ENERGY EXPENDITURE IN GROWING HEIFERS WITH DIVERGENT RESIDUAL FEED INTAKE PHENOTYPES. EFFECTS AND INTERACTIONS OF METAPHYLACTIC TREATMENT AND TEMPERAMENT ON RECEIVING STEERS

A Thesis

by

ZACHARY DEAN PADDOCK

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2010

Major Subject: Nutrition

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Approved by:

Chair of Committee,	Gordon E. Carstens
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ABSTRACT

Energy Expenditure in Growing Heifers with Divergent Residual Feed Intake Phenotypes.
Effects and Interaction of Metaphylactic Treatment and Temperament on Receiving Steers.
(August 2010)

Zachary Dean Paddock, B.S., Texas A&M University
Chair of Advisory Committee: Dr. Gordon Carstens

Cattle classified as having low residual feed intake (RFI) phenotypes are those that consume less feed than expected based on body weight and growth performance. Mechanisms contributing to the variation in RFI are not fully understood. Previous studies have shown that cattle of divergent RFI phenotypes have different levels of energy expenditures, which are associated with heat increment, basal metabolism, thermoregulation responses, and physical activity. The objectives of this experiment were to characterize residual feed intake (RFI) in growing heifers and to determine if variation in whole-animal energy expenditure contributes to differences in RFI. Brangus heifers (n =120) were individually fed a roughage-based diet (1.93 Mcal ME/kg DM) diet twice daily and feed refusals measured weekly. Heifers were weighed once weekly for 70 d and RFI calculated as the difference between actual and expected DMI from linear regression of DMI on ADG and mid-test $BW^{0.75}$. Immediately following the 70 d study, oxygen pulse rate (mL O2/heart beat) and 48-h heart rates were measured on 8 high and 8 low RFI heifers to estimate energy expenditure. Daily heart rates and oxygen pulse rates were higher ($P < 0.05$) in heifers with high RFI compared to those with low RFI. As a result, energy expenditure (kcal/$BW^{0.75}$) was estimated to be 17.4% greater ($P < 0.05$) in high-RFI heifers then low-RFI heifers.

Mortality and morbidity losses caused by bovine respiratory disease (BRD) continue to negatively impact the net revenues of the beef cattle industry. Stress can predispose calves arriving at feedlots to BRD by impairing their immune system with calves having more excitable temperaments possibly having a greater risk. The objectives of the second study was to examine the effects of metaphylactic treatment and temperament on performance, feed intake, feed efficiency, and feeding behavior traits in steers. Santa Gertrudis steers (n =119) were weighed and randomly to control (CON; no antimicrobial treatment) or metaphylactic (MET; 1.5 mL/45 kg BW of ceftiofur crystalline free acid) treatments. Steers were weighed at 14-d intervals and individual intakes and feeding behavior traits measured using a GrowSafe sytems while fed a roughage-based diet (2.21 Mcal ME/kg DM). Objective (relative exit velocity; REV) and subjective (chute score; CS) measurements of temperament were measured on arrival and on day 28 of the study. Steers with higher REV weighed less, grew slower, consumed less feed, spent less time consuming feeding, had more feeding bouts per meal, had less backfat, smaller longissimus muscle area, and higher cortisol levels. Steers treated with MET had higher ADG than those receiving CON. Cattle with higher REV that received MET had less of a decrease in ADG, DMI, time spend consuming feed, and less of an increase in feeding bouts compared to high REV steers receiving CON. Results from this study suggest that process-control strategies, which quantify and manage inter-animal variation in calf temperament may facilitate more judicious use of antimicrobial products and provide more consistent and predictable responses to metaphylactic strategies.

DEDICATION

I would like to dedicate the thesis to my wife, Casey, all of her help, love and support.

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I would like to thank my committee chair, Dr. Carstens, and my committee members, Dr. Callaway, Dr. Tedeschi, for their guidance and support throughout the course of my degree.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

FEED EFFICIENCY IN GROWING CATTLE

Feed costs are the largest expense in any cattle operation. Therefore, decreasing the amount of feed required per unit of beef through selection of efficient cattle would have a large impact on profit margins and help to maintain sustainable food production systems. Recent increases in feed costs due to rising input cost and competing industries, such as ethanol production, have reinforced the need to improve feed efficiency. Traditional measurements of feed efficiency, such as feed conversion ratio (FCR; feed: gain ratio), do not attempt to partition feed intake into that needed to support maintenance and growth requirements. Therefore FCR is strongly correlated with growth traits such that selection for low FCR will favor selection of faster growing animals thereby leading to larger mature cows (Arthur et al., 2001b; Herd and Bishop, 2000; Nkrumah et al., 2004). Larger mature size cattle will increase feed inputs cost in the cow-calf sector of beef production systems, possibly canceling out any benefit derived from improved feed efficiency of feedlot progeny (Archer et al., 1999; Herd and Bishop, 2000). Other feed efficiency measurements have been devised such as Kleiber ratio, partial efficiency of growth and relative growth rate. However these methods have also been shown to be related to growth (Arthur et al., 2001b; Nkrumah et al., 2004) , and therefore may also increase mature cow size. Selection for feed efficiency using a trait that is independent of growth rate and mature body size would have the potential to decrease feeding cost without increasing mature cow body size.

This thesis follows the style of Journal of Animal Science.

RESIDUAL FEED INTAKE

Residual feed intake (RFI) is the difference between actual DMI and expected DMI based on metabolic body weight and growth rate (Koch et al., 1963). Therefore, RFI quantifies the variation in DMI that is independent of maintenance and growth energy requirements. Cattle classified as having low RFI phenotypes are those that consume less feed than expected based on body weight and growth performance. Strong phenotype and genetic correlations between RFI and FCR are typically observed. However, numerous studies have demonstrated that RFI is not phenotypically or genetically correlated with growth rate or mature cow size (Arthur et al., 2001a; Herd and Bishop, 2000; Nkrumah et al., 2007a). Research has shown that RFI is moderately heritable in beef cattle (Archer et al., 1997; Arthur et al., 2001a; Arthur et al., 2001b), and sufficient genetic variation exists for favorable responses to occur from genetic selection (Archer et al., 2002; Archer et al., 1999; Herd and Bishop, 2000). However RFI has not been widely implanted as a selection tool. High cost associated with measuring individual animal intake has limited the use of RFI measurements by commercial cattle testing facilities. Also there is a high level expertise needed to compute RFI and statistically analysis it. As a result RFI has not been included in many breeding programs and remained in the research and academic areas. Some large commercial facilities are beginning to investment in the technology needed to calculate RFI and include it in their measured traits. Development of genetic markers for RFI would allow easier and lower cost testing. This would facilitate a broader implementation in breeding programs to improve genetic merit for feed efficiency in beef cattle. However multiple genes are likely to contribute to genetic variance in RFI, therefore a better understanding of the biological mechanisms that account for RFI need to be investigated in order to indentify candidate genes for further genetic marker development (Moore et al., 2009).

SOURCES OF BIOLOGICAL VARIATION IN RESIDUAL FEED INTAKE

Herd et al. (2004) has summarized current research into the biological factors that contribute to the variation seen in RFI of beef cattle. They estimated that 14, 9, 5 and 5% of the amount of variation in RFI came from digestion, heat increment of feed, body composition and activity differences, respectively. Thus, 67% of the remaining variation in RFI in beef cattle was unexplained. Herd et al. (2004) suggested that this remaining unexplained variation in RFI was likely related to a multitude of energy consuming biological processes such as mitochondrial proton leak, protein turnover, and ion pumping. Cattle with low RFI have been shown to have improved digestibility (Brown et al., 2005; Nkrumah et al., 2006), therefore they have less fecal energy loss. Nkrumah et al. (2006) found that cattle with low RFI had lower fecal and methane energy losses, but similar urinary energy losses, which equated to a difference of 6.3% in metabolizable energy between low and high RFI cattle. Hegarty et al. (2007) also found a difference in methane energy loss when cattle were fed ad libitum. After accounting for these differences it can be concluded that the majority of RFI variance will likely be related to variation in energy expenditures.

By definition, the sum of energy expenditures (EE) associated with basal metabolism, heat increment, thermoregulatory responses and physical activities, plus energy retained as product (e.g., milk, tissue) will equal total metabolizable energy intake (MEI) by an animal. Retained energy in growing animals is used for either protein or fat gain, with more energy required to deposit fat compared to muscle tissue because fat is more reduced than protien. On the other hand, less energy is needed to maintain fat deposits when compared to protein due to energetic cost of protein turnover. Studies with growing beef cattle have shown that 4 to 9 % of the variation in RFI is associated with differences in carcass composition (Basarab et al., 2003; Lancaster et al., 2009a). Positive weak to moderate phenotypic and genetic correlations between RFI and carcass fat traits reveal that calves with low RFI (more efficient) have a slightly leaner composition. This may cause concerns that RFI selection could lead to leaner cattle, but by adding an adjustment for carcass traits into the RFI model researchers can account for these differences in body composition. The relatively small contributions to the variation in RFI explained by differences in rate and composition of growth suggest that the majority of the variation in MEI between growing cattle with low and high RFI phenotypes is likely associated with inter-animal differences in EE.

ENERGY EXPENDITURE

In growing cattle, RE is used primarily to deposit protein or fat gain, energy expenditures are associated with heat increment of feed, basal metabolism, thermoregulation responses, and physical activity. Maintenance energy requirements have been shown to be moderately heritable in beef cattle (Hotovy et al., 1991). While the sources of energy losses that contribute to differences in whole-animal EE are not fully known, Herd et al. (2004) estimated that variation in EE associated with physical activity accounts for only 5% of the variation in RFI. Studies in poultry have shown 21% greater EE in egg laying leghorns selected for high RFI compared to those selected for low RFI (Luiting et al., 1991). Another study demonstrated that the cockerels selected for high RFI had 31% greater diet-induced thermogenesis (Gabarrou et al., 1997) than cockerels selected for low RFI. In beef cattle, 10 and 21 % higher EE was found in cattle with high compared to low phenotypes for RFI (Basarab et al., 2003; Nkrumah et al., 2006), respectively.

INDIRECT CALORIMETRY

Calorimetry is a technique used to quantify heat generated from chemical reactions. In living organisms heat production (energy expenditure) can be estimated through the indirect calorimetry which measures oxygen consumption and carbon dioxide production. Open and closed-circuit indirect calorimetry chambers have been used since the 1900's to measure oxygen consumption and carbon dioxide production in humans and animals. Traditional methods that use indirect calorimetry to measure EE of animals involve the use of respiration chambers that house individual animals. These chambers do not represent the real world environment and restrict animal activity which could both effect energy requirements and usage according to NRC (1996). A face-mask method was developed to reduce stress on the animal and collect oxygen consumption measurements in a natural environment (Taylor et al., 1982). Using the face-mask method, Aharoni et al., (2003) and Brosh et al., (1998) have shown that measuring oxygen consumption per heart beat (oxygen pulse: O_2P) over a short period of time (20 min) is representative of daily O_2P. Since oxygen is carried throughout the body by circulatory system it has been shown that heart rate measurements are predictive oxygen consumption and therefore

EE (Booyens and Hervey, 1960; Webster, 1967; Yamamoto et al., 1979). However heart rate alone may give incorrect estimates of EE values due to effects of activity level, intra-day variations, diet and other physiological conditions on both HR and EE (Brosh, 2007; Yamamoto, 1989). Since HR can contain high intra-day variation it must be recorded constantly for the full day (Brosh et al., 1998), and current technology has made this possible. The product of daily HR and short-term O_2P can then be used to predict total daily O_2 consumption and therefore EE with minimal disturbance to the cattle.

BOVINE RESPIRATORY DISEASE

Mortality and morbidity losses caused by bovine respiratory disease (BRD) continue to negatively impact the economics of the beef cattle industry. It has been estimated that BRD accounts for 70% to 80% of morbidity and 40% to 50% of mortality (Smith, 1998) in U.S. feedlots. Bovine respiratory disease has been shown to effect 14% of feedlot cattle (USDA, 1999) resulting in an estimated medical treatment cost of $12.59 per animal. In addition to medical expenses, BRD causes decreased performance (Gardner et al., 1999; Schneider et al., 2009; Smith, 1998; Waggoner et al., 2007), therefore increasing feed costs and diminishing returns. Snowder (2006) analyzed 15 years of data and found the average cost of BRD for a feedlot to be $13.59 per head. Based on a respiratory track scoring system at slaughter, Gardner et al. (1999) reported that cattle with non-active and active lung lesions had $20 and $74 less net returns, respectively. For steers with non-active lung lesions, medical cost accounted for only 25% of the loss in net returns, with 75% due to losses in carcass weight and choice yield grades. Therefore, bovine respiratory disease affects profits directly through medical costs and indirectly through decreased performance and decreased carcass value. Loneragan (2004) reported that the incidence of BRD increased by 9% per year from 1994 to 1997, and that mortality due to BRD increased 15% per year from 1994 to 2003. Bovine respiratory disease can be caused by a variety of viral and bacterial pathogens and is enhanced by poor nutrition and stressful management practices (Callan and Garry, 2002; Duff and Galyean, 2007). Therefore, strategies to reduce the incidence of BRD must include backgrounding management practices that reduce stress, improve nutrition and health prior to and during the arrival of cattle to a feedlot. However, implementing backgrounding management strategy across all cow-calf producers is unlikely, especially when the monetary returns are primarily seen by the feedlot. Higher premiums will be needed for backgrounded calves before a majority of cow-calf producers can justify the time and expense incurred from backgrounding. Furthermore, backgrounding can only reduce a calves risk of BRD, weaning stress (cow-calf separation, castration, dehorning), shipping stress (feed and water deprivation) and feedlot arrival stress (changes in diet, climate and social order) cannot be avoided and predispose calves arriving at feedlots to BRD infections by impairing their immune system. Therefore to further reduce BRD incidence, feedlots can use antibiotics in a metaphylactic capacity when cattle arrive. Due to our inability to know which calves will need antibiotic treatment for BRD, metaphylactic treatment is administered to all cattle entering a feedlot.

METAPHYLACTIC TREATMENT

Metaphylactic treatment has been shown to reduce the risk of morbidity in calves that are at high risk for BRD (Lofgreen, 1983). When morbidity exceeds 40%, metaphylactic treatment consistently reduces morbidity rates by 20 to 30 percentage units (Galyean et al., 1995). However, the beneficial responses to the use of metaphylactic antimicrobial products are often variable (Duff et al., 2000), especially in low-risk calves. Furthermore, because sub-clinical BRD can cause significant production losses, impacts of metaphylactic treatments on performance and feed efficiency should also be considered. Studies have shown metaphylactic treatment with tilmicosin to increase DMI and feed efficiency (Klemesrud et al., 1997; Vogel et al., 1998), however Galyean (1995) showed variable results. Ideally, metaphylactic treatment will reduce the effects of BRD both on a clinical and sub-clinical level, while maintaining or enhancing feed consumption, to add value to a metaphylactic treatment strategy. Generally metaphylactic treatment is administered to all cattle deemed at high-risk for BRD entering a feedlot.

Mass metaphylactic treatment has raised concerns over antibiotic resistance and is banned in many European countries. While mass metaphylactic treatment has been shown to be cost effective in relation to waiting until clinical symptoms appear methods to screen cattle upon arrival at a feedlot for metaphylactic treatment could further increase the returns of metaphylactic treatment. Methods to determine the sub-populations of arriving feedlot cattle that would benefit most from metaphylactic treatment have not been extensively investigated. Galyean (1995) showed there was no difference in level of benefits between mass metaphylactic treatment and metaphylactic treatment based on high temperature (≥ 37.9° C).

Ceftiofur crystalline free acid has been shown to be an efficacious metaphylactic treatment in newly weaned beef calves (Bremer et al., 2007). Ceftiofur is a third generation cephalosporin antibiotic originally described in 1987 (Yancey et al., 1987). Cephalosporins are a group of beta-lactam antibiotics, which prevent the synthesis of bacteria's peptidoglycan cell wall. Specifically beta-lactam antibiotic's center ring structure competitively binds the final enzyme needed for peptidoglycan synthesis. The effects of ceftiofur on growth performance, individual feed consumption and feed behavior have not been extensively evaluated. Moreover, studies have not been conducted to determine if calf temperament influences the effects of metaphylactic treatment on intake and growth performance of newly received beef calves.

TEMPERAMENT AND IMMUNE FUNCTION

Temperament has been defined as an animal's behavioral responses to handling by humans. Cattle with calm temperaments respond to human handling with minimal reactivity, while excitable cattle are nervous and flighty when handled by humans. Classification from subjective evaluation of temperament has shown excitable cattle to grow slower then calm cattle (Voisinet et al., 1997). Burrow et al. (1988) developed an objective assessment of temperament that quantifies the speed an animal exits a squeeze chute (exit velocity; EV). Exit velocity has been shown to be moderately heritable and negatively correlated with many production traits (Petherick et al., 2002). Growing calves identified as having excitable temperaments by objective measurements have been shown to consume less feed, grow slower (Brown et al., 2005; Voisinet et al., 1997), produce leaner, tougher carcasses (Ribeiro et al., 2007) than calves with calm temperaments.

Cattle temperament is associated with stress response and immune function. Glucocorticoids are a class of hormones released in response to stress. These hormones suppress the immune system by interfering with a number of immune mechanisms (Munck et al., 1984; Russo-Marie, 1992). Stress incurred during weaning, shipping, and arrival at a feedlot causes serum cortisol concentrations to increase, suppressing the immune system. Serum cortisol concentrations have been shown to be positively correlated with EV (Curley et al., 2006), and negatively correlated with ADG and feed intake (Theis et al., 2002) in growing steers. Oliphint (2006) found excitable calves to have higher cortisol levels and less immune response, measured by immunoglobulin G production in response to clostridal vaccination, compared to calm calves. Therefore, excitable calves may enter a feedlot with an impaired immune system, increasing their risk of BRD infection. Consequently, metaphylactic treatment in excitable calves may assist their immune system allowing for a better response to metaphylactic therapy when compared to a calm calf's response.

FEED INTAKE AND FEEDING BEHAVIOR

Stresses from weaning, shipping and arrival in a feedlot reduce feed intake and change feeding behavior with morbid calves showing a greater reduction in feed intake than healthy calves (Hutcheson and Cole, 1986). Morbid calves inflammatory responses are thought to be responsible for the greater reduction in feed intake through changes in metabolism, conservation of nutrients and(or) attempting to starve the pathogenic bacteria (Hart, 1991). Reduced feed intake in stressed calves can last for several weeks and may nutritionally compromise calves putting them at a higher risk for BRD. Feeding behavior traits have also been linked to health status with healthy calves spending 30% more time at the feed bunk (Sowell et al., 1998). In calves at high risk for BRD, Daniels (2000) found healthy calves consumed more meals per day and spent 60 to 70% more time at the feed bunks than morbid calves.

CHAPTER II

OBJECTIVES

ENERGY EXPENDITURE

The objectives of the first experiment were to characterize residual feed intake (RFI) in growing heifers and to determine if variation in whole-animal energy expenditure contributes to differences in RFI.

METAPHYLACTIC TREATMENT

Objectives of the second experiment were to examine the effect of metaphylactic treatment (ceftiofur crystalline free acid) and variation in temperament on performance, feed intake, feed efficiency, and feeding behavior traits during a 28 d receiving period in pre-conditioned calves. Interactions between temperament traits and metaphylactic treatment on gain, intake and feeding behavior traits were examined. Furthermore, the effect of metaphylactic treatment on subsequent performance and feed efficiency was examined.

CHAPTER III

ENERGY EXPENDITURE IN GROWING HEIFERS WITH DIVERGENT RESIDUAL FEED INTAKE PHENOTYPES

INTRODUCTION

Feed costs are the largest expense in any cattle operation. Therefore, decreasing the amount of feed required per unit of beef through selection of efficient cattle would have a large impact on profit margins and help to maintain sustainable food production systems. Traditional measurements of feed efficiency, such as feed conversion ratio (FCR; feed: gain ratio), do not attempt to partition feed intake into that needed to support maintenance and growth requirements. Therefore FCR is strongly correlated with growth traits such that selection for low FCR will favor selection of faster growing animals thereby leading to larger mature cows (Arthur et al., 2001b; Herd and Bishop, 2000; Nkrumah et al., 2004). Residual feed intake (RFI) is the difference between actual DMI and expected DMI based on metabolic body weight and growth rate (Koch et al., 1963). Therefore, RFI quantifies the variation in DMI beyond that explained by differences in maintenance and growth energy requirements. Cattle classified as having low RFI phenotypes are those that consume less feed than expected based on body weight and growth performance. Unlike FCR, numerous studies have demonstrated that RFI is not phenotypically or genetically correlated with growth rate or mature cow size (Arthur et al., 2001a; Herd and Bishop, 2000; Nkrumah et al., 2007a). Due to the high cost of measuring individual animal intake, RFI has not been included in many breeding programs. Development of genetic markers for RFI would allow a broader implementation in breeding programs to improve genetic merit for feed efficiency in beef cattle. However multiple genes are likely to contribute to genetic variance in RFI, therefore a better understanding of the biological mechanisms that account for RFI need to be investigated in order to indentify candidate genes for further genetic marker development (Moore et al., 2009).

Herd et al. (2004) estimated that 14, 9, 5 and 5% of the amount of variation in RFI came from digestion, heat increment of feed, body composition and activity differences, respectively. Thus, 67% of the remaining variation in RFI in beef cattle was unexplained. Herd et al. (2004)

suggested that this remaining unexplained variation in RFI was likely related to a multitude of energy consuming biological processes. By definition, the sum of energy expenditure associated with basal metabolism, heat increment, thermoregulatory responses and physical activities, plus energy retained as product (e.g., milk, tissue; RE) will equal total metabolizable energy intake (MEI). Retained energy in growing animals is used for either protein or fat gain, with more energy required to deposit fat compared to muscle tissue. Positive weak to moderate phenotypic and genetic correlations between RFI and carcass fat traits reveal that calves with low RFI (more efficient) have a slightly leaner composition. The relatively small contributions to the variation in RFI explained by differences in rate and composition of growth suggest that the majority of the variation in MEI between growing cattle with low and high RFI phenotypes is likely associated with inter-animal differences in EE.

In growing cattle, energy expenditures are associated with heat increment of feed, basal metabolism, thermoregulation responses, and physical activity. While the sources of energy losses that contribute to differences in whole-animal EE are not fully known, 10 and 21 % higher EE was found in cattle with high compared to low phenotypes for RFI (Basarab et al., 2003; Nkrumah et al., 2006), respectively.

MATERIALS AND METHODS

All animal care and use procedures were in accordance with guidelines for use of Animals in Agricultural Teaching and Research and as approved by the Texas A&M University Institutional Animal Care and Use Committee.

Animals and Experimental Design

One hundred and twenty Brangus heifers initial BW (264.4 ± 26.9 kg) and initial age (228.3 ± 11.7 d) were transported to Texas A&M University's O.D. Butler Animal Science Complex. The heifers were housed in 20 pens each equipped with 6 Calan gate feeders (American Calan, Northwood, NH). Heifers were trained to use the Calan gate feeders for 24 d, after which DMI was recorded for 70 d. Heifers were fed a roughage ration consisting of chopped alfalfa hay, dry rolled corn, cottonseed hulls, pelleted alfalfa, molasses, and vitamin-mineral premix (Table 3.1). Heifers were fed twice daily and feed refusals measured weekly during the 70 d trial. Heifers were weighed once weekly as well.

Date Collection

Ration ingredient samples were collected weekly and composited at 10% of each samples weight. Composited samples for each ingredient were sent off for chemical analysis to be conducted at an independent laboratory (Cumberland Valley Analytical Services, Hagerstown, MD). An estimate of the gross energy in the diet of 4.5 Mcal/kg was used to estimate metabolizable energy. Digestibility estimates were obtained for each animal using acid insoluble ash method described by (Van Keulen and Young, 1977). Digestible energy intake was calculated as the difference in gross energy intake and fecal energy loss, estimated from the individual animal digestibility estimates. The NRC (2000) estimates 18% loss of digestable energy as urine and gaseous energy, therefore metabolizable energy intake was calculated as 82% of digestible energy intake.

Body composition traits were measured on days 0 and 70 of the growing trial by a Ultrasound Guidelines Council field certified technician using an Aloka 500-V instrument with a 17-cm, 3.5-MHz transducer (Corometrics Medical Systems Inc., Wallingford, CT) and images were sent to National Centralized Ultrasound Processing laboratory (Ames, IA) for processing and estimation of 12th rib fat thickness (BF), ribeye area (REA), and percent intramuscular fat (IMF).

Oxygen Pulse

Immediately following day 49 of the study, RFI was calculated and 8 heifers with high (RFI > 1 SD) RFI and 8 heifers with low (RFI < 1 SD) RFI identified for subsequent energy expenditure measurements. Immediately following the end of the 70 d study, the heifers with divergent phenotypes for RFI were trained to use the oxygen facemask for 4 d by placing each heifer in a squeeze chute for 20 min with the facemask attached to their face. Following the training period, four oxygen pulse (O_2P; mL / heart beat) measurements were collected over a 4 d

Table 3.1 Ingredient and chemical composition of the diet fed during the study.

Item	
Ingredient	*As-fed basis*
Chopped alfalfa hay	35.00
Pelleted alfalfa	15.00
Dry rolled corn	20.95
Cottonseed hulls	5.43
Molasses	7.00
Salt	0.40
Vitamin E[1]	0.14
Trace mineral[2]	0.02
Chemical Composition	*Dry matter basis*
Dry matter %	88.05
CP, % DM	12.48
NDF, % DM	44.97
ME, Mcal/kg DM	1.93

[1] Vitamin E contained 44,000 IU/kg of product.

[2] Trace mineral contained minimum 19.0% Zn, 7.0% Mn, 4.5% CU, 4,000 ppm Fe, 2,300 ppm I, 1,000 ppm Se and 500 ppm Co.

period, separated by 4 d of heart rate (HR; beat / min) measurements. Daily DMI recorded throughout the energy expenditure measurement period.

Oxygen consumption data was recorded with the Sable System (Sable Systems, Henderson, NV) attached to a facemask. Air flow rate (standard temperature and pressure; STP) through the mask was controlled and measured by a mass flow controller (Flow Kit 500H; Sable Systems, Henderson, NV). The STP flow rate was set for each heifer to keep the CO_2 concentration in the mask at 0.8 % based on MBW and the previous days DMI. The flow kit 500H also takes a sub-sample of the mask air for analysis. Baseline ambient oxygen measurements were sampled using a mass flow sub-sampler unit (TR-SS1) at a constant STP flow of 500 ml/min. Both sub-samples run through a flow-though gas analyzing system. Humidity of the sub-sample is first determined and recorded by humidity meter (RH-100; Sable Systems, Henderson, NV). The sub-samples then pass through Drierite (W.A. Hammond Drierite Company Ltd., Xenia, OH) to remove all water. Last the sub-samples pass through an oxygen fuel cell gas analyzer (FC-1b, Sable Systems, Henderson, NV) in order to determine O_2 concentrations. Ambient temperature was measured using a thermocouple meter (TC-100; Sable Systems, Henderson, NV). One minute averages were collected over a 20 min period from the face-mask, preceded and followed by 5 min samples of baseline determination from ambient air. All data were recorded with an automated data acquisition program (Distributed MR v2.2; Sable Systems; Henderson, NV). Each day, before measurements, the system is calibrated to ambient oxygen levels of 20.95 %. A span gas containing 19.5% oxygen is then used to verify the system. At the beginning and end of the measurement day nitrogen recoveries were performed according to McLean and Tobin (1990). Briefly, nitrogen recoveries were determined by releasing 50.0 g of ultra high purity nitrogen (N_2) into the facemask attached to the sable system. The sable system records the amount of oxygen displaced by the N_2 then calculations are performed to obtain the amount of oxygen theoretically displaced by the nitrogen. The actual oxygen displacement was divided by the theoretical oxygen displacement to find a percent of oxygen detected; the average of the initial and ending percent on a given day is used to adjust all the oxygen measurements for that day.

Heart Rate (HR; beats / min) was recorded with Polar equine transmitter and monitor (Model S610i; Polar Electro Inc., Kempele, Finland). The transmitter and monitor were embedded in a 10 cm wide elastic girth strap with a velcro latch, that was placed around the animal's girth immediately behind the front shoulders. The negative electrode was positioned about 15 cm to the right of the midline and the positive electrode was positioned on the opposite side of the heifer, parallel to the left elbow. The areas around the electrodes were shaved and Electron II conductivity gel (Pharmaceutical Innovations Inc., Newark, NJ) applied to increase conductance. Heart rate measurements during the oxygen consumption measurement were averaged and recorded every 5 sec. Heart rate measurements during the 4 days of HR were averaged and recorded every 60 sec. Any time during the 4 days of HR measurements that the heifers were disturbed or removed from the pens, HR data was discarded.

Oxygen consumption (mL/min) was calculated from the product of the STD flow rate and the difference in the average of the facemask and baseline O_2 concentration measurements, and then it was adjusted by the average of the nitrogen recoveries for that day. Oxygen pulse (O_2P; mL/heart beat) was determined by the average oxygen consumption per min over the average HR per min during the same 20 min period. Total daily oxygen consumption (L / d) was calculated from the product of the average of O_2P and average daily HR. Daily EE was then calculated as the product of total daily oxygen consumption and the constant 20.47 kilojoules per liter of oxygen (Nicol and Young, 1990).

Statistical Analysis

Growth rates of individual heifers were modeled by the linear regression of 7-d BW on day of trial using the general linear model of SAS (SAS Inst., Cary, NC) and regression coefficients were used to estimate initial BW, final BW, ADG, and metabolic BW (MBW; mid-test $BW^{.75}$). Moisture analyses of diet ingredient samples were used to compute average daily DMI from feed intake data. Base residual feed intake (RFIp) was calculated within each period as the difference in observed DMI and expected DMI to meet growth and maintenance energy requirements (Koch et al., 1963). Expected DMI was calculated from the regression of DMI on ADG and MBW as follows:

$$Y_j = \beta_0 + \beta_1 \mathrm{MBW}_j + \beta_2 \mathrm{ADG}_j + e_j$$

where Yj is the DMI of the jth heifer, β_0 is the regression intercept, β_1 is the partial regression coefficient of MBW, β_2 is the partial regression coefficient of ADG, e_j = uncontrolled error term for the jth heifer.

A 2-step approach was used to determine if individual animal variation in carcass composition (ultrasound traits) affected the derivation of expected DMI (Arthur et al., 2003). First, stepwise regression analysis was performed (PROC REG; SAS Inst. Inc.) to determine the order of inclusion of ultrasound carcass composition traits in the base model, which included MBW and ADG. Second, with the order derived from stepwise regression analysis, ultrasound composition traits were sequentially added to the base model, and the resulting change in R^2 was used to determine their relative importance to account for additional variation in DMI. To evaluate the change in R^2 by the ultrasound composition traits the following model was used:

$$Y_j = \beta_0 + \beta_1 \mathrm{MBW}_j + \beta_2 \mathrm{ADG}_j + \beta_x \mathrm{X}_{jk} + e_j$$

where Yj is the DMI of the jth heifer, β_0 is the regression intercept, β_1 is the partial regression coefficient of MBW, β_2 is the partial regression coefficient of ADG, β_x is the regression coefficient on ultrasound composition trait X, e_j = uncontrolled error term for the jth heifer.

All performance, feed efficiency, and ultrasound measures of carcass composition, phenotypic Pearson correlation coefficients (PROC CORR; SAS Inst. Inc.) among feed efficiency, performance, and ultrasound carcass composition traits were generated. To further characterize RFI, heifers were classified into low and high RFI phenotype groups that were < 0.5 and > 0.5 SD, respectively, from the mean RFIp of 0.00 ± 0.66 kg/d. A fixed-effects model (PROC GLM) was used to examine the fixed effect of RFIp phenotype group on performance, feed efficiency, ultrasound composition and energy expenditure traits. Comparisons of least squares means between RFIp groups were performed by using the Tukey post hoc test.

RESULTS AND DISCUSSION

Summary statistics are presented in Table 3.2 for the performance trial. The initial age of heifers averaged 228 ± 12 d and was not different for the heifers selected for oxygen pulse

Table 3.2 Summary statistics of performance, feed efficiency and ultrasound composition traits of growing heifers

Trait[1]	Mean	SD	Min	Max
Initial age, d	228.3	11.70	201.0	256.0
Initial BW, kg	264.4	26.92	218.0	324.3
Final BW, kg	339.7	29.96	272.7	399.7
ADG, kg/d	1.08	0.17	0.73	1.45
DMI, kg/d	9.53	0.88	7.31	12.07
FCR, DMI/gain	9.01	1.21	6.54	12.19
RFIp, kg/d	0.00	0.66	-1.67	1.85
Gain: DMI	0.11	0.02	0.08	0.15
RFIc, kg/d	-0.01	0.63	-1.44	1.69
Initial BF, cm	0.43	0.13	0.23	0.76
Initial REA, cm^2	52.39	7.64	36.76	70.31
Initial IMF, %	3.16	0.70	1.24	5.10
Final BF, cm	0.66	0.19	0.28	1.09
Final REA, cm^2	63.48	8.55	41.93	79.34
Final IMF, %	3.59	0.78	1.84	5.71
Gain in BF, cm	0.23	0.10	0.03	0.46
Gain in REA, cm^2	11.05	4.63	1.94	22.58
Gain in IMF, %	0.46	0.51	-0.53	1.63

[1] FCR = feed conversion ration; RFIp = residual feed intake from base model; RFIc = residual feed intake from composition adjusted model; BF = 12th rib fat thickness; REA = ribeye area; IMF = intramuscular fat.

measurements (223 ± 6 d). Initial and final body weight of the heifers (264 ± 26.9 and 340 ± 30.0 kg) did not differ from the heifers selected for oxygen pulse measurements (259 ± 10.8 and 333 ± 8.63 kg). Average daily gain and DMI for the heifers during the performance trial was 1.08 ± 0.17 kg/d and 9.53 ± 0.88 kg/d and was not different than the heifers selected for oxygen pulse measurements (1.06 ± 0.06 kg/d and 9.57 ± 0.30 kg/d).

Metabolic body weight and ADG explained 43.0 % of the variation in DMI, which is lower than expected. Results from stepwise regression analysis determined the order of inclusion of ultrasound carcass composition traits to be gain in REA and final REA. Initial REA and initial, final and gain in BF and IMF were not selected as significant variables by the regression procedure. Gain in REA and final REA accounted for the variation in DMI equally (4 percentage units each; $P < 0.05$). When gain in REA and final REA were used together, they accounted for a total 5 percentage units ($P < 0.05$) of the variation in DMI. Therefore, the final regression model used to computer RFIc from expected DMI included gain in REA and final REA as fixed effects, in addition to MBW and ADG. The variation in DMI due to carcass ultrasound traits (5 percentage units) was similar to reported values of increases in R^2 between 2 to 4%; (Arthur et al., 2003; Basarab et al., 2003; Lancaster et al., 2009b). Moreover, reduction in SD of RFI after inclusion of carcass ultrasound traits in this study (0.66 vs. 0.63 kg/d for RFIp and RFIc, respectively) was also similar to reductions reported by Schenkel et al. (2004; 1.47 vs. 1.45 kg/d), Basarab et al. (2003; 0.66 vs. 0.62 kg/d).

The correlation between RFIp and RFIc was strong at 0.96 and similar to values reported by Schenkel et al. (2004). However, correlation coefficient between RFIp and RFIc in this study was higher than vales reported in Basarab et al. (2003) and Lancaster et al. (2009), which ranged from 0.87 to 0.92. Phenotypic correlations among growth and feed efficiency traits are presented in Table 3.3. Dry matter intake was positively correlated with ADG (0.51) and initial BW (0.44), which are in agreement with phenotypic correlations reported in growing steers (Basarab et al., 2003; Carstens, 2002; Nkrumah et al., 2007b) and bulls (Arthur et al., 2001a; Arthur et al., 2001b; Lancaster et al., 2009b; Schenkel, 2004). Both RFIp and RFIc were both strongly correlated with DMI, but independent of initial BW and ADG. This is expected because the linear regression used to compute RFI forced it to be phenotypically independent of the

Table 3.3 Phenotypic correlations among performance and feed efficiency traits in growing heifers

Trait[1]	ADG	DMI	FCR	RFIp	RFIc
IBW	0.06	0.44*	0.22*	0.00	-0.04
ADG		0.51*	-0.80*	0.00	0.02
DMI			0.08	0.75*	0.71*
FCR				0.50*	0.46*
RFIp					0.96*

[1] IBW = Initial body weight; ADG = average daily gain; DMI = dry matter intake; FCR = feed conversion ration; RFIp = residual feed intake from base model; RFIc = residual feed intake from composition adjusted model.

*Correlations are different from zero at $P < 0.05$.

component traits, ADG and body size. Most studies have reported RFI to be genetically independent of growth rate and mature body weight in growing heifers and steers (Nkrumah et al., 2004) and bulls (Arthur et al., 2001a; Arthur et al., 2001b; Lancaster et al., 2009b). However, some studies have reported week genetic correlations between RFI and body size (Herd and Bishop, 2000; Schenkel, 2004). Both RFIp and RFIc were positively correlated with FCR (0.50 and 0.46, respectively) as expected. These values are similar to reported values ranging from 0.62 in growing steers (Nkrumah et al., 2004) and 0.49 to 0.85 in bulls (Arthur et al., 2001a; Arthur et al., 2001b; Lancaster et al., 2009).

Heifers selected for oxygen pulse measurements with low RFI consumed 24% less ($P <$ 0.05) DMI and tended to have 10% lower ($P < 0.11$) FCR than selected heifers with high RFI even though ADG and initial and final BW were similar between RFI phenotypes (Table 3.4). Previous studies (Arthur et al., 2001a; Arthur et al., 2001b; Bingham et al., 2009; Carstens, 2002; Fox, 2004; Lancaster et al., 2005; Nkrumah et al., 2007b) have reported similar differences in DMI (15 to 22% lower for calves with low RFI) and FCR (19 to 21% lower for calves with low RFI) between RFI phenotypes.

Individual dry matter intake was recorded throughout the oxygen pulse measurement period, and was compared to the DMI measured during the 70-d RFI study. Oxygen pulse data was deleted for 2 heifers because their DMI differed by more than 25% between the 2 periods. Thereafter, DMI during the oxygen pulse measurement period was not different from the performance period for the selected heifers used in the oxygen pulse data analysis. Recalling heifer oxygen pulse selection was based on a preliminary 49-d RFI, the final 70-d RFI was later calculated and had a correlation coefficient of 0.85 with the preliminary RFI. Two additional heifers, one from each RFI group, were not used in oxygen pulse data analysis due to large changes between the 49-d RFI and 70-d RFI. Therefore, 5 low and 7 high RFI heifers were used in the oxygen pulse data analysis.

Energy expenditure results are presented in Table 3.5. Daily heart rates were higher ($P <$ 0.05) for high-RFI heifers compared to low-RFI heifers (89.6 vs. 97.7 beats/min). Likewise, Lancaster et al., (2005) found that growing heifers and bulls with high RFI had higher heart rates than heifers and bulls with low RFI. Heifers with high RFI also consumed more ($P < 0.01$)

Table 3.4 Least-square means of performance, efficiency and ultrasound composition for selected low and high RFI heifers

Trait[1]	Low-RFI	High-RFI	SE	P-Value
No. of heifers	5	7	-	-
Initial age, d	222.3	222.8	5.50	0.95
Initial BW, kg	252.0	266.0	10.78	0.38
Final BW, kg	320.2	346.0	8.63	0.19
ADG, kg/d	0.97	1.14	0.06	0.09
DMI, kg/d	8.27	10.87	0.30	0.0001
FCR, DMI/gain	8.62	9.59	0.38	0.11
Gain: Feed	0.12	0.11	0.01	0.09
RFIp, kg/d	-0.84	1.14	0.15	0.0001
RFIc, kg/d	-0.63	0.93	0.18	0.0001
Initial BF, cm	0.40	0.43	0.06	0.74
Initial REA, cm^2	54.90	46.84	3.72	0.16
Initial IMF, %	3.42	3.37	0.33	0.99
Final BF, cm	0.61	0.69	0.08	0.52
Final REA, cm^2	67.66	56.24	3.21	0.03
Final IMF, %	3.76	3.62	0.27	0.39
Gain BF, cm	0.21	0.26	0.08	0.39
Gain REA, cm^2	12.77	9.40	1.85	0.23
Gain IMF, %	0.34	0.25	0.23	0.75

[1] FCR = feed conversion ration; RFIp = residual feed intake from base model; RFIc = residual feed intake from composition adjusted model; BF = back fat at 12th rib; REA = ribeye area; IMF = intramuscular fat.

Table 3.5 Least-square means of energy expenditure measurements in heifers with low and high RFI phenotypes following the 70-d RFI test period fed free choice roughage ration

Item[1]	Low-RFI	High-RFI	SE	P-Value
DMI, kg/d	8.01	11.9	0.42	0.001
MEI, kcal/kg of MBW	315.6	414.5	11.53	0.001
Daily heart rate, beats/min	89.6	97.7	2.26	0.03
Oxygen pulse, mL/min	16.5	20.0	0.65	0.006
Energy expenditure, kcal/kg of MBW	138.9	167.8	5.75	0.005
Retained energy, kcal/kg of MBW	176.8	246.7	12.12	0.002

[1] DMI = Dry matter intake during indirect calorimetry measurements; MEI = metabolizable energy intake calculated from individual heifer intakes measurements and digestibility estimates; EE = energy expenditure; RE = retained energy.

oxygen per heart beat than low-RFI heifers (16.5 vs. 20.0 mL/beat). As a result, energy expenditure was estimated to be 17.4 % greater in high-RFI heifers compared to low-RFI heifers, which is in agreement with Basarab et al. (2003) and Nkrumah et al. (2004) who found that energy expenditures were 10 and 21 % greater for high-RFI cattle compared to low-RFI cattle, respectively.

CHAPTER IV

SUMMARY OF THE EFFECTS AND INTERACTIONS OF METAPHYLACTIC TREATMENT AND TEMPERAMENT ON RECEIVING STEERS

INTRODUCTION

Mortality and morbidity losses caused by bovine respiratory disease (BRD) continue to negatively impact the economics of the beef cattle industry. It has been estimated that BRD affects 14% of U.S. feedlot cattle (USDA, 1999) accounting for 70% to 80% of morbidity and 40% to 50% of mortality (Smith, 1998). Stresses from weaning (cow-calf separation, castration, dehorning), shipping (feed and water deprivation) and arrival at a feedlot (changes in diet, climate and social order) can predispose calves arriving at feedlots to BRD infections by impairing their immune system. Therefore to reduce BRD incidence, feedlots can use antibiotics in a metaphylactic capacity when cattle arrive.

Metaphylactic treatment has been shown to reduce the risk of morbidity in calves that are at high risk for BRD (Galyean et al., 1995; Lofgreen, 1983). However, the beneficial responses to the use of metaphylactic antimicrobial products are often variable (Duff et al., 2000), especially in low-risk calves. Furthermore, because sub-clinical BRD can cause significant production losses, impacts of metaphylactic treatments on performance and feed efficiency should also be considered. Methods to determine the sub-populations of arriving feedlot cattle that would benefit most from metaphylactic treatment have not been extensively investigated.

Cattle temperament is associated with stress response and immune function. Growing calves identified as having excitable temperaments by objective measurements have been shown to consume less feed, grow slower (Brown et al., 2005; Voisinet et al., 1997), produce leaner, tougher carcasses (Ribeiro et al., 2007) than calves with calm temperaments. Stress incurred during weaning, shipping, and arrival at a feedlot causes serum cortisol concentrations to increase, suppressing the immune system. Therefore, excitable calves may enter a feedlot with an impaired immune system, increasing their risk of BRD infection. Consequently, metaphylactic treatment in excitable calves may assist their immune system allowing for a better response to metaphylactic therapy when compared to a calm calf's response. Stresses from weaning, shipping and arrival in a feedlot reduce feed intake and change feeding behavior with morbid calves showing a greater reduction in feed intake than healthy calves (Hutcheson and Cole, 1986).

MATERIALS AND METHODS

All animal care and use procedures used in this study were in accordance with guidelines for use of Animals in Agricultural Teaching and Research and were approved by the Texas A&M University Institutional Animal Care and Use Committee.

Animals and Experimental Design

One hundred and nineteen Santa Gertrudis steers with arrival BW and ages of 261.0 ± 23.8 kg and 251.7 ± 15.9 d, respectively, were used in this study. Steers were vaccinated with multivalent viral vaccine (Bovishield 5 Gold, Pfizer Inc, New York City, NY) and a multivalent clostridial bacterin-toxoid (Vision 7, Ivesco LLC, Iowa Falls, IA) at approximately 3 mo of age and again at weaning (October 1 to October 20, 2007). Upon weaning, steers were treated for parasites and fed a receiving diet at the King Ranch feedyard for 28 to 49 d prior to being transported 563 km to the McGregor Research Center. Steers were weighed immediately upon arrival and placed in holding pens overnight with free choice access to hay and water. The next day, steers were weighed, fitted with passive, half-duplex, transponder ear tags (Allflex USA Inc., Dallas-Fort Worth, TX), and randomly assigned within arrival BW strata to control (CON; no antimicrobial treatment) or metaphylactic (MET; 1.5 mL/45 kg BW of ceftiofur crystalline free acid; Pfizer Inc., New York City, NY) treatments. Upon processing, steers were placed in 1 of 2 pens each equipped with 9 GrowSafe® (GrowSafe Ltd, Alberta, Canada) feed bunks. Steers were visually evaluated daily for general signs of sickness; depression, ocular or nasal discharge. Steers observed to have clinical signs of sickness were pulled and treated with antibiotics if rectal temperature exceeded 40° C. Steers were fed a roughage-based ration (Table 4.1) ad libitum, twice daily at 0800 and 1600 during the 28-d receiving period and subsequent 70-d

Table 4.1 Ingredient and chemical composition of the diet fed during the study

Item	
Ingredient	*As-fed basis*
Chopped haygrazer	40.1
Pelleted soybean hulls	19.1
Cracked corn	18.5
Cottonseed hulls	8.05
Cottonseed meal	8.70
Molasses	5.00
Salt	0.40
Vitamin ADE[1]	0.24
Trace mineral[2]	0.013
Drug premix[3]	0.032
Chemical Composition	*Dry matter basis*
Dry matter %	90.9
CP, % DM	11.7
NDF, % DM	48.8
ME, Mcal/kg DM	2.21

[1] Vitamin ADE contained 2,200,000 IU vitamin A/kg, 440,000 IU vitamin D/kg and 52,800 IU vitamin E/kg of product.

[2] Trace mineral contained minimum 19.0% Zn, 7.0% Mn, 4.5% CU, 4,000 ppm Fe, 2,300 ppm I, 1,000 ppm Se and 500 ppm Co.

[3] Drug premix contains 59.0 % Rumensin 80 (containing 176 g of monensin per kg of product) and 61.0 % Tylan 40 (containing 88 g of tylosin per kg of product).

growing period. For the first 6 d of the 28-d receiving period, the neck bars positioned in front of the feed bunks were removed to allow unencumbered access to feed as steers were acclimated to the facilities. On day 7, neck bars were re-installed to enable collection of individual-animal feed intake and behavior data. Thus, individual bunk attendance and feed disappearance data were recorded for days 7 to 28 of the receiving period, and for the entire 70-d growing period.

Data Collection

Steers were weighed at 14-d intervals during the 28-d receiving period and during the 70-d growing period. Subjective and objective assessments of temperament were obtained at processing and on day 28 of the receiving period. Subjective chute scores (CS; scale 1 = non-aggressive to 5 = aggressive) were assigned while the steers were confined in a 0.5 x 3 m weigh chute equipped with load cells that was located prior to entry to the hydraulic working chute. Exit velocity was measured as time taken to transverse a distance of 1.8 m while exiting the cattle chute (Burrow et al., 1988). Exit velocity (m/s) was transformed to relative exit velocity (REV) as the difference of each animal's exit velocity from the mean, divided by the mean exit velocity. Individual animal REV was computed as the average of REV measured at arrival and day 28. Blood samples were collected via jugular venipuncture using 10 mL Vacutioner© serum tubes (Becton, Dickinson and Company, Franklin Lakes, NJ) on day 28 of the receiving period and day 70 of the growing period stored on ice. Blood tubes were allowed to clot at 4 ° C overnight prior to centrifugation at 3,000 x *g* at 4 °C for 20 min. Serum samples were frozen at -20 °C until subsequent analysis. Serum cortisol concentrations were determined in triplicate aliquots using a single antibody RIA procedure adapted from Willard et al. (1995). The inter- and intra-assay CV were 9.8 and 4.91%, respectively. Real-time ultrasound measurements of 12th rib fat thickness (BF) and ribeye area (REA) were measured on days 0 and 70 of the growing trial by a Ultrasound Guidelines Council field certified technician using an Aloka 500-V instrument with a 17-cm, 3.5-MHz transducer (Corometrics Medical Systems Inc., Wallingford, CT). Images were sent to National Centralized Ultrasound Processing laboratory (Ames, IA) for analysis.

Individual daily feed intake and behavior data were omitted from analysis due to system failure (power outage or equipment malfunction), weather or when the proportion of daily feed supply not assigned to individual animals (unassigned feed disappearance) exceeded 5% for a given day. Data for 2 d was omitted for 1 pen during the receiving period, and 6 d for both pens during the growing period. The mean (± SD) of unassigned feed disappearance for the remaining days was 2.3 ± 0.87 and 2.9 ± 1.5% for the receiving and growing periods, respectively. Estimates for missing feed intake data were derived from linear regression of the feed intake on the day of the trial according to Hebart et al. (2004).

The GrowSafe© Intake Analysis software (version 7.17) was used to compute feed intake and feeding behavior traits, which consisted of daily frequencies and durations of feeding bouts (FB) and meal events. An individual FB commenced when the transponder for an animal was first detected and ended when the time between the last 2 transponder readings exceeded 300 s, or when the animal switched feed bunks or was interrupted by another animal, as defined by Gibb and McAllister (1999). To be considered a FB, feed had to be consumed by the animal during the event. Feeding bouts were clustered into meals using a meal criterion of 5 min, which is defined as the longest nonfeeding interval between consecutive FB to be included as part of a meal (Sowell et al. 1998; 1999). Feeding bout and meal durations were computed as the sum of all FB and meal events recorded daily, and FB and meal frequencies as the number of FB and meals recorded each day.

Diet ingredient samples were collected weekly and composited by weight at the end of the study. Moisture analysis was conducted by drying in a forced-air oven for 48 h at 105°C (AOAC, 1995), and chemical analyses of composite feed ingredient samples conducted by an independent laboratory (Cumberland Valley Analytical Services Inc., Hagerstown, MD). Metabolizable energy concentration of the experimental diet was computed using the ingredients' chemical analysis and the Cornell Net Carbohydrate and Protein System (version 5.0, Cornell University, Ithaca, NY; Fox et al., 2004).

Statistical Analysis

Linear regression of 14-d BW on day of trial using the general linear model of SAS (SAS Inst., Cary, NC) was used to estimate initial BW, final BW, ADG, and metabolic BW (MBW; mid-test $BW^{.75}$) of individual steers during the growing period. Moisture analyses of diet ingredient samples were used to compute average daily DMI from feed intake data. Residual feed intake (RFI) was calculated within the two periods as the difference in observed DMI and expected DMI to meet growth and maintenance energy requirements (Koch et al., 1963). Expected DMI was calculated from the regression of DMI on ADG and MBW as follows:

$$Y_j = \beta_0 + \beta_1 \mathrm{MBW}_j + \beta_2 \mathrm{ADG}_j + e_j$$

where Yj is the DMI of the jth bull, β_0 is the regression intercept, β_1 is the partial regression coefficient of MBW, β_2 is the partial regression coefficient of ADG, e_j = uncontrolled error term for the jth steer.

Correlations were examined between performance, feed efficiency, feeding behavior, and carcass composition traits. Data were analyzed using a mixed model that included metaphylactic treatment as a fixed effect, REV as a covariate and the interaction of metaphylactic treatment and REV. An unequal slopes model was fitted to examine possible interactive effects of metaphylactic treatment and temperament classification on dependent variables. Mean separation tests of dependent variables were tested at the mean REV minus one SD (calm steers), mean REV (moderate steers), and mean REV plus one SD (excitable steers) to examine the nature of the metaphylactic treatment X temperament interactions.

RESULTS AND DISCUSSION

Performance during the Receiving Period

During the 28-d receiving period, only 1 steer from the control treatment was classified as morbid and therefore treated with antibiotics. Summary statistics for performance, DMI, feed efficiency, feeding behavior, and carcass ultrasound traits during the 28-d receiving period are presented in Table 4.2. The ADG (1.49 ± 0.30 kg/d) were higher than expected, which likely reflects the shrunk BW obtained the morning following transport at the start of the receiving period. The average DMI recorded during the last 21 d of the receiving period was 7.68 (SD = 1.19) kg/d, and resulted in a G:F of 0.144 (SD = 0.048). The average REV based on exit velocity measured on arrival (3.29 ± 0.84 m/sec) and on day 28 of the study (3.33 ± 1.07 m/sec) was 0.0 (SD = 0.26). Relative exit velocity was used throughout the analysis to classify animal temperament. The average daily frequencies of FB and meals were 90.3 (SD = 14.7) and 15.3

(SD = 3.9) events/d, while the average durations of the daily FB and meal events were 92.6 (SD = 23.5) and 200.3 (SD = 31.4) min/d, respectively.

During the receiving period, ADG was positively correlated ($P < 0.05$) with DMI and G:F, such that steers with higher ADG consumed more feed and had higher G:F than steers with lesser ADG (Table 4.3). Dry matter intake was positively correlated ($P < 0.05$) with RFI, and as expected, G:F was negatively correlated ($P < 0.05$) with RFI. Relative exit velocity was negatively correlated ($P < 0.05$) with DMI and ADG, indicating that steers with calm temperaments consumed more feed and had higher ADG than steers with excitable temperaments. Chute scores and serum cortisol concentrations were weakly correlated ($P < 0.05$) in a negative manner with ADG, but not DMI during the receiving period (Table 4.3). Relative exit velocity was negatively correlated ($P < 0.05$) with initial BW such that steers with more excitable temperaments had lower initial BW than steers with calm temperaments. Even though steers with excitable temperaments had lower DMI and ADG than calm steers, feed efficiency traits were not correlated with temperament during the receiving period. Previous research has documented similar trends in cattle with excitable temperaments in that they did not perform as well as cattle with calm temperaments. Compared to cattle with calm temperaments, Voisnet et al. (1997) found that cattle with excitable temperaments had lower ADG, and Elzo et al. (2009) found that cattle with excitable temperaments had lower DMI. Fox (2004) found that exit velocity of growing bulls was negatively correlated with both ADG and DMI. Petherick et al. (2002) found steers having excitable temperaments had lesser body condition scores and dressing percentage. Vann et al. (2008) found as exit velocity increased final BW, ADG, and net profits decreased while cost of medical treatment had increased. In a multi-year study utilizing 21,528 cattle, Reinhardt et al. (2009) found that cattle with higher disposition scores had lesser ($P < 0.05$) initial and final BW, ADG, carcass weight, yield grade, quality grade, marbling score, and higher mortality rates. Fell et al. (1999) using cattle selected for calm or excitable temperaments by exit velocity and other methods found that cattle with excitable temperaments had lower ADG, higher serum cortisol concentrations, and greater morbidity rates.

Table 4.2 Summary statistics of performance, feed efficiency and ultrasound composition traits of steers during the 28-d receiving period

Trait[1]	Mean	SD	Min	Max
Initial age, d	251.7	15.9	215.0	282.0
Initial BW, kg	261.0	23.8	208.2	312.7
BW (day 28), kg	302.7	27.7	239.1	368.2
ADG, kg/d	1.49	0.30	0.71	2.21
DMI[2], kg/d	7.68	1.19	4.56	10.3
G:F[2], kg/kg	0.144	0.048	0.069	0.282
RFI[2], kg/d	0.00	1.09	-2.50	2.30
Relative exit velocity[3]	0.00	0.26	-0.64	0.62
Chute score[3]	1.79	0.27	1.00	4.50
Feeding bout frequency[2], events/d	90.3	14.7	55.9	123.3
Meal frequency[2], events/d	15.3	3.98	7.05	25.9
Feeding bouts per meal[2]	6.24	1.69	3.56	10.9
Feeding bout duration[2], min/d	92.6	23.5	38.1	146.9
Meal duration[2], min/d	200.3	31.4	110.5	278.1
BF (day 28), cm	0.33	0.09	0.19	0.73
LMA (day 28), cm^2	48.5	6.41	7.85	60.9
Serum cortisol (day 28), ng/mL	4.38	1.33	1.00	7.69

[1] RFI = residual feed intake; BF = back fat thickness at 12th rib; LMA = longissimus muscle area.

[2] Intake, feed behavior and efficiency traits were measured during the last 21 d of the receiving period.

[3] Relative exit velocity is the average of REV on arrival (3.29 ± 0.84 m/sec) and day 28 (3.33 ± 1.07 m/sec); chute score is the average of CS on arrival (2.16 ± 1.06) and day 28 (1.43 ± 0.67).

Table 4.3 Correlations among performance, feed efficiency and temperament traits in steers during the 28-d receiving period

Trait[1]	ADG	DMI[2]	G:F[2]	RFI[2]	REV[3]	CS[3]	Cortisol[4]
Initial BW	0.32*	0.30*	-0.12	-0.09	-0.34*	-0.14	-0.18*
ADG		0.46*	0.21*	0.05	-0.37*	-0.22*	-0.21*
DMI[2]			-0.45*	0.92*	-0.25*	-0.18	-0.17
G:F[2]				-0.47*	0.13	0.07	0.15
RFI[2]					-0.09	-0.11	-0.09
REV[3]						0.33*	0.40*
CS[3]							0.29*

[1] RFI = residual feed intake.

[2] Feed intake, feed behavior and efficiency traits were measured during the last 21 d of the receiving period.

[3] REV = Relative exit velocity is the average of REV on arrival (3.29 ± 0.84 m/sec) and day 28 (3.33 ± 1.07 m/sec); CS = chute score is the average of CS on arrival (2.16 ± 1.06) and day 28 (1.43 ± 0.67).

[4] Serum cortisol concentration on day 28.

*Correlations are different from zero at $P < 0.05$.

Due to the significant correlations between REV and ADG and DMI during the receiving period, REV was used as a covariate to examine the effects metaphylactic treatment on performance, feed efficiency and feeding behavior traits during the receiving period (Table 4.4). Compared to CON, steers that received the MET treatment had higher ADG during the first 14-d ($P < 0.02$) and the entire 28-d receiving period ($P < 0.03$), but not the last 14-d of the receiving period. There was a tendency ($P < 0.06$) for the REV covariate to interact with treatment for DMI during the last 21 d of the receiving period, with the reduction in DMI associated with higher REV being greater for control steers than for steers that received the MET treatment (Figure 4.1). Gain to feed ratio was not impacted by treatment or the treatment by REV covariate interaction. However, there was a significant treatment by REV interaction for RFI, indicating that RFI decreased as REV increased in control steers, but not in MET-treated steers. Meal frequency was not affected by treatment or REV during the receiving period, whereas, FB frequency increased as REV increased in MET-treated steers but not in the control steers (Table 4.4). For steers with excitable temperaments (1 SD above mean REV), FB frequency was higher in MET-treated than control steers (Figure 4.1). The number of FB per meal and FB duration were affected by REV such that steers with higher REV had greater number of FB per meal and longer FB duration than steers with lesser REV. However, treatment and treatment x REV were not significant for number of FB per meal or FB duration. The interaction between treatment and REV was significant for daily meal duration with meal duration decreasing as REC increased in control steers but not MET treated steers (Figure 4.2). These results suggest that negative associations of temperament on the frequency and duration of feeding behavior traits and DMI were less pronounced in MET-treated steers than control steers. Duff et al. (2000) in one experiment found that DMI increased in low-risk calves that received metaphylactic treatment. In a second experiment, Duff et al. (2000) found an increase in ADG for the first 14 d and a tendency for receiving period (d 0 to 28) ADG to increase in metaphylactic treated cattle at low risk for BRD. It has been reported that healthy cattle visit feed bunks more often and consume feed for longer amounts of time compared to sick cattle (Daniels et al., 2000; Sowell et al., 1999).

Table 4.4 Regression coefficient estimates (± SE) for regression of growth performance, intake, temperament, feeding behavior traits and carcass ultrasound composition on metaphylactic treatment and temperament by metaphylactic treatment interaction in steers during 28-d receiving period[1]

	ß$_0$		ß$_1$					TRT x REV[3]
Item	Control	MET	Control	MET	RMSE	TRT $P > F$	REV[3] $P > F$	$P > F$
Initial BW, kg	261.7 ± 2.91	260.4 ± 2.91	-29.3 ± 11.0*	-34.0 ± 11.0*	22.6	0.98	0.0001	0.77
BW (day 28), kg	301.9 ± 3.24	303.6 ± 2.30	-44.0 ± 13.0*	-43.8 ± 12.5*	25.5	0.71	0.0001	0.99
ADG (day 0 to 14), kg/d	1.85 ± 0.06	2.06 ± 0.06	-0.89 ± 0.25*	-0.67 ± 0.24*	0.49	0.02	0.0001	0.52
ADG (day 14 to 28), kg/d	1.02 ± 0.05	1.03 ± 0.05	-0.16 ± 0.19	-0.026 ± 0.18	0.37	0.87	0.47	0.61
ADG (day 0 to 28), kg/d	1.43 ± 0.04	1.54 ± 0.04	-0.53 ± 0.14*	-0.35 ± 0.14*	0.28	0.03	0.0001	0.37
DMI[2], kg/d	7.57 ± 0.15	7.80 ± 0.15	-1.89 ± 0.58*	-0.37 ± 0.56	1.14	0.27	0.006	0.06
G:F, kg/kg	0.145 ± 0.006	0.141 ± 0.006	0.014 ± 0.023	0.026 ± 0.022	0.045	0.57	0.20	0.70
RFI[2], kg/d	-0.10 ± 0.14	0.10 ± 0.14	-1.14 ± 0.55*	0.38 ± 0.53	1.08	0.31	0.32	0.05
Feeding bout frequency[2], events/d	89.4 ± 1.88	91.3 ± 1.87	-5.87 ± 7.41	15.5 ± 7.09*	14.5	0.47	0.35	0.04
Meal frequency[2], meals/d	15.1 ± 0.52	15.5 ± 0.52	-2.02 ± 2.04	-1.60 ± 1.95	4.00	0.53	0.20	0.88
Feeding bouts per meal[2]	6.32 ± 0.22	6.18 ± 0.22	0.48 ± 0.85	1.81 ± 0.82*	1.67	0.64	0.05	0.26
Feeding bout duration[2], min/d	90.9 ± 2.99	94.3 ± 2.97	-27.7 ± 11.7*	-15.0 ± 11.2	23.0	0.42	0.01	0.44
Meal duration[2], min/d	197.5 ± 3.98	203.2 ± 3.95	-45.3 ± 15.6*	1.33 ± 14.9	30.6	0.31	0.04	0.03
BF (day 28), cm	0.32 ± 0.01	0.35 ± 0.01	-0.11 ± 0.05*	-0.07 ± 0.04	0.09	0.14	0.005	0.53
LMA (day 28), cm^2	48.8 ± 0.69	48.9 ± 0.68	-0.42 ± 2.69	-0.19 ± 2.57	5.26	0.92	0.87	0.95
Serum cortisol (day 28), ng/mL	4.54 ± 0.16	4.21 ± 0.16	0.636 ± 0.181	0.541 ± 0.172	0.353	0.15	0.0001	0.63

[1] RFI = residual feed intake; BF = back fat thickness at 12th rib; LMA = longissimus muscle area; MET = metaphylactic antimicrobial therapy; TRT = metaphylactic antimicrobial treatment.

[2] Intake, feed behavior and efficiency traits were measured during the last 21 d of the receiving period.

[3] REV = Relative exit velocity is the average of REV on arrival (3.29 ± 0.84 m/sec) and day 28 (3.33 ± 1.07 m/sec).

[*] Regression coefficients are different from zero at $P \leq 0.05$.

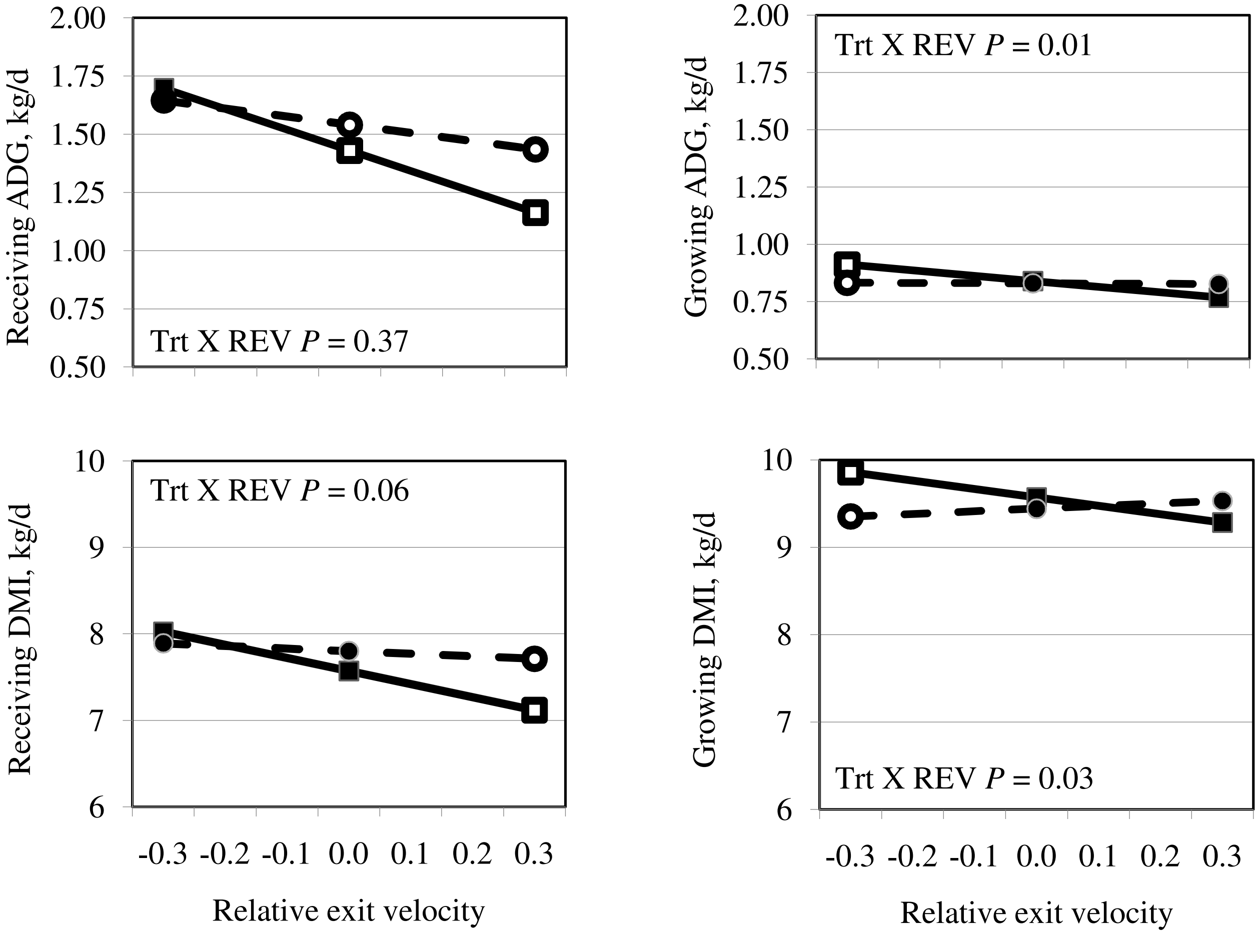

Figure 4.1. Effects of metaphylactic treatment (CON = ——, MET = – – –) and temperament (± 1 SD from mean REV) on ADG and DMI in steers during the receiving and growing periods. TRT = Control vs metaphylactic treatment; REV = relative exit velocity; Open symbols signify that treatment means differed at $P < 0.05$.

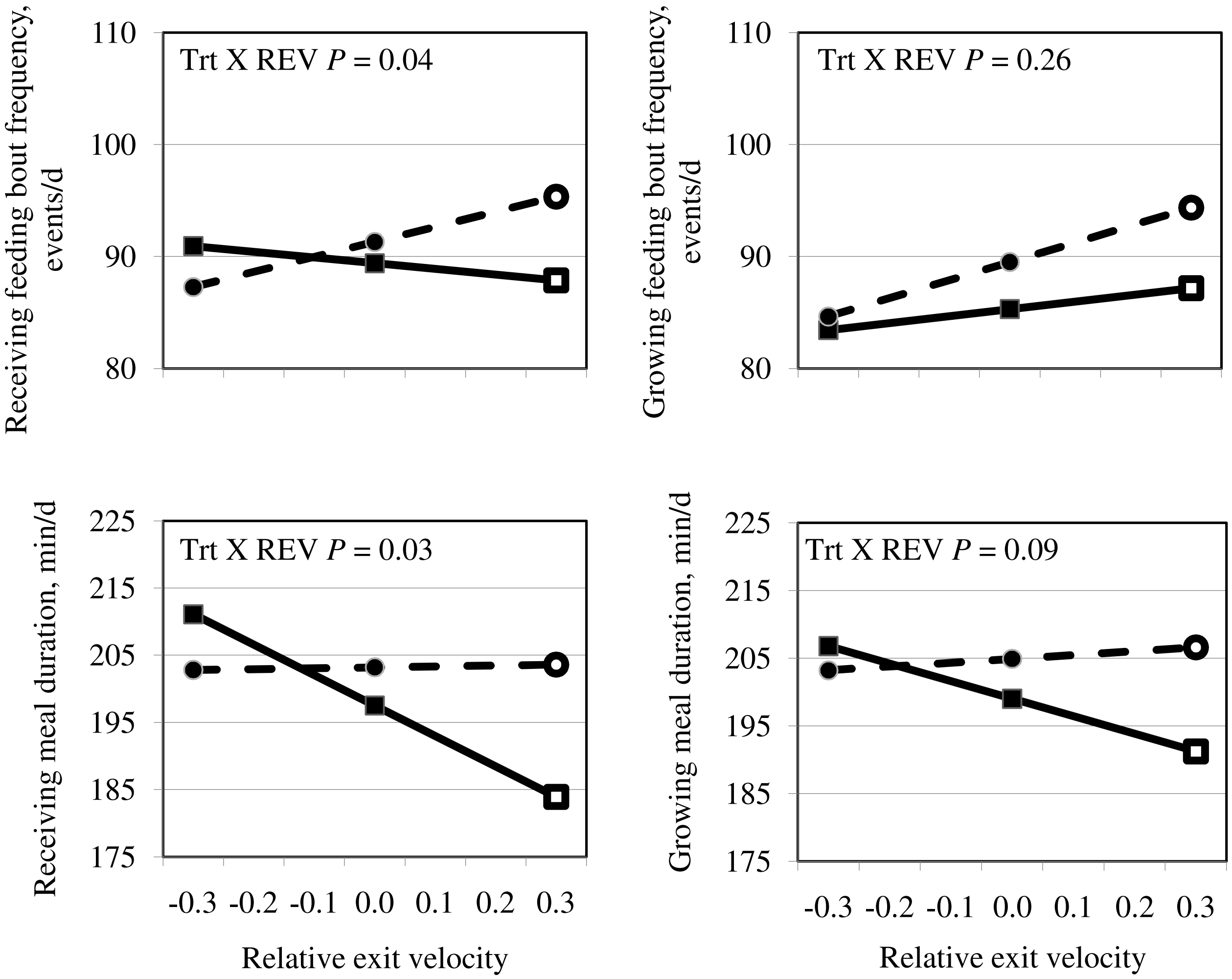

Figure 4.2. Effects of metaphylactic treatment (CON = ——, MET = – – –) and temperament (± 1 SD from mean REV) on feeding behavior traits in steers during the receiving and growing periods. TRT = Control vs metaphylactic treatment; REV = relative exit velocity; Open symbols signify that treatment means differed at $P < 0.05$.

Performance during the Growing Period

Summary statistics for performance, feed intake, feed efficiency, feeding behavior, and carcass ultrasound composition during the 70-d growing period are presented in Table 4.5, and phenotypic correlations between performance and temperament traits presented in Table 4.6. Average daily gain during the growing period (0.83 ± 0.16 kg/d) were lower than during the receiving period, but expected given the ME value of the diet. Dry matter intake was 9.5 (SD = 1.00) kg/d resulting in a G: F of 0.088 (SD = 0.016). Feeding bouts and meal events were 87.9 (SD = 14.9) and 15.5 (SD = 3.35) events/d, while FB and meal durations were 93.6 (SD = 21.5) and 202.0 (SD = 26.8) min/d, respectively. The phenotypic correlations between growth, DMI and the feed efficiency traits during the 70-d growing period were comparable to those observed during the 28-d receiving period.

Average daily gain during the growing period continued to be negatively correlated ($P < 0.05$) with REV and chute scores, which were measured on arrival and on day 28 of the receiving period. In contrast to what was observed during the receiving period, DMI during the growing period was no longer significantly correlated with either of the temperament traits.

Steers with higher REV had lower ($P < 0.05$) ADG, similar DMI and lower G:F during the growing period compared to steers with lower REV. The frequency of daily feeding bouts was greater in steers with excitable temperaments. REV did not affect daily meal frequency, but the number of FB per meal was higher ($P < 0.05$) in steers with higher REV compared to steers with lower REV. At the end of the 70-d growing period, steers with higher REV tended ($P < 0.10$) to have less BF thickness and LMA compared to steers with lower REV. Similar to the results found during the 28-d receiving period, steers with higher REV had higher ($P < 0.01$) serum cortisol concentrations than steers with lower REV at the end of the 70-d growing period. It has been documented that cattle with excitable temperaments grow slower and consume less feed than cattle with calm temperaments (Brown et al., 2005; Fox, 2004; Petherick et al., 2002; Voisinet et al., 1997), however we did not see this effect on DMI.

While ADG, DMI and G:F during the 70-d growing period were not affected by treatment, there were significant interactions between MET treatment and temperament on

Table 4.5 Summary statistics of performance, feed efficiency, feeding behavior, and ultrasound composition traits of steers during the 70-d growing period

Trait[1]	Mean	SD	Min	Max
No. of animals	119	-	-	-
BW (day 28), kg	309.1	28.2	242.9	371.5
BW (day 70), kg	367.4	32.8	287.2	449.7
ADG, kg/d	0.83	0.16	0.41	1.27
DMI, kg/d	9.50	1.00	6.75	12.9
G:F, kg/kg	0.088	0.016	0.043	0.137
RFI, kg/d	0.00	0.87	-2.06	3.19
Feeding bout frequency, events/d	87.9	14.9	47.4	126.7
Meal frequency, events/d	15.5	3.35	8.34	24.0
Feeding bouts per meal[2]	5.90	1.52	3.13	10.6
Feeding bout duration, min/d	93.6	21.5	43.8	141.6
Meal duration, min/d	202.0	26.8	129.8	280.0
BF (day 70), cm	0.47	0.13	0.28	1.07
LMA (day 70), cm^2	60.1	6.63	44.7	76.2
Serum cortisol (day 70), ng/mL	4.48	1.61	1.23	8.74

[1] RFI = residual feed intake; BF = back fat thickness at 12th rib; LMA = longissimus muscle area.

Table 4.6. Correlations among performance, feed efficiency and temperament traits in steers during the 70-d growing period

Trait[1]	ADG	DMI	G:F	RFI	REV[2]	CS[2]	Cortisol[3]
Initial BW	0.23*	0.37*	0.04	0.00	-0.41*	-0.17	-0.40*
ADG		0.43*	0.84*	0.00	-0.24*	-0.26*	-0.28*
DMI			-0.10	0.85*	-0.09	-0.06	-0.12
G:F				-0.50*	-0.20*	-0.25*	-0.23*
RFI					0.12	0.09	0.11
REV[2]						0.33*	0.50*
CS[2]							0.33*

[1] RFI = residual feed intake.

[2] REV = Relative exit velocity is the average of REV on arrival (3.29 ± 0.84 m/sec) and day 28 (3.33 ± 1.07 m/sec); CS = chute score is the average of CS on arrival (2.16 ± 1.06) and day 28 (1.43 ± 0.67).

[3] Serum cortisol concentration on day 70.

*Correlations are different from zero at $P < 0.05$.

performance (Table 4.7). Significant differences in the ß$_1$ of ADG and DMI show that steers with higher REV receiving CON had a greater decrease in ADG and DMI than steers with higher REV receiving MET. There was a tendency for the interaction between MET treatment and REV for the duration of meal events during the growing period. The decrease in meal event duration associated with an increase in REV was more evident in CON compared to MET steers. Metaphylactic treatment did not affect ultrasound measurements of BF and LMA at the end of the growing period. The interactions seen in performance traits demonstrate a carryover effect from use of MET upon arrival in low risk cattle with higher REV.

Published literature into effects of metaphylactic treatment throughout a receiving and subsequent growing period have yielded positive results on performance, feed intake and efficiency when steers were at higher risk for BRD (Galyean et al., 1995; Lofgreen, 1983). However, we did not observe any of these effects from metaphylactic treatment on performance, feed intake and efficiency during the subsequent 70-d growing period in our low risk steers.

When subjective chute scores were used to assess temperament, similar interactive effects between MET treatment and temperament were detected for most of the performance traits (data not shown). In general, REV was more effective than chute scores to assess the effects of temperament on performance responses to MET treatment. Interestingly, correlations of the same traits between the receiving and growing period, presented in Table 4.8, showed ADG, DMI, RFI and feeding behavior traits to be moderate to highly correlated suggesting performance, feed efficiency, and feeding behavior during the receiving period is maybe predictive of subsequent growing period traits.

In addition, we observed a MET treatment by temperament interaction that has not been examined in past research. Our research, showing excitable cattle benefited more from MET, supports research demonstrating that cattle with excitable temperaments are more likely to be stressed and have depressed immune systems (Duff and Galyean, 2007; Merlot et al., 2004; Oliphint, 2006). Furthermore, healthy cattle have been shown to visit feed bunks more often and consume feed for longer amounts of time compared to sick cattle

Table 4.7 Regression coefficient estimates (± SE) for regression of growth performance, intake, temperament, feeding behavior traits and carcass ultrasound composition on metaphylactic treatment and temperament by metaphylactic treatment interaction in steers during 70-d growing period[1]

	Intercepts		Slopes					
Item	Control	MET	Control	MET	RMSE	TRT *P* > *F*	REV[2] *P* > *F*	TRT x REV[2] *P* > *F*
Final BW (day 70), kg	367.3 ± 3.87	367.6 ± 3.84	-65.5 ± 15.2*	-44.0 ± 12.7*	29.7	0.98	0.0001	0.33
ADG, kg/d	0.84 ± 0.02	0.83 ± 0.02	-0.30 ± 0.08*	-0.01 ± 0.08	0.16	0.66	0.006	0.01
DMI, kg/d	9.57 ± 0.13	9.44 ± 0.13	-1.20 ± 0.50*	0.37 ± 0.48	0.99	0.50	0.23	0.03
G:F, kg/kg	0.088 ± 0.002	0.088 ± 0.002	-0.020 ± 0.008*	-0.004 ± 0.007	0.02	0.94	0.03	0.14
RFI, kg/d	0.05 ± 0.11	-0.05 ± 0.11	-0.07 ± 0.44	0.83 ± 0.42*	0.86	0.53	0.22	0.14
Feeding bout frequency, events/d	85.3 ± 1.88	89.5 ± 1.87	7.20 ± 7.38	18.7 ± 7.08*	14.5	0.12	0.01	0.26
Meal, events/d	15.3 ± 0.44	15.6 ± 0.44	-2.25 ± 1.72	0.15 ± 1.64	3.37	0.72	0.38	0.34
Feeding bouts per meal[2]	5.91 ± 0.20	5.88 ± 0.20	1.35 ± 0.77	1.29 ± 0.73	1.50	0.93	0.01	0.96
Feeding bout duration, min/d	94.1 ± 2.74	93.1 ± 2.71	-26.5 ± 10.7*	-16.49 ± 10.3	21.0	0.80	0.005	0.50
Meal duration, min/d	199.0 ± 3.46	204.9 ± 3.43	-25.9 ± 13.5*	5.66 ± 13.0	26.5	0.23	0.28	0.09
BF (day 70), cm	0.47 ± 0.02	0.47 ± 0.02	-0.09 ± 0.07	-0.07 ± 0.06	0.13	0.85	0.09	0.88
LMA (day 70), cm^2	60.0 ± 0.86	60.0 ± 0.85	-5.95 ± 3.35	-2.43 ± 3.21	6.57	0.96	0.07	0.45
Serum cortisol (day 70), ng/mL	4.55 ± 0.18	4.32 ± 0.18	0.90 ± 0.21	0.87 ± 0.20	0.41	0.63	0.0001	0.97

[1] RFI = residual feed intake; BF = back fat thickness at 12th rib; LMA = longissimus muscle area; MET = metaphylactic antimicrobial therapy; TRT = metaphylactic antimicrobial treatment.

[2] REV = Relative exit velocity is the average of REV on arrival (3.29 ± 0.84 m/sec) and day 28 (3.33 ± 1.07 m/sec).

*Regression coefficients are different from zero at $P \leq 0.05$.

Table 4.8 Correlations among performance, feed efficiency, temperament, and feed behavior traits in steers between 28-d receiving and 70-d growing period

Item[1]	Correlation coefficient	*P* > *F*
ADG, kg/d	0.23	0.01
DMI, kg/d	0.58	0.001
G:F, kg/kg	0.03	0.74
RFI, kg/d	0.42	0.001
Relative exit velocity[2]	0.64	0.001
Chute score[2]	0.50	0.001
Feeding bout frequency, events/d	0.75	0.001
Meal frequency, events/d	0.77	0.001
Feeding bouts per meal[2]	0.78	0.001
Feeding bout duration, min/d	0.82	0.001
Meal duration, min/d	0.79	0.001
Serum cortisol[3], ng/mL	0.61	0.001

[1] RFI = residual feed intake.

[2] Correlations between relative exit velocities during receiving (average of arrival and day 28) and day 70 of the growing period.

[3] Correlation between serum cortisol concentrations at days 28 and 70.

(Daniels et al., 2000; Sowell et al., 1999). Our results showed that excitable cattle receiving MET treatment tended to spend more time at the feed bunks suggesting that the excitable MET steers were in a better health status than the excitable CON.

IMPLICATIONS

Public concerns over antibiotic resistance and high drug costs have brought the use of mass metaphylactic treatments into question. Process-control strategies that quantify and manage inter-animal variation in calf temperament may facilitate more judicious use of antimicrobial products and provide more consistent and predictable responses to metaphylactic strategies, thereby improving the cost-to-benefit relationship and subdue public health concerns of use of the drugs.

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