Evaluation of Three Antimicrobial Regimens Used as Metaphylaxis in Stocker Calves at High Risk of Developing Bovine Respiratory Disease

D. L. Step, DVM, DACVIM
Terry Engelken, DVM, MS
Cristina Romano, DVM, MS
Ben Holland, MS
Clint Krehbiel, PhD

John C. Johnson, DVM, MS
W. Lawrence Bryson, PhD
Cassius M. Tucker, DVM
Edward J. Robb, DVM, MS, DACVIM

*aDepartment of Veterinary Clinical Sciences
Center for Veterinary Health Sciences
Oklahoma State University
Stillwater, OK 74078

bDepartment of Veterinary Diagnostic and Production Animal Medicine
College of Veterinary Medicine
Iowa State University
Ames, IA 50011

cDepartment of Pathobiology and Population Medicine
College of Veterinary Medicine
Mississippi State University
Starkville, MS 39762

dDepartment of Animal Science
Division of Agricultural Sciences & Natural Resources
Oklahoma State University
Stillwater, OK 74078

ePfizer Animal Health
7000 Portage Road
Kalamazoo, MI 49001

**Clinical Relevance**

A total of 894 calves at high risk for bovine respiratory disease was processed at two sites and randomly assigned to receive one of three antimicrobial metaphylactic regimens to determine if a two-drug regimen offered any advantage over the more conventional one-course regimens. On arrival, calves received either a two-course regimen of ceftiofur crystalline free acid (CCFA) followed by tulathromycin 8 days later (Group 1) or a one-course regimen of CCFA (Group 2) or tilmicosin (Group 3). At Site A, morbidity was significantly lower (52%) in Group 1 than in Group 2 (76.3%) and Group 3 (78.4%). At Site B, morbidity was significantly lower in Group 1 (2.6%) than in Group 2 (9.4%) and Group 3 (7.2%).

*This study was funded by Pfizer Animal Health, Kalamazoo, Michigan. Correspondence should be sent to Dr. Johnson: phone, 402-441-2958; fax, 402-441-2782; email, John.C.Johnson@Pfizer.com.
INTRODUCTION

Administration of antimicrobials for control (metaphylaxis) of bovine respiratory disease (BRD; also called pneumonia or shipping fever) has proven beneficial in feedlot and stocker operations handling young, lightweight, highly stressed, long-haul, high-shrink calves at risk of developing BRD.1–5 Broadly and in general, metaphylaxis reduces the impact of bacterial colonization and growth in the bovine respiratory tract, thereby ameliorating pulmonary defense, aiding pathogen clearance, and reducing subclinical infection; the most common pathogens implicated in BRD are Mannheimia (Pasteurella) haemolytica, Pasteurella multocida, and Histophilus somni (Haemophilus somnis), with Mycoplasma spp identified in some instances. As a tool in BRD management, antimicrobial metaphylaxis is designed to minimize the cumulative effects and interplay of such stressors as weaning, transport, resocialization, environmental changes (e.g., dust, ambient temperatures, rations, water sources), commingling, and large numbers of cattle moving long distances in close quarters and consequently sharing air space and pathogens.1–6 Respiratory problems, including BRD, account for more than 30% of the mortalities in cattle and calves in North America.7

BRD is a well-recognized and documented disease complex with a multifactorial pathogenesis. Mortalities and lesions associated with BRD ultimately result from bacterial bronchopneumonia.8 Morbidity ranges from 10% to 80%, with mortality frequently above 5% and potentially approaching 10% to 20% during explosive outbreaks.7 Many calves arrive at stockers or in feedyards incubating or having subclinical BRD, which is well “masked” as part of their natural defense against predators. Thus, a fair percentage of cattle never exhibiting clinical signs or pulled for BRD have lung lesions at slaughter.9 In addition, more than 60% of calves in US cow–calf operations are not vaccinated against BRD pathogens before weaning, and a high percentage of these calves are not retained for any reasonable time to allow adaptation and stress reduction as they are moved from their dams, a patterned social structure, and a pasture environment to unfamiliar stocker settings or feedlots.10

Numerous antimicrobials are effective and have received FDA approval for the control of bacterial BRD.1–6 Metaphylaxis can conserve resources (drugs, labor, animals, time, economics) and enhance animal welfare11 by reducing disease incidence and by improving response to treatment in animals that become ill and need therapy. All of the aforementioned factors directly affect an animal’s and operation’s performance and profitability.6

Previous studies conducted at six feedlots demonstrated that morbidity was significantly lower for cattle receiving ceftiofur crystalline free acid (CCFA; Excede Sterile Suspension, Pfizer Animal Health) on arrival (10.9%) than for those receiving tilmicosin (21.2%) or no medication (48.9%).12 The same investigation found that morbidity and mortality through 56 days-on-feed were similar for cattle receiving CCFA followed by a 7-day postmetaphylaxis interval (PMI) and those receiving tilmicosin followed by a 3-day PMI. The PMI is an observed period during which no further antimicrobials are used. The length of the PMI is...
based on drug pharmacokinetics in target tissues and on demonstrated clinical efficacy in field studies. Using CCFA and a 7-day PMI reduced the incidence of BRD through day 29 by 28 percentage points and through day 57 by 21 percentage points compared with the control group. Investigators noted that the 7-day PMI allows greater flexibility and focus on the part of pen riders and hospital personnel in terms of BRD surveillance in newly arrived cattle.

A separate *M. haemolytica* challenge-model study established that CCFA controlled BRD for up to 9 days after administration and resulted in lower lung lesion scores, respiratory scores, and rectal temperatures compared with tilmicosin. Pharmacokinetic data show that circulating concentrations of ceftiofur and related metabolites remain above the efficacy threshold of BRD target pathogens (>0.2 μg/ml) for more than 7 days. (The efficacy threshold is three to six times higher than the minimum inhibitory concentration required to inhibit the growth of 90% of organisms [MIC90] for BRD target pathogens.)

Three previous field studies with stocker steers compared the efficacy of tulathromycin (Draxxin Injectable Solution, Pfizer Animal Health) with that of tilmicosin (Micotil 300 Injection, Elanco Animal Health) and enrofloxacin (Baytril 100, Bayer Animal Health) for the treatment of BRD. In all three studies, first-treatment success was significantly higher (P < .05) and BRD chronics and mortalities significantly lower (P ≤ .021) with tulathromycin than with tilmicosin or enrofloxacin.

This study was designed to determine whether a two-course metaphylactic regimen offered any advantage over the more conventional one-course regimens and to evaluate the efficacy of the various medications in controlling BRD.

**MATERIALS AND METHODS**

**Animals**

Male crossbred beef stocker calves were purchased from auction markets with the goal of obtaining freshly weaned, lightweight, high-stress animals vulnerable to BRD exposure. A total of 306 calves (269 cutter bulls and 37 steers) was purchased from 56 auction markets in the southeastern United States and delivered to a backgrounding lot in Mississippi (Site A). All calves at Site A were maintained in grass paddocks for 80 days at stocking rates typical for the area. Calves initially were housed in six 50-head paddocks; approximate-
cinations (Bovi-Shield GOLD 5 and UltraChoice 7, Pfizer Animal Health), and treatment for parasite control (Dectomax Pour On or Dectomax Injectable Solution, Pfizer Animal Health). At Site A, calves grazed native mixed forage in grass paddocks and were offered supplemental milled rations without feed-grade antimicrobials that met National Research Council (NRC) standards. At Site B, calves were offered an antimicrobial-free starting ration designed to meet NRC standards. Water was available at both locations ad libitum.

Moribund calves were excluded from the study, as were animals with systemic disease or physical conditions that could interfere with the evaluation of BRD or response to BRD therapy; lameness; a known history of BRD; recent BRD therapy; severe clinical signs of BRD at processing; or any known or suspected vaccination against *M. haemolytica* or *P. multocida* within the previous 30 days. At the investigators’ discretion, calves could be removed from the study for welfare considerations at any time.

**Study Design**

The study was designed to evaluate three regimens for the control of BRD in stocker calves at high risk of developing BRD (Figure 1). Calves at the two sites were randomly assigned to one of three groups, in blocks of three, based on progression through a restraint chute during processing. On arrival, calves assigned to Groups 1 and 2 received CCFA at the label dose of 6.6 mg/kg (1.5 ml/100 lb) administered SC in the middle one-third of the posterior aspect of the ear. Calves in Group 3 received tilmicosin at the label dose of 10 mg/kg (1.5 ml/100 lb) administered SC in the neck. At Site A, all calves received 6.0 ml of either CCFA or tilmicosin, based on a target arrival mean weight of 400 lb (181.4 kg). At Site B, a dose chart with four 25-lb increments within a 100-lb range was used to ensure that no calves received a suboptimal dose of either CCFA or tilmicosin; for example, all calves weighing 401 to 425 lb received the dose volume prescribed for the 425-lb body weight. On day 8 at both sites, all calves were revaccinated and those in Group 1 received tulathromycin at the label dose of 2.5 mg/kg (1.1 ml/100 lb) administered SC in the neck as a second course of metaphylaxis. Dose volumes of tulathromycin ranged from 0.5 to 5.5 ml at Site A and were calculated at Site B using the dose chart as described previously.

According to study design, response to metaphylaxis for Group 1 was defined more stringently than for Groups 2 and 3 because of the second metaphylactic course administered 8 days after processing in Group 1. Therefore, response to metaphylaxis in Group 1 was defined as absence of any observable BRD; in Groups 2 and 3, response to metaphylaxis was defined as absence of observable BRD or successful treatment of the first incidence of BRD with no subsequent retreatment.

**Clinical Observations and BRD Management**

Clinical observers were masked from calf-to-group assignment and observed all calves at least once daily for general health and clinical

---

**The two-course regimen of CCFA and tulathromycin had markedly less morbidity than either of the one-course regimens.**
Figure 1. Three metaphylactic regimens for bovine respiratory disease (BRD). Investigators evaluated three antimicrobial regimens: one using ceftiofur crystalline free acid (CCFA; Excede; 6.6 mg/kg SC in middle third of the posterior aspect of the ear) followed by tulathromycin (Draxxin, 2.5 mg/kg SC in the neck) 8 days later (Group 1), one using CCFA (Group 2), and a third using tilimicosin (Micotil, 10 mg/kg SC in the neck; Group 3). Calves meeting BRD criteria were eligible for treatment based on their group assignment (see below for details). (SFLT = standard feedlot therapy).

Calves were purchased from auction markets; the study included 588 calves at Site A (Oklahoma) and 306 calves at Site B (Mississippi).

<table>
<thead>
<tr>
<th>Metaphylaxis Regimen</th>
<th>Eligible for Initial BRD Treatment (as needed)</th>
<th>BRD Retreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td>Excede on day 0 + Draxxin on day 8</td>
<td>Beginning on day 13 (Site A) or on day 15–23 (Site B)</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td>Excede on day 0</td>
<td>Beginning on day 8</td>
</tr>
<tr>
<td><strong>Group 3</strong></td>
<td>Micotil on day 0</td>
<td>Beginning on day 3</td>
</tr>
</tbody>
</table>

Calves were scored by exception, with only those showing evidence of BRD given a Clinical Attitude Score (CAS) as follows:

1 = Mild depression; signs of weakness usually not present
2 = Moderate depression; some signs of weakness; may be reluctant to stand
3 = Severe depression; difficulty standing; head lowered or extended
4 = Moribund; unable to rise or stand; unable to take feed or water; near death

Calves with a CAS of 1 or 2 were pulled and treated for BRD only if their rectal temperature exceeded 40.0°C (104°F); calves with a CAS of 3 or 4 were pulled and treated regardless of rectal temperature. Calves meeting BRD criteria were eligible for treatment based on their group assignment:

- **Group 1**: Eligible for standard feedlot therapy (SFLT), which consisted of florfenicol (Nuflor Injectable Solution, Schering-Plough Animal Health; 40 mg/kg SC in the neck) once beginning on day 13 at Site A (i.e., after a 5-day PMI following tulathromycin administration on day 8) or on day 15 to 23 at Site B (after a 7- to 14-day
PMI) and followed by long-acting oxytetracycline (Liquamycin LA-200 Injection, Pfizer Animal Health; 19.8 mg/kg SC in the neck) and then danofloxacin (A180, Pfizer Animal Health; 6.0 mg/kg SC in the neck q48h).

- **Group 2**: Eligible for BRD treatment with tulathromycin (2.5 mg/kg SC in the neck) once beginning on day 8, followed by SFLT as described for Group 1.

- **Group 3**: Eligible for BRD treatment with enrofloxacin (7.5–12.5 mg/kg [3.4–5.7 ml/100 lb] SC in the neck) once beginning on day 3, followed by SFLT as described for Group 1.

After treatment, animals were returned to their home paddocks or pens. The posttreatment interval (PTI; i.e., the time during which no further treatment for BRD was permitted unless warranted in the interest of animal welfare) was 3 days following florfenicol administration and 2 days following administration of long-acting oxytetracycline or the second dose of danofloxacin.

Study variables included response to metaphylaxis; number of calves never treated for BRD; BRD morbidity, mortality, and chronicity; and weight changes/calf (i.e., mean average daily gain [ADG] and calculated total gain) for 80 days (Site A) or 60 days (Site B). Withdrawal periods were observed for all of the antimicrobials used, and animals moved to or remained on pasture at the study’s conclusion, ultimately progressing through routine feeding, management, and harvest practices.

### Statistical Analyses

For Group 1, which received a two-course metaphylactic regimen (CCFA and tulathromycin), response to metaphylaxis was defined as “no BRD cases occurring during the entire study”; in Groups 2 and 3, response to metaphylaxis was defined as “one or fewer episodes of BRD with no retreatment.”

At Site A, response to metaphylaxis and BRD mortality were analyzed using a generalized linear mixed model using the logit link; the model included the fixed effect of treatment, and random effects included pasture, block within pasture, and residual. ADG was analyzed using a mixed model; the model included the fixed effect of treatment, and random effects included pasture, block within pasture, and residual. Least squares means (LSM) and 95% CIs were constructed for treatments and back-transformed where appropriate.

At Site B, success was analyzed using the Cochran–Mantel–Haenszel method stratified by pen. BRD morbidity was analyzed using a generalized linear mixed model using the logit link; the model included the fixed effect of treatment, and random effects included pen, block within pen, treatment by pen, and residual. ADG was analyzed using a mixed model, including the fixed effect of treatment; random effects included enrollment time, pen within enrollment time, block within pen within enrollment time, and residual. The LSM and 95% CIs were constructed for treatments and back-transformed where appropriate.

Differences were assessed at the 5% level of significance \( P \leq .05 \). The null hypothesis was

---

This study lends credence to considering a wider window for metaphylaxis.
that the three regimens were equivalent in the control of BRD.

**RESULTS**

**Site A**

The numbers of calves enrolled in and completing the study to final weights (i.e., day 80) are shown in Table 1. The response to metaphylaxis in Groups 1, 2, and 3 was 48.0%, 58.2%, and 40.2%, respectively ($P = .0791$; Table 2), numerically favoring the one-course CCFA metaphylaxis regimen with tulathromycin used for first treatment (Group 2).

However, as shown in Table 3, the number of calves never treated for BRD ranged from a high of 48% (49 of 102) in Group 1 to 23.5% (23 of 98) in Group 2 and a low of 21.5% (22 of 102) in Group 3. The BRD cas-
es in Groups 2 and 3, while part of the response to metaphylaxis definition, also represented BRD occurrence (morbidity). As such, morbidity in Group 1 (52.0%; 53 of 102) was significantly lower \((P < .0057)\) than in either Group 2 (76.3%; 74 of 98) or Group 3 (78.4%; 80 of 102); morbidity was similar between Groups 2 and 3 \((P = .725)\). The percent of calves needing retreatment in Groups 1 and 2 was similar: 5.0% (0 of 5) in Group 1 and 54.0% (40 of 74) in Group 2. In contrast, a much larger number of retreatments were necessary in Group 3 (76.2%, 61 of 80). A total of 98, 151, and 207 treatments for BRD (initial and retreatments) was administered in Groups 1, 2, and 3, respectively. Eight calves were classified as chronically ill (one in Group 1, four in Group 2, and three in Group 3). Five mortalities were attributable to BRD.

ADG was 1.16 kg/day (2.55 lb/day; mean total: 203 lb) in Group 1, 1.10 kg/day (2.42 lb/day; mean total: 193 lb) in Group 2, and 1.11 kg (2.45 lb/day; mean total: 196 lb) in Group 3 (Table 1). There were no differences among groups affecting ADG \((P = .3527)\), and there were no adverse or unexpected drug-related events.

Site B

The numbers of calves enrolled and completing the study to final weights (i.e., day 60) are shown in Table 1. The response to metaphylaxis in Groups 1, 2, and 3 was 97.4%, 100.0%, and 98.4%, respectively \((P = .0811; \text{Table 4})\), numerically favoring the one-course CCFA metaphylaxis regimen with tulathromycin used for first treatment (Group 2). In addition, with 588 calves enrolled, there was sufficient statistical power to detect a significant difference between Groups 1 and 2 despite the overall low morbidity \((P = .0266; \text{Table 4})\).

As shown in Table 5, 97.4% (187 of 192) of the calves in Group 1 were never treated for BRD compared with 90.6% (174 of 192) in Group 2 and 92.8% (180 of 194) in Group 3. Further, morbidity in Group 1 (2.6%; 5 of 192) was significantly lower \((P < .0208)\) than in either Group 2 (9.4%; 18 of 192) or Group 3 (7.2%; 14 of 194); morbidity was similar between Groups 2 and 3 \((P = .6193; \text{Table 5})\). Of the initial BRD cases, 33% in Group 2 and 57% in Group 3 were noted in the first 7 days after the PMI, whereas the first BRD case in Group 1 occurred 29 days after processing.

ADG in Group 1 was 1.13 kg/day (2.50

---

**TABLE 2. Response to Metaphylaxis (Site A)**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antimicrobial</strong></td>
<td><strong>No.</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>Day 0</td>
<td>CCFA</td>
<td>102</td>
</tr>
<tr>
<td>Day 8</td>
<td>Tulathromycin</td>
<td>102</td>
</tr>
<tr>
<td>Response</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Overall</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td><strong>P Value</strong></td>
<td>.0791</td>
<td>.0791</td>
</tr>
</tbody>
</table>

*Defined as no BRD through day 80 (Group 1) or the absence of observable BRD or successful treatment of the first incidence of BRD with no subsequent retreatment (Groups 2 and 3).*

*58.2% = 57 of 98 calves; four calves were removed within 7 days of arrival (one postcastration mortality, three persistently infected with bovine viral diarrhea virus).*
lb/day; mean total: 150 lb) versus 1.10 kg/day (2.44 lb/day; mean total: 146.4 lb) in Group 2 and 1.12 kg/day (2.47 lb/day; mean total: 148.2 lb) in Group 3 (Table 1). There were no treatment differences affecting performance as measured by ADG ($P = .5974$).

In terms of unexpected events, two calves were depressed after processing: one in Group 3, observed on day 0, and the other in Group 1, observed after revaccination and tulathromycin administration on day 8. Both calves improved without intervention and were normal at the next observation.

**DISCUSSION**

A negative control or nonmedicated group of contemporary calves (with no antimicrobial metaphylaxis administered on arrival) was not included in the study design; therefore, it was not possible to determine a morbidity baseline. The difference in morbidity between Site A and Site B was paradoxical but, in retrospect,
TABLE 4. Response to Metaphylaxis (Site B)

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th></th>
<th></th>
<th></th>
<th>Group 2</th>
<th></th>
<th></th>
<th></th>
<th>Group 3</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimicrobial</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0</td>
<td>CCFA</td>
<td>197</td>
<td>100.0</td>
<td>CCFA</td>
<td>196</td>
<td>100.0</td>
<td>Tilmicosin</td>
<td>195</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 8</td>
<td>Tulathromycin</td>
<td>192</td>
<td>100.0</td>
<td>——</td>
<td>——</td>
<td>——</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response²</td>
<td>187</td>
<td>97.4</td>
<td>192</td>
<td>100.0</td>
<td>191</td>
<td>98.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P Values

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th></th>
<th></th>
<th>Group 1 vs. 2</th>
<th></th>
<th></th>
<th>Group 1 vs. 3</th>
<th></th>
<th></th>
<th>Group 2 vs. 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.0811</td>
<td></td>
<td></td>
<td>.0266</td>
<td></td>
<td></td>
<td>.5278</td>
<td></td>
<td></td>
<td>.5278</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

²Defined as no BRD through day 60 (Group 1) or the absence of observable BRD or successful treatment of the first incidence of BRD with no subsequent retreatment (Groups 2 and 3).

provided valuable insight about the similarity of outcomes.

The timed, two-course metaphylactic regimen was included to observe what effect, if any, the sequential administration of two antimicrobials might have on BRD morbidity and mortality and calf performance. The two-course regimen (Group 1, CCFA and tulathromycin) had markedly less morbidity than either of the one-course regimens, regardless of location, supporting field observations that the risk period for BRD can extend well beyond the first 5 to 7 days after arrival. The timing of a one-course, on-arrival metaphylaxis program may not correlate with highest disease risk, especially when dealing with large numbers of highly commingled calves, presumably in various stages of disease incubation with multiple pathogens. Thus, this study lends credence to considering a wider window for metaphylaxis, particularly in instances in which 30% to 40% of cattle develop BRD following a one-course metaphylactic regimen.¹¹

The two-course regimen (Group 1) capitalized on the unique properties of CCFA¹⁷ and tulathromycin,¹⁸ demonstrated by previous work showing a prolonged clinical effect or benefit using either compound for the treatment of naturally occurring BRD. Despite the difference in morbidity at the two sites, calves receiving CCFA on arrival (Groups 1 and 2) at both sites responded better to first BRD treatment compared with Group 3. Reflecting the low morbidity at Site B, there were six BRD treatments in Group 1 versus 18 each in Groups 2 and 3. Similarly, but with a notably higher BRD morbidity at Site A, there were 98 BRD treatments in Group 1, 151 in Group 2, and 207 in Group 3. The lower numbers of treatments administered in Groups 1 and 2 at Site A represented an 80% to 90% improvement in treatment response over Group 3 calves, which had a higher number of second and third retreatments. Lower morbidity and an improvement in treatment response following the two-course regimen of metaphylaxis suggest that the spectrum of activity, timing of administration, PMI, and PTI are all important factors influencing the antimicrobial chosen to provide optimal control of BRD in cattle at high risk of disease.
CONCLUSIONS

In this study conducted at two sites, the metaphylactic regimen consisting of CCFA administered on arrival (Group 2) proved to be better for handling new, freshly weaned stocker calves based on the definition of response to metaphylaxis in the study design (Sites A and B, Group 2 $P = .0791$ and .0811, respectively). However, the two-course regimen (CCFA followed by tulathromycin on day 8) used in Group 1 numerically reduced BRD morbidity compared with either one-course regimen using CCFA or tilmicosin (Sites A and B, Group 1 vs. Group 2 $P = .0057$ and .0066, respectively, and Group 1 vs. Group 3 $P = .0031$ and .0208, respectively).

Calves receiving CCFA on arrival, followed by tulathromycin either as the second course of the metaphylactic regimen or as treatment for clinical BRD, demonstrated a consistent and improved response (absence of clinical signs) with fewer retreatments compared with tilmicosin administered on arrival followed by enrofloxacin for BRD treatment. Differences among the metaphylactic regimens were shown at both sites—numerically favoring Group 2 both at Site A and Site B.

This body of evidence suggests that successful and reasonable application of metaphylaxis in high-risk cattle reduces morbidity and improves BRD treatment response in stocker calves. Previous studies have demonstrated prolonged clinical effect in treating naturally occurring BRD.

### TABLE 5. Bovine Respiratory Disease (BRD) Occurrence, Treatment, and Retreatments (Site B)

<table>
<thead>
<tr>
<th>BRD Occurrence</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Therapy</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>None</td>
<td>187</td>
<td>97.4</td>
<td></td>
</tr>
<tr>
<td>BRD 1 (first occurrence)</td>
<td>Florfenicol</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>BRD 2 (first retreatment)</td>
<td>Oxytetracycline</td>
<td>1</td>
<td>20.0</td>
</tr>
<tr>
<td>BRD 3 (second retreatment)</td>
<td>—</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Dead</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

**P Values** (first occurrence, BRD 1)

<table>
<thead>
<tr>
<th>Overall</th>
<th>.0180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 vs. 2</td>
<td>.0066</td>
</tr>
<tr>
<td>Group 1 vs. 3</td>
<td>.0208</td>
</tr>
<tr>
<td>Group 2 vs. 3</td>
<td>.6193</td>
</tr>
</tbody>
</table>
with CCFA or tulathromycin. The reduction in morbidity and improved treatment response to CCFA and tulathromycin support that their spectra of antimicrobial activity, coupled with their extended clinical effect, are important factors to consider when designing a metaphylactic regimen for high-risk cattle.

ACKNOWLEDGMENTS

The authors thank Luis Burciaga-Robles and Roy Ball, Oklahoma State University, for their assistance with the animal facilities and staff, animal care, processing, and data collection; and Jimmy Bryan and staff at Prairie Livestock, Inc., West Point, Mississippi.

REFERENCES


