The effect of treatment with long-acting antibiotic at postweaning movement on respiratory disease and on growth in commercial dairy calves

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ABSTRACT

Bovine respiratory disease (BRD) is a major concern when raising replacement heifers because of the high incidence and long-term effects of this disease, such as decreased growth and increased time to first calving. The objective of this study was to determine the effect of tulathromycin (TUL) treatment at postweaning movement on the incidence of BRD in dairy replacement heifers. A total of 1,395 heifers were enrolled between November 2006 and June 2007 at a commercial heifer-raising facility. Calves were randomly assigned either to treatment with TUL or to a positive control group treated with oxytetracycline (TET). Calves treated with TUL were 0.5 times (95% CI: 0.4 to 0.7) less likely to be treated for BRD in the 60 d following enrollment than calves treated with TET. For calves that had no history of BRD in the pre-enrollment period, TET calves weighed 4.9 ± 0.5 kg less than TUL calves after 6 wk in group housing. If calves were treated for BRD in the pre-enrollment period, there was no treatment effect on growth. Calves with clinical BRD in the 60 d following movement weighed 7.9 ± 0.6 kg less than calves without BRD after 6 wk in group housing. Treatment with TUL at the time of movement to group housing had a beneficial effect on the health and performance through the prevention of BRD in dairy calves with no prior history of the disease. Moreover, BRD after movement to group housing after weaning had a significant effect on the growth of dairy calves.

Key words: antibiotic, weaning, respiratory disease, heifer

INTRODUCTION

Dairy replacement heifers undergo numerous challenges from birth until they enter the lactating herd, with many of these challenges coinciding with management changes. In the North American dairy industry,

preweaned dairy heifers are raised primarily in individual housing and after weaning are primarily housed in groups (USDA, 2007a). Potential stressors involved in this move from individual to group housing include social, environmental, transportation, and nutritional changes. The environmental stressors include increased pathogen exposure and temperature changes. If calves are required to mount a prolonged response to these multiple stressors, suppression of their immune response and disease outbreaks can occur (Carroll and Forsberg, 2007). Bovine respiratory disease (BRD) is the primary disease to which calves are susceptible at this time.

In cattle, BRD is a complex of disease processes most commonly resulting from infection with various microorganisms, including *Pasteurella multocida*, *Mannheimia hemolytica*, and *Mycoplasma* spp. The development of BRD is typically initiated by an environmental stressor and viral infection, which weakens the resistance mechanisms of the lungs and allows bacterial colonization of the lung (Yates, 1982). In an Ontario study, 15% of calves were treated for pneumonia before weaning (Waltner-Toews et al., 1986a). In a Minnesota study, the case fatality rate for BRD was about 9% (Sivula et al., 1996). The direct costs of treatment and prevention of this disease have been estimated at US\$14.71 per calf per year in milk-fed calves, as well as \$1.95 per calf per year in replacement heifers and \$9.08 per cow per year over the entire herd (Kaneene and Scott Hurd, 1990; Miller and Dorn, 1990). These studies were not able to take into account the indirect costs of this disease, which include an increased risk of culling or death before entry into the milking herd or the losses associated with delayed entry into the milking herd (Waltner-Toews et al., 1986b). Important control measures include vaccinating cows against the causal organisms, ensuring excellent colostrum management, and minimizing acute and chronic stressors such as poor ventilation, mixing of groups, overcrowding, and poor nutrition (Kahn, 2005). However, at weaning or first movement, some of these stressors cannot be avoided. As such, calves are placed at increased risk of developing BRD and additional steps may be necessary to prevent BRD.

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In 1999, 27% of small beef feedlots and 81% of large feedlots in the United States were administering an injectable antimicrobial metaphylactically to feedlot cattle for the prevention of respiratory disease (USDA, 2000). A meta-analysis of field trials indicated that for feedlot calves, the administration of oxytetracycline or tilmicosin on the day of arrival at the feedlot consistently reduced morbidity rates attributable to BRD (Van Donkersgoed et al., 1993). The movement of beef cattle into a feedlot is comparable to the movement of dairy calves from individual to group housing in that they experience similar potential stressors, including nutritional and social changes, transportation, and increased disease exposure. However, the management systems and the age and size of the animals are different between beef and dairy calves. As such, research into the use of injectable antimicrobials at the time of calf movement to prevent BRD in weaned dairy calves is necessary to determine the efficacy of this approach in the context of a dairy replacement heifer management system.

The objective of this randomized blinded clinical trial was to compare the effects of tulathromycin under commercial conditions on calf health and performance to an existing oxytetracycline treatment. Tulathromycin (Draxxin, Pfizer Animal Health Group, New York, NY) is a tiamilide compound, a subclass of macrolide long-acting antimicrobials. It is distinguished by maintaining therapeutic concentrations against pathogens commonly associated with BRD for up to 10 d (Nowakowski et al., 2004). Tulathromycin is approved for treatment and control of BRD in beef cattle and nonlactating dairy cattle. Tulathromycin has been shown to be effective in the treatment of BRD in 3- to 9-wk-old calves challenged with *Mycoplasma bovis* (Godinho et al., 2005, 2007). Oxytetracycline is a broad-spectrum tetracycline antibiotic that maintains therapeutic concentrations against pathogens associated with BRD for 3 d (Biomycin 200, Boehringer Ingelheim Vetmedica Inc., St. Joseph, MO). Oxytetracycline is approved for use in beef and dairy cattle. The hypothesis for this study was that administration of tulathromycin at a time of high risk of BRD would reduce the pathogen challenge and the risk of clinical respiratory disease in the weeks following a postweaning movement and housing change in dairy calves.

MATERIALS AND METHODS

Heifer Management and Housing

This study was conducted at a commercial contract heifer raising facility in New York State. Enrollment in

the study occurred between November 2006 and June 2007, with a total of 1,395 heifers being enrolled.

Heifer calves arrived at the farm from 7 commercial dairy farms at 1 to 5 d of age. Upon arrival at the facility, each calf was processed according to a standard farm protocol and was then moved to individual housing in a naturally ventilated nursery barn or an outdoor hutch. The farm protocol included the identification of any congenital abnormalities, measurement of serum total protein, tail docking, and the collection of a tissue sample for the detection of persistent infection with bovine viral diarrhea (BVD). Over the course of this study, no animal tested positive for BVD. Calves were vaccinated at 2 and 4 wk of age with an intramuscular modified live vaccine against infectious bovine rhinotracheitis, BVD type 1 and type 2, bovine respiratory syncytial virus, and parainfluenza-3 virus (Vista-5, Intervet Schering-Plough Animal Health, Boxmeer, the Netherlands).

Preweaned calves were fed 4 L of milk replacer (Excel Calf Milk Replacer 26/18, Grober Nutrition, Cambridge, Ontario, Canada) twice daily and had access to ad libitum calf starter and water. Weaning from milk replacer was initiated at 5 wk and completed at 6 wk of age. Calves remained in their original individual housing for approximately 2 wk after weaning, at which time they were moved to group housing in the weaning barn and enrolled in the trial. Calves that were moved to group housing after 80 d of age were excluded from this trial. A schematic representation of the trial methods and events is shown in Figure 1.

For the first 6 wk of the study, calves were housed in the weaning barn in groups of 8 to 10 calves. For the initial 3 to 4 wk in the weaning barn, calves received dry hay and pelleted heifer grain ad libitum. Calves were then transitioned onto a TMR. After approximately 6 wk in the weaning barn, calves were moved to the transition barn and housed in groups of approximately 50 calves.

Study Treatments

Before the start of the study, the farm had a pre-existing treatment protocol at movement. As such, the current study was designed as a positive control trial, with calves being assigned to treatment with tulathromycin (TUL) or the previously established oxytetracycline protocol (TET). Each calf was assigned to treatment group using a systematic random assignment method based on the unique identification number assigned to each calf on arrival, determined by their order of arrival at the farm. All TUL calves were injected with 2.0 mL of tulathromycin (Draxxin, Pfizer

Figure 1. Timeline of trial events.

Animal Health Group) by subcutaneous injection on the day of movement to group housing. Draxxin is a semi-synthetic macrolide antibiotic, containing 100 mg of tulathromycin per milliliter. All TET calves received 5.0 mL of oxytetracycline (Biomycin 200, Boehringer Ingelheim, St. Joseph, MO) intramuscularly on the day of movement to group housing. Biomycin 200 is a tetracycline antibiotic containing 200 mg of oxytetracycline per milliliter. The standard dose for TUL was determined based on the weight of the upper quartile of calves (78 kg) at enrollment. The dose of TET was part of the established weaning management protocol on the farm and was two-thirds of a full label dose. During the study, no antibiotics were administered in the feed or water. The 2 trial treatments were very different in appearance and volume used; therefore, the farm staff members responsible for administration of treatment at the time of enrollment were not blinded to treatment assignment. However, the decision as to which drug to administer was predetermined. As such, randomization to treatment group was not influenced by preconceived bias of the farm staff. Outcomes, such as detection of BRD and follow-up weight measurements, were assessed by a different set of staff members than those administering the treatment at enrollment, who were blind to treatment group allocation.

The distribution of calves in the TET and TUL groups within a pen of 10 calves in the weaning barn

was random, based upon the order in which calves were processed. Pens were open-sided. Thus, nose-to-nose and oral contact was possible between pens.

Outcome Measures

All calves were monitored daily in the nursery, weaning, and transition barns by trained barn staff for the occurrence of disease, using consistent case definitions. All disease events and treatments were recorded in the farm management database (DairyComp 305, Valley Agricultural Software Inc., Tulare, CA). The farm staff recorded fever and respiratory disease as 2 separate events. Fever was defined as an animal that was dull, off-feed, listless, with a rectal temperature $>39.5^{\circ}\text{C}$ and normal respiratory rate with no nasal discharge; respiratory disease was defined as the animal being dull, listless, with elevated respiratory rate, nasal discharge, or both. However, for the purpose of this trial, we combined these 2 diseases into one category called BRD. This approach was based on the likelihood that these 2 events are the same disease at different stages or represent animals with a slightly different clinical presentation of the same underlying condition. All calves in individual housing were treated for disease in accordance with the previously established treatment protocols of the farm. Calves were not eligible for BRD treatment for 5 d after the experimental treatment. Group-housed

Table 1. Disease variables considered in models for weight, height, and risk of bovine respiratory disease (BRD)

Disease event	Clinical signs
BRD	Dull and listless with a rectal temperature $>39.5^{\circ}\text{C}$, and/or elevated respiratory rate and/or nasal discharge
Scours	Feces are soft and do not hold form
Otitis media	One or both ears are drooping or head is tilted and calf is unable to correct position
Lameness	Abnormal gait with unknown cause
Navel ill	Navel is swollen or tender in newborn calf

animals identified with BRD were treated with ceftiofur crystalline suspension (Excede Sterile Suspension, Pfizer Animal Health Group) administered at the base of the ear, according to label instructions.

All calves were weighed upon arrival at the farm, upon enrollment in the study (approximately 8 wk of age), and at 6 wk after enrollment. Height at the withers (to the nearest inch) was measured at the same times as weight.

Farm staff performed a gross necropsy for those calves with signs of BRD that died during the first 6 wk post-enrollment. To complete this gross postmortem examination, specific digital images of the heart, lung, intestines, and trachea were taken. These images, along with a case history, were sent electronically to a pathologist at the University of Guelph (Ontario, Canada) for a morphological diagnosis. Calves that died as a result of a known problem such as physical injury or were culled from the herd did not have a necropsy performed. If necropsy results were not available, staff-designated clinical findings and diagnosis were used as the most likely cause of death.

Statistical Analysis

All analyses were performed using SAS statistical software (SAS Institute Inc., Cary, NC). Descriptive statistics and residual diagnostics were performed using Proc Freq and Proc Univariate procedures. Regression analyses were conducted using a mixed linear model (Proc Mixed) for height and weight at exit from the weaning barn, and a generalized linear mixed model with a logit-transform (Glimmix) was used to analyze the probability of BRD in the first 60 d post-enrollment. The effects of treatment and BRD on weight and height were modeled separately. The models for weight controlled for enrollment weight and age at exit measurement. The models for height controlled for enrollment height and age at exit measurement. Clustering by weekly enrollment cohort and farm of origin were included in all models as random effects. Disease variables considered for analysis are described in Table 1. In preliminary analysis, pre-enrollment disease events were divided into 2 time periods, with the disease occurring either 2 wk before enrollment (between weaning

and enrollment) or from birth to 2 wk before enrollment (weaning). Variables that were significant were found to be of similar magnitude and direction in the model; as such, these time periods were combined into one pre-enrollment category. All variables that were potentially associated ($P < 0.2$) with the outcomes in univariate analyses were included in the final model and removed by backward step-wise elimination based on partial F -tests, or multiple partial F -tests, with a P -value < 0.05 . Confounding was assessed if the exclusion of a variable changed the remaining parameter estimates by 30%. Disease variables were tested for potential interactions with treatment. All data were assessed for the assumption of normality. Weight and height models did not include calves that died before their final measurement.

RESULTS

Three calves were removed from all analysis. One TUL calf was diagnosed and treated for BRD at 1 d post-enrollment, which violated the protocol. One TET calf and one TUL calf were removed from analysis because they were more than 80 d of age at the time of enrollment on the trial. In total, 1,392 animals were included in the analysis of final outcomes.

Calves arrived at the trial facility at 3 ± 2.1 (mean $\pm$ SD) d of age and were 56 ± 7 d of age at enrollment. At enrollment, calves weighed 71 ± 11 kg and were 90 ± 4 cm at the withers. Each week, 40 ± 11 calves were enrolled in the trial. Pre-enrollment, 63.7% (887/1,392) of calves were treated for scours, 59.1% (822/1,392) were treated for otitis media, 14.3% (199/1,392) were treated for BRD, and 1.7% (24/1,392) were treated for lameness. Before enrollment, 73.3% (147/199) of calves treated for pre-enrollment BRD were also treated for otitis media. Of the calves treated for both otitis media and BRD pre-enrollment, 74.0% (108/147) were treated for otitis media before BRD. Age, weight, and height at enrollment, and pre-enrollment diseases were not significantly different between TET and TUL calves.

Incidence of BRD in the 60 d Post-Movement

Risk of treatment for BRD for the first 60 d following enrollment was evaluated for 1,392 calves. In the 6 wk

Table 2. The probability of respiratory disease in the 6 wk after movement in 1,392 weaned dairy calves, randomly assigned to treatment with tulathromycin (TUL) or oxytetracycline (TET) at the time of movement to group housing¹

Variable	Estimate	SE	Odds ratio	95% CI	P-value
Intercept	-0.44	0.34			
Treatment with TUL (relative to TET)	-0.68	0.15	0.51	0.38–0.68	<0.001
Pre-enrollment lameness (relative to calves without lameness)	-0.85	0.47	2.35	0.93–5.94	0.07
Weight gain pre-enrollment (kg/d)	-1.53	0.57			0.007

¹Logistic regression model, accounting for source farms and weekly enrollment cohort with random effects.

after enrollment, the frequency of treatment for BRD was 22.4% (156/695) in the TET calves and 13.2% (92/697) in the TUL calves. The mean time of treatment of BRD was 24.7 ± 13.4 d after enrollment and was similar ($P = 0.58$) among calves in the TET and TUL groups. The model of the outcome BRD included 3 significant fixed effects: treatment, pre-enrollment lameness, and pre-enrollment average daily gain (Table 2). There were no significant interaction terms. Controlling for the other variables in the model, TET calves were 2.0 times (95% CI: 1.5 to 2.6) more likely to be treated for BRD in the 60 d following enrollment than were TUL calves ($P < 0.0001$). There was a tendency for calves treated for preweaning lameness to be 2.3 times (95% CI: 0.9 to 6.0) more likely to be treated for BRD ($P = 0.07$). As pre-enrollment average daily gain increased, risk of BRD decreased ($P < 0.005$). For example, a calf with a pre-enrollment average daily gain of 0.5 kg/d was 1.5 times more likely to be treated for BRD than a calf with a pre-enrollment average daily gain of 0.75 kg/d.

Growth in Postweaned Dairy Calves

Twenty-one calves died before being weighed 6 wk after enrollment. Therefore 1,371 calves had exit weights and heights and were included in this analysis. The data were analyzed to determine the effect of treatment and the effect of BRD on the weight and height of calves upon exiting the weaning barn, 6 wk after enrollment. Overall, calves gained 37.3 ± 11.8 kg during the 6 wk post-enrollment and grew on average 8 ± 0.1 cm.

The effect of treatment on weight after exiting the weaning barn had a significant interaction with pre-enrollment BRD. If calves were not treated for BRD pre-enrollment, the TUL treatment increased the exit weight of calves by 4.9 ± 0.5 kg relative to TET calves ($P < 0.001$; Table 3). If calves were treated for BRD in the pre-enrollment period, treatment had no effect on BW ($P = 0.38$).

The effect of treatment on height after exiting the weaning barn had significant interactions with pre-enrollment scours and pre-enrollment BRD. Among calves with no history of BRD, TUL increased the

exit height of calves by 0.8 ± 0.1 cm ($P < 0.001$) and, among calves with no history of preweaning scours, TUL increased the exit height of by 0.7 ± 0.3 cm ($P < 0.05$) compared with TET calves (Table 4). Treatment had no significant effect on calves with a history of pre-enrollment scours or pre-enrollment BRD.

Bovine respiratory disease in the pre-enrollment or post-enrollment period affected the weight of calves when they exited the weaning barn. Accounting for weight at enrollment, age at measurement, and random effects of source farm and enrollment cohort, pre-enrollment BRD decreased the exit weight by 2.9 ± 0.7 kg ($P < 0.001$) and post-enrollment BRD decreased exit weight by 7.9 ± 0.6 kg ($P < 0.001$).

Bovine respiratory disease in the pre-enrollment or post-enrollment period decreased the height of calves when they exited the weaning barn. Accounting for height at enrollment, age at measurement, and random effects of source farm and enrollment cohort, pre-enrollment BRD decreased the exit height by 0.6 ± 0.2 ($P < 0.005$) and post-enrollment BRD decreased the exit height by 1.2 ± 0.2 ($P < 0.001$).

Death Loss

Calves were followed for 60 d following enrollment. During this time, 27 calves (1.9%) were removed from the herd because of mortality or culling. Assignment to TUL or TET groups was not associated with mortality, in that 11 and 16 calves from the TUL and TET groups were removed, respectively ($P = 0.33$). The cause of

Table 3. Least squares means ($\pm$ SEM) of the weight (kg) of commercial heifers recorded upon exit from the weaning barn controlling for age at final measurement and weight at enrollment with random effects for source farm and weekly enrollment cohort

Prewaning BRD ¹	n	Treatment ²		P-value
		TUL	TET	
Yes	190	105.5 $\pm$ 1.4	104.4 $\pm$ 1.7	0.38
No	1,181	110.6 $\pm$ 1.1	105.7 $\pm$ 1.1	<0.001

¹Bovine respiratory disease.

²Treatment with tulathromycin (TUL) or oxytetracycline (TET) at the time of movement to group housing.

Table 4. Least squares means ($\pm$ SEM) of the height (cm) of commercial heifers upon exit from the weaning barn controlling for age at final measurement and height at enrollment with random effects for source farm and weekly enrollment cohort

Health event	n	Treatment ¹		P-value
		TUL	TET	
Preweaning scours				
Yes	872	97.8 $\pm$ 0.3	97.7 $\pm$ 0.3	0.71
No	499	98.3 $\pm$ 0.4	97.6 $\pm$ 0.4	<0.005
Preweaning BRD ²				
Yes	190	97.5 $\pm$ 0.4	97.5 $\pm$ 0.4	0.97
No	1,181	98.6 $\pm$ 0.3	97.8 $\pm$ 0.3	<0.001

¹Treatment with tulathromycin (TUL) or oxytetracycline (TET) at the time of movement to group housing.

²Bovine respiratory disease.

death for these calves was most frequently attributed to BRD (Table 5). Ten calves were examined with a digital necropsy because of suspected respiratory disease or unknown cause of death. Of these cases, BRD was determined to be the most likely cause of death in 9 of the 10 cases, with one case of probable enteritis. Morphologically, bronchopneumonia was present in 8 out of 9 cases, and there was one case of probable septicemia due to fibrinous pleuritis. Of the 8 cases of bronchopneumonia, *Mycoplasma bovis* was the most likely etiologic agent in 3 of the cases; the remaining 5 cases were diagnosed as having a nonspecific bacterial cause based on the gross appearance of the lesions. Other than BRD, deaths were attributed to injury, joint infection, or bloat. Other calves were sold because of poor growth and conformation. Death or removal from the farm occurred at 38.7 ± 2.7 d after enrollment and did not differ by treatment ($P = 0.51$).

DISCUSSION

This study evaluated a novel approach to reducing the incidence and effect of BRD in dairy calves, examining the effect of a long-acting prophylactic treatment relative to a shorter acting prophylactic treatment, which is a practice that has been examined primarily in beef cattle on arrival in feedlots. The time period immediately following movement from individual to group housing is particularly critical for dairy calves. At this time, there is an increased exposure to pathogens, an

immature immune system, and many social, environmental, and dietary changes. All of these stressors put dairy calves at increased risk for the development of BRD during this time period, similar to beef calves arriving in feedlots.

The objective of this study was to compare the effect of administering a long-acting antibiotic, tulathromycin, at the time of movement to group housing on the incidence of BRD and effects on growth in dairy calves relative to a shorter acting antibiotic, oxytetracycline. The study was designed as a positive control study. It should be noted that the positive control used in this study involved continuing with an existing practice at the study farm of administering oxytetracycline around the time of weaning to all calves. The dose of oxytetracycline used was derived from the previously established program and was continued into the current study. Calculation of the dosage of oxytetracycline that would be appropriate based on the weights of calves in this study indicates that the dose of TET was lower than is considered to be optimal. As such, the underdosing of oxytetracycline may not represent the effects that would be expected with a full dose.

The National Animal Health Monitoring and Surveillance (NAHMS) reports on dairy heifers found that 5% of postweaned heifers in the United States were treated for BRD in 2002, and 6% were treated in 2007 (USDA, 2005, 2007b). However, the NAHMS study defined postweaned heifers as including all animals from weaning to first calving. The wide age variation

Table 5. Reasons for death loss and culling in the 60 d following movement to group housing

Treatment group ¹	BRD ² confirmed by digital necropsy	BRD diagnosed by farm staff (unconfirmed)	Other	Total deaths
TET	6	5	5	16
TUL	3	4	4	11

¹Treatment with tulathromycin (TUL) or oxytetracycline (TET) at the time of movement to group housing.

²Bovine respiratory disease.

encompassed by this definition would include many older animals that were at low risk of BRD. Preweaned calves have reported rates of disease ranging from 0.1 cases/100 d in Minnesota (Sivula et al., 1996) to 39% of calves in Saskatchewan (Van Donkersgoed et al., 1993). A study of herds in New York found that 25% of calves in the first 3 mo of life were treated for BRD (Virtala et al., 1996). This substantial variation in the reported rates of disease probably results from a combination of the differences in the diagnostic criteria used, age of the calves, and management conditions. In large beef feedlots, 15.5% of cattle are treated for BRD, and on small beef feedlots, 8.7% of cattle are treated for BRD (USDA, 2000). During the course of this study, 22% of calves in the TET group developed BRD, which is consistent with the above observational studies of dairy calves but is higher than what is found in beef feedlots. The elevated incidence of respiratory disease in postweaned dairy calves relative to feedlot cattle stresses the importance of finding effective techniques to manage this disease.

The results of this study indicate that calves in the TUL group were half as likely to be treated for BRD as calves in the TET group during the 60 d following movement. However, treatment did not affect mortality in the 60 d following movement. This finding may be a result of several factors. First, this was a positive control study so both groups of calves were receiving antibiotic therapy. Second, the overall mortality rate was low and if a difference between the 2 treatment groups did exist, the sample size would not be sufficient to detect it. Finally, given the long-term increased risk of death associated with clinical BRD documented by Waltner-Toews et al., (1986b), it is also possible that any difference in mortality risk between groups would not be seen until animals are older.

The failure of calves treated for pre-enrollment BRD to respond to TUL with improved growth indicates that this treatment does not compensate for an earlier occurrence of the disease. This may be because of the effect that BRD has already had on the calf's future health and performance. Despite its high incidence, otitis media was not a significant risk factor for post-enrollment BRD or decreased growth in this population of calves. There may be several reasons for this, including a program for prompt detection and treatment of otitis media on this farm that may have limited the effect of this disease. In addition, given that most calves treated for pre-enrollment BRD were also treated for otitis media, the effect of otitis media may have been accounted for when pre-enrollment BRD was included in the model. In this study, the implementation of the prophylactic therapy program at the time of movement and grouping is of the greatest benefit for calves that

do not have a history of BRD before enrollment. Therefore, it is important to emphasize that the health of pre-enrollment calves should be closely monitored to minimize this disease in the pre-enrollment period as well.

Among calves that were not treated for BRD in the pre-enrollment period, at 6 wk post-enrollment, calves in the TUL group weighed more and were taller compared with calves in the TET group. This further supports the hypothesis that TUL calves had a decreased incidence of BRD. A previous study documented a decrease in average daily gain of 0.14 g/d in calves treated for BRD during their third month of life and a decreased height of 0.2 cm for each week of BRD (Virtala et al., 1996). When this value is converted to a 6-wk time period, it becomes a loss in potential weight of 5.9 kg and potential height of 1.2 cm. In this study, calves with BRD had lower weight (7.8 ± 0.5 kg) and height (1.3 ± 0.2 cm). Calves in the TUL group showed improved weight gain of 4.8 ± 1.2 kg and height of 1.5 ± 0.3 cm compared with the TET group. The results of the current study indicate that BRD has a highly detrimental effect on the growth of dairy calves and that the administration of TUL at the start of this high-risk period can decrease the incidence of the disease and mitigate the negative outcomes associated with it. Knowledge of the benefits and limitations of a strategic antimicrobial intervention would be beneficial when management efforts are unable to overcome the risk of BRD. In addition, this approach would be beneficial to protect calves that are at high risk of BRD while contributing factors such as housing and pre-weaning disease are being addressed by farm management.

In conclusion, the use of TUL at the time of movement to group housing had a beneficial effect on the health and performance of dairy calves compared with treatment with TET, primarily through the prevention of respiratory disease in the period immediately following movement from individual to group housing.

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