/lb.
Treatment No.3:[c]	Spectinomycin (Spectam)[e] intramuscularly-5 mg/lb.
Treatment No.4:[c]	Procain Penicillin G[f] subcutaneously -30,000 IU/lb.
Treatment No.5:[c]	Tylan 200[g] intramuscularly-10 mg/lb.
Treatment No.6:[c]	Amoxicillan (Amoxi-ject)[h] subcutaneously -5 mg/lb.

[a]Boeringer-Ingelheim Animal Health, Inc., St Joseph, MO 64502.
[b]American Cyanamid, Co., Wayne, NJ 07470.
[c]Certain antimicrobial drugs used in this study were used for extra-label purposes or at extra-label dosages and require a veterinarian-client-patient relationship before use.
[d]Ceva Laboratories, Ft Scott, KS 66701.
[e]Ceva Laboratories, Ft Scott, KS 66701.
[f]Pfizer, Inc., Lee Summit, MO 64063.
[g]Eli Lilly, Inc., Indanapolis, IN 46285.
[h]Beecham, Inc., Bristal, TN 37620.

Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs (Table III). Sick animals were treated initially with the first drug in the sequence. If body temperature decreased within 24 h, the first drug was continued for two more days. If no improvement was apparent within 24 h, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

At the end of the 28-d receiving period, cattle were weighed in the morning following an overnight shrink. Blood samples again were collected from the individual cattle bled on day 1.

Both day 1 and 28 blood samples were allowed to clot at room temperature. The serum was obtained by centrifuging at 3,000 rpm, transferring the serum to a clean centrifuge tube and centrifuging again at 3,000 rpm. The serum was stored at -90 C and sent to the Diagnostic Laboratory at Michigan State University for serum vitamin E analysis.

Data were analyzed using a split plot analysis with feed vitamin E as a main plot and injected vitamin E as a sub-plot. Least square analysis of variance was performed on data for all response criteria. Response to the vitamin E feed treatments was analyzed using trial by feed vitamin E degrees of freedom as the error term. The initial models for weight gains, medical treatment, morbidity, feed intake and feed efficiency included trial, feed treatment and

trial by feed treatment interaction. Response to vitamin E injection (injection treatment) was analyzed using the residual degrees of freedom as the error term. The initial models for weight gains, medical treatment, morbidity and recurrence of BRDC included trial, injection treatment, feed treatment, all two way and three way interactions. All models, excluding feed treatment and injection treatment, were reduced when sources of variation had observed significance levels greater than .25.

Serum tocopherol concentration data was analyzed using stepwise regression of daily weight gain, morbidity, recurrence of BRDC and medical treatment against initial E (day 1), final E (day 28) and final E minus initial E concentrations. Least squares analysis of variance was also performed on the data. The models for weight gain, morbidity, recurrence of BRDC and medical treatment included initial E, final E and final E minus initial E concentrations.

Results and Discussion

Effects of supplemental vitamin E in the diet or by injection on daily gain, morbidity, and mortality are shown in Table IV. There was a tendency for increased ($p=.15$) gains during the 28-d receiving period favoring cattle fed vitamin E (1.03 vs .53 kg respectively) while gains of those cattle injected with vitamin E were not altered. The form of vitamin E supplementation

TABLE IV

EFFECT OF VITAMIN E SUPPLEMENTATION
ON WEIGHT GAINS, MORBIDITY AND
MORTALITY IN STRESSED CATTLE

Treatment	Feed E Inject E	+ +	+ -	- +	- -
Number of head		31	30	32	32
Number of head never sick		11	12	5	13
Daily gain, kg[a]		1.01	1.05	.72	.33
Daily gain head never sick, kg[a]		1.24	1.21	1.18	1.08
Morbidity, %[a]		58.68[b]	62.68[b]	87.50[c]	63.32[b]
Total Mortality, %		9.7	0	0	0

[a]Expressed as least square means.
[b,c]Means with different superscripts differ ($p<.05$).

significantly ($p<.05$) altered morbidity. Morbidity was greatest for cattle that received the injection alone (87.5%).

Effects of feeding vitamin E on feed intake and gain to feed ratio are reported in Table V. Feeding vitamin E increased ($p<.01$) feed intake (7.17 vs 6.92 kg $head^{-1}$ day^{-1}) and tended to improve ($p=.18$) gain to feed ratios. Feed intake did differ between trials.

The effects of vitamin E supplementation on weight gains, recurrence of BRDC and medical treatments in morbid cattle are reported in Table VI. Vitamin E administered in the feed tended to improve rate of gain (.93 vs .66 kg, $p=.11$) while gains of those morbid cattle injected with vitamin E were not altered. Vitamin E supplementation tended to alter ($p=.11$) the number of medical treatments required per head. Vitamin E supplemented cattle had slightly more medical treatments than non-supplemented cattle with the largest increase (34%) for cattle that received the injection alone (6.56 vs 4.91 medical treatments per head).

The effects of vitamin E supplementation on blood tocopherol concentrations are reported in Table VII. The levels of supplementation in this study did not alter serum vitamin E concentrations. The serum vitamin E at the time of processing ranged from .01 to .58 mg dl^{-1} with a mean of .25 mg dl^{-1}. On the average, the serum vitamin E concentrations declined by 25.5% during the 28-d receiving

TABLE V

EFFECTS OF FEEDING VITAMIN E ON FEED INTAKE AND GAIN TO FEED RATIO

	Control	Vitamin E
Number of pens	2	2
Feed intake, kg[a]	6.92[c]	7.17[d]
gain/feed[a]	.11	.14

[a]Expressed as least square means.
[c,d]Means with different superscripts differ ($p<.01$).

TABLE VI

EFFECT OF VITAMIN E SUPPLEMENTATION ON WEIGHT GAINS, RECURRENCE OF BRDC AND MEDICAL TREATMENTS IN MORBID CATTLE

Treatment	Feed E	+	+	-	-
	Inject E	+	-	+	-
Number of head		20	27	18	22
Daily gain, kg[a]		.90	.95	.68	.63
Recurrence of BRDC, %[a]		6.00	24.00	14.00	5.00
Medical treatments per head[a]		5.30	5.63	6.56	4.91

[a]Expressed as least square means.

period. These values are consistent with results from a survey of 286 cattle from 14 feedyards (Adams, 1982) in which serum values ranged from .01 to 2.2 mg dl^{-1} with a mean of .26 mg dl^{-1}.

Under the conditions of this study, adding vitamin E to the diet (400 IU/lb) slightly improved gains, feed intake and feed efficiency. These results are consistent with the results reported by Lee et al. (1985) and Gill et al. (1986). Although, the results from supplementation are inconsistent, injections of vitamin E tended to reduce animal performance. Some swelling at the injection site may have reduced performance. Generally, injections tend to reduce animal performance compared to less stressful means of administration of nutrients or drugs.

TABLE VII

EFFECTS OF VITAMIN E SUPPLEMENTATION ON SERUM TOCOPHEROL CONCENTRATIONS[a]

Treatment		No. of Samples	Day 1	Day 28	Reduction %
Feed E	Inject E		Means		
-	-	14	.25	.20	20.0
-	+	14	.26	.18	30.8
+	-	12	.24	.19	20.8
+	+	9	.27	.19	29.6

[a]Serum DL-alpha-tocopherol (mg/dl).

CHAPTER IV

ZINC METHIONINE FOR NEWLY RECEIVED STOCKER CATTLE

Summary

To evaluate the effect of adding zinc methionine to the diet on health and performance, 559 newly received steer and bull calves averaging 144 kg were used in a 28-d receiving trial. All cattle had ad libitum access to a 68% concentrate ration plus .91 kg prairie hay per head per day. Upon arrival, the cattle were randomly assigned to pens (16 to 19 head/pen) of which half received 3.65 g zinc methionine per head daily. Daily gains, morbidity, medical treatments, feed intake and feed efficiency were not different between zinc methionine supplemented and control groups. Morbidity was extremely high (79.4%) across all treatments which may have hidden any beneficial effect from the added zinc.

Introduction

Zinc is an essential element which functions biochemically as an activator or constituent of several dehydrogenase, peptidase and phosphatase enzyme systems

involved in nucleic acid metabolism, protein synthysis, and carbohydrate metabolism (Underwood, 1956; Vallee, 1959; Hsu and Anilare, 1966; Mills et al., 1969). Zinc has been shown to be immunostimulatory in mice, rats and chickens (Hill and Smith, 1974; Snyder and Walker, 1976; Tocco-Bradley and Kluger, 1984).

Zinc is removed from the circulating blood by the liver in response to viral, bacterial and parasitic infections (Pekarek et al., 1973). Hutcheson and Cummins (1987) reported that serum zinc levels declined after calves were challenged with virulent IBR virus. They also reported that serum levels were lower upon arrival than prior to shipment suggesting that the stress associated with transport may cause redistribution of zinc in calves. Therefore, the objectives of this study were to evaluate the health and performance responses of newly received, stressed cattle to dietary supplementation of zinc as zinc metionine at a rate of 3.65 g head $^{-1}$ day^{-1}.

Experimental Procedure

Four truck loads of calves (designated as trials), were assembled in AL by order buyers and shipped to Pawhuska, Oklahoma in the summer and fall of 1987. The origin, arrival date and weight, number of head and transit shrink for each load is summarized in Table VIII. All four loads were rested in

TABLE VIII

ORIGIN, ARRIVAL DATE, NUMBER OF HEAD, ARRIVAL WEIGHT AND INTRANSIT SHRINK FOR EACH LOAD OF CATTLE

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	Ala.	6-27-1987	145	316	4.66
Trial 2	Ala.	7-12-1987	135	322	3.99
Trial 3	Ala.	8-08-1987	145	302	8.37
Trial 4	Ala.	9-07-1987	134	334	Na[a]

[a]NA=not available.

Tennesee in route to Pawhuska. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of eight pens holding 16 to 19 animals each. Pens were randomly assigned to zinc supplement and control supplement groups.

Cattle had ad libitum access to a 70% concentrate pellet (Table IX) and were fed prairie hay (.91 kg head^{-1} day^{-1}) throughout the 28-d receiving period. The pellet contained either no supplemental zinc, or 804 mg zinc methionine/kg DM of pellet (80.4 mg Zn/kg). Two hospital pens were maintained so that sick animals received their assigned feed while in their hospital pen.

Processing and BRDC treatment procedures were conducted as reported in Chapter III of this manuscript with the exception of the sequence of drugs used for treatment of BRDC (Table X). Experimental procedures for processing and BRDC treatment are described there (Hays, 1987a).

Least squares analysis of variance was performed on data for all response criteria. Responses to the feed treatments were analyzed using pens as the experimental unit. The initial models for weight gains, medical treatment, morbidity, feed intake and feed efficiency included trial (truck load), feed treatment and trial by feed treatment interaction as class variables.

TABLE IX

COMPOSITION OF FEED SUPPLEMENT

Ingredient	IFN[a]	As Fed %
Corn, #2 ground	4-02-931	20.72
Soybean hulls	1-04-560	19.65
Wheat middlings	4-05-205	27.47
Cottonseed hulls	1-01-599	9.94
Soybean meal	5-20-637	6.16
Cane molasses	4-04-696	4.77
Calcium carbonate	6-01-069	.95
Salt	6-04-152	.28
Rice meal-run by-products		9.94
Vitamin A-30,000 IU/g		.01
Zinpro-100[bc]		.08
Rovimix E 50% SD[d]		.01
Bovatec 68[e]		.02

[a]International Feed Number.
[b]Not included in control diet.
[c]Zinpro, Inc., Chaska, MN 55318.
[d]DL-alpha-Tocopherol acetate, Hoffmann-La Roche, Inc., Nutley, NJ 07110.
[e]To provide 4.4 mg of lasalocid per kg.

TABLE X

SEQUENCE OF DRUGS USED FOR TREATMENT OF BRDC

Treatment No.1:[a]	Spectinomycin (Spectam)[b] -5 mg/lb.
Treatment No.2:[a]	Erythromycin (Gallamycin)[c] deep in the muscle -10 mg/lb.
Treatment No.3:[a]	Procain Penicillin G[d] subcutaneously -30,000 IU/lb.
Treatment No.4:	Oxytetracycline (Biomycin-C)[e] subcutaneously-5mg/lb.
	Plus
	Sulfamethazine Boluses (Sulmet-15gm)[f] 1 bolus/150 lb on day 1. 1 bolus/300 lb on subsequent days.

[a]Certain antimicrobial drugs used in this study were used for extra-label purposes or at extra-label dosages and require a veterinarian-client-patient relationship before use.
[b]Ceva Laboratories, Ft Scott, KS 66701.
[c]Ceva Laboratories, Ft Scott, KS 66701.
[d]Pfizer, Inc., Lee Summit, MO 64063.
[e]Boeringer-Ingelheim Animal Health, Inc., St Joseph, MO 64502.
[f]American Cyanamid, Co., Wayne, NJ 07470.

All models, excluding feed treatment, were reduced when sources of variation had observed significance levels greater than .20.

Results and Discussion

Effects of supplemental zinc on daily gain, mean medical treatments per head, morbidity and mortality are shown in Table XI. Animal health and performance was not effected by supplemental zinc. Morbidity was extremely high in both the zinc and control groups (69.3% and 71.4% respectively). This level of illness may have masked any benefits from zinc supplementation.

Feed intake as well as gain to feed ratio are reported in Table XII. The calves in the zinc group consumed an average of 5.04 kg of pellet per day supplying an additional 405 mg of zinc more than the calves consuming the control diet. Brandt and Elliot (1987) reported that 350 mg of zinc/day increased feed intake, gains of morbid steers and reduced sick pen days and the reoccurance of illness over non-zinc supplemented steers in a receiving study using feeder calves. The level of zinc consumed in this study should have been adequate to elicit a response.

TABLE XI

EFFECT OF ZINC METHIONINE ON WEIGHT GAINS, MORBIDITY AND MORTALITY IN STRESSED CATTLE

	Controls	Zinc
Number of head	281	278
Number of head never sick	80	85
Arrival weight, kg	144	144
Daily gain, kg[a]	.72	.71
Daily gain of head never sick, kg[a]	.88	.88
Medical treatments per head[a]	3.20	3.05
Morbidity, %[a]	71.42	69.34
Total Mortality, %	1.07	1.44

[a]Expressed as least square means.

TABLE XII

EFFECTS OF FEEDING ZINC METHIONINE ON FEED INTAKE AND GAIN TO FEED RATIO

	Control	Zinc
Number of pens	16	16
Feed intake, kg[a]	5.04	5.05
Gain/feed[a]	0.142	0.140

[a]Expressed as least square means.

CHAPTER V

RESPIRATORY SYNCYTIAL VIRUS VACCINE FOR STRESSED STOCKER CATTLE

Summary

To evaluate the effects of bovine respiratory syncytial virus (BRSV) vaccine on health and performance, five trials using 580 newly received steer and bull calves and yearlings averaging 215 kg were used in a 28-d receiving period. Cattle in trials 1 through 4 had ad libitum access to prairie hay and were fed a soybean meal-based pellet at the rate of .91 kg/day for the first 21 days and .45 kg/day during days 22-28. In trial 5, cattle had ad libitum access to a 70% concentrate diet plus prairie hay at a rate of .91 kg head^{-1} day^{-1}. The day after arrival, half of the cattle received BRSV vaccine. Though differing dietary treatments were imposed, diets had no influence on response to BRSV vaccine. Vaccination with BRSV vaccine increased ($p=.02$) daily gains by 11% (.78 vs .7 kg/day) and tended ($p<.2$) to improve feed intake and feed efficiency over non-vaccinated calves. However, mean medical treatments required per head tended ($p=.21$) to be highest and morbidity was increased ($p=.02$) by 8.1% with

BRSV vaccine. Mortality was similar among both groups. Although, the incidence of BRDC was increased, these data indicate that the administration of BRSV vaccine improved weight gains and may have improved consumption and utilization of feed.

Introduction

Bovine respiratory syncytial virus (BRSV) has been isolated from nasal and ocular secretions following outbreaks of respiratory disease in calves (Jacobs and Eddington, 1971; Rosenquist, 1974; Lehmkuhl et al., 1979). Antibody surveys have shown that the virus is widely distributed and common in cattle populations (Rosenquist, 1983). In 1984, a modified live virus vaccine was licensed; however, it was later recalled. A new vaccine has since been developed and marketed for use in cattle. The objective of this research was to study the effect of BRSV vaccine on the health and performance of newly arrived stocker and feeder cattle.

Experimental Procedure

Five hundred eighty head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in 1987. The origin, arrival date and weight, number of head and transit shrink for each trial are summarized in Table XIII. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of eight pens which had been

TABLE XIII

ORIGIN, ARRIVAL DATE, NUMBER OF HEAD, ARRIVAL WEIGHT AND INTRANSIT SHRINK FOR EACH LOAD OF CATTLE

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	OK	1-17-1987	94	529	4.08
Trial 2	AR	1-18-1987	174	514	4.55
Trial 3	KY	2-16-1987	86	514	4.46
Trial 4	KY	2-20-1987	92	488	7.83
Trial 5	AL	9-07-1987	134	334	NA[a]

[a]NA=not available.

assigned to one of the following treatments: unvaccinated controls or intramuscular vaccination with BRSV vaccine[1]. The vaccination treatments were applied at the time of processing.

Processing and BRDC treatment procedures were conducted as reported in Chapter III of this manuscript with the exception of the sequence of drugs used for treatment of BRDC (Chapter IV). Experimental procedures for processing and BRDC treatment are described there (Hays, 1987a,b).

In trials 1 through 4, cattle had free access to prairie hay and were fed .91 kg head^{-1} day^{-1} a pelleted feed supplement (Table XIV) for the first 21 days. Supplement was decreased to .45 kg head^{-1} day^{-1} during days 22-28. Cattle in trial 5 had ad libitum access to a 70% pelleted concentrate (Chapter IV: Table IX) and received .91 kg prairie per head each day. Two hospital pens were maintained to avoid mixing of treatment animals while out of their home pen.

Stastical analysis was conducted as reported in Chapter IV of this manuscript (Hays, 1987b).

Results and Discussion

Effects of BRSV vaccine on daily gains, sick pen days,

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[1]Norden Laboratories, Inc., Lincoln, NE 68501.

TABLE XIV

COMPOSITION OF FEED SUPPLEMENT--
Trial 1, 2, 3, 4

Ingredient	IFN[a]	% As Fed
Soybean meal	5-20-637	88.94
Cottonseed meal	5-01-621	5.00
Salt	6-04-152	3.00
Dicalcium phosphate	6-01-080	2.75
Vitamin A-30,000 IU/g		.11
Bovatec 68[b]		.15
Rovimix E 50% SD[c]		.09

[a]International Feed Number.
[b]To provide 33 mg lasalocid per kg.
[c]DL-alpha-tocopherol acetate, Hoffmann-La Roche, Inc., Nutley, NJ 07110.

morbidity and mortality are shown in Table XV. Daily weight gains were significantly improved (p=.02) with BRSV treatment from .70 to .78 kg. However, the average number of medical treatments per head tended (p=.21) to be lower in the control group vs the BRSV group (2.26 vs 2.51). Morbidity was high in both groups, but was lower (p=.02) in the nonvaccinated controls (50.26 vs 58.39%). Death loss was not affected by treatment.

Feed intakes and gain to feed ratios are reported in Table XVI. BRSV treament tended to increase (p=.14) feed intake and improve (p=.18) gain to feed ratios by 3.1 and 8.5% respectively. These results as well as those above were not influenced by superimposed feed treatments.

With increased morbidity resulting and more medical treatments required per head by vaccinated cattle, one would expect to see reduced weight gains and feed intake. This was not the case. Effects of BRSV vaccine on daily gains and medical treatments in the cattle that became sick are reported in Table XVII. Although nonsignificant (p>.25), the differences between treatment means among those cattle that became sick may partially explain this peculiarity. Daily gains still favored the vaccinated over the control cattle (.60 vs .52 kg respectively). However, medical treatments required per head were slightly less (4.43 vs 4.53) and the recurrence of BRDC was reduced (25 and 27%) in the BRSV vaccinated cattle that became sick.

TABLE XV

EFFECT OF BRSV VACCINE ON WEIGHT GAINS, MORBIDITY AND MORTALITY IN STRESSED CATTLE

Treatment	Control	BRSV
Number of head	289	287
Number of head never sick	143	117
Arrival weight, kg	232	232
Daily gain, kg[a]	.70[b]	.78[c]
Daily gain of head never sick, kg[a]	.68	.82
Medical treatments per head[a]	2.26	2.51
Morbidity, %[a]	50.26[b]	58.39[c]
Total Mortality, %	0.69	0.70

[a]Expressed as least square means.
[b,c]Means with different superscripts differ ($p<.03$).

TABLE XVI

EFFECTS OF BRSV VACCINE ON FEED INTAKE AND GAIN TO FEED RATIO

	Control	BRSV
Number of pens	16	16
Feed intake, kg[a]	6.83	7.04
Gain/feed[a]	0.106	0.115

[a]Expressed as least square means.

There is a delay between vaccination and an immune response in animals. Hence, the data also were analyzed with those cattle pulled as sick at processing excluded from the model (97 control head and 95 BRSV head) because BRSV vaccine could not have affected the initial sickness in these cattle. Effects of BRSV vaccine on weight gains, medical treatments per head and morbidity with these head excluded are summarized in Table XVIII. Cattle which were vaccinated with BRSV had higher ($p<.03$) weight gains (.83 vs .73 kg head^{-1} day^{-1}), more ($p<.03$) medical treatments required per head (1.49 vs 1.06), and higher ($p<.003$) morbidity (45.09 vs 31.68%) than nonvaccinated controls.

Effects of BRSV on the health and performance of sick cattle excluding those calves pulled at processing are presented in Table XIX. Average daily gains were slightly less and mean medical treatments required per head and the recurrence of BRDC were poorer in this group of BRSV vaccinated cattle. These differences are similar to those earlier discussed for all sick cattle.

Under the conditions of this study, weight gains of newly arrived cattle were improved by treatment with intramuscular BRSV vaccine. This probably was due to the tendency for an increased feed intake. However, because of poorer health response to BRSV vaccine, further studies need to be conducted with BRSV before definite conclusions concerning its efficacy can be drawn.

TABLE XVII

EFFECT OF BRSV VACCINE ON DAILY GAINS, AND MEDICAL TREATMENTS IN SICK CATTLE

	Control	BRSV
Number of head	148	172
Average daily gain, kg[a]	.52	.60
Medical treatments per head[a]	4.53	4.43
Recurrence of BRDC, %[a]	27	25

[a]Expressed as least square means.

TABLE XVIII

EFFECTS OF BRSV VACCINE ON DAILY GAINS, MEDICAL TREATMENTS AND MORBIDITY IN STRESSED CATTLE WITH SICK HEAD PULLED AT PROCESSING EXCLUDED

	Controls	Brsv
Number of head	194	193
Arrival weight, kg	227	228
Average daily gain, kg[a]	.73[b]	.83[c]
Medical treatments per head[a]	1.06[b]	1.49[c]
Morbidity, %[a]	31.68[c]	45.09[d]

[a]Expressed as least square means.
[b,c]Means with different superscripts differ ($p<.05$).
[c,d]Means with different superscripts differ ($p<.005$).

TABLE XIX

EFFECT OF BRSV VACCINE ON DAILY GAINS, MEDICAL TREATMENTS, AND RECURRENCE OF BRDC IN SICK CATTLE WITH HEAD PULLED AT PROCESSING EXCLUDED

	Controls	BRSV
Number of head	51	77
Average daily gain, kg[a]	.60	.56
Medical treatments per head[a]	3.64	3.56
Recurence of BRDC, %[a]	9.47	8.41

[a]Expressed as least square means.

CHAPTER VI

LEAD STEERS AS A MANAGEMENT TOOL FOR STRESSED STOCKER CATTLE

Summary

Four trials involving 447 newly received steer and bull calves averaging 180 kg were used in a study to evaluate the effects of lead steers (LS) on health and performance during a 28-d receiving period. Cattle in trials 1 and 2 had ad libitum access to prairie hay and were fed a soybean meal-based pellet at the rate of .91 kg/day for the first 21 days and .45 kg/day during days 22-28. In trials 3 and 4, cattle had ad libitum access to a 70% concentrate diet plus prairie hay at a rate of .91 kg per head daily. On arrival, the cattle were randomly sorted into pens of which half of the pens contained a LS, a steer that was familiar with feed and water sources. Study results were not influenced by diet or other treatments superimposed on the study. Lead steers did not influence the weight gains, feed intake or gain to feed ratio of stressed cattle. However, there was a tendency for increased (p=.20) medical treatments per head (2.65 vs 2.21) and morbidity (52.96 vs 46.62%) in the LS group over

the controls. Among those cattle that became sick, LS tended to depress (p=.21) weight gains (.49 vs .67 kg/day) and increase (p=.14) the recurrence of BRDC (23 vs 32%) over controls. LS were not provided in the sick pens. It appeared that cattle performed poorly in absence of LS when in the sickpen.

Introduction

Stress is a component of the bovine respiratory disease complex (BRDC). Its role in the BRDC is discussed earlier in this manuscript (Hays, 1987c). Weaning, the mixing of calves and changes in environment and nutrition all are perceived as stressful in calves (Phillips, 1982). Calves are subjected to additional stress when transported and processed. This reduces subsequent performance and increases disease susceptibility.

Newly received cattle are subjected often to additional stressors. Many young calves have never been exposed to feed bunks, water troughs and the complete diets associated with receiving programs in drylot facilities. Therefore, these groups of cattle go through a period of adjustment. It was hypothesized that if new cattle exposed to new surroundings had an animal acquainted with the surroundings, a lead steer (LS), adjustment might be less stressful and animal performance improved. Hence, this study was designed to evaluate the effects of a LS on the health and performance of newly received calves.

Experimental Procedure

Four hundred forty seven head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in 1987. The origin, arrival date and weight, number of head and transit shrink for each load is summarized in Table XX. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of four to eight pens containing 15 to 23 animals each. Half of the pens contained a LS which had been exposed to the pen and the diet for a minimum of two weeks. LS were selected to be similar in age and weight to newly received cattle when possible.

Cattle in trials 1 and 2 had free access to prairie hay and were fed .91 kg head^{-1} day^{-1} a pelleted feed supplement (Chapter V: Table XIV) for the first 21 days. The amount of supplement was decreased to .45 kg head^{-1} day^{-1} during days 22 to 28. In trial 3 and 4, cattle had ad libitum access to a 70% pelleted concentrate (Chapter IV: Table IX) and received .91 kg prairie hay per head daily. Two hospital pens were maintained to avoid mixing of treatment animals while out of their home pen. There were no lead steers in the hospital pens.

Experimental procedures for processing and treatment of BRDC were followed as previously described in Chapter III and IV of this manuscript (Hays, 1987a,b).

TABLE XX

ORIGIN, ARRIVAL DATE, NUMBER OF HEAD, ARRIVAL WEIGHT AND INTRANSIT SHRINK FOR EACH LOAD OF CATTLE

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	KY	2-16-1987	86	514	4.46
Trial 2	KY	2-20-1987	92	488	7.83
Trial 3	AL	7-12-1987	135	322	3.99
Trial 4	AL	9-07-1987	134	334	NA[a]

[a]NA=not available.

Least squares analysis of variance were performed on data for all response criteria. Variables other than LS were superimposed across all trials and considered in the analysis. LS consumed supplement and hay at an approximate rate of 3% of their body weight. Total daily feed consumption for cattle in pens containing a LS was corrected by this amount.

Results and Discussion

The effects of LS on daily gains, medical treatment and morbidity across all cattle are presented in Table XXI. Daily Gains were .78 kg for control cattle and .79 kg for calves in pens containing a LS. There was a tendency for increased (p=.20) medical treatments averaged across all cattle (2.65 vs 2.21) and higher (p=.23) morbidity (53 vs 46.6%) for the LS group.

Feed intake and gain to feed ratio averaged across pens are reported in Table XXII. Feed intakes were 6.2 vs 6.17 kg/day and gain to feed ratios were 0.141 and 0.134 for contol and LS groups respectively.

Performance of the cattle that became sick during the 28-d study are reported in Table XXIII. LS cattle tended (p=.21) to gain less (.49 vs .67 kg/day) than controls among this group. The recurrence of BRDC similarly tended (p=.14) to be greater for the cattle that became sick in the LS group (32 vs 23%) over the controls. It appears

TABLE XXI

EFFECT OF LEAD STEERS ON WEIGHT GAINS, MORBIDITY AND MORTALITY IN STRESSED CATTLE

Treatment	Control	LS
Number of head	225	222
Number of head never sick	86	76
Arrival weight, kg	181	178
Daily gain, kg[a]	.78	.79
Daily gain of head never sick, kg[a]	.91	.96
Medical treatments per head[a]	2.21	2.65
Morbidity, %[a]	46.62	52.96
Total Mortality, %	0.88	1.80

[a]Expressed as least square means.

TABLE XXII

EFFECTS OF LEAD STEERS ON FEED INTAKE AND GAIN TO FEED RATIO

	Control	LS
Number of pens	12	12
Feed intake, kg[a,b]	6.20	6.17
Gain/feed[a]	0.141	0.134

[a]Expressed as least square means.
[b]Corrected for LS intake by removing 3% LS body weight per day.

TABLE XXIII

EFFECT OF LEAD STEERS ON DAILY GAINS, AND MEDICAL TREATMENT IN SICK CATTLE

	Control	LS
Number of head	139	146
Average daily gain, kg[a]	.67	.49
Medical treatments per head[a]	4.61	4.77
Recurrence of BRDC, %[a]	23	32

[a]Expressed as least square means.

that the lack of a LS in the sick pen may have influenced the weight gains of the LS group. This may be supported by a slight improvement in gain of the cattle that never became sick (Table XXI). Gains within this group were .91 for controls and .96 for LS treatment calves. However, repeatability is questionable as the probability level was low ($p=.41$).

Several cattle were treated for sickness at the time of processing. Because these calves had only been exposed to the LS treatment only overnight, the data also were analyzed excluding those treated as sick at the time of processing (84 for controls and 75 for LS). The gains, medical treatments required per head and morbidity for this group of calves are reported in Table XXIII. Although gains were similar for LS and control calves (.86 and .88 kg/day respectively), again there tended to be more ($p<.10$) medical treatments required per morbid calf among the LS calves (2.19) than the controls (1.66). Morbidity tended ($p=.17$) to be higher also for the LS calves (54.06%) as compared with the controls (46.04%).

The effects of LS on weight gains, medical treatments and the recurrence of BRDC in sick cattle with sick head at processing excluded are reported in Table XXIV. Recurrence of BRDC was slightly higher ($p=.26$) in the LS calves (15.40 vs 8.34%).

TABLE XXIV

EFFECTS OF LEAD STEERS ON DAILY GAINS, MEDICAL TREATMENT, AND MORBIDITY IN STRESSED CATTLE WITH SICK HEAD PULLED AT PROCESSING EXCLUDED

	Controls	LS
Number of head	140	145
Arrival weight, kg	182	182
Average daily gain, kg[a]	.86	.88
Medical treatments per head[a]	1.66	2.19
Morbidity, %*	46.04	54.06

[a]Expressed as least square means.

TABLE XXV

EFFECT OF LEAD STEERS ON DAILY GAINS, MEDICAL TREATMENT AND RECURRENCE OF BRDC IN SICK CATTLE WITH HEAD PULLED AT PROCESSING EXCLUDED

	Controls	LS
Number of head	55	71
Average daily gain, kg[a]	.67	.61
Medical treatments per head[a]	3.75	4.08
Recurrence of BRDC, %[a]	8.34	15.40

[a]Expressed as least square means.

Although results appear to be conflicting, LS provided only in the home pens and not in the hospital pens tended to increase morbidity and medical treatments required per head. Several more trials with LS are needed to evaluate their effects on weight gain. LS in the hospital pens should also be tested.

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VITA

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