Evaluation of the Efficacy of Tulathromycin as a Metaphylactic Antimicrobial in Feedlot Calves*

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CLINICAL RELEVANCE

The purpose of this study was to determine the efficacy and cost-effectiveness of tulathromycin (DRAX) versus tilmicosin (MIC) or oxytetracycline (TET) as a metaphylactic antimicrobial in feedlot calves. Calves that received DRAX had significantly ($P < .05$) lower initial undifferentiated fever (UF) treatment and relapse rates; lower overall chronicity, overall mortality, and cause-specific mortality rates; higher average daily gains; and improved quality grades. However, calves that received DRAX also had poorer ($P < .05$) yield grades compared with calves that received MIC or TET and worse feed conversion compared with calves that received MIC. Net advantages in the DRAX group were Can$3.79/animal and Can$16.96/animal compared with the MIC and TET groups, respectively. Based on these results, DRAX is a more efficacious and cost-effective metaphylactic antimicrobial than MIC or TET in feedlot calves at ultra-high risk of developing UF. In addition, this study presents a comparison between two methods (“deads out” and “deads in”) of calculating feedlot performance variables.

INTRODUCTION

To meet consumer demands in a cost-effective manner, beef production takes place mainly in intensive commercial feedlot operations.

These sophisticated agribusinesses continually strive to minimize disease and optimize the cost of production by using the most cost-effective preventive measures and treatment pro-

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cult to properly model the economic impact of improved treatment success. This is because the various clinical outcomes (prolonged convalescence followed by recovery, sale for salvage slaughter, and death loss) have substantially different economic values. In addition, there are limited data describing the influence of tulathromycin on subsequent feedlot performance or carcass characteristics in a broad cross-section of feedlot calves at ultra-high risk of developing UF/BRD and housed and managed under typical commercial feedlot production operations. The one published study that describes the effects of tulathromycin on subsequent feedlot performance and carcass characteristics was conducted in three small populations of animals using 50-animal pens. Therefore, additional research using larger numbers of animals under commercial feedlot production conditions is required to evaluate the efficacy of tulathromycin and compare it with that of other antimicrobials commonly used for the prevention and control of UF/BRD in feedlot calves. This can be achieved by generating comprehensive outcome data from large, commercial field trials and evaluating the data with appropriate economic models.

The purpose of the clinical trial described here was to determine the relative cost-effectiveness of using tulathromycin as a metaphylactic antimicrobial on the animal health, feedlot performance, and carcass characteristic variables of feedlot calves at ultra-high risk of developing BRD in western Canada.

**MATERIALS AND METHODS**

**General Overview**

In this commercial field trial, feedlot calves at ultra-high risk of developing UF/BRD were randomly allocated on arrival to the feedlot to one of three experimental groups: tulathromycin (DRAX), tilmicosin (MIC), or oxytetracyclics. Undifferentiated fever (UF), also known as shipping fever or bovine respiratory disease (BRD), continues to be one of the most economically significant health problems in calves entering beef feedlots. Management of this disease is complex and involves the use of prophylactic or metaphylactic antimicrobials administered to calves on arrival at the feedlot, with the choice of antimicrobial based on the predicted risk of developing UF/BRD in any given population of feedlot animals. The predicted UF/BRD risk for a particular group of feedlot calves is determined based on such factors as age class (calf versus yearling), body weight (often a proxy for age), procurement method (sale barn versus ranch direct), amount of commingling before and after arrival, and previous vaccination and management history.

Tilmicosin and parenteral oxytetracycline have been proven to be effective metaphylactic antimicrobials for reducing BRD morbidity and mortality rates as well as overall mortality rates and for improving average daily gain (ADG) and feed efficiency. Tulathromycin, a triamilide member of the macrolide antimicrobial class, was developed specifically for the prevention and treatment of respiratory disease in cattle and pigs. The pharmacokinetics, microbiologic characteristics, and clinical safety and efficacy of this novel antimicrobial drug have recently been studied. In these clinical trials, efficacy was mainly measured as “treatment success” rate; however, there was limited follow-up information on treatment failures, animals designated as having chronic respiratory disease, and animals that were removed from the study during the course of each field trial.

Although treatment success rate information is useful for assessing clinical efficacy as it pertains to pharmaceutical licensing, a dearth of information describing the final clinical outcome of treatment failure makes it very difficult to properly model the economic impact of improved treatment success. This is because the various clinical outcomes (prolonged convalescence followed by recovery, sale for salvage slaughter, and death loss) have substantially different economic values. In addition, there are limited data describing the influence of tulathromycin on subsequent feedlot performance or carcass characteristics in a broad cross-section of feedlot calves at ultra-high risk of developing UF/BRD and housed and managed under typical commercial feedlot production operations. The one published study that describes the effects of tulathromycin on subsequent feedlot performance and carcass characteristics was conducted in three small populations of animals using 50-animal pens. Therefore, additional research using larger numbers of animals under commercial feedlot production conditions is required to evaluate the efficacy of tulathromycin and compare it with that of other antimicrobials commonly used for the prevention and control of UF/BRD in feedlot calves. This can be achieved by generating comprehensive outcome data from large, commercial field trials and evaluating the data with appropriate economic models.

The purpose of the clinical trial described here was to determine the relative cost-effectiveness of using tulathromycin as a metaphylactic antimicrobial on the animal health, feedlot performance, and carcass characteristic variables of feedlot calves at ultra-high risk of developing BRD in western Canada.
cycline (TET). Animals in the same experimental group were housed within the same pen, and the pen was the experimental unit. Study animals were followed from the time of allocation until slaughter; outcome variables describing animal health, feedlot performance, and carcass characteristics were measured, and comparisons were made between the tulathromycin group and the tilmicosin and oxytetracycline groups. Statistical analyses were used to determine whether differences observed in outcome variables between the experimental groups were due to the effect of the experimental groups or random chance. True differences (experimental group effects) in outcome variables \( (P < .05) \) were subsequently incorporated into economic models to determine the relative economic impact of metaphylaxis with tulathromycin versus tilmicosin and oxytetracycline.

**Study Facilities**

The study was conducted at a commercial feedlot near Strathmore, Alberta, in western Canada. The feedlot has a capacity of approximately 24,000 animals, and its basic design is representative of the standard design used in western Canada. The animals were housed in open-air, dirt-floor pens arranged side by side with central feed alleys and 20% porosity wood-fence windbreaks. Each pen has a capacity of approximately 330 animals. Two hospital facilities are located at the feedlot. Each facility is equipped with a hydraulic chute, an individual animal scale, a chute-side computer with the Feedlot Health Animal Record Management (FHARM, Feedlot Health Management Services) software program for the collection of animal health data, and separation alleys to facilitate the return of animals to designated pens. Open-air hospital pens are located adjacent to each hospital. Also, the feedlot has several receiving pens adjacent to the enclosed processing facility.

**Study Animals**

Calves enrolled in this study were exotic crossbred heifer calves purchased from auction markets throughout western Canada. Animals were transported by truck to the feedlot after assembly at the auction market. The average initial individual animal weight of pens allocated to the study was between 245 kg (540 lb) and 300 kg (661 lb).

On arrival at the feedlot, animals were moved through a hydraulic chute for a group of procedures known collectively as processing. All animals were ear tagged (to provide unique, individual animal identification), implanted with a zeranol growth implant (Ralgro, Schering-Plough Animal Health, Division of Schering Canada), and administered a multivalent clostridial/\textit{Histophilus somni} vaccine (Ultrabac 7/Somubac, Pfizer Animal Health, Pfizer Canada). In addition, each animal received an infectious bovine rhinotracheitis (IBR) virus, parainfluenza-3 (PI 3) virus, bovine viral diarrhea virus (BVDV), and bovine respiratory syncytial virus combination vaccine (Pyramid FP 5, Wyeth Animal Health, Division of Wyeth Canada); a \textit{Mannheimia haemolytica} bacterin–toxoid (One Shot, Pfizer Animal Health); and topical doramectin (0.5%) (Dectomax Pour-On Solution,
### Equations Used to Calculate Morbidity and Mortality Rates

<table>
<thead>
<tr>
<th>Equation</th>
<th>Formula</th>
</tr>
</thead>
</table>
| **Initial UF Treatment Rate**                                                                 | \[
| = \frac{\text{No. of Animals Initially Treated for UF}}{\text{No. of Animals Allocated}} \times 100\% \]
| **First UF Relapse Rate**                                                                    | \[
| = \frac{\text{No. of First UF Relapses}}{\text{No. of Animals Initially Treated for UF}} \times 100\% \]
| **Initial NF Treatment Rate**                                                                 | \[
| = \frac{\text{No. of Animals Initially Treated for NF}}{\text{No. of Animals Allocated}} \times 100\% \]
| **First NF Relapse Rate**                                                                    | \[
| = \frac{\text{No. of First NF Relapses}}{\text{No. of Animals Initially Treated for NF}} \times 100\% \]
| **Overall Chronicity Rate**                                                                  | \[
| = \frac{\text{No. of Animals Designated as Chronic}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Overall Wastage Rate**                                                                     | \[
| = \frac{\text{No. of Animals Designated as Chronic That Did Not Die}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Overall Mortality Rate**                                                                   | \[
| = \frac{\text{No. of Mortalities Due to All Causes}}{\text{No. of Animals Allocated}} \times 100\% \]
| **BRD Mortality Rate**                                                                        | \[
| = \frac{\text{No. of Mortalities Due to BRD}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Histophilosis* Mortality Rate**                                                             | \[
| = \frac{\text{No. of Mortalities Due to Histophilosis}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Metabolic Mortality Rate**                                                                  | \[
| = \frac{\text{No. of Mortalities Due to Metabolic Disease}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Arthritis Mortality Rate**                                                                  | \[
| = \frac{\text{No. of Mortalities Due to Arthritis}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Miscellaneous Mortality Rate**                                                              | \[
| = \frac{\text{No. of Mortalities Due to Causes Other than BRD, Histophilosis, Metabolic Disease, or Arthritis}}{\text{No. of Animals Allocated}} \times 100\% \]
| **Relative Risk**                                                                             | \[
| = \frac{\text{Rate of Disease in the DRAX Group}}{\text{Rate of Disease in the MIC or TET Group}} \]

*Disease due to Histophilus somni infection.

BRD = bovine respiratory disease; NF = no fever; UF = undifferentiated fever.

**Equations Used to Calculate Ancillary Production Variables**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter Weight</td>
<td>( \text{Total Slaughter Weight} ) ( \frac{\text{No. of Animals Slaughtered}}{\text{No. of Animals Slaughtered}} )</td>
</tr>
<tr>
<td>Weight Gain</td>
<td>( \text{Average Slaughter Weight} - \text{Average Initial Weight} )</td>
</tr>
<tr>
<td>Carcass Weight</td>
<td>( \frac{\text{Total Carcass Weight}}{\text{No. of Carcasses}} )</td>
</tr>
<tr>
<td>Dressing Percentage</td>
<td>( \left( \frac{\text{Total Carcass Weight}}{\text{Total Slaughter Weight}} \right) \times 100% )</td>
</tr>
<tr>
<td>DOF</td>
<td>( \text{Average Slaughter Date} - \text{Average Allocation Date} )</td>
</tr>
<tr>
<td>DDMI</td>
<td>( \frac{\text{Total Dry Matter Fed}}{\text{No. of Animal Days}} )</td>
</tr>
</tbody>
</table>

\( ^a \)100% dry matter basis.

**DDMI = daily dry matter intake; DOF = days on feed.**

Pfizer Animal Health) at a dose of 1.0 ml/10 kg. All heifers were administered an abortifacient, cloprostenol (375 µg IM; Estrumate, Schering-Plough Animal Health).

At an average of 70 days on feed (DOF) for each pen, all animals were reimplanted with Ralgro; vaccinated with an IBR virus, PI, virus, BVDV, and bovine respiratory syncytial virus combination vaccine (Bovi-Shield NC 4, Pfizer Animal Health); and treated for external parasites with topical permethrin (5%) (Boss Pour-On, Engage Animal Health) at a dose of 3 ml/45 kg. At an average of 140 DOF for each pen, all animals were implanted with an estradiol benzoate–treburethol acetate combination growth implant (Synovex Plus, Wyeth Animal Health) and vaccinated with an IBR and PI, virus combination vaccine (Bovi-Shield IBR-PI3, Pfizer Animal Health). At both 70 and 140 DOF, all three pens within each replicate were handled within an interval of 2 consecutive days.

**Experimental Design**

During processing, individual animals \( (N = 9,915) \) from each processing group were randomly assigned to one of three experimental groups and received a single dose of antimicrobial drug as follows:

- **MIC** \( (n = 3,306) \): Tilmicosin (Micotil, Elanco Animal Health, Division Eli Lilly Canada) at 10.0 mg/kg SC
- **TET** \( (n = 3,303) \): Oxytetracycline (Tetradure LA-300, Merial Canada) at 30.0 mg/kg IM
- **DRAF** \( (n = 3,306) \): Tulathromycin (Draffin Injectable Solution, Pfizer Animal Health) at 2.5 mg/kg SC

Animals in each experimental group were housed in separate pens, with 10 pens in each experimental group for a total of 30 pens. Five animals (two from the DRAX group, two from the MIC group, and one from the TET group) received the wrong antimicrobial drug at allo-
cation and were excluded from the animal health summary and analysis.

**Feeding Program**

Standard mixed complete feedlot diets, formulated to meet the nutritional requirements of feedlot cattle, were offered ad libitum. Diets were blended by combining dry-rolled grain (barley only or barley and wheat), barley silage, tallow, medicated premix, and granular supplement in truck-mounted mixer boxes (Harshmixer, Hydraulics Unlimited, Eaton, CO) equipped with electronic load cells. The medicated premix contained chlortetracycline (Aureomycin, Alpharma Canada) and was formulated into mixed, complete feedlot diets at a level of 1,000 mg of chlortetracycline/animal/day. Diets containing the medicated premix were fed until an average of 56 DOF for each pen. The starter granular supplement contained lasalocid (Bovatec Medicated Premix, Alpharma Canada), formulated into mixed complete feedlot diets at a level of 36 mg/kg of diet dry matter on a 100% dry matter (DM) basis. The finisher granular supplement contained monensin (Rumensin, Elanco Animal Health) and chlortetracycline (Aureomycin) formulated into mixed, complete feedlot diets at levels of 25 and 35 mg/kg DM, respectively. The withdrawal granular supplement contained monensin (Rumensin) and tylosin (Tylan, Elanco Animal Health) formulated into mixed complete feedlot diets at levels of 25 and 11 mg/kg DM, respectively.

For each pen, the starter granular supplement was included in the mixed complete diets from arrival until an average of 56 DOF; the finisher granular supplement was included in the mixed complete diets beginning at an average of 56 DOF to a minimum of 5 days before shipment of slaughter animals; and the withdrawal granular supplement was included in the mixed complete diets for at least 5 days before shipment of slaughter animals. The granular supplement and medicated premix were manufactured by a com-
mmercial feed mill (Landmark Feeds, Strathmore, Alberta, Canada). Diets were delivered to the pens once or twice daily using truck-mounted mixers on load cells. Daily feed allowances to each pen were recorded. Water was provided ad libitum. On completion of allocation for each replicate, the animals were adapted to a finisher diet over a 30- to 45-day period by increasing the proportion of dry-rolled grain and decreasing the proportion of barley silage at approximately 4-day intervals. Within each replicate, diet changes occurred on the same date for each pen.

### Sampling

Each new shipment of grain was sampled on delivery to the feedlot, and silage was sampled daily. The DM content of each grain and silage sample was determined, and commodity DM values were updated monthly. From these data, the monthly average DM content of each diet was calculated and used to determine the monthly DM intake for each pen.

The finishing diet was sampled at approximately 1-month intervals. These samples were analyzed for crude protein (CP), acid detergent fiber (ADF), calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), sodium (Na), and salt (NaCl) (Norwest Labs, Lethbridge, Alberta, Canada).

An ear skin biopsy was collected from each animal that died during the study. The biopsy samples were tested for BVDV using immunohistochemistry (IHC) to identify animals persistently infected (PI) with BVDV (Prairie Diagnostic Services, Saskatoon, Saskatchewan, Canada).

### Animal Health

Experienced animal health personnel, who were blinded to the experimental status of each pen, observed the study animals once or twice daily. Animals deemed to be “sick” were individually sorted from their penmates, moved to the hospital facility, and diagnosed and treated according to the computerized treatment protocols provided by the consulting veterinarians. The treatment protocols used were the same for all three experimental groups. The antimicrobials used for initial and relapse treatments are described in Table 1.

In this study, the case definition for UF was an elevated rectal temperature (≥105.0˚F), lack of abnormal clinical signs referable to body systems other than the respiratory system, and no previous treatment history for no fever (NF). The case definition for NF was a rectal temperature below 105.0˚F, a lack of abnormal clinical signs referable to body systems other than the respiratory system, and no previous treatment history for UF. Animals in all three experimental groups were eligible for diagnosis and treatment for UF or NF beginning 3 days after allocation.

After receiving initial UF or NF therapy and being returned to their original feedlot pens, animals subsequently selected as “sick” by the pencheckers were diagnosed as UF or NF relapses, provided there was an absence of abnormal clinical signs referable to organ systems other than the respiratory tract. All animals relapsing subsequent to initial UF therapy were defined as UF relapses (i.e., first UF relapse, second UF relapse, or third UF relapse), and all

### Table 1. Antimicrobials Used for Initial and Relapse Therapy for Undifferentiated Fever (UF) and No Fever (NF)

<table>
<thead>
<tr>
<th>Time of Therapy</th>
<th>UF</th>
<th>NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Nuflorena</td>
<td>LA 200b</td>
</tr>
<tr>
<td>First relapse</td>
<td>Baytrilc</td>
<td>Nuflorea</td>
</tr>
</tbody>
</table>

*Florfenicol (Nuflo, Schering-Plough Animal Health, Division of Schering Canada).

*Long-acting oxytetracycline (Liquamycin LA-200, Pfizer Animal Health, Pfizer Canada).

*Enrofloxacin (Baytril 100, Bayer Healthcare, Animal Health Division).*
animals relapsing subsequent to initial NF therapy were defined as NF relapses (i.e., first NF relapse, second NF relapse, or third NF relapse). The maximum number of UF or NF treatment regimens permitted for all animals in the study was four (i.e., initial UF or NF therapy, first UF or NF relapse, second UF or NF relapse, and third UF or NF relapse); once an animal was treated as a third UF or NF relapse, no further treatment for UF or NF was given.

Animals identified as “sick” subsequent to third UF or NF relapse therapy were deemed to be “chronics,” as were animals that were unsuitable to be returned to their designated feedlot pens based on subjective appraisal of the attitude and appearance of each animal. Chronics that did not die during the study were defined as wastage. Finally, all other diseases were treated according to a standard feedlot protocol provided by the consulting veterinarians. All animal health events, including treatment date, presumptive diagnosis, drug(s) used, and dose(s) used, were recorded on FHARM. All animals that died during the study were necropsied by the attending feedlot veterinarian, and the cause of death was determined based on gross post-mortem examination findings.

**Marketing**

Cattle were sold under normal marketing procedures: The feedlot manager determined that a replicate, or a portion thereof, was ready for sale based on visual appraisal and/or weight data. Animals were scheduled for slaughter and transported to the packing plant. In general, approximately the same number of animals was shipped from each experimental group within a replicate to the same packing plant (Cargill Foods, High River, Alberta, Canada) on the same day. However, in the last shipment from each pen in a replicate, all remaining animals in each pen, as opposed to an equal number of animals from each pen, were shipped to the same packing plant on the same day.

**Data Collection and Management**

Initial weight and hip height (inches) were measured for each animal at processing. These data were subsequently imported into a spreadsheet program (Microsoft Office Excel 2003), where the average initial weight and average hip height were calculated for each pen. These baseline variables were used to assess the homogeneity of animals in each experimental group. The computerized animal health data were verified and summarized. From these data, risk rates for initial UF treatment, first UF relapse, initial NF treatment, first NF relapse, overall chronicity, overall wastage, overall mortality (mortality due to all causes), BRD mortality (mortality due to BRD), histophilosis mortality (mortality due to *Histophilus somni* infection), metabolic mortality (mortality due to metabolic disease), arthritis mortality (mortality due to arthritis), and miscellaneous mortality (mortality due to causes other than BRD, histophilosis, metabolic disease, or arthritis) rates were calculated for each pen (see page 186).

The ancillary production variables—slaughter weight, weight gain, carcass weight, dressing percentage, DOF, and daily dry matter intake (DDMI)—were calculated for each pen (see page 187).

The feedlot performance variables—ADG and the dry matter intake:gain ratio (DM:G)—were calculated for each pen. Feedlot performance variables were calculated by two methods: The live weight basis method used the live weights obtained at the time of sale, and the carcass weight basis method used the hot carcass weights obtained from the packing plant (see page 188).

The quality grade (QG) and yield grade (YG) of each carcass were collected at slaughter. With respect to QG, the proportions of animals grading Canada Prime, Canada AAA, Canada AA,
TABLE 2. Economic Model Input Values\(^a\) and Sensitivity Analysis

<table>
<thead>
<tr>
<th>Description (unit)</th>
<th>Input Value</th>
<th>Change Evaluated in Sensitivity Analysis</th>
<th>Economic Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial UF treatment cost (Can$/animal)</td>
<td>Can$25.00</td>
<td>Can$1.00</td>
<td>Can$0.11</td>
</tr>
<tr>
<td>First UF relapse treatment cost (Can$/animal)</td>
<td>Can$19.69</td>
<td>Can$1.00</td>
<td>Can$0.05</td>
</tr>
<tr>
<td>Initial NF treatment cost (Can$/animal)</td>
<td>Can$2.15</td>
<td>Can$1.00</td>
<td>Can$0.04</td>
</tr>
<tr>
<td>Purchase price (Can$/100 lb body weight)</td>
<td>Can$110.00</td>
<td>Can$10.00</td>
<td>Can$1.68</td>
</tr>
<tr>
<td>Yardage rate (Can$/day)</td>
<td>Can$0.17</td>
<td>Can$0.01</td>
<td>Can$0.08</td>
</tr>
<tr>
<td>Interest rate (%/year)</td>
<td>4.00%</td>
<td>1.00%</td>
<td>Can$0.20</td>
</tr>
<tr>
<td>Ration cost (Can$/ton [100% DM basis])</td>
<td>Can$190.00</td>
<td>Can$10.00</td>
<td>Can$0.40</td>
</tr>
<tr>
<td>Quality grade Canada prime premium (Can$/100 lb carcass weight)</td>
<td>Can$20.00</td>
<td>Can$1.00</td>
<td>Can$0.04</td>
</tr>
<tr>
<td>Quality grade Canada AAA premium (Can$/100 lb carcass weight)</td>
<td>Can$11.00</td>
<td>Can$1.00</td>
<td>—</td>
</tr>
<tr>
<td>Quality grade Canada A discount (Can$/100 lb carcass weight)</td>
<td>— Can$6.00</td>
<td>Can$1.00</td>
<td>—</td>
</tr>
<tr>
<td>Yield grade Canada 1 premium (Can$/100 lb carcass weight)</td>
<td>Can$3.00</td>
<td>Can$1.00</td>
<td>Can$0.49</td>
</tr>
<tr>
<td>Yield grade Canada 3 discount (Can$/100 lb carcass weight)</td>
<td>— Can$3.00</td>
<td>Can$1.00</td>
<td>Can$0.25</td>
</tr>
</tbody>
</table>

\( ^a \)Values should be interpreted as the effect on the economic analysis that is associated with the input value changes evaluated in the sensitivity analysis.

\( DM \) = dry matter; \( NF \) = no fever; \( UF \) = undifferentiated fever.

Canada A, B1 (lack of fat cover or devoid of marbling), B2 (yellow fat), B4 (dark red rib eye), D2 (carcass maturity with medium muscling and/or yellow fat), and D4 (carcass maturity with excessive fat) were calculated for each pen. With respect to YG, the proportions of Canada Prime, Canada AAA, Canada AA, and Canada A carcasses grading Canada 1, Canada 2, and Canada 3 were calculated for each pen.

Statistical Analysis
Data were analyzed using an analytical software program (SAS System for Windows, Release 9.1, SAS Institute, Cary, NC).

Animal health variables were compared between the experimental groups (DRAX versus MIC and TET) using linear logistic regression modeling techniques, controlling for intra-pen clustering of disease using the methods described by McDermott and colleagues.\(^{35,36}\)

Baseline, ancillary production, feedlot performance, and carcass characteristic variables were compared between the experimental groups using least squares analysis of variance for repli-
cate and experimental group effects. The baseline variables were tested as covariates of the ancillary production and feedlot performance variables and were included in the final model used for comparison of each variable between the experimental groups when significant (P < .05) baseline variable effects were detected.

**Economic Analysis**

The relative cost-effectiveness of the experimental groups was calculated using a computer spreadsheet program (Microsoft Office Excel 2003) that simulates all economic aspects of feedlot production. The DRAX group was compared with the MIC group and the TET group. In the economic model, the initial weight (611 lb), final weight (1,225 lb), feeder price, slaughter price, processing cost, ration cost, yardage rate, and interest rate were fixed for both experimental groups. The costs of metaphylactic antimicrobial therapy used in the analysis were Can$25.92/animal for

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**TABLE 3. Baseline Data Summary**

<table>
<thead>
<tr>
<th>Baseline Variable</th>
<th>Experimental Group</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRAF</td>
<td>MIC</td>
<td>TET</td>
</tr>
<tr>
<td>Initial weight&lt;sup&gt;a&lt;/sup&gt; (lb)</td>
<td>611.8</td>
<td>609.5</td>
<td>610.9</td>
</tr>
<tr>
<td>Hip height&lt;sup&gt;b&lt;/sup&gt; (in)</td>
<td>44.65</td>
<td>44.59</td>
<td>44.63</td>
</tr>
</tbody>
</table>

<sup>a</sup>Calculated as the summation of the individual animal initial weights, corrected for the shrink from purchase to arrival at the feedlot.

<sup>b</sup>Average hip height of the animals in each pen.

**TABLE 4. Ancillary Production Data Summary**

<table>
<thead>
<tr>
<th>Ancillary Production Variable&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Experimental Group</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRAF</td>
<td>MIC</td>
<td>TET</td>
</tr>
<tr>
<td>Slaughter weight&lt;sup&gt;b&lt;/sup&gt; (lb)</td>
<td>1,219.0</td>
<td>1,205.1</td>
<td>1,200.6</td>
</tr>
<tr>
<td>Weight gain&lt;sup&gt;c&lt;/sup&gt; (lb)</td>
<td>607.2</td>
<td>595.5</td>
<td>589.7</td>
</tr>
<tr>
<td>Carcass weight&lt;sup&gt;d&lt;/sup&gt; (lb)</td>
<td>744.5</td>
<td>735.7</td>
<td>733.5</td>
</tr>
<tr>
<td>Dressing percentage&lt;sup&gt;e&lt;/sup&gt;</td>
<td>61.07</td>
<td>61.05</td>
<td>61.09</td>
</tr>
<tr>
<td>DOF&lt;sup&gt;f&lt;/sup&gt; (day)</td>
<td>229.2</td>
<td>227.9</td>
<td>227.3</td>
</tr>
<tr>
<td>DDMI&lt;sup&gt;g&lt;/sup&gt; (lb/animal/day)</td>
<td>18.34</td>
<td>17.57</td>
<td>17.67</td>
</tr>
</tbody>
</table>

<sup>a</sup>See page 187 for the equations used to determine ancillary production variables.

<sup>b</sup>Represents the average net live weight of animals sold for slaughter.

<sup>c</sup>Represents the average weight gain of animals sold for slaughter.

<sup>d</sup>Represents the average carcass weight of animals sold for slaughter.

<sup>e</sup>Represents the average dressing percentage of animals sold for slaughter.

<sup>f</sup>Represents the average number of days on feed (DOF) of animals sold for slaughter.

<sup>g</sup>Represents lb of feed consumed/animal/day.

DDMI = daily dry matter intake.
Draxxin, Can$14.18/animal for Micotil, and Can$8.48/animal for Tetradure LA-300. Outcome variables describing the animal health, feedlot performance (carcass weight basis ADG and carcass weight basis DM:G), and carcass characteristics of each experimental group were incorporated into the model when significant $(P < .05)$ differences existed between the experimental groups. When there were no significant $(P \geq .05)$ differences between the experimental groups, the animal health, feedlot performance, and carcass characteristics of the control (MIC or TET, depending on the comparison) group were used for both experimental groups in a comparison. All other factors were fixed in the economic simulations. The value of a dead animal was Can$0.00. Feed consumed by animals before death was not estimated. The input values used in the economic model are summarized in Table 2.

### RESULTS

Pen-based summary statistics for the baseline variables are presented in Table 3. The experimental groups were considered homogenous $(P \geq .05)$ with respect to average initial weight and average hip height, with the exception that the purchase weight of animals in the DRAX group was 2.3 lb heavier than the purchase weight of animals in the MIC group $(P = .013)$.

The ancillary production data summary is presented in Table 4. Slaughter weight, weight gain, carcass weight, DOF, and DDMI were significantly $(P < .05)$ higher in the DRAX group compared with the MIC and TET groups. There was no significant $(P \geq .05)$ difference in the dressing percentage of the DRAX group compared with the MIC and TET groups.

The morbidity and mortality data summaries are presented in Tables 5 and 6, respectively. Initial UF treatment; first UF relapse; initial NF treatment; overall chronicity; and overall, BRD, and histophilosis mortality rates were significantly $(P < .05)$ lower in the DRAX group compared with the MIC and TET groups. There were no significant $(P \geq .05)$ differences in first NF relapse; overall wastage; or metabolic, arthritis, or miscellaneous mortality rates between the DRAX group and the MIC and TET groups.

Feedlot performance variables are summarized in Table 7. On both a live weight basis and a carcass weight basis, ADG was significantly $(P < .05)$ higher in the DRAX group compared with the MIC and TET groups. However, on both a live weight basis and a carcass weight basis, DM:G of the MIC group was significantly $(P < .05)$ improved compared with the DRAX group. There were no significant $(P \geq .05)$ differences in DM:G between the DRAX and TET groups on either a live weight basis or a carcass weight basis.

The carcass characteristic data summary is presented in Table 8. The proportion of carcasses grading YG Canada 1 was significantly $(P < .05)$ lower in the DRAX group compared with the MIC and TET groups. This observation was balanced with a significantly $(P < .05)$ higher occurrence of YG Canada 2 carcasses in the DRAX group compared with the MIC group and a significantly $(P < .05)$ higher occurrence of YG Canada 3 carcasses in the DRAX group compared with the TET group. In addition, there were significantly $(P < .05)$ more QG Canada AAA carcasses and fewer QG Canada AA and QG Canada A carcasses in the DRAX group compared with the TET group. There was no significant difference in the occurrence of “off grades” (B and D grades) in the DRAX group compared with the MIC and TET groups.

---

*aAll values are presented in Canadian dollars (Can$).*
TABLE 5. Morbidity Data Summary\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Morbidity Variable</th>
<th>Experimental Group</th>
<th>Comparison</th>
<th>Relative Risk\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRAX</td>
<td>MIC</td>
<td>TET</td>
</tr>
<tr>
<td>No. of animals</td>
<td>3,304</td>
<td>3,304</td>
<td>3,302</td>
</tr>
<tr>
<td>Initial UF treatment</td>
<td>113 (3.42)</td>
<td>464 (14.04)</td>
<td>562 (17.02)</td>
</tr>
<tr>
<td>First UF relapse</td>
<td>26 (23.01)</td>
<td>179 (38.58)</td>
<td>218 (38.79)</td>
</tr>
<tr>
<td>Initial NF treatment</td>
<td>118 (3.57)</td>
<td>252 (7.63)</td>
<td>276 (8.36)</td>
</tr>
<tr>
<td>First NF relapse</td>
<td>42 (35.59)</td>
<td>89 (35.32)</td>
<td>121 (43.84)</td>
</tr>
<tr>
<td>Overall chronicity</td>
<td>32 (0.97)</td>
<td>75 (2.27)</td>
<td>96 (2.91)</td>
</tr>
<tr>
<td>Overall wastage</td>
<td>20 (0.61)</td>
<td>29 (0.88)</td>
<td>31 (0.94)</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Numbers in parentheses are percentages.
\textsuperscript{b}Five animals (two each in the DRAX and MIC groups and one in the TET group) received the wrong antimicrobial at allocation and were excluded from the animal health summary and analysis.
\textsuperscript{c}Ratio of the rate of disease in the DRAX group divided by the rate of the disease in the MIC or TET group.
\textsuperscript{d}Calculated for each relative risk; corrected for pen and replicate effects using generalized linear modeling techniques.

TABLE 6. Mortality Data Summary\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Morbidity Variable</th>
<th>Experimental Group</th>
<th>Comparison</th>
<th>Relative Risk\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRAX</td>
<td>MIC</td>
<td>TET</td>
</tr>
<tr>
<td>No. of animals</td>
<td>3,304</td>
<td>3,304</td>
<td>3,302</td>
</tr>
<tr>
<td>Overall mortality</td>
<td>75 (2.27)</td>
<td>162 (4.90)</td>
<td>199 (6.03)</td>
</tr>
<tr>
<td>BRD mortality</td>
<td>10 (0.30)</td>
<td>62 (1.88)</td>
<td>84 (2.54)</td>
</tr>
<tr>
<td>Histophilosis\textsuperscript{e} mortality</td>
<td>9 (0.27)</td>
<td>34 (1.03)</td>
<td>29 (0.88)</td>
</tr>
<tr>
<td>Metabolic mortality</td>
<td>27 (0.82)</td>
<td>28 (0.85)</td>
<td>38 (1.15)</td>
</tr>
<tr>
<td>Arthritis mortality</td>
<td>4 (0.12)</td>
<td>2 (0.06)</td>
<td>8 (0.24)</td>
</tr>
<tr>
<td>Miscellaneous mortality</td>
<td>25 (0.76)</td>
<td>36 (1.09)</td>
<td>40 (1.21)</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Numbers in parentheses are percentages.
\textsuperscript{b}Five animals (two each in the DRAX and MIC groups and one in the TET group) received the wrong antimicrobial at allocation and were excluded from the animal health summary and analysis.
\textsuperscript{c}Ratio of the rate of disease in the DRAX group divided by the rate of the disease in the MIC or TET group.
\textsuperscript{d}Calculated for each relative risk; corrected for pen and replicate effects using generalized linear modeling techniques.

\textsuperscript{e}Disease due to \textit{Histophilus somni} infection.

\textsuperscript{f}BRD = bovine respiratory disease.
In the economic analysis, there was an advantage of Can$16.96/animal in the DRAX group compared with the TET group as a result of lower treatment and mortality rates, improved ADG, and improved QG, even though there was inferior YG and a higher metaphylactic antimicrobial cost in the DRAX group. In addition, there was an advantage of Can$3.79/animal in the DRAX group compared with the MIC group because of lower treatment and mortality rates, improved ADG, and improved QG, despite the inferior feed efficiency and YG and higher metaphylactic antimicrobial cost in the DRAX group. A detailed summary of the economic analysis is presented in Table 9, and a summary of the economic model sensitivity analysis is presented in Table 2.

Testing ear skin biopsies from animals that died during the study detected 16 animals that had positive IHC staining of hair follicles for BVDV, which represents a minimum BVDV PI rate of 0.16% in the study animals. There were two PI animals detected in the DRAX group (2.67% of animals that died), four PI animals detected in the MIC group (2.47% of animals that died), and 10 PI animals detected in the TET group (5.03% of animals that died).

**DISCUSSION**

Based on the results of this study, tulathromycin appears to be a potent antimicrobial that is superior to tilmicosin and oxytetracycline as a metaphylactic antimicrobial in feedlot calves. This is evidenced by the reductions in morbidity and mortality and the improvement in ADG observed in this study. Although tulathromycin is approximately two to three times more expensive than tilmicosin or oxytetracycline, it is still a more cost-effective metaphylactic antimicrobial in calves at ultra-high risk of developing UF than either tilmicosin or oxytetracycline, and its use results in a lower net cost of feedlot production. As shown in the sensitivity analysis, the cost-effectiveness of using metaphylactic tulathromycin when calves at ultra-high risk of developing UF arrive at the feedlot is robust over a wide range of economic conditions.

The direct economic effects calculated previously and the substantial reduction in morbidity observed in the DRAX group have several intangible benefits. First, the lower number of animals that become sick with UF and require therapy when metaphylactic tulathromycin is used will result in reduced use of antimicrobials in the beef production system. Second, the use of metaphylactic tulathromycin has the potential to improve overall animal well-being because fewer animals will get sick and less animal handling and convalescent pen use will occur. Finally, the use of metaphylactic tulathromycin is likely to reduce the amount of labor required for disease detection and treatment because fewer an-
animals need to be treated and rehandled. This is of particular importance in areas of the world, such as western Canada, where there are shortages of qualified personnel to work in beef feedlots.

When compared with tulathromycin, using tilmicosin resulted in significantly ($P < .05$) improved DM:G. The exact cause for this result is unknown. Perhaps tilmicosin has a direct effect on feed conversion. Alternatively, the use of tulathromycin may have resulted in the survival of more animals with suboptimal feed conversion that would have otherwise died had they received tilmicosin. This explanation is partially supported by the fact that the mortality rate in the DRAX group was significantly ($P < .05$) lower than that in the MIC group. Another factor that must be considered is that cattle in the DRAX group were fed to a heavier carcass weight than cattle in the MIC group. Further investigation is warranted to determine the effect of using tulathromycin on DM:G.

Within each replicate, the same number of animals from each experimental group was marketed to the same packing plant on the same day in an attempt to control for the inherent day-to-day variation observed in carcass grading at packing plants. However, because the mortality rates observed in the DRAX group were lower than those observed in the MIC and TET groups, a small but consistently higher proportion of animals in each MIC and TET pen were marketed in the first marketing groups from each replicate. This phenomenon resulted in the reported differences in DOF between the three experimental groups. It is unlikely that this small difference materially changed the feedlot performance or carcass characteristic outcome variables. However, if strategies to market the same proportion of animals from each experimental group in a replicate on the same day, instead of the same number of animals, are used, this “study design–induced” observation can be avoided while still managing to control for the inherent day-to-day variation observed in carcass grading at packing plants.

The calculations used in this study for feedlot performance variables included the feedlot exit weight of all animals, including the weight of dead animals at the time of death. This represents the biologic ADG and DM:G that oc-

<table>
<thead>
<tr>
<th>TABLE 7. Feedlot Performance Data Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Variable$^a$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Average daily gain$^b$</strong></td>
</tr>
<tr>
<td>Live weight basis$^c$</td>
</tr>
<tr>
<td>Carcass weight basis$^d$</td>
</tr>
<tr>
<td><strong>Dry matter intake:gain ratio$^e$</strong></td>
</tr>
<tr>
<td>Live weight basis$^c$</td>
</tr>
<tr>
<td>Carcass weight basis$^d$</td>
</tr>
</tbody>
</table>

$^a$See page 188 for the equations used to determine performance variables.

$^b$Expressed as lb/animal/day. The effect of animals that died has been removed from the average daily gain values.

$^c$Calculated using shrunk live weights obtained before slaughter.

$^d$Calculated using carcass weights obtained at slaughter; converted to live weights using a fixed dressing percentage of 60.0%.

$^e$Dry matter intake:gain ratio (DM:G) is a ratio of the lb of feed (expressed on a 100% dry matter basis) necessary for 1 lb of gain. The effect of animals that died has been removed from the DM:G values.
curred during the feeding period. This is commonly referred to as a “deads out” method because the effects of death loss have been excluded from the calculations. Other methods for calculating feedlot performance variables used by some researchers and feedlot operators are known as “deads in” methods. In the most commonly used version of the “deads in” method, the feedlot exit weight used for dead animals is zero. Consequently, this creates a blended outcome variable that represents not only biologic ADG and DM:G but also the effects of death loss. As a result, when this “deads in” method is used, it is invalid to consider mortality data separately because a “double count-

### TABLE 8. Carcass Characteristic Data Summary

<table>
<thead>
<tr>
<th>Carcass Characteristic Variable</th>
<th>Experimental Group</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRAX</td>
<td>MIC</td>
<td>TET</td>
</tr>
<tr>
<td><strong>Yield Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada 1</td>
<td>57.24</td>
<td>63.90</td>
<td>63.08</td>
</tr>
<tr>
<td>Canada 2</td>
<td>26.86</td>
<td>21.80</td>
<td>24.44</td>
</tr>
<tr>
<td>Canada 3</td>
<td>15.89</td>
<td>14.31</td>
<td>12.47</td>
</tr>
<tr>
<td><strong>Quality Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada Prime</td>
<td>1.43</td>
<td>0.89</td>
<td>0.87</td>
</tr>
<tr>
<td>Canada AAA</td>
<td>50.28</td>
<td>48.28</td>
<td>46.71</td>
</tr>
<tr>
<td>Canada AA</td>
<td>44.67</td>
<td>47.09</td>
<td>47.92</td>
</tr>
<tr>
<td>Canada A</td>
<td>0.92</td>
<td>1.50</td>
<td>2.11</td>
</tr>
<tr>
<td>B1</td>
<td>0.00</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>B2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>B4</td>
<td>2.67</td>
<td>2.18</td>
<td>2.32</td>
</tr>
<tr>
<td>D2</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D4</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*All numbers are expressed as percentages.*

*Presented as the proportion of carcasses within a pen that graded each yield grade listed.*

*Presented as the proportion of carcasses within a pen that graded each quality grade listed.*

---

### TABLE 9. Economic Analysis Summary

<table>
<thead>
<tr>
<th>Variable</th>
<th>DRAX vs MIC</th>
<th>DRAX vs TET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial undifferentiated fever treatment</td>
<td>Can$3.50</td>
<td>Can$4.49</td>
</tr>
<tr>
<td>First undifferentiated fever relapse</td>
<td>Can$0.11</td>
<td>Can$0.11</td>
</tr>
<tr>
<td>Initial no fever treatment</td>
<td>Can$0.43</td>
<td>Can$0.64</td>
</tr>
<tr>
<td>Overall mortality</td>
<td>Can$17.89</td>
<td>Can$25.58</td>
</tr>
<tr>
<td>Average daily gain</td>
<td>Can$2.08</td>
<td>Can$1.61</td>
</tr>
<tr>
<td>Dry matter intake:gain ratio</td>
<td>–Can$7.68</td>
<td>—</td>
</tr>
<tr>
<td>Quality grade Canada prime</td>
<td>Can$0.79</td>
<td>Can$0.82</td>
</tr>
<tr>
<td>Quality grade Canada AAA</td>
<td>—</td>
<td>Can$2.89</td>
</tr>
<tr>
<td>Quality grade Canada A</td>
<td>—</td>
<td>Can$0.52</td>
</tr>
<tr>
<td>Yield grade Canada 1</td>
<td>–Can$1.47</td>
<td>–Can$1.29</td>
</tr>
<tr>
<td>Yield grade Canada 3</td>
<td>—</td>
<td>–Can$0.75</td>
</tr>
<tr>
<td>Metaphylactic antimicrobial cost</td>
<td>–Can$11.86</td>
<td>–Can$17.66</td>
</tr>
<tr>
<td><strong>Total economic advantage for DRAX</strong></td>
<td>Can$3.79</td>
<td>Can$16.96</td>
</tr>
</tbody>
</table>
More of death loss effects would occur. Moreover, the use of this “deads in” method can generate misleading results that fail to describe the situation thoroughly and accurately. A comparison between these two methods, or other methods for calculating feedlot performance values, has not been previously reported in the veterinary literature.

A summary of feedlot performance variables using the “deads in” method is presented in Table 10. When the data generated from this study using the “deads out” method (Tables 6 and 7) are compared with the same data calculated using the “deads in” method (Table 10), the limitations of the latter method are clearly demonstrated. For example, reporting death loss separate from biologic ADG and DM:G (Tables 6 and 7) shows that the use of metaphylactic tulathromycin resulted in significantly (P < .05) lower mortality, improved ADG, and inferior DM:G when compared with the use of metaphylactic tilmicosin. However, reporting outcome variables that combine the effects of mortality and feedlot performance (Table 10) would have erroneously concluded that the only difference between the use of metaphylactic tulathromycin and tilmicosin was significantly improved (P < .05) ADG in animals that received metaphylactic tulathromycin. This is a misleading finding that would be further compounded by “double-counting” of death loss effects if the mortality data demonstrating that metaphylactic tulathromycin resulted in lower mortality rates were also considered. Moreover, the “deads-in” method would obscure the fact that the DM:G of animals receiving metaphylactic tilmicosin was significantly (P < .05) worse than that of animals receiving metaphylactic tilmicosin.

The number of PI calves detected in the TET and MIC groups was higher than that of the DRAX group. This observation could have confounded the overall mortality rates in the experimental groups since PI calves have lower survival rates and are more prone to infection. However, the gap in the mortality rates between the DRAX group and the other two

<table>
<thead>
<tr>
<th>TABLE 10. Performance Data Summary Using Calculations That Do Not Include the Feedlot Exit Weight of Dead Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance Variable</strong></td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Average daily gain</td>
</tr>
<tr>
<td>Live weight basis</td>
</tr>
<tr>
<td>Carcass weight basis</td>
</tr>
<tr>
<td>Dry matter intake:gain ratio</td>
</tr>
<tr>
<td>Live weight basis</td>
</tr>
<tr>
<td>Carcass weight basis</td>
</tr>
</tbody>
</table>

*See page 188 for the equations used to determine performance variables. It must be noted that feedlot performance calculations that do not include the feedlot exit weight of dead animals already include the effects of death loss. As a result, it is invalid to also consider mortality data separately because doing so would represent “double counting” of death loss effects.

*Expressed as lb/animal/day. The effect of animals that died is included in the average daily gain values.

*Calculated using shrunken weights obtained before slaughter.

*Calculated using carcass weights obtained at slaughter; converted to live weights using a fixed dressing percentage of 60.0%.

*Dry matter intake:gain ratio (DM:G) is a ratio of the lb of feed (expressed on a 100% dry matter basis) necessary for 1 lb of gain. The effect of animals that died is included in the DM:G values.
groups is substantial and more than that which could be accounted for by the presence of more PI calves in the MIC and TET groups. Because PI testing was done only on dead animals, it is not possible to determine the true percentage of PI calves in each experimental group. The number of calves tested for being PI was higher in the TET and MIC groups than in the DRAX group. Even if the occurrence of PI calves had been the same in all three groups, more PI calves would have been found in the TET and MIC groups. Furthermore, whether the presence of PI calves in a pen affects the animal health and feedlot performance of pen-mates is an ongoing debate, and answering this question is beyond the scope of this study.

**CONCLUSION**

The results of this study demonstrate that it is more cost-effective to administer metaphylactic Draxxin on arrival at the feedlot to calves at ultra-high risk of developing UF than to administer metaphylactic Micotil or metaphylactic Tetradure.

**ACKNOWLEDGMENTS**

We thank the management and staff of Strangmuir Holdings Ltd., Strathmore, Alberta, Canada, for their assistance and cooperation in conducting this study. In addition, we thank Dr. Lonty Bryant, Pfizer Animal Health, for his valuable input and review of the discussion section regarding "deads in" versus "dead out" feedlot performance calculations.

**REFERENCES**


